BIO CIRCULAR CITIES

Exploring the circular bioeconomy potential in cities

Report documenting the definition of the decision tree background logic

Deliverable D4.2 of WP4

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Exploring the circular bioeconomy potential in cities

BBI JU
Bio-based Industries Consortium
Horizon 2020 European Union Funding for Research & Innovation

This project has received funding from the Bio-based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 101023516. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio-based Industries Consortium.

Technical References

Grant Agreement N°	101023516	Acronym	BIOCIRCULARCITIES
Full Title	Exploring the circular bioeconomy potential in cities. Proactive instruments for implementation by policy makers and stakeholders.		
Work Package (WP)	WP4 – Transferability and replicability to other international cases		
Authors	Mélanie Guiton, Laurent Chion, Tomás Navarrete Gutiérrez		
Document Type	Deliverable		
Document Title	Report documenting the definition of the decision tree background logic		
Dissemination Level (mark with an "X" in the column to the far right)	CO	Confidential, only for partners of the Consortium (including the Commission's Services)	
	PU	Public	X
	PP	Restricted to other programme participants (including the Commission Services)	
	RE	Restricted to a group specified by the Consortium (including the Commission Services)	

Document History

VERSION	DATE	PARTNER	RESPONSIBLE
1	06/06/2023	LIST	Mélanie Guiton
2	23/06/2023	LIST	Mélanie Guiton

Reviewers

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Executive summary

The BioCircularCities (BCC) guidelines constitute the main outcome of the Work Package 4 - “Transferability and replicability to other international cases” of the BCC project. The BCC guidelines were developed in order to valorise the outcomes from the theoretical work and from the regional pilot theoretical and practical developments that were released during the BCC H2020 project. The guidelines were developed as a web application, accessible online (with an internet connection). It consists of an interactive questionnaire 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 BioCircularCities web tool relies on the consideration of a list of influential criteria which was established from what has emerged from the analysis of a literature-based state of the art of the main drivers and barriers towards the development of biocircular value chains for biomass waste management (D4.1), and incorporating feedback provided by the local stakeholders in the Living Labs.

The evaluation of the compatibility between several biocircular technologies characterised on the background of the application and the specific context and priorities described by the user of the web application relies on a background logic, defined through a simple scoring system. The scoring system allows to rank each technology included in the BCC guidelines background database in accordance with the answers provided by the user of the web application to a set of simple questions aiming at specifying the local or regional territory context in which the biocircular technological route would be implemented, in terms of specific type of feedstock from bioresidues, technoeconomic and environmental capacities and priorities, and policy support.

The BCC guidelines position themselves in support to the design of circular 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 circular bioeconomy.

The added value of the BCC guidelines is that they position themselves in-between the web platforms that usually provide generic information on technological solutions without considering the specific context in which they should be implemented, and the sophisticated circularity or sustainability assessment tools that require specific competences and/or a significant amount of quantified data and information. The guidelines are designed to be used by public or private organisations like local or regional authorities in charge of planning or managing the treatment of bioresidues, that are not necessarily highly proficient in biocircular technological routes.

The aim of the deliverable D4.2. is to document the background setting of the BCC guidelines that were developed including the discussion of the transferability and replicability of the BCC project results and outcomes, and the description of the main principles of the BCC guidelines and of the set of significant criteria for screening the compatibility between biocircular technologies options and the context of the territory in which it should be implemented. Finally, the background logic leading to the classification of biocircular technologies options depending on the specific territorial context of concern is explained.

The next deliverable, "D4.3. Web application in practice: short guidance for the practitioner" will describe the content of the BCC guidelines, how to practice the web application and which type of results can be obtained.

List of acronyms

AD	Anaerobic Digestion
BCC	BioCircularCities
CCRI	Circular Cities and Regions Initiatives
EC	European Commission
EU	European Union
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
MBT	Mechanical Biological treatment
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 web application 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 manyfold, addressing the policy, techno-economic and environmental barriers and drivers towards 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 bioresidues management and valorisation. These two perspectives were addressed through the analysis of legislative and regulation documents (D3.1, D3.2), as well as through literature review (D4.1), and were illustrated with the investigation of three specific and independent regional case studies planning transition to circular bioeconomy for biowaste and bioresidues management in local or regional areas, respectively in Spain (Metropolitan area of Barcelona), in Italy (Metropolitan city of Naples), and in Bulgaria (Province of Pazardzhik). For each of them, starting from the current situation, potential scenarios improving the valorisation of biowaste and bioresidues and contributing to bioeconomy were developed, their feasibility were discussed with the regional stakeholders during the living lab sessions, and their sustainability and circularity were assessed through LCA and LCC (D2.2). A review of the existing tools and guidelines that can be used throughout the development process of a biocircular strategy has been carried out and detailed in D4.1. In total, 19 tools or guidelines have been identified as potentially relevant considering the scope of the BCC project and with the global approach released by the Circular Cities and Regions Initiative (CCRI) in 2022. The CCRI methodology constitutes the most recent guide of reference from the EU Commission for the deployment of circular solutions in cities and urban areas and relying on three main stages – Map-Design-Implement – considering the technological, scientific and governance issues of potential circular solutions.

Only 4 out of these 19 instruments are dedicated to the identification of circular or sustainable actions or pathways. These tools and guidelines generally allow the identification of generic solutions, but they rarely reach the step of providing support in the identification of concrete technological options to be implemented. 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 supportive tool contributing to remediate this gap. In order to maximise the added value provided by the BCC guidelines, they shall be replicable to different types of biomass waste, given any geographical, political and socio-economic contexts.

The conclusions from the literature (D4.1) and policy framework analysis (D3.2) of the drivers and barriers towards sustainable biocircular economy, together with the experience of the BCC pilots (translated through the deliverables of WP2 and WP3) and the feedback from the local stakeholders and international experts during the Living Labs, Peer Review Sessions, Advisory Board meetings showed that multiple parameters would influence strategic and technological choices for biowaste and bioresidues management. Those parameters being specific to each application and highly variable from one territorial context to the other, it makes full sense to develop an interactive web-based tool as guidelines, rather than fixed written guidelines resuming the set of conditions to be reached to make one specific technological option efficient for the specific context of concern.

The BCC guidelines position themselves in support to the design of circular 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 circular bioeconomy.

It shall be applicable once some targets or performance objectives on e.g. landfill reduction, increase of bioenergy generation, reduction of greenhouse gases emissions, to be reached through the implementation of one or several suitable biocircular technologies have been specified. Hence, it is assumed that issues like the identification of the most promising economic sector(s), e.g. green chemistry, energy production, etc..., to be targeted or the identification of strategic stakeholders to be involved were clarified based on the BCC guidelines consultation, and that phases to be developed for the further implementation are not covered by the guidelines and would be addressed below the BCC guidelines consultation.

The BCC web tool relies on the consideration of a list of influential criteria which was established from what has emerged from the analysis of a literature-based state of the art of the main drivers and barriers towards the development of biocircular value chains for biomass waste management. This is fully detailed in Deliverable D4.1 of the project. The legal drivers and barriers specific to the three biocircular pilot value chains (D3.2) were also considered in the web tool.

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

The present deliverable D4.2 intends first to discuss how 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 living labs in the pilot areas, and of the outcomes from the different advisory board meetings

and peer review sessions with international experts. Second, the D4.2 reports the main principles of the BCC guidelines and comments the set of criteria identified as relevant for screening the compatibility among the type of bioresidues selected (e.g. forestry residues) as feedstock, biocircular technological options depending on it (e.g., production of biochemicals) and the territorial context in which the biocircular solution should be implemented. Finally, the background logic leading to the classification of biocircular technologies depending on the specific territorial context of concern is explained.

1. Transferability and Replicability

The development of the BCC project WP4 and its deliverables aim at ensuring the transferability and the replicability of the work and outcomes that were released along the project by institutional partners and local areas representatives that were involved in the project. The objective is that the main outcomes of the BCC project can be exploited and further advanced and improved with other cases from various local or regional areas in Europe.

The BCC guidelines target policy makers who oversee organising and optimising the management, valorisation and elimination of biowaste and bioresidues, and shall be replicable to different European territorial (local or regional) contexts, each being specific in terms of objectives, constrains and drivers (types of organic feedstock, geographical, political and economic contexts). Hence, it was decided to develop the BCC guidelines as a supportive interactive tool in which the user is invited to describe its own local or regional context and biocircular objectives, according to which the tool provides some suitable technological options for improving the management of different types of organic waste (e.g. municipal biowaste).

The added value of the BCC guidelines is that they position themselves in between the web platforms, that usually provide generic information on technological solutions without considering the specific context in which they should be implemented, and the sophisticated circularity or sustainability assessment tools, that require specific competences and/or a significant amount of quantified data and information.

In this sense, the BCC guidelines fulfil the gap of decision-making support identified by the local stakeholders of the three different selected value chains during the local Living Lab sessions. During these sessions, the key stakeholders from each pilot area were brought together to discuss the project developments. The stakeholders indeed reported that they did not know of any existing tools endorsing similar functionalities such as those of the BCC guidelines. Moreover, the most commonly known existing tools are too technical and require a lot of prior and specific technical information that is often difficult for decision-makers to obtain. The BCC guidelines are accessible through a web application for all policy makers or related persons with a technical background in the field of organic waste valorisation and treatment.

The BCC guidelines fulfil the expectations of the Living Labs participants to get more and easily accessible information about biocircular technologies and value chains, and to gain awareness about the parameters that influence technological or value chain choice. The BCC guidelines intend to achieve this aim by inviting the user to define the characteristics of the territorial context in which the biocircular solution is planned, according to the technical, political, socio-economic, and environmental drivers and barriers towards circular bioeconomy that were identified along WP2, WP3 and WP4 of the BCC project. In addition, the BCC guidelines contribute to transfer knowledge and information on several valuable biocircular technologies since they support the first stage of the design of biocircular solutions or pathways.

The BCC guidelines shall be consulted once some targets or performance objectives to be reached through the implementation of one or several suitable biocircular technologies have been specified. Hence, it is assumed that also issues like the identification of the most promising economic sector(s) to be targeted (e.g. market for green chemistry, market for biomethane) or the identification of strategic stakeholders to be involved in the new value chain need to be addressed beforehand.

The BCC guidelines do not intend to provide a "ready to implement" business plan, but to bring some first clues about what could be suitable in terms of technological pathways, given a specific context. Also, in order to maximise its impact at the European level, the scope of the tool is defined to cover the whole of Europe. Hence, potential specific restrictions or incentives existing in one specific country or region with regard to one or several technologies are not considered and will not be identified by the BCC guidelines. Finally, the next steps for further implementation of the biocircular options, such as the setting of a techno-economic business plan, are not covered by the guidelines.

2. BCC Guidelines principles and development steps

2.1. BCC guidelines main principles

The BCC guidelines intend to screen the socio-economic, political (waste collection system, available subsides) and environmental territory in which the biocircular solution(s) shall be implemented, and to estimate which biocircular technological pathway(s) for the biowaste or bioresidues valorisation would be potentially compatible with the described priorities and strategy. The goal is to support the stakeholders' decisions for screening the priorities for potential actions to move forward with sustainable, circular bioeconomy planning and implementation for biowaste management. The guidelines are designed to be used by public or private organisations like local or regional authorities in charge of planning or managing the treatment of bioresidues, that are not necessarily highly proficient in biocircular technological routes.

As mentioned in the previous section, the BCC guidelines are accessible through a web application accessible at https://bcc.list.lu/. The user is invited to answer a set of questions that will describe the specificities of his territory context , in terms of technical, political, socio-economic, and environmental targets and constraints (see Table 1), later on called "biocircular criteria". On the background of the user interface, a portfolio of technologies has been considered and each technology was characterized according to the same biocircular criteria, allowing to identify if the technology would be compatible with the characteristics of the context for implementation. (

Figure 1).

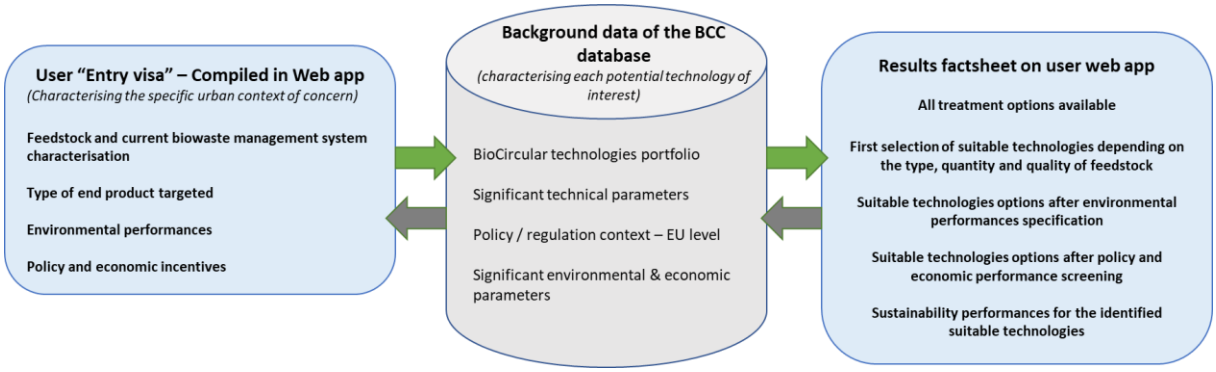


Figure 1: Global structure of the BCC Guidelines Web Application

The list of biocircular criteria that were considered both for the set of questions asked to the user, and for characterising each technology, has been established based on the analysis of drivers and barriers systematically influencing strategic choices, decisions and operations along the biocircular value chains. The detailed analysis is

available in D4.1 and D3.2. In a summary, the drivers and barriers could be classified according to seven driving forces required to be considered for enhancing transition towards a sustainable, circular bioeconomy.

First of all, an efficient transition towards sustainable and circular bioeconomy for biowaste and bioresidues management requires a solid and up to date policy framework. This is challenging for a concept like circular bioeconomy. Firstly, because the scope is large and complex and policies related to various economic sectors need to be considered. On the other hand, polices that do not directly target the bioeconomy may also have some impact. The challenge also comes from the fact that circular bioeconomy implementation is quite recent in a fast- evolving techno-economic context, resulting in a constant emergence of new issues to be integrated into the global and specific policy frameworks at the same time.

Second, the regulation of interactions between the different sectors involved in the bioeconomy is mainly driven by the market, which itself is largely driven by the consumers or clients' demand. Hence, the shift to more sustainable consumption patterns in support to the market transition towards sustainable circular bioeconomy is also a driving force, inducing to integrate consumer behavioural change as central to market orientation.

Moreover, changes in consumption patterns would support the transition towards biocircular systems at the territorial scale, but it could not be effective without the engagement of the different stakeholders playing a role along the biocircular value chain, and without the consideration of the interconnectedness of the value chains.

Another driving force is the need for the development of a skilled and competent workforce at the European level, to strengthen the competitiveness of European bioeconomy, including businesses and public authorities, and create jobs.

In addition, the bioeconomy offers the opportunity to develop innovative value chains, calling for research and development and infrastructure development. The economic and human resources public investments from governments are significant levers, but the potential for innovation shall also attract private investments along the value chain.

Then, the sustainable management and use of biological resources constitutes a pillar of the EU bioeconomy strategy, and a tricky challenge which is essential to address in order to transform efficiently the economy towards bioeconomy. Bioeconomy systems would be beneficial to the society only if the consumption and production models converge through the consideration and the respect of the regenerative capacity of the planet, considering the increasing demand for biomass from additional sectors and markets. This is achievable through the local development of circular bioeconomy with biorefinery, energy recovery and composting, and short domestic supply chains in order to limit the potential conflicts and pressure existing for the supply of biomass and its demand for various local purposes.

More generally, overall sustainability of circular bioeconomy systems is of primary importance, making it essential to assess and understand the sustainability performances of the new business models and value chains. The environmental performances the user would like to target are are addressed in the BCC guidelines, but the environmental and economic performances of the different biocircular scenarios for each of the three regional

pilots were fully assessed applying Life Cycle Assessment and Life Cycle Costing (BCC project WP2). The first results are available in D2.2.

The biocircular criteria considered in the BCC guidelines, which are listed in Table 1, hence aim at covering all the driving forces summarised above. Each biocircular criteria is addressed through one or several questions to the user in the BCC guidelines web application. The biocircular criteria related questions were grouped into 4 categories. The first category intends to address the feedstock properties (e.g. composition and quality in terms of content of high-value substances or molecules, presence of contaminants etc.) and current management pathway. The second category gathers criteria associated to the type of end product(s) that would be expected from the biocircular technology, their level of readiness towards the market and their economic competitiveness. The third category considers criteria dedicated to identifying the potential objectives targeted in terms of environmental performances. Finally, the fourth category addresses the investment and collaboration capacities.

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

Criteria to be considered in the web application use with regard to the context of the waste stream under consideration at local or regional level. In the BCC background database (Figure 1), 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 CC Impact reduction (%) compared to theconventional counterpart
	Process energetic yield (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)

The list of biocircular criteria presented here is also considered for characterising each biocircular technology included in the background database of the BCC guidelines web application. The background logic implemented to evaluate the compatibility between technologies from the database and the specific context described by the web application user is detailed in the next section 4.

The fourteen technologies included in the BCC guidelines background database include, 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 process), biochemical conversion routes (Enzymatic processing, Industrial fermentation, Solid state fermentation), and more conventional routes (Incineration, Landfill). The complete list of technologies is summarised in Table 2. Their technical description is documented in the BCC project deliverable D4.3, as well as the way they are characterised according to the list of biocircular criteria.

Table 2: List of biocircular technologies included in the BCC guidelines web application

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

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

2.2. Procedure for the BCC Guidelines web application development and test phase.

BCC partner LIST started to develop a Beta version of the tool in November 2022 by structuring the IT background architecture of the web application. Then the content visible on the user interface was implemented progressively, with the list of questions to the user organised on four pages of the web application. In parallel, the background logic allowing to treat the answers provided for the technologies' specificities was also implemented, and a first set of technologies was characterised according to the biocircular criteria.

By the end of February 2023, a first version was presented to the project consortium partners ENEA, Fundació ENT, Civitta and ACR+, who provided a first set of comments and feedback to further improve and develop the application.
Then, a beta version of the BCC guidelines web application was demonstrated during the 3rd round of Living Labs in each pilot area, and participants were invited to give their feedback and suggestions on their expectations for such a tool.

The beta version was generally well received by local stakeholders, who appreciated the purpose of the tool and commented positively on its usefulness compared to other similar tools, if known.

The beta version of the BCC guidelines web application was also presented to the BCC project Advisory Board, as well as to the BCC project peer reviewers, who were invited to test it during the 3rd project Peer Review Session.

All feedback on improving the BCC guidelines provided during the Living Labs by local stakeholders, Advisory Board members and peer reviewers was considered, combined and integrated as far as possible into the final version of the web application.

3. Detailed description of the background logic

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

For each question, the web application user is invited to choose their answer from a set of pre-defined answers, with each answer option representing one of the options considered to characterise each technology in the background. The user cannot give free answers, otherwise the scoring system could not run correctly. 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 web application user described through the application questionnaire.

The basic principles of the scoring system are the following:

- All technologies start with a zero (0) score.
- For each single-choice question, a technology will score +1 in case the user's answer matches the technology characteristics for the considered biocircular criteria 100%, or a score of -1 in case the answer is not aligned with the technology characteristics.
- For each multiple-choice question, a technology will score +1 in case the user provided one single answer and it matches with one of the technology specificities, +2 in case the user provided multiple answers and all match with the technology specificities for the considered biocircular criteria, or it will score -1 in case the user provided multiple answers and one or several, but not all, match the technology specificities,
- In the case one technology is not concerned by the criteria under consideration, it will be scored 0.
- +
- These five specific questions may disqualify a technology:
    - In case the type of waste selected by the user is not compatible with the technology,
    - in case the user is not interested in technologies that are not existing yet at the industrial scale and the technology only exists at the pilot stage,
    - in case the social acceptance level expressed by the user for the targeted end product (product released by the biocircular technology) is acceptable to the user and not compatible with the level of acceptance identified for the technological end product,
    - in case the user expects market price of the end product to be competitive with that of the conventional counterpart, which is not the case for the technology-specific end product.
    - in case the user selected some environmental impacts which would constitute a barrier to their development in their local or regional area and the technology induces these types of impacts.

Technologies are not scored and not ranked according to the comparison of their respective technical, economic, or environmental performances, but they are scored exclusively considering the compatibility of each technology with the specific territorial context and target priorities described by the web application user.

Scores and ranking of technologies are provided after each category of questions has been answered, so it is possible to follow the evolution of the scoring and ranking of the technologies at different stages of the questionnaire.
This is important to consider, since the user could tend to search for a technology that achieve the maximum scores for all criteria (e.g. high economic revenues, high environmental performances, high TRL, etc.), but in reality compromises would certainly be needed. Having the possibility to see how the different answers narrow down the

list of technologies or reorganise their ranking, can be a way to try and find a balance between all the different criteria.

Final results (individual technology score and ranking) are provided after the four categories of questions have been answered. The technology with the highest score is ranked as the most suitable or compatible with the description of the specific context described through the entire set of questions. The technology with the second highest score is ranked as the second potentially most suitable one, etc.

On the final results page, some information on sustainability performance (environmental and socio-economic) are provided for each technology, independently of the ranking, depending on the information available in the literature, and also relying on the results of the LCA and LCC from the BCC project for the technologies assessed.

The list of questions asked through the BCC guidelines and the full background logic implemented for each question to be answered through the application, allowing a matching between the technologies and the specific context in which they could be implemented, is given in Annex I.
The deliverable 4.2 and its Annexes are representative of the BCC guidelines version available on 15/06/2023. The final version might vary slightly from what is described in Annex I.

The details about the BCC guidelines web application technologies, features and code structure and architecture are given in the Annex II of the present report.

Conclusion and further steps

The BCC guidelines were developed in order to valorise the outcomes from the theoretical work and from the regional pilot theoretical and practical developments that were released during the BCC H2020 project. The guidelines were developed as a web application, accessible online (with an internet connection). It consists of an interactive questionnaire 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 BCC guidelines intend to be a screening tool, supporting the identification of potentially suitable technological solutions. It 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.
The BCC guidelines allow to map the specificities of the territory context for implementation, documented with the information provided by the web application user answering questions through the application, with the characteristics of a set of fourteen technologies.

The current version of the BCC guidelines resulting from the BCC project opens doors for further development in the framework of potential follow-up projects. Several suggestions and ideas already raised up from the partners consortium and from the local stakeholders, who all tested the BCC guidelines during its development phase.
First, the set of technologies available in the tool could be enlarged, and the technologies already included could be further specified, including several variants for each technology. Then, a way shall be found to integrate more specific elements of local political context in the ranking process. Also, it would be helpful and relevant to provide more detailed economic and financial information (costs, public incentives and subsides) specific to the different technologies, in the set of information provided in the Results page. Finally, it could significantly add value to integrate or combine such guidelines with other tools providing complementary functionalities, like geographical mapping of stakeholders, sustainability assessment, etc.

ANNEX I: BCC Guidelines web application – Background Logic

Step 1 – Characterisation of the organic waste of concern and of the current existing management system.

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?	- Mixed organic waste from Municipal Solid Waste - Separated organic fraction from Municipal Solid 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 wood stream 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 Technology = sorting at source not mandatory >> +1pt If user choice = No and Technology = sorting at source required >> -1 pt If user choice = No and Technology = 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 Technology = 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 Technology = 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 Technology plastic tolerance = 0% >> -1 If user plastic contaminant ≠ 0% and Technology plastic tolerance ≠ 0% >> +1 If user plastic contaminant = 0% and Technology plastic tolerance = 0% >> +1 If user plastic contaminant = 0% and Technology plastic tolerance ≠ 0% >> +1 If user % is not filled >> +0 If technology plastic tolerance is unknown >> +0 If user metal contaminant ≠ 0% and Technology metal tolerance = 0% >> -1 If user metal contaminant ≠ 0% and Technology metal tolerance ≠ 0% >> +1 If user metal contaminant = 0% and Technology metal tolerance = 0% >> +1 If user plastic contaminant = 0% and Technology plastic tolerance ≠ 0% >> +1 If user % is not filled >> +0 If technology metal tolerance is unknown >> +0 If user Paper contaminant ≠ 0% and Technology Paper contaminant tolerance = 0% >> -1 If user Paper contaminant ≠ 0% and Technology Paper tolerance ≠ 0% >> +1 If user Paper contaminant = 0% and Technology Paper tolerance = 0% >> +1 If user Paper contaminant = 0% and Technology Paper tolerance ≠ 0% >> +1 If user % is not filled >> +0 If technology paper tolerance is unknown >> +0 If user Other impurities ≠ 0% and Technology Hazardous contaminant tolerance = 0% >> -1 If user Other impurities ≠ 0% and Technology Hazardous contaminant tolerance ≠ 0% >> +1 If user Other impurities = 0% and Technology Hazardous contaminant tolerance = 0% >> +1 If user Other impurities = 0% and Technology Hazardous contaminant tolerance ≠ 0% >> +1 If user % is not filled >> +0 If technology Hazardous tolerance is unknown >> +0 If user Other impurities ≠ 0% and Technology Volatile/Non volatile chemical tolerance = 0% >> -1 If user Other impurities ≠ 0% and Technology Volatile/Non volatile chemical tolerance ≠ 0% >> +1 If user Other impurities = 0% and Technology Volatile/Non volatile chemical tolerance = 0% >> +1 If user Other impurities = 0% and Technology Volatile/Non volatile chemical tolerance ≠ 0% >> +1 If user % is not filled >> +0 If technology Volatile/Non volatile chemical tolerance is unknown >> +0
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 biowaste, in tons, is generated in total, annually?	*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

Step 2 - Type of end product targeted

User interface		Background logic
Question for the app user	**Multiple choices available for the user**	
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 Technology = industrial scale >> +1 If user = No and Technology = pilot scale >> Technology out If user = No and Technology = 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 bio-based product - Bio-based products arousing neutral interest (no specific interest or rejection) - Products already available in the market inducing public reluctance (because of direct or indirect nuisances) - Only products which are well accepted / already largely available in 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 Technology = competitive >> +1 If user = Yes and Technology = high competitiveness >>+2 If user = No and Technology = low competitiveness >> +1 If user = No and Technology = competitive >> +1 If user = No and Technology = high competitiveness >>+1

Step 3 - Environmental performances

User interface		Background logic
Question for the app user	**Multiple choices available for the user**	
Which conventional counterpart the obtained output should substitute in priority?	- Heat from natural gas - Electricity - Natural gas from the grid - other Fossil Fuel (diesel/gasoline/oil) - Synthetic fertiliser and/or soil amendments - Synthetic chemical block - Other chemical product - 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?	From - 10% to - 20% From - 20% to - 30% 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 natural ecosystems Waste and/or coproduct	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)

Step 4 - Political and economic incentives

User interface		Background logic
Question for the app user	**Multiple choices available for the user**	
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: - highly specific: need for collaboration with research institute - medium complexity: need for existing competences in the market - low qualification required: operator	if user = Research institutes, on biorefinery processes and Technology = biorefinery >> +2 if user = Research institutes, on biowaste energy conversion and Technology = energy recovery >> +2 if user = Research 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
Is there any opportunity to collaborate locally with	*The user can choose several options:* - Research institutes, on biorefinery processes - Research institutes, on biowaste energy conversion - Research 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, equipment's 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 = eligible to subside >> +2 If user = no and Technology = eligible to subside >> +1 If user = yes and Technology = not or moderately eligible to subside >> +1 If user = no and Technology = not or moderately eligible to subside >> -1
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?	- Can support 100% of costs, no interest for subsides - Can support 100% of costs, but interested by subsides - 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% >50%	If user range = technology range >> +1 If user range > technology range >> -1 If user range < technology range >> +1

ANNEX II: Technical description of the IT technological development

Goal

The BCC Web application consists of asking the user some questions to get information context which will give technologies a score (positive or negative) to find the best one for the associated context. Currently the web application is hosted by LIST and can be accessed at: https://bcc.list.lu .

Architecture

The web application is built with a client-side approach only: all data and algorithms used to calculate the scores run inside the web-browser of the users, including scoring the user answers.

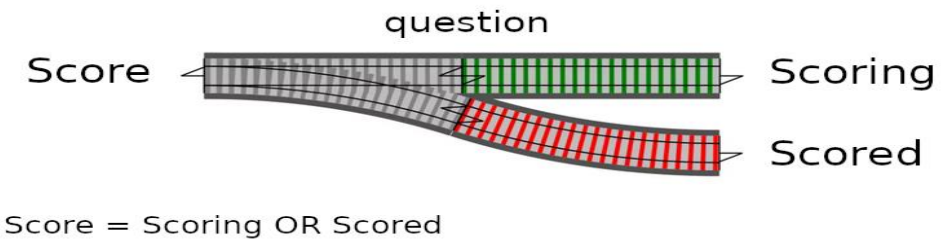
Structure

The full application is split along 6 main sections: 1 for the presentation of the app, 4 dedicated to the categories of criteria for which the user should answer questions and a last one dedicated to presenting the results.

Scoring system algorithm

The core of the application is the scoring system algorithm. It consists of 3 main components, the score types, the logic functions for questions and the technologies to assess.

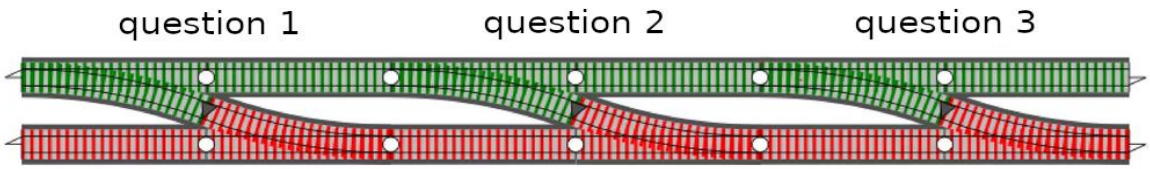
- **Score types** represent a score of a technology. Scoring type can be changed, increased or decreased by a certain amount according to the answers given to the questions logic. The score can also be "frozen": it means that the technology is not fit for the purpose.
- **Logic function for questions**: Each question has its own logic function to edit a given Scoring object and/or to freeze it by returning a Scored object. If an already Scored object is given to the function it is simply returned without applying any changes.



Technologies to assess consist of several fields and start with a Scoring object of value zero.

Technology assessment implementation

Every technology is assessed by evaluating every question. This consists in applying a comparison of the technology characteristics for a given question/answer association.



Web application technologies used

The web application is build on top of the Nuxt framework (https://nuxt.com/). On top of the framework, other web technology components are used within the application. The following table lists the components with their license and use in the web application.

Table 3: BCC web application third party components and their licenses

Name	Version	Usage	Editor Website	License
Pinia	2.0.30	State management store	https://github.com/vuejs/pinia	MIT
@pinia/nuxt	0.4.6	Link between nuxt and pina	https://github.com/vuejs/pinia	MIT
Nuxt	3.1.2	Web framework	https://github.com/nuxt/nuxt	MIT
vite-plugin-vuetify	1.0.2	Link between vuetify component and nuxt.	https://github.com/vuetifyjs/vuetify-loader	MIT
Vuetify	3.1.4	UI components	https://vuetifyjs.com/en/	MIT
@nuxtjs/i18n	8.0.0-beta10	I18n	https://github.com/nuxt-modules/i18n	MIT
@mdi/font	7.1.96	Icons	https://www.npmjs.com/package/@mdi/font	Apache-2.0

Web application features

The web application provides four core features: score the technologies based on 4 different categories of questions, visualize the results of the scoring, export the answers given to the questions, and import the answers given to the questions.

www.biocircularcities.eu