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A circular economy approach for lifecycles of products and services

Report on the development of a standardized n-step maturity level model with needed skills for CE collaboration

Deliverable 4.5

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Summary

Deliverable 4.5 (D4.5) comprises a public report on the development of a standardized n-step maturity level model with needed skills for Circular Economy (CE) collaboration. As component of Stakeholder Interaction, being an essential part of WP4 where fundamental Information and Communication Technology (ICT) solutions of the project are developed, implemented and tested, the work done in T4.7 "Core Brokerage & Matchmaking Systems Development" focuses directly on the development of core ICT solutions. In this way Stakeholder Interaction goes hand in hand with the support of interoperability in traceability, Life Cycle Assessment (LCA) analysis services and the support of the Circular Economy Business Models (CEBM) implemented in the project. When it comes to CE, processes aiming at an efficient use of misplaced resources (waste) should be sustained by a dedicated Brokerage System (BS). At the same time, the European Commission (EC) calls for the adoption as a key message in its Environmental Action Plan (CEAP) in the context of the European Green Deal:

"LESS WASTE, MORE VALUE".

In CIRC4Life therefore, the BS on the one hand should be set in place to allow producers to allocate secondary resources that otherwise would be a candidate for waste dumps. On the other hand, for a wide usage of brokerage processes, in T4.7 core logics and rules for handling data are studied and unified in a first approach into a BS.

The three CEBMs developed in CIRC4Life being in perfect accordance with the three main pillars of the CEAP by the EC: a) Designing sustainable products, b) Empowering consumers and public buyers as well as c) Circularity in production processes, the BS represents a digitized solution to more circular production procedures. Skills and resources needed for these innovative entrepreneurial activities are finally identified and made assessable and manageable in the proposed BS of CIRC4Life. The creation of a standardized n-step maturity model for needed skills in CE collaboration on different levels thus stands in the centre of the report and the work done. A self-assessment to classify the CE maturity of companies and the following matchmaking between n-tier suppliers to decide based on their sustainability performance and preferences are unified on a trusted partner platform. For the CE collaboration of companies, as one form of stakeholder interaction in CIRC4Life, the BS provides transparency between potential partners about their status and several activities, e.g. regarding ecological, social and economic topics. Following the principles of sustainability: economic, social and environmental – recently extended by the perspective on CE, the CE matchmaking methodology was a logical step towards a complete solution using a multiple-approach and relevance scoring. These three essential core components now build the framework of the D4.5 Report:

- **Standardized n-step maturity level model** – leading to the company specific Sustainability Score based on a self-assessment.
- **Brokerage System** – serving as a CE platform where companies may exchange commodities with trusted partners.
- **CE Matchmaking** – using the CE Relevance Score and a multi-level approach for companies to find a perfect match in terms of CE principles.

Support to the concept coming from D7.3, "Report on the stakeholder involvement along the supply chain" by ALIA, and D7.4, "Experience and recommendations of end user engagement across circular business model development" by LAU, was welcome. D7.3 shows a methodology based on indicators for partner selection. The common usage of data on the waste patterns represents a good example for synergies between BS and demonstrators in the different domains of the DEMOs in CIRC4Life. D7.4, where CE collaboration based on the ecosystemic approach is described, clearly points out the need for an implementation of the BS to foster the building of CE collaborations and of new CEBMs based on the value chain actors' sustainability performance.

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Acronyms and Abbreviations

Abbreviation	Description
BS	Brokerage System
B2B	Business to Business
CE	Circular Economy
CEAP	Circular Economy Action Plan – The European Green Deal
CEBM	Circular Economy Business Model
CELLL	Circular Economy Laurea Living Labs tool
CTI	Circular Transition Indicators
DX.Y	Deliverable X.Y
EC	European Commission
ETW	EcoTransIT World
EU	European Union
GDSN	Global Data Synchronization Network
GHG	Greenhouse Gas Emissions
GLEC	Global Logistics Emissions Council
GLN	Global Location Number
GPC	Global Product Code
GTIN	Global Trade Item Number
GUI	Graphical User Interface
ICT	Information and Communication Technology
IS	Industrial symbiosis

LCA	Life-Cycle-Assessment
LGTIN	Lot GTIN
MVP	Minimal Viable Product
M2M	Machine to machine
NTM	Network for Transport Measurements
SDG	Sustainable Development Goal
SGTIN	Serialized GTIN
SSCC	Serial Shipping Container Code
T X.Y	Task X.Y
UNSPSC	United Nations Standard Products and Services Code
x_{arithm}	Arithmetic mean

1. Goal and Motivation

Scarcity of resources is one of the most demanding challenges today. The reuse and recycling of materials is therefore an important issue in developing CE approaches. In the future, companies will need innovative solutions that enable them to utilize resources more efficiently. There is a huge potential to reduce the consumption of primary resources by returning by-products of manufacturing processes or materials declared as waste back to process in a closed loop and by trading them efficiently.

The European Green Deal announced in December 2019, is clear on what Europe must do to create a sustainable economy. Here, industrial symbiosis (IS) has been identified as a very promising approach to help the EU reach its carbon-neutral ambitions. IS is defined as "the use by one company or sector of underutilized resources broadly defined (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials) from another, with the result of keeping resources in productive use for longer." (European Committee for Standardisation, 2018). Currently only 12% of secondary materials and resources being brought back into the economy, there is clear room for improvement (European Commission, 2020a). Innovations in green technology, combined with EU initiatives aimed at Digitizing European Industry, including making better use of big data and artificial intelligence (Industry 4.0), and evidence of more corporate social responsibility are all positive signs that IS can build a stronger following.

That is why value chains need to be rethought in a different way. It is crucial that the right partners find each other to engage new circular processes. For this purpose, CE collaborations must be strengthened. This is exactly what this report is about. Within the framework of Task 4.7, a concept was developed which aims to provide the technical basis for mobilizing and linking interested partners in a BS. This platform economy idea goes in line with the interconnected ecosystem approach described in D7.4. However, the actual clue is the logic of how companies are selected in a matchmaking process. Only when the best-fit partners are brought together, circular approaches can succeed beyond the boundaries of the company.

Due to its complexity and multidimensional structure, the overall concept in D4.5 was processed in different iterative steps. Within a standardized n-step maturity model, a KPI called Sustainability Score was developed that helps companies to evaluate their own sustainability performance in a self-assessment. The self-assessment is based on the three pillars of sustainability (ecology, society, economy) and a new, fourth pillar „Circular Economy". Furthermore, there was a need to apply these ideas coming from the maturity model in the context of matchmaking processes. Here, a methodology has been designed to achieve the needed skills for CE collaboration between different stakeholders. This creates the innovative room for further novel CEBM.

2. CE Collaboration in the CIRC4Life Context

2.1. Methodology and Limitations

In order to achieve the goal of a successful CE collaboration, the following approach has been selected for the development of a holistic concept. In a first step, a KPI scheme was developed, which is determined based on a self-assessment. The resulting Sustainability Score represents the outcome of the standardized n-step maturity model. In the second step, basic functionalities of a Trusted Partner Platform, the so-called BS, were developed in order to enable the technical connection between partners with different needs and purposes. This was the basis to strengthen CE collaboration independently of the industry and supply chain stage. In the last step, the methodology was developed which supports the idea to match the best-fit partners.

This CE matchmaking approach described in chapter 5 is an extension of the work described in the chapter 3 on "Self-assessment and Sustainability Score" and the D7.3, "Report on the stakeholder involvement along the supply chain". In the D7.3 a methodology based on indicators for partner selection is presented. The explained method in chapter 5, a more generic approach for matchmaking is presented. As described in the "Report on the stakeholder involvement along the supply chain" there is a need for collaboration between Task 4.7 and 7.4. This is further articulated by using the data on the waste patterns as guidelines and examples for the development of a BS. In addition, CE collaboration is based on the ecosystemic approach described in D7.4, which supports the need for development and implementation of the BS and the idea of building collaborations and new CEBMs based on the value chain actors' sustainability performance.

It should be noted that this report is prepared in the framework of WP4: ICT platform is merely an initial theoretical concept which was developed in T4.7. This work is a good starting point for further developments, which can be incorporated into the concept iteratively. Testing the system with all relevant stakeholders, such as producers or other user groups, is not part of this work. However, it is recommended to involve these groups in a future proof and implementation process, to develop a system that meets all relevant needs and criteria. More information about the potential future development can be found in chapter 6.

2.2. Embedding T4.7 in the ICT architecture

In D4.1 ICT platform specifications were described as the core of the CIRC4Life system (D4.1, chapter 5.1: ICT overview, page 45).

To assure that the ICT platform is compliant with the changing end user requirements, an easily adjustable solution was needed. An ecosystem of subsystems with different layers served by a central platform with a Service Oriented Architecture (SoA) was therefore designed and developed. This method provides the necessary flexibility for iterative design and development (Figure 1) of dynamically alternating business models.

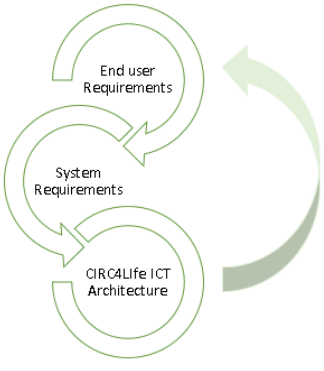


Figure 1 Iterative ICT design

The ICT platform consists of the core platform of the system, data providers to the system including Escrow Database of Products and any other legacy data that could be potentially needed, three independent modules (each for every CEMB): 1. Recycle/Reuse Module (including the intelligent bins), 2. Traceability Module and 3. LCA Module and four different end users' environments.

Among the end user environment, four different interfaces enable the application of provided services in CIRC4Life to the system users:

1. End Users' Toolbox (Consumer Eco Account, Eco Shopping Module)
2. Retailer Tool for Eco Accounting
3. Impact Assessment Tool
4. Stakeholders' Interaction Toolbox (BS, business-to-business (B2B) system for Stakeholder Interaction)

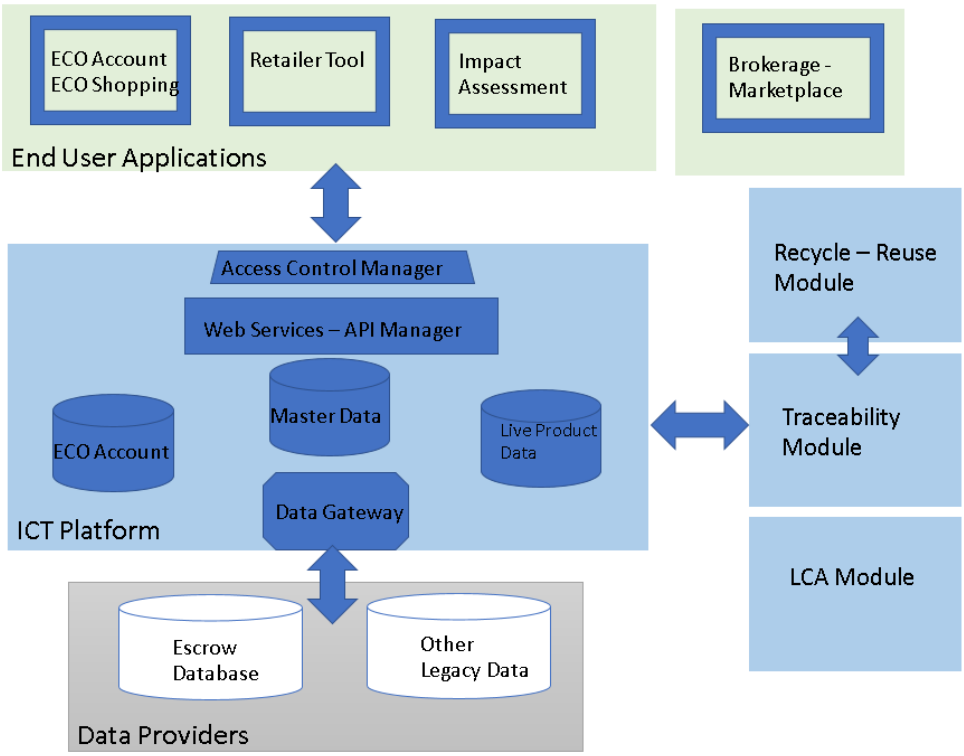


Figure 2 Overall ICT platform architecture

The BS itself is part of (4.) Stakeholders' Interaction Toolbox, where B2B transactions shall be enabled or supported by intelligent mechanisms and methodologies like the sourcing of secondary products or raw materials in a digitized way. Provision and procurement of resources have a large impact on the material efficiency of a producer. From this perspective, every producing company can be a potential provider and receiver of secondary goods. In accordance to the three CEBMs the integration of already used goods plays an important role in the creation of sustainable products. For CIRC4Life thus a BS was crucial to be offered to help innovative suppliers to get access to physical side-streams from others – and vice versa.

The question is how to bring trading partners of secondary products together? How to identify the needs of supply chain actors, especially when not linked to the same value-chain? In that context the cross-industry market transparency for buyers and sellers gets more and more important. That was the reason why CIRC4Life decided to create - in addition to its main platform components - also a digital trading platform for secondary goods and resources that connects, informs, integrates, protects and mobilizes interested companies. As

visualized in Figure 3 the trusted partner platform connects supply with demand between the providing and the receiving parties. The BS enables therefore the exchange of data, products and knowledge both on the operational and the strategic level. More information about the core functionalities of the BS can be found in chapter 4.

Figure 3 The concept of the CIRC4Life Brokerage System

What is the mechanism by which partners come together and what criteria play an important role? The trading mechanisms could be of course focused on commercial details like price, quality, distance or amount. But when it comes to a matchmaking in the context of CE further criteria should be considered which are e.g. directly linked to sustainable engagement at the company level. For the CIRC4Life CE matchmaking the developers envisage not only evaluation criteria like price and quality into short-term considerations, but long-term and hence strategical considerations.

For that reason, an additional KPI, called Sustainability Score, has been designed in T4.7. In order to calculate a substantial Sustainability Score, a standardized n-step maturity level model was developed. The concept behind is described in detail in chapter 3. This is the basis of the approach in chapter 5, which presents a further developed and specified platform like a BS. It enhances the matchmaking procedure and takes into account aspects like circularity performance, materials flow with special enhancement on the loop tightness and Green House Gas emissions from transport of the good from the producer to the receiver. The approach has the additional advantage of a relevance score between two companies, in contrast to single score assessment. The single score might be perceived by companies as an evaluation, while relativity score provides rather the information on how relevant two partners are in terms of their circular cooperation.

2.3. New Circular Economy Action Plan and the Brokerage System

On March 11, 2020, the EC announced in Brussels via press release that a new CEAP within the European Green Deal is adopted (European Commission, 2020). It represents one of the main building blocks of the European Green Deal, Europe's new agenda for sustainable growth and strives to reduce its consumption footprint and doubles its circular material use rate in the coming decade. The CEAP aims at changing the way we produce and consume. Sustainable products need to become the norm to reduce resource-use and waste-generation.

The focus of the CEAP has been put on the sectors that use most resources and where the potential for circularity is higher. According to EU estimations, those sectors are: electronics and ICT; batteries and vehicles; packaging; plastics; textiles; construction and building; food; water and nutrients. Of course, one of the main goals is always to ensure that less waste is generated.

In this context the CIRC4Life BS together with a standardized n-step maturity level model with needed skills for CE collaboration could be considered as one significant step forward. The EC expects to have "[...] innovative models based on a closer relationship with customers, mass customization, the sharing and collaborative economy, and powered by digital technologies, such as the internet of things, big data, blockchain and artificial intelligence […]" "[...] not only [to] accelerate circularity but also the dematerialization of our economy and make Europe less dependent on primary materials". Thus, the development of a matchmaking concept bringing together supply and demand of physical goods as well as bridging the gap between business partners within new CE business models is pioneering the path for a large number of enterprises. The BS in CIRC4Life shows many of the characteristics required to work as product-as-service models and serves as digital solution - in this case here, to enable collaboration along value-chains on different levels.

As the CEAP by the EC focuses on the following three main pillars: a) Designing sustainable products, b) Empowering consumers and public buyers and c) Circularity in production processes, the project CIRC4Life delivers with its CEBM proposed solutions based on digitized procedures. The skills and resources needed for these innovative entrepreneurial activities are finally made manageable in the BS of CIRC4Life. The key message in the EC's CEAP "LESS WASTE, MORE VALUE" emphasizes the role of secondary materials in the innovative production technologies. The support of waste prevention and circularity - and at the same time increasing recycled content, promoting safer and cleaner waste streams and ensuring high-quality recycling – can be easily encouraged by an open, domain cross-cutting and objective BS of CIRC4Life. In that way CIRC4Life's BS also enhances "[...] the role of standardization based on the on-going assessment of existing standardization work at national, European and international levels" with the goal of creating a well-functioning EU market for secondary raw materials. Another core factor by the CEAP in favor of the digital BS with its digital matchmaking and integrated CE-scoring for goods and companies is the EC's striving for an European data space for smart circular applications with an "[...] architecture and governance system to drive applications and services such as product passports, resource mapping and consumer information."

2.4. The Role of GS1 Standards

The CE approach implies the rethinking of production, distribution and consumption business models. An ecosystem is needed, which ensures interactions and interdependencies based on structured product data. Well-structured data represents an infinite source of knowledge and its indicators can help policy makers and economic actors to make the right decisions as well as to identify effective levers of sustainable change.

To achieve the CE goals, data should be efficiently exchanged at a very large scale. If economic players will continue to work in silos, structuring data within a limited environment and guarding data jealously, the real change is not going to happen. Under a circular perspective, the real value of data can not only be linked to the technology that will use the data in a proprietary environment. The real value of data is in the way it is structured and on the open standards it is based on. A sustainable CE change at a large scale is not going to happen unless data is structured based on global open standards for product identification, data capture and share which enable interoperability.

In a digitized supply chain using e.g. CE brokerage processes, GS1 Standards, more specific the GS1 ID keys and traceability standards, enable companies to access information about items in their supply chains, and share this information with trading partners. ID keys enable organizations to assign standard identifiers to products, documents, physical locations and more. As GS1 ID keys are globally unique, they can be shared between organizations, increasing supply chain visibility for trading partners. For the CIRC4Life project the most important GS1 ID keys and standards are:

GLN: The Global Location Number (GLN) can be used by companies to identify their locations, giving them complete flexibility to identify any type or level of location required.

Figure 4 GLN Structure

GTIN: The Global Trade Item Number (GTIN) can be used by a company to uniquely identify all its trade items. GS1 defines trade items as products or services that are priced, ordered or invoiced at any point in the supply chain. There are four GTIN formats. For applications that require a uniform 14-digit format, leading zeroes need to be added:

1. 000000nnnnnnnn (GTIN-8)
2. 00nnnnnnnnnnn (GTIN-12)
3. 0nnnnnnnnnnnn (GTIN-13)

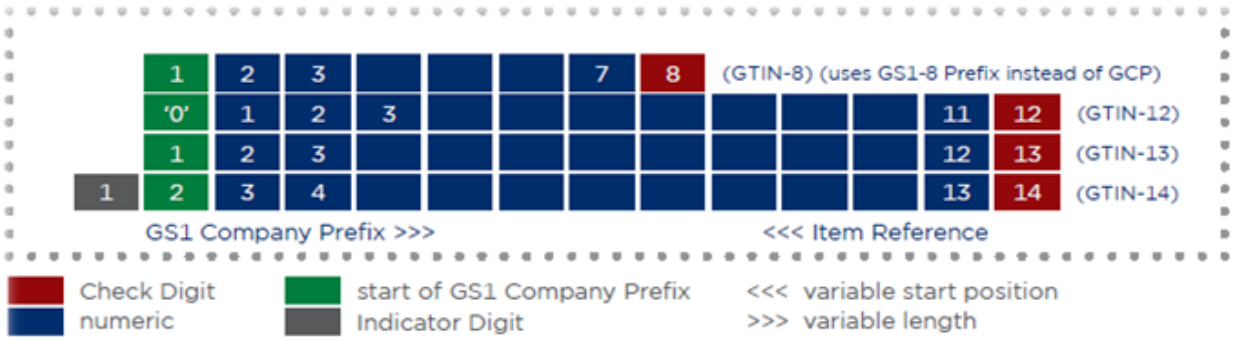


Figure 5 GTIN Structure

SGTIN: The Serialized GTIN (SGTIN) is a common term for the combination of GTIN and serial number. SGTIN is an identifier which makes it possible to uniquely identify each product or service.

SSCC: The Serial Shipping Container Code (SSCC) can be used by companies to identify a logistic unit which can be any combination of trade items packaged together for storage and/or transport purposes; for example a case, pallet or parcel.

Figure 6 SSCC Structure

For the CIRC4Life project, the most important GS1 communication standard is EPCIS.

EPCIS: Electronic Product Code Information Services (EPCIS) is a standard for the capture and exchange of visibility data of serialized (or lot-specific) objects identified with an Electronic Product Code (EPC). Examples for objects relevant within a supply chain encompass products, shipments, documents, locations, returnable transport items as well as assets. EPCIS is a data carrier agnostic solution. Each time an EPC is read within a supply chain, an event is generated containing visibility data encompassing four dimensions: what (uniquely identified objects), where (location and read point), when (time of event) and why (status and business process). The events are stored in decentralized or centralized databases (EPCIS repositories). An EPCIS repository has a capture interface for storing as well as a query interface for retrieving event data.

A central component of the CIRC4Life project is the extension of the existing EPCIS standard by specific sustainability values, the so-called ECO Extension (see D5.1, chapter 7.1) (Figure 6). This could be a decisive lever in the future when it comes to evaluate sustainability of products along the supply chain to make this data transparent to the consumer or other partners in the value chain network.

Business context / data content		EPCIS elements	Dimension
On calendar week 31/2018	→	eventTime	WHEN
at farmer Robert's barn	→	bizLocation	WHERE
at pen XYZ	→	readPoint	
the pigs A,B and C	→	EPCList	WHAT
have been fattened	→	bizStep	WHY
and consumed 213 kg of feed 123/ batch 456	→	eco:input	ECO
and consumed 391 litres of water	→	eco:input	
and produced 68 kg of CO2	→	eco:output	
and produced 57 kg of manure	→	eco:output	

Figure 7 EPCIS ECO extension described in D 5.1

The fundamental concept behind CE is to enable product data to be shared among all entities involved or simply interested in the same data for many different purposes and perspectives. This concept implies a big change because for many players, the main principle is still to "keep your data" on the grounds that "data is the new oil". But this is not enough when it comes to CE activities in the value chain network. It is data quality, data sharing and the illimited use made by so many diverse actors that create real value.

3. Self-assessment and Sustainability Score

In purpose of Task 4.7, a standardized methodology is defined to derive the maturity level in terms of sustainability at a company level. In order to determine the maturity level, a methodology based on a self-assessment has been created. Filling in the self-assessment, will lead to a company's specific Sustainability Score, which shows the maturity level in terms of their sustainability performance and therefore classifies the considered companies. The Sustainability Score resulting from the self-assessment tool builds the basis for the multilevel approach with regard to the CE Relevance Score described in chapter 5.

3.1. State of the Art – Desktop Research on Self-Assessment Tools

Currently, indicators of CE are still at an initial stage of development. It is barely possible to capture the whole CE performance of a product. However, there are already some approaches that have different focuses in the evaluation of the CE performance of a product or organization. The following paragraphs give an overview of selected self-assessment tools that already exist.

In "Resource Duration as a managerial indicator for Circular Economy performance" Franklin-Johnson and colleagues (2016) deploy an indicator called "Resource Duration" for environmental evaluation performance linked to CE. Their indicator measures the material retention based on the time a resource is used regarding the following aspects: initial lifetime, refurbishing, and durability gained through recycling (Franklin-Johnson et al., 2016). Amaya (2012) offers a framework for designers, willing to quantify environmental benefits provided by closed-loop strategies for manufactured goods. Thereby he considers remanufacturing as well as product-service-system solutions. The model makes it possible to evaluate the processes from an ecological point of view using non-classical disposal scenarios. From this perspective, remanufacturing could be an end-of-life scenario (for example).

Due to the lack of circularity indicators, the Ellen MacArthur Foundation launched the "Circularity Indicators Project" in 2015. These indicators support the decision making for industrial practitioners, internal communication or evaluation of a company and can be used to compare different products or simplify the definition of product circularity targets (Saidani et. al., 2017). In addition, the Ellen MacArthur Foundation launched the Circulytics tool in January 2020. The tool enables companies to evaluate and measure their circularity and gives guidance on further embedding CE strategies (Ellen MacArthur Foundation, 2020). Another existing tool to measure circularity is the Material Circularity Indicator (MCI) (Ellen MacArthur Foundation, 2020), which operates on product and business model performance level.

Moreover, already existing self-assessment questionnaires laid the basis for the self-assessment tool. The following documents are particularly indicative: EcoVadis CSR Rating Methodology: Scoring Principles (EcoVadis, 2016), drive sustainability (CSR Europe, 2018), Circular Transition Indicators (CTI) (World Business Council for Sustainable Development, 2020) and the supplier self-assessment questionnaire from Ceres (Augustine et al., 2020).

3.2. Overall concept description

The above described desktop research provided helpful insights and interesting impulses to create the initial approach for the CIRC4Life n-step maturity model. The following abstracts outline the considerations taken by drafting the self-assessment concept.

3.2.1. Dimensions of the Maturity Model

The idea of a standardized n-step maturity model should primarily help companies to classify their sustainability performance and its related activities for their corporate strategy. For this reason, the fundamental dimensions of sustainability need to be considered within the CIRC4Life self-assessment tool: Accordingly, social, ecological and economical sustainability should also be taken into account. To have a common understanding within this document, the dimensions considered in the n-step maturity model are defined as following (derived from the United Nations (UN)):

- **Social**

  According to the UN, the pillar Social Sustainability is about "[…] identifying and managing business impacts, both positive and negative, on people. The quality of a company's relationships and engagement with its stakeholders is critical. Directly or indirectly, companies affect what happens to employees, workers in the value chain, customers and local communities, and it is important to manage impacts proactively."
  The social dimension plays an important role within the UN Global Compact's principles, as the first six relate to social topics. Among others, human rights are of high importance (UN, 2020a).

- **Environmental**

  The world is challenging climate change, water, energy, biodiversity and agriculture. Therefore, companies whose business models are obviously linked and are dependent on the use of natural resources, either directly or indirectly via their supply chains, need to address their environmental responsibilities vehemently, as stakeholders put on a lot of pressure.
  "Companies have to move beyond traditional approaches based largely on compliance and narrow risk assessments. Business needs to actively address environmental risks and opportunities and have major efforts underway with business in the areas of climate, water and food." (UN, 2020b).

- **Economical**

  Some companies, investors and leaders have recognized for themselves that it is not enough to focus only on "[…] short-term profits because natural disasters, social unrest or economic disparity can damage long-term prosperity." (UN, 2020c).
  It is understood that sustainability is not only demanded by stakeholders, but also indispensable for the long-term survival of the company as it offers new opportunities for business models, etc.
  "New markets are emerging rapidly due to megatrends such as population growth, resource scarcity or global health risks." (UN, 2020c).

Bearing in mind, that the main focus of the CIRC4Life project is set on CE, a reasonable extension of the three pre-defined dimensions was included within the concept of the n-step maturity model with the fourth dimension: Circular Economy/Circularity. Based on the fundamental ideas of the Ellen MacArthur Foundation (2017), which focuses "[…] on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems […]" with a high level of acceptance by many industrial companies, this dimension is therefore defined as follows and serves as a framework for the underlying criteria (see chapter 5.2.2):

- **Circular Economy/Circularity**

  The linear economy as it is existing today, needs to be aligned to the challenges of limited natural resources, which the society is facing. An integral shift towards a CE and thus a rethinking of essential processes like the efficient management of resources, intelligent production concepts such as Eco-Design and the sustainable use of products must be enforced. "Shifting the system involves everyone and everything: businesses, governments, and individuals, cities, products, and jobs. By designing out waste and pollution, keeping products and materials in use, and regenerating natural systems it is possible to reinvent everything." (Ellen MacArthur Foundation, 2017)

The combination of the three dimensions of sustainability extended by the aspect of CE aims at creating an innovative and valuable approach that gives companies a holistic view of their sustainability performance, drives business awareness and action in achieving the Sustainable Development Goals (SDGs), formed by the UN (UN, 2020d), by 2030. Business institutions prepare themselves around the world for a more sustainable future, but to succeed, the global goals must turn into local business actions.

3.2.2. Criteria per Dimension and Design of Questionnaire

After defining the main pillars for the self-assessment, the corresponding subcategories/criteria were to be specified. Therefore, a desktop research on relevant reporting systems and reference documents has been conducted. Amongst others, the SDGs (UN, 2020d), the Global Reporting Initiative (GRI, 2020), but also criteria embedded in the EcoVadis platform (EcoVadis, 2016) and Circularity Check Landing Page (Ecopreneur, 2019) have been screened to identify main topics from which a relevant set of criteria for the self-assessment has been derived. The criteria of the CE Dimension contribute in particular to the activities of a company that promotes resource-efficient activities, especially when it comes to the design of a product. Figure 8 outlines the defined dimensions as well as the corresponding criteria, on which the questionnaire is based.

It should be noted that the dimensions as well as the respective criteria are interrelated and complement each other. But the decisive difference between the classical dimensions and the new dimension CE, is the circular approach. It is possible to take measures e.g. to improve criteria in the environmental dimension (reduce GHG emissions) without leaving the linear approach. It is an important and correct step, but it does not yet lead to a circular process with closed loops. Therefore, criteria as described in the CE Dimension like obsolescence or maintainability should be considered to evaluate the overall sustainability performance including CE.

Dimension	Criteria	Self-Assessment	Standards and/or Audit Schemes & Certificates for reference (exemplary)
environmental	Water Usage	Does your organization set targets to reduce water consumption?	
	Biodiversity	Are strategies for preserving biodiversity anchored in business operations - is your organization certified according to relevant standards aimed at protecting biodiversity?	
	Waste Management	Does your organization have a recycling program to reduce or eliminate pollution and waste in its operations?	
	Energy	Does your organization considers renewable energy sources to be used? Are there specific targets to increase the share of renewable energy sources or for increasing energy efficiency?	EMAS
	Packaging	Does your organization have goals and targets to reduce, reuse, and recycle the amount of secondary packaging used for its products?	
	Materials and Ressources	Does your organization have a program and/or procedures to reduce the use of resources (other than water), and promote sustainable natural resource practices?	
	Emissions	Does your organization have set targets in relation to reduce air emissions?	Science Based Targets, EMAS, GHG Protocol, ISO 14064
	Distribution and Logistics	Does your organization calculate the Carbon Footprint of logistical processes or ask for reduction measures?	DIN EN 16258, GHG Protocol
economical	Collaborative Projects for Sustain	To what extent do you engage in collaborative projects to broaden your sustainability engagement? Please name examples	
	Corporate Sustainable Strategy	To what extent does your company pursue a Corporate Sustainability Strategy?	
	Supplier Management	Do you ask your suppliers who wish to work with you to sign a Code of Conduct or other relevant documents that will ensure compliance with key guidelines for environmental and social behavior?	
social	Child and Forced Labor	To what extent are auditing processes of relevant certifications/ standards in place? Being updated on a regular basis?	ILO, SA8000, Fairtrade
	Non-Discrimination	To what extent are auditing processes of relevant certifications/ standards in place? Being updated on a regular basis?	ILO, SA8000, Fairtrade
	Working Conditions	To what extent are auditing processes of relevant certifications/ standards in place? Being updated on a regular basis?	ILO, SA8000, Fairtrade
	Employee Health and Safety	To what extent are auditing processes of relevant certifications/ standards in place? Being updated on a regular basis?	ILO, SA8000, Fairtrade, OHSAS18000
	Career Management and Training	To what extent have training programmes been established to individually support employees?	
	Social Engagement	Is your organization socially active? Please name those activities.	
Circular Economy	ECO-Design - Reusability	To what extent has your organization redesigned their products or services for optimal use and reuse?	
	ECO Design - Recyclability	To what extent has your organization redesigned their products or services for optimal use and recyling?	Minimum standard for the assessment of the recyclability of packaging according to § 21 Para. 3 VerpackG
	ECO-Design - Obsolescence	To what extent has your organization redesigned their products or services for prolonged product life time and/or improved functionality?	
	ECO-Design - Maintainability	To what extent does your organization ensure, that products are conceptualized in a modular way in order to facilitate maintenance and/or repair of the product over the total lifetime?	
	ECO-Design - Used Materials	To what extent does your organization obtain the input for the product is coming from recycled materials, reused components, waste/by-products from other products or production processes, and/or suppliers with a sustainability certificate?	
	Collection and Return Scheme	Does your organization support the efficient recycling capabilities of materials after first produce use or has a system for take back management or collection for recycling?	

Figure 8 Questions per criteria

The questions of the self-assessment are formulated in such a way that a company can provide a qualitative assessment of the respective maturity level per criteria (Bertels, 2014). Companies must rate their own sustainability performance according to the following four maturity levels:

- Our organization is not involved in this practice
- Our organization engages in this practice at an ad-hoc level
- Our organization is beginning to engage in this practice in a more systematic way
- This practice is well embedded in our organization

However, the overall maturity level is being derived from the Sustainability Score, which is explained in chapter 3.3.

Figure 9 shows a different way of presenting the defined dimensions and criteria. This visualization should simplify the interpretation of the results and allow conclusions to be drawn towards the maturity level of the individual company.

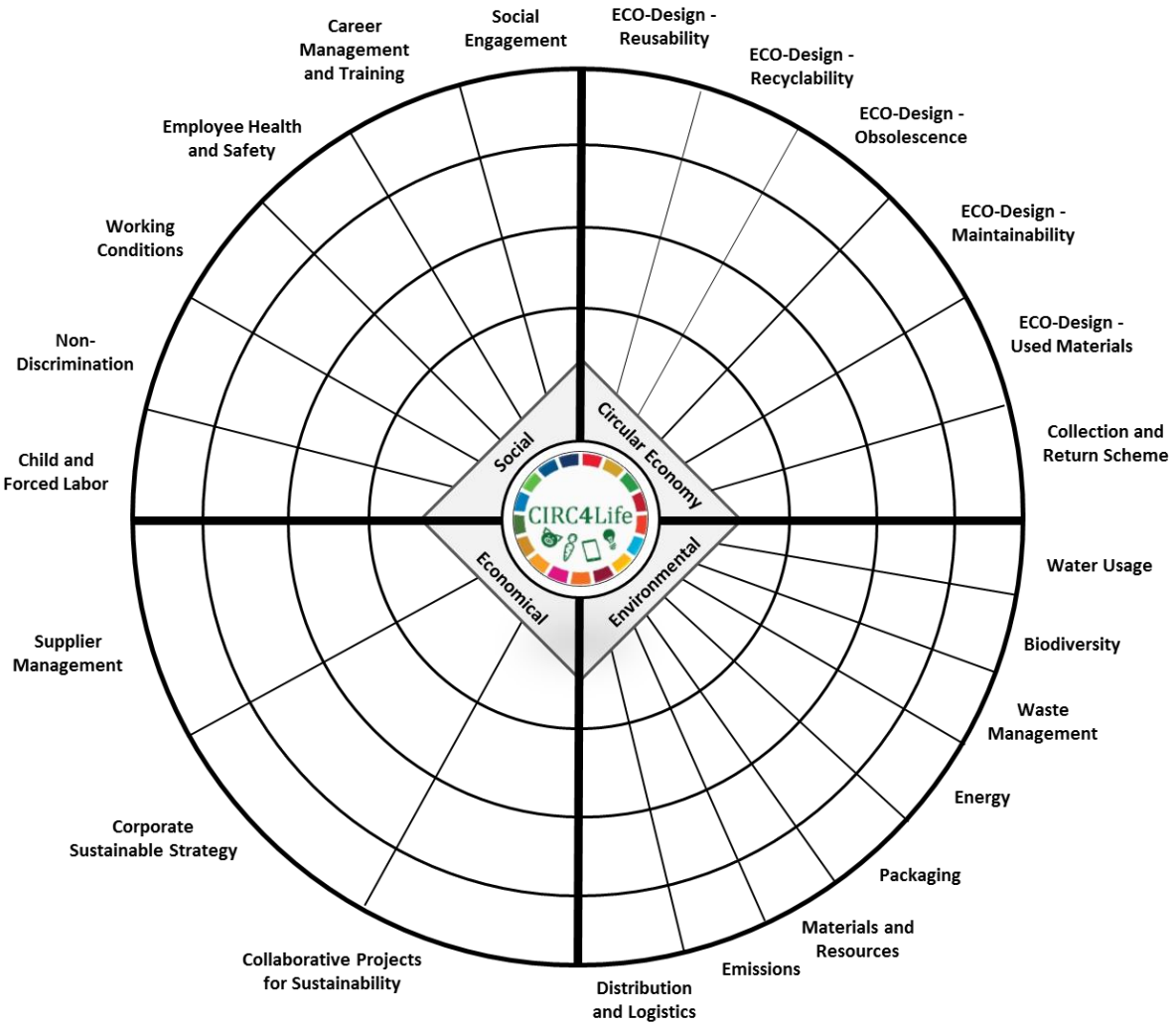


Figure 9 Circular Maturity Model

3.3. Weighting and Calculation of Sustainability Score

As presented in Figure 9, the economical pillar covers four criteria, the CE dimension five, the social pillar six and the environmental dimension seven criteria. In order to make the qualitative ratings on the respective degree of maturity level per criteria measurable, the four maturity levels are scored as follows:

- **1 Point =** Our organization is not involved in this practice
- **2 Points =** Our organization engages in this practice at an ad-hoc level
- **3 Points =** Our organization is beginning to engage in this practice in a more systematic way
- **4 Points =** This practice is well embedded in our organization

Per criteria, a maximum of four points can be achieved.

Within the conception, also the weighting of the four dimensions has been under discussion. In the first step, it was agreed to create the concept as understandable and comprehensible as possible. For this reason, it was decided to apply the same weighting for the named dimensions. However, future developments might consider a more differentiated approach. This results in the following assumptions for the scoring calculation, which is presented in a simple example (Figure 10).

Score of Dimension a = x_{arithm} of dimension a (criterion x + criterion y + criterion z = score/number of criterion)
Overall Score = $\sum x_{arithm}$ dimension a + x_{arithm} dimension b + x_{arithm} dimension c + x_{arithm} dimension d
Maximum Score = 16

Example calculation:

Dimension a	maturity level	Dimension b	maturity level	Dimension c	maturity level	Dimension d	maturity level
criterion x	2	criterion xx	2	criterion yz	3	criterion zz	3
criterion y	3	criterion xy	3	criterion zy	1	criterion za	4
criterion z	4	criterion yx	3			criterion az	2
		criterion yy	4				
$\bar{x}_{arithm}$	**3**	$\bar{x}_{arithm}$	**3**	$\bar{x}_{arithm}$	**2**	$\bar{x}_{arithm}$	**3**

Overall Score 3+3+2+3 = 11 out of 16 maximum points

Figure 10 Example calculation of Sustainability Score

The interpretation of the overall Sustainability Score – in this case a score of 11 points – is explained by a so-called result template, which gets individually adapted to a certain company, depending on the Sustainability Score and feedback given to each criterion. Attached to each dimension, specific actions for recommendations are mentioned to give companies guidance on how to improve their sustainability performance. Further details are being described in chapter 3.3.2.

Figure 11 visualizes the calculation example presented above in Figure 10. It becomes immediately apparent on which criteria a company has already been working on more intensively and which areas need to be addressed in greater depth in the future. For example, criterion “z” and “za” are very well embedded in the company’s business, strategy and/or processes. Whereas criterion “zy” gives lots of room for further developments.

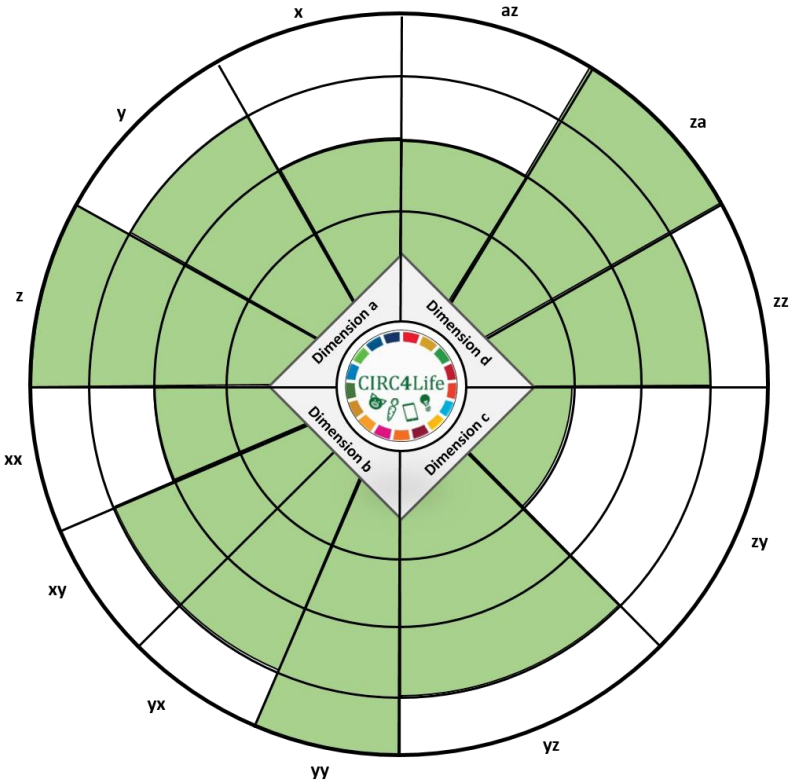


Figure 11 Visualized Calculation Example

3.3.1. Value Proposition – Why making Use of a Self-assessment Tool?

The self-assessment tool with corresponding Sustainability Score enables a standardized approach (the basis is a uniform questionnaire, as described in the previous chapters) to make the sustainability performance of a company comparable and assessable. This lays the basis for an industry benchmark and thus gives the user the chance to stand out with a positively evaluated score and therefore as an interesting contractual partner in direct comparison to competitors on the platform. The score can therefore be used for positioning and acts as a kind of company ID in the field of sustainability.

3.3.2. Result Template

Companies which fill in the self-assessment questionnaire do not only receive an overall Sustainability Score but obtain together with the filled in Circular Maturity Model (see Figure 9) a so-called result template.
The result template should entail the following main content:

- It puts the company's Sustainability Score in an overall context - explanations are given that help to interpret the maturity level of the specific company profile.
- The template provides an overview of an industry benchmark – these insights enable companies to understand what potential can be raised in the future regarding their sustainability activities in each of the four dimensions and specific criteria.
- Recommendations for action tailored to the individual company should be given. On the one hand relating to the overall score, but also broken down to the individual dimensions. This requires the ability to provide automated recommendations for action for each criterion and each associated maturity level.

In order to offer companies a certain degree of guidance or to create incentives for continuous development and improvement, there are numerous tools that support, for example, the strategic design in the CE context. Those tools could be deposited within the result template process to provide direct assistance based on the recommendations for action. To give an example of such a tool, the CE strategy mapping developed within the CIRCIT project is worth mentioning (CIRCit Nord, 2020).

4. Brokerage System

For CE collaboration it is crucial that the right partners find each other to engage new, circular processes. In the following chapter 4 a concept is developed which aims to provide the technical basis and its core functionalities for mobilizing and linking interested partners in a BS.

4.1. As-Is-Situation

Production within a company is the transformation of production factors into products (goods and services). Several other processes and effects of the external and internal environment influence this process. While the production process is the company's main activity, waste or by-products are also generated, which do not provide a direct added value and increase the company's costs (Ciulli et al., 2019). Looking at the food supply chain, for example, it becomes clear which volume of waste or by-products occurs at various levels of the supply chain. Food waste is not only an ethical and economical problem, but also burdens the environment with its limited natural resources, which are created by disposal and landfilling as well as the associated overproduction and overuse of natural resources (Devin and Richards, 2018). The reduction of waste along supply chains actively contributes to achieving the United Nation's Sustainable Development Goals, represented in particular by Goal No. 12 "Ensure sustainable consumption and production patterns " (United Nations, 2020):

- support the fight against climate change (food waste alone generates about 8% of global greenhouse gas emissions)
- save nutritious food for redistribution to those in need, helping to eradicate hunger and malnutrition (about 43 million people in the EU cannot afford a quality meal every second day)
- save money for farmers, companies and households (European Parliament, 2020).

All actors involved have a responsibility to prevent and avoid waste. From those who produce and process food (farmers, food producers and processors), to those who provide food for consumption (hospitality, retail), to the consumers themselves. The existence of waste and by-products indicates overproduction and an imbalance between supply and demand. This implies an inefficient use of scarce resources, which are thrown away instead of being processed or used in alternative production processes. Considerable costs and effort could also be saved if a supplier's waste was passed on to or processed by a potential buyer. The waste of one actor can be used as a resource by one or more others (Ciulli et al., 2019). Unfortunately, there is currently no connection between waste or by-product generators and potential receivers. The lack of suitable links between the actors in the supply chain hinders an efficient and effective waste flow and thus its recycling (Garrone et al., 2016). Innovative concepts must be created to bring together parties not previously associated, in order to facilitate coordination, collaboration and the pursuit of common goals regarding the further use of waste or by-products. The BS serves as an enabler for such innovative approaches in terms of CE collaboration. The core functions will be defined below.

4.2. Focus and Target Group

The main focus of the BS is the development of a B2B solution that enables players from different industries and different supply chain stages to come virtually together in order to bring their commodities into the cycle of CE regardless of whether it is waste, a by-product or overproduction. The target group, respectively the potential users of such a BS, can essentially be divided into six elements – Producer, Processor, Distributor, Retailer, Supplier plus Others (includes also consumers, social charities and restaurants which could benefit indirectly from the BS). In traditional supply chains, these players work to achieve the common goal of supplying an end product at the right time at the right place, in the right quantity to the end customer. In other words, the aim ahead is to first acquire raw materials, convert these raw materials into specified end products and then make these available to the retailer, who is selling those products at the Point of Sale. This process can be transferred to any other industry.

By looking at waste or by-products in a supply chain, it quickly becomes clear that each actor becomes a producer regardless of his position in the value chain. The classic view of the supply chain is no longer sufficient as visualized in Figure 12 – from a linear to a circular economy (Ellen MacArthur Foundation, 2020). The issue of waste should be emphasized as an integral issue that plays an equal role in every part of the value chain. When defining the requirements for a target group, the differentiation between the supply and demand of goods becomes more important. That is the reason why the focus on the user requirements is based on the two perspectives: producers of goods and receiver of goods, independent of the role as supplier, manufacturer, retailer or disposer.

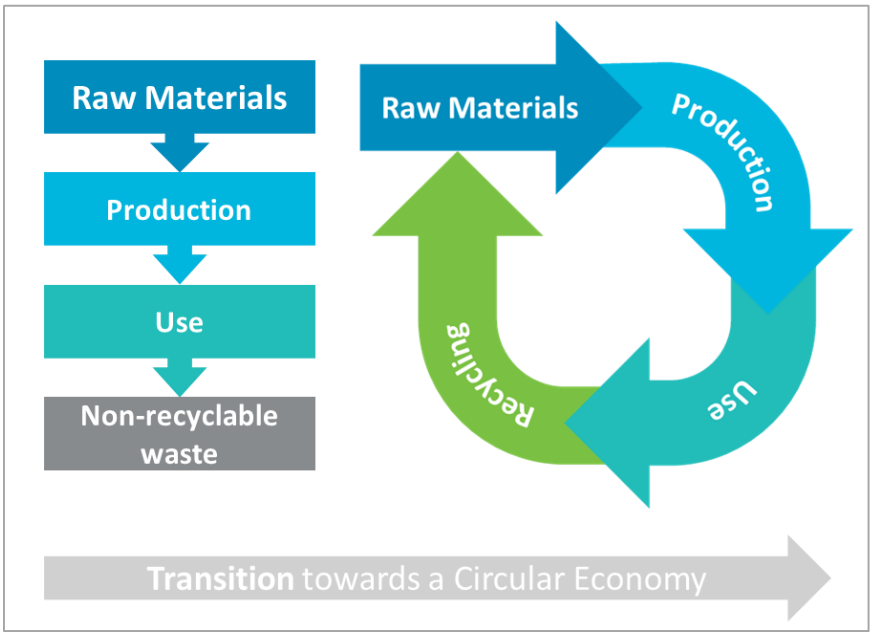


Figure 12 Differentiation between a linear and a circular approach

4.3. Requirements by Target Group

The as-is-situation shows that companies must deal with different challenges to handle their waste management processes. There is a substantial need for action to connect companies, raise their knowledge and giving advice to organize their waste processes in a more sustainable and efficient way. Various requirements for a BS can be derived from the target group described above. In the following section, the needs and requirements of those target groups will be outlined and classified into the following five categories (Ciulli et al., 2019):

- INFORM
- MOBILIZE
- PROTECT
- CONNECT
- INTEGRATE

INFORM – Raising Knowledge
As sustainability and circularity issues get more and more important, it seems inevitable, that the BS gives guidance in an informative manner about social and environmental consequences of waste. Therefore, the platform might help to further integrate sustainability matters into the company-related strategic objectives and raises an overall awareness. This possibly also improves the reputation of certain companies in terms of being acknowledged by its engagement with connection to sustainability activities. The BS could also help to

build knowledge within the company in regard to the question “What is the waste/ product worth?” and give general guidelines to easier estimate the potential quality.

MOBILIZE – Building Networks
There is a lack of connection between potential providers of by-products and suitable receivers of these products. Setting up a BS could lead to extended networks and communities, engaging also small companies to get in contact with business partners and to create new business models, which result from e.g. recycled or waste material etc. Furthermore, the collaborative approach of a BS and well-outlined success stories could possibly mobilize a wide range of interested stakeholders, such as governmental institutions. A growing community might engage governmental institutions to develop legislations and strategies in the mid-term to promote e.g. the reduction of food waste.

PROTECT – Secure Transparency
Data Security plays a vital part to make the platform being a success. To engage as many companies as possible in supporting the idea of reducing waste material as well as building closed loops with supply chain partners, several prerequisites need to be ensured. The protection of company specific data is essential and should be implemented to a high standard of quality. Further, the fulfillment of possible regulatory and legislative requirements should be transparent and accessible to users.

CONNECT – Ensuring Interoperability
To minimize the hurdle of using the BS and to get as many companies as possible engaged, it is crucial that technical IT requirements are aligned to standard management processes and necessary interfaces are in place. As a result, interested companies get connected quickly, so that they are still able to focus on their core business. On top of that, potential users do not have to invest in any kind of upgraded IT infrastructure to make use of such a platform, which would lead to a decreased interest.

INTEGRATE – Impact Assessment
A responsible and more sustainable handling of by-products and waste will be a success factor in the long term. In order to be able to justify positive effects by making use of the BS and to assure the companies´ strategic alignment, users/companies require a possibility to measure the impact of using such a platform. Besides receiving insights on social and environmental impacts in connection with closed loop management, economical KPIs should not be neglected and therefore the creation of reports including financial measurements is indispensable. This might motivate and integrate third parties to engage in a BS as positive effects become verifiable.

4.4. Core Functions

Core functions of the BS were identified by discussions and alignments with relevant project partners (ALIA, JS and ICCS). The tool’s structure was elaborated in several iterative steps. In chronological order and as a prerequisite, the whole process starts with a 'Landing Page’ followed by several mandatory steps:

1. Registration
2. Listing
3. Matchmaking
4. Search
5. Communication
6. Rating
7. Reporting
8. Transaction and payment

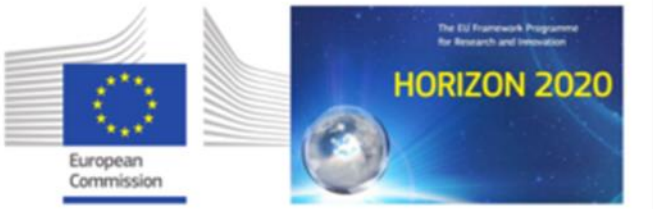
In the following sections, each core function is described with its relevant aspects. The developed brokerage tool is available under the link: https://circ4life-brokerage.iccs.gr/

Landing Page

For a BS the online access to a reliable environment as well as the opportunity to sign binding contracts are two key factors for the targeted users. Users also raise their expectations concerning the persistence and security of websites and require assured service level agreements (SLA) usually followed by a section dedicated to frequently asked questions (FAQ) and the choice of language which is impeditive for an international co-working space. The following questions should be answered on the starting page:

- On which funding project does this platform rely on?
- What is offered here? What are the main benefits?
- What are the main functionalities?
- To what extent does this website offer a potential user the solution to his problem?

An explanatory text as an introduction to the BS helps users to find a confirmation for their decision to have chosen this platform. A suggestion for the starting page may consist of the following text:

> Welcome to the CIRC4Life research project!
>
> We are an EU-funded research project aiming to develop and implement a circular economy approach for sustainable products and services through their value and supply chains.
> Scarcity of resources is one of the most challenging topics today. The reuse and recycling of materials is therefore an important issue in developing circular economy approaches. We are convinced that there is a huge potential to reduce the use of primary resources by returning by-products of manufacturing processes or materials declared as waste back to process in a closed-loop.
> A pivotal part of processes aiming at an efficient use of resources (declared as waste) are brokerage processes. They allow different actors to locate available resources, which are needed for own (e.g. production-) processes, and otherwise would be categorized as waste.
> This is why we developed the Circular Economy Brokerage System which targets business operators from different industries and supply chain stages to bring them virtually together in order to facilitate coordination, collaboration and the pursuit of common goals with regard to the further use of waste or by-products - regardless of whether it is waste, a by-product or overproduction.
>
> 
>
>
> This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776503.

In general, state-of-the-art authentication and authorization mechanisms should be used. A data protection declaration is required by law and is provided accordingly.

1) Registration

The user registration ensures that essential information about providers and receivers is entered. However, it will be possible to see and to search for offered products without registration. This is an important additional

function to teaser business partners and to start a first activity finally leading to a brokerage transaction. The following data fields are identified as most important for completing a user account:

User Account Field
Company name*
Short name
Contact surname*
Contact first name
Street*
Street number*
Zip code*
City*
Country (drop down) *
Contact phone number
Contact mail*
Website
GLN
VAT number
Industry sector, selectable according to NACE Code List (European Commission, 2008)*, e.g. meat, farming (fruit and vegetables), LED, tablets + others
Confirmation of privacy policy*
Confirmation of the General Terms and Conditions of Business*
Company size
CE self-assessment (see chapter 5)

Another set of data fields becomes relevant to also assign an administrator (User 1-n*) for the company:

User Account Field
Surname*
First name*
Division/Department*
Position*
Mail*
Phone number*
Access rights* (Admin who is allowed to add new users)

Data fields marked with a "*" are mandatory and those written in **bold letters** are visible for all kind of users, also for not registered ones.

2) Listing

Listing is one of the core components of the BS and the trigger for all subsequent transaction processes. Listing can be viewed from both sides – an initial decision needs to be taken by a user whether a) he wants to supply commodities in the role of a provider or b) he demands commodities in the role of a receiver. Starting from the situation of a company willing to place a tender of a secondary product, the user has to create an offer, running through a wide range of defined data fields. These data lay the basis for the later matching algorithms, thus the whole brokerage success is based on the input given here.

The backend of such a system would provide a hierarchical commodity structure to be better able to search and structure the resulting report. It could also be helpful to have interfaces in place to existing other relevant

data bases like static or dynamic product data for business process management, e.g. linking to *fTRACE (*https://www.ftrace.com/de/de) with its batch related traceability data or *atrify (*https://www.atrify.com/), a full-service provider for GDSN. A very useful add-on would be bridging with established product classification systems (e.g. eclass, GPC, UNSPSC (GS1 US)).

For the Listing, the user follows an online template. He must fill in various data fields:

- **Industry Sector** (CIRC4Life: meat, farming, tablets, LED, others) (Selection Field):
  Four industries are represented in CIRC4Life and another open field can be chosen, if the categories do not fit the product to be offered.

- **Commodity** (Text Field):
  This is where the good has to be named or described.

- **Identifier** (Selection Field):
  Numbering systems and barcodes to better identify and distinguish commodities shall be applied here, e.g. batch number, GTIN, SGTIN or even LGTIN (see Chapter 2.4).
  - Kind of commodity (Description) based on UNSPSC and eclass followed by a set of hierarchical steps like segment, family, class, commodity (becoming finer and finer)
  - Source of commodity (Selection Field): The provider has to classify his offered commodities into different categories to clarify their origin and general background, e.g. waste, by-products, excess production or stock.

- **Quantity** (in unit of measurement) (Selection Field):
  The user can choose from different units of measurement and fill in the quantity as a number.

- **Price** (in € or other currency):
  The provider has to type in how much the buyer has to pay. At a later step the price in relation to the unit (e. g. price per ton) is calculated in the backend and shown as first orientation.

- **Location** (ZIP code, city, country, SGLN) with google maps integration (Text Field):
  This is where the goods are currently stored and ready for collection.

- **Date of Production** (optional for industry sector tablets, LED and others, obligatory for meat and farming):
  Especially for food this date is important for the later use in other products.

- **Date of Expiry/Best Before** (optional for industry sector tablets, LED and others, obligatory for meat and farming):
  This date is directly related to the production date because of food safety reasons and quality.

- **ECO Points** on product level (optional - check boxes yes/no, amount: X)
  Here users can attach ECO point data to their products being offered, which inform about the providers contribution to the sustainability of a product or the circular effect in terms of reuse or recycle.

- **Type of Packaging** (Text Field):
  The receiver needs to know how the product has to be handled during transportation and storage.

- **Upload** of files (Upload Option):
  Opportunity of uploading files such as pictures, certificates, etc. gives the buyer the option to make a better assessment of the products' quality.

- **Comment** (Text Field):
  The provider can optionally type in any kind of additional information, may it be on the product itself or the way how to accomplish the negotiations.

- **Incoterms** (Selection Field):
  Standardized international delivery clauses which serve as a contract between seller and buyer. They cover all tasks, risks and costs associated with the worldwide movement of goods and are considered the most important trading conditions.

Of course, the fields used vary depending on whether the listing includes a supply or a demand.

3) Search

A potential purchaser of listed commodities on the BS should be able to make use of a user-friendly platform and easy to handle search functionalities. The primary goal of the tool should be to enable a convenient purchasing process for the customer according to his needs, in order to ensure that further sale transactions take place. Therefore, the user should have the possibility to benefit from a structured query for his search.

- **Filters** - to ensure that a user can purchase the products he wants according to his preferences, a reasonable set of filter criteria needs to be in place. In essence, all relevant data fields explained in section "listing" must be created as a filter, to lay the basis for a useful match making. One crucial filter is the industry sector (here aligned with the four defined industry sectors of the CIRC4Life project).

  In addition, a high number of displayed offers can be filtered by specifying e.g. the maximum quantity the purchaser demands, what price he is willing to pay or the maximum distance he is willing to accept for the purchase of the product. Other indicators could be the date of production or the date of expiry. Furthermore, a filter option in connection with a star-rating is imaginable (see 6) Ratings).

- **Rankings** - as soon as the buyer has carried out an initial filtering of the offers available, by clicking on one or more of the filters listed above, further selection processes are intended to support the efficient search for the needed product like in bestseller rankings. Two selection fields are highly recommended: i. CE Total Relevance Score (see chapter 5) and ii. Price. Price plays the decisive role in the usual marketplaces, but this concept rather supports the CE idea. For this reason, the ranking functionality according to the CE Total Relevance is applicable and should be the leading criteria. Separate rankings based on the criteria described in Chapter 5 will be obtained for the marketplace.

4) Matchmaking

The success factor of the BS lies in the intelligence in matching two partners (receiver and provider). In order to implement CE holistically, collaborations beyond the actual company boundaries are essential and necessary. In order to act circular, competences from different perspectives must be combined and work hand in hand. Collaboration is therefore the key factor when it comes to operationalizing CE. In this case, the BS serves as an enabler for collaboration. The BS is designed to connect companies that at first glance do not belong together

or whose product and service portfolios have nothing in common. To mobilize partners to collaborate who would never have started the exchange without a platform.

The essential component is the logic on how partners are matched on a platform. Due to the relevance of this topic, the procedure and methodology of this functionality is described in chapter 5 in detail. In order to avoid that parameters such as price or industry are the leading criteria of the algorithm, chapter 5 describes which other parameters are used to achieve the best result for a CE collaboration. Regardless of the logic, functionalities in a BS need to be considered to inform the concerned candidates about the potential matches:

- **CE Notification** - a message (e-mail) is distributed automatically at regular intervals, maybe daily or weekly.
- **CE Alert** - an instant notification is sent out to immediately and personally inform about the appropriate candidates.
- **CE Partner Listing** - high performing companies in terms of the CE Scoring will be remarkably promoted on the platform.

It is important to note that operational links between supply and demand ideally result in a strategic cooperation between partners and companies. So that extended networks and communities can emerge and grow with needed skills for CE collaboration.

5) **Communication**

The platform should ensure the opportunity for business partners to communicate with each other (e.g. via chat-function). This option supports interactive exchange and can support transactions and collaborations on the platform. For example, to find out further details of the offerings.

6) **Rating**

There should be a functionality to rate a transaction or a collaboration partner afterwards, e.g. with stars. This rating helps providers of the BS to improve its services. And if it is possible to evaluate the quality of a transaction with a specific provider, other users are able to deduce from the rating whether a professional provider is hiding behind the offer and whether a business relationship is advisable.

7) **Reporting**

In order to give users the opportunity, to find out which transactions were completed, how their own performance was in general and how much waste they saved, reports on this should be available at any time. Because operational reporting is essential for control, administration or evaluation of the transactions made in the past. Ideally, business analytics can be based on this, which provides the users with transparency and motivate them to continue using the tool. It is conceivable, for example, that this could also be supported by incentive systems.

8) **Payment and Transaction**

Functionalities to conclude a purchase procedure may depend heavily on specific parameters of the Business Model or even regulatory conditions in different countries. Of course, this is an integral part of the basic functionalities. The transaction must be as much convenient for the user as possible, i.e. not many steps should be necessary to buy or sell commodities. In addition, the process should be a drafted approach concerning payment and comprises only a couple of thoughts to be shared at this point facilitated by credit card companies, virtual paying platforms or even others.

4.5. Interfaces

To ensure that the BS is used widely, the setting of offers and requests in the BS should be as simple and fast as possible for the user. For this reason, the following two options for data entry are made available to the user:

- **GUI/WEB Interface** - The most important interface for data entry into the BS is the GUI. Via the central GUI, the user has the possibility to make offer and demand information visible in order to contact or collaborate with potential partners.

- **Machine to Machine (M2M)** - In an extended stage of development, it is conceivable that the owner's systems are directly linked to the BS via a machine-to-machine interface. So that the relevant data can be entered in a targeted manner and without an additional manual effort. This process takes place without direct manual intervention by the user.

4.6. Non-functional Requirements

In general, the trusted partner platform should include the following non-functional aspects:

- **Usability** - the user interface and all error messages must be created in English and Spanish language. The BS should be available 24/7 (24 hours, 7 days a week), so that the authorized user of the BS is able to start a search at any time. The platform needs to be useable in an intuitive way, so that the user does not need any instructions.

- **Reliability** - once the search query has been completed, the BS should be able to display the correct information for the desired object. The maturity of the application plays an important role. Only an error-free working platform will motivate the users to continuously use the BS. Therefore, a high degree of maturity must be ensured during the realization of the requirements.

- **Efficiency** - the reaction time of the system should be less than 2 seconds. The access to the database with the information of the result service and the transferred data should be kept as low as possible. Once data has been retrieved, it must be made available locally - at least until the application will be closed.

- **Transferability** - the BS is initially programmed as a web application. However, it should also be possible to display the application in a mobile view on a smartphone or a tablet.

- **Security** - the requirements regarding the data protection, the data security and the access protection are to be fulfilled according to the GDPR regulation. The BS should also fulfil the security requirements according to the "Recommendations of the Federal Office for Information Security" (Bundesamt für Sicherheit in der Informationstechnik (BSI)) on the use of active and dynamic content in the world wide web.

5. CE Matchmaking Methodology

The previous chapter 4 describes the core functionalities of a BS, which provides the technical basis to initiate and operationalize CE collaborations. As already mentioned, the CE matchmaking logic plays in this context the decisive role. Therefore, in this chapter the approach of the CE matchmaking methodology is described in detail.

5.1. Method Development

Throughout the development of the method, the criteria for the circular assessment of businesses in a context of CE matchmaking processes were studied and defined. It was decided that initially a platform intended only for materials will be developed, with the possibility of further enhancement by incorporating water and energy matchmaking in the future. The methodologies behind two recently developed circularity measurement tools for companies presented to public; namely Circulytics (Ellen MacArthur Foundation, 2020) and CTI tool (World Business Council for Sustainable Development, 2020), were analyzed. The data from D7.3 of the CIRC4Life project, "Report on stakeholder involvement along the chain", was used for better illustrating the principles of matchmaking and the BS approach and their variability depending on the sector.

5.2. Method Description

The methodology for the BS is based on a multi-level approach to match two companies, willing to become more circular and looking for closing their loops in an innovative and, at the same time, economically reasonable way. The matchmaking methodology graph is presented in Figure 13. Final matching is based on the relevance scoring between two companies (Business 1 and Business 2), one of them being provider and the other one being receiver. The Total Relevance Score is obtained by adding up weighted partial relevance scores (A, B & C) obtained respectively from level approaches 1, 2 and 3:

$$\text{TOTAL RELEVANCE SCORE} = \alpha*A + \beta*B + \gamma*C$$

The values α, β and γ are currently under development.

Each level approach (1 to 3) is embodying a different factor, which is always presented in a form of proximity (relevance) between two businesses. The following factors are taken into account in the multi-level approach to matchmake between two marketplace users:

- **1st level:** Compliance with CE principles involving a questionnaire (Relevance Score A)
- **2nd level:** Material flows including the tightness of the loop (Relevance Score B)
- **3rd level:** Greenhouse gases (GHG) emissions from the transport (Relevance Score C)

Each of these factors is translated into relevance scores between businesses: A, B and C, respectively.

The Total Relevance Score allows the companies willing to close their loop, to find the best possible match in terms of CE principles. Matchmaking is performed at resource and company level.

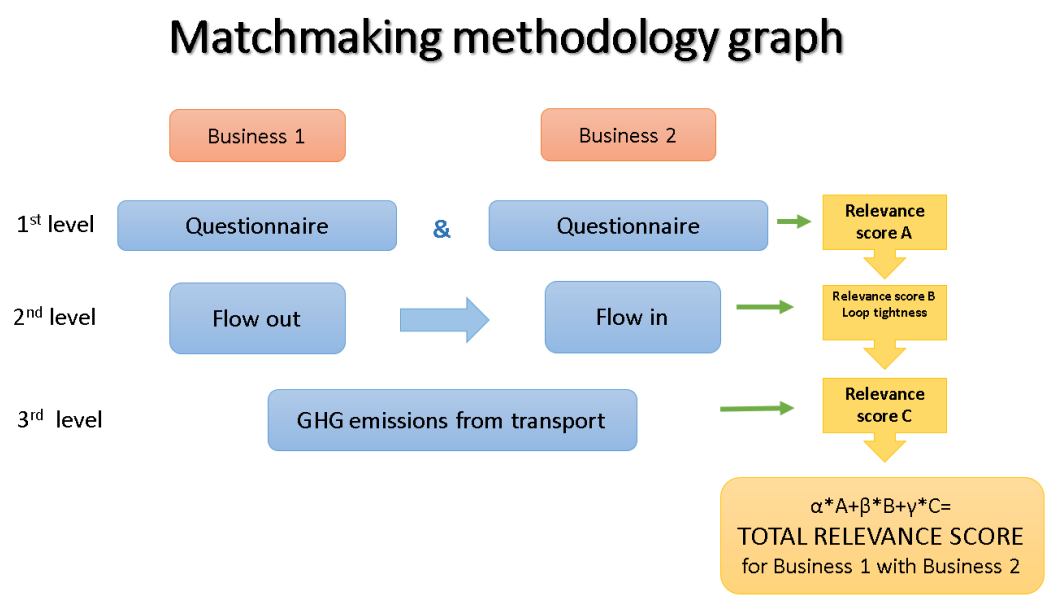


Figure 13 Multilevel approach to matchmaking, methodology graph.

5.2.1. Compliance with CE Principles – 1st Level

The relevance between two users (Business 1 and Business 2) in compliance with CE principles is assessed in the form of a questionnaire that both fill in. The questionnaire is inspired by the themes for enabler indicators (Ellen MacArthur Foundation, 2020b) developed for Circulytics. The Circulytics' themes (for the enablers category) were designed in such a way that they reflect the transition of a business starting from a strategic planning to operation, which is fully based on the CE principles. The enablers category themes used by Circulytics are: Strategy and Planning, Innovation, People & Skills, Systems Processes & Infrastructure and External Engagement. Each of these themes has been considered and laid the basis to create one or two relevant questions per category. Depending on the theme the questions are either based or interpretation of the theme to match better marketplace context, e.g in the theme 5, where we ask about engagement in brokerage systems or on selected, slightly modified Circulytic's questions, where no need for significant adjustments for marketplace context was necessary (e.g. theme 4). Also questions from the self-assessment and Sustainability Score (described earlier in subchapter 3.2.2. of this report, which come from the Ecopreneur tool Circularity Check (Ecopreneur, 2019) with small modifications were used in the questionnaire. The final set of questions (Figure 14) was created based on a combination of above-mentioned sources and specific needs of the concept.

Circulytics Theme, (enablers category)[1]	Questions
1. Strategy & Planning	1. To what extend is CE incorporated in your company's strategy?
2. Innovation	2a. To what extend has your company redesigned its products so that they follow the principles of CE (e.g. prolonged product lifetime, easiness of reuse/repair, etc.)?
	2b. To what extend does your organization ensure that the input materials for the product are coming from recycled materials, reused components, waste/by-products from other products or production processes?

[1] Ellen MacArthur Foundation, 2020b

3. People & Skills	3. To what extend is the personnel who will use the tool trained in CE principles?
4. Systems, process & infrastructure	4a. To what extend can your software be applied for CEBM?
	4b. To what extend can your infrastructure systems be adopted/used for the needs of CEBM?
	4c. To what extend have the processes used in your company been modified so that they follow CE principles?
5. External engagement	5a. To what extend do you make use of the brokerage system?
	5b. To what extend are your business partners implementing CE principles?

Figure 14 The set of questions used for the questionnaire and corresponding Circulytics themes.

5.2.2. Answers & Weighting

There are four possible answers to each of the questions, where answer 4 indicates high level of compliance with CE principles and 1 non-engagement in a particular action. This qualitative answers come from (Bertels, 2014) with one additional response (the first one):

1. Our organization is not involved in this practice
2. Our organization engages in this practice at ad-hoc levels
3. Our organization is beginning to engage in this practice in a more systematic way
4. This practice is well embedded in our organization

In the matching relevance technique used for the BS, one matching relevance score is assigned in case of identical answer of both users. The relevance score decreases as the numbers assigned to the answers are growing apart. The proposed scoring scheme is presented in Figure 15.

Answer company X	Answer company Y	Assigned relevance score
1	1	1
1	2	0,75
1	3	0,5
1	4	0,25

Figure 15 Scheme of assigning relevance scores between two companies based on the answers (1,2,3 or 4) they provide to each question from the questionnaire.

The approach shown in Figure 15 is an example and can be applied to many other combinations between companies. As in case of the Sustainability Score, for the moment no weighting has been used. It might though be applied in the future.

5.2.3. Flow Analysis – 2nd Level

The second level approach of the CE matchmaking methodology relies on the material analysis of in- and outflows. Both tools which methodologies were analyzed, i.e. Circulytics and CTI, rely at some stage on the materials flow.

In **Circulytics,** the materials flow analysis is embedded by the themes 6 & 7, Input and Output, respectively of the enabler category. Additionally, indicator's category outcomes deal almost exclusively with the material flows with outcome questions adjusted to the activity of the company. There is a special package of questions

for businesses like financial institutions, energy providers or other companies, which operation is not based on materials but rather on services (Ellen MacArthur Foundation, 2020 c).

CTI's methodology is based on the analysis of mass flows, distinguishing between circular and linear flows as depicted in Figure 16 from "Circular Transition Indicators V 1.0 Metrics for business, by business". The CTI tool consists of three modules: "Close the loop", "Optimize the loop" and "Value the loop". The first module, the only one which is obligatory, consists of two indicators related to materials i.e. percentage of circular inflow and percentage of circular outflow. There is a separate indicator for the share of renewable energy and for water circularity, the last one being still under development.

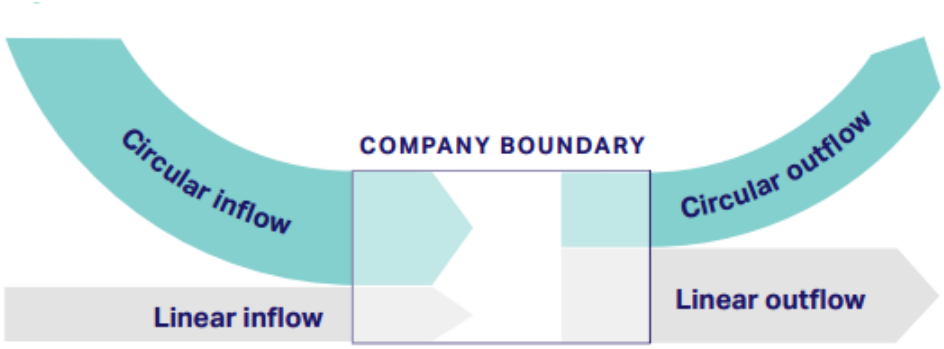


Figure 16 Materials flows as featured by the CTI tool, "Close the loop" module. (World Business Council for Sustainable Development, 2020)

The second module "Optimize the loop" consists of two indicators: the quantity of critical inflow, representing the percentage of critical/scarce materials and the share of the recovery type (Figure 17). This last indicator is of special interest for CE matchmaking within the BS, as it provides the user with information on the recovery of the material and on the way, it can be reincorporated within the value chain. Based on the data provided by the user, the CTI tool calculates the contribution of the recovered material in five categories: reused/repaired, refurbished, remanufactured, recycle and biodegraded/composted (World Business Council for Sustainable Development, 2020). This approach is particularly suitable for a BS, as it facilitates the matching process and enables closing the loop. Although the CTI tool does not distinct between different types of recovery strategies, when calculating the companies' circularity, tighter recovery circles are recommended. This type of loops should be of preference by the businesses, as they are more effective in terms of CE and consequently, the retained value of the product is maintained. The tighter the loop, the less resources, energy, labor, material are consumed (Ellen MacArthur Foundation, 2013).

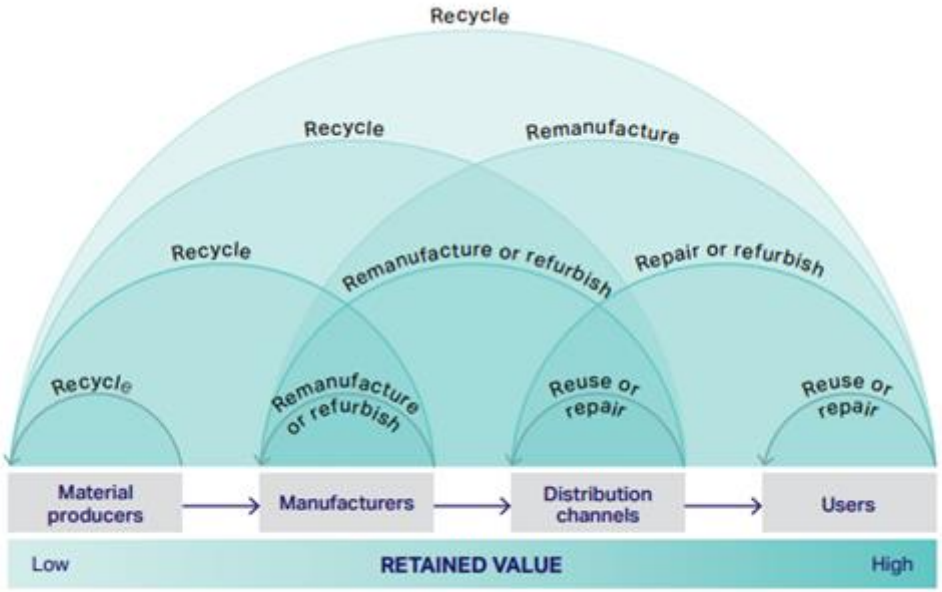


Figure 17 Retained value depending on how tight the recovery loops are (World Business Council for Sustainable Development, 2020)

This reasoning is included in the BS methodology by giving the priority, in a form of a higher relevance score, to stakeholders being closer with each other within the value chain. The detailed methodology behind the relevance score B calculation is currently under development.

5.2.4. GHG Emissions from Transportation – 3rd Level

The third factor which is included in the multilevel approach are the GHG emissions from a potential transportation of the material of interest from one BS user to another (from the provider to the receiver). A GHG emissions calculator has a clear advantage over a simple distance comparison. By using the online calculator, information like the type of transport (road, sea, air, etc.) and the weight of the transported material in terms of environmental impact are also included in the assessment. The calculations of relevance score C will be performed based on the result from one of the available online calculators. The relevance score from GHG emissions will have a value between 0-1. The exact emission ranges per relevance score being currently under development. A short review of available GHG emission calculators, followed by a brief analysis in the context of the BS is presented below.

- **ChemMultimodal** is a tool developed within ChemMultimodal Interreg Central Europe project (ChemMultimodal, n.d.). It is targeted towards chemical and logistic businesses and has integrated choice of transport on different modes. The modal shift was applied to demonstrate that multimodal transport contributes to reduction of CO_2 emissions (Cichosz et al., 2018). The tool is based on the activity-based method (Mc Kinnon and Piecyk, n.d.) and accounts only for CO_2 emissions.
  ChemMultimodal is available here: https://ifsl50.mb.uni-magdeburg.de/chemmultimodal/

- **World (ETW)** is used for calculation of energy consumption and GHG, CO_2 and air pollutants emissions of freight transport (including intermodal). It is accredited for the GLEC (Global Logistics Emissions Council) framework (Smart Freight Center, n.d.) and in accordance with EN 16258 (Schmied and Knör, 2012) and the GHG Protocol Corporate Standard (World Business Council for Sustainable Development and World Resources Institute, n.d.). ETW is managed by EcoTransIT World Initiative. The members of

the initiative originate from diverse economic sectors but are all using the tool and are interested in its further development (EcoTransIT World, n.d.).

EcoTransIT World can be found here: https://www.ecotransit.org/calculation.en.html

- **NTMCalc 4.0** created by the Network for Transport Measurements (NTM). NTM is a non-profit organization aiming at development of methods for reliable calculations of environmental performance within the transport sector (Network for Transport Measurements, n.d.). The tool allows for cargo and passenger calculations.

  NTMCalc 4.0 can be found here:
  https://www.transportmeasures.org/ntmcalc/v4/basic/index.html#/

- **Pier2Pier** is a CO_2 emissions calculator developed by Pier2Pier company (Pier2Pier, n.d.) for shipping lines, truckers and leasing companies, to be able to advertise themselves and inform about their services and routes.

  Pier2Pier is accessible here https://www.pier2pier.com/Co2/

The BS requires a calculator that is suitable for transport of very diverse materials. Most of the calculators presented here aim at freight and passenger transport. In case of BS transactions, it has to be kept in mind, that some of them will concern relatively lightweight materials, that will be transported by passenger car. From the calculators analyzed in this report, only the NTMCalc 4.0 has this option integrated. Further studies on reduction of GHG emissions show, that collaborative activities in the field of transport and logistics may lead to higher GHG efficiency (Bungart and Leick, 2018). Several platforms were conceptualized and implemented and work in different domains. Future work of CE matchmaking could go in the direction of integrating them as additional services to just pure GHG calculators. The exact integration of the calculator within the BS is under development.

5.3. Use of Waste Patterns for the Development of the BS

Data on the waste patterns in the supply chain and business opportunities (chapter 3 and chapter 4 from D7.3, “Report on stakeholder involvement along the chain”) are of value for the creation of CE matchmaking processes. The study was conducted for the two main sectors in CIRC4Life: food and electrical and electronics sector. Within the food sector, two sub-sectors were examined: meat as well as vegetables. Within the electrical and electronics sector, the lighting and tablet sub-sectors were analyzed. The data presented in D7.3 is used in the chapter 5.3 and interpreted in the context of a BS. This type of data can be used to provide advice on the solutions for the companies on how to close the loop within the sectors that have been analyzed.

In the CEAP the authors and the EC identified several key product value chains where to focus and intensify sectorial actions (European Commission, 2020). Here the EC aims at closely cooperating with stakeholders. Two of these seven key product chains in the plan are those also worked on in CIRC4Life: besides the food also the electrical and electronics sector.

5.3.1. Food industry

A common pattern of the studied food subsectors is that waste is produced all along the supply chain. There are two types of waste: inorganic (e.g. paper and cardboard, plastics, metals) and organic (e.g. biowaste). The inorganic waste is usually recycled and reused by the respective industry (e.g. paper or plastic industry) or it is thermally exploited to produce energy. The combustion process is not recommended mainly due to the emission of toxins into the environment (Verma et al., 2016). A BS is a potential enabler of increasing the recycling and reuse rate of the inorganic waste.

Organic waste coming from the meat industry can be used as a valuable resource by other food sectors or industries (Figure 18). Examples of such industries are cosmetic, pharmaceutical or paper industries. Organic biowaste coming from plants production is mostly composted on farms, both in case of the crops being primary source for animal feed for the meat sector and in case of vegetables sector. The biowaste produced on different levels of the value chain (including distribution and retail), can be used for energy generation or biogas production, as well as landfilled.

Waste	Next Use	User Group
Biowaste	Compost	Farmers
	Organic fertilizers	Organic fertilizers producers
	Insect's breeding	Animal feed manufacturers
Paper and Cardboard	Composted	Farmers
	Recycled	Paper industry
Plastic	New sustainable packaging	Recycling companies
	Energy production	Industry sector

Figure 18 Waste from vegetable sector and its possible next use with relevant user group (table from D7.3)

The multitude of possibilities for collaboration based on waste from food, demonstrates that a CE matchmaking processes will greatly facilitate the potential cooperation within the sectors, but also between industries, helping to reduce the huge impact that food sector imposes on the environment. It is worth mentioning, that some CE approaches and partnerships are already well established along the supply chain and could be considered as a good starting point for the BS.

With respect to the food, water and nutrients sector, the EC strongly focuses in the CEAP (European Commission, 2020) on ensuring the sustainability of renewable bio-based materials through actions following the "Bioeconomy Strategy and Action Plan". At the same time, the commission is targeting directly also on food waste reduction as a key action under the forthcoming EU "Farm-to-Fork Strategy". While 20% of the food produced in the EU is lost or wasted, the EU comprehensively addresses entire food value chains. Especially under its "Sustainable Products Initiative", the EU plans to increase the sustainability of food distribution and consumption. Here the substitution of single-use packaging, tableware and cutlery by reusable products in food services is in the center of their activities. The focused measurements of CIRC4Life with its CEBMs in the sector of food are completely aligned with the above-mentioned intentions of the EU including also the SDGs and the general directives under the New Green Deal.

5.3.2. Electrical and Electronics Sector

Electrical and electronic sector's waste patterns differ significantly from those observed in the food industry, where waste is produced along the chain. In case of tablets and the lighting sector, the recovery and reuse of raw materials is of major interest when it comes to waste strategies. Raw materials are still crucial for state-of-the-art production chains in many industries. It is therefore the final product as such and its end of life that are of major importance – in contrast to the several processing steps in the food chain. Efficient collection and recycling and reuse of crucial resources is key to waste handling in this sector which causes different challenges in comparison to the food sector. The potential users of the BS are formed by a variety of companies and other entities, e.g. waste management companies, collection scheme organizations and recyclers as well as

manufactures of tablets/lighting but also companies using tablets in their everyday work which could act as potential providers.

The main stages of the tablet production (extraction and processing of raw materials, component production and assembly) have great environmental impact due to mining activities (Oluranti et al. 2020) and manufacturing of electronics which is material intensive (Williams et al. 2002). In the context of the analysis for the BS, focus is set on the stages of collection, refurbishment and recycling, defined by the D7.3 CIRC4Life as of major importance to the sector and having potential of enabling electronic waste reduction at product, part, component and material scale through the use of the brokerage tool. The collection stage can be followed by different scenarios. After a check-up with possible repair procedures, a tablet is being put on the (second hand) market again. For this scenario a BS could be of potential use. The second scenario, for tablets that are not fixable, recycling of the raw materials is the solution. However, this approach poses some challenges. Many materials are not being recovered due to high cost of recycling and low demand of refurbished components on the market. Including a matchmaking BS in the process could potentially increase the recycling rate, at this point. Apart from the raw materials, metals and plastics are also piled up. There is however a problem of possible contamination of plastics, which makes its reuse impossible. Additionally, for non-fixable tablets, potentially BS could be of help by connecting users at component level (for non-contaminated elements) to facilitate refurbishment.

The lighting sector supply chain's waste patterns resemble greatly the one of the tablets sectors with most of the production stages taking place in the Far East. The crucial stages are again collection and recovery with the later one posing biggest challenges. Therefore, a similar approach of the BS is a potential enabler. The waste patterns analysis shows that diverse waste patterns must be considered in the development of a CE matchmaking. The in-depth knowledge of sector specific waste patterns facilitates this process.

As electronics and ICT consumption has been significantly growing during the last years and lots of waste being recycled outside the EU, the EC is setting in its CEAP a clear priority to reduce losses and gain efficiency by starting a separate EU "Circular Electronics Initiative" for mobile phones, tablets and laptops to ensure devices are designed for higher energy efficiency and durability, reparability, more upgradability, maintenance, better reuse and recycling. Within this strategy, four pillars are identified: right to repair, introduction of a common charger, an EU-wide take back system to return or trade-in used devices and finally the restriction of hazardous substances (European Commission, 2020).

5.4. Direct and Indirect Matchmaking

The analysis of waste patterns and innovative opportunities of interactions between the stakeholders shows that each value chain has its specific requirements and that there are numerous, often non-obvious possibilities for collaboration in the spirit of CE. The unapparent matches might have to do with yet unknown uses of resources but also with indirect matches. The matchmaking methodology supports also indirect matches that require repurposing, which is the core of CE.

The typical match is a simple case, where the material outflow from a BS user matches directly the demand of the other one. An example can be seen in Figure 19: The biowaste from plant agriculture, which for some reason is not composted on the farm, appears in the BS as a direct match for an organic fertilizer producer. If additionally, the two users get a high relevance score from the questionnaire (Relevance Score A) and are located relatively close, releasing low amount of GHG during transportation of the biowaste (Relevance score C), they have a good chance for collaboration and closing their loops in the tightest possible way.

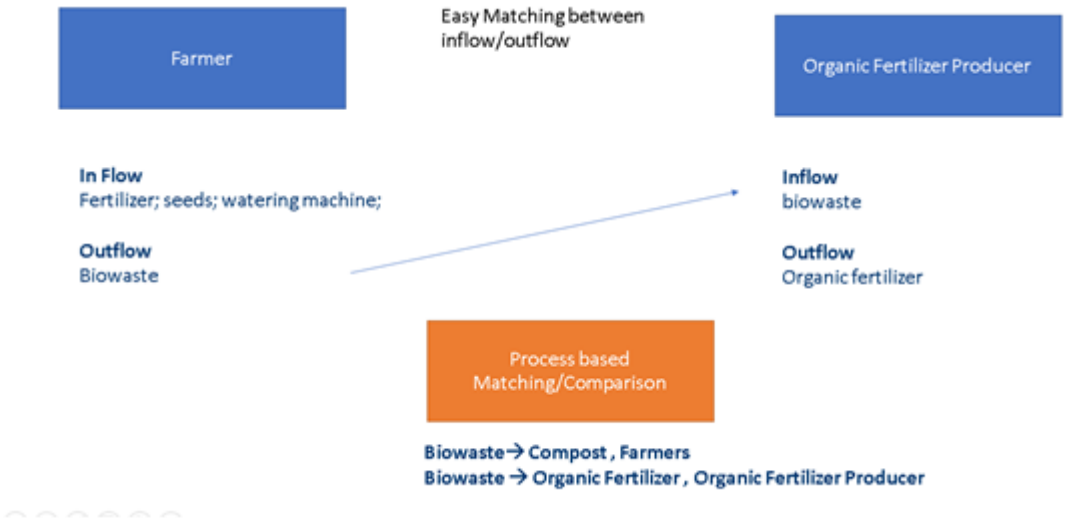


Figure 19 Second level approach, direct match

In Figure 20 another use case (Figure 18) is shown. A chicken producer in need of animal feed products, in collaboration with a farmer that provides organic waste, can collaborate to find the intermediate step, which is the livestock feed manufacturer. Organic waste is produced in most segments of the food sector. It is of interest for innovative practices like organic fertilizer producers, composting companies or insect's breeders. Insects are used for animal feed, as they are a good source of dietary proteins. In the case depicted in Figure 20, the match is unobvious and requires an intermediate collaboration step. There is need for cooperation between two users (farmer and chicken producer) to repurpose the waste and find an intermediate stakeholder (insect breeding company) to close the loop.

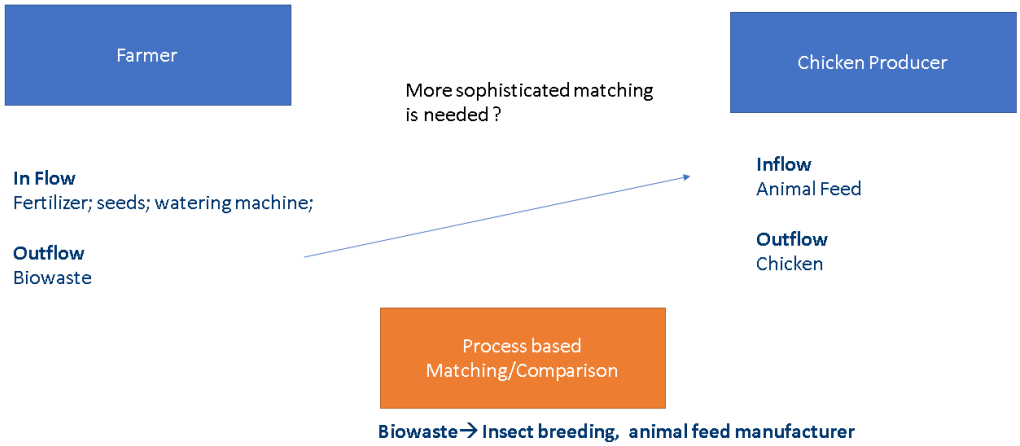


Figure 20 Second level approach with intermediate step

With this approach, the indirect matches are incorporated within the assessment, making it easier for companies to find collaboration, also when it involves repurposing.

6. Future Work

During the studies for D4.5 various approaches were identified and collected to further improve and develop the BS as well as the n-step maturity model and the CE matchmaking concept within the CIRC4Life project, but also in future projects to come. While researching processes have been conducted and a workshop session explicitly on the self-assessment tool and the corresponding Sustainability Score has been organized, ideas for further developments emerged. Hence, those ideas for further developments, will be outlined in the following.

In the first step, it has been decided to consider a balanced weighting approach for the four dimensions of the questionnaire. Further iterations should explore a differentiated weighting for the four pillars since different sustainability criteria are important for different business areas, locations and other factors, so that they should be weighted accordingly. However, the weighting should be easy to understand. The next step could be to define criteria, which should be considered when creating a weighting model.

While currently the three dimensions defining sustainability (environmental, social, economic) clearly focus on a company or business level, the fourth dimension CE rather focuses on the product level. Based on this, the extension of further dimensions, criteria and the sector focus, but also the implications and potential synergies are to be analyzed in detail before.

Filling-in the questionnaire for the time being is characterized by subjective assessments and thus leaves room for interpretation. This makes it difficult to compare and validate the information provided. Therefore, it becomes obvious that the concept at this point has specific potential for improvement. There is a need for transparency and further developments regarding the validation of the data provided. Certain technologies and concept ideas should be considered: a) Making use of digital traceability, connection with globally established standards such as EPCIS, blockchain and the use of distributed ledger technology or, b) integration and access to the platform by auditing companies.

Taking a closer look at the questionnaire and the corresponding answering options in terms of ratings, it becomes obvious, that a more qualitative approach was chosen here. It is recommended to consider more heterogenous and scalable answering options, specifically requests for quantitative data. To name a few examples, the criteria energy (concrete consumption values and accounts in Watts) or emissions (carbon footprint) can be mentioned. Further, it might be worth to explore, whether four maturity levels are suitable, or a more granular rating system should be introduced. In addition, the appropriate and necessary legal framework should be defined and in place by the time the BS and the n-step maturity model are introduced.

As mentioned, the development of the multi-level approach methodology is ongoing. The exact weighting of the Relevance Scores and therefore the final shape of the equation describing the Total Relevance Score needs to be further analyzed. The values α, β, γ are under development. In case of the GHG emission the ranges of emissions per score need to be defined. Once this is done, the method can be initially tested and examples provided. There is a possibility of its integration within the Living Labs in CIRC4Life. Further development of the CE matchmaking approach involves widening the method by including the water and energy matchmaking.

The concept of CE collaboration and proposed matchmaking methodology should be further integrated into the eco-systemic CE business model development. CEBM innovations are by nature ecosystem based (Tsujimoto et al., 2018) since they require collaboration, communication, and coordination within complex networks of interdependent but independent actors/stakeholders. Thus, there is a need for practical and easy solutions for companies across the supply chain to find the “right” collaborators. The self-assessment can be used as the initial stage by the companies interested in CEBMs to evaluate own readiness and to find matching partners for co-creating a shared strategic vision for ecosystem based CEBM in a multi-stakeholder setup. The BS can be

combined with the tools for development of CEBMs, such as the Board game (CELLL) for co-creating ecosystems based on CEBM, developed by Santonen et. al (2020) based on the CIRC4Life project. Further development of the integrated approach to CE innovations based on the collaborative models and digital solutions is needed.

7. Conclusion

Food waste and linear use of resources become more and more a major challenge for today's society. The CIRC4Life project and the holistic approach of the BS, also including the n-step maturity model, whose concept is at the center of D4.5, as well as the multi-level approach methodology behind the BS based on the relevance score, show approaches to counteract this trend and to create solutions for CE collaboration. Such approaches aim at making CE and related business models accessible and applicable to companies, regardless of size and sector.

As already highlighted in D7.4, "ecosystem approaches are relevant for analyzing and developing novel circular economy business models in context of CIRC4Life, since in order to be successful in circular economy, there is a need to 1) optimize energy and material flows, 2) value capture and value creation in the case of closed loop system (Geissdoerfer et al., 2017), which is ideally eliminating all resource input into and leakage out of the system, is only possible if multiple actors are collaborating within interconnected ecosystems via different types of platforms, 3) new (ICT and other collaboration) platforms and connections between the platforms are needed to manage and produce to enable circular economy solutions and finally 4) intensive collaboration between private companies, public sector, academia and also with end-users is needed to generate and manage successful circular economy solutions, which have market acceptance." This report provides a concept to address above challenges and provides a general approach and a methodology for CE collaborations.

Nevertheless, holistic ecosystem approaches are very complex, and new ideas and expansion initiatives have emerged during the development of this concept. They could not be fully implemented in the current status quo due to limited time available. Accordingly, potential for further developments can be exploited for research projects to come.

It should also be noted that the CE approach will only be successful, if numerous companies - preferably large and well-known companies as role models - make use of such platforms and concepts to actively integrate them into their own business processes and strategies. If companies do not open up and rethink their production processes, the procurement of raw materials or the disposal of waste, approaches like the BS are doomed to failure. In order to make it easier for companies to integrate CE collaborative approaches and instruments into their business processes and to initially sensitize them for this topic, the CIRC4life consortium pursues the objective of disseminating the projects´ results and making them available to all interested parties, policy makers included.

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