BIO CIRCULAR CITIES

Exploring the circular bioeconomy potential in cities

Webtool in practice: short guidance for the practitioner

Deliverable D4.3 of WP4

Credits

Disclaimer

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Contents

Executive summary

The present report constitutes the third deliverable – D4.3 – of Work Package 4 (WP4) of the BioCircularCities (BCC) project. The BCC WP4 intends to develop some guidelines facilitating the replication of the approaches defined and experienced in each of the three regional pilots involved in the project, for preparing the transition towards a sustainable biowaste management system in compliance with the circular bioeconomy principles.

The BCC guidelines aim to overcome the lack of easily accessible tools to help public authorities and private entities identify available technologies for sustainable transformation based on a set of criteria that are largely influenced by the surrounding urban and regional context.

The BCC guidelines were developed to valorise the outcomes of the theoretical work and the regional theoretical and practical developments that were published during the BCC H2020 project. The guidelines were developed as a webtool, accessible online (with an internet connection). It consists of an interactive questionnaire on the most significant technical, political, socio-economic and environmental criteria that would influence the planning and implementation of a biocircular technology to improve the management and valorisation of organic waste and residues in a specific territory.

The BCC webtool relies on the consideration of a list of influencing criteria that emerged from the analysis of a literature-based state-of-the-art analysis of the main drivers and barriers for the development of biocircular value chains for organic waste management (D4.1), including feedback provided by the local stakeholders in the Living Labs. The drivers and barriers identified in the policy framework on biowaste and bio-based products relevant to the three BCC pilot area value chains (D3.2) were also considered in the webtool.

The aim of D4.3 is to provide practical guidance to practitioners on how to use the BCC webtool by guiding users on how to answer the different questions elaborated for each criterion of the BCC guidelines, documented in the definition of the decision tree background logic (D4.2), and how to generate the different results. D4.3 also provides a technical description of the fourteen technologies included in the BCC webtool. Finally, the user guidance is illustrated with a case study.

List of acronyms

AD	Anaerobic digestion
APC	Air pollution control
BCC	BioCircularCities
CC	Climate change
CED	Cumulative energy demand
CHP	Combined heat and power
EU	European Union
GHG	Greenhouse gas
LCA	Life cycle assessment
LCB	Lignocellulosic biomass
LCC	Life cycle costing
LFG	Landfill gas
MBT	Mechanical biological treatment
MSW	Municipal solid waste
OFMSW	Organic fraction of municipal solid waste
SSF	Solid state fermentation
SW	Solid waste
WP	Work Package

Introduction

The BioCircularCities (BCC) guidelines constitute the main outcome of the WP4 "Transferability and replicability to other international cases" of the BCC project. The BCC guidelines are accessible through a webtool for all policy makers or related persons with a technical background in the field of organic waste valorisation and treatment and will strongly support the exploitation of the project results.

The BCC project is many-fold, addressing the policy, techno-economic, environmental and social barriers and drivers towards a circular bioeconomy from: (i) the policy and regulations perspective, pointing out potential gaps and expectations to enhance the transition with more efficient political and legislative instruments, and (ii) the value chain perspective, highlighting tangible and practical requirements from the field and related stakeholders for the successful development of circular bioeconomy solutions for bio-residues management and valorisation. These two perspectives were addressed through the analysis of the CBE regulatory framework at EU level and at national, regional and local level for the three pilot areas (D3.1, D3.2), as well as through an extensive literature review (D4.1). In addition, they were illustrated by examining the development of economically and environmentally sustainable organic waste valorisation models through three 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).

Considering the state-of-the-art together with the scope and objective of the BCC project, it was decided to develop the BCC guidelines as a supporting tool to help bridge this gap. In order to maximise the added value of the BCC guidelines, they shall be applicable to different types of organic waste, regardless of geographical, political and socio-economic contexts. The BCC guidelines position themselves in support to the design of biocircular solutions to valorise key bio-residues (e.g., municipal biowaste, agro-industrial organic waste, forestry residues) through the identification of the key circular technological routes matching with the specific local or regional area characteristics and priorities for the implementation of the circular bioeconomy.

The BCC webtool relies on the consideration of a list of influencing criteria that emerged from the analysis of a literature-based state-of-the-art analysis of the main drivers and barriers for the development of biocircular value chains for organic waste management. This is described in detail in Deliverable D4.1 of the project. The drivers and barriers identified in the policy framework on biowaste and bio-based products relevant to the three BCC pilot area value chains (D3.2) were also considered in the webtool.

The BCC guidelines support the transferability and replicability of the results and the conclusions from the BCC project as a whole, considering the local stakeholders' feedback during the three Living Labs per pilot area and the outcomes of the three Advisory Board meetings and Peer Review Sessions with international experts in each case. This was described in detail in the previous Deliverable D4.2, which also presents the main principles of the BCC guidelines and explains the set of criteria identified as relevant for assessing compatibility among the type of bio-residues selected as feedstock (e.g. forestry residues), the biocircular technological options depending on it (e.g., production of biochemicals) and the territorial context in which the biocircular solution should be implemented. In addition, the background logic leading to the classification of biocircular technologies depending on the specific territorial context of concern is also explained in detail in D4.2.

The present D4.3 provides a practical guidance to the practitioner on how to use the BCC webtool by guiding users in answering the different questions elaborated for each criterion of the BCC guidelines and documented in the definition of the decision tree background logic. This guidance also contains a practical case to facilitate comprehension of how the different results are generated. D4.3 also provides a technical description of the fourteen technologies included in the BCC webtool.

1. BioCircularCities webtool

1.1. Webtool purpose and objectives

The BioCircularCities (BCC) webtool supports the identification of the most suitable technological options (bio-circular technologies) for improving biowaste management.

The BCC webtool relies on the consideration of a list of influential criteria that emerged from the analysis of the literature-based state-of-the-art of the main drivers and barriers for the development of biocircular value chains for organic waste management, and from the experiences of the pilot areas. This is fully described in Deliverable D4.1 of the project and summarised in Table 1.

Table 1: List of influencing criteria for the choice of a suitable biocircular technology for the valorisation of different types of organic waste and residues, depending on the local or regional specific context, and on specific characteristics from different technologies

Criteria to be considered in the webtool use with regard to the context of the waste stream under consideration at local or regional level. In the BCC background database, each technology will also be characterised according to these criteria.	
1. Feedstock and current system characterisation	Type of feedstock
	Continuous and regular availability of feedstock
	Sorting at source / Separate collection system
	Specific sorting after collection in order to separate the organic fraction
	Non-hazardous contaminant acceptance / High quality feedstock
	Capacity (in terms of feedstock acceptance) for one average single plant
	Price and price stability of feedstocks at the end of waste state compared to landfill tax
	Compatibility with multi-regional vs. local supply chains
	Waste hierarchy category (Recycling (high value), Recycling (medium and low value), Recovery (energy and heat), Disposal (least preferred option – maximum 10% landfill by 2035)
	Potential contribution to EU targets for energy recovery from biowaste (e.g. REPowerEU biomethane target)
	Potential contribution to EU biowaste recycling targets
2. Type of end product targeted	Category of the economic value of the end product
	Capacity (in terms of feedstock acceptance) for one average single plant
	Existing regulation regarding the product output (EU quality and safety standards…)
	Social acceptance of a new product
	Competitiveness compared to conventional products / market price for the bio-based products
3. Environmental performances	Conventional product counterpart / Substitution potential
	Target for climat change (CC) Impact reduction (%) compared to the conventional counterpart
	Process energetic yield (cumulative energy demand (CED) produced *vs.* CED consumed)
	Reduced land consumption compared to conventional bio-based resources
	Other significant sources of environmental impacts (toxicity, air emissions, waste…)
4. Political and economic incentives	Need for developing specific competences
	Additional specific equipment required (for any of the various processing steps) compared to the current situation
	Available subventions from the EU Commission /national or regional entities (Yes / No – Which conditions?): taxes, fees, economic incentives, or subsidies
	Net benefits (Value added vs. life cycle costs, considering available subsidies)

These criteria may result from the feedstock properties (e.g. composition and quality in terms of the content of high-value substances or molecules, presence of contaminants etc.). The efficiency of technological options for recycling or recovery is also of importance, as are the potential associated technical constrains. Finally, the most convenient pathway towards organic waste valorisation strongly depends on drivers and barriers related to the local surrounding political and socio-economic context, and on the potential sustainability strategic targets for the local authorities and private stakeholders endorsing the responsibility of organic waste management.

The objective of the webtool is to provide some first clues about what could be suitable in terms of technological pathways, given a specific context. The BCC webtool does not aim at providing a "ready to implement" business plan.

Warning: The scope of the BCC webtool is generic to the EU, hence potential specific restrictions existing in a specific country or region regarding one or more technologies are not covered by the tool.

1.2. How does the BCC webtool work?

The webtool screens the socio-economic, political and environmental context of the territory where the value chain is to be implemented according to a list of influential criteria and evaluates which technological pathway(s) for the biowaste valorisation would potentially be compatible with the surrounding context described, based on their own specificities with regard to each criterion.

The background mechanisms of the webtool (Figure 1) is fully explained in D4.2.. The full characterisation of technologies is available in chapter 3 of this deliverable.

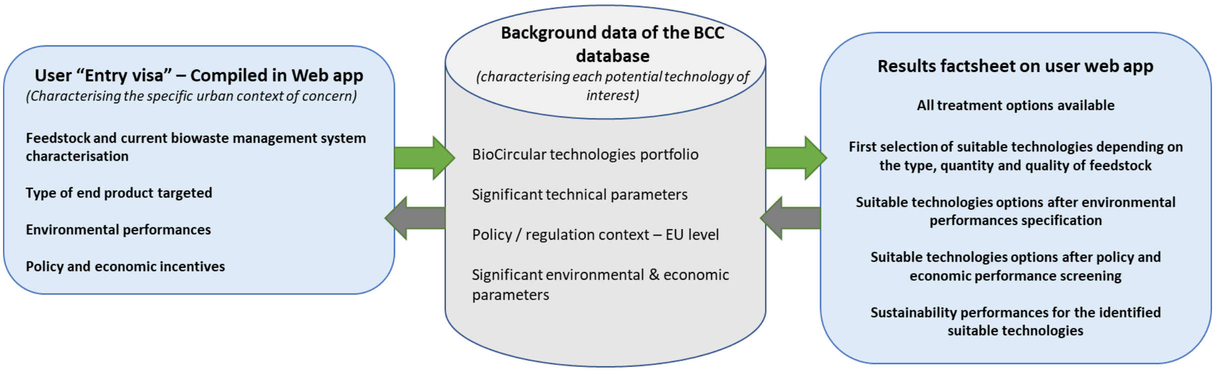


Figure 1: Global structure of the BCC Guidelines integrated into the webtool

1.3. BCC webtool user guide

1.3.1. Access to the webtool

The BCC guidelines are accessible through a webtool at https://bcc.list.lu/.

The user is redirected to the home page ("Home") of the webtool (Figure 2). This home page provides brief information on the context of its development as part of the BCC project, the tool purpose, and an introduction to its organisation and functioning system.

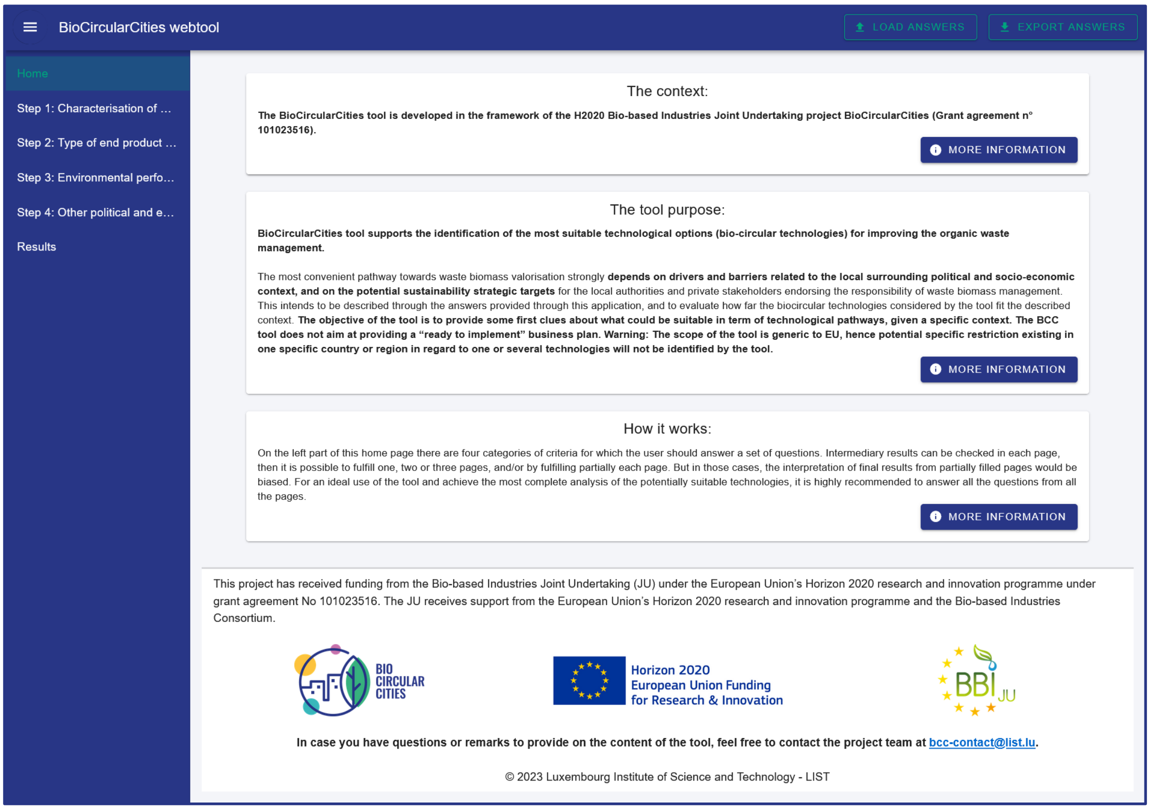


Figure 2: BCC webtool home page

Users can find more details on the information provided on the home page by clicking on MORE INFORMATION

On the left part of this home page there are four categories of criteria with questions to be answered by the user:

- Step 1: Characterisation of the available feedstock and the current existing biowaste management system
- Step 2: Type of end product targeted
- Step 3: Environmental performances
- Step 4: Other political and economic incentives

For optimal use of the tool and to obtain the most complete analysis of the potentially suitable technologies, it is highly recommended to answer all questions on all the pages. However, intermediary results are visible on each page, so it is possible to fill in one, two or three pages, and/or to partially fill in each page. But in these cases, the interpretation of the final results of partially filled pages would be biased.

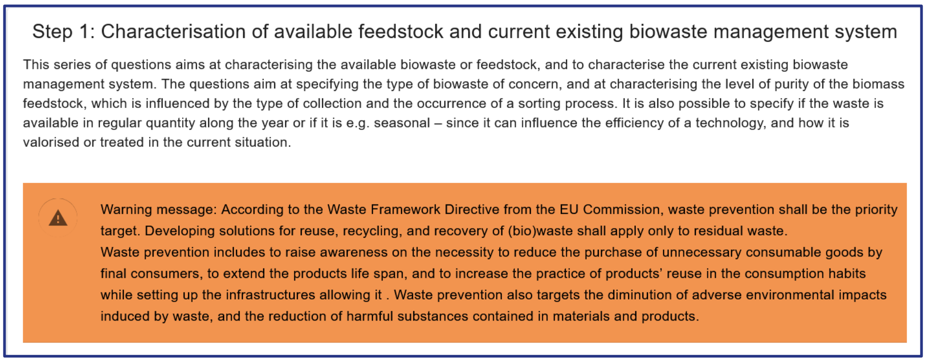
The webtool also offers additional functionalities:

Home	Back to the home page
Results	Summarises the final ranking obtained
LOAD ANSWERS	Import results (in json format) entered during a previous session
EXPORT ANSWERS	Export results in json format

1.3.2. Identification of the most suitable technological options

Step 1: Characterisation of the available feedstock and the current existing biowaste management system

Let's start with step 1, which aims at characterising the available biowaste or feedstock, and to characterise the current existing biowaste management system. A full description of the objective of the step 1 is provided at the top of the page (figure 3).


Step 1: Characterisation of available feedstock and current existing biowaste management system

This series of questions aims at characterising the available biowaste or feedstock, and to characterise the current existing biowaste management system. The questions aim at specifying the type of biowaste of concern, and at characterising the level of purity of the biomass feedstock, which is influenced by the type of collection and the occurrence of a sorting process. It is also possible to specify if the waste is available in regular quantity along the year or if it is e.g. seasonal – since it can influence the efficiency of a technology, and how it is valorised or treated in the current situation.

Warning message: According to the Waste Framework Directive from the EU Commission, waste prevention shall be the priority target. Developing solutions for reuse, recycling, and recovery of (bio)waste shall apply only to residual waste.
Waste prevention includes to raise awareness on the necessity to reduce the purchase of unnecessary consumable goods by final consumers, to extend the products life span, and to increase the practice of products' reuse in the consumption habits while setting up the infrastructures allowing it . Waste prevention also targets the diminution of adverse environmental impacts induced by waste, and the reduction of harmful substances contained in materials and products.

Figure 3: Description the questions from Step 1 of the BCC webtool

The first question aims at selecting which type of biowaste is of concern (figure 4). A drop-down menu is provided to the user who can choose among the categories of biowaste of concern in the BCC project:

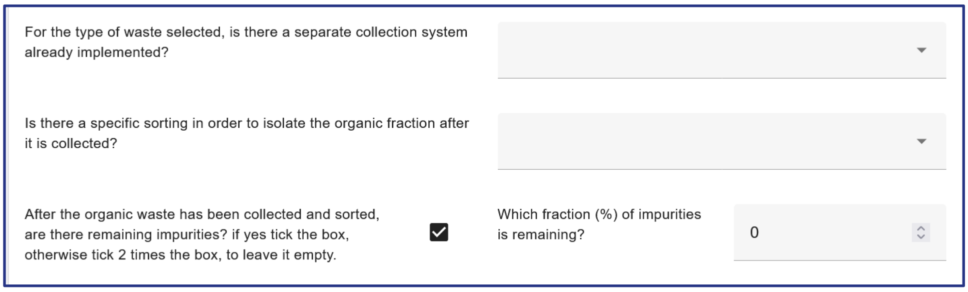
- **Municipal organic waste** – possible to specify which one in particular (e.g. biowaste mixed with residual waste - which can be separated by mechanical-biological treatment (MBT plant); separately collected biowaste; separately collected garden waste)
- **Agro-industrial processing losses** – possible to specify which one in particular (e.g. coffee ground, dairy products, etc.)
- **Forestry residues** – possible to specify which one in particular (e.g. natural wood residues, bark, etc.)

It is very important to specify information in this first question because some technologies, especially biorefinery technologies, like chemical treatment, are highly selective on the type and quality of the biomass feedstock.


Which type of biowaste, which will serve as feedstock for the valorisation technology, would you like to consider?

Figure 4: Question on the selection of the organic waste type

To continue with those criteria, the next three questions (Figure 5) intend to characterise the level of purity of the organic waste feedstock, which is influenced by the type of collection. For municipal biowaste, separate collection will be mandatory by 2024, which will lead to an increase in biowaste available for the valorisation. In addition, the quality of the organic material is further refined through a sorting process so that it can be better used as feedstock.


For the type of waste selected, is there a separate collection system already implemented?

Is there a specific sorting in order to isolate the organic fraction after it is collected?

After the organic waste has been collected and sorted, are there remaining impurities? if yes tick the box, otherwise tick 2 times the box, to leave it empty.

Which fraction (%) of impurities is remaining?

0

Figure 5: Questions on the characterisation of the purity of the biomass feedstock

For the type of biowaste selected, is there a separate collection system already implemented? The user only has to answer "Yes" or "No" to this question by using the drop-down menu.

Is there a specific sorting in order to isolate the organic fraction after it is collected? The user only has to answer "Yes" or "No" to this question by using the drop-down menu.

After the organic waste has been collected and sorted, are there remaining impurities? In this question, the user must first tick whether there are any impurities left. If the user ticks the box, an additional field appears to indicate the type and percentage of remaining impurities.

To complete the previous question: If the user is in possession of information about the composition of the collected and sorted waste, he has the possibility to indicate the percentage of the different types (Figure 6). If the information is not known, this part can left blank.

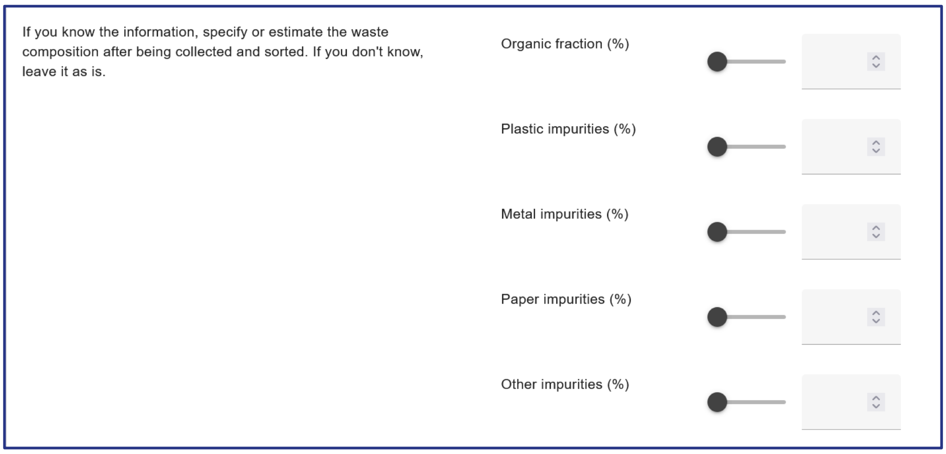


Figure 6: Question about the availability of information on waste composition after being collected and sorted

The next question (Figure 7) aims at characterising the flow of waste generated along the year: is it regular in quantity and quality throughout the year (this can influence the efficiency of a technology) and which quantity is available (in terms of capacities of different technologies).

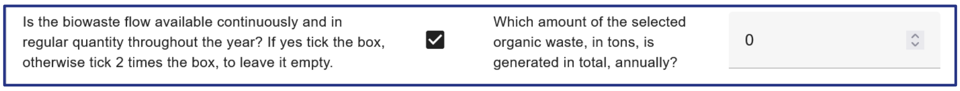


Figure 7: Question on continuous and regular availability of a biowaste flow throughout the year

The next question (figure 8) intends to gauge the readiness to accept to pay equivalent, lower or higher costs for a better valorisation of biowaste of concern than he pays for landfilling. For this question the user must select one of the three answers provided in the drop-down menu:

- Higher
- Equivalent
- Lower

Depending on the answer and the evolution of operating costs for each technology, some points are credited and others lose some points.

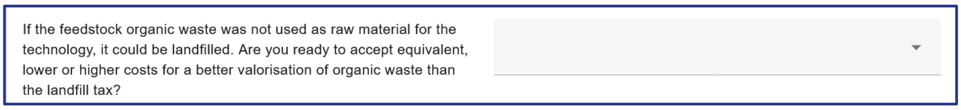


Figure 8: Question about willingness to pay more than the amount of a landfill tax to better valorise the biowaste of concern

The next question (figure 9) intends to confirm the geographical source of the organic waste concerned. For this question, the user must select one of the two answers provided from the drop-down menu:

- Exclusively local
- Multi-regional or international

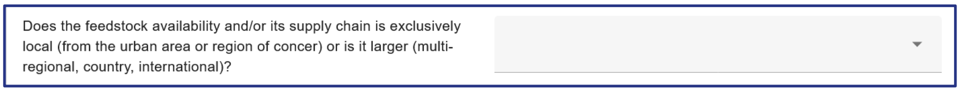
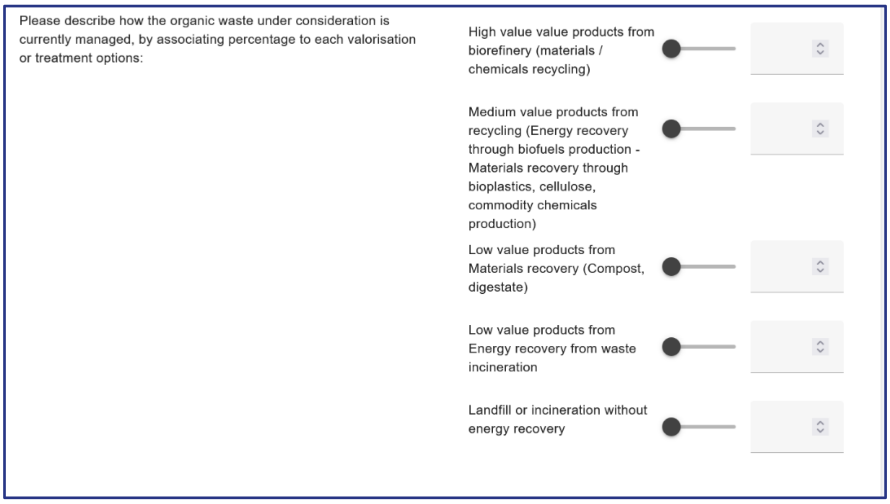


Figure 9: Question to identify the geographical source of a certain organic waste

This question intends to confirm or not if the source of an organic waste is exclusively local or not (multi-regional or international). If this is not the case, e.g. for highly specific wastes used as feedstock for a biorefinery process (e.g. bread waste with a certain composition), some local technologies will fall out of scope or would lose some points for being more sustainable and circular if the whole supply chain is local.

Finally, the last question of Step 1 (Figure 10) intends to describe how the organic waste under consideration is currently managed by associating percentages to each of the valorisation or treatment options indicated in the question.


Please describe how the organic waste under consideration is currently managed, by associating percentage to each valorisation or treatment options:

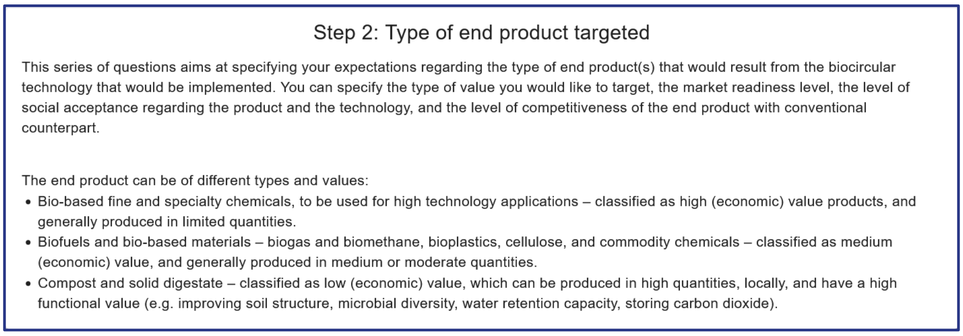
- High value value products from biorefinery (materials / chemicals recycling)
- Medium value products from recycling (Energy recovery through biofuels production - Materials recovery through bioplastics, cellulose, commodity chemicals production)
- Low value products from Materials recovery (Compost, digestate)
- Low value products from Energy recovery from waste incineration
- Landfill or incineration without energy recovery

Figure 10: Question about the way of management of the organic waste in question

When all the questions are filled in, you can see at the bottom of Page 1 the first trend in the ranking of technologies available in the tool, which depends on the answers to the questions on this page. To move to the next page of the webtool and answer the questions Step 2, the user can directly click on "Step 2: Type of end product targeted" in the menu on the left side of the page or on the "Next" button available after the last question.

Step 2: Type of end product targeted

Let's continue on Page 2, which aims at specifying the expectations in terms of the type of end product expected. Similar to the Step 1, a full description of the objective of the Step 1 is provided at the top of the page (Figure 11).


Step 2: Type of end product targeted

This series of questions aims at specifying your expectations regarding the type of end product(s) that would result from the biocircular technology that would be implemented. You can specify the type of value you would like to target, the market readiness level, the level of social acceptance regarding the product and the technology, and the level of competitiveness of the end product with conventional counterpart.

The end product can be of different types and values:

- Bio-based fine and specialty chemicals, to be used for high technology applications – classified as high (economic) value products, and generally produced in limited quantities.
- Biofuels and bio-based materials – biogas and biomethane, bioplastics, cellulose, and commodity chemicals – classified as medium (economic) value, and generally produced in medium or moderate quantities.
- Compost and solid digestate – classified as low (economic) value, which can be produced in high quantities, locally, and have a high functional value (e.g. improving soil structure, microbial diversity, water retention capacity, storing carbon dioxide).

Figure 11: Description of the questions from Step 2 of the BCC webtool

The first question of Step 2 (Figure 12) aims at specifying which type of end product the user would like to target. The user must select one of the three answers provided in the drop-down menu:

- High value products: for example, bio-based fine and specialty chemicals, to be used for high technology applications, generally produced in limited quantities.
- Medium Value products: for example, biofuels and bio-based materials – biogas and biomethane, bioplastics, cellulose, and commodity chemicals. Generally produced in medium or moderate quantities.
- Low Value products: for example, compost and solid digestate, which can be produced locally in high quantities and have a high functional value, e.g. contributing to improving the soil.

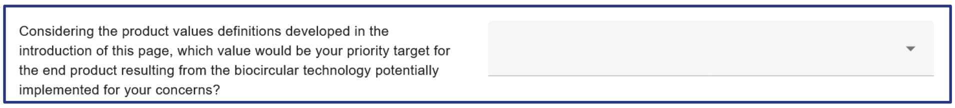


Figure 12: Question to specify which type of product the user would like to target

The second question (Figure 13) aims to specify if technologies existing only at pilot scale (small production capacity, potential discontinuous/batch production process, lower rentability…) can be of interest to the user. For this question the user has just to answer "Yes" or "No" by using the drop-down menu.

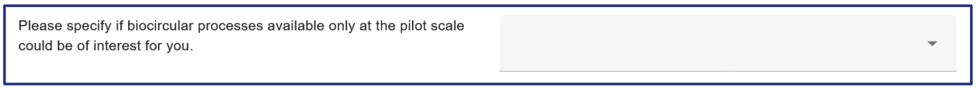


Figure 13: Question whether technologies existing only at pilot scale are of interest to the user

In the third question (Figure 14), the user is invited to specify the market readiness they would ideally seek by choosing one or several options provided in the drop-down menu:

- EU quality and safety standard existing
- EU certification existing
- EU certification under definition
- EU quality and safety standard under definition
- Market already existing
- No matter if nothing is available yet

Figure 14: Question on expected standards and certifications for potential end products

The fourth question (Figure 15) asks the user to indicate the level of social acceptability for the end product generated by the valorization technology, using the options available in the drop-down menu:

- Niche market for a bio-based product
- Bio-based product arousing neutral interest (no specific interest or rejection)
- Products already available on the market inducing public reluctance
- Only products which are well accepted / already widely available on the market

With this question, if for some of the technologies e.g. the end product is a niche product, the technology would lose points.

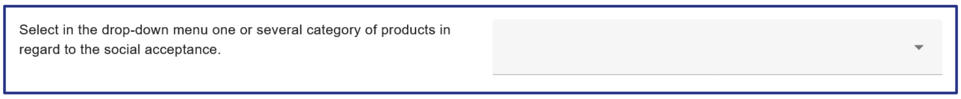


Figure 15: Question about the expected social acceptance for a potential end product

The final question of Step 2 (Figure 16) is to know if the user would like to focus on an end product which would be competitive with their conventional counterpart from a selling cost perspective. For this question the user has to just answer “Yes” or “No” by using the drop-down menu.

Figure 16: Question to know if the user would like to focus on an end product which would be competitive with their conventional counterpart from a selling cost perspective

For this question, the background algorithm specifies that a technology that delivers a less than competitive end product should be disqualified.

Once all the questions for Step 2 are completed, you can see at the bottom of the page the results of the new ranking of available technologies in the tool, which depends on the answers to this second set of questions. Comparing the results of Step 1, it is now possible to compare the score obtained in Step 1 with the score obtained in Steps 1 and 2.

To go on the next page of the webtool and answer the questions of Step 3, the user can directly click on “Step 3: Environmental performances” provided in the menu on the left side of the page or on the button “Next page” available after the last question. The user also has the possibility to go back to the previous questions and answers provided in Step 1 by clicking on the “Previous page” button.

Step 3: Environmental performances

Let’s continue with Page 3, dedicated to identifying the potential objectives targeted in terms of environmental performances. This third page contains four questions and a short description (Figure 17) about the aim of this step.

Figure 17: Description of step 3 question of BCC webtool.

The first question (figure 18) aims to identify which conventional counterpart the obtained end product should substitute in priority. The user can choose one or several counterpart end products listed in the drop-down menu:

- Additives / Ingredients for food making
- Electricity
- Natural gas from the grid
- Heat from natural gas
- Other chemical products

- Other fossil fuels (diesel/gasoline/oil)
- Synthetic chemical blocks
- Synthetic fertilisers and/or soil amendments

Figure 18: Question on the counterpart end product to be substituted in priority

In the second question (Figure 19), the user can specify which range of greenhouse gas (GHG) reduction they would like to target with the new biocircular technology that would be suitable to their context. The user must choose a percentage range of GHGs listed in the drop-down menu:

- 0%
- From - 10% to - 20%
- From - 20% to - 30%
- From - 30% to - 40%
- From - 30% to - 50%
- \>- 50%

Figure 19: Question about the extent of greenhouse gas reduction to be achieved

The third question (Figure 20) is the same as the previous one, but relates to energy efficiency and compares the net energy created by the end product (including embodied energy) to the net energy consumed to convert the biomass feedstock into the end product. The user must choose a percentage range for resource efficiency listed in the drop-down menu:

- Equivalent
- From 20% to 40%
- From 40% to 60%
- From 60% to 80%
- \>80%

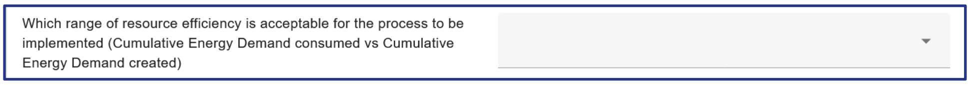


Figure 20: Question about the range of resource efficiency that is acceptable for the process to be implemented

The last question (Figure 21) allows the user to indicate what potential environmental impacts that could be caused by a selected technology or product use or consumption outcome would be a specific barrier to its development in the urban area/municipality in question. The user can choose one or several options listed in the drop-down menu:

- Impacts on air quality and human health
- Impacts on water and aquatic organisms (plants and animals)
- Impacts on human health and ecosystems
- Impacts on soil and terrestrial ecosystems

Depending on the user specification, some technologies could lose some points or be disqualified.

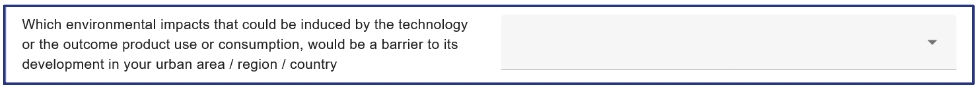


Figure 21: Question on which environmental impacts could be induced

Once all questions for Step 3 are completed, at the bottom of the page you can see the results of the new ranking of available technologies, depending on the answers given for this second series of questions. At the bottom of the page, it is now possible to compare the score obtained from Steps 1 and 2 to the score obtained from Steps 1, 2 and 3.

To go on the next page of the webtool and answer questions of Step 4, the user can directly click on "Step 4: Other political and economic incentives" provided in the menu on the left side of the page or on the "Next page" button available after the last question. The user has also the possibility to go back on the questions and answers provided in Step 2 by clicking on the button "Previous page".

Step 4: Other political and economic incentives

We are now going to answer the last set of questions on the fourth page, dedicated to refining the user's statement on some criteria related to policy incentives and economic issues. This last page, as the previous ones, contains a short description (Figure 22) about the aim of this step.

Figure 22: Description of the questions of Step 4 of the BCC webtool

The first question of Step 4 (Figure 23) aims to identify the capacity of a municipality, company or institution using the tool to invest in the development of technical competences of operators. In this question, the user must first check the box, after which additional field appears to indicate whether or not the user is willing to invest in competencies. The user must select one of the options provided in the drop-down menu:

- Readiness to invest in low-skilled competences (e.g. to train process operators)
- Readiness to invest in competences already existing in the market
- Readiness to invest in developing highly specific competences in collaboration with research institutes

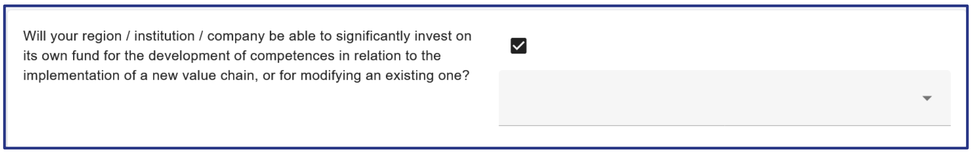


Figure 23: Question on the readiness to invest in the development of competences

The second question (Figure 24) also allows the user to indicate whether there is a possibility to collaborate with research institutes or other similar companies or entities than the user's one. Some technologies that are innovative or still under development would not be possible to implement without such collaboration. For this question, the user must choose one of the options provided in the drop-down menu:

- Research institutes on biorefinery processes
- Research institutes on organic waste energy conversion
- Research institutes on organic waste material recycling
- Similar or complementary companies or institutions
- None

Figure 24: Question on local collaboration opportunities

The questions three and four (Figure 25) aim to identify the capacity of a municipality or organisation using the tool to invest in the development of infrastructure. For this question, the user must first check the box and can then choose one of the options provided in the drop-down menu of question 4:

- We can support 100% of the costs, no interest in subsidies
- We can support 100% of the costs, but are interested in subsidies
- Project not feasible without external financial support

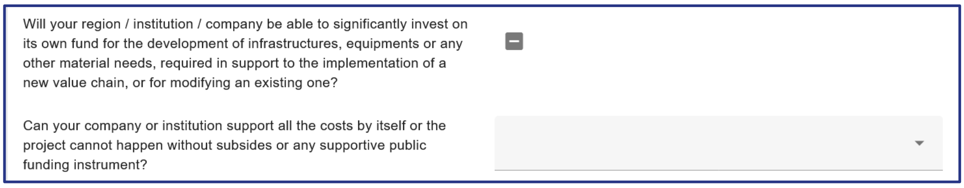


Figure 25: Question on ability to invest in the development of infrastructure

Finally, the user is asked to estimate which net benefits he or she would target with the new technology (Figure 26). For this question, the user must choose one of the options provided in the drop-down menu:

- + 10%
- + 20 %
- + 30%
- + 40 %
- >50 %

Figure 26: Question on which net benefits are targeted

Once all the questions for Step 4 are completed, at the bottom of page you can see the results on the new ranking of available technologies in the tool, depending on the answers to this fourth series of questions. At the bottom of the page, it is now possible to compare the score obtained from Steps 1, 2 and 3 to the score obtained from Steps 1, 2, 3 and 4.

To go on the next page of the webtool and obtain a summary of the ranking of the available technologies, the user can directly click on "Results" in the menu on the left side of the page or on the "See results" button available after the last question.

Results

The “Results” page (Figure 27) summarises the final ranking and clicking on the “More info” button (Figure 28) for each technology provides some additional information about the environmental, economic and social performances of the technologies. The information available in the current version of the tool is based on scientific literature. Additionally, following the LCA and LCC evaluation performed in the framework of BCC project (D2.3), general recommendations are provided in this page.

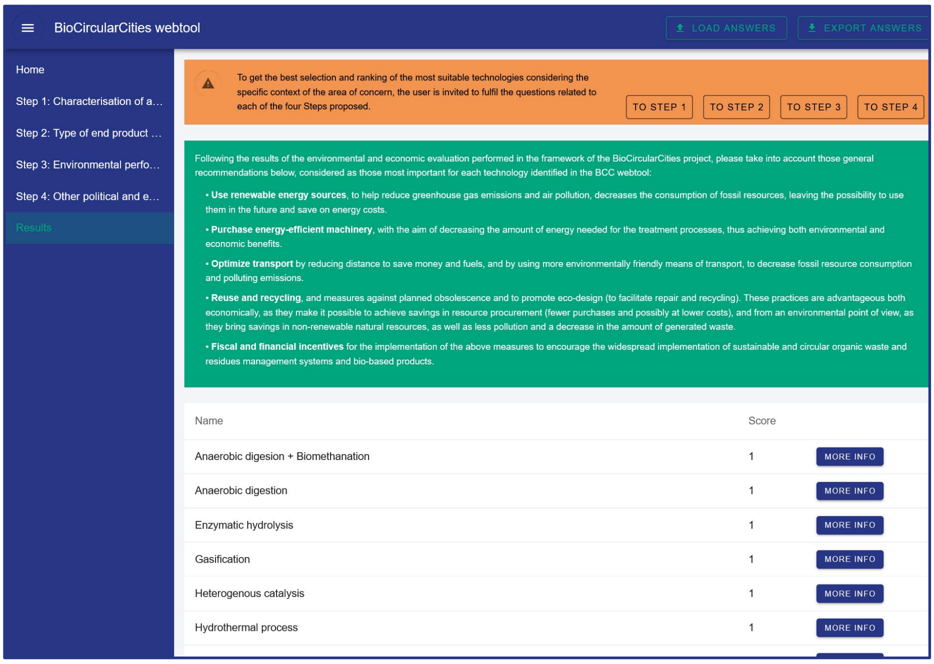


Figure 27: Results page summarising the ranking of the integrated technologies

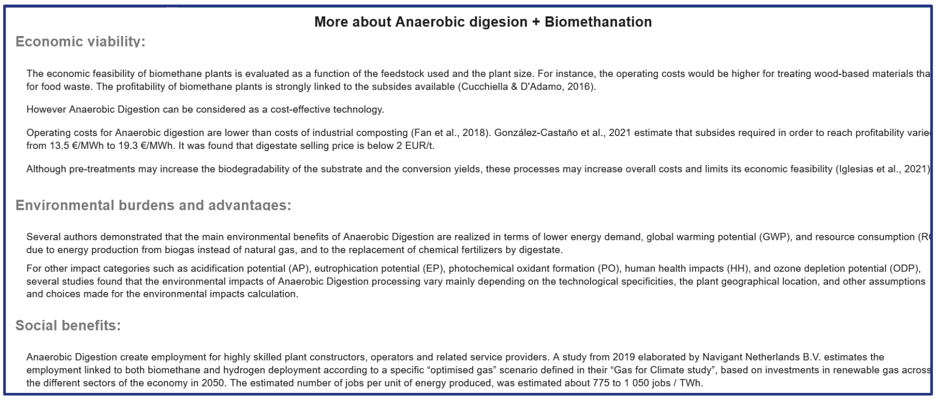


Figure 28: Example of information available when clicking on “More info”

2. Case study

This section aims to present a concrete case study to illustrate the previous section describing the BCC webtool. All steps and questions are covered in this section.

In this case study presented below is related to a municipality which is looking to improve the management of the mixed organic waste from households. The improvement of organic waste management and valorisation is considered as a top priority for this municipality both to create economic value and to improve the environmental sustainability of its practices.

For this municipality the volume of waste available from local collection represents 20 000 tons for the sole municipality area. In the case there is not already implemented separate biowaste collection. However, a mechanical-biological sorting (MBT plant) before treatment is already performed to isolate the organic fraction. After the sorting, some impurities (10%) are remaining, but there are not characterizes. The waste treatment currently in place is shared between three options: incineration with energy recovery (20%), composting after mechanical biological treatment (20%) and landfill (60%).

To improve its organic waste management, it must be noticed that the municipality has limited financial resources but is ready to invest on infrastructure and to achieve competences. Additionally, the municipality would like to focus on efficient solutions, considering economic and environmental aspects, in short to mid-term.

Let's now start introducing this case study in the BCC webtool.

Step 1: Characterisation of the available feedstock and the current existing biowaste management system

For the case study (Figure 29), the type of biowaste of concern is "Biowaste mixed with residual waste ". Concerning the next 3 questions, it is specified that there is no specific collection, but a specific sorting process to remove a maximum of impurities occurs. At the end the organic fraction constitutes 90% of the mixed organic waste, the composition of the remaining 10% impurities is not specifically known. For the next question it is indicated that the biowaste flow is available continuously and in regular quantity throughout the year and that the quantity available (regarding the different technologies' capacities) is 20 000 tons. For the next question which intends to confirm the source of the biowaste amount it is indicated that it is exclusively local. Finally, for the question of the current valorisation composting and incineration represent 20% each. The rest (60% or 12 000 tons) is landfilled.

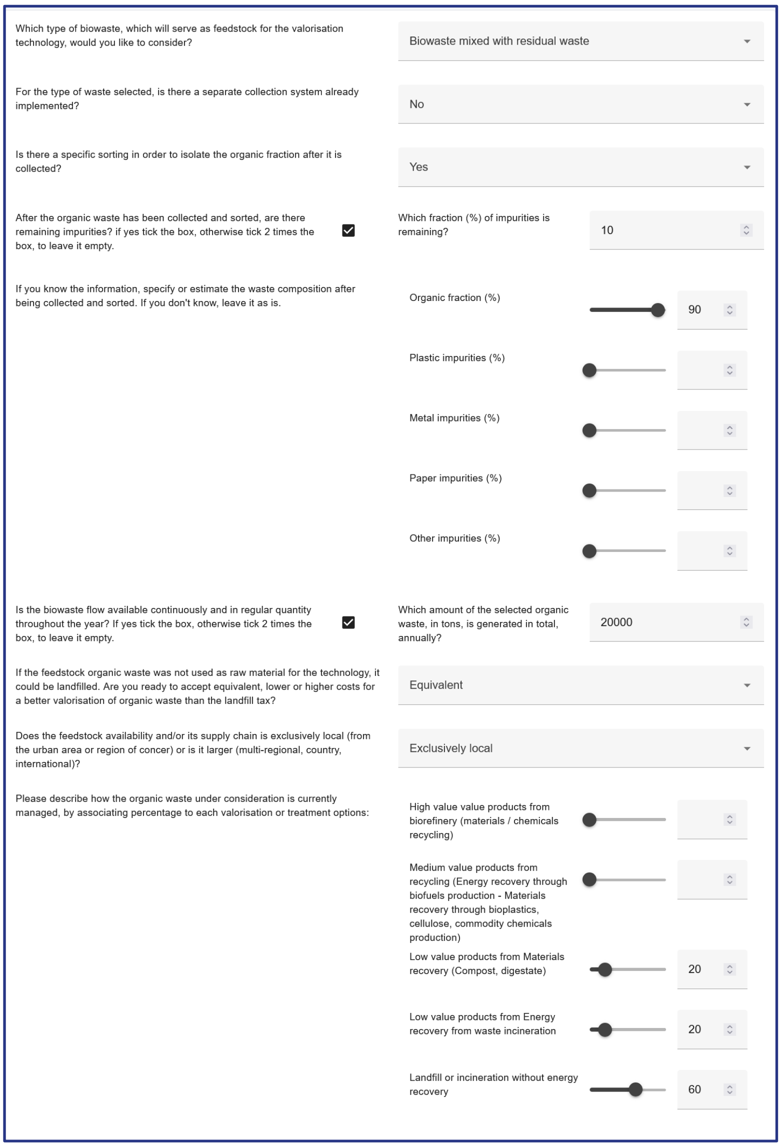


Figure 29: Answers to the series of questions characterising the available organic waste feedstock and the current existing biowaste management system

At the bottom of the first page (Figure 30), it is now possible to see the first trend on the ranking of available technologies in the tool, depending on the answers given for the series of questions.

- The anaerobic digestion considered here is applicable only to source-separated biowaste. The same context applies to Chemical treatment (e.g. solvent extraction). This is why both technologies are already disqualified.
- The MBT approach, with anaerobic digestion or composting, is applicable to the organic waste mixed with residual waste, and so it is still in the race, together with incineration with energy recovery and landfilling.

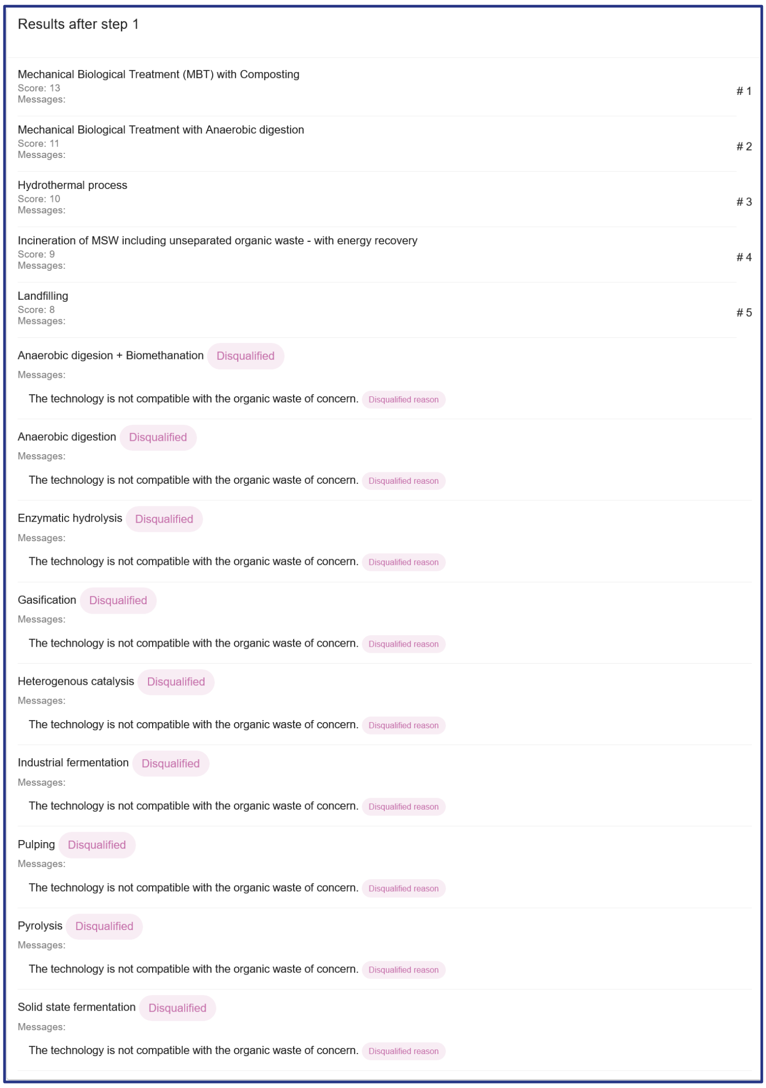


Figure 30 Results of the first trend for the ranking of available technologies

Step 2: Type of end product targeted

For the second step (Figure 31), in the first question specifying which type of product to target let's choose medium value products, like this, technologies delivering low value products or high value products will lose some points, while technologies releasing medium value products will gain points. For the second question to specify if technologies existing only at pilot scale can be of interest, the answer to choose is "yes". In the third question to specify the market readiness level we would ideally target, for this case study the 5 first options (existing or under definition standard or certification) are chosen. For the next question on the level of social acceptance that would be acceptable for the end product generated by the valorisation technology, the products already existing on the market which could however induce public reluctance, and products with neutral interest (no specific interest nor rejection from the large public) are selected. For the final question to know about the possibility to focus on the end product which would be competitive with their conventional counterpart from the selling cost perspective, the answer is "yes", since the municipality would like a quick return on investment.

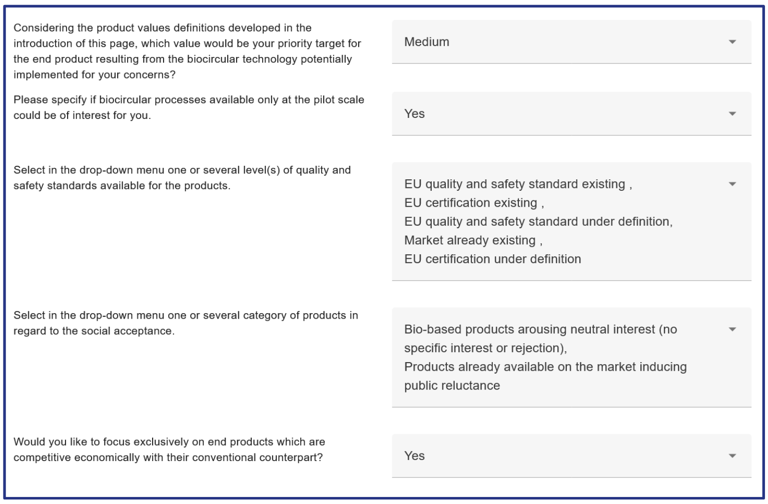


Figure 31: Answers to the series of questions specifying expectations regarding the type of end product(s) that would result from the biocircular technology used

According to the answers provided in Step 2 (Figure 32), the landfill is disqualified when looking at the cumulative scores obtained from Steps 1 and 2. From these results, it is possible to see that MBT with anaerobic digestion ranks first among the most suitable technologies, considering the answers given to the questions from Steps 1 and 2. This is followed by composting and incineration. The three other technologies are disqualified.

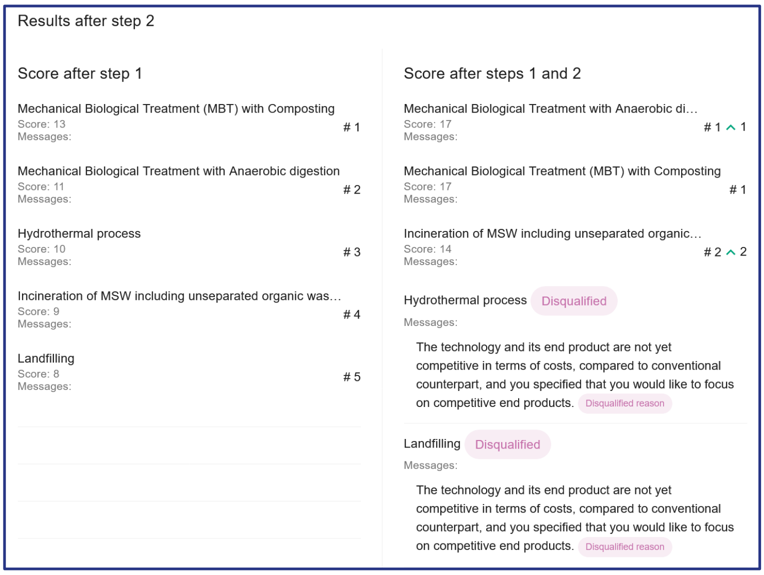


Figure 32: Results of the ranking of available technologies after Step 2

Step 3: Environmental performances

For Step 3 (Figure 33), the first question is to identify one or more end products to substitute conventional products. For this case study, since the municipality is seeking a quick return on investment, "heat from natural gas" and "synthetic fertilisers" were selected, whose market deployment is already advanced. For the next question, which range of GHG reduction to target for with the new biocircular technology, it is chosen to target a significant reduction of minimum 20% (-20 to -30%). This means that technologies allowing GHG emissions reduction lower than 20% compared to the production of counterpart products, will lose some points. The next question is equivalent to the previous one, but for energy efficiency and in this case study, a minimum ratio of 20% (20-40%) is selected. The last question on the environmental impact that could be induced by the technology or the use or consumption of the product that would be a barrier to its development, for the case study, "impacts on human health and ecosystems" are specified.

Which conventional counterpart the obtained end product should substitute in priority?	Heat from natural gas, Synthetic fertiliser and/or soil amendments
Which magnitude of Greenhouse Gases reduction would you target, compared to the production of a conventional product counterpart?	From - 20% to - 30%
Which range of resource efficiency is acceptable for the process to be implemented (Cumulative Energy Demand consumed vs Cumulative Energy Demand created)	From 20% to 40%
Which environmental impacts that could be induced by the technology or the outcome product use or consumption, would be a barrier to its development in your urban area / region / country	Impacts on human health and ecosystems

Figure 33: Answers to the series of questions to identify the potential objectives targeted in terms of environmental performances

At the bottom of the page (Figure 34), it is now possible to compare the score obtained from Steps 1 and 2 to the score obtained from Steps 1, 2 and 3. It appears that, in the case study, the ranking of technologies remains the same than after the Step 2 but only 1 point differentiates MBT with anaerobic digestion and MBT with composting. At this stage, both MBT with anaerobic digestion and MBT with composting are the most suitable technologies.

Results after step 3

Score after step 1 and 2		Score after steps 1, 2 and 3	
Mechanical Biological Treatment with Anaerobic digestion Score: 17 Messages:	# 1	Mechanical Biological Treatment with Anaerobic digestion Score: 16 Messages:	# 1
Mechanical Biological Treatment (MBT) with Composting Score: 17 Messages:	# 1	Mechanical Biological Treatment (MBT) with Comp… Score: 15 Messages:	# 2 ∨ -1
Incineration of MSW including unseparated organic was… Score: 14 Messages:	# 2	Incineration of MSW including unseparated organi… Score: 14 Messages:	# 3 ∨ -1

Figure 34: Results of the ranking of available technologies after Step 3

Step 4: Other political and economic incentives

For this case study, the user in Step 4 (Figure 35) is ready to invest in developing competences that already exist in the labour market, he does not want to invest in the development of specific innovative/unique competences. This is in line with its requirement to get a return on investment as fast as possible. It is also indicated that there is opportunity to collaborate locally with similar companies or institutions. For the infrastructure the municipality cannot afford all the costs, so it shall focus on technologies for which public subsidies or other means of external co-funding exist (not feasible without financial support). For the net benefits, in this case the target is a new suitable technology with a net benefit of +20%.

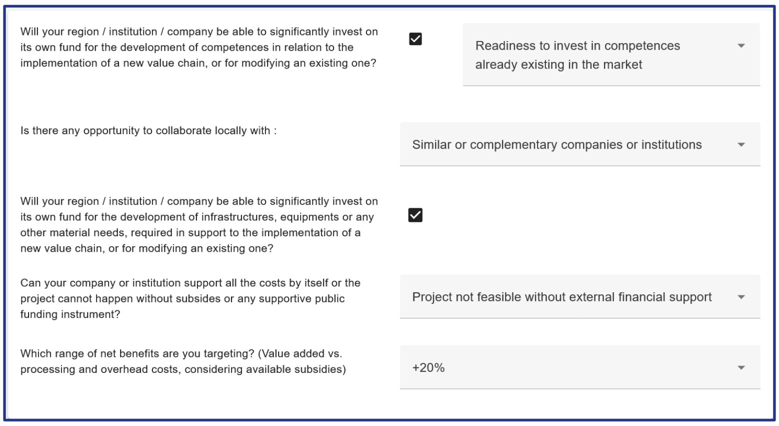


Figure 35: Answers to a series of questions in Step 4 to refine the statements on some of the criteria related to policy incentives and economic issues

At the bottom of the page (Figure 36), you can now see that the ranking of the technologies based on the results from Steps 1, 2, 3 remain unchanged. "MBT with anaerobic digestion" is identified as the most suitable technology considering the specific local context and objectives defined in the webtool questionnaire. The gap between this technology and "MBT with composting" as well as with "incineration" is more significant, which confirms that "MBT with anaerobic digestion" is the most suitable technology.

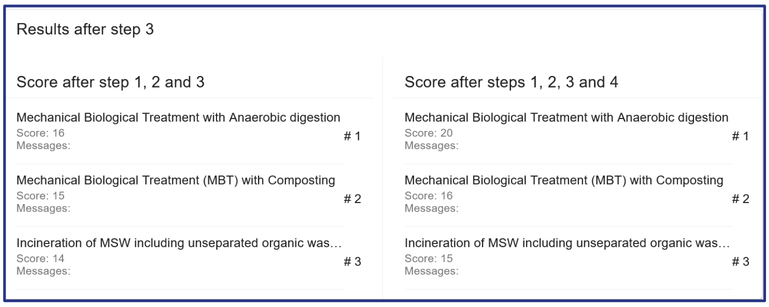
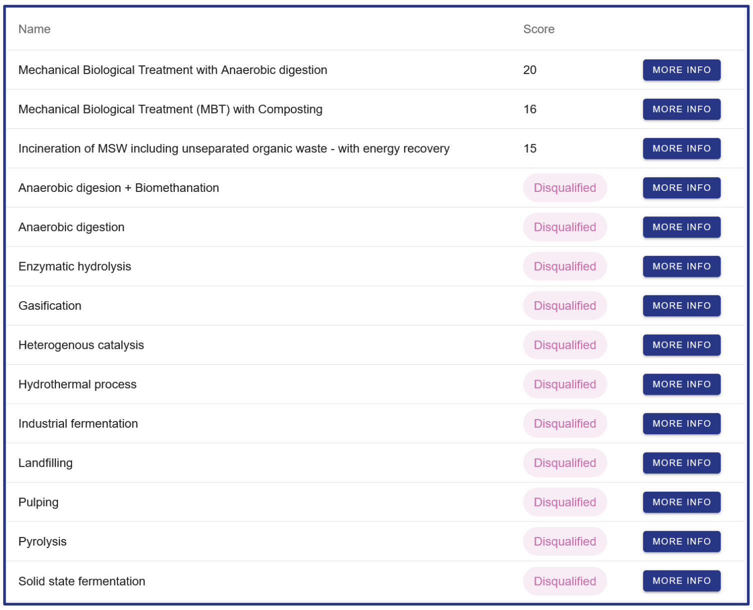


Figure 36: Results of the ranking of the available technologies after Step 4

Results

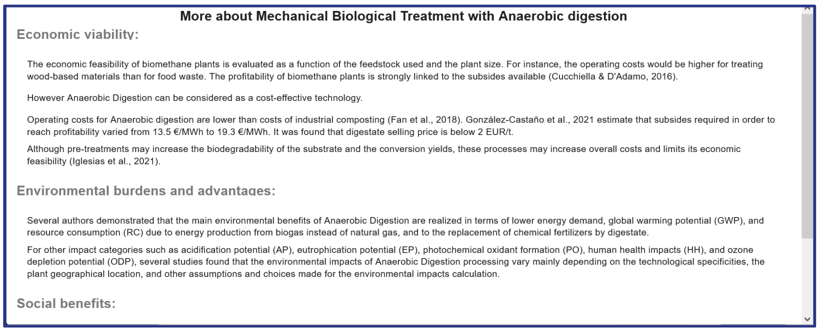
The "Results" page (Figure 37) summarises the final ranking obtained for this case study.



Name	Score	
Mechanical Biological Treatment with Anaerobic digestion	20	MORE INFO
Mechanical Biological Treatment (MBT) with Composting	16	MORE INFO
Incineration of MSW including unseparated organic waste - with energy recovery	15	MORE INFO
Anaerobic digesion + Biomethanation	Disqualified	MORE INFO
Anaerobic digestion	Disqualified	MORE INFO
Enzymatic hydrolysis	Disqualified	MORE INFO
Gasification	Disqualified	MORE INFO
Heterogenous catalysis	Disqualified	MORE INFO
Hydrothermal process	Disqualified	MORE INFO
Industrial fermentation	Disqualified	MORE INFO
Landfilling	Disqualified	MORE INFO
Pulping	Disqualified	MORE INFO
Pyrolysis	Disqualified	MORE INFO
Solid state fermentation	Disqualified	MORE INFO

Figure 37: Final ranking of the available technologies

By clicking on the “More info” button, the user has additional information of the most suitable technology (Figure 38), which in this case study is the “Mechanical Biological Treatment with Anaerobic Disgestion”.



More about Mechanical Biological Treatment with Anaerobic digestion

Economic viability:

The economic feasibility of biomethane plants is evaluated as a function of the feedstock used and the plant size. For instance, the operating costs would be higher for treating wood-based materials than for food waste. The profitability of biomethane plants is strongly linked to the subsides available (Cucchiella & D'Adamo, 2016).

However Anaerobic Digestion can be considered as a cost-effective technology.

Operating costs for Anaerobic digestion are lower than costs of industrial composting (Fan et al., 2018). González-Castaño et al., 2021 estimate that subsides required in order to reach profitability varied from 13.5 €/MWh to 19.3 €/MWh. It was found that digestate selling price is below 2 EUR/t.

Although pre-treatments may increase the biodegradability of the substrate and the conversion yields, these processes may increase overall costs and limits its economic feasibility (Iglesias et al., 2021).

Environmental burdens and advantages:

Several authors demonstrated that the main environmental benefits of Anaerobic Digestion are realized in terms of lower energy demand, global warming potential (GWP), and resource consumption (RC) due to energy production from biogas instead of natural gas, and to the replacement of chemical fertilizers by digestate.

For other impact categories such as acidification potential (AP), eutrophication potential (EP), photochemical oxidant formation (PO), human health impacts (HH), and ozone depletion potential (ODP), several studies found that the environmental impacts of Anaerobic Digestion processing vary mainly depending on the technological specificities, the plant geographical location, and other assumptions and choices made for the environmental impacts calculation.

Social benefits:

Figure 38: Additional information related to the most suitable technology

For the technologies disqualified during the different steps, it is also possible to know why it was disqualified by directly clicking on the button “Disqualified” (Figure 39).

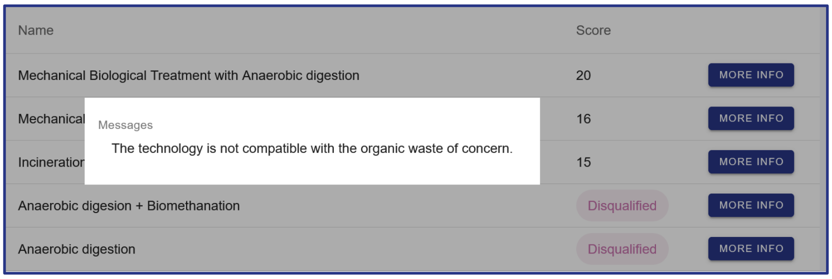


Figure 39: Example of the reason why the “Anaerobic digestion + biomethanation” technology was disqualified

3. Technologies portfolio

The BCC webtool takes into consideration fourteen technologies and includes, among others, the technologies that were addressed in the three regional pilot areas, including chemical conversion routes (anaerobic digestion, composting, biomethanation), thermochemical conversion routes (extraction of functional ingredients, gasification, pyrolysis, hydrothermal processes), biochemical conversion routes (enzymatic processing, industrial fermentation, solid state fermentation), and more conventional routes (incineration, landfill). Table 2 provides and overview of the selected technologies (as already mentioned in D4.2) and the main technologies are described in detail in Chapters 3.1 to 3.12.

Table 2: List of biocircular technologies included in the BCC webtool

	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 (AD)	
			Mechanical Biological Treatment (MBT) + AD	
Biomethane obtained from food related waste or from wood bark, cellulose, lignin or woody side streams			AD + 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

This section provides a short description of the fourteen technologies included in the BCC webtool. The Annex of this deliverable complements this section and provides information about the characteristics of the fourteen technologies and how they are taken into account in the decision-making process of the BCC webtool.

3.1. Anaerobic digestion (with or without MBT, with or without biomethanation)

Anaerobic digestion (AD) describes a series of biological processes during which microorganisms break down organic matter in the absence of oxygen, resulting in the generation of two main products: biogas (mainly composed of methane and carbon dioxide, as well as hydrogen sulfides, ammonia and waste vapor in smaller amounts) and digestate (Lytras et al., 2021; Al-Wahaibi et al., 2020). AD consists of four bio-metabolic stages: hydrolysis (disintegration of the feedstock into monomers), acidogenesis (conversion of the monomers into volatile fatty acids), acetogenesis (transformation of the volatile fatty acids into acetic acid, CO_2 and H_2) and methanogenesis (conversion of acetic acid and some of the H_2 into CH_4 and CO_2 (Briassoulis et al., 2021; Atelge et al., 2020; Braguglia et al., 2018; Vasco-Correa et al., 2018). Regarding digestate processing, the first step is often to separate the solids from the liquid resulting from AD. The solid fraction can then be further composted and used as soil improver, while the liquid fraction is applied as nitrogen-rich fertilizer or further processed and sold as concentrated liquid fertilizer (Logan & Visvanathan, 2019).

Biomethanation refers to the further upgrading of biogas resulting from AD to biomethane, containing 95–97% of CH_4 and 1–3% of CO_2 (Lytras et al., 2021). This involves two steps (Di Maria et al., 2019; O'Connor et al., 2021). Firstly, a cleaning process enables to treat biogas and remove toxic compounds, mainly H_2S and CO_2, and H_2O (Briassoulis et al., 2021). Secondly, the upgrading process itself enables to increase the calorific value of biogas, which can be done through several methods, such as membrane separation, water scrubbing, chemical absorption and pressure swing adsorption (Ardolino et al., 2021; Rajendran & Murthy, 2019).

Biogas and biomethane coming from an AD process can substitute heat and/or electricity (to be used in CHP unit, boiler or absorption chiller), while digestate can substitute synthetic fertilizer. Biomethane can also be used as vehicle fuel or injected into natural gas grids (Ardolino et al., 2021; Iglesias et al., 2021; Lytras et al., 2021; Vasco-Correa et al., 2018).

The feedstock suitable for AD is composed of the organic fraction of municipal solid waste, food waste, agricultural waste (crop residues and animal waste) and energy crops, forestry residues (lignocellulose), livestock manure, sewage sludge and algae. In general, wastes which are high in moisture can be an excellent feedstock for AD, whereas woody wastes including a higher proportion of lignocellulosic materials are better suited for composting (Halkos & Petrou, 2021). A common approach to the AD treatment of food waste is its co-digestion with various co-substrates (different types of feedstocks) to enhance biogas and biomethane yield (Lytras et al., 2021).

A pre-treatment prior to the AD process is not mandatory but can be needed depending on the feedstock. It is required for lignocellulosic biomass as it has a rigid structure and thus a limited degradability under AD condition without pre-treatment. A pre-treatment is not required for the other substrates but recommended to optimise digestion activity (substrate availability and digestibility), methane content, biogas yields and reduction of pathogens. The type of pre-treatment to be used varies according to the type of substrate (Atelge et al., 2020). It can be physical, chemical, thermal, biological, electrochemical or combined methods (Lytras et al., 2021; Hashemi et al., 2021; Di Maria et al., 2019; Millati et al., 2020; Zamri et al., 2021; Kumar & Samadder, 2020).

3.2. Mechanical biological treatment and composting

Composting refers, in general, to "a process of aerobic biologically controlled maturation of the organic substance by which simpler, more stable, hygienic, richer in humic compounds material is produced." (Neri et al., 2018). The degradation of the OFMSW is performed under the action of micro-organisms and by adding bulking material, which "helps air to enter the heap of compost for a stable composting process to occur." (Logan & Visvanathan, 2019).

Composting can be carried out in open systems, i.e. static piles, turned piles or aerated windrows at open air, or closed systems, i.e. closed reactors such as rotatory drums, composting tunnels or confined piles with textile cover or composting piles inside closed buildings with a gas management system (Jedrczak, 2018; Sánchez et al., 2018).

Compost can be used as a substitute of synthetic fertilizers (Krstić et al., 2019; Neri et al., 2018).

According to Krstić et al. (2019), there are six basic types of materials and raw materials for composting: the residues of food processing (compost material made after the processing of fruit, vegetables, grains and meat); manure and agricultural by-products formed in farrow, feedlots, incubators, farms, greenhouses and the like; the residues from forestry and wood industry, including the bark, sawdust and fiber residues from the production of paper; organic waste or waste sludge generated by treating the waste sludge in plants for purification and recycling of waste water; the leaves, shrubs, twigs and other plant residues such as yard and garden waste; the separated organic waste, comprising a composting sorted fractions of municipal waste. Waste made of lignocellulosic materials are more suitable for composting than high moisture waste, which is best used in the AD process (Halkos & Petrou, 2021). As for AD, composting can be performed in batch-fed or continuous fed mode (Dsouza et al., 2021).

A pre-treatment is needed prior to composting process if no source separation system is applied (Sánchez et al., 2018). In order to ensure better conditions for composting, different ways of preparing waste or its treatment can be used, such as magnetic separation, screening for separation according to size and drying and humidifying of waste. In some plants, the separation of metal parts and compost product enrichment can be done at the end of the process as compost post-treatment (Krstić et al., 2019). At home, the aeration of the pile to prepare the organic material well to the composting process has to be ensured (Sulewski et al., 2021).

3.3. Incineration

3.3.1. Incineration of the biowaste sorted out from MSW with energy recovery

Incineration is a process through which the carbon in waste is oxidized into carbon dioxide in the presence of air while hydrogen is oxidized into water at temperatures above 800°C. This leads to a reduction of up to 85% in biowaste volumes (Awasthi et al., 2021). The heat produced during the incineration process can be recovered and used for energy purposes. Ashes are also generated by incineration as a solid output to be sent to landfill (Di Maria & Micale, 2015).

The principal steps are the transportation of the waste to the incineration plant where it is stored in a bunker before being transferred to the incineration chamber. The waste is then combusted at high temperatures, using either natural gas or fuel oil for the initial ignition and for maintaining the high combustion temperatures (Jeswani et al., 2016).

The heat resulting from the incineration of biowaste is often applied for turning steam turbines to generate electricity and/or for heat exchangers either for industry or district heating (Awasthi et al., 2021).

Before being incinerated, biowaste can undergo a drying step as pre-treatment in order to reduce the water content of the feedstock and thus increase the heating value (Awasthi et al., 2021; Vakalis et al., 2017).

3.3.2. Incineration of municipal solid waste (MSW) with energy recovery

The outputs coming from the incineration of MSW are heat and electricity. The electricity can be exported to the national grid, while the heat can be exported to district heating systems. Moreover, there is a possibility to reuse the MSW incineration residues as construction material (cement, concrete, ceramic, glass and glass-ceramic), adsorbent (for dyes) or in geotechnical (road pavement, embankments landfill cover material) and agricultural applications (soil amendment). However, heavy metals can be found in elevated concentrations and may affect the environment (Margallo et al., 2015). Incineration of MSW also generates APC (air pollution control) residues, including fly ash, which is sent to landfill and bottom ash, which is processed into aggregates after ferrous metals recovery. The remaining bottom ash can be used as a road-construction material (Jeswani et al., 2016).

MSW is compatible with the incineration process. It consists mainly of organic waste (food waste, cooking waste and residues from houses, restaurants, cafes, canteens and markets), but also paper, plastic, glass, metal, textile, garden waste, wood and electronic waste (Hasan et al., 2021; Jeswani et al., 2016). Incineration needs a regular feedstock input to operate and be viable (Fernández-González et al., 2017).

3.4. Thermochemical treatments (generic)

Thermochemical treatments of biowaste include four main steps: feedstock pre-treatment, thermal conversion, utilization of acquired products, and ash and air pollution control (APC) residues management (Dong et al., 2018). The thermochemical conversions include four alternative processes: (1) combustion to produce heat and/or electricity, (2) pyrolysis to obtain bio-oil (as main output), synthesis gas (syngas) and biochar, (3) gasification to generate syngas, and (4) high-pressure liquefaction (Zucaro et al., 2020). Pyrolysis can be slow, fast or flash (Hasan et al., 2021).

Compared to waste-to-energy incineration, gasification is a more complex treatment method since it requires one additional step (syngas conversion).

Syngas and biochar can be used as energy sources (Hasan et al., 2021; Tsui & Wong, 2019; Dong et al., 2018). The pyrolytic fluid resulting from volatile gas condensation can be used as a gasoline product after additional upgrading or as building blocks (Tsui & Wong, 2019). Biochar can be used as soil amendment (Tsui & Wong, 2019), as a fertiliser after some processing (Hasan et al., 2021) or as carbon for biomaterials (Tsui & Wong, 2019). The solid residues resulting from thermochemical treatments may be recycled as road construction materials or concrete aggregate (Dong et al., 2018).

In addition to MSW, different types of feedstocks are compatible with thermochemical treatments, mainly agricultural biomass. Pyrolysis is especially used for lignocelluloses. It can treat microcrystalline cellulose, xylan, lignin and polypropylene, softwood residues, sugar cane straw, paper mill waste or rice husk. Pyrolysis remains more applicable to plastic waste as to household waste (Torres-Lozada et al., 2023). Gasification can be used for olive kernels; olive tree cuttings; palm trunk waste; wood and straw waste. High moisture biowaste is not appropriate for a traditional gasification process because of its low heating value. An option to improve this condition can be the co-gasification with other drier organic materials (e.g. wood) or the application of hydrothermal gasification (Awasthi et al., 2021). Thermochemical treatment feedstocks are generally classified into three categories (Fiorentino et al., 2017): I generation (corn, sugar cane, sugar beet, palm and soy oils); II generation (lignocellulose, forestry/agricultural residues, energy crops); III generation (algae).

A specific sorting after collection is not required but a pre-treatment is needed if mixed MSW or lignocellulosic materials are used as feedstock (Hasan et al., 2021; Tsui & Wong, 2019). Gasification needs a pre-treatment (Torres-Lozada et al., 2023). The pre-treatment is mechanical/physical and can be milling, extrusion, steam explosion (Fiorentino et al., 2017), drying and/or shredding with the aim of size reduction and homogenization (Dong et al., 2018).

3.5. Landfill

According to the definition given by Nanda & Berruti (2020), landfilling is "the procedure of organized disposal of biodegradable and non-biodegradable wastes in a designated terrestrial burial site or landfill, which is located away from a municipality's suburban areas." Landfills can be classified into three different types (Nanda & Berruti, 2020): a) open dump landfills (land area where MSW is disposed in an open environment in contact with air), b) semi-controlled landfills (operated landfills where MSW is sorted on-site, shredded and compacted before disposal) and c) sanitary landfills (advanced varieties of semi-controlled landfills). Landfill gas (LFG) is the end product of the landfill technology if there is a recovery system (Sauve & Van Acker, 2020).

Anaerobic conditions can be developed inside a landfill due to several layers of soil combined with disposed organic matter, which results in AD and landfill gas generation (Nanda & Berruti, 2020). If the system enables landfill gas recovery, this gas can be used to produce electricity and heat (Jeswani et al., 2016).

MSW is compatible for a landfill technology. This includes kitchen waste, yard waste, paper and cardboard, plastic and rubber, metal, glass, electronic waste, miscellaneous and inert materials (Nanda & Berruti, 2020). Continuous and regular availability of feedstock is not required for landfill.

Landfill does not need a sorting at source or a separate collection system. A specific sorting after collection can be applied as a pre-treatment in case of semi-controlled or sanitary landfills (Nanda & Berruti, 2020).

In the BCC project, it is clear that, in line with the European target of 10% landfill (and 65% selective collection), this option should be avoided.

3.6. Enzymatic processes

Enzymatic processes[1]) refer to enzymes, which are proteins that act as biocatalysts (biological catalysts). In terms of biomass valorization, there are two applications for enzymatic processes: biomass pretreatment and polysaccharide hydrolysis.

Lignocellulosic biomass (LCB), which is mainly characterized by the presence of two carbohydrate polymers (cellulose and hemicellulose) and an aromatic polymer called lignin, can be collected as waste from forestry, agricultural and industrial activities. Other LCB components, present in smaller quantities, are ash, pectin and protein.

The enzymatic process requires pre-treatment, which falls into the category of "biological pre-treatment". These biological pretreatment systems rely on biological agents (e.g. enzymes) to delignify the lignocellulose and make the enzymatic hydrolysis process more convenient. Other lignocellulosic biomass pretreatment methods include physical (e.g. mechanical), chemical (e.g. acid and alkali), physico-chemical (e.g. steam explosion) methods and a combination of these.

3.7. Industrial fermentation

Industrial fermentation[2] is a biotechnological process that uses microorganisms (whether genetically modified or not) and in particular bacteria, yeasts, fungi or algae. It is a multidisciplinary technology that integrates disciplines such as biochemistry, microbiology, molecular genetics and process technology.

Depending on the type of microorganisms and its genetic modifications, a various range of feedstocks can be used. Lignocellulose is present in garden and park waste and cellulose is present in food waste such as fruit and vegetable waste. Starch is present in food waste such as potatoes, corn, wheat or cassava. In the case of starch, this can be used directly by amylase-producing microorganisms, in particular filamentous fungi. However, to allow its use in a wider range of fermentations, starch is generally converted into glucose or dextrins by enzymatic hydrolysis. Oils and fats are present in food waste such as sauces, used cooking oils and fats. They can be used directly as a fermentation substrate. As for dairy waste, whey, the liquid by-product of cheese making, is used as a source of fermentable carbohydrates and nitrogen. Sugar-rich waste streams, on the other hand, can be derived from food industry waste, for example from the confectionery industry.

Depending on the type of raw material and its purity, specific pre-treatment technologies are required to provide fermentable substrates for the microorganisms. In general, this involves a size reduction step, after which the ground biomass can be processed to separate the desired substrate, using, for example, centrifugation, filtration,

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[1] Enzymatic Processes - Tech4Biowaste. (s. d.). https://www.tech4biowaste.eu/wiki/Enzymatic_processes [Accessed on 31 August 2023)]

[2] Industrial Fermentation - Tech4Biowaste. (s. d.). https://www.tech4biowaste.eu/wiki/Industrial_fermentation [Accessed on 31 August 2023)]

evaporation or crystallization. It should be pointed out that it is necessary to take into account the fact that some of the above-mentioned raw materials only provide the carbon source (which represents around 50% of the weight of most micro-organisms); in this case, other nutrients such as nitrogen, phosphate and potassium must be added.

3.8. Solid state fermentation

Solid state fermentation[3] (SSF) is a type of fermentation with a low water content in the substrate. The resulting solid substrate is inoculated with the microbial culture, which is generally carried out under controlled conditions (temperature, light and humidity). Other factors such as nutrient levels, C/N ratio, raw material/inoculum ratio, pH and mixing can also be controlled. SSF is a so-called "traditional culture" technique of food technology and involves all cultures of micro-organisms on a solid substrate without a free liquid phase. Besides traditional food processing methods, solid state fermentation is also used for the industrial production of a diverse range of other products, such as enzymes, biogas, pigments and antibiotics. SSF can also be applied in many different fields as food and aroma production, production of medicines, waste treatment or environmental technology.

SSF is especially suitable for the cultivation of filamentous organisms, like ascomycetes and basidiomycetes. But it is also suitable for various yeasts and bacteria. A large diversity of microorganisms can be used for SSF and therefore a wide range of substrates can be used as feedstock.

The feedstock can be a food product such as rice or wheat bran, but as well a wide range of agro-industrial residues can be used to produce citric acid. Wood can also serve as a feedstock.

A pre-treatment can be needed and can be done via additives or heat.

3.9. Gasification

Gasification[4] is the conversion of a solid or liquid organic compound in two phases, a gas and a solid phase. The gas phase, also called "syngas" or "producer gas", has a high heating power and can be used for power generation or biofuel production. The product of syngas is a gas mixture of carbon monoxide (CO), hydrogen (H_2), methane (CH_4), and carbon dioxide (CO_2), as well as light hydrocarbons, such as ethane and propane, and heavier hydrocarbons, such as tars. Some undesirable gases, such as sulphidric (H_2S) and chloridric acid (HCl), or inert gases, such as nitrogen (N_2), can also be present in the syngas. On the other side, the solid phase, called "char", includes the organic unconverted fraction and the inert material present in the treated feedstock. Conversion of organic material is then achieved by exposing the feedstock to high temperatures, typically 700°C - 1100°C in the presence of a gasifying agent. The gasifying agents usually used are air, oxygen, steam or a mixture thereof.

[3] Solid State fermentation - Tech4Biowaste. (s. d.). https://www.tech4biowaste.eu/wiki/Solid_state_fermentation [Accessed on 31 August 2023)]

[4] Gasification - Tech4Biowaste. (s. d.). https://www.tech4biowaste.eu/wiki/Gasification [Accessed on 31 August 2023)]

Several advantages are offered by the gasification of organic material offers. The produced syngas can be more efficient than direct combustion of the original feedstock, and can be used for multiple applications, such as heat and electricity generation, as transport fuel, as raw material for chemicals.

Usually, for gasification, wood and other lignocellulosic biomass are used. It can also be designed to convert the dry organic fraction of MSW. Depending on the nature of the organic material, the presence of the moisture content generally varies from 5% to 35%.

A pre-treatment can be needed and can be done via sizing or drying.

3.10. Hydrothermal process

Hydrothermal processing[5] is a thermochemical conversion process that is used to convert biomass into valuable products or biofuel. The process is usually performed in water at 250-374°C under pressures of 4-22 MPa. The process can also be carried out under self-generated pressure. The hydrothermal process is divided into two reaction conditions, namely subcritical and supercritical water conditions and there are determined by the critical point of water (i.e., 374°C and 22.1 MPa). The biomass is degraded into small components in water. Based on the target products, which are usually bio-crude, syngas or hydrochar, the process conditions (temperature, pressure and residence time) are chosen.

The most suitable feedstocks for hydrothermal processing are feedstocks with a high moisture content which include feedstocks such as anaerobic digestion digestate, manures, sewage sludge, food waste, municipal wastes and aquatic biomass such as micro- and macroalgae.

3.11. Pyrolysis

Pyrolysis[6] is a conversion technology that, in presence of heat and absence of oxygen, uses a thermochemical process to convert organic compounds into valuable products which can be solid, liquid or gaseous. The chemical transformations of substances are usually accompanied by the breaking of chemical bonds which leads to the conversion of more complex molecules into simpler molecules which may also combine with each other to build up larger molecules again.

Usually wood and herbaceous feedstocks are processed which are composed differently, which qualifies garden and park waste as suitable feedstock. It must be noted that all kind of biowaste contains hydrocarbonaceous material, which means that it can also be processed via pyrolysis. However, the composition of the feedstock has an impact on the pyrolysis process and therewith on the products which can be obtained.

[5] Hydrothermal Processing - Tech4Biowaste. (s. d.). https://www.tech4biowaste.eu/wiki/Hydrothermal_processing [Accessed on 31 August 2023)]
[6] Pyrolysis - Tech4Biowaste. (s. d.-b). https://www.tech4biowaste.eu/wiki/Pyrolysis [Accessed on 31 August 2023)]

The pre-treatment of the feedstock has an impact on the pyrolysis process, its efficiency, and the yield of certain products. Several types of pre-treatments can be used, such as densification (e.g. pressure-densification), steam explosion, wet torrefaction, ammonia-fibre expansion, composting (e.g. decomposing via fungi).

3.12. Heterogenous catalysis

Heterogeneous catalysis[7] is a catalysis in which the catalyst and the feedstock are in different phases. In practice, this often means that the feedstock is a liquid or gas and the catalyst is a solid. There is a wide variety of catalytic systems and many reactions can be catalysed with a solid catalyst but heterogeneous catalysis is the most widely used form of catalysis in the current chemical industry.

Due to the wide range of available catalysts and the large spectrum of reactions they can catalyse the feedstock range for heterogeneous catalysis is quite significant. These range from biomass feedstocks, such as lignocellulose, lignin, cellulose, sugars and fatty acids, to biomass-derived products, such as glycerol and furfural.

A pre-treatment of the feedstock is usually needed and for a heterogeneous catalysis it is depending on the specific process and feedstock used.

3.13. Pulping

Pulping[8] is a process that extracts fibrous material from biomass, most commonly as a precursor for paper making. The process is often combined with fractionation processes to separate and valorise lignin. There are several pulping processes and the main ones include mechanical, chemical, and a combination of mechanical and chemical pulping in a hybrid pulping process. The mechanical pulping relies on physical separation methods without adding any chemicals but water to reduce the damage to the fibres from friction. On the other side, chemical pulping uses chemicals to remove the lignin from the pulp. The hybrid pulping processes use chemicals to soften the lignin before a physical separation results in a pulp that still contains a substantial amount of lignin. There is also a biological pulping process which uses biotechnology.

The feedstock used to perform a pulping process needs to have a high fibre content. This means that before the pulping process, any material that is low in fibres should be removed.

The used biomass for pulping and the fractionation process is often woody biomass and needs a pre-treatment, i.e. to be debarked and then chipped.

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[7] Heterogeneous catalysis - Tech4Biowaste. (s. d.). https://www.tech4biowaste.eu/wiki/Heterogeneous_catalysis [Accessed on 31 August 2023)]
[8] Pulping and Fractionation - Tech4Biowaste. (s. d.). https://www.tech4biowaste.eu/wiki/Pulping_and_fractionation [Accessed on 31 August 2023)]

Conclusion

The BCC guidelines were developed in order to valorise the outcomes of the background research and theoretical work, as well as the developments of the three pilot areas released within the BCC H2020 project. The BCC guidelines intend to be a screening tool, supporting the identification of potentially suitable technological solutions. The guidelines were developed as a BCC webtool that can be accessed online (with an internet connection). It consists of an interactive questionnaire with 23 questions on the most significant technical, political, socio-economic and environmental criteria which would influence the planning and implementation of a biocircular technology for improving the management and valorisation of organic waste and residues in a specific territory.

The evaluation of the compatibility between technologies from the database and the specific context described by the user of the webtool relies on a background logic defined through a simple scoring system, allowing to rank each technology in accordance with the answers provided by the webtool user.

For each question, the webtool user is invited to choose his answer from a set of pre-defined answers, with each answer option representing one of the options considered characteristic of specific technologies in the background. The user cannot give free answers, otherwise the scoring system could not run correctly. The result is a ranked list of the 14 technologies selected based on the responses given, with an integrated explanation of the technologies and background information on the rankings. There is no direct comparison between technologies, the scoring is established in accordance with their suitability for the territorial context, including the priorities of the webtool user described through the application questionnaire.

The BCC webtool does not pretend to provide a full set of technical specifications and a business plan structure. It should be perceived as an informative tool on available biocircular technologies for local decision-makers.

ANNEX: BCC Guidelines of webtool – Technologies characteristics

User interface		Background logic
Question for the app user	**Multiple choices available for the user**	
Which type of biowaste, which will serve as feedstock for the valorisation technology, would you like to consider?	- Municipal organic waste *Sub choices:* Biowaste mixed with residual waste / Separately collected biowaste / Separately collected garden waste - Agro-industry processing losses: *Sub choices:* Coffee ground / Coffee silverskin / Fruits / Vegetables / Cereals / Dairy products / Fish-based food / Meat and Derivatives / Oilseed crops / Sugar and starchy crops / lignocellulosic waste or by-products - Forestry residues *Sub choices:* Bark / natural woodstream residues / Wood mixed with glue or other additives from industrial activities	If user choice = feedstock specified in technology >> +1 pt If user choice ≠ feedstock specified in technology >> Technology is out
For the type of waste selected, is there a separate collection system already implemented?	Yes / No	If user choice = Yes and Technology = sorting at source required >> +1 pt If user choice = Yes and Tecnology = sorting at source not mandatory >> +1pt If user choice = No and Technology = sorting at source required >> -1 pt If user choice = No and Tecnology = sorting at source not mandatory >> +1pt
Is there a specific sorting in order to isolate the organic fraction after it is collected?	Yes / No	If user choice = Yes and Technology = organic fraction must be isolated >> +1 pt If user choice = Yes and Tecnology = isolation of organic fraction not mandatory >> +1pt If user choice = No and Technology = organic fraction must be isolated >> -1 pt If user choice = No and Tecnology = isolation of organic fraction not mandatory >> +1pt
After the biowaste collection and sorting, is there remaining impurities?	Yes/No	If user = Yes and technology = 100% organic acceptance >> -1 If user = Yes and technology ≠ 100% organic min acceptance >> +1
If yes, which fraction (%) of impurities is remaining?	*The user enters a value btw 1 and 100*	
Can you specify a value in % for specific impurity categories:	*The user specify a value in % for each line:* Organic fraction (%) Plastic impurities (%) Metal impurities (%) Paper impurities (%) Other impurities (%)	If user plastic contaminant ≠ 0% and Tecnology plastic tolerance = 0% >> -1 If user plastic contaminant ≠ 0% and Tecnology plastic tolerance ≠ 0% >> +1 If user plastic contaminant = 0% and Tecnology plastic tolerance = 0% >> +1 If user plastic contaminant = 0% and Tecnology plastic tolerance ≠ 0% >> +1 If user % is not filled >> +0 If technology plastic tolerance is unknown >> +0 If user metal contaminant ≠ 0% and Tecnology metal tolerance = 0% >> -1 If user metal contaminant ≠ 0% and Tecnology metal tolerance ≠ 0% >> +1 If user metal contaminant = 0% and Tecnology metal tolerance = 0% >> +1 If user plastic contaminant = 0% and Tecnology plastic tolerance ≠ 0% >> +1 If user % is not filled >> +0 If technology metal tolerance is unknown >> +0 If user Paper contaminant ≠ 0% and Tecnology Paper contaminant tolerance = 0% >> -1 If user Paper contaminant ≠ 0% and Tecnology Paper tolerance ≠ 0% >> +1 If user Paper contaminant = 0% and Tecnology Paper tolerance = 0% >> +1 If user Paper contaminant = 0% and Tecnology Paper tolerance ≠ 0% >> +1 If user % is not filled >> +0 If technology paper tolerance is unknown >> +0 If user Other impurities ≠ 0% and Tecnology Hazardous contaminant tolerance = 0% >> -1 If user Other impurities ≠ 0% and Tecnology Hazardous contaminant tolerance ≠ 0% >> +1 If user Other impurities = 0% and Tecnology Hazardous contaminant tolerance = 0% >> +1 If user Other impurities = 0% and Tecnology Hazardous contaminant tolerance ≠ 0% >> +1 If user % is not filled >> +0 If technology Hazardous tolerance is unknown >> +0 If user Other impurities ≠ 0% and Tecnology Volatile/Non volatile chemical tolerance = 0% >> -1 If user Other impurities ≠ 0% and Tecnology Volatile/Non volatile chemical tolerance ≠ 0% >> +1
Please, confirm the biowaste flow is available continuously and in regular quantity along the year	Yes/No	If user choice = yes and Technology = continuous process and user amount = or > technology capacity (Consider max value of range interval) >> +1 If user choice = yes and Technology = continuous process and user amount < technology capacity (Consider max value of range interval) >> -1 If user choice = yes and Technology = periodic process and user amount = or > technology capacity (Consider max value of range interval) >> -1 (with recommendation) If user choice = yes and Technology = periodic process and user amount < technology capacity (Consider max value of range interval)>> +1 If user choice = no and Technology = continuous process and user amount = or > technology capacity (Consider min value of range interval) >> +1 (with recommendation) If user choice = no and Technology = continuous process and user amount (Consider min value of range interval) < technology capacity >> Technology is out If user choice = no and Technology = periodic process and user amount = or > technology capacity (Consider min value of range interval) >> -1 (with recommendation) If user choice = no and Technology = periodic process and user amount = or < technology capacity (Consider min value of range interval) >> +1 If user choice = yes and Technology = no constrain >> +1 If user choice = no and Technology = no constrain >> +1
Which amount of the selected biowast	*The user enters a specific number in tons*	
If the feedstock biowaste was not used as raw material for the technology, it could be landfilled. Are you ready to accept equivalent, lower or higher costs for a better valorisation of biowaste than the landfill tax?	- Higher - Equivalent - Lower	If user choice = higher >> +2 If user choice = equivalent >> +1 If user choice = lower >> -1
Does the feedstock availability and/or its supply chain is exclusively local (from the urban area or region of concern) or is it larger (multi-regional, country, international)?	- exclusively local - multi-regional or international	If user choice = exclusively local and technology = local supply >> +1 If user choice = exclusively local and technology = global supply >> +1 (with recommendations) If user choice = multi-regional or international and technology = local supply >> -1 If user choice = multi-regional or international and technology = global supply >> +1 (with recommendations)
Please describe how the biowaste under consideration is currently managed, by associating percentage to each valorisation or treatment options:	*The user specify a value in % for each line:* - % High value value products from biorefinery (materials / chemicals recycling) - % Medium value products from recycling (Energy recovery through biofuels production - Materials recovery through bioplastics, cellulose, commodity chemicals production) - % Low value products from Materials recovery (Compost, digestate) - % Low value products from Energy recovery from waste incineration - % Landfill or incineration without energy recovery	If user (% biorefinery + % recycling + % materials recovery) > 55 and If user (% landfill) > 10 and technology = recycling >> +1 If user (% biorefinery + % recycling + % materials recovery) > 55 and If user (% landfill) < 10 and technology = recycling >> +1 If user (% biorefinery + % recycling + % materials recovery) < 55 and If user (% landfill) > 10 and technology = recycling >> +2 If user (% biorefinery + % recycling + % materials recovery) < 55 and If user (% landfill) < 10 and technology = recycling >> +2 If user (% biorefinery + % recycling + % materials recovery) > 55 and If user (% landfill) > 10 and technology = Energy recovery >> +2 If user (% biorefinery + % recycling + % materials recovery) > 55 and If user (% landfill) < 10 and technology = Energy recovery >> +1 If user (% biorefinery + % recycling + % materials recovery) < 55 and If user (% landfill) > 10 and technology = Energy recovery >> +1 If user (% biorefinery + % recycling + % materials recovery) < 55 and If user (% landfill) <10 and technology = Energy recovery >> +1 If user (% biorefinery + % recycling + % materials recovery) > 55 and If user (% landfill) > 10 and technology = Incineration wo energy recovery or landfill >> -2 If user (% biorefinery + % recycling + % materials recovery) > 55 and If user (% landfill) < 10 and technology = Incineration wo energy recovery or landfill >> -1 If user (% biorefinery + % recycling + % materials recovery) < 55 and If user (% landfill) > 10 and technology = Incineration wo energy recovery or landfill >> -2 If user (% biorefinery + % recycling + % materials recovery) < 55 and If user (% landfill) < 10 and technology = Incineration wo energy recovery or landfill >> -1 If user (% biorefinery + % recycling + % materials recovery) > 55 and If user (% landfill) > 10 and technology = Biorefinery >> +1 If user (% biorefinery + % recycling + % materials recovery) > 55 and If user (% landfill) < 10 and technology = Biorefinery >> +1 If user (% biorefinery + % recycling + % materials recovery) < 55 and If user (% landfill) > 10 and technology = Biorefinery >> +2 If user (% biorefinery + % recycling + % materials recovery) < 55 and If user (% landfill) < 10 and technology = Biorefinery >> +2

	Individual characteristics of technologies						
Question for the app user	**Anaerobic digestion**	**Mechanical Biological Treatment with Industrial Composting**	**Incineration of MSW including unseparated biowaste (grey bin) - with energy recovery**	**Landfilling**	**Mechanical Biological Treatment with Anaerobic digestion**	**Anaerobic digestion + Biomethanation**	**Pre-treatment & Enzymatic hydrolysis**
Which type of biowaste, which will serve as feedstock for the valorisation technology, would you like to consider?	- Agro-industry / Food processing loss: All types - Forestry residue - Separately collected biowaste	Municipal organic waste: *sub choices*: Biowaste mixed with residual waste / Separately collected biowaste - Agro-industry / Food processing loss: Fruits - Vegetables - Cereals - Meat - Coffee - Garden waste / vegetal waste - Forestry residue - Bark or natural wood residue	Municipal organic waste: *sub choices:* Biowaste mixed with residual waste / Separately collected biowaste - Agro-industry processing losses: *Sub choices:* Coffee ground / Coffee silverskin / Fruits / Vegetables / Cereals / Dairy products / Fish-based food / Meat and Derivatives / Oilseed crops / Sugar and starchy crops / lignocellulosic waste or by-products - Forestry residues *Sub choices:* Bark / natural woodstream residues / Wood mixed with glue or other additives from industrial activities	Municipal organic waste: *sub choices*: Biowaste mixed with residual waste / Separately collected biowaste - Agro-industry processing losses: *Sub choices:* Coffee ground / Coffee silverskin / Fruits / Vegetables / Cereals / Dairy products / Fish-based food / Meat and Derivatives / Oilseed crops / Sugar and starchy crops / lignocellulosic waste or by-products - Forestry residues *Sub choices:* Bark / natural woodstream residues / Wood mixed with glue or other additives from industrial activities	Municipal organic waste: *sub choices*: Biowaste mixed with residual waste /	- Agro-industry / Food processing loss: All types Municipal organic waste: *sub choices*: Separately collected biowaste - Garden waste / vegetal waste - Bark or natural wood residue	- lignocellulosic waste or by-products - Seperated organic fraction from MSW - Garden waste / vegetal waste - Bark or natural wood residue
For the type of waste selected, is there a separate collection system already implemented?	Sorting at source not mandatory	Sorting at source not mandatory	Sorting at source not mandatory	Sorting at source not mandatory	Sorting at source not mandatory	Sorting at source not mandatory	Sorting at source not mandatory
Is there a specific sorting in order to isolate the organic fraction after it is collected?	Yes. Organic fraction must be isolated - through mechanical sorting process	ganic fraction must be isolate	organic fraction must be isolated	isolation of organic fraction not mandatory	Yes. Organic fraction must be isolated - through mechanical sorting process	Yes. Organic fraction must be isolated	Yes. Organic fraction must be isolated
After the biowaste collection and sorting, is there remaining impurities?	echnology ≠ 100% organic min acceptanc	logy ≠ 100% organic min acce	logy ≠ 100% organic min acce	logy ≠ 100% organic min acce	Technology ≠ 100% organic min acceptance	Technology ≠ 100% organic min acceptance	Technology = 100% organic min acceptance
If yes, which fraction (%) of impurities is remaining?							
Can you specify a value in % for specific impurity categories:	Technology plastic tolerance ≠ 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = 0 Hazardous contaminant tolerance = 0%.	Technology plastic tolerance ≠ 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = n.a. Hazardous contaminant tolerance ≠ 0%.	Technology plastic tolerance = 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = n.a. Hazardous contaminant tolerance ≠ 0%.	Technology plastic tolerance ≠ 0%. Technology metal tolerance ≠ 0%. Volatile/non volatile chemical tolerance ≠ n.a. Hazardous contaminant tolerance ≠ 0%.	Technology plastic tolerance ≠ 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = 0 Hazardous contaminant tolerance = 0%.	Technology plastic tolerance ≠ 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = 0 Hazardous contaminant tolerance = 0%.	Technology plastic tolerance = 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = 0 Hazardous contaminant tolerance = 0%.
Please, confirm the biowaste flow is available continuously and in regular quantity along the year	Continuous process	Continuous process	Continuous process	No constrain	Continuous process	Continuous process	Periodic process (lab to pilot scale, not running continuously)
Which amount of the selected biowast	Capacity = [20000 - 200000] tons	Capacity = [150 - 300000] tons	apacity = [20000 - 200000] tor	Large	Capacity = [20000 - 200000] tons	Capacity = [20000 - 200000] tons	Capacity < 2000 tons/year
If the feedstock biowaste was not used as raw material for the technology, it could be landfilled. Are you ready to accept equivalent, lower or higher costs for a better valorisation of biowaste than the landfill tax?	Lower to equivalent	Higher	Equivalent	n.a.	Lower to equivalent	Lower to equivalent	Higher
Does the feedstock availability and/or its supply chain is exclusively local (from the urban area or region of concern) or is it larger (multi-regional, country, international)?	Local	Local	Local	Local	Local	Local	Local or multi-regional or international
Please describe how the biowaste under consideration is currently managed, by associating percentage to each valorisation or treatment options:	Energy recovery	Recycling	Energy recovery	Landfill	Recycling	Energy recovery	Biorefinery

	Individual characteristics of technologies						
Question for the app user	**Pre-treatment & Industrial fermentation**	**Pre-treatment & Pyrolysis**	**Solid state fermentation**	**Gasification**	**Hydrothermal process**	**Heterogenous catalysis**	**Pulping**
Which type of biowaste, which will serve as feedstock for the valorisation technology, would you like to consider?	- Agro-industry / Food processing loss: Fruits / Vegetables / Dairy products / Oilseed crops / Sugar and starchy crops '- lignocellulosic waste or by-products Municipal organic waste: *sub choices*: Separately collected biowaste - Garden waste / vegetal waste - Bark or natural wood residue	- Garden waste / vegetal waste - Bark or natural wood residue	- Agro-industry / Food processing loss: Fruits / Vegetables / Coffee silverskin / cereals	- lignocellulosic waste or by-products Municipal organic waste: *sub choices:* Separately collected biowaste - Garden waste / vegetal waste - Bark or natural wood residue	Municipal organic waste: *sub choices*: Biowaste mixed with residual waste / Separately collected biowaste - Agro-industry processing losses: Fruits / Vegetables / Cereals / Dairy products / Fish-based food / Meat and Derivatives / Oilseed crops / Sugar and starchy crops	- lignocellulosic waste or by-products Municipal organic waste: *sub choices:* Separately collected biowaste - Agro-industry / Food processing loss: Fruits / Vegetables / Dairy products / Oilseed crops / Sugar and starchy crops - Garden waste / vegetal waste - Bark or natural wood residue	- lignocellulosic waste or by-products - Bark or natural wood residue
For the type of waste selected, is there a separate collection system already implemented?	Sorting at source not mandatory	Sorting at source not mandatory	Sorting at source not mandatory	Sorting at source not mandatory	Sorting at source not mandatory	Sorting at source not mandatory	Sorting at source not mandatory
Is there a specific sorting in order to isolate the organic fraction after it is collected?	Yes. Organic fraction must be isolated	Yes. Organic fraction must be isolated	Yes. Organic fraction must be isolated	Yes. Organic fraction must be isolated	Yes. Organic fraction must be isolated	Yes. Organic fraction must be isolated	Yes. Organic fraction must be isolated
After the biowaste collection and sorting, is there remaining impurities?	Technology = 100% organic min acceptance	Technology = 100% organic min acceptance	Technology = 100% organic min acceptance	Technology = 100% organic min acceptance	Technology = 100% organic min acceptance	Technology = 100% organic min acceptance	Technology = 100% organic min acceptance
If yes, which fraction (%) of impurities is remaining?							
Can you specify a value in % for specific impurity categories:	Technology plastic tolerance = 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = 0 Hazardous contaminant tolerance = 0%.	Technology plastic tolerance = 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = 0 Hazardous contaminant tolerance = 0%.	Technology plastic tolerance = 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = 0 Hazardous contaminant tolerance = 0%.	Technology plastic tolerance = 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = 0 Hazardous contaminant tolerance = 0%.	Technology plastic tolerance = 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = 0 Hazardous contaminant tolerance = 0%.	Technology plastic tolerance = 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = 0 Hazardous contaminant tolerance = 0%.	Technology plastic tolerance = 0%. Technology metal tolerance = 0%. Volatile/non volatile chemical tolerance = 0 Hazardous contaminant tolerance = 0%.
Please, confirm the biowaste flow is available continuously and in regular quantity along the year	Periodic process (batch/pilot scale, continnuous fermentations are relatively rare)	Continuous	Periodic process (batch/pilot scale)	Continuous	Continuous	Continuous	Continuous
Which amount of the selected biowast	Capacity < 10 tons/year	Capacity > 40 000 tons/year	Capacity <10 tons/year	Capacity: [8 000 - 10 000] tons/year	Capacity: [200 - 500] tons/year	n.a.	n.a
If the feedstock biowaste was not used as raw material for the technology, it could be landfilled. Are you ready to accept equivalent, lower or higher costs for a better valorisation of biowaste than the landfill tax?	Equivalent	Higher	Higher	Equivalent	Higher	Higher	Equivalent
Does the feedstock availability and/or its supply chain is exclusively local (from the urban area or region of concern) or is it larger (multi-regional, country, international)?	al or multi-regional or internatio	l or multi-regional or internati	cal or multi-regional or internation	Local	Local	Local	Local
Please describe how the biowaste under consideration is currently managed, by associating percentage to each valorisation or treatment options:	Biorefinery	Recycling	Biorefinery	Recycling / Energy recovery	Biorefinery	Biorefinery	Recycling

Step 2 – Type of end product targeted

User interface: Question for the app user	User interface: Multiple choices available for the user	Background logic
Considering the product values definitions developed in the introduction of this page, which product value would be your priority target?	- High - Medium - Low	If user = High and technology = high product value >> +1 If user = High and technology ≠ high product value >> -1 If user = Medium and technology = Medium product value >> +1 If user = Medium and technology ≠ Medium product value >> -1 If user = Low and technology = Low product value >> +1 If user = Low and technology ≠ Low product value >> -1
Please specify if processes available only at the pilot scale could be of interest?	Yes / No	If user = Yes and Technology = pilot scale >> +1 If user = Yes and Tecnology = industrial scale >> +1 If user = No and Technology = pilot scale >> Technology out If user = No and Tecnology = industrial scale >> +1
Which market readiness level would you agree to target for the biobased product obtained from the treatment or processing of the biowaste under consideration?	*The user can choose several options:* - EU quality and safety standard existing - EU certification existing - EU certification under definition - EU quality and safety standard under definition - Market already existing - No matter if nothing is available yet	If user unique choice = technology readiness level >> +2 If at least one user multiple choices = technology readiness level >> +1 If all user choices (1 or +) ≠ technology market readiness level >> -1
Which level of societal acceptance would you target?	*The user can choose several options:* - Niche market for a bio-based product - Bio-based products arousing neutral interest (no specific interest or rejection) - Products already available on the market inducing public reluctance (because of direct or indirect nuisances) - Only products which are well accepted / already widely available ~~in~~ on the market	If user unique choice = technology acceptance level >> +2 If at least one user multiple choices = technology acceptance level >> +1 If all user choices (1 or +) ≠ technology acceptance level >> Technology is out
Would you like to focus exclusively on end products which are competitive with their conventional counterpart?	Yes / No	If user = Yes and Technology = low competitiveness >> Technology is out If user = Yes and Tecnology = competitive >> +1 If user = Yes and Technology = high competitiveness >>+2 If user = No and Technology = low competitiveness >> +1 If user = No and Tecnology = competitive >> +1 If user = No and Technology = high competitiveness >>+1

Individual characteristics of technologies	Anaerobic digestion	Mechanical Biological Treatment with Industrial Composting	Incineration of MSW including unseparated biowaste (grey bin) - with energy recovery	Landfilling	Mechanical Biological Treatment with Anaerobic digestion	Anaerobic digestion + biomethanation	Enzymatic hydrolysis
Product value	Biogas= medium value Digestate = low value	Compost = low value	Medium value	Low value	Biogas= medium value Digestate = low value	High value	High value
Pilot scale	industrial scale pilot scale	Industrial scale	Industrial scale	Industrial scale	industrial scale pilot scale	industrial scale pilot scale	pilot scale
Market readiness level	Market already existing / EU quality and safety standard existing	isting / EU quality and safety	Market already existing / EU quality and safety standard existing	Market already existing / EU quality and safety standard existing	Biogas= EU quality and safety standard existing Digestate= EU quality and safety standard existing	Market already existing / EU quality and safety standard existing	EU quality and safety standard existing
Societal acceptance	Products already available ~~in~~ on the market inducing public reluctance (because of direct or indirect nuisances)	particular interest or rejecti	Public reluctance	Public reluctance	Products already available ~~in~~ on the market inducing public reluctance (because of direct or indirect nuisances)	Products already available ~~in~~ on the market inducing public reluctance (because of direct or indirect nuisances)	Bio-based products arousing neutral interest (no specific interest or rejection)
Competitiveness	High competitiveness	High competitiveness	Competitive	Low competitiveness	High competitiveness	High competitiveness	Low competitiveness

Individual characteristics of technologies	Industrial fermentation	Pyrolysis	Solid state fermentation	Gasification	Hydrothermal process	Heterogenous catalysis	Pulping
Product value	High value	Medium value	High value	Medium value	High value	High value	Medium value
Pilot scale	pilot scale	pilot scale	pilot scale	Industrial scale	pilot scale	Industrial scale	Industrial scale
Market readiness level	EU quality and safety standard existing	EU quality and safety standard existing	EU quality and safety standard existing	Market already existing / EU quality and safety standard existing	EU quality and safety standard existing	Market already existing / EU quality and safety standard existing	Market already existing / EU quality and safety standard existing
Societal acceptance	Bio-based products arousing neutral interest (no specific interest or rejection)	Bio-based products arousing neutral interest (no specific interest or rejection)	Bio-based products arousing neutral interest (no specific interest or rejection)	Bio-based products arousing neutral interest (no specific interest or rejection)	Bio-based products arousing neutral interest (no specific interest or rejection)	Bio-based products arousing neutral interest (no specific interest or rejection)	Bio-based products arousing neutral interest (no specific interest or rejection)
Competitiveness	Competitive	Low competitiveness	Low competitiveness	Competitive	Low competitiveness	Competitive	Competitive

Step 3 – Environmental performances

User interface: Question for the app user	User interface: Multiple choices available for the user	Background logic
Which conventional counterpart the obtained output should substitute in priority?	- Heat from natural gas - Electricity - Natural gas from the grid - Other Fossil Fuels (diesel/gasoline/oil) - Synthetic fertilisers and/or soil amendments - Synthetic chemical blocks - Other chemical products - Additives / Ingredients for food making	If user unique choice = technology substitution product >> +1 If user multiple choices = technology substitution products >> +2 If at least one user multiple choices = technology substitution product >> +1 If all user choices (1 or +) ≠ technology substitution product >> -1
Which magnitude of GHG reduction would you target, compared to conventional counterpart?	0% From - 10% to - 20% From - 20% to - 30% From - 30% to -40% From - 30% to -50% > - 50%	If user range = technology range >> +1 If user range > technology range >> -1 If user range < technology range >> +1
Which range of resource efficiency is acceptable for the process to be implemented (CED consumed vs CED created)	Equivalent From 20% to 40% From 40% to 60% From 60% to 80% >80%	If user range = technology range >> +1 If user range > technology range >> -1 If user range < technology range >> +1
Which environmental impacts that could be induced by the technology or the outcome product use or consumption, would be a barrier to its development in your urban area / region / country	*The user can choose several options:* Impacts on air quality and human health Impacts on water and aquatic organisms (plants and animals) Impacts on human health and ecosystems Impacts on soil and terrestrial ecosystems	If user unique or all multiple choice = technology identified impacts >> Technology is out If at least one user multiple choices but not all = technology identified impact >> -1 If all user choices (1 or +) ≠ technology market identified impact >> +1 (with recommendations)

Individual characteristics of technologies	Anaerobic digestion	Mechanical Biological Treatment with Industrial Composting	Incineration of organic fraction, with energy recovery for use in CHP unit	Landfilling	Mechanical Biological Treatment (MBT) with Anaerobic digestion	Anaerobic digestion + biomethanation	Enzymatic hydrolysis
Conventional counterpart	Biogas: Heat & Electricity for use in CHP unit, boiler, absorption chiller Digestate: Synthetic fertilizer	- Synthetic fertilisers and/or soil amendments - other chemical products *(seed starters, container mixes, soil amendments, mulches and Natural fertilizers)*	Heat (Thermal energy) from natural gas.	n.a.	Biogas: Heat & Electricity for use in CHP unit, boiler, absorption chiller Digestate: Synthetic fertilizer	- Natural gas from the grid - other Fossil Fuel (diesel/gasoline)	- Synthetic chemical block - other chemical product - Additives / Ingredients for food making
GHG reduction	From -30 to -40%	From -10 to -20%	>50%	0%	From -30 to -40%	>50%	>50%
Resource efficiency	>80%	Equivalent	40% to 60%	lower than 0	>80%	>80%	Equivalent
Environmental impacts	Impact on air quality and human health	Impact on air quality and human health	Impact on air quality and human health	Impact on air quality and human health	Impact on air quality and human health	Impact on air quality and human health	Impact on air quality and human health
	Impacts on soil and terrestrial ecosystems	Impacts on human health and ecosystems	Impact on water and aquatic organisms (plants and animals)	Impacts on human health and ecosystems	Impacts on soil and terrestrial ecosystems	Impacts on soil and terrestrial ecosystems	Impacts on human health and ecosystems
	Impact on water and aquatic organisms (plants and animals)	Impacts on soil and terrestrial ecosystems	Impacts on human health and ecosystems	Impacts on soil and terrestrial ecosystems	Impact on water and aquatic organisms (plants and animals)	Impact on water and aquatic organisms (plants and animals)	
	Impacts on human health and ecosystems		Impacts on soil and terrestrial ecosystems		Impacts on human health and ecosystems	Impacts on human health and ecosystems	
	Impacts on soil and terrestrial ecosystems						

Individual characteristics of technologies	Industrial fermentation	Pyrolysis	Solid state fermentation	Gasification	Hydrothermal process	Heterogenous catalysis	Pulping
Conventional counterpart	- Synthetic chemical block - other chemical product - Additives / Ingredients for food making	- Synthetic chemical block - Other chemical products - Synthetic fertiliser and/or soil amendment - other Fossil Fuel (diesel/gasoline/oil)	- Synthetic chemical block - other chemical product - Additives / Ingredients for food making	- Other chemical products - Heat from natural gas - Electricity - other Fossil Fuel (diesel/gasoline/oil)	- Synthetic fertilisers and/or soil amendments - Heat from natural gas - Electricity - other Fossil Fuel (diesel/gasoline/oil)	- Chemical blocks - Other chemical products	- Chemical blocks - Other chemical products
GHG reduction	From -10 to -20%	From -10 to -40%	From -10 to -20%	From -10 to -20%	From -10 to -20%	From -10 to -20%	From -10 to -20%
Resource efficiency	Equivalent	Equivalent	Equivalent	Equivalent	Equivalent	Equivalent	Equivalent
Environmental impacts	Impact on air quality and human health	Impact on air quality and human health	Impact on air quality and human health	Impact on air quality and human health	Impact on air quality and human health	Impact on air quality and human health	Impact on air quality and human health
	Impacts on human health and ecosystems	Impacts on human health and ecosystems	Impacts on human health and ecosystems	Impacts on human health and ecosystems	Impacts on human health and ecosystems	Impacts on human health and ecosystems	Impacts on human health and ecosystems
							Impact on water and aquatic organisms (plants and animals)
							Impacts on soil and terrestrial ecosystems

Step 4 – Other political and economic incentives

User interface		Background logic	Individual characteristics of technologies													
Question for the app user	**Multiple choices available for the user**		**Anaerobic digestion**	**Mechanical Biological Treatment with Industrial Composting**	**Incineration of MSW including unseparated biowaste (grey bin) - with energy recovery**	**Landfilling**	**Mechanical Biological Treatment with Anaerobic digestion**	**Anaerobic digestion + biomethanation**	**Enzymatic hydrolysis**	**Industrial fermentation**	**Pyrolysis**	**Solid state fermentation**	**Gasification**	**Hydrothermal process**	**Heterogenous catalysis**	**Pulping**
Will your region / institution / company be able to significantly invest on its own fund for the development of competences in relation to the implementation of a new value chain, or for modifying an existing one?	Yes / No If yes: The user can choose several options: - Readiness to invest in low-skilled competences (e.g. to train process operators) - Readiness to invest in competences already existing in the market - Readiness to invest in developing highly specific competences , in collaboration with research institutes	if user = Research institutes, on biorefinery processes and Technology = biorefinery >> +2 if user = Reasearch institutes, on biowaste energy conversion and Technology = energy recovery >> +2 if user = Reasearch institutes, on biowaste material recycling and Technology = recycling >> +2 if user = Similar or complementary companies or institutions >> +1 if one or several user choices match with Technology category >> +1 If none of user choices match with Technology category >> -1	Energy recovery	Recycling	Energy recovery	Landfilling	Energy recovery	Energy recovery	Biorefinery	Biorefinery	Recycling	Biorefinery	Recycling / Energy recovery	Biorefinery	Biorefinery	Recycling
Is there any opportunity to collaborate locally with	*The user can choose several options:* - Research institutes, on biorefinery processes - Reasearch institutes, on biowaste energy conversion - Reasearch institutes, on biowaste material recycling - Similar or complementary companies or institutions															
Will your region / institution / company be able to significantly invest on its own fund for the development of infrastructures, equipments or any other material needs, required in support to the implementation of a new value chain, or for modifying an existing one?	Yes / No	If user = yes and Technology = elligible to subside >> +2 If user = no and Technology = elligible to subside >> +1 If user = yes and Technology = not or moderatly elligible to subside >> +1 If user = no and Technology = not or moderatly elligible to subside >> -1	Elligible to subside	Moderatly elligible to subside	Moderatly elligible to subside	No subside	Elligible to subside	Elligible to subside	Elligible to subside	Elligible to subside	Elligible to subside	Elligible to subside	Elligible to subside	Elligible to subside	Elligible to subside	Moderatly elligible to subside
Can your company or institution can support all the costs by itself or the project cannot happen without subsides or any supportive public funding instrument?	- We can support 100% of the costs, no interest in subsidies - We can support 100% of the costs, but Interested in subsidies - Project not feasible without external financial support															
What would be the acceptable range for net benefit? (Value creation vs processing and overhead costs without considering potential subsidies)?	+10% +20% +30% +40% >50%	If user range = technology range >> +1 If user range > technology range >> -1 If user range < technology range >> +1	+10% to +30%	+10% to +20%	+10%	n.a.	+10% to +30%	+10% to +30%	Max +10%	Max +10%	Max +10%	Max +10%	+10% to +30%	Max +10%	+10% to +30%	+10% to +30%

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