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BIO CIRCULAR CITIES

Exploring the circular bioeconomy potential in cities

BioCircularCities Trilogy – Webinars

Episode 2: Identifying the most promising biocircular technological options
The Biocircularcities Webtool in action

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Objectives – Replicability and transferability of the BioCircularCities project outcomes

- Objective: Develop a web app providing guidelines for the definition and implementation of a better strategy for biowaste management according to bioeconomy, circularity and sustainability principles

Task	Timeline	Deliverables and DL
T4.1 Set the scope of applicable bioeconomy, circularity and sustainability principles, criteria, objectives and actions	March to December 2022	D4.1 End December 2022 *Report documenting the definition of the Scope of circular bioeconomy for biowaste management in urban areas.*
T4.2 Structure the legislative framework in order to make specific links to the potential actions to be implemented	March 2022 to June 2023	D4.2 End June 2023 *Report documenting the definition of the decision tree background logic*
T4.3 Develop some guidelines and a supporting tool with a web interface	June 2022 to September 2024	D4.3 End September 2023 *Web application in practice: short guidance for the practitioner*

The Scope of Circular Bioeconomy for biowaste management in urban areas

Adopted approach

3 Main Axes:

- Analysis of the scope of the global Circularity and Bioeconomy concepts, the associated European targets and incentives, and the correlations which can be established between them
- Review of the existing supporting approaches, guidelines and tools has in order to position the BCC guidelines and clearly define its objectives.
- State of the art of the main drivers and barriers towards the development of sustainable circular bioeconomy value chains for biomass waste management

➢ **Structure for the BCC guidelines framework**

Circular & Sustainable Bioeconomy scope

<table>
<tr><th rowspan="2">EU Pillars of Bioeconomy</th><th colspan="4">Waste Framework Directive – Waste hierarchy</th></tr>
<tr><th>Waste prevention / Reduction</th><th>Reuse</th><th>Recycling</th><th>Other recovery</th></tr>
<tr><td>Ensuring food and nutrition Security</td><td>Minimising waste
SDG 12</td><td></td><td colspan="2">Avoid competition of biomass production with food production.
SDG 2 & 12</td></tr>
<tr><td>Reducing dependence on non-renewable and unsustainable resources</td><td>Prioritise renewable resources Minimise use of scarce resources
SDG 12</td><td>Minimise use of scarce resources
SDG 12</td><td></td><td></td></tr>
<tr><td>Mitigating and adapting to climate change</td><td colspan="2" rowspan="2">Promote solutions inspired and supported by nature

Extended use & Second-hand market
SDG 12</td><td colspan="2" rowspan="2">Support close loop system SDG 8 , 9 & 12
Maximise material intensity and Resource efficiency SDG 7 & 8
Design for separation and recovery SDG 8 , 9 & 12
Specific waste Collection and sorting SDG 11</td></tr>
<tr><td>Managing natural resources Sustainably</td></tr>
<tr><td></td><td colspan="4">Carbon sequestration in soils connected to use of soil improvers / Biogenic carbon storage
SDG 9 & 13 & 15

GHG reduction SDG 13</td></tr>
<tr><td></td><td colspan="2"></td><td>Minimise use of water and land SDG 6 & 15
Protect Biodiversity SDG 15</td></tr>
<tr><td></td><td rowspan="2">Minimising biowaste
SDG 12</td><td></td><td>Cascading use of biomass SDG 9</td></tr>
<tr><td></td><td></td><td>Maximise waste value recovery SDG 7 & 8</td></tr>
<tr><td>Strengthening European competitiveness and creating jobs</td><td colspan="4">Local and low impact economies. Employment, Economic development, Linkage between rural and urban economies SDG 1, 4, 8, 9, 17</td></tr>
</table>

SDG stands for: "Sustainable Development Goals" (United Nations, 2019)

- **The ultimate purpose of a sustainable, circular bioeconomy strategy for biowaste valorisation** is to support the transition towards **production and consumption systems**

✓ whose environmental impacts are reduced to a minimum,

✓ bringing societal benefits,

✓ through the development of economically viable technological solutions.

Review of already existing guidelines and tools

	Authors	Type of supporting instrument	Scope (product/process, value chain, territory)	Type of resources / Sector of concern	Bio-circular strategy development stage supported by the tool or guideline	Targeted public
EU Framework for Bioeconomy monitoring	European Commission JRC. Giuntoli et al. 2020	Web platform	All	All	Transverse to Map – Design – Implement stages	Industrial, researcher and public stakeholders
The Biowaste Hub	SCALIBUR H2020 project. 2022	Web platform	All	Biowaste	Transverse to Map – Design – Implement stages	Industrial, researcher and public stakeholders
TECH4BIOWASTE database	H2020 project Tech4Biowaste.	Web platform	Process and product description	Food waste and Garden waste	Transverse to Design and Implement stages	Technology providers and users
EASETECH	Technical University of Denmark. 2015 Clavreul et al. 2014	Tool	Process Value Chain Territory (City or larger area)	Environmental technologies applied to all types of waste.	Assess and evaluate the pathways or solutions	Researchers, consultants, public authorities as well as technology developers.
LCA-IWM	J. den Boer. 2007	Tool	Municipality Waste value chain / management systems	All type of waste	Assess and evaluate the pathways or solutions	Policy makers/ Public Authorities, Industrial stakeholders
MSW-DST	US EPA and RTI International. RTI International. 2012	Tool	Waste value chain	All type of waste	Assess and evaluate the pathways or solutions	Policy makers/ Public Authorities, Industrial stakeholders
BioMonitor tool	H2020 project BioMonitor. Van Leeuwen et al. 2021	Tool	Product / value chain / market (>> territory)	Agro-food, bio-based products, forest resources, wood based products, bioeconomic sectors	Assess and evaluate the pathways or solutions	Policy makers/ Public Authorities, Industrial stakeholders
DECISIVE	H2020 project DECISIVE. 2021	Tool	Process and Urban area	Urban biowaste	Assess and evaluate the pathways or solutions	Local authorities and environmental service companies
Food waste prevention calculator	De Lorentiis et al. 2020	Tool	Food waste value chain.	Food waste	Assess and evaluate the pathways or solutions	Policy makers/ Public Authorities
DELIGES	Delgado et al. 2019.	Tool	Value chain including waste collection, pre-treatment, treatment and application.	Biowaste in general	Assess and evaluate the pathways or solutions	Public and private stakeholders making decision along biowaste value chain
ReSOLVE framework	The Ellen MacArthur Foundation, 2017.	Tool	Product / process / value chain	Generic to material and energy flows	Identify solutions and actions	Companies – Industrial stakeholders
Urban Opportunity Framework – Circle City scan tool	Circle Economy. 2020	Tool	Territory: Urban and cities territory	Focus on circularity for several urban themes: water, solid waste, energy, organics, buildings, consumables.	Identify solutions and actions	Cities' decision makers / Public local Authorities / Local authorities / Urban planners
Causal Loop Diagrams (CLD)	Bassi et al. 2021	Tool	Territory	Generic and not limited to bio-resources. Focus on circularity development for material and energy flows.	Assess and evaluate the pathways or solutions	Industrial, researcher and public stakeholders
Value Chain Approach	UNEP. 2021	Tool	Value chain	Not dedicated to bioeconomy. Focus on circularity for Food flows, and also construction and textile.	Identify solutions and actions	Policy makers and industrial decision makers
Circular Strategies Scanner	CIRCit NORDEN. 2020	Tool	Product / Service.	Generic and not limited to bio-resources. Focus on circularity development for material flows.	Identify solutions and actions	Manufacturing industries
SWOLF – Solid Waste Optimization Life-Cycle Framework	Stanisavljevic et al. 2017	Raw scientific model	Value chain: Solid Waste Management Process: Individual technology	Solid waste (bio and other)	Assess and evaluate the pathways or solutions	Policy makers and industrial decision makers
Urban Metabolism Analyst – UMAn	Rosado et al. 2017.	Raw scientific model	Product / Territory.	Generic and not limited to bio-resources. Focus on circularity development for material flows.	Assess and evaluate the pathways or solutions	Cities' decision makers / Public local Authorities / Local authorities / Urban planners
Urban Circularity Assessment (UCA)	CITYLOOPS H2020 project. 2022	Raw scientific model	Product / Territory.	Generic and not limited to bio-resources. Focus on circularity development for material flows.	Assess and evaluate the pathways or solutions	Cities' decision makers / Public local Authorities / Local authorities / Urban planners
MCDA	Pieratti et al. 2019	Methodological approach	Value Chain	Forest wood chain as a case study – replicable to other biowaste value chain	Assess and evaluate the pathways or solutions	n.n

- 3 Web platforms
- 12 tools
- 4 raw scientific models

- Addressing (bio)waste value chain
- Product or territorial approach
- Assessing materials and/or energy flows, sustainability, circularity

Review of already existing guidelines and tools

- ✓ Oriented towards industrial or policy / authorities stakeholders
- ✓ Majority are focused on sustainability assessment.
- ✓ Powerful but not easily accessible to non-expert targeted public

- ✓ Few are informative platforms, dedicated to the identification of circular and sustainable actions and pathways.
- ✓ Generally do not reach the step of providing support in the identification of concrete technological options to be implemented in relation to a specific context.

Objective and scope of the BCC Guidelines

- Support the definition of a better strategy for biowaste management according to bioeconomy, circularity and sustainability principles, through the identification of the most suitable biowaste treatment options.

Biowaste

How to avoid landfill and create value

Many options exist

- Recycling in high value biobased chemicals and products
- Recycling nutrients into compost, biogas, biomethane
- Incineration with energy recovers

- **Which one is the most suitable considering a specific context?**

Drivers and barriers towards the development of a sustainable and circular bioeconomy

Drivers and Barriers need to be identified in order to understand which are the criteria of influence to be considered for the choice of a technological pathway, considering a specific urban or territorial context.

- "Drivers" are defined as Strenghts or Opportunities
  - Valuable actions or facts already implemented
  - Potential added value that the further development of sustainable and biocircular value chains would bring.

- “Barriers” to the development of biocircular value chains are defined as Weaknesses or Threats
  - Slowing down the design and implementation of biocircular solutions,
  - Potentially causing problems or undermine the development of biocircular value chains.

Drivers and barriers towards the development of a sustainable and circular bioeconomy

Strengths
- Demand driven development enhances the market to adapt and manage the transition more efficiently.
- Awareness-raising activities and providing good information to consumers .
- Targets on municipal waste recycling are set at 55% for 2025, 60% for 2030 and 65% for 2035.
- Rural development policies are a crucial component to be integrated into the implementation of Bioeconomy.
- WFD 2018 targets for recycling induce to limit the presence of contaminants among collected waste.
- Separate collection of biowaste will become mandatory on 01/01/2024.
- Succes stories (already achieved developments) can enhance innovation and cooperation between public and private sectors, and mutualising initiatives from the private sectors.
- Promising alternative routes for biorefining, compatible with rural development, resilience, and system efficiency.
- Food wastes can be an important feedstock for small-scale biorefineries.

Weaknesses
- Mobilisation of private investments.
- Further investments for transfer knowledge into innovation.
- Engage citizenships is a long process.
- Lack of understanding of concepts, choices and co-benefits by the stakeholders along the value chain (businesses, citizenships, final user).
- Inadequate awareness and participation of consumers/citizens.
- The consumer behavioural change can significantly influence decision making.
- Consumers rooted consumption habits and patterns can be a limitation.
- Lack of acceptance of waste-based products.
- Missing framework to seize and communicate about sustainability to different stakeholders,
- Need for clear rules on labelling.
- Lack of standardisation.
- Lack of a long-term policy pull.
- Lack of regional CE policy formulation and coordination.
- Lack of targets and objectives related to the implementation of policies.
- The environmental and economic costs of the biowaste valorisation can be beneficial or not.
- Transformative land use practices are not well addressed.
- Impacts of the bioeconomy at the regional or local level are not well adressed.
- Need to cover the "valley of death" of bioeconomy innovation.
- Infrastructure capacity can be limited.
- Matching the treatment capacity to the volume of the collected waste can be critical.
- Low TRL of circular innovations.
- There is a gap between laboratory research and its transfer to industrial-scale commercial application.
- Too low collaboration between researchers, industries and governments.
- No comprehensive statistics on the socio-economic performances of bio-based industries is available.
- A change of paradigm is required, the focus of Member States is not enough on the development of bioeconomy considering the biowaste value chain.
- Better understanding of potential synergies and trade-offs of technology and policy options is necessary.
- Sustainability evaluation and monitoring need to be further developed and strengthened (models and metrics).

Opportunities
- Shift towards more sustainable consumption patterns.
- Well-being, health and resilience need to be seen as necessary co-drivers of market interactions.
- Strong engagement of citizen and young people.
- Give active roles to people
- The development of biomaterials and ecosystem services will gain significantly
- Economic incentives for bio-waste collection and treatment.
- Need to face the projected 'biomass gap' between supply and demand of biomass for food, materials and energy.
- The continuous or improved provision of Ecosystem services shall get an economic value.
- Promote short domestic sustainable bioeconomic supply chains.
- Sustainable and inclusive business models.
- Separation of bio-waste at source is a basic condition for achieving high-quality outputs.
- Investing for the creation of skills, quality jobs and opportunities
- Sustainable regional economic development.

Threats
- High upfront investment costs & Financing risks related to long and uncertain payback times.
- Time lags between making an investment and starting operation.
- Resource price distortion
- Market and demand risks
- The interaction between food & feed, fibre, chemicals, energy etc. is currently driven by markets and prices, with few policy interventions.
- Difficulties in balancing and coordinating economic development and environmental regulation.
- Lack of long term vision related to CE return investments.
- Innovation outside the bioeconomy sphere could be more competitive than bioeconomy solutions/products.
- EU biorefinery activities are dominated by large-scale projects to achieve cost-effectiveness and high efficiencies.
- Efficiency and viability of new business model can induce some technological and/or logistic deficiencies.
- Technical feasibility of biowaste processing faces limitation and challenges, mainly related to the supply chain of biomass waste.
- The conventional bioenergy pathways are under threat.
- Biophysical limitations of the natural resources value chain are under consideration.
- Lack of knowledge of procedures in businesses.
- Lack of experience and skills among public authorities.
- Success of biocircular models depend strongly on the joint consideration of cross-cutting issues, multiple objectives, and competition between the different (industrial and energy) sectors of the bioeconomy.

The equilibrium between drivers and barriers seems unbalanced, the number of barriers identified from a literature review was almost twice the number of identified drivers.

Driving forces Under which the influencing drivers and barriers can be grouped:

1. Appropriate and up to date policy framework
2. Shift to more sustainable consumption patterns – market transition
3. Cross sectoral cooperation and innovation
4. Development of a skilled and competent workforce at the European level
5. Sustainable management and use of biological resources
6. Funding and investment resources to support a competitive development
7. Ensuring sustainability

Driving forces Under which the influencing drivers and barriers can be grouped:

1. Appropriate and up to date policy framework

- Challenge for circular bioeconomy:
  - the scope is large and complex,
  - policies that do not target directly the bioeconomy can as well have some effects,
  - circular bioeconomy implementation is quite recent and the techno-economic context in which it happens is evolving fast.

2. Shift to more sustainable consumption patterns – market transition

- Transition toward the bioeconomy is largely driven by the market, itself is largely driven by the consummers demand
  - Well-being, health issues and resilience capabilities shall be seen as co-drivers of market interactions
  - Secondary resources (e.g. from biowaste transformation) are potentially not competitive compared to primary fossil resources

3. Cross sectoral cooperation and innovation

- Need for engagement of the different stakeholders playing a role along the biocircular value chain,
- Need to consider the interconnectedness of the value chains.

Driving forces Under which the influencing drivers and barriers can be grouped:

4. Development of a skilled and competent workforce at the European level

- The lack of experience and skills, expertise and technical know-how on biocircular concepts and approaches from businesses and public authorities
- Limited understanding of the associated sustainability benefits.

5. Sustainable management and use of biological resources

- Need for consideration of the regenerative capacity of the planet.
- The increasing demand for biomass from additional sectors and markets can place some sectors under threat, like the electricity and heat production,
- Pressure on the management of land transformation, causing indirect damages on the biodiversity and climate change.
- Regional development of circular bioeconomy through biorefinery, energy recovery and composting is put forward

Driving forces Under which the influencing drivers and barriers can be grouped:

6. Funding and investment resources to support a competitive development

- Development of new value chains requires research and development and offer opportunities for innovation,
- The public economic and human resources investment is the determinant,
- The potential for innovation shall attract private investments along the value chain.

7. Ensuring sustainability

- Transverse to other driving forces
- Need to deepen the understanding and assessment of sustainability performances of the new business models and value chains.

Criteria of influence

For the choice of a suitable bio-circular technology for biowaste valorisation, depending

- On cities and urban areas specific context,
- And on specific characteristics from technologies.

1. Feedstock and current system characterisation	**2. Type of End product targeted**
3. Environmental Performances	**4. Political and economic incentives**

➢ More details available!

Consult the related project deliverables:

➢D4.1: Definition of the Scope of Circular Bioeconomy for biowaste management in urban areas

- Identifying and structuring the principles, concepts, contextual values and parameters that would influence the design of new biocircular value chains and technical pathways for biowaste valorisation and treatment.
- Main vectors and bottlenecks towards the development of sustainable circular bioeconomy value chains for biomass waste management, classified under various "driving forces" for a successful sustainable, circular bioeconomy strategy.

https://biocircularcities.eu/wp-content/uploads/2023/02/Biocircularcities_Circular-bioeconomy-scope_biowaste-management_urbanareas.pdf

D3.2: Regulatory gap and opportunity analysis for a circular bioeconomy

- Deep analysis of the circular bioeconomy European regulatory framework in order to raise drivers and barriers that favour or hinder the transition to a more biocircular system for biowaste management.

https://biocircularcities.eu/wp-content/uploads/2023/02/Biocircularcities_Regulatory_Gap_Opportunities_Analysis.pdf

And much more available on BioCircularCities website: https://biocircularcities.eu/resources/

The BCC guidelines

Setting guidelines for identifying the most suitable biowaste treatment options

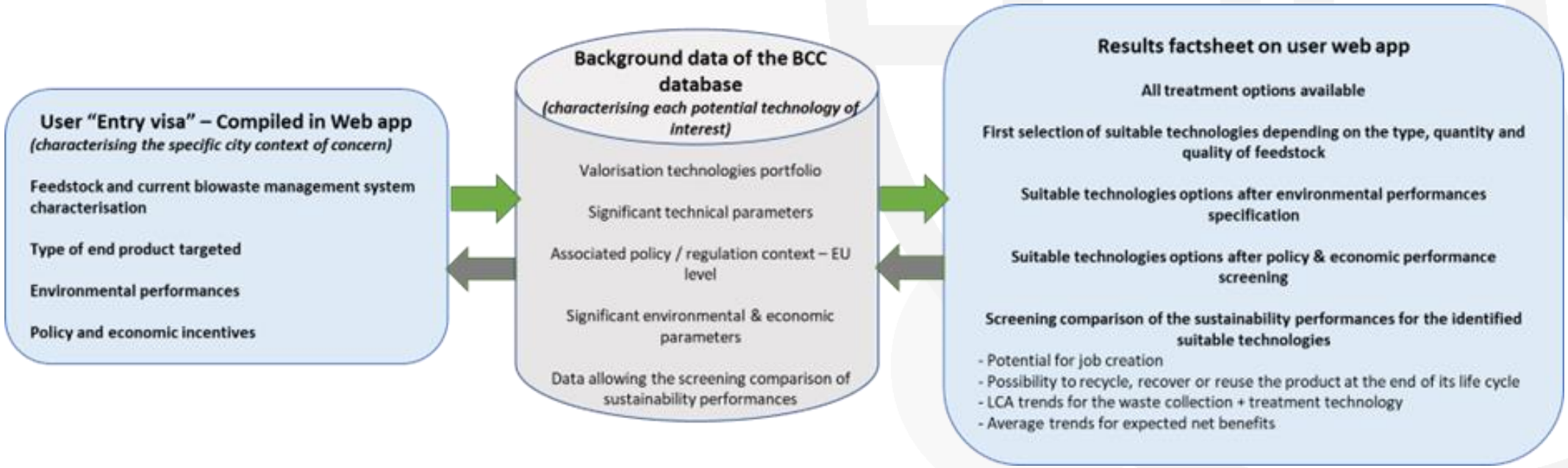
➢ BCC Guidelines format:

Web application supporting the identification of the most relevant options in terms of biowaste management and valorisation technologies.

- https://bcc.list.lu/

Setting guidelines for identifying the most suitable biowaste treatment options

- BCC Guidelines format: Web application supporting the identification of the most relevant options in terms of biowaste management and valorisation technologies.



BCC Guidelines: 14 technologies considered in the final version of the application

	Biochemical processes	Thermochemical processes	Chemical processes	Other
Bulk/Specialty chemicals obtained from food related waste or from wood bark, cellulose, lignin or woody side streams	Enzymatic process	Gasification	Heterogeneous catalysis	Pulping
	Industrial fermentation	Hydrothermal process*		
	Solid state fermentation	Pyrolysis**		
Bio-based functional ingredients / Food ingredients obtained from food related waste	Enzymatic process			
	Industrial fermentation			
	Solid state fermentation			
Biogas obtained from food related waste or from wood bark, cellulose, lignin or woody side streams			Anaerobic digestion	
			Mechanical Biological Treatment (MBT) + Anaerobic Digestion (AD)	
Biomethane obtained from food related waste or from wood bark, cellulose, lignin or woody side streams			Anaerobic digestion + Biomethanation	
Compost obtained from food related waste or from wood bark, cellulose, lignin or woody side streams			MBT + Composting	
Other				Landfill
				Incineration of MSW - with energy recovery

*only applicable to food related waste
**only applicable to wood processing waste and forestry residues

➢ More details available!

Consult the related deliverable:

➢D4.2: Report documenting the definition of the decision tree background logic

Soon available at https://biocircularcities.eu/resources/

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Thank you

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BCC guidelines: Case study 1

Hypothetical User: A Municipality which is looking for improving the management of the mixed organic waste from households.

Volume of waste available from local collection, regular quantity and quality along the year: 20 000 tons for the sole municipality area

No separated waste collection already implemented.

Sorting before treatment is already performed to isolate the organic fraction.

Some impurities (<10%) are remaining after sorting, but they are not characterised.

The current treatment is shared between

- Incineration with energy recovery – 20%
- Mechanical biological treatment with composting – 20%
- Landfill – 60%

The improvement of the organic waste management and valorisation is a top priority for the municipality, both to create economic value and to improve the environmental sustainability of its practices.

The municipality

- Has limited financial resources but is ready to invest on infrastructure and to achieve competences.
- Would like to focus on efficient solution (economically and environmentally speaking) in short to mid-term.