**Grant Agreement number**: 101037031
**Project acronym:** FRONTSH1P
**Project title:** A FRONTrunner approach to Systemic circular, Holistic & Inclusive solutions for a new Paradigm of territorial circular economy
**Type of action**: Deployment of systemic solutions with the support of local clusters and the development of regional community-based innovation schemes

Deliverable Number: D2.2

# Regional Circularity Booster Toolkit

## Development of the operational model and methodology of collecting data, updating, and sharing methodologies to specific groups of stakeholders.

| | |
|---|---|
| Delivery type: | Report |
| Lead beneficiary: | RIC Pro-Akademia |
| Lead author: | Ewa Kochańska |



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| Contractual delivery date: | 30.04.2023 |
| Delivery date: | 28.04.2023 |
| Dissemination level: | Public |



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# Partners



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| HISTORY OF CHANGES | | | |
|---|---|---|---|
| Version | Date | Author/Contributor | Changes |
| 01 | 14.04.2023 | Ewa Kochanska | Released to all co-authors |
| 02 | 15.04.2023 | Rafal Lukasik | Pre-quality review |
| 03 | 25.04.2023 | Dariusz Bielinski | Quality review |
| 04 | 25.04.2023 | Grzegorz Liskiewicz | Quality review |
| 05 | 26.04.2023 | Ewa Kochanska | Technical&quality review |
| 06 | 27.04.2023 | Iwona Adamkiewicz | Quality review |

## Disclaimer





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# Executive summary

The overall objective of the FRONTSH1P project is to ensure the green and just transition of the Polish Lodzkie Region towards decarbonization and territorial regeneration through demonstration at TRL7 of four Circular Systemic Solutions (CSS), interconnected one each other and facing the identified regional challenges/opportunities. FRONTSH1P systemic approach will be enabled by a circular governance model that connects environmental policies with social justice through just transition ensuring environmental sustainability, jobs and social inclusion. The flexibility and modularity of the four CSSs guarantee a high replicability and scalability to other territories across Europe and beyond and this will be demonstrated with the involvement of four additional Regions across EU.

The CSSs are key enablers of a systemic circular model that fosters territorial deployment along five key axes:

1) multi-stakeholders, participatory community-based innovation schemes;
2) circular governance and business models for high replicability and scalability potential;
3) holistic economic, social and environmental assessment;
4) knowledge transfer and dissemination via links with the Circular Cities and Regions Initiative (CCRI);
5) digital platform and methodology for data collection and sharing within the EU General *Data Protection Regulation* and open data compliant frameworks.

This report – Deliverable 2.2 (D2.2) is the result of the work carried out under the Work Package 2 - Regional Systemic Circular Economic Approach, Task 2.2. - Regional Circularity Booster Toolkit. D2.2 meets the FRONTSH1P key enabler and requirement, presents the initial approach of the digital platform creation and methodology for data collection and sharing scheme elaboration. The EU General Data Protection Regulation and open data compliant frameworks have been addressed in D2.2 too.

We embedded the main goals and structure of the Regional Circularity Booster Toolkit (RCBT) (Figure 1) on the current development megatrends, i.e., on-demand, collaborative and app-economy, which intertwine and strengthen the crucial FRONTSH1P paradigm – circular economy development on the regional and local level. We focused attention on the Lodzkie Region as the area for testing and improving the four CSSs before they are replicated



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in the other regions in EU: Campania (Italy), Friesland (Netherland), North Region (Portugal) and Sterea Ellada (Greece).

Within this Report, we considered all aspects impacting development of circularity in a region:

- Technological: Innovative technologies, based on the selected types of waste collected in a region. Accordingly, to the circular economy paradigm as well as the main assumption of the FRONTSH1P project, waste and by-products: before substances or items accompanying the main manufacture cycles are become waste or by-products - are seen as valuable resources for CSSs' production. Hence, the following type of waste are of the D2.2 consideration: wooden packaging waste (CSS1), organic waste (CSS2), wastewater (CSS3) and plastic and rubber waste (CSS4).
- Institutional: Impact of regional and local policy in terms of creating conditions for development of circularity was analyzed. We drew attention to the involvement of local authorities and their unused institutional potential in the development of circularity, as well as the possibility of wider use of good practices created in other EU regions.
- Social: We analyzed the social key drivers that are conducive to a local circular economy development. Such aspects as a labor market, an education system, qualifications and skills available in a region, social acceptance for environmentally friendly changes etc., were discussed. We drew attention to the possibilities of involving marginalized social groups in circular initiatives, for example, in start-ups or social cooperatives establishment or creating networks as contractors for larger companies.

The report is structured via a "top-down" approach, i.e., from more general questions to a specific operating model of the RCBT. RCBT is a set of 5 on-line tools for collecting, sharing and updating information to specific groups of FRONTSH1P stakeholder community, boostering the regional circular economy development:

1) Overarching Regional Circularity Booster;
2) Regional Circularity Technology Booster;
3) Regional Circularity Social Booster;
4) Regional Circularity Institutional Booster;
5) Regional Circularity Booster Mapping.



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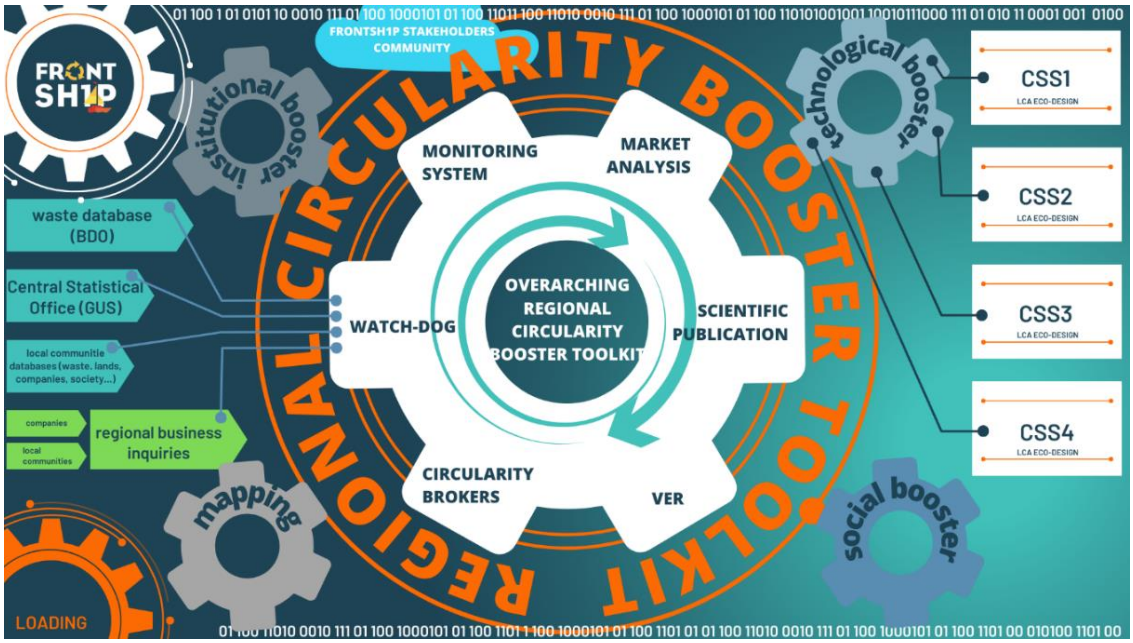


*Figure 1: Scheme of information structure of the Regional Circularity Booster Toolkit*

The Overarching Circularity Booster toolkit provides a basic informational background for the rest of toolkits. It contains groups of information tailored to the needs of the FRONTSH1P stakeholder community. Among them are selected market analysis, scientific publication in scope of circularity, monitoring system with the circularity self-assessment procedures and the voluntary emission reduction (VER) scheme. There are presumptions of two advanced interfaces elaborated – the Circularity broker and the Circularity watch-dog, located on Overarching RCBT and facilitating the management of fast data circulation. The mapping tool will enable visualization of a region in a scope interesting for the user, e.g., where the specific waste processing installations are located, where the specific by-products are ready for picking-up, etc.

Summing up: the RCBT will be based on IT cloud platform as the decision support means, allowing transparent quantification of technical, economic, social, and environmental aspects. These include toolkits for resource management, monitoring circular economy indicators, thresholds of ecodesign, and value chain quantification parameters for simulating the territorial deployment of an overall circular economy value network enabled by CSSs.



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The report is a result of 16 months-long work within WP2. A team of 19 project partners, guided by the Research and Innovation Center *Pro-Akademia* worked on its final form. We join common work and teamwork approach and D2.2 is a result of collaborative effort by a group of specialists with complementary skills, working towards a common goal – the fundaments of RCBT. We are convinced that each member of the author's team put its contribution essential for achieving goals of the Task 2.2.



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# 1. Introduction

## 1.1. The most important megatrends impact regional development and FRONTSH1P project implementation

*A FRONTrunner's approach to systemic, holistic and integrative circular solutions for the new paradigm of territorial circular economy* project directly addresses the current economic and social challenges in Europe and around the world. The project is interdisciplinary, involving the quadruple helix: scientists (academia), companies, social communities as well as regional and local administration. Project activities gathered around four CSSs, which develop specific and innovative technologies, are embedded in the local environment and strongly involve regional and local governments and communities.

The project involves specialists of the technical fields: power, environmental and chemical engineers, data processing and ICT specialists, ecodesigners, etc., environmental areas: biologists, agricultural specialists, etc., economists and sociologists, as well as industry practitioners from SMEs and large international companies.

The project is supported by the Advisory Board, to which belong high-class experts from 4 countries: Italy, UK, Spain, and Poland and by the European circular economy stakeholder platform - Association of Cities and Regions for Sustainable Resource Management.

Therefore, within the project it is feasible to face the most important current global megatrends: Circular economy, Collaborative economy, On-demand economy and App/web - driven economy paradigms as presented in Figure 2.

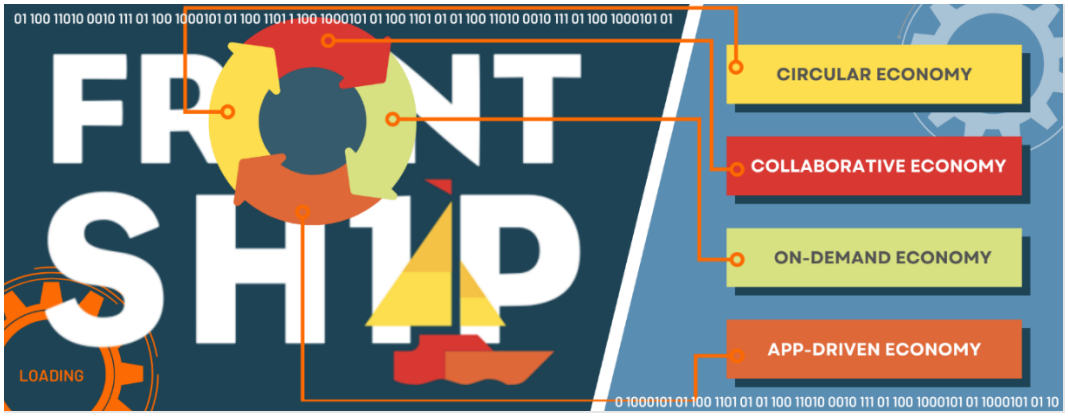


*Figure 2: FRONTSH1P project' incorporation of the current global economic megatrends*



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## How are the circular economy megatrends addressed in the FRONTSH1P project?

Accordingly to the European Parliament (EP) definition [1], circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. When a product reaches the end of its life, its materials are kept within the economy wherever possible. These can be productively used repeatedly, thereby creating further value. The European Commission presumes that the circular economy paradigm implementation is a departure from the traditional, linear economic model, which is based on a take-make-consume-throw away pattern. This model relies on large quantities of cheap, easily accessible materials and energy.

In practice, the circular model of socio-economic development should imply reducing waste to a minimum. It is in line with the concept of the waste hierarchy as given in Figure 3. The main idea of the waste hierarchy model is to prevent/avoid things becoming waste in the first place [2]. It is essential and the most preferred option in the waste hierarchy. Less waste means less need to reuse products, less disposal and most importantly, less waste at landfill sites.


*Figure 3: Traditional Waste Hierarchy Concept*

The waste hierarchy is crucial for the FRONTSH1P project: the technologies, implemented within CCSs create nearly-zero waste approach from the technical point of view but also thanks to the systemic approach to implementation of circular economy principles in practice. However, within the FRONTSH1P project, waste hierarchy is considered as a general and flexible guideline for formulating waste regional and local policies, taking into account environmentally desirable solutions together with industrial and socio economic perspectives [3].



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The European Commission's 2008 Waste Framework Directive [4] introduced the term “4R”: Reduce, Reuse, Recycle and Recover. Since then, researchers have proposed R - frameworks beyond the 4Rs, such as 6Rs [5] or even 9Rs [6]: Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover (Figure 4).

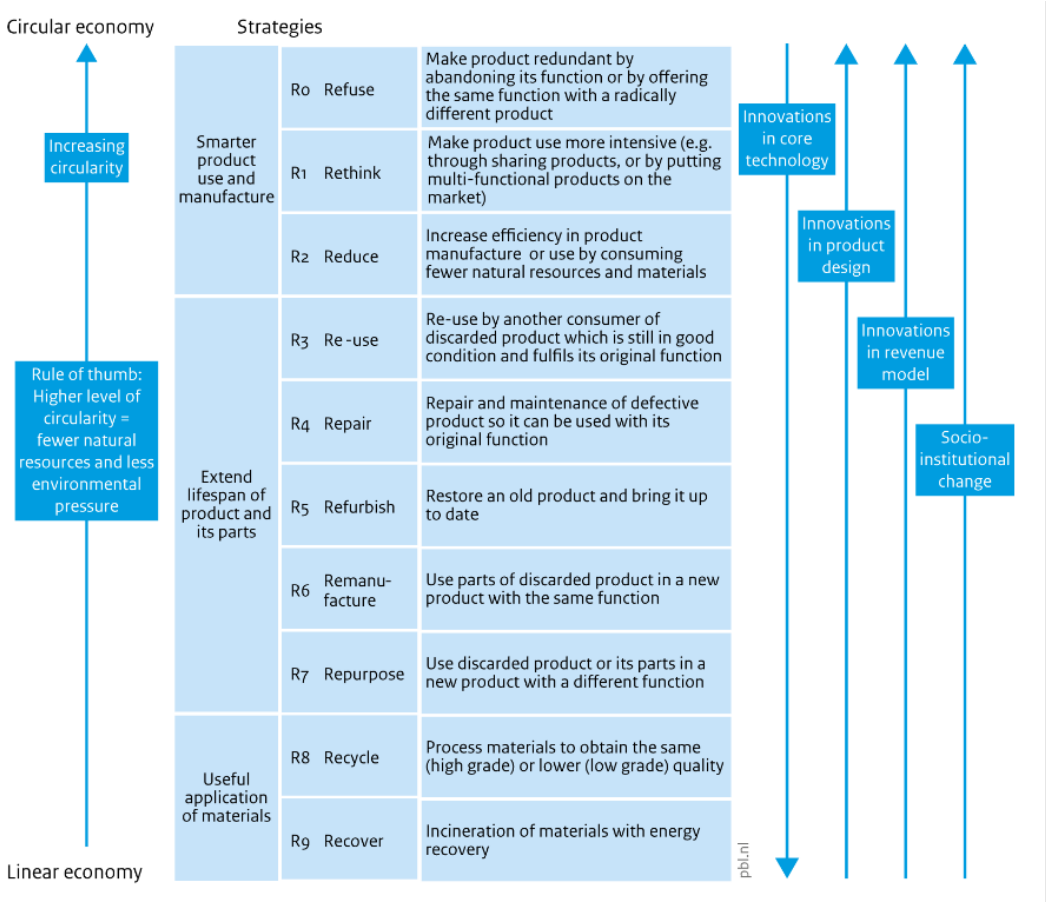


*Figure 4: 9R Strategies [7]*

The FRONTSH1P project addresses the paradigm of the circular economy as defined by the European Parliament, the 9R Strategies (Figure 4) and waste hierarchy concept (Figure 3) and moves them forward. In the result of rethinking of the role of waste in the circularity development, we are willing to change the mind-set from waste management to resource management. Consequently, we are trying to identify what resources, apart from waste, can facilitate and contribute to the development of a circular economy.

CSS approach, proposed in the project means preventing from making waste of not only semi-finished products or by-products including $CO_2$. Within the Frontsh1p project, we



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would like to boost entire unused regional potential including exploitation of marginalized and contaminated soils, groups of communities, remaining on the margins of the social mainstreams, regional and local governments, often breaking them out of routine conservative attitudes.

Similarly, as we define 'by-product', we propose to call all this type of ‘wastes’, as the ‘by-regional potential or by-local potential’, which could be used in order to boost circularity on regional or local levels.

## How is the on-demand economy megatrend addressed in the FRONTSH1P project?

On-demand economy is defined as the instant and pervasive access to goods and services, tailored to meet the individual’s needs [8]. In the last decade, social and economic habits have changed dramatically. The immediacy of our connected world, thanks to instant communication, media and trade, powered the sense of entitlement of all B2B and B2C market participants to immediately satisfy needs [9,10].

On-demand economy megatrend is radically changing the way we transact in the market at the global level and revolutionizing business models, in which companies manage their production and service delivery. At the same time, individuals are radically changing their lifestyle. Under pressure of the On-demand economy rules, decision making processes, concerning both daily and long-term issues, purchases and interactions with the labor market are changing. They must be faster and should consider the rapid pace of changes in the market.

The on-demand economy will experience exponential growth in many aspects of the economy and social life, e.g. amount of every-day information processing. This new paradigm shift is analogous to the disruption imposed by the internet boom. Now, our needs and desires become instantly achievable through the speed and convenience of execution just as the Internet revolutionized the way we acquire knowledge in the late 1990s.

The new organization of the global market and on-demand economy paradigm implementation not only enables or facilitates new processes of production, delivery or organization, but fundamentally redefines the size, scope and role of industry. For sure, information technologies development and dissemination are essential for these changes.

We can see how digital facilitation contributes to an exponential increase in the speed of transactions, expanding the pool of potential service providers and sellers. Online technologies are a tool to change the way and rate of participants' engagement in a particular transaction. Therefore, in the conditions of an over-exponential growth of available



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information, on-demand economy, equipped with ICT communication tools, building and maintaining an industrial symbiosis becomes problematic. There is no need any longer to be bound by long-term contracts, while the economic world offers volatile opportunities that are easy to take advantage of. However, a fundamental asset is to have access to an information base, tailored to our needs and, what is more important, competence on how to use it, facing on-demand economic challenges.

## How is the collaborative economy megatrend addressed in FRONTSH1P project?

Already in 2016, the European Parliament noticed, that "The arrival of collaborative economy is associated with many benefits for consumers and the economy as a whole." [11]. Collaborative economy is defined [12] as a marketplace where consumers/clients create specific nets to meet their wants and needs. Collaborative economies consist of giving, swapping, borrowing, trading, renting, and sharing products and services for a fee, between an individuals or companies who have something and an individuals or companies who need something - generally with the help of a web-based intermediary. A collaborative economy may also be known as a "shared economy," "sharing economy," or a "peer-to-peer economy."

Tempo of implementation of the collaborative economy paradigm, which is observed in last few years, was affected by two complex groups of causes [13]:

- firstly: *increasing public awareness*: growing concern about climate change and growing interest in environmental issues - extreme heat waves and droughts caused by climate change, forest fires, hurricanes, floods, etc.;
- secondly: *global economic and social crises*: because of the Covid-19 pandemic, traditional, long supply chains have collapsed and in many areas of the economy there has been a turn towards a centripetal direction, i.e., local, quasi-autarkic economic development, based on the local potential, including underused resources, better waste management and social inclusion. The war in Ukraine and in the consequence the embargo imposed on Russian energy resources caused a crisis on the energy market and consequently on the food market. Inflation has risen dramatically all over the world.

The Collaborative economy could be an answer to the above-mentioned global challenges. Five key sharing sectors (P2P finance, online staffing, P2P accommodation, car sharing and music/video streaming) have the potential to increase global revenues from around $15 billion now to around $335 billion by 2025. In the UK, these five sharing sectors could generate revenues of around £9 billion by 2025 [14]. It is worth to quote a statement of Veronique Laury, CEO of Castorama [15]: "Most retailers missed the first revolution in retail



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that digital technology brought: e-commerce. I am determined not to miss the second one: which I believe is collaborative consumption. We will not be just a retailer in the future – we will be an organization helping you to improve your home."

The Collaborative economy and collaborative consumption are driven by the development of information, communication and cloud computing technologies, growing consumer awareness, the creation of collaborative online communities as well as social media trading/sharing [16].

Collaborative Economy sectors differ from traditional ones in three basic features [14]:

1) Business models are hosted via digital ICT platforms that combine demand and dynamically share bandwidth in real time.
2) Transactions are made through various methods that offer access instead of full ownership, such as: sharing, subscription, resale, swap and P2P.
3) Shoppers like individuals, but as well as companies and local administrations are more comfortable and fell more connected and locally anchored, being provided with products in a way that involves deeper social interaction than traditional methods of trade and exchange.

The Collaborative economy results in the so-called social inclusion, engaging not only the main stream of social potential in the implementation of the principles of the Circular economy, but also activating "by-social potential" and "by-regional potential" [17].

The FRONTSH1P project will open room to test a few assumptions of the Collaborative economy in practice. Companies and municipalities will be encouraged to test different transaction methods such as: sharing, subscription, resale, swap/exchange and P2P:

- Sharing: the most tangible will be the joint use of the RCBT, the open access ICT FRONTSH1P platform supporting circularity - sharing access instead of full ownership.
- Subscription: companies can subscribe to offers from local NGOs or communities.
- Resale: by-products generated in technological processes within one CSS, as well as $CO_2$ or packaging, could be sold as desirable raw materials for production in other CSSs, otherwise they would become a waste.
- Swap: the FRONTSH1P opens the door to building relationships in the quadruple helix. By anchoring business relations in the local environment, it will be possible to develop new business models that are uncommon for the traditional economy. As part of the project, local activities are planned, such as swapping organic waste for waste bags made of biodegradable plastic, or using the local currency received for plastic waste.
- P2P: P2P technology and services could be adopted by different business activities within CSSs. Semi-peer-to-peer services created within the RCBT and the



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FRONTSH1P platform could help to leverage CSSs' technology in practice. The FRONTSH1P platform will allow to overcome the transaction costs of trust, enforcement and information asymmetries that have traditionally been addressed by using trust third parties, as banks have traditionally dealt with. While the RCBT will not offer payment processing services as the professional P2P platform, the FRONTSH1P platform as a semi-peer-to-peer platform will provide trustworthy, up-to-date market information to help establish a buy-sell relationship in line of circular and on-demand economy paradigms.

## How is the app-economy megatrend addressed in the FRONTSH1P project?

Starting in 2008, Apple has put the cornerstone for the app-economy vision and coined its widely touted and trademarked slogan "There's an App for that." The app economy ideas quickly migrated to Android and mobile platforms. Since then, tens of billions of mobile apps have been designed and downloaded. Generally, the app-driven economy refers to the range of economic activity performing in digital space and surrounding mobile applications. Mobile apps and cloud computing technology created new opportunities for entrepreneurs and changed the way business is done. Cloud computing technology gives users access to storage, files, software, and servers through their internet-connected devices: computers, smartphones, tablets, and wearables [18].

Already in 2012 Ray Kurzweil, the Google engineer and futurist said in an interview with the Wall Street Journal, entitled “Technology and the New, Improved You”, that "*A kid in Africa has more technology at his disposal than the president of the United States did 15 years ago.*"[19] A dramatic increase in the number of new business platforms, as well as in smartphone connected consumers, simplify and secure purchase flows, enables explosion of new types of business models, represented by such business as: Uber - the largest transport company without its own cars, Alibaba, Amazon - the world's largest wholesalers without its own stationary stores, Airbnb - the largest tourist network without its own hotel base and many others cases. The digital transformation in line with the paradigm of the app-driven economy is accelerating global socio-economic changes. It has a significant impact on many areas of life, including private life and social inclusion, social activity, but also public administration, industrial structure and business networks.[20]
Essential to an app-economy and a collaborative economy as well as an on-demand economy and finally – a circular economy development is business platform, managed by a company or group that acts as an intermediary to facilitate consumers’ ability to rely on each other.



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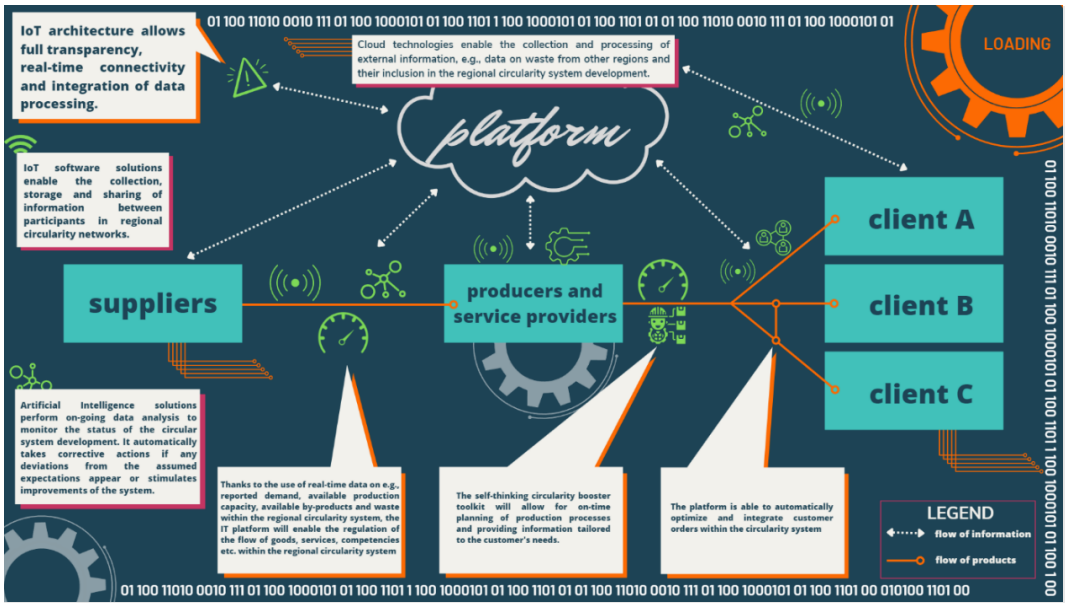


*Figure 5: The general assumptions to self-thinking platforms*

Platforms located in clouds technology are service-based systems enabling communicating and carrying out transactions, also collecting, processing and sharing data in different relationships user groups, i.e., B2B, B2C, C2C, B2B2C and B2C2C (Figure 5).

## Selected EU platforms for implementation of industrial or regional circularity - lesson learned for RCBT development

Considering how to build an optimal platform, i.e., the RCBT that is supporting regional circularity and addressing quadriple helix perspectives within the FRONTSH1P project - it is worth to examine the examples of the following ones:

1. www.restado.de (Figure 6)

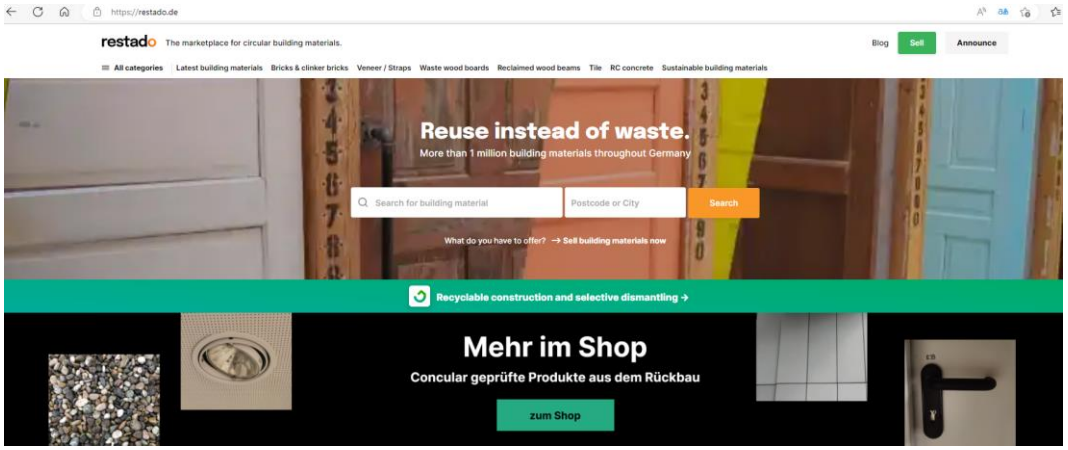


*Figure 6: Reuse instead of waste platform*



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The Restado platform is the largest marketplace for recycled building materials in Europe, providing a circular solution, serving private and professional sellers and buyers. Materials available on the platform come from ex-construction or oversupply or are left over from various projects. About one million items worth over EUR 40 million are available on the platform, i.e., bricks, wood, tiles, windows, doors and facade elements. Using the platform reduces the level of waste and at the same time cuts $CO_2$ emissions. It is worth saying that transactions carried out via the platform allowed to save over 1 million tons of greenhouse gases.

2. www.circulor.com (Figure 7)

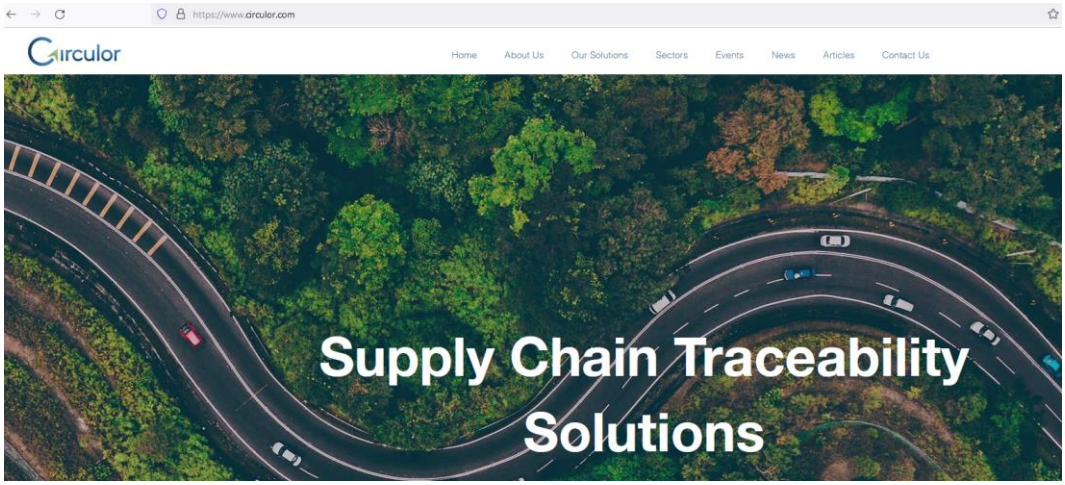


*Figure 7: Supply Chain Traceability Solutions platform*

The Circulor platform is a tool for tracking goods and measuring external costs in the supply chain. It improves the transparency of flows in the supply chain of the electro mobility industry. It supports the development of a closed loop in the sectors related to the production of lithium-ion batteries providing a platform for assessment, measurement and responsible use battery acquisition. It is able to trace the origin of recycled materials and reduces use of new as well as reduces the carbon footprint resulting from the production of batteries for electric vehicles. Circulor uses block chain, machine learning and IoT.



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3. www.circularbenchmarktool.eu (Figure 8)

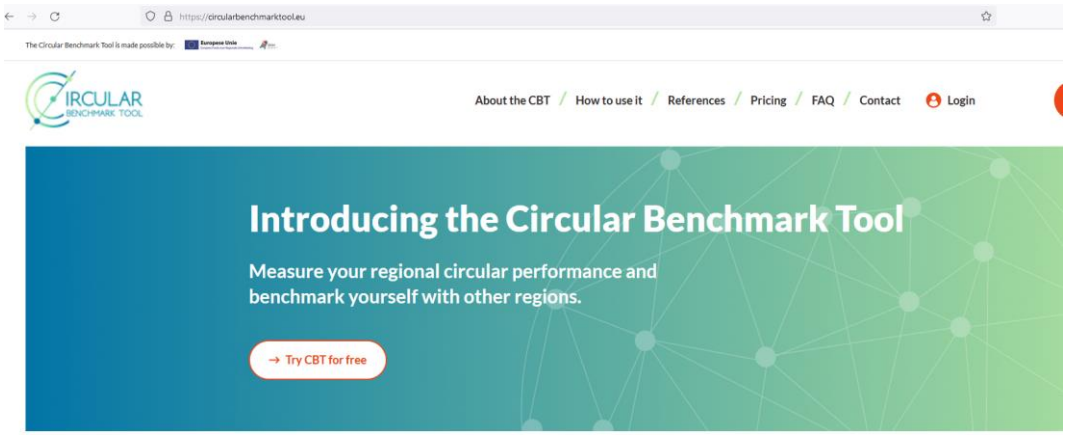


*Figure 8: The Circular Benchmark Tool platform*

The Circular Benchmark Tool (CBT) [21] consists with ICT solutions for an effective assessment to understand, visualize, and compare the transition towards a circular economy for regions and provinces. One of the aims of the CBT is to act as replicable tool for knowledge exchange to improve regional circular performance and facilitate cross-regional learning about circular economy.

The methodology behind the CBT is developed in a stepwise approach based on learning, validating and applying. It uses 6 overarching indicators addressing:

- Circular procurement: how a region and the regional stakeholders engage public and private suppliers to increase procurement (and do this themselves), based on circular economy principles;
- Value chain activation: how a region stimulates circular value creation among stakeholders, including businesses within and across supply chain, resulting in or fostering systemic circular solutions;
- Access to funding: how a region enables access to public and/ or private finance circular activities, projects and organization that play a key role in the circular economy;
- Good governance: how a region orchestrates, facilitates, promotes and enables the circular economy transition;
- Circular society: how a region creates awareness, motivates people, develops and deploys circular knowledge and skills that contribute to the circular economy transition;
- Integrated policy framework: how a region establishes and integrates coherent circular policy domains to align policy, instruments and legislation with circular principles.



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The CBT is built on the maturity levels assessment: mapping, planning, doing, checking and acting, leading by examples (Figure 9).


*Figure 9: CBT's Maturity levels of assessment*

The proof of concept of the CBT was developed within the Replace project, financed within the Interreg Europe Program [22] and the IT solutions were worked out by the Northern Netherlands Alliance. Finally, after discussion with the CBT management team on the google meet communication platform, on Monday, January 9, 2023, we can conclude that there is room for interesting cooperation between CBT and the FRONTSH1P project and the RCBT as shown in (Figure 10).

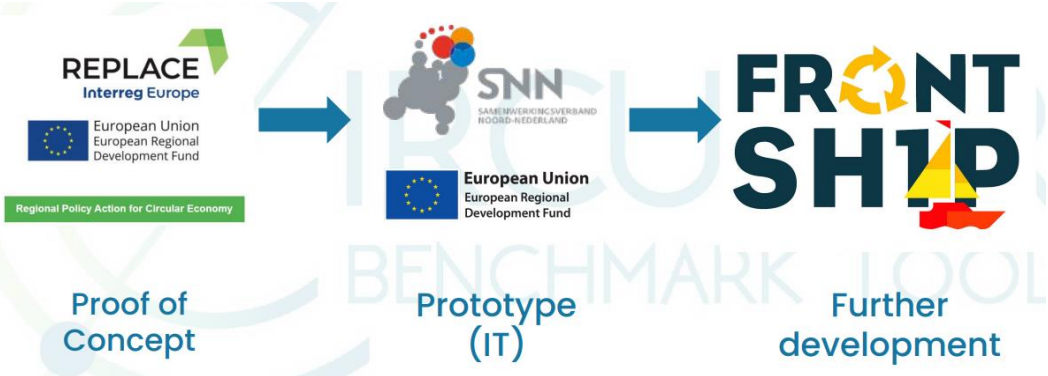


*Figure 10: Potential for cooperation across CBT and RCBT.*



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4. www.mamodpad.wastemaster.pl (Figure 11)

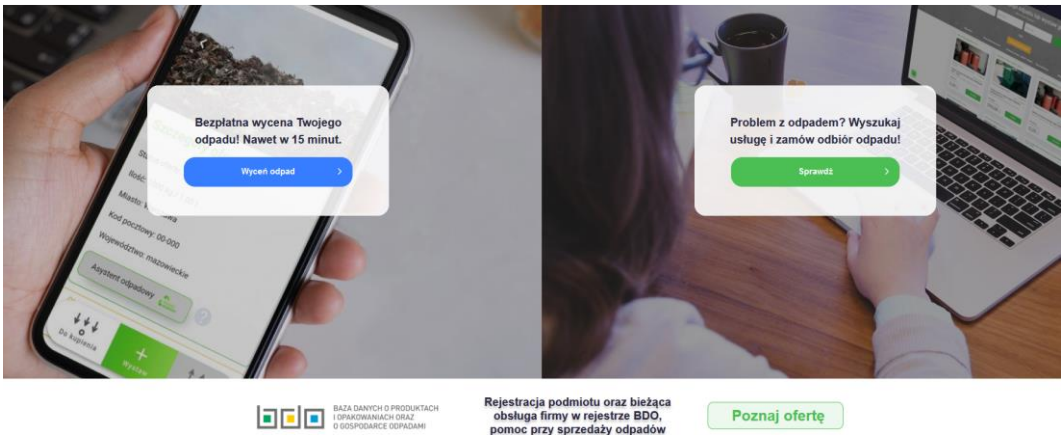


*Figure 11: MamOdpad.WasteMaster Platform*

The MamOdpad.WasteMaster Platform is a matchmaking tool, delivered only in Polish and acts as a national waste exchange, joining waste producers and potential contractors. The website is a database of information on a wide spectrum of wastes, such as: scrap, non-ferrous metals, electronic waste, used batteries, textiles, catalysts, medical waste. Interesting from the CSS1 perspective is info of such waste as wooden waste, wastepaper, packaging waste, construction waste. CSS2 managers can find on the platform data in scope of bio-waste used cooking oil and municipal waste. For CSS4 development will be useful information of plastics, tires, RDF, chemical waste, used oil.

Entities - companies or individuals - interested in the MamOdpad Platform can find there the right waste as well as order a collection or delivery service throughout Poland. The MamOdpad.WasteMaster platform connects recycling companies and makes their offers available to interested parties to reuse waste in accordance with the circular economy paradigm. The platform brings together large and small companies as well as local governments and individuals with recyclers, who offer waste purchase. The waste exchange on MamOdpad.WasteMaster Platform works online.

It works across platforms:

- Android: https://play.google.com/store/apps/details?id=pl.wastemaster&pli=1;
- iOS operating system: https://apps.apple.com/pl/app/wastemaster/id1533301159?l=pl
- web version: https://app.wastemaster.pl/offers (Figure 12).



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*Figure 12: WasteMaster Application*

Additionally, to ensure proper segregation, the platform offers the option of ordering containers for a specific type of waste collection, e.g., containers for wood, insulation materials, etc. At the end of 2022 year, the most popular waste on MamOdpad.WasteMaster Platform was plastics.

6. https://obec.ecta.si/ (Figure 13)

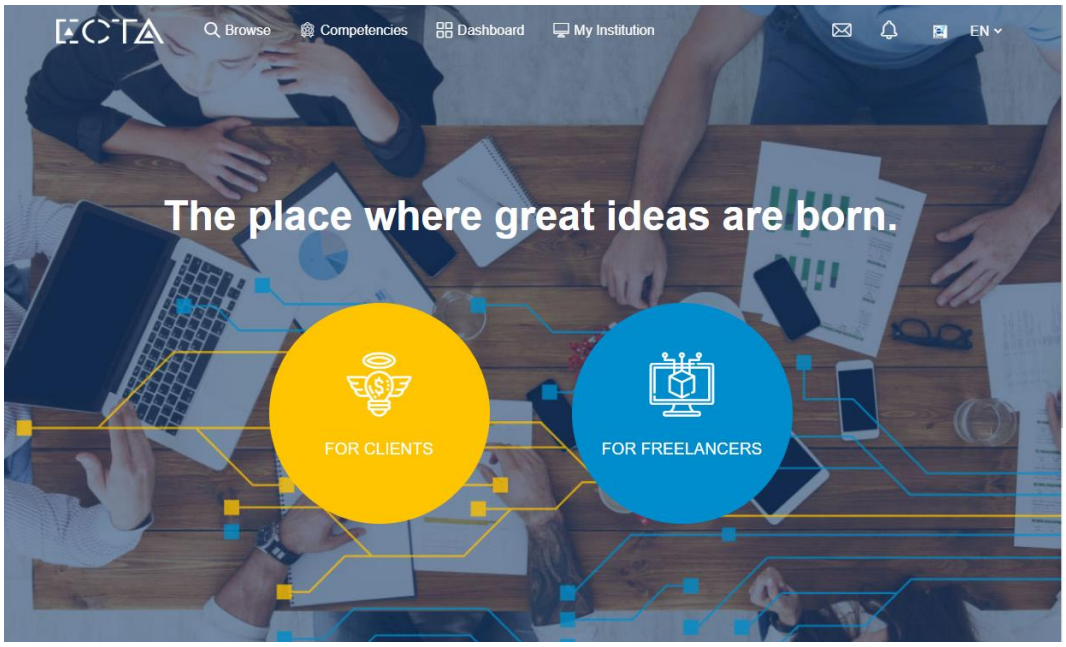


*Figure 13: The ECTA Platform*

ECTA is a platform that enables the standardization and issuance of competencies and credentials. ECTA platform can be an example how to identify circular economy opportunities in the local labor market.



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The platform was developed under the OBEC project (One Block for Educational Credentials; 2020-1-SE01-KA204-077803) within an innovative Erasmus+ project which aim was to explore the possibilities that Blockchain Technology in the educational field.

The main focus of the project was on how Blockchain Technology could issue certifications that are trustworthy and recognized in various national contexts. This would be beneficial to the speed at which migrants, exchange students, ex-pats and those with alternative learning backgrounds integrate into the labor market.

The ECTA platform adds to this aim competencies which are crucial for successful integration at various levels. This is based on four main functionalities of the platform: generating degrees and programs for educational institutions, generating competencies for learners, referred to as "freelancers" based on these programs, generating competencies for freelancers based on the projects they have been active in, and registration of competencies. The issuers of the training courses or programs referred to as "clients" can develop training courses and encode the competencies based on the contents of this program to the ECTA platform (Figure 14).


*Figure 14: A competency-based on a training course*

These competencies are categorized into base competencies and categories. Base competencies refer to a "parent competency" that includes various competencies, such as "entrepreneurship". The category to a broader spectrum of the context the competency is often used in, such as "business" for example.
Upon completion of a program, the freelancer collects multiple competencies. These competencies will appear on the personalized freelancer page. Eventually, degrees will also appear on this page creating an overview of the educational track of record of the freelancer (Figure 15).



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*Figure 15: An overview of the educational track of record of a student*

Employers have access to the ECTA platform to either encode competencies and programs to the platform for their employees or recruitment purposes. This eventually increases the employability of the target audience of the project and thus helps to achieve the project's main aim.

Summarizing: The lessons learned from the analysis [23] of the platforms portrayed above, are at the core of RCBT.
The RCBT, planned within the FRONTSH1P project is a "self-thinking" platform that meets all main assumptions of the architecture of cloud computing technology.
The RCBT, which is to support the circularity paradigm implementation in line with new megatrends, addresses flows of all kind of assets: information, products, services [24]. Additionally, the RCBT will present information, looked-for circular development in real time with up-dated geo-location.

The RCBT has been conceived as a set of on-line tools for collecting and sharing information concerning the available in the region feedstock and waste streams, needed for CSSs' technology implementation. Feedstock is understood broadly and refers to by-products from production, but also marginal lands and unused administrative and social potential.

The RCBT will empower Circular Economy Brokers that will proactively engage stakeholders and citizens in creating opportunities for circular business and social innovation. The development of the operational model and methodology of collecting data, updating it and sharing it to specific groups of stakeholders will be worked out.



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## 1.2. CircuPancture Model as a step towards circular economic transition for the Lodzkie Region

The basic way to coordinate circular policy (D 2.1) is a platform “RCBT”. In particular, the module supporting and creating conditions for social, economic and environmental policies in the region will be beneficial for public authorities.

The circular economy aims to minimize the negative effects of anthropopressure and is an opportunity to continue the processes of socio-economic development. It is also a stage in the evolution of the used-to-date socio-economic systems. However, both represent insufficient motives to adapt the principles of its functioning. The traditional approach to shaping and modifying the conditions of development policy relies on implementation of new rules embodied in a new set of standards, regulations and incentives prepared by public authorities. The traditional approach for development policy is ineffective in many territories. As research results showed, in the Lodzkie Region there are many market failures and a low integration of activities among various stakeholders(D2.1). These conditions reduce the effectiveness of the traditional, arbitrary, holistic approach during implementation of circular economy. Therefore, it needs bilateral intervention. Firstly, it is necessary to prepare favorable conditions for the transformation of the economy at the regional level. A regional Action Plan for Implementation of the Circular Economy is needed. Secondly, an active and integrated bottom-up intervention is in high demand.

The operationalization of the Circular Governance Model will depend on (D2.6):

- development of the Circular Governance Model in the Lodzkie Region, with particular involvement of the community and other stakeholders,
- preparation of a policy roadmap.

The development of the Circular Governance Model is struggling as it requires an approach different from the typical methodology of strategic management. The high number of market failures, the low level of interaction between local stakeholders and the ineffectiveness of incentives, including the low level of GPP application, force the use of a different method to implement and to manage a circular territorial cluster (D2.1). The transformation of the economy from a traditional market model to a circular economy requires profound changes not only in structures but also in the awareness of its participants. The existence of a circular economy requires building new business models based on the following philosophy: Collaborative economy, On-demand economy, App/web - driven economy.



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In systems/territories that do not have the ability to self-adapt to the circular economy, a different approach for the implementation of the Circular Governance Model is necessary. The philosophy of "small steps" aimed at achieving strategic goals using an adaptive approach should be applied. It is important to implement innovative solutions. These solutions should be implemented as a sandbox project. It means that they should be tested, corrected and implemented on an ongoing basis. Such a way of achieving the goals will enable their promotion and diffusion, as a consequence of replication in other territories. For this purpose, we propose to implement an innovative Circular Governance Model, which we call the CircuPuncture Model (Figure 16).

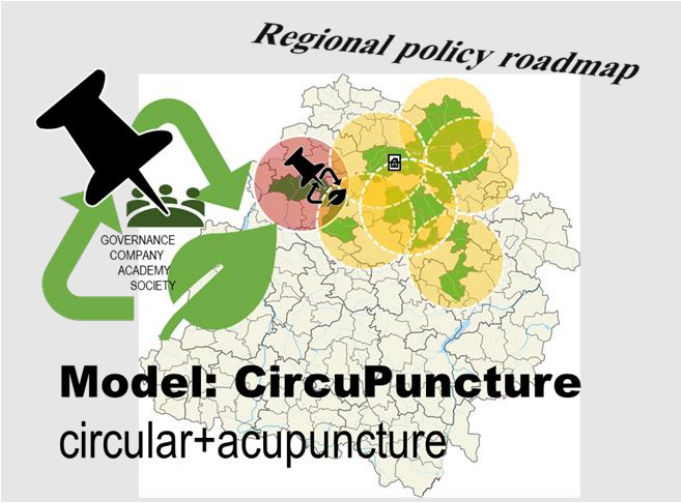


*Figure 16: Circular Governance Model by dint of CircuPuncture*

The name of the model comes from the combination of two words: "circular" and "acupuncture". The idea of the model has its roots in urban planning and ways of reengineering cities [25]. CircuPuncture Model is:

- a method based on integrated tools of interpersonal and collective communication, supported by ICT technologies ("app economy" [26]);
- methodology for implementing small-scale investments in a situation where it is difficult to initiate and implement a holistic vision of development in one step or with one large project;
- method of action to implement strategic goals involving in activities for development individual stakeholders;
- a method of bottom-up action initiated by individuals/(stakeholders) aware of the conditions and needs of the organization of the circular economy;



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- method of coordination and, consequently, integration of multi-agency, dispersed sectoral and cross-sectoral activities/(projects);
- the mechanism of coexistence of the social, economic and natural spheres based on market logic;
- mechanism of coexistence of the social, economic and natural spheres based on symbiosis and sharing;

To sum up, CircuPuncture is a strategy of acting on a smaller, local scale. As stated above CircuPuncture methodology relies on creating, organizing, managing and improving the Circular Territorial Cluster (CTC). The local territory is treated as a laboratory for creating, implementing and testing innovative projects - Circular Local Booster (CLB). CLB is then ready for replication to other places in the cluster or to other CTCs.

CTC is not a simple sum of industrial symbiosis and industrial clusters. It also contains specific characteristics (more in D2.1). The CTC is not an ordinary industrial cluster because it is not based on companies from the same sector or related sectors. This is a fundamental difference. The CTC is not just industrial symbiosis because the primary objective of operating in an economic network is not limited to SDGs and managing the closed cycle of natural resources. The CTC is a kind of locally embedded economic network. Embedding in this case has a strong link to the existence of short supply chains for raw materials and goods. In this network, besides the classical actors for Helix models (Triple, Quadruple, Quintuple Helix), citizens (Society) play an important economic role. Here, society is a co-producer, an active, economic market participant. The CTC is a multi-sector network due to the thematic scope of the Circular Economy. An important area of CTC interest is waste, which is perceived as multi-component raw material. Therefore, their use involves partners from various economic sectors. CTC is built on added value chains created between companies of various industries. This type of relationship is based on both individual and collective benefits. The functioning of this type of cluster requires an appropriate environment – an entrepreneurial social ecosystem. It combines the properties of an Innovation Milieu (industrial cluster) with the features of ecological systems by including inhabitants as producers of goods and raw materials. The local community is a key actor in change and the missing link. The issue is not only about passive awareness. The local community is obliged to engage in circular systems actively: by changing and adjusting its norms of behavior, assuming the role of producers (prosumers), consciously shaping market preferences and market demand, and independently providing each other services. The circular economy is strictly territorial. This means that the properties of the territory - the



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properties of each of the key stakeholder groups are crucial for building the competitiveness of CTC.

Participants involved in the circular territorial cluster are partners (institutional or individual) with varying degrees of autonomy and objectives. The independence of individual partners fosters innovation and investigation. The cooperation between them is renewable and long-term. The CTC enables access to scarce resources and skills. The CTC's partners share the costs and risks of the projects. An important factor determining the network's competitiveness is its members' complementarity and the synergy effect. Entities forming this type of circular territorial cluster may belong to other networks at the same time. The networking of actors, communication channels and management relationships is horizontal. The traditionally understood organizational hierarchy loses importance, and the dominant structure is flat. By moving away from formally independent units, better conditions for cooperation are created. The coordination between parties is negotiation and agreement rather than competition. Individual organizations and the entire circular territorial cluster have higher flexibility and adaptability. There is a noticeable intermingling of market actors; such arrangements are referred to as borderless organizations [27]. Partnership in this network is based on mutual trust, shared ideology, and reputation [28].

The CTC uses an open innovation model scheme. The processes of knowledge diffusion and mutual learning are like collective intelligence choices. So, collective decision-making capacity is more important than a potentially better individual solution in a particular community. This method of optimizing choices results from limitations in the perception of the circular economy market, concerning legal and formal barriers and market failure, and secondly, the lack of incentives or differentiated effectiveness of incentive communication models. CTC is a business vehicle because profit is the strongest motivation for partner involvement, including society. Hence, relationships besides cooperation between circular economy market actors are also competitive. The business model for organizing the local circular economy market in the CTC formula can take many forms. Still, its important feature is the dominant market nature of regulations, enhanced by CSSs (more in D2.1).

The CircuPuncture model requires tailored preparation of the communication and transactional infrastructure, the involvement of circular brokers, coordinating institutions and diagnostic information. The activities will concern the development of the RCBT, a set of on-line tools for collecting and sharing information regarding the available feedstock and waste streams.



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Model CircuPuncture allows a set of good practices to be replicated in order to achieve the benefits of cooperation on a territorially larger scale. Clearly, there is a need for proper coordination of such a cooperation arrangement. Therefore, we proposed the management framework of the CircuPuncture model (Figure 17).

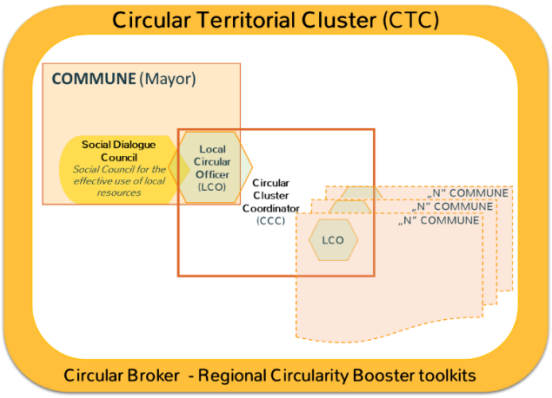


*Figure 17: Management framework of the CircuPuncture model*

Circular Cluster Coordinator (CCC) (example: ZM Bzura) – an entity, association that initiates and seeks participants for cooperation, and then coordinates and mediates in further stages of operation. It is characterized by a high level of competence in communication, negotiation and coordination of distributed units. The role of the CCC in establishing cooperation comes down primarily to identifying key necessary competencies, negotiations between partners and providing circular territorial cluster participants with advisory assistance in formulating cooperation rules. Once the circular territorial cluster is operational, the CCC's initiative mainly manifests in supporting and facilitating the network development process and searching for other market actors. The most important function of the CCC is to replicate the CircuPuncture model to subsequent municipalities. Consequently, the aim is to ensure that the conditions for a circular economy function in each commune. Of course, this transition will consider local differences - each time, the CircuPuncture model should be adjusted to the territory.

An essential link in this system is the local community, which must actively participate in the implementation, operation, and development of the CircuPuncture's management model. They are perceived as co-producers of final products and services. The Social Dialog Council (SDC) will be a helpful body in relations with local communities. Its role is not only to interact with society but also to ensure the efficient use of resources.



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The SDC guarantees the democratization of the management process, which is a condition for the functioning of the circular economy. The SDC is a team of local community leaders. Close cooperation between the Local Community Officer and the SDC is important for creating and adapting circular development policy to local needs.

The RCBT platform, functioning as a Circular Broker of a cluster, is a space and a tool that facilitates the implementation of CircuPuncture.



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# 2. Methodological approach to data sources

The development of circularity in the region is about building openness to changes among local actors who create a functional system, and it also emphasizes that it is entirely a subsystem of more complex existing systems. An important element are the databases prepared at various levels of local government administration. The current approach to analyze databases indicates the challenges faced by entities managing this data resource. It leads to building the interoperability of databases supported simultaneously by their openness. Open access should be understood in many dimensions in public administration and inter-institutional collaboration. Data openness is also important for the science sector, which can provide multidimensional research. The research results are easier to reach by local communities, which are a primary link in building circularity.

Among identified gaps related to data accessibility are users outside the institutions operating the databases that have difficulties or no access to their content. This situation leads to longer decision-making chains that may affect the interest of circular economy operators in resources that can be recycled and reused. Readers should also point out that the best dataset, constituting “the mother base”, may become a geospatial database that will link the other databases through the spatial location. It is because in the EU open access to spatial data has been developed since 2007 based on the Infrastructure for Spatial Information in the European Community (INSPIRE) directive [29,30].

Databases and the recommendation for their interoperability lead to the generation of an interconnected vessel effect in database resources. This leads to synergy, which is a desirable effect in any development process. Obtaining the synergy effect and replicating solutions nationally and in the European Union will allow the development of an economy of scale, which will significantly support the idea of building circular clusters. Interoperability is also expected to lead to increased opportunities for linking different thematic databases not necessarily directly related to the circular economy [31]. It will represent the added value resulting from the creation of databases.

Studies on database interoperability (Table 1) indicate that institutional databases endeavor to generate ties. An example of such databases is those developed by Statistics Poland. Spatial databases are also of great importance, with a high degree of interoperability locally and in EU space, thanks to the INSPIRE Directive [32,33].



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*Table 1: Potential for interoperability in the Polish databases in the field of circular development*

| NO | DATABASE NAME | SHORTCUT NAME | SOURCE | CONNECTION WITH OTHER DATABASES |
|---|---|---|---|---|
| 1 | Regional Fund for Environmental Protection and Water Management in Lodz | WFOŚiGW | https://www.wfosigw.lodz.pl/ | Lack of direct connection |
| 2 | National Science Centre Poland | NCN | https://www.ncn.gov.pl/ | Lack of direct connection |
| 3 | Waste Catalogue | WC | http://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20140001923/O/D20141923.pdf | Lack of direct connection |
| 4 | Database on Products, Packaging and Waste Management | BDO | https://bdo.mos.gov.pl/ | Lack of direct connection |
| 5 | Registry of an Entities of National Economy | REGON | https://wyszukiwarkaregon.stat.gov.pl | TERYT |
| 6 | Local Data Bank | BDL | https://bdl.stat.gov.pl/bdl/start | TERYT, BDOT10k |
| 7 | National Official Register of the Territorial Division of the Country | TERYT | https://eteryt.stat.gov.pl/eTeryt/rejestr_teryt/aktualnosci/aktualnosci.aspx | Registry of an Entities of National Economy |
| 8 | The Database of Topographic Objects | BDOT10k | https://www.geoportal.gov.pl | TERYT |
| 9 | Intellectual Property Rights - e-Search | IPR | https://uprp.gov.pl/pl | Lack of direct connection |
| 10 | Combined nomenclature | CN | http://www.klasyfikacje.gofin.pl/cn2023/12.0.html | Lack of direct connection |
| 11 | Central register and information on economic activity | CEIDG | https://aplikacja.ceidg.gov.pl/ceidg/ceidg.public.ui/search.aspx | Lack of direct connection |
| 12 | Tax Publishing House GOFIN sp. z o.o. | GOFIN | https://www.gofin.pl/ | Polish Classification of Activities |
| 13 | An information and service website for entrepreneurs | - | https://www.biznes.gov.pl/pl/tabela-pkd | Lack of direct connection |

*Source: own compilation*

The challenge for circular region-building activities will be to build knowledge bases connected with resources generated in each region. It should form the basis for cooperation



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between Eurostat and Statistics Poland and counterparts of national statistical bodies in all EU Member States to build data sets in the scope of circular economy indicators. It is particularly important for identifying circular economy needs both regionally and at lower levels of administrative divisions, which will allow more accessible adaptation of proposed circular economy solutions.

Action taken on the circular economy should also include building databases on waste imports between countries. Such projects lead to a distortion of the information available on recycling, recovery and reusing in individual Member States. It is associated with a change in the coding of waste. Such actions lead to a distorted assessment of circularity in the region and the country or the EU. Measures to monitor the flow can be based on the SENT (System for Electronic Transport Supervision) IT system, which is used to circulate heating fuel.

The biggest challenge regarding regional circularity-building opportunities is the collection of real-time data supported by spatial references. Platform connected to this goal will open up an information base about the region's circularity-building potential. The spatial database construction is expected to lead to multi-directional links between generators, recyclers, and companies interested in using a specific type of waste. In the first instance, the platform will focus on the collection of CSS data contained in the FRONTSH1P project. The next step will be expanding it with new elements beyond the needs identified by the project partners. The data exchange platform will become the basis for implementing circularity in practice. Depending on the GIS database attributes used in the design process, it will be possible to perform analyzes through object features and spatial analyses. In the latter case, readers should note that the database will support planning the shortening of supply chains used by companies interested in a particular resource type. The unification of the platform will allow its implementation in other regions of Poland and the EU.



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# 3. Data needs of RCBT

Information in its raw form is useless to any organization. Data pre-processing is one of key elements allowing for its efficient use. Therefore, raw data should be processed and translated into purposeful information: useful, justified and tailored to the profile of specific stakeholders. "Tailor-made information" means the appropriate content considering data needs of the recipients, the appropriate form, adjusted to competences and ability to read and understand recipients, as well as the appropriate moment of its delivery.

Preparing accurate and purposeful information as part of the data processing process is a considerable challenge. It requires the organizers of the data processing to know the information needs of the recipients. The term "data processing" means a series of different operations that are performed on data in an automated or manual manner. It includes activities such as collection, recording, organization, structuring, storage, adaptation or modification, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction of data. Data processing in its essence refers to the extraction of information through organizing, indexing and manipulating data. Information here means valuable relationships and patterns that can help solve problems of interest [34].

From the perspective of the regional circularity development, purposeful information and data processing are crucial for implementation of CSS as well as for creation complex regional strategies or action plans, addressing jointly quadruple helix interests.

The next step is the identification of available databases, containing information, addressing stakeholders' data needs, together with analysis of their organization, structure, time of up-dating etc. The crucial aspects of databases investigation are to identify and select the appropriate codes, which enable purposeful information extraction. The data processing stages will be performed by cloud computing solutions. The cloud computing tools will be adopted and implemented to process appropriate data within FRONTSH1P project and finally share the purposeful, tailored information for regional circularity development.

We have assumed several rules for processing and finally sharing the information on the FRONTSH1P platform:

- information should be easy to find and brief.
- presentation of the information should be logical, of highly specific content and directly relevant and to the needs of FRONTSH1P' stakeholders and all users beyond the project.



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- the clear, concise wording as well as a common language of benefit [35] should be practiced on the FRONTSH1P platform.
- procedure of sharing the kind of information that users might not be actively looking for, but knowing would benefit them.

All purposeful data on the FRONTSH1P project platform will be presented in readable, intuitive formats such as charts, diagrams, and documents, which stakeholders across the project can easily understand and use (Figure 18).
The data processing tasks will be developed step by step by a team of data organization and management scientists within WP2 undertakings and data processing engineers within WP7 activities.

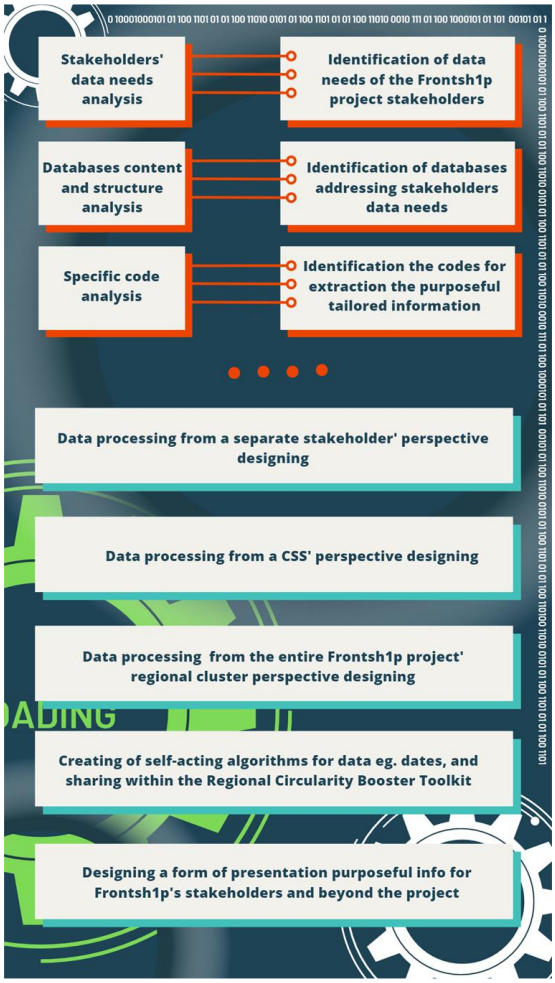


*Figure 18: General schemes of data needs for boostering regional circularity*



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## 3.1. Overarching RCBT

RCBT is a set of tools that enable the implementation of the circular economy model into the economic and social practice of the Lodzkie Region, and then into the other regions. The main presumption and the benefit too are managing unused local potentials. By unused or so called regional by-potential we mean:

- Firstly: locally available resources and raw materials, focusing attention on waste, but also marginal lands, which are the basis for the development of technology under CSS1, CSS2, CSS3 and CSS4. For the development of the circular economy from the technological perspective, the Technological Booster Toolkit has been defined.

  In addition to securing resources for technological processes for each CSS, the Technological Circularity Booster will collect and provide information on by-products that may appear at various stages of production. The set of specific by-products may be offered for the other CSSs on an industrial symbiosis basis or for sale on available markets. Sales directions will be determined by LCA and ecodesign analysis. Similar LCA and ecodesign analyzes dedicated to final products of each CSS technology will be carried out in scope of the final products.
- Secondly: locally available and not fully used institutional potential, especially in terms of creating local policies in line with development of circularity. Local authorities on the regional level (Lodzkie Region, as well as Campania Province in Italy, Friesland in Netherland, CCRD North-Region in Portugal and Sterea Ellada in Greece), as well as cities and municipalities and their associations, can significantly impact the development of circularity. However, taking into consideration current development megatrends: circular, on-demand, cooperative and app-driven economy, their role is changing. Local administration is expected to be an active participant in the transition processes from a linear, hierarchical and consumption economy, incrementaly polluting our planet, to a circular and environmentally friendly economy. Entrepreneurs and citizens desire partner relations with local authorities and expect comprehensive knowledge and communication skills from them. Simultaneously, they expect that, considering the interests of individual companies and people, the local administration will stimulate the local development of circularity, using a set of e.g., incentives, local taxes and other means like special tailored subsidies, tax reliefs, targeted promotion, etc.

  Within the FRONTSH1P we assume that the implementation of the circular economy model by local institutions will be orchestrated with the quadruple helix approach. In



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order to facilitate the implementation of the above objectives, local institutions will be supported by a set of information tools – The Regional Institutional Booster Toolkit.

– Thirdly: locally available but not fully used social potential that can be easily engaged in entire CSSs enlargement. Moreover, the social inclusion to circular local economy development is a path for synergies in many dimensions: economic, intellectual, environmental. So, just as companies and local authorities are expected to have comprehensive knowledge of economic megatrends and communication skills, the same expectations apply to NGOs and citizens. The Regional Circularity Social Booster will support non-governmental organizations to create new values for local society, establishing close, beneficial cooperation links to companies.

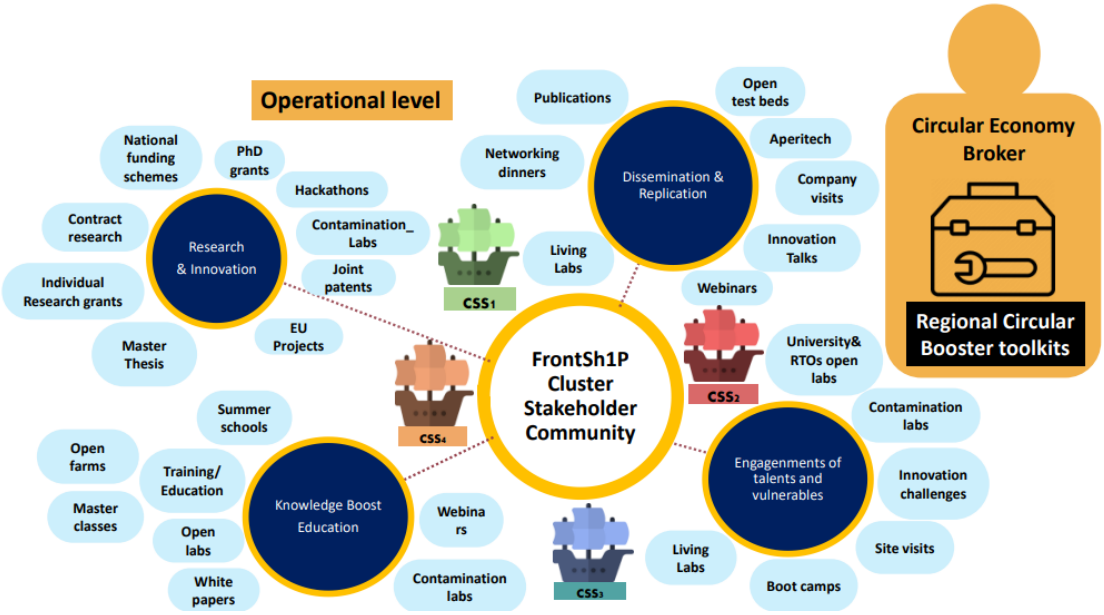


*Figure 19: The RCBT for FRONTSH1P stakeholders' community*

The cluster stakeholder community is at the heart of the FRONTSH1P systemic solutions. In order to meet all the expectations presented in Figure 19 and to ensure the dynamic development of CSSs, the Overarching Regional Circularity Booster Toolkit (ORCBT) has been planned, which is going to be in accordance with the current socio-economic megatrends. The role of ORCBT is to provide the FRONTSH1P stakeholders community with tailored, key strategic information of interdisciplinary character, anchoring circular activities in the current local reality in the global and European perspectives (Figure 20).



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Therefore, the ORCBT consists of the following tools:

1) Selected current market analysis (see sub-point 7.5) regarding the development of circularity and useful for institutional, social and technological Toolkits. The ORCBT will periodically review information bases where current research and reports, prepared by market research agencies are located, e.g., market analysis under CSSs interests, reports on the state of the environment or reports on social awareness research in areas important for the regional circularity development.
2) Compiling, updating and sharing the scientific knowledge in scope of circularity as well as the current regulations (see sub-point 6.8). By making the results of the latest scientific achievements published in such databases as Scopus or Springer available to the general public and all RCBTs, together with admission to the open-source knowledge repositories of leading university publications, the high scientific quality of FRONTSH1P solutions can be guaranteed. On the other hand, access to updated legal regulations along the global, EU, national, regional and local levels, legal consistency of all FRONTSH1P activities will be maintained.
3) The VER Program (see sub-point 6.3), not only in scope of principles, but also practical guidelines and tips on how to become an active participant in the Program will be made available on the ORCBT. We believe that the VER concept will be attractive for all stakeholders of FRONTSH1P communities, i.e., for companies, local administration, NGOs and citizens.
4) Within the FRONTSH1P project the new concept of circularity brokers is launched as Circular Economy Brokers. Circular Economy Brokers are seen more as cloud ICT tool within the ORCBT than a person dedicated only for circularity development for one or more institutions. The Circularity brokers as a kind interface will be able to support all RCBT - companies, local institutions, NGOs and citizens, offering specific tailored information.
5) The Circularity Broker will have his best companion, the circularity watch-dog – an interactive tool for collecting and automatically transferring information to the selected recipients in scope of their identified needs and offers, prepared by all FRONTSH1P community stakeholders. The watch-dog will look after opportunities for the development of local circularity, will track available waste and, more broadly, by-products and by-potential, and after finding it, will announce it loudly. Moreover, it will bring the acquired information to the recipients who are waiting for it. Then, the watch-dog will look after the important data on command from the Circularity broker. In practice, the circularity watch-dog - the interactive tool - will look for, find and immediately transfer data to the identified recipients, guided by a set of appropriate parameters.



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6) The task of Regional Circularity Booster Mapping (see sub-point: 4.5) is to generate a geodatabase for mapping the studied Lodz Region in Poland, which will be applicable to the other four regions of replication, in Portugal, Italy, Greece and Netherlands. Mapping will enable the identification of favorable spatially inducible synergies between waste or by-products suppliers and recipients, facilitating regional logistics planning and implementation of material reuse, regeneration and recycling technology cycles. Additionally, mapping, thanks to on-going visualization of the region will not only contribute to stimulating circular industrial symbiosis but will facilitate social and administrative involvement in expanding economic niches based on CSSs technologies. It will support eco-business creation, spread environmental awareness and support development more participatory, responsible and collaborative entrepreneurship.

7) The FRONTSH1P monitoring framework Circular economy monitoring system model for the Lodzkie Region aims to assess the results and progress towards full circularity, including all dimensions: social, educational, public, governance, economic and environmental, with the intention of being described as complete as possible picture. Therefore, the monitoring system requires the development of a set of indexes, indices or indicators of qualitative and quantitate character, facilitating assessment of all areas of regional circularity. The task of monitoring circularity requires the cooperation of all partners and orchestration complementary knowledge and skills. The circular economy monitoring system will be implemented and tested in the Lodzkie Region, then it will be replicated and adapted for implementation in other EU regions.

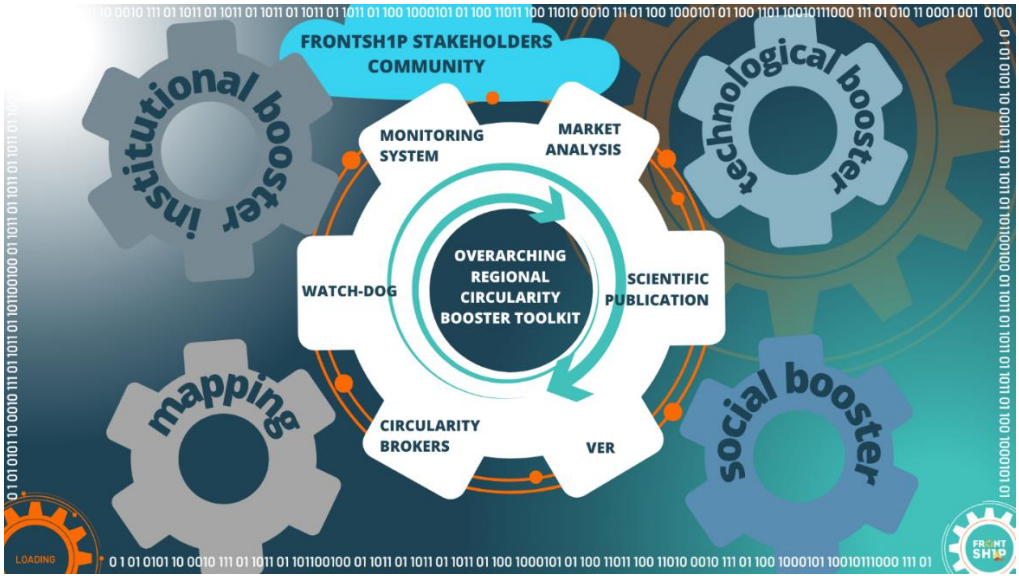


*Figure 20: Scheme of the Overarching RCBT*



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## 3.2. Regional Circularity Technological Booster Toolkit

### Recipients of the Regional Circularity Technological Booster

The main recipients of the Regional Circularity Technological Booster (RCTB) (Figure 21) are primarily entrepreneurs developing technologies defined under CSS1, CSS2, CSS3 and CSS4, in line with the circular economy paradigm and addressing European development megatrends. We assume that the RCTB will be useful both in the planning phase of investing in circular projects and in the stage of developing economic activities based on the use of all resources available in the region, mainly waste and by-products materials.

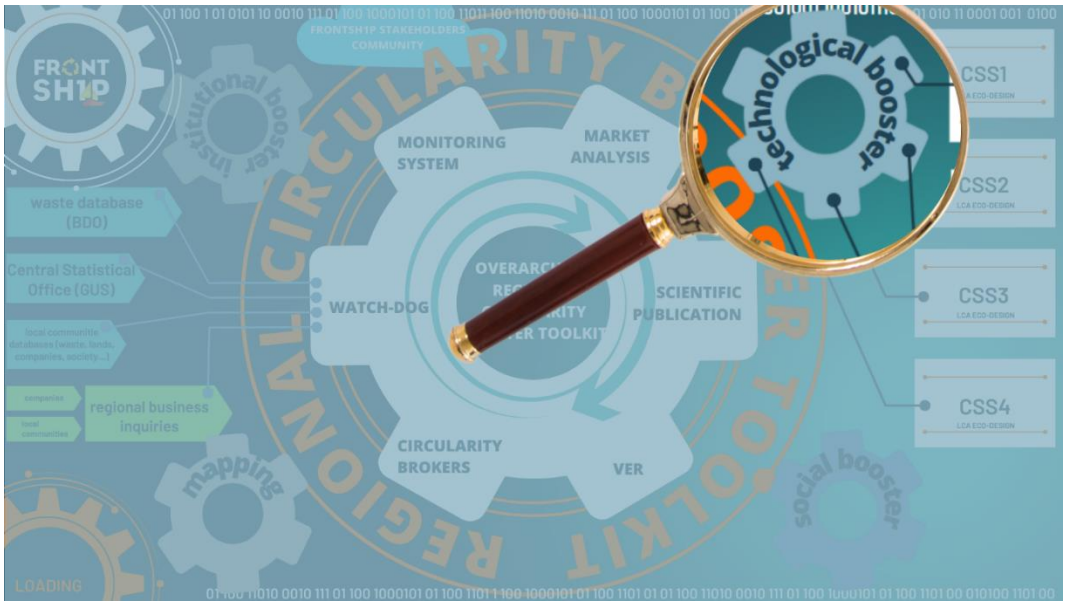


*Figure 21: The RCTB position among the full set of the FRONTSH1P toolkits*

The recipients of the RCTB are therefore primarily small and medium-sized enterprises, start-ups and natural person(s) willing to set up a circular SME. However, additional forms of circular economic activity, such as public-private enterprises and social cooperatives, will be supported by the RCTB.

The full list of the potential recipients of the messages and inspiration of the RCTB could be incorporated with the classification of economic activities, e.g.:

- Dealing with CSS1 technology:
  - Manufacturers of wooden containers;
  - Rental and leasing of other machinery, equipment and tangible good etc.;



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  - Recyclers of non-hazardous waste, especially wood packaging waste;
- Dealing with CSS2 technology:
  - Growing of other non-perennial crops;
  - Production of meat products, including poultry meat products;
  - Manufacture of prepared feeds for farm animals;
  - Manufacture of sugar;
  - Milk processing and cheese making;
  - Manufacture of bread;
  - Manufacture of fresh pastry goods and cakes;
  - Manufacture of soft drinks;
  - Production of mineral waters and other bottled waters;
  - Restaurants and other eating places;
- Dealing with CSS3 technology:
  - Wastewater treatment;
  - Flue gases emitters, e.g., industries producing energy, cement, iron or mining;
  - Anaerobic digestion plants;
  - Plants of fertilizers and bio stimulants;
- Dealing with CSS4 technology:
  - Manufacture of the rubber products;
  - Treatment and coating of metals;
  - Maintenance and repair of motor vehicles excluding motorcycles;
  - Building works related to erection of residential and non-residential buildings;
  - Recovery of sorted materials;
  - Dismantling of wrecks.

Together with the entrepreneurs, who are the obvious recipients of the Regional Circularity Technological Booster toolkit, public institutions and social organizations are the beneficiaries of the Toolkit as well.

Public institutions can use information on the CSSs technologies being developed and on the needs of entrepreneurs in terms of e.g., materials and waste management to create regional policies and regional governance models of circularity. In addition, local administration can create suitable conditions for development of local circular networks or regional industrial symbiosis.



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Society – the FRONTSH1P stakeholder community and NGOs as recipients of the Toolkit will encourage wider engagement in the circular economy development in area of e.g., gaining new competencies or creating circular social enterprises.

## Context of FRONTSH1P project goals and links with the Overarching, Institutional, Social and Mapping Boosters

The RCTB enables development of four CSSs technologies. In order to achieve the synergy effect, the RCTB is embedded in Overarching Toolkit as well as it cooperates with other data processing tools, supporting institutional and social aspects of circular economy development and regional mapping.

The following links and interconnections among RCTB and all other booster toolkits are of the greatest importance from the perspective of the entire FRONTSH1P project goals achievements:

RCTB -> ORCBT:

- Technological watch-dog: on-going watching for new resource supply opportunities for CSSs - materials, waste, by-products and for new, demand for offer of by-products and final products of CSSs;
- Circularity brokers: on-going matching CSSs needs and offers with the regional circularity stakeholders, mainly with the business contractors and then – sharing with the appropriate recipients, selected in accordance with the set of specific, dedicated parameters;
- Monitoring system: on-going circular business assessment in economic, environmental and social dimensions. The monitoring system, available on the Overarching Booster Toolkit, will equip CSSs managers with a set of indicators and measurement tools to conduct ongoing business self-assessment;
- Market analysis: on-going presentation and sharing the current regional, national and European market context in relation to the CSSs technology;
- Scientific publication: on-going reviewing scientific databases in scope of circularity and sharing the selected articles or books with the FRONTSH1P stakeholders' community in accordance with their specific needs;
- VER concept: on-going improvement of the VER concept of $CO_2$ management and sharing the tailored procedures with the FRONTSH1P stakeholders' community in accordance with their specific characteristics.



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RCTB -> Regional Circularity Institutional Booster Toolkit: ongoing sharing information in scope of legal, environmental or

RCTB -> Regional Circularity Social Booster Toolkit: ongoing monitoring of regional social engagement and sharing invitations to social events involvement as well as good practices from other regions;

RCTB -> Regional mapping: on-going geo-visualization of the regional resource (materials, waste, by-products) availability.

### Main components of Regional Circularity Technological Booster

On the current stage of the FRONTSH1P project performance, the Regional Circularity Technological Booster consists of four specific algorithms, dedicated to each CSS step-by-step development. Within the information procedure of data processing three main components will be implemented;

1) algorithms for providing each CSS with tailored information on raw materials (materials, by-products and waste) necessary for production;
2) algorithms for collecting data on by-products appearing during the technological process of a given CSS and transferring them to recipients indicated by LCA, firstly among the FRONTSH1P stakeholders' community;
3) algorithms for collecting data on final products and transferring it to recipients indicated by LCA, firstly among the FRONTSH1P stakeholders' community.

The separate approaches to the data processing layer of each CSS technology scheme will be integrated into one regional, unified collaborative information network. This should facilitate the achievement of industrial symbiosis.

### Contexts of benefits for the Lodzkie Region and for the replication regions

The RCTB will help in regional transition towards circularity in the Lodzkie Region and then – in replication regions in EU.

The following benefits can be expected:

- the introduction of innovative circular technologies next to local community to the every-day life that can be an example to follow-up;
- implementation the socio-economic regional course in line with the global megatrends (Figure 2);



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- providing information on implemented circular technologies in the one-stop-shop formula;
- promoting the 9R rule in economic practice in terms of waste management (Figure 4);
- limiting the amount of waste generated in the region;
- expanding the network of industrial cooperation with the participation of small and medium enterprises, start-ups and natural persons as well as municipal enterprises and social cooperatives;
- encouraging new business models development, focused on the improvement of environmentally-friendly technologies;
- supporting the adaptation of professional education and skills to the needs of developing the circular economy;
- promoting a community-cantered economy.



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## 3.3. Regional Circularity Social Booster Toolkit

Regional Circularity Social Booster (RCSB) is a space on the platform where one can gain knowledge and tools to support the processes of social involvement in the circular economy. The idea behind the RCSB is an open data exchange system that gives each user the opportunity to introduce their own practices/tools that increase the circularity of households and entire local communities (municipalities/communities/housing cooperatives). On the platform, the user will be able to act in two distinct roles:

a) an entity that wants to improve its circularity through self-assessment and implementation of selected tools (circular household and circular community, housing cooperative, commune)
b) an entity that wants to share good practice in the field of tools increasing circularity.

RCSB is intended to strengthen the development of circularity by providing access to tools and information on opportunities to develop circularity.
The platform, due to its open nature, encourages users to share knowledge. The availability of various data in one place facilitates knowledge and tools sharing to improve circularity and involve citizens in the idea of a circular economy.

### Recipients of the RCSB

The tool will be targeted at 4 main groups:

a) local government, mainly the lowest level, i.e., the commune, which will be able to carry out an analysis and to implement a tool under the RCSB in order to strive to achieve the highest possible indicators within the framework of the "circular commune" idea.
b) housing associations and cooperatives -on the level of communities/cooperatives are introduced to Booster due to the wide possibilities of using tools. In the case of urban communities, the involvement of the municipality itself may be too small. That is why we introduce to the tool entities that indirectly manage housing space and can conduct effective activities at the level of increasing circularity.
c) residents who want to be circular - as part of the RCSB, it will be possible to self-assess the circularity of the household. The use of the RCSB by the resident will be an element of information and educational activities carried out by local governments. The RCBS will include links between the “circular municipality” and the “circular household.”
d) other implementers of activities for the circular economy.



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## Context of FRONTSH1P project goals and links with other products

One of the key solutions to be developed as part of the project is the model of incorporating residents into the circular economy. As part of the project, a definition of "citizens' engagement" was developed (D4.2). Considering its scope, the tool will enable evaluation and support a) attitudes of direct residents (implementation of, among others, the 9R principle) b) supporting activities under the responsibility tool recipients.
In accordance with the content of the definition, the Regional Circularity Social Booster model and a set of tools relating to the direct behavior of residents and activities that can support these behaviors have been developed.

As part of RCSB, we want to strengthen the idea of:

- circular commune/community/cooperative - RCSB will provide data and tools to develop the idea of a circular community as a key element of the development of citizens engagement. The RCSB will develop a self-assessment tool with a set of indicators evaluating the municipality/community/housing cooperation. One of its elements will be the degree of circularity of households.
- circular household - RCSB will provide data and tools to support the idea of citizens engagement. Households will be able to assess their circularity through a self-assessment tool and use tools to develop circular behaviors. The household circularity index will be one of the indicators of the "circular commune". Therefore, we assume that the set of tools for residents should include incentives that can be launched by the commune to increase engagement of its inhabitants.

The tools of the RCSB will relate to the specific waste and by-products indicated by the FRONTSH1P project and the specificity of each CSS. However, due to the various dimensions of social behavior, the RCSB will also consider a broader view of circularity issues.

RCSB will include solutions resulting from individual Work Packages and CSSs:

1) training programs on the use of 3D printing as an opportunity to develop a new branch of the labor market (WP6 - CSS4)
2) models and analyzes related to the establishment of local social enterprises in the area of circular economy, creating opportunities for professional activation of people from groups at risk of social exclusion WP4 (CSS2), WP6 (CSS4) and analyzes in the area of W3 (CSS1) and WP5 (CSS3).



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3) a model for creating local microgrant programs as a tool involving residents in their own activities in the area of circularity (WP7)
4) model of a local currency tool encouraging participation in the circular economy (WP7)
5) training programs for farmers on CSS2 (WP7) solutions
6) diagrams and examples of information and promotion activities in the field of developing the idea of circular economy (WP7)
7) educational programs in the field of circular economy (WP9)

RCSB is one of the five Boosters that are to function within the RCBT. Through its content, RCSB is to strengthen the broadly understood social dimension of the circular economy.
The aim of the RCSB will be to provide knowledge and tools for circularity assessment and the inclusion of the local community in the circular economy. RCSB will be based on open data. The main source of data will be their own sources, including studies developed under FRONTSH1P and external references. It is mainly the existing data, studies and tools that will drive the content of the RCSB. Our idea is to integrate as much data as possible about existing solutions on RCSB. The platform is supposed to make it possible for users to use data, but also supply the RCSB with own proposals of useful data that will relate to the tools indicated in the RCSB.

## How RCSB works?

RCSB will be an open platform with the possibility of including solutions developed by various partners. Functionality will be ensured by the possibility of using examples and solutions that are developed and implemented around the world. RCSB toolkit will include the option to review solutions developed by other contractors and link them to their websites/tools. This is to increase the possibility of exchanging information between various creators and mutual promotion. The rules of posting materials on the platform will be specified in the regulations.

The RCSB will be used, among others, the following data:
- own sources - studies created as part of the FRONTSH1P project.
- external references - websites containing e.g., studies, models, good practices related to the substantive topic of RCSB.
- external references to databases and analysis, e.g., regarding the situation on the regional labor market.



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In order to access the data, the RCSB user goes through the process of registering and setting up an account.
After logging in, the user has 3 choices:

1) self-assessment of circular lifestyle.
2) to view materials and use the content of the RCSB.
3) to post own solutions and tools through the "add information" function.

The implementation of path 1 ends with obtaining a report on the “circular lifestyle” of the household/community/cooperative/municipality. The report will indicate the level of fulfillment of the circular assumptions. The results will be available in the form of e.g., an axis with a score from 0 to 10. The level of circularity achieved as a result of the self-assessment should direct the user to the section with solutions, they can take to improve circularity. In the case of path 3, each entry of new data into the database should result in sending information to users about the update in the RCSB resources (Figure 22).



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*Figure 22: Draft scheme of the Regional Circularity Social Booster Toolkits.*

## Circularity Assessment Tools- self-assessment tool

In this section, RCSB users will be able to use the tools for self-assessment of their circularity. The proposed set of diagnostic tools will allow recipients to determine to what extent (at what level) of circularity they are currently (diagnostic aspect), and at the same time to estimate the distance from the adopted pattern (normative aspect). The self-



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assessment will also result in identifying areas in which the ideas of circularity are implemented and those in which additional actions should be taken.

A diagnostic tool dedicated to individuals - circular citizen/circular household, will include a questionnaire available on-line that will allow you to obtain a self-diagnosis (defining attitudes and beliefs towards CE in 3 components: cognitive, affective and behavioral) and to indicate areas where the ideas of circularity are implemented and where additional actions should be implemented. Due to the need to data and their sensitive nature, feedback in the form of a survey result will be available only to respondents.

Toolkits targeted at group entities - circular commune/circular housing cooperative/circular housing community, were divided into two groups depending on the level of self-diagnosis performed by the subject. It was assumed that there are two possible paths: simple diagnosis and in-depth/extended diagnosis (optional). Therefore:

Diagnostic tools at the basic level include:

1) a questionnaire addressed to the diagnosed entity. The data source in this case will be the answers in the questionnaire.
2) a list of indicators including selected quantitative and qualitative data at the disposal of the entity, showing the level of its circularity.
3) a questionnaire addressed to residents/households living in a given territory, partly identical to the self-assessment tool dedicated to residents/households at the individual level, extended by an analysis of their needs in terms of meeting the requirements of circularity (what is missing?). This part of the diagnosis requires the use of a representative sample to generalize the obtained results. The data source will be the answers to the questionnaire.

Diagnostic tools at the advanced level include e.g., [36,37] (Table 2)

1) interview scenarios (individual in-depth interviews IDI and/or focus group interviews FGI) addressed to selected groups of respondents (local experts/entrepreneurs/ representatives of local authorities). Data source - respondents' answers [38–40].
2) scenarios for conducting workshops using e.g., *design thinking* (work in small groups with various stakeholders moderated by an expert), tools such as: Persona Matrix, Problem Map, Discussion - round table, etc. Data source - as mentioned above [41–44].



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The result of self-assessment will indicate which Regional Circularity Social Booster tools should be used to improve the diagnosed level of circularity. All tools will be available on the platform in an interactive form [45–49].

*Table 2: Diagnostics self-assessment toolbox addressed for two types of recipients*

| TYPE OF RECIPIENT | TOOL EXAMPLES | DATA SOURCES FOR EVALUATION LEVEL OF FULFILLMENT OF THE CIRCULARITY REQUIREMENTS |
|---|---|---|
| Circular citizens/household | ▪ a set of indicators for self-assessing household circularity.<br>▪ resident/household self-assessment questionnaire. | 1) EcoHarmonogram application https://app.ecoharmonogram.pl/gospodarka-obiegu-zamknietego.<br>2) Information from respondents showing their attitudes and beliefs in presence of CE in 3 components: cognitive (knowledge), affective (attitude) and behavioral (behavior). |
| Circular commune/circular housing cooperative/circular housing community | ▪ self-assessment questionnaire of the diagnosed entity.<br>▪ a set of indicators defining the level of circularity of the diagnosed entity.<br>▪ and in the area covered by its operation.<br>▪ self-assessment manual.<br>▪ self-assessment questionnaire and CE needs survey conducted on a representative sample of residents/households residing in the area of operation of the entity. | 3) Available quantitative and qualitative data directly and/or indirectly related to the level of circularity of the diagnosed entity and the area covered by its operation, collected by the entity, by its appropriate units and institutions/enterprises subordinate to it and/or related to it, which can provide such data.<br>4) Information on the current activities in the field of circularity undertaken by the entity and data showing the effects of these activities in the case of communes, publicly available statistical data (local data bank www.bdl.stat.gov.pl) directly and/or indirectly related to the level of circularity in the commune area respondents' answers showing their attitudes and beliefs in presence of CE in 3 components: cognitive (knowledge), affective (attitude) and behavioral (behavior) and their CE implementation needs. |

*Source: own compilation*



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## Tools to implement a circular household

Tools, presented in Table 3 are addressed to residents in order to help them to implement the circular household model.

*Table 3: Toolbox for transforming households into the circular household model*

| ADDRESSED PROBLEMS | EXAMPLE OF TOOLS | DATA SOURCES |
|---|---|---|
| How to implement the refusing principle in households? | ▪ information and educational materials on how to develop an assertive attitude towards consumerism trends - how to say no | ▪ Own source; materials developed in other WPs of the FRONTSH1P project (especially WP 9)<br>▪ External reference: Portals and websites of implementers of other projects on the topic of circularity containing descriptions of tools/good practices/solution catalogs; e.g.: self-check questions: https://sustainability-success.com/6-rs-of-sustainability-lifestyle-9-3-rs/?utm_content=cmp-true |
| How to implement the reducing principle in households ? | ▪ information and educational materials, tools for planning responsible purchases,<br>▪ database of good practices. | |
| How to implement the reusing principle in households? | ▪ information and educational materials on the principles of reusing.<br>▪ database of good practices.<br>▪ a catalog of solutions related to the reuse of things. | |
| How to implement the principle of repairing in households? | ▪ information and educational materials about the repairing principle.<br>▪ database of good practices.<br>▪ list of repair points. | |
| How to implement the principle of repurposing things in households? | ▪ information and educational materials about the principles of repurposing.<br>▪ database of good practices. | |
| How to implement the recycling policy (recycling) in households | ▪ information and educational materials on recycling principles | |
| How to implement sharing principle in households | ▪ information and educational materials on the principles of sharing.<br>▪ list of fair-share/ food sharing points. | |



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| | | |
|---|---|---|
| How to implement the principle of leasing in households? | ▪ information and educational materials on the principles of leasing<br>▪ database of good practices<br>▪ list of leasing services | |

*Source: own compilation*

## Tools for the implementation of the circular/community/cooperative/municipality

The aim of the first toolkit will be to provide information and knowledge about the circular economy in the local community. The tool will contain a number of examples of materials, information and educational activities that could be undertaken to increase awareness in the area of circular economy. The tool is mainly intended to help representatives of local governments/communities/housing cooperatives to conduct effective information campaigns and education activities (Table 4).

*Table 4: Toolbox for raising awareness and knowledge about the circular economy in the local community*

| THE TYPE OF THE TOOL | TOOL EXAMPLES | DATA SOURCES |
|---|---|---|
| Tools for conducting information and promotion activities regarding circular economy in the local community e.g., how to implement the 9R principles at the household/community/cooperative/municipality level. | ▪ examples of handouts<br>▪ examples of information campaigns<br>▪ a model for creating local Circular Days (based on Parzeczew) | ▪ Own source - links to promotional materials of the campaign developed as part of the FRONTSH1P project.<br>▪ Own source: Circular Day model developed as part of the FRONTSH1P project. |
| Tools for conducting educational activities regarding circular economy in the local community. | ▪ examples of courses and trainings for different target groups from children to entrepreneurs (materials developed under WP 6 and WP 9) | ▪ Own source - link to the script file.<br>▪ External reference: links to websites with developed courses and educational activities in the field of circular economy; e.g., https://ekonsument.pl/p34_zasada_3r.html |
| An educational tool on proper waste segregation in a given commune/community/housing cooperative with a waste search engine, a | ▪ EcoHarmonogram in Parzeczew<br>▪ examples of other on-line applications | ▪ External reference: links to the websites with developed examples of tools or applications; e.g., |



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| | | |
|---|---|---|
| guide on reading labels, upcycling, a scanner of symbols from packaging, sharing good practices. | | https://www.ecoharmonogram.pl/ |
| A tool intended for specific target groups, differentiated by age, e.g., for children and teenagers, showing how everyday things are made, what circular economy is and why it is worth "taking care" of the waste we produce. | ▪ city games<br>▪ outdoor games (escape room + geocaching based on e.g. ) | ▪ External reference: links to websites with educational information programs; e.g., good practice example of city games in Finland: https://my2050.fi/in-english/ |
| Change of thinking from a linear economy to a circular economy, product life cycles. | ▪ short educational videos | ▪ External references: links to websites with educational information programs; e.g., Story of stuff video: https://www.youtube.com/watch?v=9GorqroigqM |

*Source: own compilation*

The second toolkit for the implementation of the circular municipality will focus on tools aimed at increasing the involvement of the local community in the idea of circular economy. The tools are to enable specific solutions to be launched in the local community to increase its circularity (Table 5).

*Table 5: Toolbox for engaging citizens in the circular economy in the commune*

| THE TYPE OF THE TOOL | TOOL EXAMPLES | DATA SOURCES |
|---|---|---|
| Tools for conducting social consultations in the area of circular economy at the local level | ▪ consultation model/toolbox<br>▪ examples of activities | ▪ Own source; materials developed in other WPs of the FRONTSH1P project (especially WP 9)<br>▪ External reference: Portals and websites of implementers of other projects on the topic of circularity containing descriptions of tools/good practices/solution catalogues |
| Tools encouraging selective waste collection | ▪ local currency model developed by FRONTSH1P.<br>▪ examples of solutions in the field | ▪ External references: links to websites with examples of local currency models introduced; e.g., https://plasticbank.com, https://www.plasticsforchange.org/abo |



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| | | |
|---|---|---|
| | | ut-us<br>https://hollandcircularhotspot.nl/case/zero-waste-lab-waste-as-a-currency |
| A tool enabling the exchange, collection, repair of items (implementation of the 6 R principles at the level of the community/cooperative/municipality) | ▪ application examples | ▪ External references: links to websites with examples of applications; e.g., EcoHarmonogram (EcoSchedule): https://app.ecoharmonogram.pl/gospodarka-obiegu-zamknietego |

*Source: own compilation*

## Tools for the development of social entrepreneurship (SE) in the area of circular economy in the commune

A tool addressed to people/organizations/municipalities willing to develop social enterprises in the area of circular economy in the local community. The tool will include a list of case studies of social enterprises operating in the circular economy, tools for creating partnerships, templates of business plans and models developed in the project (Table 6).

*Table 6: Toolbox for developing social entrepreneurship (SE) in the area of circular economy in the commune*

| THE TYPE OF THE TOOL | TOOL EXAMPLES | DATA SOURCES |
|---|---|---|
| A tool showing good SE operating practices in the area of circular economy | ▪ case studies of social enterprises | ▪ own source; materials developed in other WPs of the FRONTSH1P project, the toolkit will include reference to the FRONTSH1P educational platform developed in WP9<br>▪ External reference: Portals and websites of implementers of other projects on the topic of circularity containing descriptions of tools/good practices/solution catalogs; e.g., Green Loop Project https://www.greenloop-project.eu/ |
| Tools for creating partnerships in the area of circular economy and social entrepreneurship | ▪ partnership rules, contract/agreement | |
| Tools diagnosing the potential of the local community to develop social entrepreneurship in the area of circular economy | ▪ resource and needs analysis.<br>▪ stakeholder analysis.<br>▪ examples of surveys, lists of existing data for analysis | |
| Social enterprise creation tools | ▪ BMC's business model.<br>▪ business plan, market analyzes in the area of waste management | |

*Source: own compilation*



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## Tools for development of circular economy-based labor market in the commune

The aim of the tool is to increase access to knowledge about the possibilities of creating jobs in the circular economy and available courses/training and job offers. The tool is to increase the competences of the commune inhabitants needed in the local circular economy system (Table 7).

*Table 7: Toolbox for evaluating and developing circular economy-based labor market in the commune*

| THE TYPE OF THE TOOL | TOOL EXAMPLES | DATA SOURCES |
|---|---|---|
| Analysis of trends in the labor market in the circular economy | ▪ regional databases on directions of labor market development | ▪ External references: labor market data maintained by public employment services |
| Tools for the development of competences and professional qualifications in the area of circular economy | ▪ training databases<br>▪ a catalog of professional trainings developed under FRONTSH1P, e.g., in the field of 3D design | ▪ External references: links to pages with current courses and training to improve professional qualifications; e.g., https://www.udemy.com/topic/3d-printing/ https://www.coursera.org/courses?query=3d%20printing https://www.youtube.com/watch?v=EABJKS19BbA |
| Job offers database | ▪ databases of regional job offer | ▪ External references: Internet portals containing information about current job offers with categories related to the circular economy; e.g., https://unjobs.org/themes/circular-economy |

*Source: own compilation*

## Contexts of benefits for the Lodzkie Region and replication regions

RCSB is of key importance for the development of the circular economy idea in the Lodzkie Region. The RCSB toolkits on the implementation of the circular municipality and "circular household" ideas will need to be strengthened at the regional level through:



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a) conducting activities promoting the tool, e.g., advertising campaigns.
b) introducing solutions encouraging local communities to develop the idea of circularity, e.g., introducing evaluation criteria in regional funds that will consider the circularity of the municipality and encourage self-assessment and anticipating appropriate actions in projects to increase circularity indicators.
c) coordination of activities in the field of adapting tools and solutions carried out by various regional entities cooperating with regional authorities.

Replication regions, similarly to the Lodzkie Region, can directly transfer solutions from RCSB to their communities. The open data entry system within the RCSB will allow replication regions to supplement the tools with their solutions that will be used to implement the idea of "circular households'' and "circular municipalities". Extension of the RCSB with examples of solutions used in other partner regions will enable better data exchange. This is an important element of RCSB's idea that it can use practices from different communities. This approach gives users the opportunity to learn about various practices and tools and adapt them to their own use.



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## 3.4. Regional Circularity Institutional Booster

Regional Circularity Institutional Booster (RCIB) is part of an online platform that collects RCBT. RCIB is to strengthen the development of circularity by providing access to knowledge about the state of the level of circularity in comparison to other regions. RCIB is a module which main function is to support management processes under the Circular Governance Model.

FRONTSH1P will create a Circular Governance Model that allows territorial stakeholders to manage their transitions towards circular value chains, going beyond the existing conceptualizations of governance practices and including participatory, inclusive and socially innovative governance frameworks. This model is based on five interconnected dimensions implementing circular feedback loops driven by the Regional Strategy for Territorial Transition: technology, environment, citizen communities, governance and economic sustainability. This governance model allows exploiting the project results beyond local boundaries allowing a participatory, open, inclusive and socially innovative approach that includes key actors in the territories, such as public authorities and civil society as beneficiaries, as well as industry, farmers, NGOs, cooperatives, associations as stakeholders and key enablers in new circular value networks triggered by the four CSSs.
RCIB toolkit will be a benchmarking platform whose basic function will be reporting and providing good practices (Figure 23).

Recommendations obtained from the RCIB toolkit will concern (D2.4):

- the definition of political recommendations with impact on local CEAP;
- business recommendations regarding to new business models and new value chains for companies involved at the regional level;
- social recommendations based on the developed model for citizens engagement and reskilling, including labor market innovation;
- environmental recommendations with a life cycle and circular approach.

Public authorities will be the key addressees of reports from the analytical module. A special role of initiation, showing good practices and coordinating the unorganized circular market was assigned to local and regional governments. RCIB Toolkit is a platform supporting circular public policies implementation.

The Institutional Booster Toolkit is especially dedicated to:



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- Regional authorities
- Local authorities
- Inter-municipal association
- Social cooperatives.

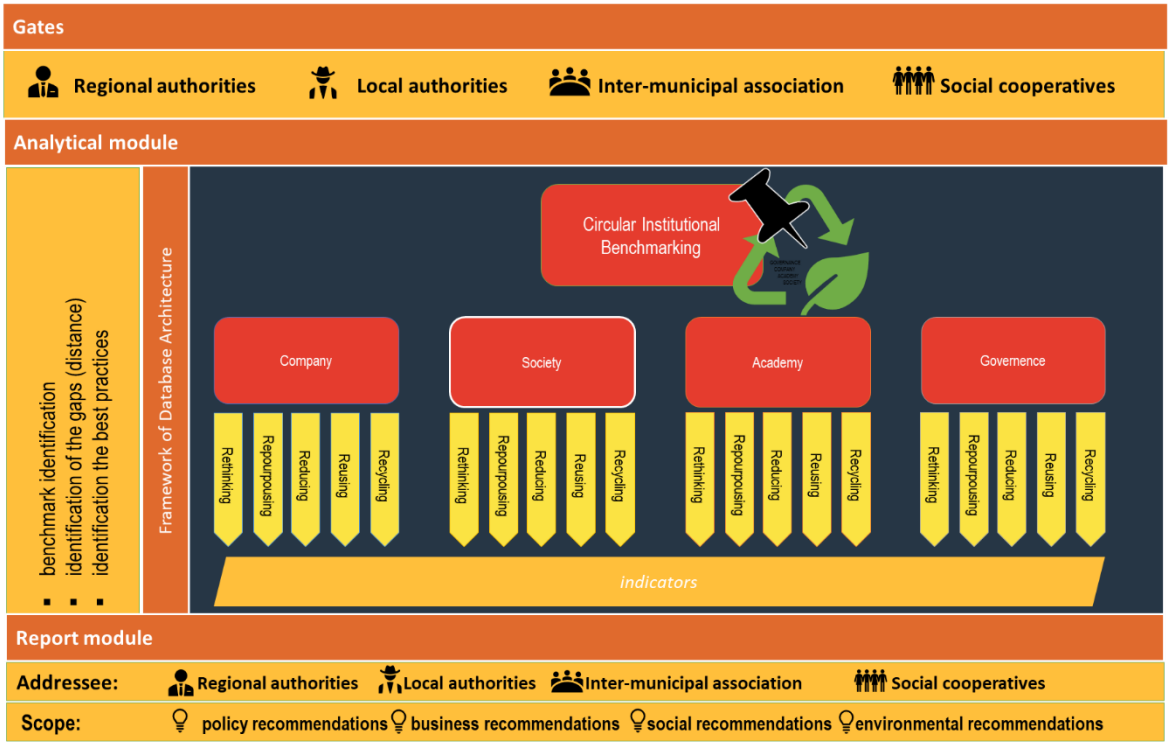


*Figure 23: Framework of benchmarking dedicated to the Regional Circularity Institutional Booster Toolkit development.*

Details on how to prepare the RCIB benchmarking are presented in Table 8.



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*Table 8: Basic characteristics of RCIB benchmarking*

| CATEGORY | FEATURE: |
|---|---|
| Type: | Competitive benchmarking |
| Accessibility: | Online on the RCBT platform after registering and logging in |
| Aim: | (1) identification of the distance from the pattern,<br>(2) identification of good practices,<br>(3) improving efficiency |
| Report client | ▪ Regional authorities<br>▪ Local authorities<br>▪ Inter-municipal association<br>▪ Social cooperatives |
| Benchmark type: | Competitive entity with the best results recorded in the system |
| Basic areas and sub-areas of benchmarking | I level: Company, Society, Academy, Government<br>II level: Rethinking, Repurposing, Reducing, Reusing, Recycling<br>III level: if needed (will be defined during the research) |
| Basic research methods and techniques | analysis of secondary sources, questionnaire interview (standardized), data of circular brokers |
| Data normalization method: scaling and coding | The material collected during the research will be coded and inserted to the database according to the algorithm. In the case of questions with an ordinal scale, the values indicated by individual respondents will be directly entered into the database. However, in the case of statistical indicators, the indicators will be transposed on a ten-point scale using an interval, and in the next step they will be coded and entered into the spreadsheet. The study does not assume the use of weights, each of the variables has the same rank. The transposition of statistical data on a *n*-point interval scale should be done according to the following method: $Y = \frac{x_{max} - x_{min}}{n}$ were Y– interval, $x_{max}$ – maximum value of the normalized variable x, $x_{min}$ – minimum value of the normalized variable x |
| Benchmarks: | Indication of benchmarks appropriate for the client category at the level of areas (synthetic benchmark) and sub-areas (sub-synthetic benchmark) based on the maximum values of individual indicators (arithmetic mean of the maximum indicator values) |
| Basic criteria for inserting best practices | ▪ resource saving;<br>▪ democratization of decision-making processes;<br>▪ social engagement. |



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| | |
|---|---|
| Basic best practice reporting criteria | **I category:**<br><br>(I.1) Systematicity and durability of solutions;<br>(I.2) Innovation (novelty) of the applied solution;<br>(I.3) Efficiency (effectiveness) of the applied solution,<br>(I.4) Ease of replication (initiative scalability) by other CTCs<br>(I.5) Possibility of implementation (difficulty)<br><br>**II category:**<br><br>(II.1) Policy<br>(II.2) Business<br>(II.3) Social<br>(II.4) Environmental<br><br>**III category**<br><br>(III.1) Relation to the CSS1 category<br>(III.2) Relation to the CSS2 category<br>(III.3) Relation to the CSS3 category<br>(III.4) Relation to the CSS4 category |

*Source: own compilation*

The results of benchmarking are to support the coordination of regional policy activities in the field of strengthening the circular economy. In particular, they will support the preparation of Action Plan at the regional level and the implementation of circular missions and challenges at the level of local policies. It is a tool supporting the implementation of the Circular policy framework based on the CircuPuncture model.

Different data sources will be used in benchmarking. RCIB Toolkit will benefit from the following data:

- Primary data: own studies created as part of the FRONTSH1P project, source data from benchmarking clients;
- Secondary data: external institutions` databases containing data illustrating the state of the circular economy. Among others, the data of the following institutions will be used: Regional Fund for Environmental Protection and Water Management in Lodz, National Science Centre Poland, Waste Catalogue, Database on Products, Packaging and Waste Management, Registry of an Entities of National Economy, Local Data Bank, National Official Register of the Territorial Division of the Country, The Database of Topographic Objects, Intellectual Property Rights - e-Search (Table 8).

The mechanics of work on the Regional Circularity Institutional Booster module platform is multi-threaded (Figure 24).



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Benchmarking is dedicated to four groups of users. The user has two options:

1) entrance to the analytical and diagnostic module. Output: Gaps report;
2) entrances to the best practice module. Output: Best practice report.

For stakeholders operating at the local level: Local authorities, Inter-municipal association and social cooperatives, a dedicated analytical and diagnostic module will be prepared as part of FRONTSH1P.

In the case of the first group of stakeholders: Regional authorities, the user will be invited to enter the analytical and diagnostic module developed, among others, by in SCREEN, REPLACE projects: Circular Benchmark Tool (CBT) (https://circularbenchmarktool.eu/how-to-use-it).

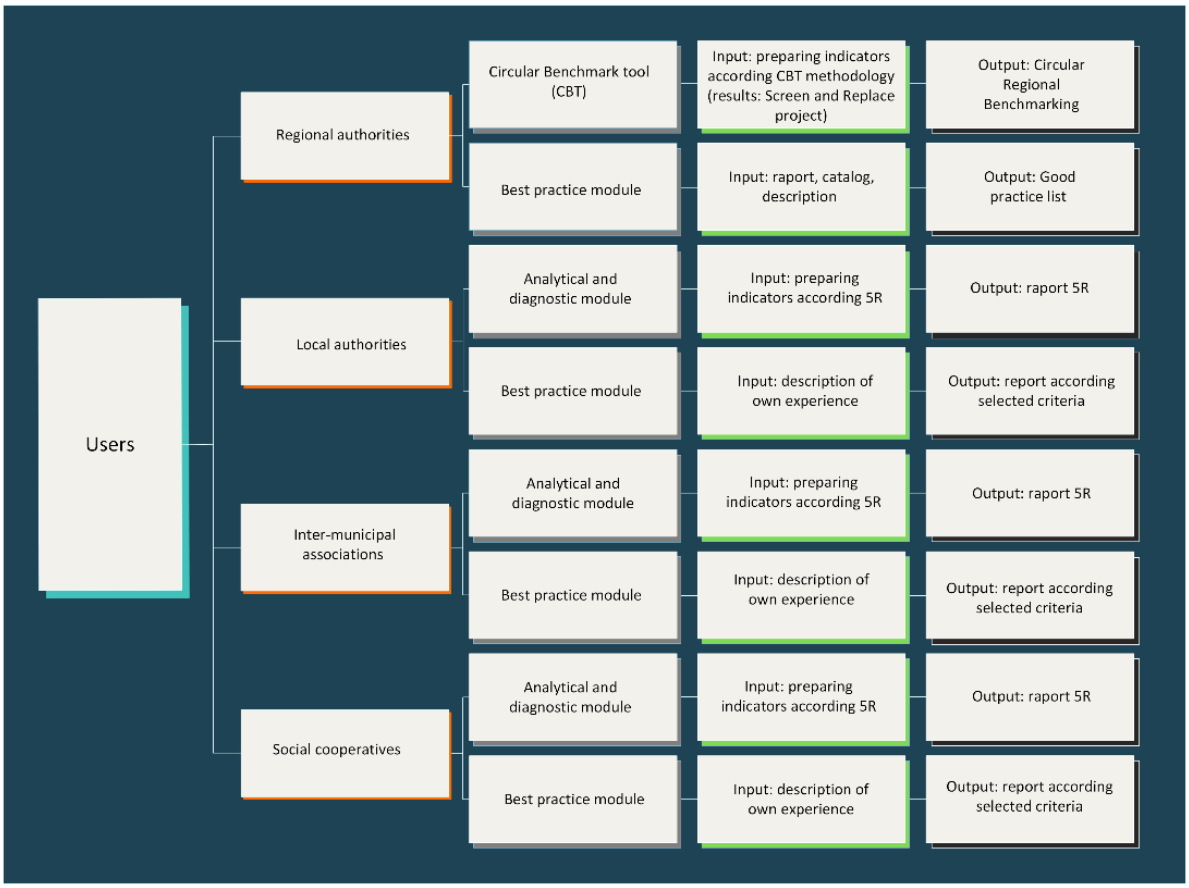


*Figure 24: Draft of the Regional Circularity Institutional Booster Toolkits*



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In summary, local authorities and other RCIB toolkit users can achieve the following benefits to strengthen their own circularity:

- better recognition / diagnosis of processes in the organization,
- information on development gaps in the area of CE implementation,
- good practices suggesting smart solutions,
- suggestions for updating local development strategies to strengthen circularity (challenges and mission areas),
- identifying areas of dormant activity and challenges in this area,
- awareness of the benefits of strengthening the circularity of one's own unit,
- disclosure of areas of possible CSS involvement for the competitiveness and efficiency of closed loops.



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## 3.5. Regional Circularity Booster Mapping

A key step in the FRONTSH1P Regional Circularity Booster Mapping (RCBM) toolkit is the generation of a geodatabase for mapping the Polish Lodzkie Region under study, which will be applicable to other four replication regions.

RCBM will enable the identification of favorable spatial-inducible synergies between waste providers and recipients, facilitating regional logistic planning and the implementation of circular technological circuits of material reuse, remanufacturing and recycling. The aim is to boost industrial symbiosis, economic circularity and social involvement in active regional intervention practices. Ultimately, it aims increasing a regional self-independence, expand technological niches and eco-businesses, spread ecological awareness and support a more participative and responsible entrepreneurship.

Georeferentiation, i.e., the assignment of a georeference to a location, is a key-issue when addressing circularity mapping. A spatial system integrating descriptive information to the location data is the basis for analysis and mapping, allowing to understand patterns and relationships in a geographic context. Thus, communication is more efficient while allowing better management and decision making.

### Ontology of geospatial information

The representation of geospatial information within computerized systems has been widely addressed and developed to provide suitable data manipulation, analysis and visualization mechanisms [50,51]. A geospatial database or geodatabase is a database capable of storing spatial data that contains three elements; i.e., feature classes, raster datasets or tables. Among others, geodatabases allow centralized Geographic Information System (GIS) data management, easiness to manage and access, and modelling of flow of resources along a geometric network [52]. The access of geospatial data has increased widely using internet services, which made available online interactive maps for stakeholders. These maps show different levels of information that can be used according to the needs. The availability of open access data and platforms allows the generation of maps for stakeholders-oriented objectives. An example is given with Nomenclature of territorial units for statistics (NUTS) geodatabase [53] where the information is available for geographical statistical units dataset with attribute tables and respective areas (polygons). Other examples include Copernicus Services, e.g., https://land.copernicus.eu/# with land cover classification such as Corine Land Cover, Urban Atlas, etc. The interactive maps produced can also be made available through e.g., Web Map Services (WMS) for each of the stakeholders to use on their own GIS system.



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To solve geospatial data heterogeneity problems and support geospatial information retrieval and semantic interoperability over the Web, the use of a geospatial ontology can be considered, as it is a formal explicit description of concepts or meanings of words in a well-defined and unambiguous manner [54]. In computer science, ontology is a data model that represents a domain by detailing the entities that comprise it and the semantic relationships between them. Ontologies generally include individuals, classes, attributes and relations [52,54]. Geospatial ontologies represent geospatial concepts and properties for use over the Web [54].

### State of the art in scope of circular economy mapping

Local analyses of regional data collected through mapping tools were foreseen in several research projects. The SCREEN project (www.screen-lab.eu) involved 17 European Regions, including the Lodzkie region, working together to define a replicable and scalable approach, to support European Regions in the transition to new Circular Economy cross-regional value-chains. A mapping tool was used to map the baseline situation in these regions in terms of existing technological, industrial, research and innovation, and education capabilities, as well as emerging Circular Economy initiatives [55]. The DigiPrime project (www.digiprime.eu) included a specific service, the DigiPrime Pilot 5 "Cross-regional value chains' identification", whose scope was to identify cross-sectorial and cross-regional circular economy value-chains, based on the methodology developed within the SCREEN project. The original methodologies and tools, further validated by a group of different international stakeholders, were conceived as a powerful instrument for supporting regional officers in charge to foster the transition towards a circular economy to have an overview of the existing and potential value chains, as well as to be notified about possible new cross regional or cross sectorial synergies and value chains [56]. The service enabled the use of the lean management method of value stream mapping in the context of circular economy processes. BIOPLAT-EU project (https://webgis.bioplat.eu/#/map) promoted the market uptake of sustainable bioenergy in Europe using marginal, underutilized, and contaminated lands for non-food biomass production through the provision of a web-based platform that served as decision support tool. This Web Platform tool combined the Geographic Information System (GIS) maps with the Sustainability for Europe and Neighboring countries (STEN) tool provided by BIOPLAT-EU, to assess the sustainability of selected bioenergy investments on marginal and underutilized lands in Europe and Ukraine [57,58]. The REPAiR project (https://h2020repair.eu) provided local and regional authorities with an innovative transdisciplinary open source Geodesign Decision Support Environment (GDSE) developed



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and implemented in Peri-Urban Living Labs (PULLs) in six metropolitan areas [59]. These strategies intended to promote the use of waste as a resource, thus supporting the ongoing initiatives of the European Commission towards establishing a strong Circular Economy. The CONVERTE project (https://converte.lneg.pt/) identified different types of endogenous biomasses generated in Portugal, that could be applied in the short-medium term in viable technological solutions to produce electricity, heat, energy vectors and advanced biofuels, and that fulfilled all the sustainability criteria defined by the European Directives, in particular the (EU) Directive 1513/2015 (ILUC). Three databases for georeferenced mapping in mainland Portugal were created and implemented, namely: (i) areas/soils suitable for energy crops; (ii) areas/soils/waters suitable for the culture of microalgae; (iii) and agricultural/forestry species cultivated, the respective residues generated and that of potential bioenergy interest for the national territory [60].

## Context of FRONTSH1P objectives

A key step in the FRONTSH1P RCBT is the generation of a geodatabase for mapping the stakeholders involved in the development of CSSs in the Lodzkie Region under study. These CSSs comprise circular approaches for the valorization of wood packaging waste (CSS1), food and feed waste (CSS2), the reuse of wastewater and nutrients (CSS3), and the recycling of urban and industrial plastic and rubber waste (CSS4). The circular approaches are designed to be adjustable to other four FRONTSH1P replication regions, i.e., the North Region of Portugal, the Campagna region in Italy, the municipality of Livadia in Central Greece, and Friesland province in the Netherlands.

RCBM will enable the identification of favorable spatial-conditioned/inducible synergies between waste providers and recipients, facilitating regional logistic planning and the implementation of circular technological circuits of material reuse, remanufacturing and recycling. The aim is to boost industrial symbiosis, economic circularity and social involvement in active regional intervention practices. Ultimately, it aims increasing a regional self-independence, expand technological niches and eco-businesses, spread ecological awareness and support a more participative and responsible entrepreneurship.

## Information in the maps

RCBM tool includes the geolocated information (geodatabase) of each stakeholder divided into levels with increasing detail, which contain to specific map layers. The database includes information on stakeholder identifiers, supranational waste and economic identifiers, specific value-circularity levels, technological data, marginal lands and social indicators. The purpose



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is to allow a general characterization of each stakeholder and, if desirable, to move to detailed surveys on the mapping platform within each CSS to drive specific interactions within the same value circle (map-driven symbiosis).

Depending on the detail, the information can be made available at different levels of access to the users of the RCBM, since it can refer to purely statistical data with information accessible to the public, up to more detailed technological data for which the stakeholder wishes to maintain some level of protection or claim restricted disclosure. It is to be expected that quantitative information and specifications within each CSS will tend to be of more restricted access, which however should be managed by the RCBT responsible so as not to compromise the strong commitment of FRONTSH1P to the promotion of stakeholder interactions.

In all cases, the importance of pursuing the harmonization of terms with a common vocabulary, typical of the field of research, to be used in data collection surveys and cartographic instruments should be stressed.

The information in the RCBM be divided into the following levels: (LEVEL 1) basic identification data; (LEVEL 2) data about the type of waste and/or by-products generated, processed or managed; (LEVEL 3) distribution of the stakeholders by CSSs and specific value-circularity level; (LEVEL 4) advanced circularity indicators relating to technological and social/regional indicators that may be relevant in specific surveys and that can be modified for each replication region of the FRONTSH1P project.

### Geospatial data

1) The data will be collected from specific questionnaires distributed to each stakeholder who fills in the necessary information. The information will be converted into an Excel file to create the maps.
2) Georeferenced information is received from each stakeholder, by filling in the respective longitude and latitude (in WGS84-EPSG:4326) of their location. The data will be imported and stored in the form of a geodatabase (gdb).
3) ArcGIS (2023) software will be used for data processing and symbolization.
4) Web Map Services (WMS), following Open Geospatial Consortium (OGC) standards, will be published to allow the visualization of information dynamically.
5) The final project web map will be produced in ArcGIS Online to interactive display the geographic information, organized as layers, on top of a basemap.



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The OpenGIS® Web Map Service Interface Standard (WMS) provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases. A WMS request defines the geographic layer(s) and area of interest to be processed. The response to the request is one or more geo-registered map images (returned as JPEG, PNG, etc.) that can be displayed in a browser application. The interface also supports the ability to specify whether the returned images should be transparent so that layers from multiple servers can be combined or not.

OGC - Open Geospatial Consortium
https://www.ogc.org/standards/wms

ArcGIS Online is an online, collaborative web GIS that allows you to use, create, and share maps, scenes, apps, layers, analytics, and data." ArcGIS Online enables users to access geospatial layers from worldwide locations, create new content, and connect layers across the ArcGIS platform. In addition to web maps, applications are able to be created from configurable templates for enhanced user experience.
Basemaps serve as a reference map on which you overlay data from layers and visualize geographic information. Basemaps are the foundation for your maps and provide context for your work.

ESRI
https://www.esri.com/en-us/arcgis/products/arcgis-online/overview
https://pro.arcgis.com/en/pro-app/latest/help/mapping/map-authoring/author-a-basemap.htm

## Data required for each on-line map layer

LEVEL 1 – Basic and unique stakeholder identification (Figure 25)

1.1. Identification of FRONTSH1P stakeholders and respective geolocation.

Data requirements:

- Stakeholder identification and website
- Geo-located data of the stakeholder: GPS coordinates (WGS84)

The World Geodetic System 1984 (WGS84), EPSG:4326, is the reference frame used by the Global Positioning System (GPS) and developed by the USA Department of Defense. It is now maintained by the U.S. National Geospatial Intelligence Agency (NGA). WGS84 has been revised six times since its original realization in 1987.

Department of Defense Agency, World Geodetic System 1984
DMA Technical Report, 2nd ed. 1991, USA

1.2. Classification of each stakeholder according to territorial and economic supranational identifiers (NUTS regions; Classification of economic activities in the European Community (NACE)).

Data requirements:



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- National and supra-national territorial identification of the stakeholder: Address, county, NUT3 region, country.
- Type of stakeholder (municipal, industrial or agricultural).
- Economic classification of the stakeholder (NACE)

The Nomenclature of Territorial Units for Statistics (NUTS) was drawn up by Eurostat to provide a breakdown of the economic territory of the European Union into territorial units to produce regional statistics and for targeting political interventions at a regional level. The NUTS classification has been used in EU legislation since 1988, however, it was only encoded into a formal Regulation of the European Parliament and the Council in 2003.

The NUTS serves several objectives: It ensures harmonised standards in the collection and transmission of regional data; It guarantees that published regional statistics are based on comparable data; It enables the analysis and comparison of the socio-economic situation of the regions based on harmonised data; Policy interventions such as the European Structural and Investment Funds can be specifically targeted to support disadvantaged and less competitive regions

NACE (Statistical classification of economic activities in the European Community) is the acronym used to designate the various statistical classifications of economic activities developed since 1970 in the European Union. NACE provides the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g., production, employment, national accounts) and in other statistical domains.

The statistics produced on the basis of NACE are comparable at European and, in general, at world level. The use of NACE is mandatory within the European Statistical System.

NACE Rev.2, Statistical classification of economic activities in the European Community, EUROSTAT 2008, ISSN 1977-0375



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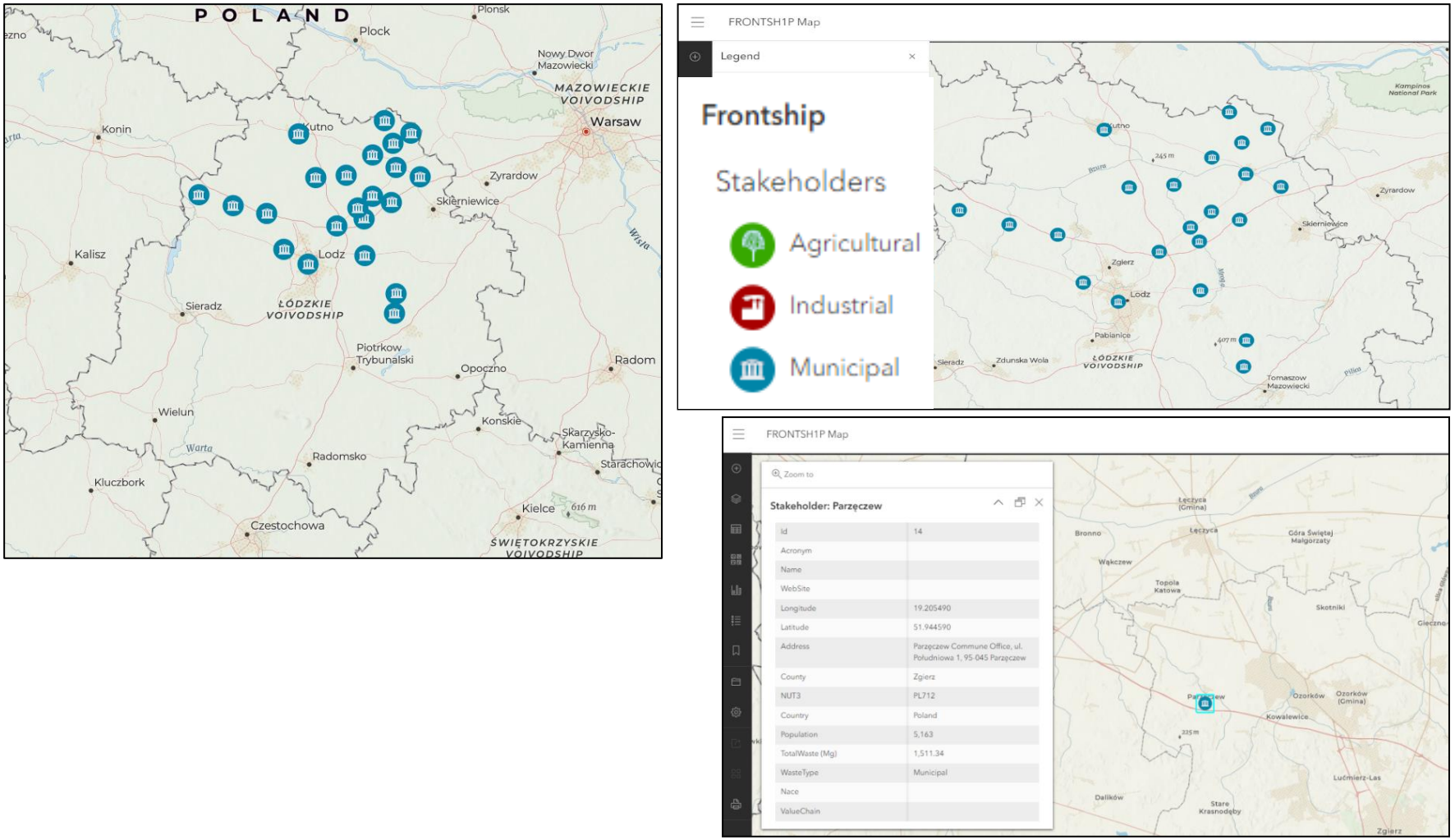


*Figure 25: Exemplary LEVEL 1 map layer with the basic and unique identification of each stakeholder (Lodzkie region and detail of Parzeczew municipality; based on MSW data (2021)),*



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LEVEL 2 – Waste/feedstock type and value-circularity level

2.1. Identification of the type and amount of waste generated, received and/or processed by each geolocated stakeholder (Figure 26).

Data requirements:

- Type of waste/resource (major waste/resource type, e.g., municipal, industrial, agricultural)
- Waste code (waste supranational identifier: European Waste Catalogue (EWC))
- Volume/Amount of generated/managed waste (by EWC)
- Optional if relevant: additional information in case of seasonality constraints

> European Waste Catalogue (EWC) - the EWC is a list of waste types, established by the European Commission Decision 2000/532/EC1, which categorizes wastes based on a combination of what they are, and the process or activity that produces them. It provides a standard framework for the comparison of waste data (statistics) across all member states.
> The EWC is divided into 20 chapters, most of which are industry-based, although some are based on materials and processes. Individual waste types are assigned a six-digit code: the first two digits specify the chapter, the next two specify the subchapter, and the last two are specific to the waste type.
>
> Guidance on classification of waste according to EWC-Stat categories
> Commission of the European Communities, EUROSTAT 2010

2.2. Positioning of each stakeholder in the respective value-circularity level.

Data requirements:

- Allocation of the geolocated stakeholder into defined value-circularity level(s):
  1) Gathering of core resources – ore mining, agriculture and farming
  2) Primary Material Processing – separation, filtering, sieving
  3) Production – manufacturing and assembly, food processing
  4) Packaging & Distribution – warehousing, transportation, retail
  5) Use/Service – consumer use, service providing
  6) Collection – reverse logistics, separation
  7) Disposal – recovery, landfilling



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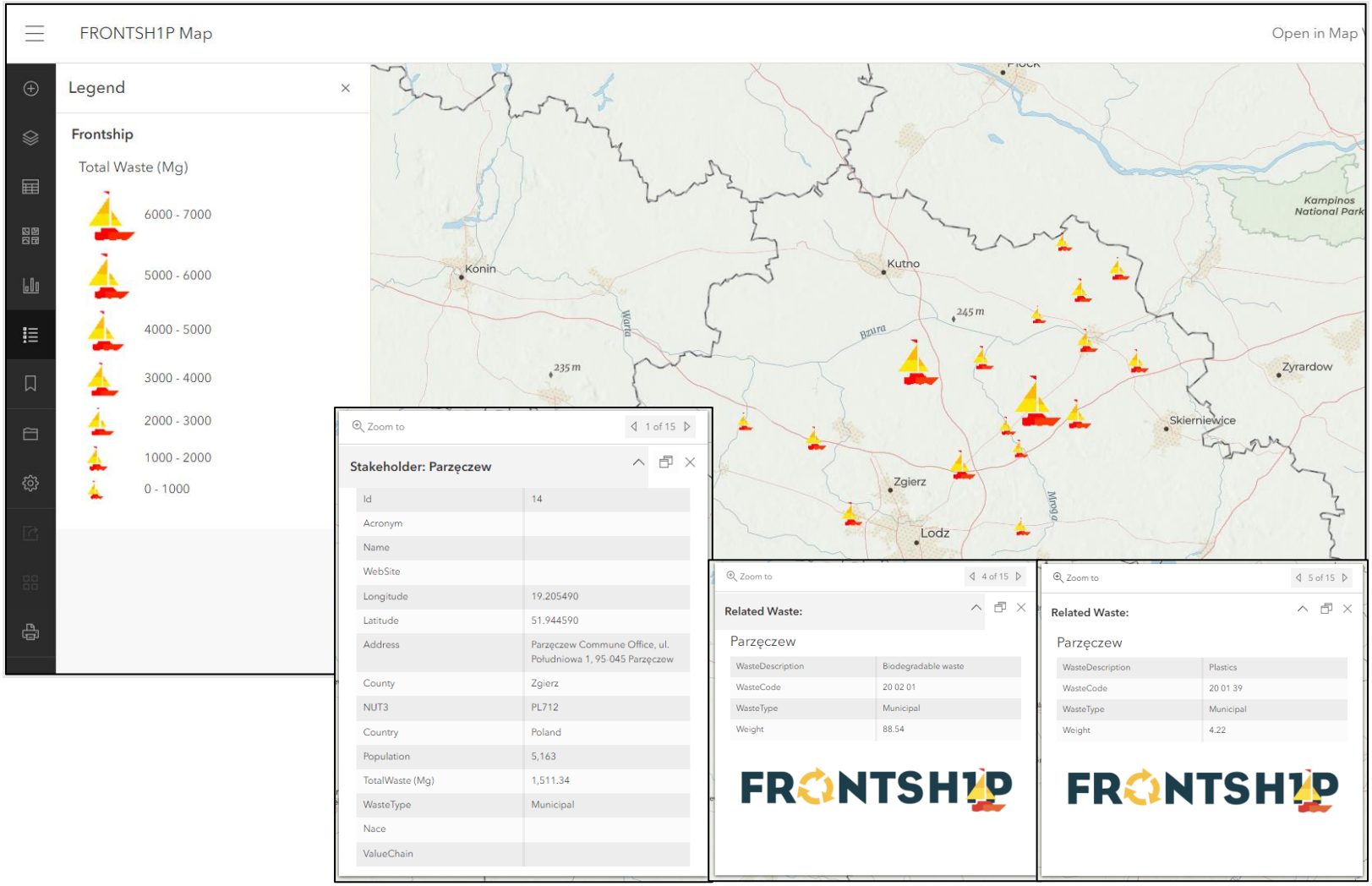


*Figure 26. Exemplary LEVEL 2 map layer for the waste characterization and data in the associated information tags according to the respective waste type and code (Lodzkie region and detail of Parzeczew municipality; based on MSW data (2021)).*



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LEVEL 3 – Stakeholder and CSSs (Figure 27)

3.1. Positioning of each stakeholder within defined CSSs

Data requirements:

- Allocation of the geolocated stakeholder to one or more defined CSSs:
  1) CSS1: Wood packaging
  2) CSS2: Food and feed
  3) CSS3: Water and nutrients
  4) CSS4: Plastics and rubber waste

3.2. Within the selected CSSs, subsequent placement of each stakeholder by value-circularity level

Data requirements:

- Stakeholder identification
- Economic activity (NACE)
- Position in a defined value-circularity level(s) (acc. to section 2.2. in LEVEL 2)
  1) Type of waste (EWC)
  2) Volume/Amount of generated/managed waste (distributed by EWC)

LEVEL 4 – Advanced circularity indicators

4.1. Identification of land without current use

Data requirements:

- Use data available from Urban Atlas 2018* (or updates)— Copernicus Land Monitoring Service, namely class 13400: "Land without current use" (Urban Atlas 2018 — Copernicus Land Monitoring Service)
- Use data available from Statistics Poland (Statistics Poland - Local Data Bank) for cities with more than 100 000 inhabitants

4.2. Technological indicators and distribution networks

Data requirements:

- Industrial and/or processing capacity of the stakeholder
- Involvement of the stakeholder in Research and Innovation activities
- Map of logistic centers, road and rail routes

4.3. Relevant social indicators

Data requirements:

- Regional unemployment data / resident population (active population)
- Identification of NGOs and similar civil society organizations



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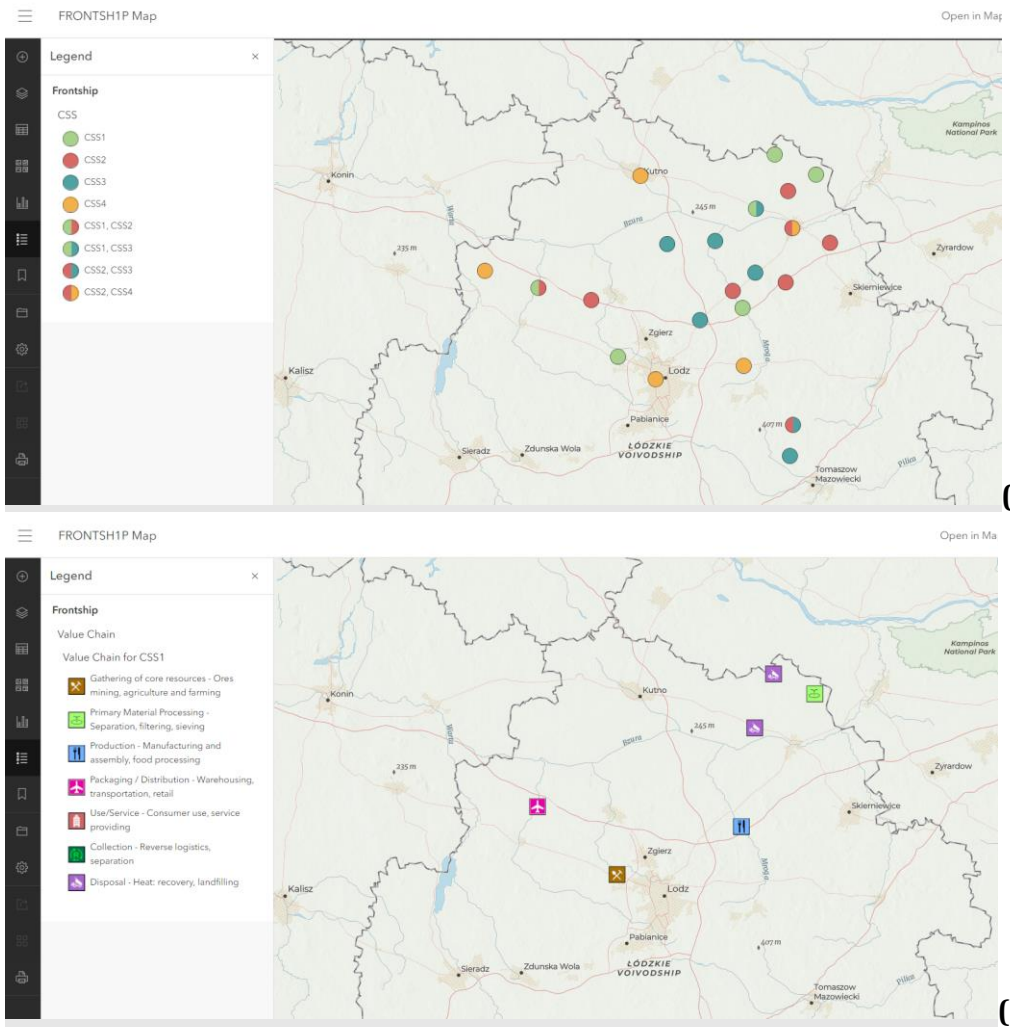


*Figure 27. Exemplary LEVEL 3 map layer of (a) stakeholder distribution by CSS and (b) distribution of CSS1 stakeholders by value-circularity level(s) (Lodzkie region).*



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# 4. Characteristic of data corresponding to the needs of RCBT users

Data corresponding to the needs of users of the RCBT and collected on the FRONTSH1P platform can be characterized in the following dimensions presented below.

### Information necessary to manage raw materials, by-products and final products of CSSs' production, in line with the circularity paradigm:

1) external database, collecting information on available waste;
2) external statistical information databases, collecting contact details regarding recyclers – the tailored lists of companies would being the potential suppliers of waste for production within the CSSs;
3) external statistical information databases, collecting contact details for owners of by-products (before they are turned into waste) of their technological processes - the tailored lists of companies and wholesalers, being the potential suppliers of by-products for production within the CSSs;
4) external statistical information databases, collecting contact details of the companies, the potential contractors of the by-products (before they are turned into waste) of the technological processes of CSSs' technology - the tailored lists of companies, would being the most perspective potential consumers of by-products for their own production, indicated considering LCA and ecodesign perspectives;
5) external statistical information databases, collecting contact details of the companies, the potential contractors of the final products of the technological processes of CSSs' technology - the tailored lists of companies, would being the most perspective potential consumers of by-products for their own production, indicated considering LCA and ecodesign perspectives.

### Information necessary to manage $CO_2$

Management of $CO_2$ emissions and emissions reduction is a multidimensional subject because it concerns, among others, setting climate goals, understanding the steps that will actually contribute to mitigating the climate change affected by global warming, and finally developing a technology that will bring us closer to success or may reduce the scale of problems related to climate changes.

To manage emissions reduction we define goals, a time horizon and available methods regarding ways to achieve improvement, for example, by improving energy efficiency. Once a target is set, we can quantify the results of activities taken and risk in case of delays or failure. However, organizations can only reduce emissions to a certain level - finally, most companies or end users will reach the limit where the only chance for further reduction will be through

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the voluntary offset programs (in the case of the FRONTSH1P project, the emerging prototype VER program). Participation in voluntary reduction schemes from the perspective of $CO_2$ management supports investor's decarbonization and can also contribute to a real reduction in global $CO_2$ emissions.

The most important information in development of VER programs is the benchmark value of emissions before the project implementation. For that purpose, the baseline activity (business as usual) needs to be defined. With this information, it is possible to assess whether the actions taken as part of reduction projects will actually bring environmental benefits. As a part of the baseline, information on the entire life cycle of a project or activity is collected to minimize the risk of missing some emissions that are either generated or unmeasured or could be double-counted, which would disturb the transparency of the voluntary reduction system.

Key data areas, needed to be included in the process of $CO_2$ emissions and reduction management are:

- baseline,
- information on the emissivity of activity, known as business as usual,
- reduction target,
- level of decarbonization achieved.

### Information necessary to assess the circular development in the region

The monitoring framework that will be developed in Task 2.3 will offer an overview on the state of circular economy in the region, supporting the identification of important drivers for circular development. The information needed to populate the monitoring framework will cover the following aspects:

- Public sphere;
- Private sector;
- Education;
- Society;
- Environment.

In this context, multiple data sources are needed, from the regional databases to the national and European: the presence of stakeholders belonging to different areas of the Quadruple Helix within FRONTSH1P consortium will facilitate the collection of dedicated new indicators, measuring specifically circular aspects.

For example, data regarding circular economy in Higher Education, within the "Education" macro area, represent particularly important indications regarding the level of commitment toward circular transition and the readiness in the short term of highly trained workforce endowed with specific skills to enable circular economy. Currently, data is collected by the Universities for management purposes, having in the Consortium Higher Education institutions could facilitate the testing and the adoption of novel indicators, such as "number of students



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that successfully participated in University courses dealing with Circular Economy", "Number of Researchers working in Circular Economy projects", "Number of PhD dealing with circular economy", "Amount of funding in EUR allocated to Circular economy research projects".
The last indicator listed is also very important because it can be compared with the amount of funding that private companies dedicate to circular economy, giving an important comparison to evidence whether the main investor in circular economy is the public or the private sector: this can lead to new policy decisions, considering higher level education in CE as a proxy for short-term circular development.

### Information necessary to consider the potential for the development of circularity on the regional market

The competitiveness of the regional market is shaped by external and internal factors. This includes the development of the regional circular economy. The most important external factors include, first of all, EU policies. Internal determinants of development depend on the efficiency of adaptation of circular solutions of regional stakeholders of the quadruple helix: business, government, academy and society. Information is needed from each of these stakeholders to consider the potential for developing circularity in the regional market.
The monitoring of the business sector in terms of the development of circular economy in region should consist of the analysis of:

- data on industrial waste streams (data from, among others, Local Data Bank, Database on Products and Packaging and Waste Management, incomplete data),
- data on the involvement of enterprises in the implementation of projects in the field of circular economy (data from, among others: the Ministry of Development Funds and Regional Policy, the Ministry of Agriculture and Rural Development, the Marshal's Office regarding the implementation of projects under the financial perspective of European funds for 2014-2020 and 2021- 2027; National and Provincial Fund for Environmental Protection),
- data on expenditure on innovative activity in enterprises in relation to GDP (Central Statistical Office),
- data on the share of renewable energy sources in total production of electricity (BDL);
- data on organic producers (BDL; Agricultural and Food Quality Inspection).

Government sector monitoring of circular economy development in the region should consist of analysis:

- data on sustainable (including green) public procurement (data from the Public Procurement Office),
- data on the implementation of ecological solutions in the field of energy (data of the Central Office of Building Control: Register of Applications, Decisions and Notifications in Construction Matters),



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- data on air quality assessment (according to point data available, for example: Chief Inspectorate of Environmental Protection; Airly webpage: https://airly.org/map/pl/),
- data on wastelands (BDOT10k, Central Office of Geodesy and Cartography),
- data on water potential in ecosystems (BDOT10k Central Office of Geodesy and Cartography).

Monitoring of the academy sector in terms of development of circular economy in region should consist of analysis of:

- data on the involvement of scientific and research institutions in the implementation of R&D&I projects in the field of circular economy (data from, among others: the Ministry of Development Funds and Regional Policy, the Ministry of Agriculture and Rural Development, the Marshal's Office regarding the implementation of projects under the financial perspective of European funds for 2014- 2020 and 2021-2027; National and Voivodship Fund for Environmental Protection),
- data on gross expenditure on R&D activity in relation to GDP.

The monitoring of the society sector in the development of the circular economy in the region should consist of analyzing data on the potential for social engagement. These areas are described above.



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## 4.1. Circular Systematic Solutions. Context of Implementation Plans of CSSs

### 4.1.1. CSS1

The main ideas of CSS 1. How to use wood packaging waste and by-products of wood packaging production and wholesale for boosting regional circular development?

Wood is one of the most common materials used in industry for packaging mainly due to its versatility, strength, durability, reusability, antibacterial effects, no need of chemical treatments and theoretical low environmental impacts. Indeed, wood crates, boxes, drums, reels, cages and pallets are typically used to handle, store, load and transport not only fragile and heavy goods, like machines and plants, but also products coming from the food sector.

After prolonged use, wood packaging might show defects or damage that make it not repairable and reusable anymore and, once it becomes unsuitable for its original purposes, it is usually discarded and disposed of as a waste.

According to CSS1 approach, wood packaging waste is firstly sorted based on its quality. High quality wood (40% of the wood packaging residues collected) will be reused, refurbished, and recycled to produce wooden goods. Low quality wood and wooden residues (60%) will be gasified to produce heat and $CO_2$ (through renewable gas combustion) and char. The technological core of CSS1 is a biomass gasifier which acts as a polygenerative system, coupled with a post carbon capture unit for $CO_2$. Indeed, the gasifier is not only designed for energy purposes, but also to produce valuable goods such as char to be used as pigment/filler in plastics (as substitute of fossil fuel-based carbon black) or additive for compost and, after gas combustion, $CO_2$ to be used for industrial purposes (e.g., foaming agent in the plastic industry) (Figure 28). This approach allows biomass gasification to be considered as a zero-waste process providing both renewable energy and bio-based products.



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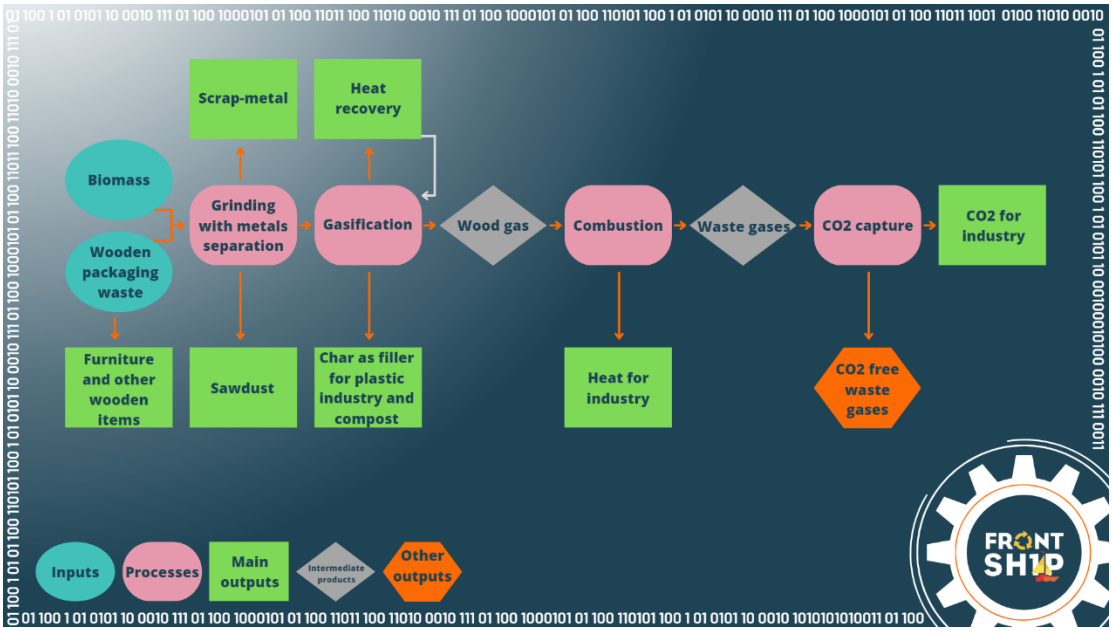


*Figure 28: Scheme of the CSS1 technological processes.*

CSS1 implementation described above exploits only partially all the opportunities that the gasification technology could offer.

In fact, in a wider perspective, apart from the production of renewable heat, char and $CO_2$ foreseen by CSS1, the wood gas obtained by the gasification of biomass could be used in combined heat and power (CHP) systems to provide both thermal and electrical power or further purified and treated (biologically or chemically) to produce chemicals and synthetic fuels with a wide spectrum of applications (Figure 29).

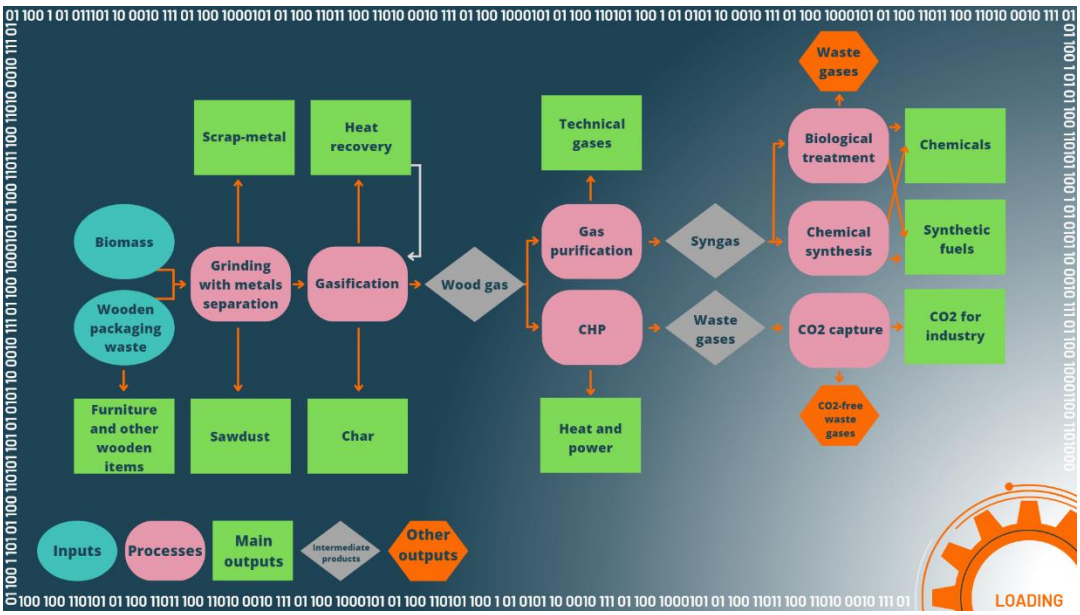


*Figure 29: Gasification technology potential.*



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## Data requirements

The application of a circular approach for the valorization of wood packaging residues allows the minimization of waste and all the issues related to its management, the preservation of resources and the reduction of GHG emissions and for the production of low impact products such as wooden goods (e.g., furniture), renewable heat, char to be used as compost or as pigment/filler in the plastic industry, and $CO_2$ for the industrial sector. Moreover, citizens could play an active role in each stage of the valorization chain, increasing their awareness on sustainability and circular economy, and indirectly benefitting from the environmental advantages that the CSS will bring.

## Ontology of the CSS1

Wood packaging waste includes all the materials deriving from wood items utilized in transportation, storage and delivery of bulky products that get discarded by their users because overworn, damaged, or no longer suitable for their intended use. The most common source item in this space is represented by pallets used in logistics. Pallets are relatively high-value products with relatively long lifespans that undergo multiple cycles of reuse, and their end of life typically involves a recovery of its manufacturing wood material. Such recovery takes place by grinding the disposed of pallet, separating unwanted materials (e.g., metal parts), and possibly reducing the material to coarse chips. In cases of high-quality residual materials that get discarded because the users cannot find suitable reuse, the recovery procedure simply involves reintroducing the as received pallets into a secondary market. From research conducted within FRONTSH1P (D3.1) and from previous information available to consortium partners, a picture of high material recovery efficiency emerges relatively to current wood packaging recycling into secondary markets from data collected on Poland and from a Northern Italian operator.

Overall, the Polish data point to a national recovery of up to 87% of the wood that enters the market, while the Italian operator reported a reintroduction of more than 90% of the materials collected into secondary markets. Such secondary markets include primarily the production of wooden panels for the construction industry (both as building materials and as ancillary construction materials) and the use in energy generation (typically in combustion for combined heat and power or simply for heat generation). The use of more advanced technologies for energy recovery from the residues of packaging wood recycling processes at the current market conditions must primarily involve the exploitation of very low-quality residues that do not find sufficient remuneration in current secondary markets through their conversion to industrially relevant energy vectors, such as high-temperature heat and power.

In this context, gasification represents a technological solution potentially suitable for decentralized exploitation of wood recycling residues that can support local industrial



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operations through energy provision. Gasification relies on the high-temperature conversion of woody biomass to a combustible gas (syngas) that can be valorized in internal combustion engines to drive power generation while supplying recoverable heat or in conventional boilers to supply hot water. Full industrial setups rely on the combination of a gasification reactor and either an internal combustion engine or a syngas fueled boiler. The full process train can either be supplied by a single manufacturer or purchased from multiple ones. Most commercial systems intended for combined heat and power production, or solar heat production typically rely on air gasification technology. Several manufacturers are available in Europe supplying small-scale solutions that range from tens of kW to less than one MW of power supply capacity. Project partner Burkhardt (BKT) is one such example. As a fundamental by-product of the process gasification generates char, a carbonaceous material with high surface area that potentially finds a wide variety of applications in existing industrial contexts, from the adsorption of contaminants in liquid and gaseous effluents to the production of soil conditioners. Char's suitability for different applications depends on a set of physical and chemical parameters including specific surface area, hydrocarbon and heavy metals contamination and contamination from other organic compounds.

Post-combustion carbon capture (PCC) is a process relying on the separation of carbon dioxide from gaseous effluents derived from the combustion of various types of fuels. PCC enables capturing climate pollutant carbon dioxide while making it available for industrial processes that require pure $CO_2$ as a process fluid. PCC can rely on a set of technologies that include $CO_2$ absorption in a liquid solvent via chemical or physical processes as well as on novel technologies making use of electrochemical systems. Context of FRONTSH1P, PCC will be implemented as a downstream process integrated into syngas combustion for the separation of pure $CO_2$ from combustion products, which will serve plastics manufacturing processes.

The use of novel technologies for the production of advanced energy vectors from residual materials addresses the challenges posed by European directives on both waste management (Waste Framework Directive) and renewable energy production (Renewable Energy Directive II - RED II), that, among others, set a target for and overall, 32% of renewable energy to be produced by 2030 specifying clear emissions reduction targets. RED II poses a 14% renewable energy target for the transportation sector where 3.5% of the overall energy will have to be supplied through so-called "advanced biofuels", a definition implying that these biofuels will have to be produced starting from residual materials rather than primary feedstocks. Instead, the Waste Framework Directive introduced the concept of the waste hierarchy, regulating that any residual materials that cannot be valorized through reuse or materials recovery (recycling) should be exploited for energy recovery.



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## Presentation of the FRONTSH1P aims context

Valorization of wood packaging waste through a CSS is one of the objectives of the FRONTSH1P. By the development and demonstration of four different CSSs, FRONTSH1P aims at ensuring a green and just transition of EU regions, starting from the Lodzkie Region in Poland towards decarbonization and territorial regeneration, addressing the current challenges and needs of the Regions, transforming them into opportunities for economic growth, social inclusion, as well as improvement of the quality of life for citizens, reconnection between the urban and rural context.

The specific objectives of CSS1 - a circular approach to wood packaging waste are:

1) Creation of a new value chain based on wood packaging waste valorization, involving the whole community and implementing the circular economy approach (refurbishing, reusing, recycling, energy recovery);
2) Coupling of biomass gasification for renewable heat generation and post-combustion capture of $CO_2$ towards carbon negative emissions;
3) Exploitation of char as pigment/filler in the plastic industry or as additive for compost;
4) Exploitation of $CO_2$ as foaming agent in the plastic industry.

## CSS1 technology of processing of pallets waste and technology of data processing context

Technologies relevant to the data collection and processing context include the local availability of both pre-treatment systems such as wood grinding and chipping, metal separation, drying and pelletizing, gasification systems, syngas combustion and carbon capture and separation systems. To this adds a network of engineering and construction operators that can implement the technologies in real operational contexts of Figure 30.

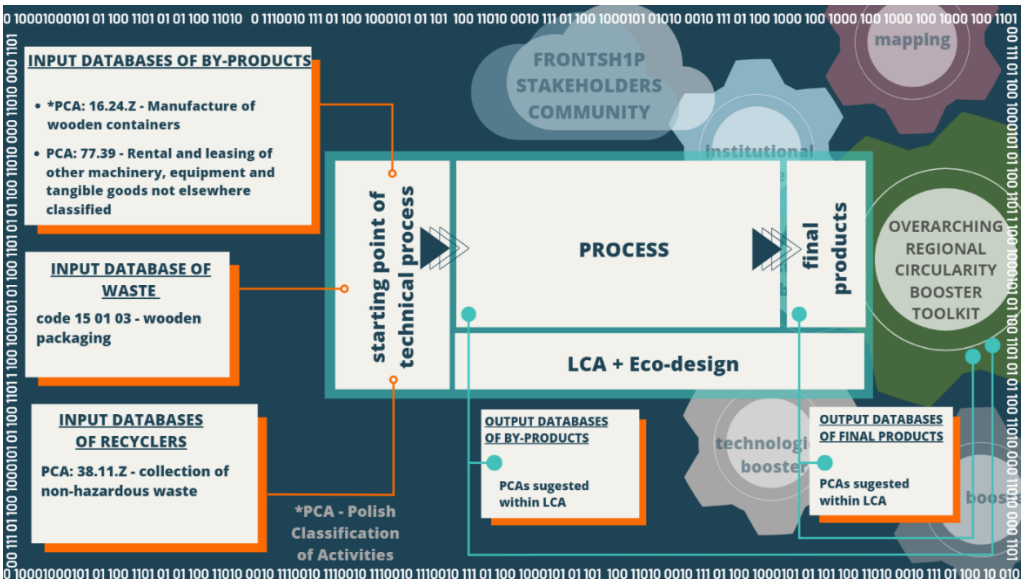


*Figure 30: The scheme of data processing layer dealing with the CSS1 technology.*



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The CSS1 technology, in context of data processing, is based on four main sources of data:

1) database related to the waste of pallets (wood packaging residues); this database is composed of companies dealing with wood packaging waste (recyclers). Here we use three codes for data processing: waste code, which characterizes of type of waste Table 9, Polish Classification of Economic Activities (PKD), which characterizes type of economic activities, geo-location, which enables to present the available waste on the maps (Figure 27).

2) database related to by-products from the production of pallets (Table 10). Here, we use two codes for data processing: PKD, which characterizes type of economic activities with a geo-location, which enables to present the waste on the maps (Figure 26).

3) database related to by-products from the wholesalers of pallets (Table 11). Here, we use two codes for data processing: PKD, which characterizes type of economic activities with geo-location, which enables to present the waste on the maps (Figure 27).

4) information delivered by the Broker of Circularity.

Table 9 contains the waste code characterizing wooden waste:

- 15 - Packaging waste; sorbents, wiping cloths, filter materials and protective clothing not included in other groups
- 1501 - Packaging waste (including separately collected municipal waste packaging waste)
- 150103 - Wood packaging.

*Table 9: Database of the pallet waste code*

| DATABASE OF THE PALLET WASTE CODES | |
|---|---|
| WASTE CODE | DESCRIPTION OF CODE |
| 15 | Packaging waste; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified |
| 15 01 | Packaging waste (including separately collected municipal packaging waste) |
| 15 01 03 | Wood packaging |

*Source: own compilation*

Table 10 presents companies from the Lodzkie region, which in the registration documents also declare activities related to wood packing.

The following columns of the table include: the exact address of the enterprise, NIP, REGON (PL: Krajowy Rejestr Urzędowy Podmiotów Gospodarki Narodowej - a register kept by the President of the Central Statistical Office). REGON is also understood as the REGON



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identification number, i.e., a nine-digit identifier assigned to an entity in this register.), indication whether the PKD code in a specific enterprise defines the predominant activity.
Companies entered into the CEIDG, which, among others, conduct activities characterized by the PKD code 16.24.Z Production of wooden packaging (manufacture of pallets, box pallets and other transport packaging, of wood).

*Table 10: Database of producers of pallets with PKD and geo-location in the Lodzkie Region (suppliers of by-products)*

| DATABASE OF PALLETS PRODUCERS IN THE LODZKIE REGION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 16.24.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS1 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Eurobruk | 97-225 Ujazd, ul. Buków 11 | 7732084856 | 100532722 | No | 4415 20 20 |
| 2. | Sylvia | 91-111 Łódź, ul. Traktorowa 63 | 7282236992 | 101561884 | No | 4415 20 20 |
| 3. | Tartacznictwo i sprzedaż tarcicy Lech Bojdo | 96-200 Rawa Mazowiecka, ul. Jana Sobieskiego 143 | 7731008793 | 590165669 | No | 4415 20 20 |
| 4. | Trans-Fer | 95-080 Tuszyn, ul. Młynkowa 51 | 7261635149 | 471313151 | No | 4415 20 20 |
| 5. | Firma usługowa Kamil Bajerowski | 97-310 Moszczenica, Jarosty, ul. Miła 7 | 7712614819 | 100824643 | No | 4415 20 20 |
| 6. | Salopak | 99-418 Bełchów, ul. Piaskowa 3A | 8341579181 | 750717869 | No | 4415 20 20 |
| 7. | Joma | 97-300 Piotrków Trybunalski, ul. Zalesicka 153 | 7711801092 | 100150630 | No | 4415 20 20 |
| 8. | Tamtam Marcin Grzędowski | 95-080 Tuszynek Majoracki, ul. Kasztelańska 32 | 7712324174 | 101568969 | No | 4415 20 20 |
| 9. | Rawdróg | 96-232 Regnów, ul. Rylsk 46 | 8351017349 | 750238577 | No | 4415 20 20 |
| 10. | Agromal-bis Przemysław Malewski | 98-200 Chojne, ul. Słoneczna 12 | 8272089159 | 731654483 | No | 4415 20 20 |

*Source: own compilation*



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Table 11 presents enterprises entered into the CEIDG, which, among others, conduct activities characterized by the PKD code 77.39.Z Rental and leasing of other machinery, equipment and tangible goods, not elsewhere classified (pallet rental).

*Table 11: Database of rental and leasing of pallets companies in the Lodzkie Region*

| RENTAL AND LEASING OF PALLETS DATABASE IN THE LODZKIE REGION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 77.39.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS1 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Alte- Motorrad Maria Lenk-Berger | 93-410 Łódź,<br>ul. Pabianicka 130, | 7291417960 | 362503717 | No | 4415 20 20 |
| 2. | API Bartosz Walczak | 95-070 Rąbień,<br>ul. Okrężna.37 | 9471540338 | 472315956 | No | 4415 20 20 |
| 3. | Bioveri Michał Królikowski | 95-100 Dąbrówka Wielka,<br>ul. Kościelna.10 | 7321832920 | 473268331 | No | 4415 20 20 |
| 4. | Budomal | 90-642 Łódź,<br>ul. Włókniarzy.221/225 | 7281237038 | 471370893 | No | 4415 20 20 |
| 5. | Dolko Radosław Doliński | 95-070 Aleksandrów Łódzki,<br>ul. Warszawska 70, | 9471768107 | 470982447 | No | 4415 20 20 |
| 6. | Eltim T. B | 92-016 Łódź,<br>ul. Zaspowa 22/24 | 7291186348 | 100879029 | No | 4415 20 20 |
| 7. | Ewja Jarosław Stasiak | 99-307 Strzelce, Karolew 9 | 7752438866 | 100253778 | No | 4415 20 20 |
| 8. | Granit-System | 97-515 Masłowice, Strzelce Małe 87 | 7722117583 | 365545372 | No | 4415 20 20 |
| 9. | Hoss-Trans | 95-080 Tuszyn,<br>ul. Brzezińska 43 | 7711388344 | 472938284 | No | 4415 20 20 |
| 10. | IS Instal-Serwis | 95-080 Tuszyn,<br>ul. Rzgowska 1 | 9471004953 | 100813823 | No | 4415 20 20 |

*Source: own compilation*



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Table 12 presents companies entered into the CEIDG, which, among others, conduct activities characterized by the PKD code 38.32.Z Recovery of raw materials from segregated materials (sorting and granulating plastics to obtain secondary raw materials for the production of pipes, flowerpots, pallets, etc.).

*Table 12: Database of recovery of wooden material companies in the Lodzkie Region*

| RECOVERY OF RAW MATERIALS FROM SEGREGATED MATERIALS DATABASE IN THE LODZKIE REGION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 38.32.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS1 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Auto-Complex | 95-030 Rzgów, Czyżeminek.30 | 7282277560 | 472273666 | No | 4415 20 20 |
| 2. | Rolmech | 99-416 Bednary, ul. 10 Pułku Piechoty 1 | 8341526724 | 100782880 | No | 4415 20 20 |
| 3. | Olmat | 99-400 Łowicz Dąbkowice Górne.35 | 8341161725 | 750045967 | No | 4415 20 20 |
| 4. | Petaso | 97-300 Piotrków Trybunalski, ul. Juliusza Słowackiego 303 | 7712253818 | 592254549 | No | 4415 20 20 |
| 5. | Przedsiębiorstwo Usługowe Staks | 97-300 Piotrków Trybunalski, ul. Belzacka 97B | 7712907384 | 384073820 | No | 4415 20 20 |
| 6. | FHU Fagen | 99-300 Kutno, Krzesin 1 | 7751040920 | 100853751 | No | 4415 20 20 |
| 7. | Ramilla | 99-400 Łowicz Małszyce.35 | 8341594996 | 750780193 | No | 4415 20 20 |
| 8. | Center Office Biuro Doradztwa Inwestycyjnego Jarema Marjański | 90-303Łódź, ul. Brzeźna 18 lok. 2 | 7271505997 | 100672682 | No | 4415 20 20 |
| 9. | KKR-Recykling | 95-050Konstantynów Łódzki, ul. J. Kochanowskiego 71 | 7271805357 | 100773561 | No | 4415 20 20 |
| 10. | ABC - Wędrowniczek - Zbigniew Siekiera | 99-417 Bolimów, Kęszyce-Wieś.32 | 8360007824 | 750118755 | No | 4415 20 20 |

*Source: own compilation*



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Table 13 presents companies entered the CEIDG, which, among others, conduct activities marked with the code PKD 38.11.Z Collection of non-hazardous waste.

*Table 13: Database of recyclers of pallets waste with PKD and geo-location in the Lodzkie Region*

| NON-HAZARDOUS WASTE DATABASE IN THE LODZKIE REGION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 38.11.Z | | | | | |
|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS1 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | CN CODE |
| 1. | Fagus | 91-604 Łódź, ul. Stasia 11 | 7261060045 | 100201942 | 38.11. |
| 2. | Roboty drogowe i ziemne. Usługi maszynami drogowymi Mariusz Szulc | 97-220 Rzeczyca, Glina 36 | 7731352645 | 591885383 | 38.11. |
| 3. | Tamak | 98-331 Nowa Brzeźnica Konstantynów 4 | 5741432451 | 592092242 | 38.11. |
| 4. | Torbud | 93-327 Łódź, ul. Torowa 12 | 9820304399 | 100558590 | 38.11. |
| 5. | Rolmech | 99-416 Nieborów, Bednary, ul. 10 Pułku Piechoty 1 | 8341526724 | 100782880 | 38.11. |
| 6. | Firma Usługowa Kamil Bajerowski | 97-310Jarosty, ul. Miła 7 | 7712614819 | 100824643 | 38.11. |
| 7. | Petaso | 97-300 Piotrków Trybunalski, ul. Juliusza Słowackiego 303 | 7712253818 | 592254549 | 38.11. |
| 8. | Staks | 97-300 Piotrków Trybunalski, ul. Belzacka 97B | 7712907384 | 384073820 | 38.11. |
| 9. | Przedsiębirstwo Wielobranżowe Elektrobud | 99-300 Nowe Sójki 3 | 7751028333 | 610167618 | 38.11. |
| 10. | Center Office Biuro Doradztwa Inwestycyjnego Jarema Marjański | 90-303 Łódź, ul. Brzeźna 18 m 2 | 7271505997 | 100672682 | 38.11. |

*Source: own compilation*



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Table 14 presents companies entered into the CEIDG, which, among others, conduct activities marked with the PKD code 46.73.Z Wholesale of wood, construction and sanitary materials.

*Table 14: Database of wholesalers of pallets with PKD and geo-location in the Lodzkie Region (suppliers of by-products)*

| DATABASE OF SELLERS OF WOOD AND CONSTRUCTION AND SANITARY MATERIALS IN THE LODZKIE REGION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 46.73.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS1 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Trans – Kop | 61, 95-080 Tuszyn, ul. Stefana Żeromskiego 61 | 7711106498 | 590392655 | No | 46.01. |
| 2. | A & R Radosław Stefaniak | 91-223 Łódź, ul. Morgowa 9 | 9471194103 | 471992933 | No | 46.01. |
| 3. | Ania | 95-080 Tuszyn, Modlica 96 | 7711639220 | 100338345 | No | 46.01. |
| 4. | Alte- Motorrad | 93-410 Łódź, ul. Pabianicka 130 | 7291417960 | 362503717 | No | 46.01. |
| 5. | Anga | 98-200 Sieradz, ul. POW 64a | 8271354501 | 731658334 | No | 46.01. |
| 6. | Architektura formy | 90-768 Łódź, al. Włókniarzy 207 | 7251035620 | 473238287 | No | 46.01. |
| 7. | Armet | 99-107 Daszyna, Łubno 60 | 6661486439 | 101522157 | No | 46.01. |
| 8. | Biurokreacja | 95-070 Aleksandrów Łódzki, ul. Józefa Piłsudskiego 5 | 7291396382 | 473085760 | No | 46.01. |
| 9. | Udomal | 90-642 Łódź, ul. Włókniarzy, 221/225 | 7281237038 | 471370893 | No | 46.01. |
| 10. | Dam – Dach | 98-270 Złoczew, ul. Lututowska 2 | 8272186879 | 101263448 | No | 46.01. |

*Source: own compilation*

Data on wood waste producers was obtained using open online databases. After entering the right keywords, the PKD database this database allows identifying activity codes related to wood and pallets.



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The available search criteria allow companies to be searched using filters. For the purposes of the project, companies with a pre-defined PKD code were selected. The search area was narrowed down to the Lodzkie Region. Unfortunately, the search engine does not offer the possibility of sorting the search results. Therefore, it is not possible to rank the companies, e.g., from the largest to the smallest or according to turnover. Moreover, it is not possible to enter the PKD code of interest as the main PKD code of the entities searched for.

The companies, listed in tables 10-14 are an example and a test case showing that the RCBT has large potential of merging stakeholders to initiate beneficial collaboration.
Benefits of implementing a data processing system addressing the underused potential of wood packaging for the development of circularity in the Lodzkie Region and replication regions.

Fundamental benefits relevant to data collection and processing include the following broad indices:

- Reduced waste generated/increased material valorization efficiency;
- Reduced waste management costs for regional operators;
- Reduced consumption of fossil energy vectors (e.g., natural gas or coal) and related savings;
- Reduced GHG emissions from energy generation for the industry;
- Replacement of fossil-based materials with bio-based ones (e.g., pigments/fillers for the plastic industry);
- Increase awareness on the valorization potential of wood packaging waste.



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### 4.1.2. CSS2

Waste collection, treatment and their disposal cause environmental pressures, i.e., greenhouse gases (GHG) and other air pollutant emissions and emissions to water and soil and threatens biodiversity through littering. Environmental impacts of waste depend largely on the amount and characteristics of the waste as well as its management. In addition to direct impacts from waste management, generation of waste is generally a sign of a waste of resources, with the associated environmental impacts of resource extraction and use. The shift from landfill to more recycling and recovery that has taken place in many countries for a number of waste streams in the last 10–15 years has clearly reduced the pressures of waste on the environment.

If a wider perspective is taken, which includes the GHG emissions avoided by replacing virgin materials with recycled materials and by using recovered waste instead of fossil fuels for energy supply, the environmental benefits of better waste management are even higher [61]. Different waste or by-products (i.e., sugar-rich streams (fruits) and cooking oils), especially from industrial sources, could be valorized in moder biorefineries as biobased inputs for the creation of new materials, in substitution of virgin biobased feedstocks [62]. This approach will reduce GHG emission linked to virgin material production (vegetable oils, sugars) and also partially reduce the impact related to waste management. Often those by-products are already collected and used for the production of low value product (ingredient in animal feed, biogas production etc.), but within CSS2 we believe that modern biorefineries could have the possibility to increase the added value of those products before those wastes/by-products goes transferred for their actual use, recovering from them new valuable feedstock.
The issues related to the valorization of this kind of biobased feedstocks are mainly related to the seasonality of the products, purity, valuable products concentration, contamination, stability and conservation of the feedstock and therefore the logistics related to its recovery. But the valorization of the feedstock could allow biorefineries to diversify material origin and better adapt to market price changes.

Whitin biorefineries biobased feedstock derived from waste and byproduct could be used, following a fully circular approach, to produce certified biodegradable and compostable bioplastic for Organic Fraction Municipal Solid waste collection. Those certified product [63] could allow the collection of organic waste in material that in industrial composting condition completely biodegrades returning to soil as biobased material, allowing the production of high-quality compost. Produced compost could then be used as organic soil improver and fertilizers in marginal lands. Those recovered lands could allow the production of low impact vegetable oils that can enter biorefineries for the production of biolubricants. Scheme of the CSS2 technological processes is given in Figure 31.



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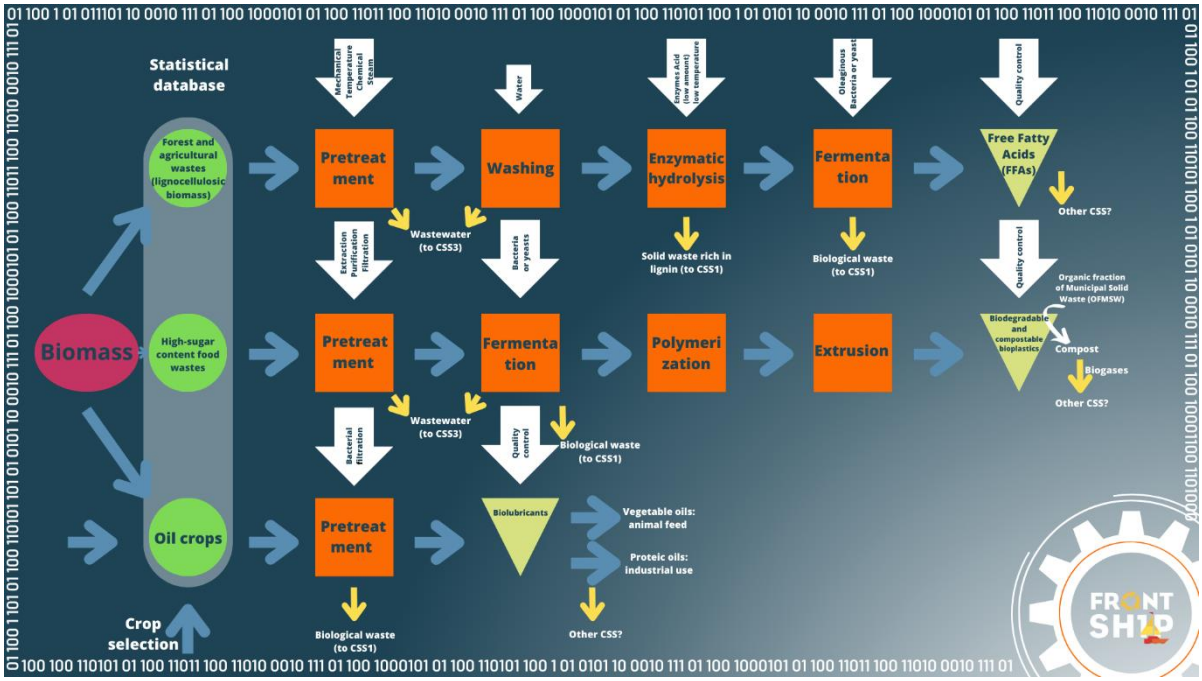


*Figure 31: Scheme of the CSS2 technological processes*

An important issue to perform this closed cycle is related to the implementation of efficient and organized waste collection systems in order to avoid material contamination of non-compostable material in organic compost (such as: plastic and micro plastics, metals, glass etc.). Therefore, a clear legislative programming as well as appropriate data processing system Figure 32 should be implemented in order to organize and define territorial approach based on local and local characteristics.

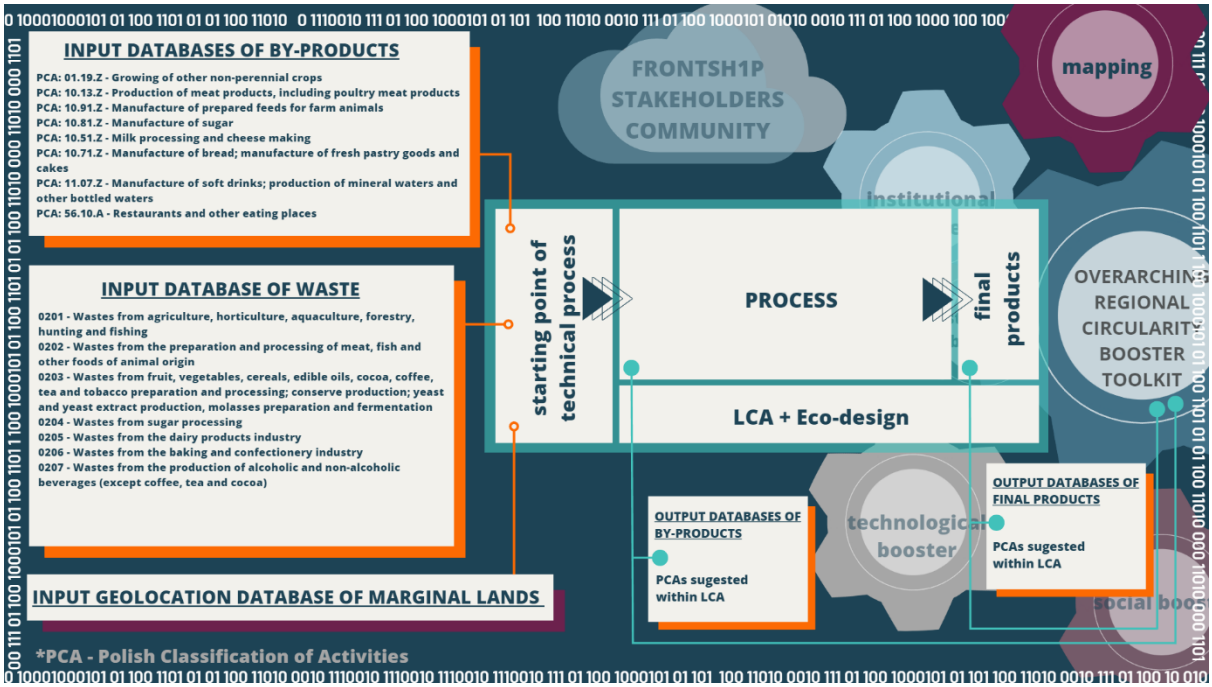


*Figure 32: The scheme of data processing layer dealing with the CSS2 technology.*



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## Ontology of the CSS2 technology

Agro-industrial wastes - materials obtained as wastes from the agricultural field and agriculture-related industries from various processes such as the production of agricultural outcomes such as fruits, meat, vegetables, dairy products, etc. [64].

Biodegradability - The ability of an organic substance to turn into simpler substances through the activity of micro-organisms (biodegradation). If the biodegradation process is complete, the organic substance is converted entirely into simple molecules: water, carbon dioxide, methane and new biomass [65].

Biolubricant - The term biolubricants applies to all lubricants, which are both rapidly biodegradable and non-toxic to humans and other living organisms, especially in aquatic environments [66].

Bioplastic - Biodegradable and/or bio-based plastic [65]

Biorefineries - Biorefining is the sustainable processing of biomass into a spectrum of bio-based products (food, feed, chemicals, materials) and bioenergy (biofuels, power and/or heat) [67]

By-products - A secondary product from the industrial production of other products, that are economically less important than these [65].

Compostability - The property of biodegradable organic matter (food and grass cuttings, manure, some types of bioplastic, etc.) of being converted into compost in composting plants [65].

Compost - The result of bio-oxidation and humification of a mixture of organic materials (for example, plant cuttings, kitchen scraps and gardening waste, such as leaves and grass cuttings) by macro and micro-organisms in the presence of oxygen. The compost is used as a nutrient for farmland [65].

Marginal lands - Farmland that is not used for agricultural purposes, unproductive for economic or social reasons, located in areas characterized by natural disadvantages, in mountain areas or other but which could be used for agricultural purposes through the intervention of means normally available from the farm. They are usually referred to in different terms: unused, degraded, insufficiently used, uncultivated, desolate and abandoned. Fallow land (land included in the crop rotation system but temporarily uncultivated, worked or not, which does not provide any harvest for the entire duration of the agricultural year) is excluded [65].



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OFMSW - The fraction of municipal waste consisting of food scraps and grass cuttings or animal waste that comes from domestic or industrial sources [65].
Speciality crops – Fruits and vegetables, tree nuts, dried fruits and horticulture and nursery crops, including floriculture, and can be defined as intentionally cultivated plants. Wild plants are not considered specialty crops even though they may be used for the same purpose as cultivated plants [68].

### CSS2 technology in context of the FRONTSH1P aims

The main goal of the CSS2 is to develop methodology and toolkits to support the regional transition to a more circular economy, promoting the use of various types of local sources of waste as raw materials.
The CSS2, strictly interconnected with other CSSs, has key innovations in:

- $CO_2$ assisted pre-treatment of agro-industrial waste combined with biotechnological treatments for the obtaining of Free Fatty Acids (FFAs) as component for foaming biomaterials;
- Establishment of innovative oil crops cultivations (i.e., sunflower, milk thistle) in marginal and abandoned agricultural areas to obtain vegetable oils that can be transformed in biodegradable biolubricants, insulating materials and locally available animal feed supplements formulations;
- production of biobased building blocks (diols and dicarboxylic acids) from second generation feedstock (from regional agro-industrial waste rich in sugars) for the formulation of new compostable bioplastics (compostable bags for OFMSW collection).

Input database of waste, depicted in Figure 32 is presented Table 15, which contains waste codes characterizing waste from:

- group 02: waste from agriculture, horticulture, hydroponics, aquaculture, forestry, hunting and fishing, food preparation and processing (30 types of waste from subgroups: 02 01, 02 03, 02 04, 02 05, 02 06 and 02 07);

and subgroups:

- 02 01 - Waste from agriculture, horticulture, hydroponics, forestry, hunting and fishing
- 02 02 - Waste from the preparation and processing of food products of origin
- 02 03 - Waste from the preparation and processing of food products and stimulants and waste of plant origin, including waste from fruit, vegetables, cereal products, edible oils, cocoa, coffee, tea, as well as the preparation and processing of tobacco, yeast and the production of yeast extracts, preparation and fermentation of molasses (except 02 07)
- 02 04 - Waste from the sugar industry



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- 02 05 - Waste from the dairy industry
- 02 06 - Waste from the baking and confectionery industry
- 02 07 - Wastes from the production of alcoholic and non-alcoholic beverages (excluding coffee, tea and cocoa)

*Table 15: Database of waste codes for CSS2.*

| WASTE CODE DATABASE FOR CSS2 | |
|---|---|
| WASTE CODE | DESCRIPTION OF CODE |
| **02** | **Waste from agriculture, horticulture, hydroponics, aquaculture, forestry, hunting and fishing, food preparation and processing** |
| 02 01 | Waste from agriculture, horticulture, hydroponics, forestry, hunting and fishing |
| 02 01 01 | Wash and cleaning residues |
| 02 01 02 | Waste animal tissue |
| 02 01 03 | Waste plant mass |
| 02 01 04 | Plastic waste (except packaging) |
| 02 01 06 | Animal waste |
| 02 01 07 | Wastes from forestry |
| 02 01 08* | Agrochemical waste containing hazardous substances |
| 02 01 09 | Waste agrochemicals other than those mentioned in 02 01 08 |
| 02 01 10 | Metal waste |
| 02 01 81 | Dead animals and waste animal tissue representing specified and high risk material other than those mentioned in 02 01 80 |
| 02 01 82 | Dead animals and slaughtered out of necessity |
| 02 01 99 | Other waste not specified |
| 02 02 | Waste from the preparation and processing of food products of origin |
| 02 02 01 | Waste from washing and preparation of raw materials |
| 02 02 02 | Waste animal tissue |
| 02 02 03 | Raw materials and products unsuitable for consumption and processing |
| 02 02 04 | Sludge from in-house sewage treatment plants |
| 02 02 81 | Waste animal tissue constituting specified and high-risk material, including waste from the production of meat and bone feed other than those mentioned in 02 02 80 |
| 02 03 | Waste from the preparation and processing of food products and stimulants and waste of plant origin, including waste from fruit, vegetables, cereal products, edible oils, cocoa, coffee, tea, as well as the preparation and processing of tobacco, yeast and the production of yeast extracts, preparation and fermentation of molasses (except 02 07) |



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| | |
|---|---|
| 02 03 01 | Sludges from washing, cleaning, peeling, centrifugation and separation of raw materials |
| 02 03 03 | Extraction waste |
| 02 03 04 | Raw materials and products unsuitable for consumption and processing |
| 02 03 05 | Sludge from in-house sewage treatment plants |
| 02 03 80 | Pomace, sludge and other waste from the processing of plant products (except 02 03 81) |
| 02 03 81 | Waste from the production of plant feed |
| 02 03 82 | Tobacco waste |
| 02 03 99 | Other waste not specified |
| 02 04 | Waste from the sugar industry |
| 02 04 01 | Sludge from beet cleaning and washing |
| 02 04 02 | Non-normative calcium carbonate and sugar chalk (defection lime) |
| 02 04 80 | fruit remnants |
| 02 05 | Waste from the dairy industry |
| 02 05 01 | Raw materials and products unsuitable for consumption and processing |
| 02 05 02 | Sludge from in-house sewage treatment plants |
| 02 05 80 | Waste whey |
| 02 05 99 | Other waste not specified |
| 02 06 | Waste from the baking and confectionery industry |
| 02 06 01 | Raw materials and products unsuitable for consumption and processing |
| 02 06 03 | Sludge from in-house sewage treatment plants |
| 02 06 80 | Useless to use food fats |
| 02 06 99 | Other waste not specified |
| 02 07 | Wastes from the production of alcoholic and non-alcoholic beverages (excluding coffee, tea and cocoa) |
| 02 07 01 | Waste from washing, cleaning and mechanical grinding of raw materials |
| 02 07 04 | Raw materials and products unsuitable for consumption and processing |
| 02 07 05 | Sludge from in-house sewage treatment plants |
| 02 07 80 | Pomace, must and fermentation sediments, decoctions |
| 02 07 99 | Other waste not specified |

*Source: own compilation*

The following columns of the table contain: the exact address of the company, NIP, REGON. REGON is also understood as the REGON identification number, i.e., a nine-digit identifier assigned to an entity in this register), indicating whether the PKD code in a specific enterprise determines the dominant activity.



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Table 16 presents companies entered the CEIDG database, which, among others they conduct activities marked with the PKD code 01.19.Z Other non-perennial agricultural crops.

*Table 16: Database of plant production companies in the Lodzkie Region*

| DATABASE OF PLANT PRODUCERS IN THE LODZKIE REGION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 01.19.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS1 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Fatima | 96-100 Łódź<br>Miedniewice 25 | 8341586459 | 750812639 | No | 12.07. |
| 2. | Inter-Kell | 95-060 Brzeziny<br>ul. Strykowska 1 | 7272449060 | 100007803 | No | 12.07. |
| 3. | Elkon | 95-047 Brzeziny<br>Lubiska-Kolonia 10 | 8331365811 | 101720360 | No | 12.07. |
| 4. | Brad | 98-100 Łódź<br>ul. Sienkiewicza 23 | 8311497165 | 731625808 | No | 12.07. |
| 5. | 3MP | 97-220 Rzeczyca<br>Sadykierz 18 | 7732389076 | 101027647 | No | 12.07. |
| 6. | Adamczyk | 97-425 Zelów,<br>Łobudzice 4 | 7691751906 | 101055052 | No | 12.07. |
| 7. | Adex | 95-039 Sokolniki-Las<br>ul. Królowej Jadwigi 39 | 7321501169 | 472152514 | No | 12.07. |
| 8. | Adkar | 92-402 Łódź<br>ul. Zakładowa 20a | 7282250590 | 101670946 | No | 12.07. |
| 9. | Emilka | 95-035 Ozorków,<br>ul. Zgierska 9 | 7322000216 | 380812605 | No | 12.07. |
| 10. | Adrian Dawidowicz | 93-485 Łódź,<br>ul. Franciszka Plocka 15 | 7292638261 | 101490434 | No | 12.07. |

*Source: own compilation*



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Table 17 presents companies entered into CEIDG, which, among others they conduct activities marked with the PKD code 10.13.Z Manufacture of meat products, including poultry meat products.

*Table 17: Database of meat processing companies in the Lodzkie Region*

| MEAT WASTE BASE<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 10.13.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS1 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Luxor | 94-216 Łódź, ul. Zakręt 5 | 7270005146 | 004287205 | No | 16.01. |
| 2. | Zakład Przetwórstwa Mięsnego | 26-340 Drzewica, Żdżary 11A | 7991508920 | 385889802 | No | 16.01. |
| 3. | Euro - Sak | 97-217 Lubochnia, Olszowiec 63A | 7731695049 | 590723589 | No | 16.01. |
| 4. | Truck partner | 95-047 Brzeziny Lubiska-Kolonia 10 | 8331365811 | 101720360 | No | 16.01. |
| 5. | Adkar | 92-402 Łódź ul. Zakładowa 20a | 7282250590 | 101670946 | No | 16.01. |
| 6. | Emilka | 95-035 Ozorków, ul. Zgierska 9 | 7322000216 | 380812605 | No | 16.01. |
| 7. | Adrian Dawidowicz | 93-485 Łódź, ul. F. Plocka 15 | 7292638261 | 101490434 | No | 16.01. |
| 8. | AGJ | 99-232 Zadzim, Chodaki 29 | 7261724930 | 472266360 | No | 16.01. |
| 9. | Zakład produkcji wędlin, podrobów i mięs | 97-319 Będków Remiszewice 5 | 7732233405 | 592265553 | No | 16.01. |
| 10. | Masarnia | 26-332 Sławno, Zachorzów 19A | 7681729331 | 364605623 | No | 16.01. |

*Source: own compilation*



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Table 18 presents companies entered into CEIDG, which, among others they conduct activities marked with the PKD code 10.91.Z Production of finished feed for livestock.

*Table 18: Database of meat feed production companies in the Lodzkie Region*

| BASE OF WASTE FROM MEAT FEED PRODUCTION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 10.91.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS1 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Rolmech | 99-416 Bednary, ul. 10 Pułku Piechoty 1 | 8341526724 | 100782880 | No | 23.01. |
| 2. | Abbapol | 90-307 Łódź, Al. J. Piłsudskiego 15 | 8941631085 | 931083838 | No | 23.01. |
| 3. | Abo-tech | 96-100 Skierniewice, ul. J. Zamoyskiego 31 | 8361852929 | 367818970 | No | 23.01. |
| 4. | Emilka | 95-035 Ozorków, ul. Zgierska 9 | 7322000216 | 380812605 | No | 23.01. |
| 5. | Adrian Dawidowicz | 93-485 Łódź, ul. F. Płocka 15 | 7292638261 | 101490434 | No | 23.01. |
| 6. | Agro | 97-318 Czarnocin, Główna 160 | 7730003635 | 590428057 | No | 23.01. |
| 7. | Agro-car | 98-300 Ruda, ul. Floriańska 49 | 5761414255 | 160088203 | No | 23.01. |
| 8. | Agro-Invest Poland | 99-400 Łowicz Bratkowice 14 | 8341515873 | 100238448 | No | 23.01. |
| 9. | Agropasz | 98-313 Konopnica, Anielin 1 | 8321982376 | 100834713 | No | 23.01. |
| 10. | Agrox | 98-300 Wieluń, Sieniec 1D | 8322023293 | 100607957 | No | 23.01. |

*Source: own compilation*



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Table 19 presents companies entered into CEIDG, which, among others they conduct activities marked with the PKD code PKD 10.81.Z Production of sugar.

*Table 19: Database of sugar production companies in the Lodzkie Region*

| BASE OF WASTE FROM SUGAR PRODUCTION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 10.81.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS1 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Adkar | 92-402 Łódź<br>ul. Zakładowa 20a | 7282250590 | 101670946 | No | 17.01. |
| 2. | Emilka | 95-035 Ozorków,<br>ul. Zgierska 9 | 7322000216 | 380812605 | No | 17.01. |
| 3. | Adrian Dawidowicz | 93-485 Łódź,<br>ul. F. Plocka 15 | 7292638261 | 101490434 | No | 17.01. |
| 4. | Zakład Cukierniczy | 92-770 Łódź,<br>ul. Byszewska 4 | 7280127081 | 470040780 | No | 17.01. |
| 5. | Arkadiusz Balcerowiak | 98-160 Sędziejowice,<br>Grabno 7a | 8942751466 | 387602414 | No | 17.01. |
| 6. | Atmmg | 92-703 Łódź,<br>ul. Brzezińska 230 PC | 7272362057 | 101810442 | No | 17.01. |
| 7. | Awero | 91-829 Łódź,<br>ul. Z. Czarnego 10 | 7251098514 | 365880136 | No | 17.01. |
| 8. | Bartłomiej Musielewicz Master | 92-431 Łódź,<br>ul. Ketlinga 23 | 7731067548 | 590747644 | No | 17.01. |
| 9. | Bioever | 95-006 Brójce,<br>Pałczew 67 | 7281714751 | 471633743 | No | 17.01. |
| 10. | Eko-Plan | 97-400 Bełchatów,<br>Os. Dolnośląskie 229/9 | 8321743507 | 592042209 | No | 17.01. |

*Source: own compilation*



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Table 20 presents companies entered into CEIDG, which, among others they conduct activities marked with the PKD code 10.51.Z Milk processing and cheese making.

*Table 20: Database of dairy processing companies in the Lodzkie Region*

| DAIRY PROCESSING COMPANIES<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 10.51.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS2 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Adkar | 92-402 Łódź, ul. Zakładowa, nr 20a | 7282250590 | 101670946 | No | 04.06. |
| 2. | "EMILKA" | 95-035 Ozorków, Zgierska, nr 9 | 7322000216 | 380812605 | No | 04.06. |
| 3. | Adrian Dawidowicz | 93-485 Łódź, ul. Franciszka Plocka 15, lok. 4 | 7292638261 | 101490434 | No | 04.06. |
| 4. | AGALO | 95-006 Bukowiec, ul. Nowa 16 | 7251890673 | 365840020 | No | 04.06. |
| 5. | Agma | 99-400 Łowicz, ul. A. Mickiewicza 12 | 8341742416 | 101154831 | No | 04.06. |
| 6. | ALE JAJCARZ | 90-737 Łódź, ul. S. Żeromskiego 22, lok. 13 | 7272826924 | 369672311 | No | 04.06. |
| 7. | Top Green | 97-545 Gomunice, ul. Wojska Polskiego 86 | 8271964961 | 731492508 | No | 04.06. |
| 8. | Artegon | 94-117 Łódź, ul. Krzemieniecka 20A, lok. 48 | 7272613766 | 100540845 | No | 04.06. |
| 9. | Atmmg Solutions | 92-703 Łódź, Brzezińska 230 PC | 7272362057 | 101810442 | No | 04.06. |
| 10. | Awero | 91-829 Łódź, ul. Zawiszy Czarnego 10 | 7251098514 | 365880136 | No | 04.06. |

*Source: own compilation*



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Table 21 presents companies entered into CEIDG, which, among others, they conduct activities marked with the PKD code 10.71.Z Bread production; production of fresh pastry products and biscuits.

*Table 21: Database of bread production companies in the Lodzkie Region*

| WASTE BASE FROM BREAD PRODUCTION AND FRESH PASTRY AND BISCUIT PRODUCTION POLISH CLASSIFICATION ACTIVITY CODE (PKD): 10.71.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS2 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Bioveri | 95-100 Dąbrówka Wielka, ul. Kościelna 10 | 7321832920 | 473268331 | No | 19.04. |
| 2. | Kremiko | 95-200 Pabianice, ul. Morwowa 10 | 7311820648 | 524036593 | No | 19.04. |
| 3. | Piekarnia - Cukiernia Niechcice | 97-340 Rozprza Niechcice, ul. Częstochowska 4 | 7281517826 | 100981740 | No | 19.04. |
| 4. | Gredka | 97-300 Piotrków Trybunalski, ul. J. Słowackiego 14 | 7712519305 | 100724491 | No | 19.04. |
| 5. | Trojanka | 97-425 Zelów, ul. Poznańska 8a | 7691845205 | 100977832 | No | 19.04. |
| 6. | 4user | 91-321 Łódź, ul. ks. Stanisława Brzóski 38 | 7262281848 | 362212813 | No | 19.04. |
| 7. | Piekarnia Stanisław Kaźmierczak | 99-100 Łęczyca Leźnica Mała 27A | 7750010472 | 610040705 | No | 19.04. |
| 8. | Ab Art Pracownia Reklamy | 91-739 Łódź ul. Brzeska 11 | 7261723209 | 472254634 | No | 19.04. |
| 9. | Piekarnia Rustykalna | 99-120 Piątek Piekary 14 | 7282123609 | 100713323 | No | 19.04. |
| 10. | Adam | 95-054 Ksawerów, ul. Zachodnia 36 | 9471296743 | 100106037 | No | 19.04. |

*Source: own compilation*



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Table 22 presents companies entered into CEIDG, which, among others, they conduct activities marked with the PKD code 11.07.Z production of non-alcoholic beverages; production of mineral waters and other bottled waters.

*Table 22 : Database of soft drinks production companies in the Lodzkie Region*

| WASTE BASE FROM PRODUCTION OF SOFT DRINKS AND PRODUCTION OF MINERAL WATERS AND OTHER BOTTLED WATERS<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 11.07.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS2 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Emilka | 95-035 Ozorków, ul. Zgierska 9 | 7322000216 | 380812605 | No | 22.02. |
| 2. | Adrian Dawidowicz | 93-485 Łódź ul. Franciszka Plocka 15 | 7292638261 | 101490434 | No | 22.02. |
| 3. | Agnieszka Dadusz | 98-100 Łask Kopyść 48 | 7651103673 | 731505168 | No | 22.02. |
| 4. | Alantoni | 93-519 Łódź ul. Myśliwska 23 | 7262501356 | 100889708 | No | 22.02. |
| 5. | Andre | 90-609 Łódź, ul. Andrzeja Struga 11 | 7292029711 | 386011496 | No | 22.02. |
| 6. | ATA | 26-332 Sławno, ul. T. Chachulskiego 3 | 7681004444 | 590396676 | No | 22.02. |
| 7. | Artegon | 94-117 Łódź, ul. Krzemieniecka 20A | 7272613766 | 100540845 | No | 22.02. |
| 8. | Atmmg Solutions | 92-703 Łódź, ul. Brzezińska 230 | 7272362057 | 101810442 | No | 22.02. |
| 9. | Awero | 91-829 Łódź, ul. Zawiszy Czarnego 10 | 7251098514 | 365880136 | No | 22.02. |
| 10. | Bartłomiej Kacprzak | 90-640 Łódź, ul. 28 Pułku Strzelców Kaniowskich 45 | 7681681274 | 101313933 | No | 22.02. |

*Source: own compilation*



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Table 23 presents companies entered into CEIDG, which, among others, they conduct activities marked with the PKD code 56.10.A Restaurants and other permanent catering establishments.

*Table 23: Database of restaurants in the Lodzkie Region*

| DATABASE OF RESTAURANTS IN THE LODZKIE REGION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 56.10.A | | | | | | |
|---|---|---|---|---|---|---|
| NO. | MAIN PRODUCERS OF SOURCES FOR CSS2 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Gastronomia | 95-015 Głowno, Kilińskiego 16 | 7331214508 | 471690557 | No | 56.10. |
| 2. | Kamienica | 95-015 Głowno, ul. Targowa 76 | 7331278075 | 521100072 | No | 56.10. |
| 3. | Konrad | 92-412 Łódź, ul. Rokicińska 142 | 7282572431 | 100560902 | No | 56.10. |
| 4. | Mard - Pol | 95-070 Aleksandrów Łódzki, ul. Targowa 22 | 9471295979 | 472329533 | No | 56.10. |
| 5. | AB | 94-109 Łódź ul. Pienista, nr 2 | 7272477091 | 472958298 | No | 56.10. |
| 6. | Abra | 93-487 Łódź, ul. Eugeniusza 22A | 6581797580 | 292855005 | No | 56.10. |
| 7. | Actes | 91-212 Łódź, ul. Wersalska 47/75 | 7261800861 | 472235944 | No | 56.10. |
| 8. | Monter | 98-235 Błaszki, Borysławice 114 | 8271931453 | 731653294 | No | 56.10. |
| 9. | Mussana | 95-070 Antoniew, ul. Słowiańska 136 | 7260250140 | 471736555 | No | 56.10. |
| 10. | Sklep spożywczy | 95-035 Ozorków, Kupiecka 14 | 7321260412 | 471984856 | No | 56.10. |

*Source: own compilation*

## CSS2 data needs and data processing

- List of agro-industrial transformers working in the region that deals with high sugar content products (Fruits, cereals, sugar beet, etc.)
- List of agro-industrial companies using high quantity of high oleic oil for fried products (industrial producers of potato chips, producer of fried products in industrial plants, etc.)
- List of by-products and waste codes for the products identified before.



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- Estimation of production and current processing of these products at national level in Poland.
- Number of citizens in the regions,
- Number of households
- Perspectives in terms of polish current and future legislations regarding waste collection.

### Contexts of the benefits for the Lodzkie Region and the replication region

- Fundamental benefits relevant to data collection and processing include the following broad indices:
- Reduced waste generated/increased material valorization efficiency;
- Reduced waste management costs for regional operators related to reduced volumes of unsorted waste;
- Reduced GHG emission from the substitution of virgin material with waste valorization feedstocks;
- Production of energy through anaerobic digestion of organic fraction municipal solid waste;
- Production of valuable compost reusable in agriculture from the management of organic fraction municipal solid wastes;
- Reduced GHG emissions from energy generation;
- Replacement of fossil-based materials with bio-based ones (e.g., biolubricants; fertilizers, bags for waste collection);
- Increase of awareness on the valorization potential of final biodegradable and compostable products;
- Increased revenues for local farmers thanks to the valorization and use of non-productive lands;
- Territorial regeneration thanks to the cultivation of new crops in marginal lands and thanks to the use of high-quality compost as remediation strategy.



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### 4.1.3. CSS3

How to use wastewater and flue gases as feedstock for microalgae biomass for boosting regional circular development?

Wastewater is the water leftover (used water) after being used in anthropogenic activities namely domestic, municipal, industrial, agricultural, and mining, among others, constituted by a complex mixture of many different types of pollutants, which can cause aesthetic problems (such as odors), disease-causing pathogens (viruses, bacteria) and excess nutrients which can trigger eutrophication, over stimulating the growth of plants. On the other hand, decomposing organic waste as well as extreme sedimentation can uptake dissolved oxygen and threaten the survival of aquatic life.

Untreated wastewater is a major issue. Its discharge brings a wide range of toxicity, especially to aquatic life and other adverse environmental effects, being detrimental to society and to the economy. The world population growth together with augmented urbanization, economic development, global warming and the increasingly degradation of natural environments are putting too much pressure over safe and sufficient water supplies which are becoming increasingly scarce. A significant part of the solution is to produce less pollution and improve the way wastewater is managed and treated.

An increasingly more circular, sustainable economy needs decreasing contamination of ecosystems, and enhancing the treatment, recycling, and safe reuse of wastewater as a source of water, energy, nutrients, and other recoverable materials. So far, safely reused wastewater has been undervalued as a resource to the bioeconomy. Regions such as the Lodzkie region in Poland must exploit the enormous opportunities created for its valorization.

Treated wastewater and reuse in municipal activities, sustainable agriculture, energy production and industrial development should help to meet increasing demand.

Benefits considerably compensate for the costs of better wastewater management, with positive impacts on life quality, public health, environmental and economic sustainability, boosting new business opportunities and more 'green' employment.

Wastewater should be pivotal in industrial symbiosis, as industry acts as a major water consumer and wastewater discharger. On the other hand, there is a strong connection between the increases of carbon dioxide (and other greenhouse gas emissions and global warming together with climate change, which require urgent measures to protect earth's ecosystems as well as humankind. Several attempts have been proposed to limit $CO_2$ (and other GHG) emissions and slow down global warming such as the Kyoto Protocol (1997), the Paris Agreement (2016) and the European Green Deal (2019), being the long-term outcome the climate change mitigation towards the European ambition to be the first climate-neutral continent by 2050. The European Green Deal is expected to transform the EU into a modern, resource-efficient, and competitive economy, ensuring economic growth decoupled from



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resource use, no citizen and no region left behind, the development of a circular economy, the protection of biodiversity and no net emissions of GHG by 2050. The topic of decarbonizing the energy sector has been placed at the top of EU priorities.

Carbon capture and storage (CCS) technologies have been expected to be a major tool for reducing atmospheric $CO_2$ concentration, being pivotal in climate change mitigation. Conventional CCS processes (geological, physical, and chemical) are known to be complex, highly power intensive, somewhat expensive, and environmentally doubtful. Biological CCS technologies using microalgae have been proposed as environmentally-friendly promising alternative offering a completely different approach—not only to trap $CO_2$ but also to immediately use it for circular energy production and generation of bio-based products, creating value as well.

As microalgae grow in aqueous medium, directly dissolving $CO_2$-rich gases through this environment is a highly effective way of sequestering $CO_2$ to be further used as a biological carbon source through photosynthesis using solar energy. Due to their higher efficiency, higher $CO_2$ fixation rates and higher biomass productivities compared to conventional higher plants, microalgae production with flue gases can be used as a feedstock for biobased products and bioenergy, reducing carbon footprint and generating revenues. One ton of microalgae (dry weight basis) uptakes roughly two tons of $CO_2$, which means that an area of 1 ha (10000 $m^2$) can capture approximately 6.7 tons/day of $CO_2$. Research proved that microalgae have utilized successfully 90–99% $CO_2$ from natural gas processing industries as well as 13–15% of $CO_2$ in flue gas composition from thermal power plants. Moreover, microalgae also absorb excess nutrients and organic matter contained in wastewaters, playing a role in addressing water pollution.

Since microalgae produced with flue gases and wastewaters still hold a great valorization potential, CSS3 aims at presenting innovative bioremediation strategies for biological carbon sequestration and wastewater treatment together with the exploitation of the microalgal end-products.
According to CSS3 approach, secondary wastewater is treated with microalgae. The technological core of CSS3 is a photobioreactor which acts as a poly regenerative system, coupled with a post carbon capture unit for $CO_2$. Indeed, the FBR is not only designed for energy purposes (biogas generation), but also to produce valuable goods such as biofertilizers and biostimulants to be further used as substitute of either conventional fertilizers or organic fertilizers but much better. So, CSS3 technology can be seen as a negative carbon and a zero-waste process and providing both renewable energy and bio-based products.



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The application of a circular approach for the valorization of wastewaters and flue gases not only allows for the minimization of waste and all the issues related to its management, the preservation of resources and the reduction of GHG emissions, but also for the production of products with low carbon and water footprints such as biostimulants for the agricultural sector and renewable biogas (biomethane), for the industrial, agricultural and residential sector as well. Furthermore, citizens are expected to play an active role in different stages of the valorization chain, increasing their awareness on sustainability and circular economy, and directly and indirectly taking advantage from the environmental benefits that the CSS3 will bring.

CSS3 proposes a novel and universal solution independently of the origin of wastewater, while consuming less energy and enhancing nutrients recovery like nitrogen and phosphorus from wastewater. Previous results clearly demonstrated the potential of the microalgal-based wastewater treatments for regenerating high quality water, from the effective removal of nutrients and subsequent use in agriculture, avoiding the use of chemicals, and fossil-based fertilizers, saving energy and GHG emissions. SS3 can have various applications in FRONTSH1P regions in treating either waste streams of the other SS chains or implemented individually in agricultural, urban, and industrial wastewater applications. A modular micro-algae wastewater management plant to develop a closed water cycle to reuse wastewater more than once and to clean it and extract nutrients to be used in bio-stimulants before giving the water back to the environment is expected to be used. BZURA, LNEG and STAM will approach Polish, Italian and Portuguese regional authorities for replication, based on the performances and results of the pilot in the Lodzkie Region. Of great support will be Parzeczew and Carmasciando to demonstrate the feasibility for the local agriculture sector. Nevertheless, further research is needed to scale-up from TRL5 to 7, to optimize the best treatments and conditions, as well as the understanding of the bioactive activity of the microalga biomass/extract and its effect on germination and improved growth of plants.

The presence of heavy metals, toxicity and pathogens should also be further investigated in order to assess the impact of the biostimulant product developed on a sustainable and healthy practice.

## Ontology of the CSS3

- Anaerobic digestion - Process of biological degradation (treatment) of organic matter in the absence of oxygen which occurs in digesters. Output: digestate (a more or less liquid fraction) and biogas.
- Biogas- Gas produced by the biological degradation (fermentation) of organic matter in the absence of oxygen. Crude (raw) biogas indicates the gaseous effluent discharged from an anaerobic digester. Typical biogas composition: 60 to 80% methane, 30 to 40% $CO_2$ and other minor gases ($H_2S$, $NH_3$, $H_2$)).



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- Biomethane - Gas resulting after the purification step (or upgrading) of biogas that can be adequate to be further injected into a gas network or utilized as a replacement for natural gas.
- Biostimulants - Plant biostimulants are substances, mixtures, and micro-organisms which, differently from straight fertilizers, are not as such inputs of nutrients, but nevertheless stimulate plants' natural nutrition processes. They act in addition to fertilizers, with the aim of optimizing the efficiency of those fertilizers and reducing the nutrient application rates and are by nature more like fertilizing products than to most categories of plant protection products. Such products are therefore eligible for CE marking under Reg 1009/2019 and excluded from the scope of Reg (EC) No 1107/2009 on Plant protection products (e.g., pesticides).
- Carbon capture and storage (CCS) - process relying on the separation of carbon dioxide from gaseous effluents, its transportation and final storage.
- Digester, or anaerobic digester - A sealed tank or container where the biological anaerobic digestion of animal manure or organic matter occurs, and from which results the production of biogas.
- Digestion- The breaking down of sludge and other waste biologically by microorganisms, mainly bacteria. Results in by-products such as methane gas, carbon dioxide, sludge solids and water. Aerobic digestion requires oxygen, anaerobic digestion requires the absence of oxygen.
- Greenhouse Gas (GHG) - An atmospheric gas, which is transparent to incoming solar radiation but absorbs the infrared radiation emitted by the Earth's surface. The main greenhouse gases are carbon dioxide, methane, and CFCs.
- Microalgae - Microscopic eukaryotic organisms composed of single differentiated cells able to obtain energy using chromophores. Generally single-celled but can occur as filamentous or colonial (Definitions taken from EN 17399:2020 - Algae and algae products - Terms and definitions.)
- Nutrients -Organic or non-organic chemical compounds essential for plant growth.
- Primary Wastewater Treatment-The first process usually associated with municipal wastewater treatment to remove the large inorganic solids and settle out sand and grit.
- Secondary Wastewater Treatment - Second biological process of digestion with bacteria.
- Sludge - The solid waste material which settles out in the wastewater treatment process, sometimes biosolids. Can be dewatered and reused or disposed of.
- Tertiary Wastewater Treatment - Wastewater Biological and/or Chemical polishing to eliminate organics, solids, and nutrients.
- Valorization - Further use of a product in a value-added application.
- Volatile solids (%VS)- Physico-chemical parameter expressing the amount of volatile solids in a liquid sample.
- Wastewater - The water leftover (used water) after its use in anthropogenic activities namely domestic, municipal, industrial, agricultural, mining, etc.



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## Wastewaters: from challenge to opportunity

Wastewater (WW) coming from agriculture and industrial processes in the Lodzkie region pollutes water streams triggering the degradation of local natural ecosystems as well as arable land and causing water eutrophication. Maintaining extensive fertilization in the Lodzkie region with a significant share of soil with agricultural phosphorus deficit leads to a considerable reduction of soil production potential, since Phosphorus scarcity is becoming a limiting factor for plant and animal production. CSS3 will enhance and validate in the region agricultural and Industrial wastewater treatments with microalgae that will generate a revenue stream through the production of bio-fertilizers and bio-stimulant from algal biomass and will purify WW removing eutrophication agents.

Scheme of the CSS3 technological processes is given in Figure 33.

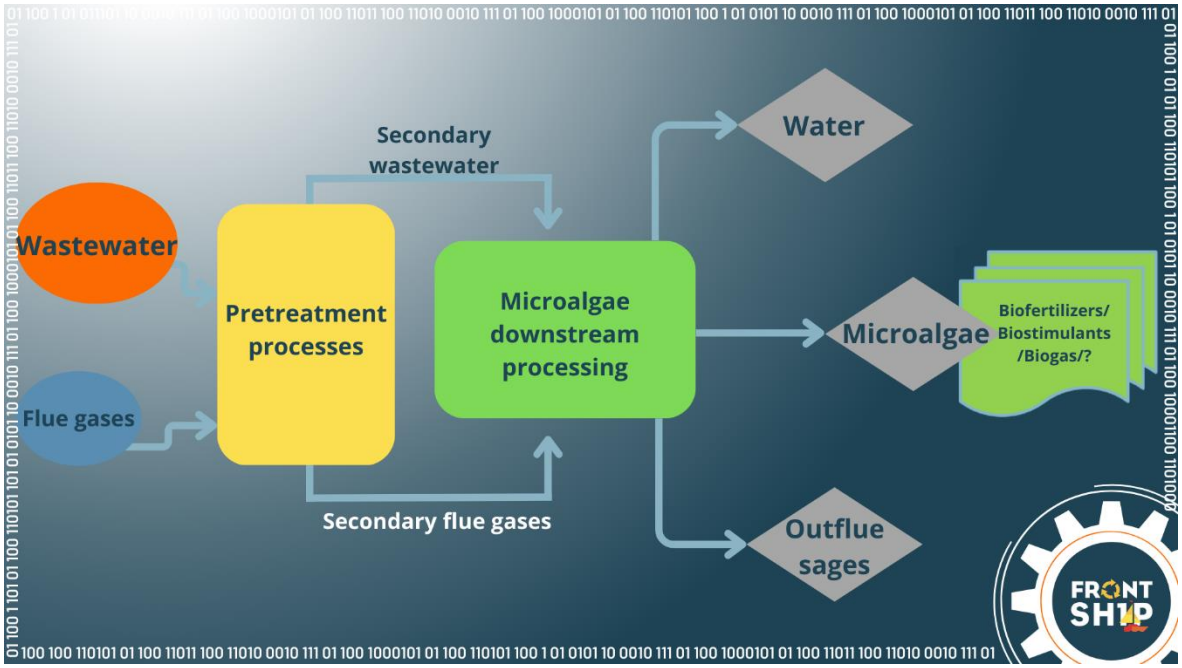


*Figure 33: Scheme of the CSS3 technological processes*

The actual annual production of WW nutrients from agriculture in the region approximates 360 thousand Mg/ha. If transformed into bio-stimulant farmer additional income of 1€ per Mg of nutrients extracted by 2030.

From research conducted within FRONTSH1P CSS3 (D5.1) and from previous information available to FRONTSH1P CSS3 consortium partners, high carbon and nutrient circular recovery efficiency is expected from flue gases and secondary wastewaters in the Lodzkie region. In this context, microalgae-mediated processes represent a technological bio-based solution for cleaning waters and flue gases with significant energy savings compared to conventional methods. This biological solution can even be replicated locally and implemented at a smaller scale by households.



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## CSS3 context of the FRONTSH1P aims

Valorization of water and nutrients (in wastewaters and flue gases) through a CSS3 is one of the objectives of the H2020 – Green Deal project FRONTSH1P.
By the development and demonstration of four different CSSs, FRONTSH1P aims at ensuring a green and just transition of the Polish Lodzkie Region towards decarbonization and territorial regeneration addressing the current challenges and needs of the Region, transforming them into opportunities for economic growth, social inclusion, decarbonization, improvement of the quality of life for citizens, reconnection between the urban and rural context.

The specific objectives of CSS3 - a circular approach to water and nutrients are:

1) draft the framework Technical and non-technical state of the art, requirements and success criteria to satisfy the implementation of the technological and non-technological solutions required in CSS3;
2) identify measures that have the strongest leverage for a sustainable-oriented improvement of products through Life cycle thinking and ecodesign;
3) develop CSS3 community-based innovation schemes to Reduce liquid and gaseous wastes through Microalgae Biotransformation towards upgraded biogas (biomethane) and bio-based products such as biofertilizers and biostimulants;
4) develop CSS3 demo plant towards bio-based products;
5) collect data in technological, economic, social and environmental dimensions and share them on the RCPB tool.

## CSS3 technology of processing wastewaters and flue gases and technology of data processing context

Technologies relevant to the data collection and processing context include Carbon Capture and Storage (CCS) from flue gases and a secondary and/or tertiary wastewater treatment step(s) using microalgae biotechnology in photobioreactors. Data sources are the local availability of both wastewaters and flue gases (carbon capture and separation systems, if any), microalgal biomass production systems, biomass separation and utilization for agriculture purposes, anaerobic digesters construction and operation, biogas utilization and/or purification towards biomethane and further final uses. To this array of data should be added a network of engineering, construction operators and technicians that can implement the above-mentioned technologies under real operational context.

The CSS3 technology in context of data processing (Figure 34, Figure 35) is based on several sources of data:

1) database related to the wastewater treatment plants (WWTP). This database is composed of entities receiving untreated (raw) wastewater from different releasers (regardless of the type, could they be companies, industries, municipalities, agriculture associations) yielding treated water as a final product/service. In Poland, there is no code



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for wastewater because it is not treated as waste. For stabilized municipal sewage sludge a code is allocated as follows: 19 08 05.

2) database related to flue gases emitters mostly industries producing energy, cement, or mining. Two codes for data processing are used: PKD, which characterizes type of economic activities with a geo-location, which enables to present the flue gases availability on the maps (Figure 27)

3) database related to the main anaerobic digestion plants as receivers of microalgal biomass for energy valorization in the Lodzkie Region (receivers of microalgal biomass as intermediate product for biogas-biomethane production). Again, two codes are used for data processing: PKD, which characterizes type of economic activities with geo-location, which enables to present the anaerobic digestion on the maps (Figure 26)

4) database related to the main plant fertilizers/biostimulants wholesalers as end-users of microalgal biomass for bio-based products valorization with PKD and geo-location in the Lodzkie Region (Table 24).

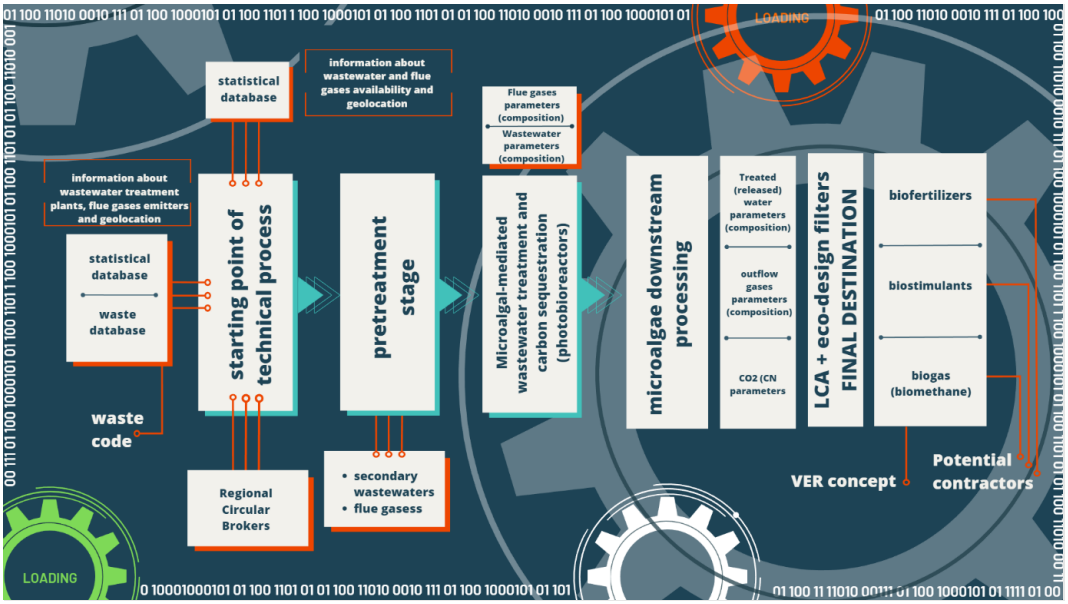


*Figure 34: The scheme of data processing layer dealing with the CSS3 technology.*



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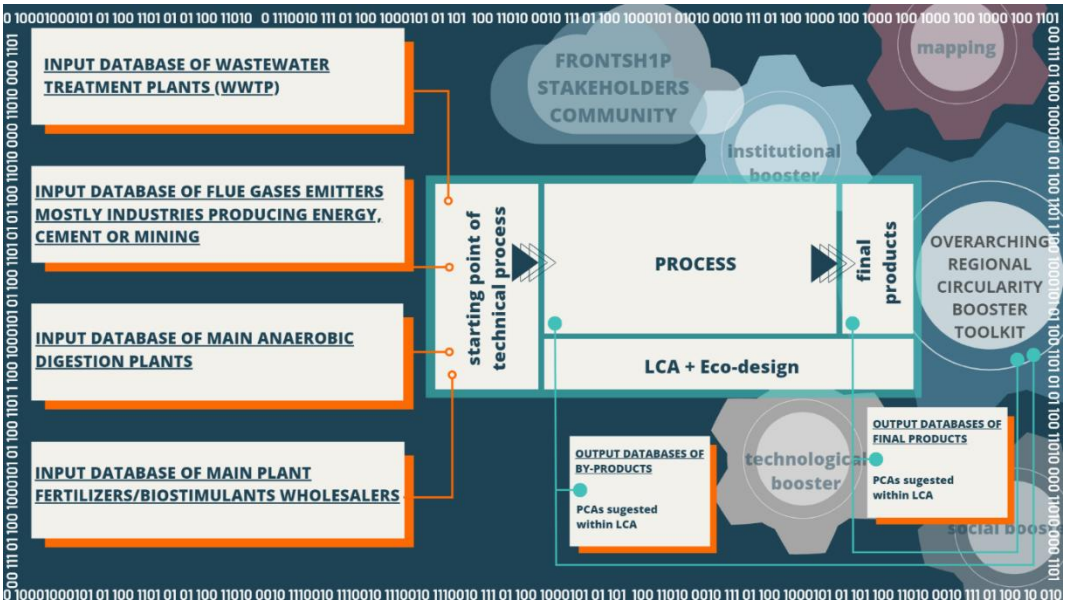


*Figure 35: The scheme of database layer dealing with the CSS3 technology.*



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*Table 24: Database of wastewater treatment plants in Lodzkie Region*

| DATABASE OF WASTEWATER TREATMENT PLANT IN THE LODZKIE REGION | | | | | |
|---|---|---|---|---|---|
| NO. | OWNER/USER | FLOW RATE Q $m^3$/year | BOD5 kg/year | TN kg/year | TP kg/year |
| 1. | Grupowa Oczyszczalnia Ścieków Sp. z o. o. w Łodzi | 69782631 | 607109 | 609202 | 43963 |
| 2. | Miejski Zakład Wodociągów i Kanalizacji w Głownie | 707267 | 4505 | 30688 | 255 |
| 3. | Miejskie Przedsiębiorstwo Wodociągów i Kanalizacji Sp. z o.o. w Zduńskiej Woli | 4758723 | 20938 | 50142 | 1460 |
| 4. | Solan INVESTMENT Sp. z o.o. w Głownie | 304234 | 1572 | 2189 | 56 |
| 5. | "JOGO" - Łódzka Spółdzielnia Mleczarska w Łodzi | 72570 | 829 | 1506 | 601 |
| 6. | Grupowa Oczyszczalnia Ścieków Sp. z o.o. w Kutnie | 5679351 | 27431 | 47763 | 1135 |
| 7. | Przedsiębiorstwo Gospodarki Komunalnej w Radomsku | 3885260 | 21629 | 38998 | 2030 |
| 8. | Zakład Wodociągów i Kanalizacji Sp. z o.o. w Łodzi | 217453 | 629 | 100 | 228 |
| 9. | Moszczanka - km 2,9 (poprzez kanał tłoczny o dł. 12,9 km i kanał otwarty - Goleszankę o dł. 10,6 km) | 4699029 | 19877 | 34162 | 2303 |

*Source: https://www.wios.lodz.pl/Wykaz_oczyszczalni_sciekow,34 , 2017*

Table 24 is an exemplification of data framework for the CSS3 development.



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### 4.1.4. CSS4

Elastomers are one of the three main groups of polymer types, along with thermoplastics and duroplastics. Vulcanized elastomers, i.e., rubber, are used to manufacture a wide range of items, which, due to their unique properties, versatility, flexibility, mouldability or insulation properties, are used in many industries. The best-known rubber products include pneumatic tires or seals. The rubber is also used to make many other items, such as children's toys, thermal and acoustic insulation, electrical insulation mats, electric cables, shoe soles, conveyor belts, etc. In the vast majority of cases, in order to make rubber from elastomer, it is necessary to carry out a vulcanization process, which gives these materials their unique functional properties. During this, cross-links are formed between macromolecules (made up mainly of carbon atoms). These bonds, in a nutshell, are more stable than the bonds in the macromolecule which makes material recycling of such materials virtually impossible.

According to the approach described in CSS4, rubber products would be processed to produce products that could be reused in industry. The core of the proposed solution is the pyrolysis process. Rubber waste would be collected and then reinforcements in the form of steel wires or cords (found, for example, in tires or conveyor belts) would be separated from them. After this separation, the rubber waste would be milled to obtain ground rubber. This material can then be subjected to various processes, such as:

- reuse with vulcanization promoters to obtain different types of mats,
- treatment with bacteria that can convert the gum into cellulose,
- and, most importantly for CSS4, preheated to get rid of the halogen elements present in the waste.

Once the halogens have been removed, the ground rubber can be pyrolyzed to produce oils (used as lubricants, plasticizers, etc.), pyrolysis carbon black (filler, sorbent, etc.), synthetic gas that can be burned to produce heat and carbon dioxide (e.g., polymer foaming).

#### Ontology of the CSS4

Elastomers - are polymeric plastics or natural materials that are characterized by their ability to deform reversibly under the action of mechanical forces, while maintaining the continuity of their structure. Elastomers are a broader group of materials than rubbers, which are only one class of elastomer.

Rubber - an elastomer made up of aliphatic polymer chains (for example, polyolefins) that have been cross-linked to some extent during the vulcanization process.

Polymers - chemicals with very high molecular weights that are made up of repeated units called mers.



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Vulcanization - the chemical process of cross-linking polymer molecules leading to rubber.

Pyrolysis - a degradation process occurring at high temperatures and carried out without oxygen or other intentionally added reactants.

Halogens - chemical elements of the 17$^{th}$ group of the periodic table. These include fluorine, chlorine, bromine, iodine, astatine and tennessine.

## Presentation of the FRONTSH1P aims context

Valorization of wood packaging waste through a CSS is one of the objectives of the H2020 – Green Deal project FRONTSH1P.
By the development and demonstration of four different CSSs, FRONTSH1P aims at ensuring a green and just transition of EU regions, starting from the Lodzkie Region in Poland towards decarbonization and territorial regeneration, addressing the current challenges and needs of the Regions, transforming them into opportunities for economic growth, social inclusion, as well as improvement of the quality of life for citizens, reconnection between the urban and rural context.

The specific objectives of CSS4 (Figure 36) - a circular approach to urban and industrial plastic/rubber waste:

1) to optimize a high TRL pyrolysis system for chlorinated compounds;
2) to further develop a high TRL supercritical $CO_2$ expansion system for insulating biomaterials;
3) to demonstrate low-cost 3D printing for repairing household appliances.

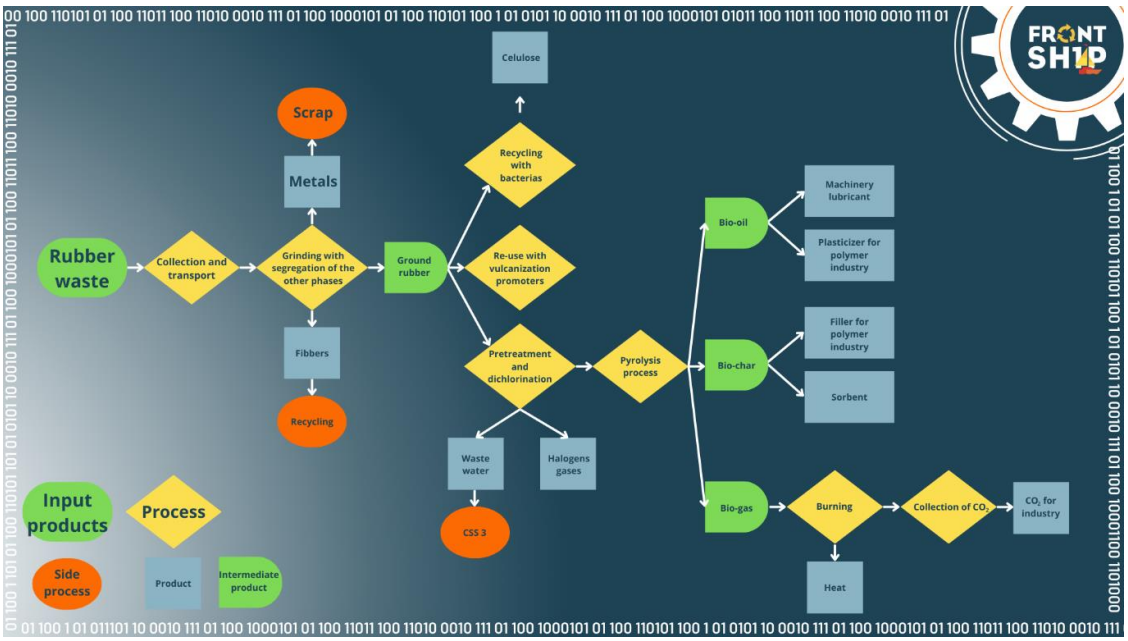

*Figure 36: Scheme of the CSS4 technological processes.*



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The CSS technology in context of data processing is based on several sources of data as given in Figure 37.

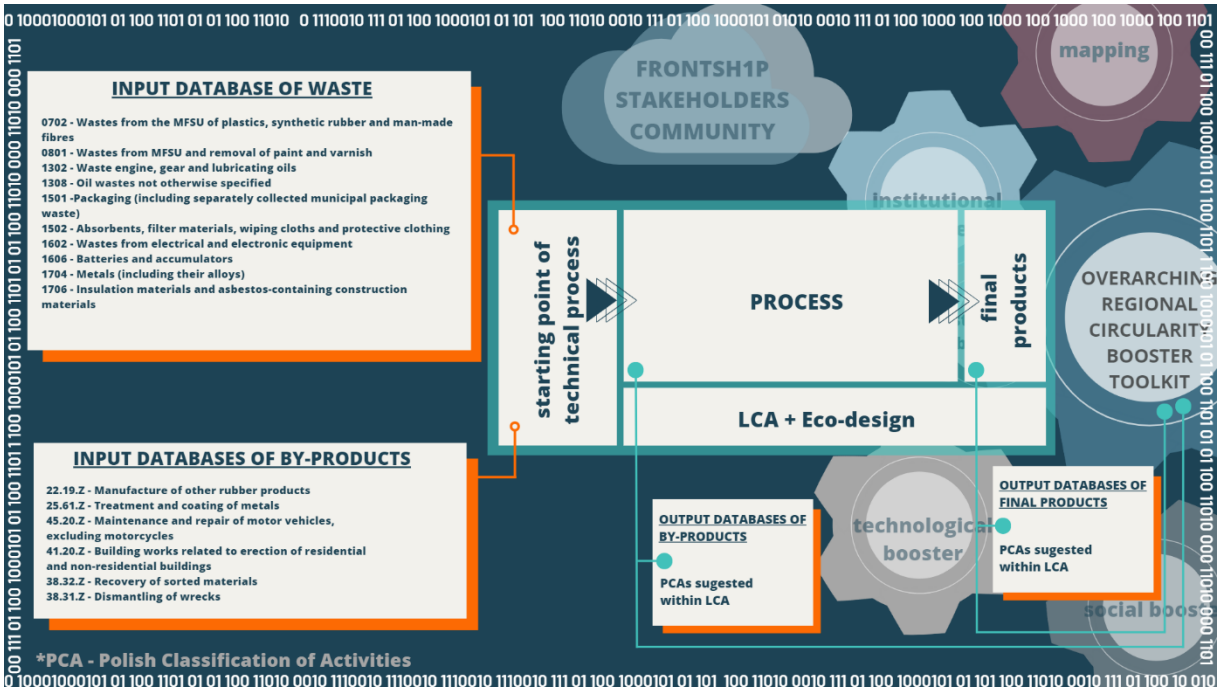

*Figure 37: The scheme of data processing layer dealing with the CSS4 technology.*

Table 25 contains waste codes characterizing waste from:

- group 7 - Wastes from the production, preparation, marketing and use of products of the organic chemistry industry
  - subgroup 07 02 - Waste from the production, preparation, marketing and use of plastics, rubbers and synthetic fibers
- group 8 - Wastes from the production, preparation, marketing and use of protective coatings (paints, varnishes, ceramic enamels), putty, adhesives, sealants and printing inks
  - subgroup 08 01 - Wastes from production, preparation, marketing and use as well as disposal of paints and varnishes.
- group 13 - Waste oils and liquid fuel wastes (excluding edible oils and groups 05, 12 and 19)
  - subgroup 13 02 - Waste engine, gear and lubricating oils
  - subgroup 13 08 - Waste oil not included in other subgroups.
- group 15 - packaging waste; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified.
  - subgroup 15 02 - Absorbents, filter materials, wiping cloths and protective clothing.
- group 16 - Wastes not included in other groups.



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- subgroup 16 02 - Waste electrical and electronic devices
- group 17 - Waste from the construction, renovation and dismantling of buildings and road infrastructure (including soil and soil from contaminated areas)
  - subgroup 17 04 - Waste and scrap metal and metal alloys
  - subgroup 17 06 - Insulation materials and construction materials containing asbestos.

*Table 25: Waste code database for CSS4.*

| WASTE CODE DATABASE FOR CSS4 | |
|---|---|
| **WASTE CODE** | **DESCRIPTION OF WASTE** |
| **07** | **Wastes from the production, preparation, marketing and use of products of the organic chemistry industry** |
| 07 02 | Waste from the production, preparation, marketing and use of plastics, rubbers and synthetic fibers |
| 07 02 01* | after rinsing with water |
| 07 02 14* | waste containing hazardous substances |
| 07 02 17 | waste containing silicone |
| 07 02 80 | rubber waste |
| 07 02 99 | rubber waste |
| **08** | **Wastes from the production, preparation, marketing and use of protective coatings (paints, varnishes, ceramic enamels), putty, adhesives, sealants and printing inks** |
| 08 01 | Wastes from production, preparation, marketing and use as well as disposal of paints and varnishes |
| 08 01 12 | paint and varnish waste |
| **13** | **Waste oils and liquid fuel wastes (excluding edible oils and groups 05, 12 and 19)** |
| 13 02 | Waste engine, gear and lubricating oils |
| 13 02 05* | engine oils and greases |
| 13 08 | Waste oil not included in other subgroups |
| 13 08 99* | used oils |
| **15** | **Packaging waste; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified** |
| 15 01 | Packaging waste (including separately collected municipal packaging waste) |
| 15 01 01 | paper waste |
| 15 01 02 | plastic waste |
| 15 01 03 | wood waste |
| 15 01 10* | contaminated packaging |
| 15 02 | Absorbents, filter materials, wiping cloths and protective clothing |



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| | |
|---|---|
| 15 02 02* | filtering materials |
| **16** | **Wastes not included in other groups** |
| 16 02 | Waste electrical and electronic devices |
| 16 02 13* | worn appliances with hazardous components |
| 16 02 14 | used devices |
| 16 06 | Batteries and accumulators |
| 16 06 01* | lead batteries and accumulators |
| **17** | **Waste from the construction, renovation and dismantling of buildings and road infrastructure (including soil and soil from contaminated areas)** |
| 17 04 | Waste and scrap metal and metal alloys |
| 17 04 01 | copper |
| 17 06 | Insulation materials and construction materials containing asbestos |
| 17 06 04 | mineral wool waste |

*Source: own compilation*

Tables 26, 27, 28, 29, 30, 31 present companies from Lodz Region, whose activities may generate waste that can be included in the groups listed in Table 25. The tables are the exemplification of data framework for the CSS2 development.

The following columns of the presented below tables contain: the exact addresses of the companies, NIP, REGON. REGON is also understood as the REGON identification number, i.e., a nine-digit identifier assigned to an entity in this register), indicating whether the PKD code in a specific enterprise determines the dominant activity.

Table 26 presents companies entered into the CEIDG, which, among others, conduct activities characterized by the PKD code 22.19.Z Manufacture of other rubber products.



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*Table 26: Database of rubber processing companies in the Lodzkie Region*

| DATABASE OF RUBBER PRODUCTS PRODUCERS IN THE LODZKIE REGION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 22.19.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO | MAIN PRODUCERS OF SOURCES FOR CSS4 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | BestGum | 97-427 Rogowiec, ul.Św.Barbary 3 | 7692177510 | 100698606 | Yes | 40.09. |
| 2. | SemperTrans | 97-427 Rogowiec, Wola Grzymalina 11 | 7690502319 | 590019382 | Yes | 40.09. |
| 3. | Hutchinson Poland | 34-300 Żywiec ul. Leśnianka 73 | 5531694417 | 070773928 | No | 40.09. |
| 4. | 8.kuba.nawrot | 90-254 Łódź, ul. Piramowicza 4/27 | 7292336229 | 100707966 | No | 40.09. |
| 5. | AAG Service | 99-340 Krośniewice, ul. Kolejowa 25/6 m 31 | 7751378180 | 472972140 | No | 40.09. |
| 6. | Acomp | 93-133 Łódź, ul. Jana Kilińskiego 242 | 7291048304 | 472261031 | No | 40.09. |
| 7. | Adam Nejman | 91-464 Łódź, ul. Zgierska 95/15 | 7292658200 | 381019599 | No | 40.09. |
| 8. | Adrenalina Michał Smagalski | 95-200 Pabianice, ul. Piłsudskiego 3E | 7311010168 | 471227463 | No | 40.09. |
| 9. | Adrian Andrzejczak usługi remontowo-budowlane EMILKA | 95-035 Ozorków, ul. Zgierska 9 | 7322000216 | 380812605 | No | 40.09. |
| 10. | Adrian Dawidowicz | 93-485 Łódź, ul. Franciszka Plocka 1/4 | 7292638261 | 101490434 | No | 40.09. |

*Source: own compilation*



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Table 27 presents companies entered into the CEIDG, which, among others, conduct activities characterized by the PKD code 25.61.Z Metalworking and coating of metals.

*Table 27: Database of metal processing companies in the Lodzkie Region*

| DATABASE OF METALWORKING AND COATING OF METALS COMPANIES IN THE LODZKIE REGION POLISH CLASSIFICATION ACTIVITY CODE (PKD): 25.61.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO | MAIN PRODUCERS OF SOURCES FOR CSS4 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Pracownia Dekoracji i Wystroju Chatka Ech | 90-360 Łódź, ul. Piotrkowska 238 | 7271935829 | 472327994 | No | 25 |
| 2. | Allspaw | 97-410 Kleszczów, Łuszczanowice, ul. Sportowa 11/2 | 5080047643 | 101768970 | No | 25 |
| 3. | Bud-Mar | 95-030 Rzgów, Kalinko 13A | 7712383171 | 100354663 | No | 25 |
| 4. | Eland-Trans | 95-080 Tuszyn, Modlica 107 | 7291016586 | 471716995 | No | 25 |
| 5. | Kom-Visionr | 98-331 Dubidze, ul. Ogrodowa 8 | 7722177467 | 100701538 | No | 25 |
| 6. | MR Transport | 99-100. Łęczyca, ul. Hanki Sawickiej 2 | 5070093274 | 365278592 | No | 25 |
| 7. | Elsimet II | 97-300 Piotrków Trybunalski, ul. Próchnik 2 | 7712033784 | 590587175 | No | 25 |
| 8. | Balmet | 95-050 Konstantynów Ł ul. Wyspiańskiego 15 | 7270010609 | 008227878 | No | 25 |
| 9. | Barwil | 97-300 Piotrków Trybunalski, ul. Mireckiego 23 | 7711106848 | 100804356 | Yes | 25 |
| 10. | VDC Automatic | 94-047 Łódź, al. Wyszyńskiego 8/34a | 7271214455 | 470545511 | No | 25 |

*Source: own compilation*



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Table 28 presents companies entered into the CEIDG, which, among others, conduct activities characterized by the PKD code 45.20.Z Maintenance and repair of motor vehicles, excluding motorcycles.

*Table 28: Database of repair vehicles companies in the Lodzkie Region*

| DATABASE OF MAINTENANCE AND REPAIR OF MOTOR VEHICLES COMPANIES IN THE LODZKIE REGION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 45.20.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO | MAIN PRODUCERS OF SOURCES FOR CSS4 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Alte- Motorrad | 93-410 Łódź, ul. Pabianicka 130 | 7291417960 | 362503717 | No | 45.20. |
| 2. | Auto Błysk | 95-030 Rzgów, Grodzisko 55 | 7282761646 | 381127774 | No | 45.20. |
| 3. | Auto- Complex | 95-030 Rzgów, Czyżeminek 30 | 7282277560 | 472273666 | No | 45.20. |
| 4. | Auto-Bilarex | 95-030 Rzgów, Prawda 65 | 7291195850 | 100343702 | No | 45.20. |
| 5. | Auto-Folie | 98-310 Czarnożyły, Raczyn 103 | 8322009471 | 365118279 | No | 45.20. |
| 6. | Autoserwis Góralski | 93-418 Łódź, ul. Starorudzka 10/12 | 7282450544 | 366138083 | No | 45.20. |
| 7. | Bartuś Mechanika Pojazdowa | 95-080 Tuszyn, ul. Rzgowska 24/26 | 7282283069 | 101411417 | No | 45.20. |
| 8. | Blach - Lak | 99-150 Grabów, Jaworów 24 | 6661053545 | 472794069 | No | 45.20. |
| 9. | Blacharstwo, Lakiernictwo Samochodowe Robert Duluk | 99-107 Daszyna, Krężelewice 21 | 7281566701 | 472219336 | No | 45.20. |
| 10. | Car-Land | 99-150 Grabów, Kobyle 1 | 7752161063 | 472791088 | No | 45.20. |

*Source: own compilation*



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Table 29 presents companies entered into the CEIDG, which, among others, conduct activities characterized by the PKD code 41.20.Z Construction works associated with constructing residential and non-residential buildings.

*Table 29: Database of construction companies in the Lodzkie Region*

| DATABASE OF CONSTRUCTION WORKS COMPANIES IN THE LODZKIE REGION POLISH CLASSIFICATION ACTIVITY CODE (PKD): 41.20.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO | MAIN PRODUCERS OF SOURCES FOR CSS1 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Trans – Kop | 95-080 Tuszyn, ul. Żeromskiego 61 | 7711106498 | 590392655 | Yes | 45.21. |
| 2. | 2 X 2 Biuro Rachunkowo-Ubezpieczeniowe | 99-100 Łęczyca, Siedlec 45 | 7752362399 | 101028144 | Yes | 45.21. |
| 3. | Architektura Formy | 90-768 Łódź, al. Włókniarzy 207 | 7251035620 | 473238287 | Yes | 45.21. |
| 4. | Allspaw | 97-410 Kleszczów, Łuszczanowice, ul. Sportowa 11/2 | 5080047643 | 101768970 | Yes | 45.21. |
| 5. | Bud-Mar | 95-030 Rzgów, Kalinko 13A | 7712383171 | 100354663 | Yes | 45.21. |
| 6. | Budomal | 90-642 Łódź, ul. Włókniarzy 221/225 | 7281237038 | 471370893 | Yes | 45.21. |
| 7. | Champion | 93-441 Łódź, ul. Skrajna 30 | 9690186285 | 240992100 | Yes | 45.21. |
| 8. | Dam - Dach | 98-270 Złoczew, ul Lututowska 2 | 8272186879 | 101263448 | No | 45.21. |
| 9. | Domek PUH | 95-080 Tuszyn, ul. Szymanowskiego 30 | 7291335073 | 590632266 | No | 45.21. |
| 10. | Eltim T.B | 92-016 Łódź, ul. Zaspowa 22/24 | 7291186348 | 100879029 | No | 45.21. |

*Source: own compilation*



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Table 30 presents companies registered in CEIDG database, which, among others, conduct activities characterized by the PKD code 38.32.Z Recovery of raw materials from segregated materials.

*Table 30: Database of recovery material company in the Lodzkie Region*

| DATABASE OF COMPANIES RECOVERING OF RAW MATERIALS FROM SEGREGATED MATERIALS IN THE LODZKIE REGION<br>POLISH CLASSIFICATION ACTIVITY CODE (PKD): 38.32.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO | MAIN PRODUCERS OF SOURCES FOR CSS4 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Auto- Complex | 95-030 Rzgów, Czyżeminek 30 | 7282277560 | 472273666 | No | 39.01. |
| 2. | Agabi S.C. Agnieszka Biniek | 98-220 Zduńska Wola, ul. Szadkowska 45 | 8291065881 | 101606291 | No | 39.01. |
| 3. | Żwiromax | 95-006 Kurkowice, ul. Słoneczna 13 | 7281895161 | 471731316 | Yes | 39.01. |
| 4. | Agro-Service | 96-230Biała Rawska, Grzymkowice 1 | 8351128439 | 750152798 | No | 39.01. |
| 5. | Alex PHU | 90-360 Łódź, ul. Piotrkowska 232/22 | 7251307550 | 100006703 | No | 39.01. |
| 6. | AMW-Łódź | 93-355. Łódź, ul. Białostocka 19/36 | 7291951524 | 473043767 | No | 39.01. |
| 7. | Anyszka | 99-440 Zduny, Retki 50 | 8341515838 | 750113367 | No | 39.01. |
| 8. | Apus | 91-341Łódź, ul. Brukowa 16 | 7291017640 | 471373259 | No | 39.01. |
| 9. | AS Chem-Eko | 96-100 Skierniewice, ul. Warszawska 1C | 7261529720 | 100122013 | No | 39.01. |
| 10. | Autobana | 98-260Burzenin, ul. Złoczewska 43D | 8272054942 | 101303455 | No | 39.01. |

*Source: own compilation*



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Table 31 presents companies entered into the CEIDG, which, among others, conduct activities characterized by the PKD code 38.31.Z Disassembly of used products.

*Table 31: Database of disassembling companies in the Lodzkie Region*

| DATABASE OF COMPANIES DISASSEMBLING OF USED PRODUCTS IN THE LODZKIE REGION POLISH CLASSIFICATION ACTIVITY CODE (PKD): 38.31.Z | | | | | | |
|---|---|---|---|---|---|---|
| NO | MAIN PRODUCERS OF SOURCES FOR CSS4 | ADDRESS | TIN (TAX IDENTIFICATION NUMBER) | REGON | MAIN ACTIVITY YES/NO | CN CODE |
| 1. | Granit- System | 97-515 Masłowice, Strzelce Małe 87 | 7722117583 | 365545372 | No | 38.32. |
| 2. | ROLMECH | 99-416 Bednary, ul. 10 Pułku Piechoty 1 | 8341526724 | 100782880 | No | 38.32. |
| 3. | Firma Usługowa Kamil Bajerowski | 97-310 Jarosty, ul. Miła 7 | 7712614819 | 100824643 | No | 38.32. |
| 4. | Staks | 97-300 Piotrków Trybunalski, ul. Belzacka 97B | 7712907384 | 384073820 | No | 38.32. |
| 5. | FHU Fagen | 99-300Kutno, Krzesin 1 | 7751040920 | 100853751 | No | 38.32. |
| 6. | Firma Handlowa Ramilla | 99-400. Łowicz, Małszyce 35 | 8341594996 | 750780193 | No | 38.32. |
| 7. | Sort Robert Niezabitowski | 96-230 Biała Rawska, ul. Mickiewicza 26/25 | 8351186299 | 750734299 | No | 38.32. |
| 8. | ABC - Wędrowniczek - Zbigniew Siekiera | 99-417 Bolimów, Kęszyce-Wieś 32 | 8360007824 | 750118755 | No | 38.32. |
| 9. | ABC Dom Andrzej Masztanowicz | 99-400 Łowicz, ul. Bawełniana 4 | 8341211127 | 750481898 | No | 38.32. |
| 10. | Ab-Greg | 97-300 Piotrków Trybunalski, ul. Barwna 12 | 6571399524 | 160275566 | No | 38.32. |

*Source: own compilation*

## WP2 context - data needs, data processing etc.

The collection and processing of data from a technology perspective should include information on the collection and processing sites for rubber waste and the solutions available in the region for the grinding of rubber and the processing of the resulting pulp. It would also



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be necessary to include pyrolysis technology and the use of products resulting from this process.

Sources that include databases related to rubber waste and the companies that generate and process this waste, including by-products generated during the process, should be particularly crucial in the context of data processing.

### Contexts of the benefits for the Lodzkie Region

The primary benefits associated with data collection and processing include the following broad indicators:

- Reduced waste generation/increased efficiency of material valorization;
- Reduced waste management costs for regional operators;
- Reduced consumption of fossil energy vectors (e.g., natural gas or coal) and associated savings;
- Reduced greenhouse gas emissions from power generation for industry;
- Replacement of fossil materials with bio-based materials (e.g., pigments/fillers for the plastics industry);
- Increased awareness of the valorization potential of rubber waste.



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## 4.2. Circular economy monitoring system model for the Lodzkie Region

A circular model aims to maintain the value of products, services, materials and resources for as long as possible, extending their life beyond the first consumption, minimizing the generation of waste, *the fewer products we discard, the less materials we extract, the better for our environment* [69]. Cities, regions and territorial clusters can act as potential engines to close waste and material 'loops', providing a fertile ground for implementing, demonstrating and replicating innovative CSSs. In this context, monitoring the transition and its progression becomes crucial, not only to ensure that the CSSs actually work, but also to facilitate effective governance by providing access to relevant information, data, measurements, good practices and guidelines to policy-makers.

With the aim of developing a Circular Economy monitoring system, a preparatory initial desk research was implemented to gather an overview of the state of the art of the Monitoring Framework for Circular Economy already developed in Europe, while offering valuable insights and inputs on how to structure FRONTSH1P monitoring system. At this stage, a variety of sources were considered with a particular focus on existing CE monitoring frameworks that assess the circularity within subnational areas.

For the purpose of summarizing the work performed through the Desk Research, two examples of existing monitoring systems are presented here.

### Key drivers of the monitoring system

European Commission and Eurostat [70] propose a monitoring tool assessing circular economy progress at countries and European levels, analyzing 4 thematic areas:

- Production and consumption,
- Waste management,
- Secondary raw materials,
- Competitiveness and innovation.

The instrument considers 31 indicators, distributed roughly equally between the 4 main categories.

From the conceptual point of view, the proposed framework is straightforward, clear, schematic and concise. On the other hand, it accounts mainly for economic and market aspects; in addition, the category dedicated to secondary raw material is currently not viable because of the lack of proper legislation in EU. Indeed, it appears discouraging from Task 2.3 point of view, that Eurostat, the official statistical bureau of the European Union, is not able to collect all the data to promptly populate the monitoring framework.



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A fitting example of monitoring system applied at regional level in Poland is the one for Malopolskie, contained in 'Circular Economy Indicators as a Supporting Tool for European Regional Development Policies' [71].
The paper analyses existing CE indicators, the principles for designing such indicators, the typologies, the main characteristics and the sources for data collection. Drawing from the Sustainable Development Goals SDG, the authors clarify that simplicity and transparency are essential to generate an effective monitoring framework, proposing a limited number of indicators concentrating on CE focus areas.
Seven dimensions are identified, containing a total of 25 indicators:

- Economic prosperity economy
- Zero-waste economy
- Innovative economy
- Energy-efficient and renewable energy-based economy
- Low carbon economy
- Smart economy
- Spatially effective economy

Also, this monitoring system focuses only on the economic dimensions, disregarding any other aspect.
On the contrary, FRONTSH1P monitoring framework has the objective of assessing the performances and the progresses toward a full circular transition, thus including all societal, educational, public, governance, economic and environmental aspects, with the intent of describing as-complete-as-possible-picture.

After the review of the state of art, the implementation of the monitoring system requires the collaboration of all task partners, exploiting complementary knowledge and skills. The overall approach, used to develop a comprehensive circular economy monitoring framework, follows a place-based methodology, to deliver an assessment and monitoring tool that is both effective for the Lodzkie region and easily replicable and adaptable in other regions.
The literature review is crucial to establish a consistent model, able to advance the current knowledge and accounting for assumptions, limitations, considerations and guidelines evidenced in the already-existing monitoring frameworks: the study of the work previously done in the field is highly beneficial for the definition of the monitoring model for the Task 2.3.
The scope of FRONTSH1P monitoring system is broad: all aspects of the circular transition are here included: in addition, the exploitation and roll-out are central factors, accounted from the very early stages of the creation of the model because of the need to easily apply the monitoring to other territorial contexts.

Task 2.3 monitoring system includes five macro focus areas (Figure 38):

- Public sphere



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- Private sector
- Education
- Society
- Environment


*Figure 38: Focus areas of the Place-based monitoring framework for Circular Economy of Task 2.3.*

Each of these focus areas is further divided into micro-categories, endowed with sets of indicators. For example, the first focus area 'Public Sphere' contains macro-categories such as policy, legislation and public authority: all are described through indicators assessing the state of the art of circular economy in the field (i.e., policy: amount in EUR of ERDF funds destined to CE, legislation: number of new laws for circular economy; public administration: n of civil servant employed in circular economy).

### Data requirements and data sources for the monitoring system development

Considering the widest possible scope of FRONTHSH1P monitoring system and its willingness to measure every aspect relevant for the transition toward a circular model, in a viable manner that is not only relevant for the Lodzkie region, but replicable and effective for all European regions, it appears clear that a significant effort is demanded for the data-population, with information coming from different data sources. Most of the indicators contained in FRONTHS1P monitoring model are theoretical and represent the need to initiate the process of gathering information.

The accounting and harmonization of the already-collected data at regional level is a key initial step that will allow the development of a bottom-up system that considers and exploit Lodzkie capabilities; support from local partners is essential here.

Generally, the availability of data represents the most important barrier, and is the reason behind the construction of monitoring system for CE around theoretical indicators (i.e., see The OECD Inventory of Circular Economy indicators [72],

FRONTHS1P has the opportunity to develop a monitoring system in close collaboration with representatives from all the actors of the Quadruple Helix, hopefully leading to the generation of a set of indicators that are measurable within the local contexts and have clear and reliable data sources.



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## Capabilities of replication the monitoring system in the EU regions

FRONTSH1P monitoring framework will be validated in the Lodzkie region but the model will be fully exploitable in other regions. The creation of a general model with focus areas and macro-categories facilitates the replication: some assessment areas present easy-to-retrieve data and account for public sphere, education and society aspects that are common to all territories.

On the other end, environment and private spheres are designed in a manner that allows for tailoring based on the characteristics of every region (different production patterns, industrial landscapes and economic specialization). The involvement of FRONTSH1P consortium members not based in Lodzkie Region in the work of Task 2.3, especially the representatives of other regions, will ensure the consideration of replication needs throughout the entire proceedings of the implementation phase.



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## 4.3. Voluntary Emission Reductions Concept

Global warming is a major environmental issue being currently addressed within different institutions in EU and beyond. It is well understood, by Consortium Members as well as businesses within the Lodzkie Region and entire Poland that certain actions for reducing carbon emissions have to be made to tackle current and future environmental challenges. In order to do so, the European Commission established an emissions trading system (EU ETS), which is a cornerstone of the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively. EU ETS covers around 40% of the EU's greenhouse gas emissions and is a major program supporting the process of achieving a climate-neutral EU by 2050 [73].

A major part of the remaining 60% of carbon emissions in the EU are made by other companies and industries, which are not participating in EU ETS (transport, agriculture, waste, industrial emissions outside the EU ETS etc.). Nevertheless, some of these companies in Poland acknowledge the challenge of climate neutrality. In order to support the common goal, they are ready for additional investments and changes. These companies understand our Consortium's effort as crucial for reaching their goals regarding climate neutrality. As they cannot participate in EU ETS, they can still offset their carbon emissions by investing in voluntary reduction projects. During its lifecycle, the technology project implemented in FRONTSH1P will create negative carbon emissions, which may help other companies to support the common goal of investing into the decarbonization process and reaching climate neutrality. VER Program will not only generate possibility for offsetting GHG for other companies but also ensure that they are credible.
Although in 2012 voluntary emission markets lost its fast grooving pace and the indexes lowered but the positive changes are observed in recent years [74,75]. Increased companies are aware of the problem of $CO_2$ emission and are looking for methods to reduce their carbon footprint.

### Ontology of VER concept

The glossary of terms presented below is a basic source of high-level knowledge related to VER. The platform should include key descriptions of the different elements related to the prototype VER scheme (Table 32).



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*Table 32: Ontology of VER concept*

| | |
|---|---|
| Voluntary Emission Reduction Program | nonobligatory offset system supporting the accomplishment of the desired emissions reduction target, compliant with the worldwide recognizable standards; the system provides a framework for the issuance, verification, registration and trading of VER certificates resulting from implementation of the emissions reduction projects; participation in the system (either as a project proponent or a certificate purchaser) is voluntary and anyone - natural or legal person can be a participant; |
| Greenhouse gas | gases trapped in the Earth's atmosphere which are responsible for holding back heat in the atmosphere. Greenhouse gases include $CO_2$, $CH_4$, $N_2O$, Fluorinated gases; |
| GHG emission | release of a GHG into the atmosphere (as in ISO 14064); |
| GHG removal | withdrawal of a GHG from the atmosphere (as in ISO 14064); |
| Carbon dioxide equivalent | metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential (as in Eurostat); |
| GHG emissions reduction | either a reduction in GHG emissions or an increase in removals or storage of GHGs from the atmosphere, relative to baseline emission; |
| Emissions reduction project | a project whose implementation will result in a permanent, verified reduction of GHG emissions; |
| Voluntary Emission Reduction target | measure by which greenhouse gas emissions in the Lodzkie region are to be permanently reduced under the VER scheme over a defined period. An objective set by the local authority, expressed in metric tons of Carbon Dioxide Equivalent; |
| Carbon offset | GHG emissions reduction used to compensate for emissions that occur elsewhere; |
| Voluntary Emission Reduction credit | a certificate entitling its holder to retire a certificate and therefore claim emissions reduction by one metric ton of Carbon Dioxide Equivalent. VER credits are produced as a result of emissions reduction project and may be purchased by an entity seeking to offset its emissions; |
| Sustainable Development Goals (SDGs) | UN-developed 17 Sustainable Development Goals to promote activities related to pro-environment, pro-social, pro-health, among others; |

*Source: own compilation*

## VER concept in the RCBT

The VER scheme will be proposed and tested in the FRONTSH1P platform as an important tool within the RCBT for managing $CO_2$ emission (Figure 39).



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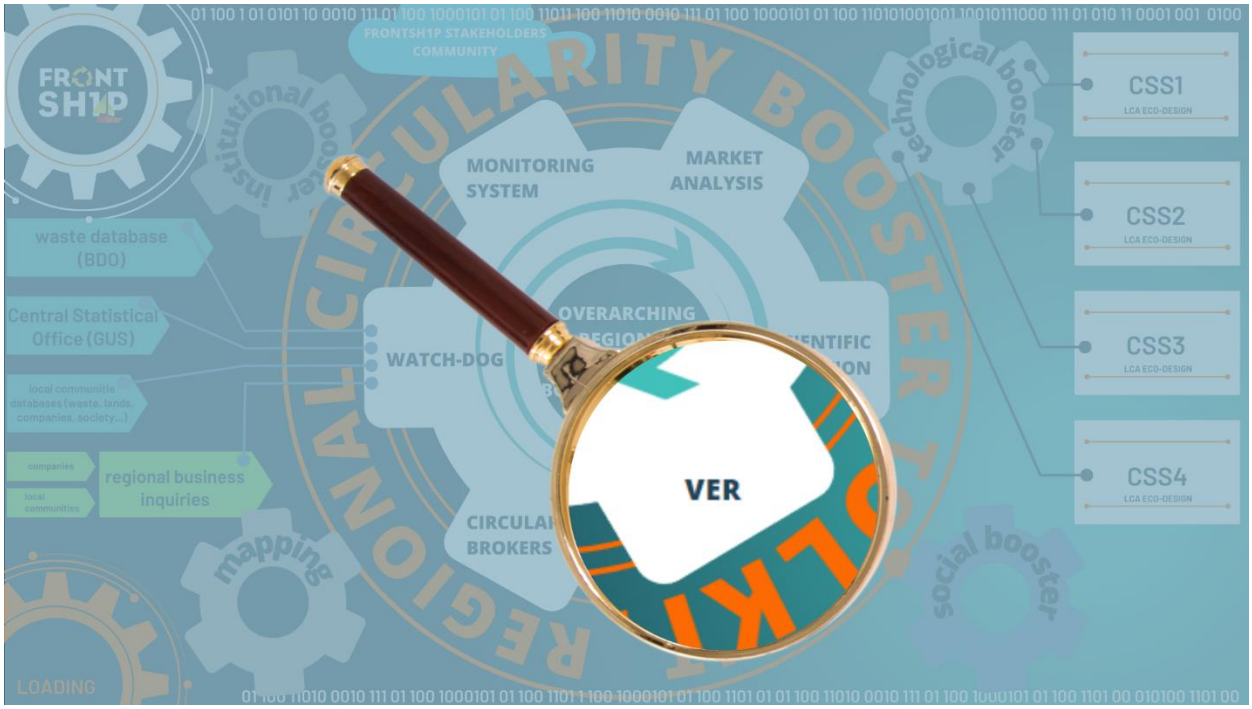


*Figure 39: Position of VER concept among the RCBT*

A schematic approach to the implementation of a prototype of the program for voluntary $CO_2$ reductions is outlined below. The platform that will aggregate the knowledge and present it to a wider audience. It should include an overall perspective on the scope that the VERs cover, together with the purpose of their creation, potential acquisition or retirement. Given that in the FRONTSH1P project, VER concept is implemented on the basic level (with no awarding of units) the knowledge contained in the platform should accurately describe the opportunities arising from the operation of the system and a single point of aggregation of data on reduction projects.

The FRONTSH1P activities supporting the development of the circular economy also carry the objective of reducing $CO_2$ emissions in the technological fields to which they apply. Implementation of projects that will result in GHG reductions has an important impact on the possibility of generating VER credits on their basis. Activities involving technological projects in the CSS also allow the acquisition of voluntary reduction credits to have a social dimension that will involve local stakeholders.

VER are not obliged by any law or regulation but originate from other companies' motivations for supporting mitigation of climate change. The value stream generated from such an approach may support investments and efforts to promote Circular Economy not only in the Lodzkie Region, but as well within national and European scope. The benefit of the VERs market is currently on the rise, as companies, local governments, NGOS and other



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organizations are expected to reduce their GHG emissions as well as heavy industry participating in EU ETS.

Participating in VER scheme will allow for them to:

- make quantitative contribution to emission reductions,
- support GHG reductions management,
- increase public relations,
- support other companies' interest in GHG reductions,
- manage corporate responsibility (CSR) and ensure climate neutrality.

We foresee that implementing VER will generate negative carbon emissions during its full operation. Credits can be redistributed around non-EU ETS and ETS participating companies and organizations, boosting additional stream of low carbon, or carbon neutral investments (Figure 40).

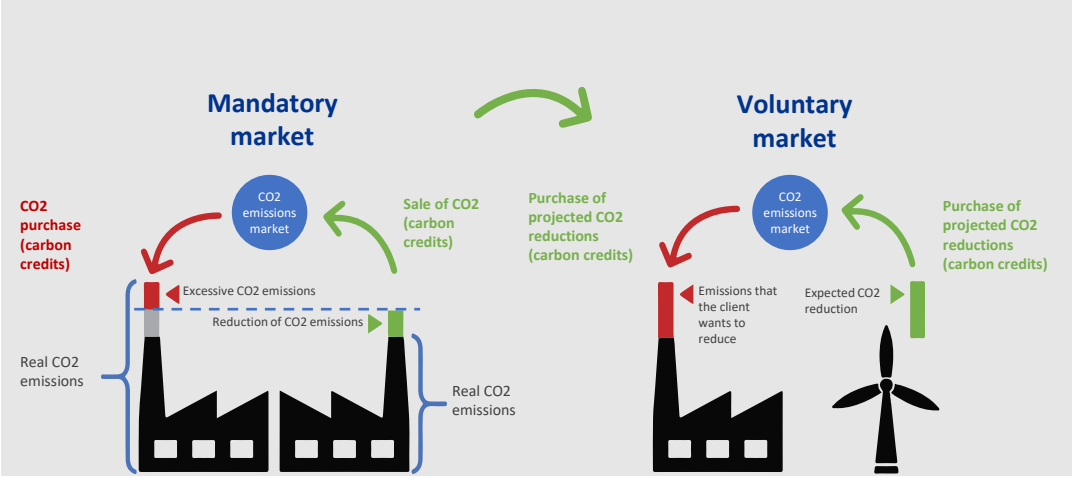


*Figure 40: VER Concept implemented in the FRONTSH1P project.*

Designing a VER solution will require key information on $CO_2$ emissions. Therefore, the starting point for the preparation of the program and the analysis of the potential for pro-environmental measures which will result in a reduction of $CO_2$ emissions to the environment are the results of the LCA analysis. The LCA analysis, on which the system will be based, will provide an estimate of the threshold from which emission reductions will be credited.



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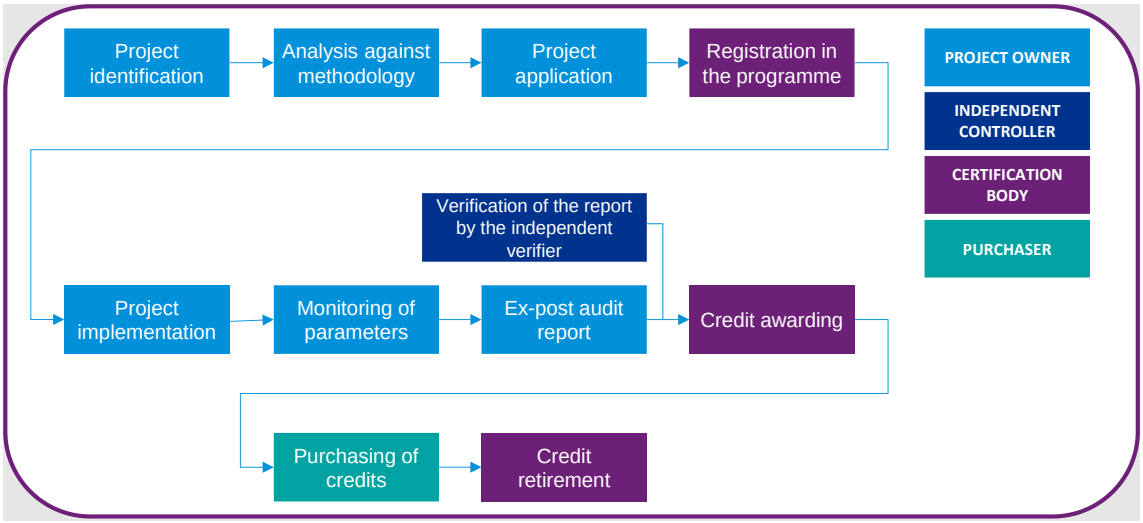


*Figure 41: The Scheme of VER approach.*

Under the VER concept, there will be four main groups of participants/beneficiaries (Figure 41). Based on the planned project activities, a potential sequence of events and activities in the concept has been developed. The concept has three main groups of tasks. Initially, a reduction project is submitted to the concept, verified and registered. Then, the project is implemented into operation. Throughout the project lifecycle, emissions are examined to assess the actual reduction of $CO_2$ emissions. This process culminates in an audit and the award of VER credits/units. The final step can be the process of selling and surrendering credits, which is done as the last element in the chain of measures. This workflow is exemplary and may change during the course of the project development, but the individual task groups should remain the same.

## Roles in VER concept and benefits for stakeholders

The following list presents the main functions and roles of the different groups involved in the VER concept.

Administrators

- supervising the submission, implementation and verification of projects,
- issuing certificates,
- issuance of virtual currency,
- supervising the purchase and retirement of certificates,
- maintaining the leaderboard.

Project proponents/owners

- development and implementation of technological solutions,

Verifiers – Independent Controller/Certification Body



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- confirming projects' compliance with the methodology,

Purchasing certificates,
- option to offset own emissions,
- ESG activities,
- contributing to emission reductions,
- participation in the leaderboard,

Society
- environmental education,
- social supervision,
- building public awareness and responsibility.

VERs will be based on globally recognized norms and standards. The program will follow the principles described in ISO 14064 and documents related to the Clean Development Mechanism [76]. Furthermore, based on the Kyoto agreement, we want to involve the public sub-municipalities responsible for the ETS. Their participation will allow the process to be transparent and work in parallel to develop the recognition of voluntary schemes as schemes that actually have an impact on reducing GHG emissions.

### VER – current and future data needs

The operation of the VER concept is based on providing a measurable comparison of $CO_2$ emissions from industry-typical activities (without countermeasures - daily business) with those of reduction projects that aim to reduce $CO_2$ emissions to the environment. Bearing in mind that mitigation activities should result in a reduction of GHG emissions, it is possible to verify how this will translate into reductions throughout the supply chain, product or factory. To carry out the verification, the project proponent must submit a project fiche, which describes the current activities, the countermeasures (reduction project) and a rough calculation of the emissions of the activity with the expected reduction.

Subsequently, the application will be analyzed, and, in the case of a positive assessment, the project may be considered eligible for support and participation in the program, but credits confirming the achieved reduction will only be issued after an ex-post audit has been carried out. Such an approach will allow for full transparency and mitigate the risks of possible differences between the declared projected $CO_2$ reductions.

To carry out all steps properly, potential technology partners implementing reduction projects should submit calculated $CO_2$ emissions from so-called daily business. This will determine the baseline, the value of which will be the benchmark from which all reductions will be made.



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The baseline will be the reference from which all realized $CO_2$ reductions can be evaluated for the issuing of VERs (Figure 42).


*Figure 42: Predicted information to be included in the platform at a later stage of VER development.*

The list contains preliminary information that may appear on the platform in the future as the project develops. The list is not complete and does not necessarily have to include those elements. Their implementation will depend on the results of the project activities.

Registry of reduction projects

- Amount of $CO_2$ emitted vs. avoided,
- Project information,
- Information about the implementing entity,
- Project status based on Initial concept of VER program.

Standard application documents for the program

- Project idea note (PIN),
- Project design document (PDD)

Program statistics

- Emissions,
- Number of participants,
- Number of projects, etc.



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## 4.4. LCA, S-LCA and LCC

All products, technologies, processes, or services, during their lifetime, resulting in burdens to the environment, because of the resources consumption, the emission of substances in the natural environment, and other environmental exchanges. Life Cycle Assessment (LCA) analysis is a well-defined and standardized methodology used for evaluating environmental performance and identifying their weakest spots throughout their life cycle so as to be re-evaluated. The social-LCA (s-LCA) and the Life Cycle Costing (LCC) studies assess the effect of a product's life cycle in terms of societal impact on the communities and the economic impact and viability on the value chain. In parallel, the spots that require actions to be taken are highlighted and alternatives for improving them are proposed.
NTUA is responsible for performing the LCA, the s-LCA, and the LCC analyses over each of the four CSSs. Their implementation will be held in accordance with ISO 14040:2006, ISO 14044:2006, and the International Life Cycle Data (ILCD) Handbook.

### State-of-the-art regarding the application of Life Cycle tools for evaluating circular strategies

LCA is considered the most internationally accepted tool to support environmental decision-making processes. In view of this it can provide a systematic framework to evaluate the environmental effects of Circular Economy (CE) strategies and identify and manage options for improvement [77]. There are many definitions of CE in literature, indicates the contribution of CE to environmental and economic innovation and growth. The industries' cooperation can reduce raw materials use and waste disposal. However, the flows extending the system boundaries can cause considerable external environmental impacts [78].

The implementation of LCA on CE systems can quantify the overall impact. The LCA combined with LCC in a joint framework for the evaluation of the environmental and economic performance of CE strategies constitutes the eco-efficiency analysis. It can be used to justify the environmental and economic viability of CEs [79]. In this regard, product developers can measure the environmental performance of various product and supply chain configurations, compare circular strategies and ensure a positive environmental balance from the design of new circular products or services. On this basis, environmental, economic, and social benefits that can be quantified in financial and utility terms will serve as a tool for the involved parties for more efficient, effective, and scientifically indicated decisions and will boost the by-product synergy. There are a few of ways LCA can be used to support this [80].

1) Highlight areas of improvement: The implementation of LCA can detect the stages within the life cycle of a specific solution that results in the highest impact in terms of resource consumption, pollution, etc. As the "weakest" points of the life cycle have been identified,



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alternative options for addressing these impacts, and improving the overall solution performance are proposed, and their potential is assessed.

2) Investigate alternative cases changing external factors: LCA offers the opportunity to examine the impact of external factors. This can be achieved by altering the input parameters of an LCA, e.g., by applying changes in the energy mix or, in the transportation options, by deploying new technologies, or by developing alternative procedures. The nature and the scope of the changes can be used to investigate alternatives that may vary among geographies or with time.
3) Compare similar solutions: LCA is efficient as a comparative tool as well. It can offer valuable and precise information when most parts of a system remain stable. For example, LCA could be used to compare the environmental impact of different energy mix consumption choices, when all the other parts of the model do not change.
4) Use in later stages of innovation: The more known the input data is, the more useful an LCA becomes. The latter stages of an innovation process or the improvement of an existing system can be proved as the best phase to apply LCAs. How and what materials and resources will flow through the system will be available, making the LCA more reliable. When an LCA is implemented in the early stages of an innovation process, it should be approached cautiously.

### FRONTSH1P circular solution under LCA approach

The FRONTSH1P project promotes circular systemic models and solutions toward decarburization and territorial regeneration to ensure a green and just transition.
LCA in the context of CE, can be expected to have broader scopes, analyzing all the steps necessary to prove the benefits in a circular context [81]. It is common practice in industrial symbioses to consider only the flows inside the complex, excluding the impact outside this ecosystem. To avoid this, the up streams and down streams outside the system must be contained in the analyses [82]. For this purpose, the proposed approach will comprise the CE system at different levels, e.g., inter-enterprise circulation, regional circulation, and social circulation.

On the same motif, the levels will include the CSSs at the unit level, the CSSs interconnection level, and the regional level. At the unit level, the LCA will be implemented for the CSSs independently, considering their technologies, their input flows (materials, water, energy, etc.), and their outputs (products, solid waste, liquid wastes, emissions, etc.). At the CSSs interconnection level, the interdependencies of the different CSSs will be evaluated. The outputs of one CSS can become the input of more than one CSS. In this phase, LCA will evaluate the impact of the different paths. In the case of the regional level, except for the CSSs collaboration, the flows entering and exiting the region will be included in the analyses.



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The different processes and/or procedures will be addressed as black boxes. Information collected from the other partners via questionnaire inventories will be used to establish the baseline. For better filtering and evaluation of the information used and the cases to be chosen, weighting factors will be defined. The outcome will be used as the benchmark decision - making criteria to recognize waste management towards a circular economy as well.

Due to the different characteristics of the cases and the paths generated, the need emerges for a tool to facilitate the results' evaluation and comparison. The generation of a rating system deriving from the combination of the defined criteria and the LCA, S-LCA, and LCC outcome, will cover this need. In this context, the LCA application can provide the optimum technology mix for the municipal solid waste (MSW) from a resource efficiency perspective.
This will be achieved by identifying the different flows and connections among the "waste providers and the recipients". The different routes will be matched and assessed using weighting factors. Namely, some of them are, the quantities "produced" and required, the distance of transportation, etc. During this interoperable process, a robust base of recommendations will be consolidated, suggesting the most appropriate options in each case.

### Exploitation of results from RCBT

The proper understanding and utilization of results is of high importance to translate the outcomes into specific solutions and to transmit and highlight the positive impact on the public's quality of life. RCBT will operate as the communication link between the LCA results and the public. A simple and approachable tool that will enable the interested parties to have access to and comprehend the function and the value of CE systems for the environment and economy. To achieve this target the information generated from the analyses will be visualized and presented appropriately to become comprehensible to the public.

For utilizing the analysis results in the frame of the RCBT there is a need for transformation in order to be compatible with the Toolkit. Data will be interpreted and parameterized to ensure the communication of the different kinds of data that will be used in RCBT. The data transformation is necessary not only for data being compatible with the Toolkit but for being understandable to the viewers as well. Following this condition there will be a cautious selection of the terms used, so they will be widely recognizable. Where this is not applicable, there will be a proper explanation.
The impact categories that will be used for the evaluation of the FRONTSH1P solutions will be defined during the LCA implementation process. The results of the impact categories that will be under consideration in each step of the multi-level analyses, such as Global Warming Potential (GWP 100 years) and Health and Safety, will be the input for the tool. This will provide an overview of the whole system in terms of environmental, economic, and societal impact. Qualitative evaluation and filtering of the different waste streams, the flows, the



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interdependencies of the waste streams and the solutions, the potentials of each path analyzed, and their functionality in the region will be available as well.

The prementioned outcomes will contribute to the RCBT to encourage both stakeholders' and citizens' understanding of the environmental, social, and economic impact and the benefits of such circular economy systems and will facilitate their inclusion. Through LCA results used in the RCBT, public awareness will raise for the environmental, social, and economic aspects creating sustainable awareness.



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## 4.5. Ecodesign

The current production and consumption patterns are exceeding the Earth's carrying capacity and it can have severe consequences for our living conditions now and in the future. The overexploitation of resources, to meet the current needs, are still linked to a linear economy or the take-make-waste paradigm based on the assumption that natural resources are available, abundant, easy to source and cheap to dispose of. The global economy is now only 7.2% circular; and it's getting worse year on year—driven by rising material extraction and use [83]. Therefore, we must deal with the global sustainability challenges, and we need a new circular approach to production and consumption system [84].

We need a fundamental transition into a more sustainable production and consumption system and thinking circular can help to address many of these challenges. Circular economy can be seen as a tool to operationalize sustainable development principles through efficient and eco-effective use of resources [84].
This transition must be an integrated and holistic approach to which all value chains have to contribute. The entire production and consumption system needs to change and be improved in innovative and sustainable ways. In this regard, the design practice makes an important contribution and has a key role in the definition of the features and the profile of products and services towards more sustainable solutions, focusing on "*Use less, use longer, use again and make clean*".

### Ontology of ecodesign

The ecodesign approach was developed and explored in the past decades, focusing on the integration of environmental aspects into the product development process, by balancing ecological and economic requirements at all stages of the product development process, striving for products that make the lowest possible environmental impact throughout their life cycle [85,86].
The design for circular economy, or circular design, can be seen as an upgrade and development of the concept in order to attain a higher level of sustainability. It relates the design and development of products, services and product-service systems that replace the conventional end-of-life concept by closing, slowing and narrowing the resource flows in production, distribution and consumption processes. This is enabled by innovation and novel business and organizational models and aims to accomplish sustainable development through supporting ecosystem functioning and human well-being, and through responsible production and consumption [84].

Disregarding the differences between the concepts, we herewith use the term ecodesign in a broad sense, i.e., encompassing the circular design approach. The ecodesign presupposes a



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holistic and systemic approach, which fits perfectly in the FRONTSH1P and in the development of solutions that cross the various CSSs of the project, thus promoting new solutions and new business models with greater potential for sustainability and creation of value for the project's stakeholders and for the target regions of its replication.
A circular business model articulates the logic of how an organization creates, delivers, and captures value to its broader range of stakeholders while minimizing ecological and social costs. Circular business models contribute to a circular economy by adhering to the circular economy's three fundamental principles [87]:

- Design out waste and pollution;
- Keep products and materials in use;
- Regenerate natural systems.

## Presentation of the FRONTSH1P aims context

The ecodesign approach within the FRONTSH1P project aim is to identify measures that have the strongest leverage for an environmentally oriented improvement of a product or value chain.
The framework developed for the ecodesign activities will provide guidelines for LCA and S-LCA, integrating a circular design perspective and needs; the identification of the circular design strategies with more potential to the identified products; the identification of improvement opportunities and measures for the strategies – illustrated with examples and case studies.

Aiming to promote the ecoefficiency of the production system, the design approach will be based on the definition of the value chain, considering the entire life cycle of the product. The identification and quantification of inputs and outputs of materials and energy at all stages, as well as the equipment used, will optimize the system by applying the following ecodesign strategies when possible and applicable, focusing on. The efficiency of the system can also be enabled by the use of digitization/industry 4.0 to monitor and optimize the use of equipment and processes.
The decision-making regarding one approach could be addressed by the environmental and social LCA's and LCC that will be conducted by NTUA plus the calculation of the ecodesign indicators.

## Data needs from the perspective of the ecodesign tasks

The ecodesign and circularity approach are built on the value chain defined within each CSS. In this regard, information and data from each process of product flow must be collected and provided by each CSS team.



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DATA NEEDS

System in focus: The CSS as a whole and each actor/activity/process of the value chain, following the life cycle stages: sourcing, production, use, end-of-life, logistics (packaging, transportation, and storage).

Characterization of the value chain(s) under analysis:

- Identification of the actors in the value chain of the product considering the entire life cycle.
- Relevant information about each actor: description, role in the value chain, sustainability certifications and labels.
- Position of each actor in the value chain

Data related to inflows, outflows, energy and water [88]:

Resource inflow per element/stage of the value chain

- Type and mass of material content in inflow (total quantity)
- Type and mass of reused content in inflow
- Type and mass of recycled content in inflow
- Type and mass of renewable content in inflow

🔔Remark: Resource inflows refer to all resources that flow through the system boundary into the system in focus, except water and energy, which are accounted for separately.

Resource inflows are measured to quantify four types of content:

1) recycled content;
2) reused content;
3) virgin, renewable content and
4) virgin, non-renewable content.

The four types of content should be mutually exclusive. (1) to (3) are considered circular, whereas (4) is considered non-circular.

Reused content: a resource inflow is reused content if it has already served a use. It includes materials and parts, but not materials that have been processed through a recycling operation.

Recycled content: material that has been reprocessed from a recovered material, through a manufacturing process, and transformed into a final product or an input to be incorporated in a product. Only pre-consumer and post-consumer materials shall be considered as recycled content.



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Renewable material: biomass that is sourced or managed in a sustainable manner, i.e., replenishable at a rate equal to or greater than the rate of depletion and regenerative (i.e., that support positive outcomes for nature).

RESOURCE OUTFLOWS

Resource outflow per element/stage of the value chain

- Type and mass of material content in outflow (total quantity)
- Type and mass of reusable content in outflow
- Type and mass of recyclable content in outflow
- Type and mass of renewable content in outflow
- Lifetime of the outflow
- Industry average lifetime of the outflow

🔔Remark: The resource outflows refer to resources that flow out of the system boundary of the system in focus (i.e., the CSS as a whole and each step of the life cycle as shown in the table), except water and energy, which are accounted for separately.
They include secondary materials produced as well as outflows accounting for non-recoverable resources such as hazardous waste and emissions.
The three core circularity indicators for recycling rate, content that is reused and content for renewable recirculation should be mutually exclusive and represent the circular outflows. The remaining are linear outflows.

Outflows from the system that are considered waste or emissions should be identified and calculated separately:

- Solid waste
- Emissions to water
- Emissions to air
- Emissions to land

The average lifetime of a product or material relative to the industry average is represented by the product durability, compared to the durability of sectorial standard products. It applies to the main output(s) of the CSS('s), such as the insulation material (CSS 4).

Reuse content: content from a resource outflow that will be recovered for reuse in the production, maintenance or repair of other resources/products. Typically, this is related to products and/or parts.

Recycled content: content from a resource outflow that is recovered and recycled into secondary material for use as an inflow to the system in focus or by another organization, CSS or region. Typically, this is related to materials.



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Recirculation of outflow: outflow content that is recirculated at end of life for safe return to the biosphere (biodegradation) and meets the qualifying criteria for recirculation (i.e., that originates from a biological source and is suitable for composting, anaerobic digestion or otherwise biodegraded fulfilling criteria set by international guidelines and standards, taking all precautions to avoid negative effects to the environment.

ENERGY

- Energy inflow (total quantity and type)
- Renewable
- Energy outflow (quantity and type).
-

🔔Remark: Energies relevant to a given process or system can be subdivided into:

- Energies derived from renewable energy sources.
- Energies derived from virgin non-renewable resources (e.g., fossil fuels or sources that are not managed sustainably including biomass).
- Energies derived from residual, non-renewable sources.

WATER

- Water Inflow from all sources (total volume and type).
- Water inflow from circular sources.
- Water outflow (volume and type).

🔔Remark: The circularity indicators for water consider water inflows, water outflows, internal water reuse and water quality.

Water inflows that are from circular sources fulfil all the following quality criteria:

1) Prior use or natural renewability: non-virgin or recycled water and non-fresh natural sources (e.g., sea or brackish), "rapidly" renewable fresh water sources, such as surface water from areas that are not water-stressed, renewable and harvested rainwater that are completely renewed by precipitation and natural flows.
2) Governance: strong water governance with equitable and sustainable allocation to all users.
3) Connectivity to discharge: water from a site that can be discharged back to original water source once treated.

Water discharged according to circularity requirements: water used in operations that leaves the infrastructure for reuse by another organization or is returned to the water source at the same or better-quality level than extracted. Losses, such as effluents, spillages or evaporation are treated as non-circular outflows.



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## Contexts of the benefits for the Lodzkie Region and replication regions

Analysis of the value chains of the CSSs' and the identification of value losses and opportunities could lead to the identification of new solutions with a high impact in the region, promoting the collaboration and symbiosis within the CSS's and other stakeholders in the region.

The method applied and the definition of strategies guidelines and criteria for the identification of new opportunities with sustainability and circularity potential can be adopted by other regions in Poland and in Europe, fostering the cooperation and the development of new circular solutions in products, services and business models.

## Application of ecodesign/circular design to FRONTSH1P

The following examples illustrate the application of ecodesign thinking to sectors of activity close to those being studied in the different systemic solutions of FRONTSH1P.

### 1) TECMEM

The TecMeM – Tecnologia e membranas em movimento [technologies and membranes in motion] was developed by CEBAL, Portugal.

- Value losses: (1) high added-value nutrients from wastewater that results from cheese, wine and olive oil production; (2) water consumption in the production process and (3) wastewater discharge.
- Opportunities: recovery of the nutrients; saving of production water; reduction of wastewater production.
- Technological solution: sequence of membranes: microfiltration, ultrafiltration, nanofiltration, reverse osmosis.
- Obstacles: very small producers with low investment capital, regional dispersion.
- Ecodesign solution at service level Figure 43: A mobile membranes unit was designed that provides the treatment service to the producers, with treatment capacities of 6000L/h and 3000 L/h.
- Potential ecodesign solution at equipment's level (not known, this is just illustrative): design for repair, design for long-life, modular design, preventive maintenance, eco-efficiency at production and use.



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*Figure 43: Mobile membranes unit developed within the TeCMeM project.*

## 2) MARTOS

MARTOS Pallets and Pellets is a Portuguese company that operates in the national forest sector, with activities such as forest exploration, wood trade and transformation, and the production of pallets and subproducts.

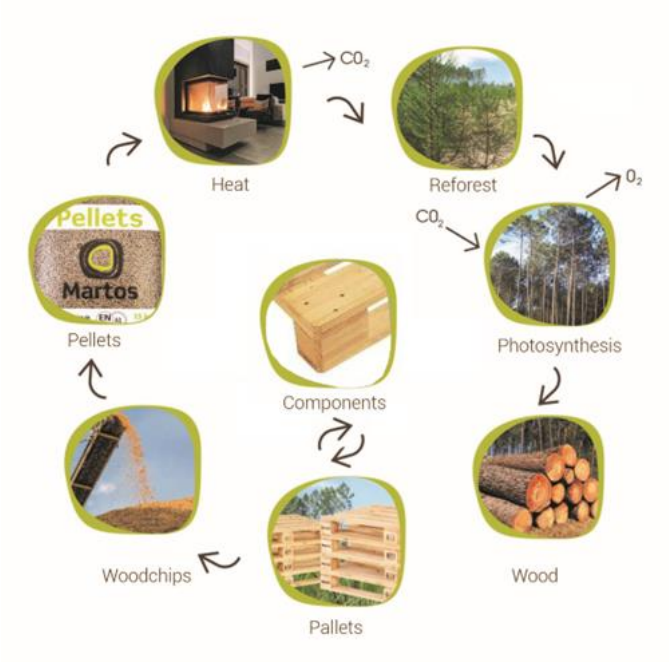


*Figure 44: Value chain at MARTOS Pallets and Pellets*

MARTOS Pallets and Pellets Company already operates in a circular way Figure 44. Nevertheless, during its participation in the CIRCO Hub Project with LNEG it was identified that damaged pallets were discarded and burnt, although parts of them still had value.

Thus, the opportunity has been identified: take back service of damaged pallets for refurbishing. If that option is no longer available, the Company cuts and glues the salvageable boards to produce cubes that are incorporated in the production of new pallets (structural component in the corners), replacing virgin solid wood.



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## 4.6. Circular Economy Brokers

*"Science and art only become useful when put into practice for public use."*
*Stanislaw Staszic (1755-1826), the Polish philosopher, pioneer of cooperative economy, political writer and publicist.*

The role of brokerage has been conceptualized in literature already in the twentieth century as relationships bridge the gaps between social, business and academia worlds. Duncan J. Watts [89] and Mark S. Granovetter [90] stated that the essence of brokerage is an "intensive" search for information about a specific opportunity versus an "extensive" approach, exploiting well known revenue streams of homogeneous information, specific for only one activity. People used to focus on activities inside their own group and on the single activity, what impacts the gaps in information flow between groups, or more simply - creates structural holes [91]. The information or knowledge that cannot be transferred to other actors is kept - consciously or not - by its possessor and maintains its original value. Brokerage entails bridging structural holes, i.e., "joining previously unconnected parties to facilitate coordination, collaboration and the pursuit of common goals" [92]. Brokering, defined in this way is seen as a revolutionary opportunity for the development of innovation and technology by facilitating the flow of dedicated information between industry and scientists and establishing stable, long-term relations, beneficial for both sides. Therefore, innovation or technology brokers get their chances to be a promoter of innovation.

The innovation broker was seen as a profession and defined in 2006 as an agent in any aspect of the innovation process between two or more parties. Such intermediary activities include: helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between bodies or organizations that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaborations [93]. For two decades, innovation brokering has been identified as a profession, hence - the innovation or technology broker was seen as a concrete man, practicing this profession.
Innovation or technology brokers in the EU and US were bounded especially with universities. The task of the innovation broker was to obtain data from scientists, research groups as well as entrepreneurs about their information needs or about their offers, and then - to select, process and transfer the tailored information to the appropriate recipients. The innovation broker was expected to also use information sources such as scientific publications, industry magazines, conference presentations, trade fair offers, etc. Therefore, effectively fulfilling such wide-ranging and extremely complicated tasks by innovation brokers is a challenge indeed.

Thus, in Guidance on Innovation Procurement (2021/C 267/01) [7] the problem of how to mobilize innovation brokers was discussed. The European Commission states that the links



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between companies, including start-ups and innovative SMEs, offering innovative solutions on the one side, and public buyers, on the other side, are often weak and do not arise spontaneously. Innovation brokers, as being a part of the overall innovation life cycle, are expected to build or strengthen the ecosystem of innovation. Within the above Guidance, the EC suggests that brokers should e.g., advise public buyers on how to join the networks to share knowledge, exchange good practice and communicate to the market (e.g., market consultation, joint commitment for future innovation procurement).

The review of the literature, dedicated to summarizing practices of brokerage of innovation and the analysis of RIC's own experience with innovation and technology brokering leads to the conclusion that a new paradigm of brokering in line with the current socio-economic mega trends should be created. Hence, new brokers of circularity are expected to support on-demand, collaborative and first of all – circular economy development. The feasibility of these complex tasks is possible only when properly tailored IT computing tools are implemented in the circularity ecosystem. Thus, in the new brokering of circularity paradigm, current development trends are orchestrated.

In line with the new paradigm of brokerage, the brokers of circularity should be defined as the interfaces between all stakeholders of the regional or local circularity development. Their main tasks are translation the different languages [35] of the several entities and align information needs with outputs [94]. The broker as interface is not understood any longer as an external person or even an external institution to the organization or company, but rather as its internal officer, equipped with the IT toolkit for dealing with the information of the organization needs just in time and addressing its specific demand. On the other hand, a circular broker [29] as an interface should have easy access to database with full information convenient for boostering a regional circular development. We are talking about two-way access here: the broker should be able to use the database for his specific purposes, but also provide information to the database himself. The other brokers will be able to use such data immediately.

### Position of the brokers of circularity for boostering the FRONTSH1P project's aims

Within the FRONTSH1P project the Circular Economy Brokers are to proactively engage stakeholders and citizens in creating opportunities for circular business and social innovation (Figure 45). The project concept of brokerage of circularity addresses four economic megatrends and the Circular Economy Brokers are seen more as a cloud ICT tool within the RCBT on the FRONTSH1P platform then a person dedicated only for circularity development for one or more institutions.



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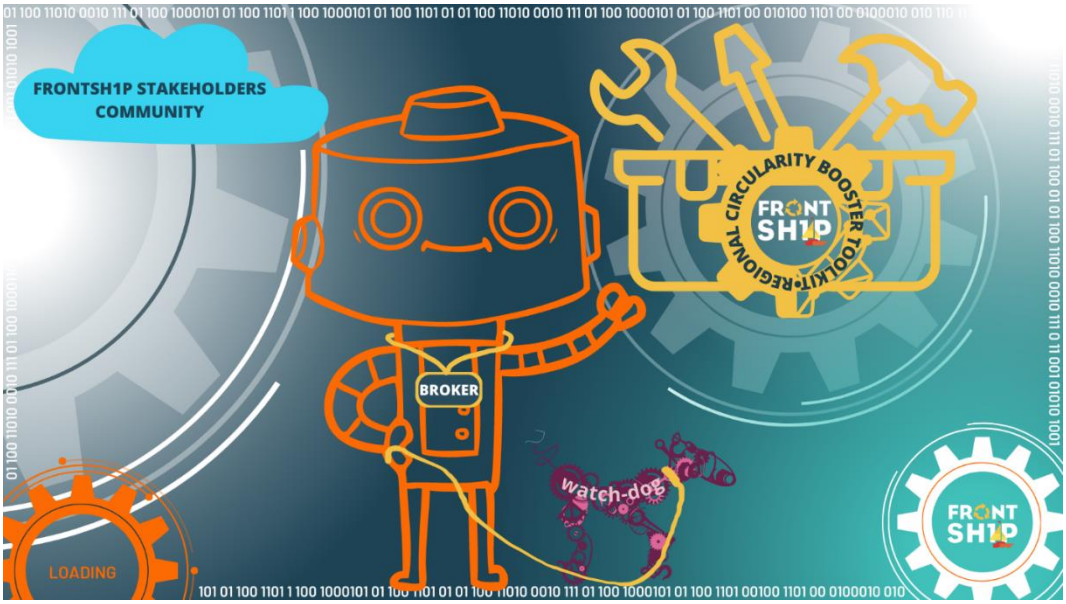


*Figure 45: Circularity broker and the watch-dog interfaces among the RCBT*

Thus, Circularity brokers as a kind of tool within the RCBT will be able to support stakeholders and citizens in their activities for circularity development thanks to:

1) easy access to up-to-date, complete and selected information, tailored to the needs of the stakeholder;
2) easy transfer, submission and visualization on the platform of individual offers in terms of owned by-products or waste, accessible for sale;
3) access to current market analyses in relation to specific technologies or products;
4) access to the VER platform and the ability to manage $CO_2$ emissions;
5) the capability to locate or to find interesting information on regional maps;
6) the ability to conduct a self-assessment of the state of implementation of the circularity paradigm in one's own institution using a set of specialized indicators;
7) raising awareness and knowledge of circularity on e-learning platforms;
8) familiarization with examples of good practices in the development of circularity in various EU regions.

## Cloud circularity brokerage in context of data processing

The circularity broker as an interface will perform all the tasks described above. It will be challenging to fix the set of keywords that stakeholders use to search for and enter their own data on the FRONTSH1P platform. Simultaneously, another challenge will be establishing procedures not only to protect users' online privacy, but also to ensure the cyber security of the databases and data processing procedures on the platform Figure 46.



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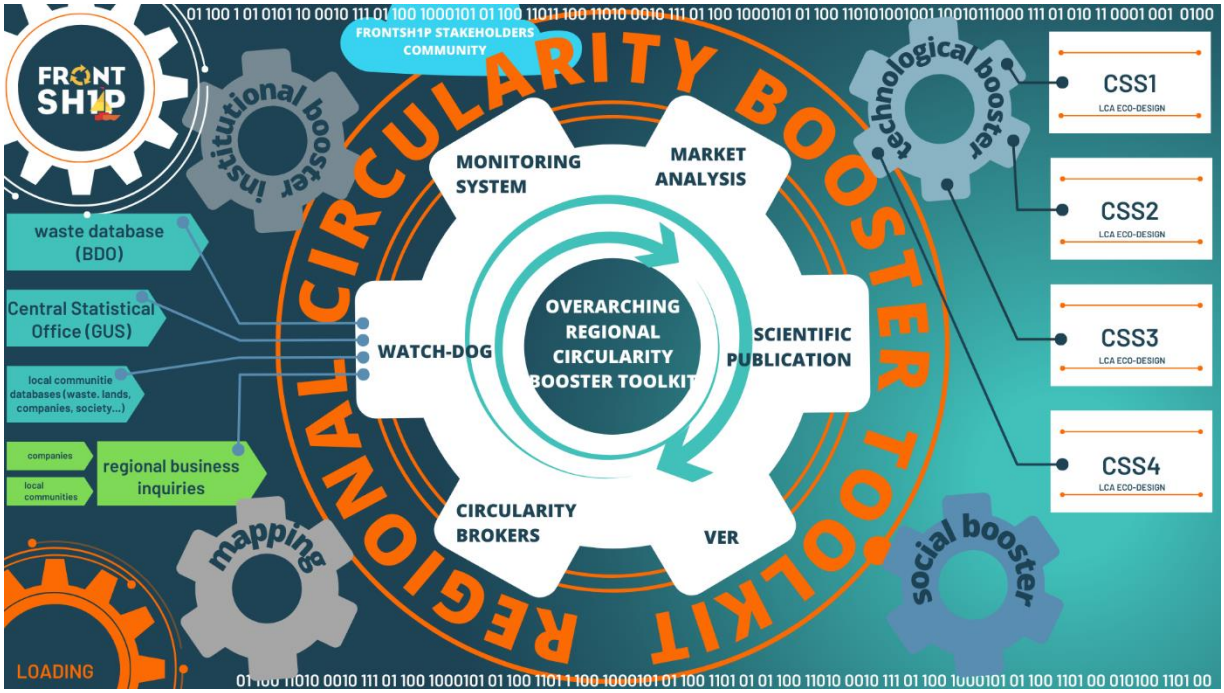


*Figure 46: Position of the Circular Economy Broker on the FRONTSH1P RCBT in context of data processing*

Within the WP7, tasks of building and implementation of comprehensive data privacy measures and practical solutions that mitigate risk and enhance efficiency of the circularity brokerage will be developed.

## Benefits of the cloud circularity brokerage for the Lodzkie Region replication regions

The added value for the Lodzkie Region and the other EU regions of the proposed circularity brokering paradigm is access to appropriate, dedicated/ tailored and up-to-date information for the various stakeholders of circularity, e.g., companies, local administration, social cooperatives as well as non-governmental organizations, households and individuals. The Circular Economy Broker as an interface on the FRONTSH1P platform will allow all stakeholders of circularity at the regional level to create opportunities for circular business and social innovation.

For local administration, a circularity broker will contribute to creating a beneficial environment for circular economy growth, will facilitate the search for good practices or patterns for how to initiate and support such model of regional development.



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# 5. Analysis of existing database in the Lodzkie Region in scope of FRONTSH1P project needs.

The aim of the FRONTSH1P project is to develop and implement new solutions for the circular economy leading to the green transformation of the Lodzkie Region and then to transfer the good practices to the other EU regions.
Systemic models and solutions implementing circularity meet the needs of the region. The use of available reliable sources of information on packaging, products, and waste (waste database) ensures a smooth flow of information, which will ultimately lead to the development of long-term activities based on a closed-loop management model.

The main objective of WP2, Task 2.2 is to develop methodologies and toolkits to support the regional transition to a circular economy. This toolkit considers different types of local waste sources as raw materials for reprocessing, reusing, recycling, and up-cycling.
The waste database is the primary source of information on products, packaging, and waste management. Thanks to the use of defined waste codes, communication is faster and easier. The information coming from the waste database is the basis for further processing of the information. In the process of processing data from many sources, the information flowing to the ordering party will be quick to find, consistent, and logical.
The information is legible, thanks to the presentation of data in tables and appropriate sections without extensive descriptions. In addition, the language of the information provided in the waste code – is clearly defined by the legislator without leaving room for individual interpretation.
What is more, the information is quite exhausting, which results from the obligation to record and report on packaging, products, and waste.

The database on products, packaging, and waste management has been changing and evolving since 2018. An advantage of the Waste Database waste system is that the website http://www.bdo.mos.gov.pl/ contains detailed instructions on how to use the database. The information is logically arranged, and the chapters of the manual refer to the departments located in waste database. The instructions are also published in the form of videos, which is a great help for navigating the system.

Another facilitation in using the waste database system is the possibility to take part in webinars. It is worth noting that these training courses are divided thematically according to the departments that exist in the waste database system. This is a great convenience because the user does not have to waste time, one can proceed directly to the part that actually interests him and applies. The user has the option of choosing a specific date with the target training in



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the field that interests him. Training is organized online with the possibility to ask questions. Before joining the training, one must sign up for it, and provide a name, surname, company denomination, and e-mail address. In the e-mail we receive confirmation of registration for the training and a link to the online meeting. The link works from any browser, which is also convenient. Having programs such as Teams or Zoom is not required. Chat is open during training. The participant of the training can ask a question during the training at any time. In addition, a Q&A session is planned at the end, where you can address the instructor again with further questions. There is also a dedicated helpline that one can use.

Bearing in mind the needs and challenges of the FRONTSH1P project, waste database should develop elements of the system, which would be beneficial for users.

Based on the FRONTSH1P communities experiences, as well as on social media waste database users' opinions, and results of the survey conducted by Interseroh https://portalkomunalny.pl/firma/interseroh-organizacja-odzysku-opakowan-4/ – waste database can be improved and shall continue to evolve and develop. As we know, records should be kept on an ongoing basis.

Waste database functionalities enable the comprehensive collection and management of information on waste management. In addition, they provide entities with fully electronic registration, records, and contact persons responsible. The analysis and evaluation of this data make it possible to diagnose the state of waste management on a national scale and to forecast trends of changes.
The waste database records also enable increased control over regional and national waste management and ensure monitoring of the flow of waste streams.

Benefits of implementing waste database:

- Increasing control over the national waste management and ensuring monitoring of the flow of waste streams by enabling waste records to be archived in the waste database.
- Optimization of the reporting process on waste management.
- Optimization of the processes of entry into the waste database Register, updating data and deleting entities from the register by introducing an electronic form.
- Reduction of irregularities in the waste management sector.

The FRONTSH1P project is focused on the Lodzkie Region and is intended to contribute to the green transformation of the region. The RCBT is an IT solution that allows you to implement the solution in other regions and provinces.



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The use of unified coding of information on the type of waste, according to the EU waste statistics regulation [95], to  will be a breakthrough step in circularity and building a green transformation. The improved flow of information between areas of Europe will have a significant impact on the expansion of the RCBT.

Currently, the waste database provides access to register links in the European Union. The register is available to other EU Member States for electrical and electronic equipment and waste equipment (Figure 47).


*Figure 47: Links to Registers kept in other EU Member States in the field of electrical and electronic equipment and waste equipment.*



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## 5.1. Waste Database available in the Lodzkie Region

The Marshal of the Lodzkie Region, in accordance with art. 49 of the Act on waste, keeps a register of entities introducing products, products in packaging and managing waste. The waste database register (in Polish: Baza Danych Odpadów, BDO) (Figure 48) is mainly used by state administration, national, regional and local authorities and environmental protection inspection on the regional; and national levels.

The waste database register – BDO - was launched in January 2018, on the platform: http://www.bdo.mos.gov.pl/. The Ministry of Environment of Republic of Poland is an owner and manager of the BDO platform.

Until the end of 2019, BDO used to perform only the functions of a register of entities. Since January 2020, the scope of waste database has significantly expanded, and from 2021 it is a mandatory tool for entities keeping records of waste. In the following years, new obligations related to waste records in the system were introduced. Further changes are expected in 2023.

The BDO is a public database that allows to review information related to economic activities in scope of waste management. Within BDO one can find such information as: an Id of company, type of waste produced by a company, waste codes, and what permits have been granted to the company.

Starting from 2020, the waste database BDO functions not only as a register of producers of waste, but also as a database on products, packaging, and waste management (waste database system).

In practice, BDO addresses two functions: the public waste database register and the waste database system. The Public database register is available only for reviewing. The Waste database system is open to authorized representatives of companies, in order to log in, to keep company's records of waste and to submit annual waste reports.


*Figure 48: Waste Database /Polish: Baza Danych Odpadowych/ platform*

The entity that is obliged to report of the waste, before transferring it, must issue a Waste Transfer Note/ Municipal Waste Transfer Note (in Polish: KPO/ KPOK) electronically in the waste database system. The note will contain such information as the type (the code) and quantity of reported waste, the planned date and time of transport, and the place to which the waste should be delivered. When transporting the waste, the transporting entity is obliged to have a waste transfer note/municipal waste transfer note confirmation. By generating such



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confirmation, the waste transporter will automatically confirm that he is aware of what he is transporting. On the other hand, the entity taking over the waste is obliged to confirm the receipt of the waste immediately at the time of weighing it at the place of collection. In the final stage, the person transporting the waste still has to confirm the service of transporting the waste to the place designated in the waste transfer note.

The waste management process is gradual and requires coordinated actions of the entity generating the waste and the waste collection and transport company. The first step within this process is selection of the waste code. It should always be made in accordance with Table 33.

*Table 33: Waste management process*

| Step 1 | Step 2 | Step 3 |
|---|---|---|
| Select a waste group, e.g., 17 | Select a waste subgroup, e.g., 17 04 | Select the type of waste, e.g., 17 04 05 |
| The first four digits indicate the source of the waste, which determines the selection of the correct waste code | | The last two digits indicate the type of waste |

The detailed waste classification procedure should be as follows:

- Step 1. Waste is classified according to its source in groups from 01 to 12 or from 17 to 20 (note: group 20 is municipal waste that is not recorded by the producer). However, we cannot assign a code ending in 99 (other waste not listed) at this stage.
- Step 2. If no appropriate item is found in groups 01 to 12 or 17 to 20, the waste is classified in groups 13 to 15.
- Step 3. If the appropriate item is not found in the above steps, the waste is classified in group 16, containing waste not included in other groups.
- Step 4. If no appropriate item is found in group 16, the waste is classified in the group according to the source of generation, assigning them a code ending in 99 (other wastes not listed).

The registration obligation was introduced in January 2018. An entity subject to the obligation to keep records of waste must register in the waste database register (BDO). Subsequently, the Marshal assigns a nine-digit registration number for entities reporting products or packaging and managing waste. The waste database registration number must be held not only by industry or waste management companies but also, for example, by dental offices and clinics, doctor's offices, car workshops, research units, sawmills, companies bringing products/ goods in packaging, and many other entities.

Summing up: the following type of entities are presented in BDO waste database is a register of entities:

- waste management companies;



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- waste producers, including such waste as tires, lubricating oils, vehicles, batteries, accumulators, electrical and electronic equipment, disposable plastic products etc.;
- introducing products in packaging;
- running retail or wholesale units where plastic shopping bags are offered, covered by the recycling fee according to Art. 40a of the Act of 13 June 2013 on the management of packaging and packaging waste [96]

There are a few exceptions to registration in the waste database. Non-legal entities and organizational units that are not entrepreneurs, using waste for their own needs, like:

- Entities in possession of the land surface where municipal sewage sludge is used for agricultural purposes, are exempt from the obligation to obtain a permit for waste processing;
- Entities conducting activities other than economic activity in the field of waste management, which collect packaging waste and waste in the form of used consumer goods, including pharmacies collecting medicines and medicine packaging, shops accepting used consumer goods, schools, educational and educational institutions or offices and institutions with waste collection systems (non-professional waste collection activities);
- Waste producers who are farmers managing the area of agricultural land below 75 ha, unless the activity in the field of waste generation requires a permit;
- In the field of transport - entities transporting their own waste [96].

The information content of BDO is clear, systematized, and accessible for all. Even an unregistered user can review information about the entity/company in the field of waste, packaging and products.

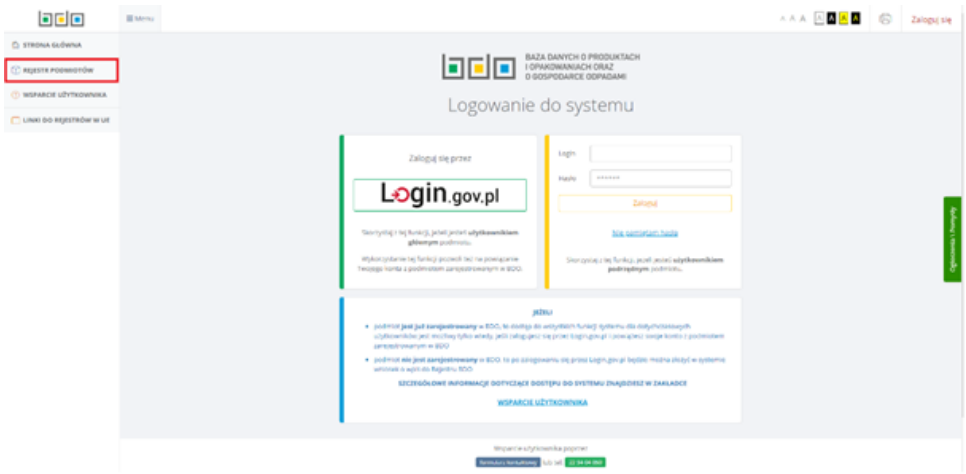


*Figure 49: Waste Database website - logging into the system*

In the "Registry of entities" tab, the user can browse for the required entity/entities and information about it/them. One can start searching for by such keywords as the company's name, registration number, or EU VAT number (Figure 49).



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There is also an option to choose a region, county, or commune. You can start browsing for entities by selecting the appropriate section, which is obligatory for entrepreneurs. A search engine for processes or waste codes is also available.
The search results appear in the table, where we see the name of the entrepreneur, registration number, tax identification number, and address. The most precious information is the waste codes for which the entity fills in the annual waste report, their description, and information on whether the given waste is EX waste. "EX" means that the code with this designation covers only the waste specified in the third column of the Annex to the Regulation, separated from the type of waste specified in the provisions issued on the basis of [96].
The data that the user obtains covers the type of waste and its diversity. The database does not provide information on the amount of waste to an external user.



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## 5.2. The Polish Classification of Economic Activities

The Polish Classification of Economic Activities was established by the Regulation of the Council of Ministry of the Polish Classification of Activities (in Polish: Polska Klasyfikacja Działalności, PKD). It can be defined as an identification, division and grouping of economic activities performed by entities operating on the market.

The Polish Classification of Activities (PKD) has an important statistical function. The structure of the PKD is based on the European Union's statistical classification of economic activities NACE Rev.2.

PKD consists of five levels:

- level one - SECTION - denoted by a one-letter symbol, divides the general collective into 21 groups of activities, which consist of activities related to each other from the point of view of the traditionally formed general division of labor;
- the second level - DIVISION - denoted by a two-digit numerical code, divides the overall aggregation into 88 groupings of activities, comprising activities by characteristics that are essential both in determining the degree of similarity and in considering the linkages that exist within the national economy (e.g., in input-output tables);
- the third level - GROUP - denoted by a three-digit numerical code, comprises 272 groupings of activities, distinguishable by reference to the production process, the purpose of production, or the nature of the service or the nature of the recipient of these services;
- the fourth level - CLASS - denoted by a four-digit numerical code, includes 615 groupings of activities, distinguishable primarily from the point of view of specialization of the production process or service activities;
- the fifth level - SUBCLASS - marked with a five-character alphanumeric code and includes 654 groupings. It was introduced in order to distinguish the types of activities characteristic for the Polish economy and subject to statistical observation. If at the national level no additional subdivision was made at the subclass level in relation to the international level (class=subclass), such a subclass was marked with the letter Z.

In the PKD Classification, economic activity is divided into the following divisions – sections [97]:

Section A - Agriculture, forestry, hunting and fishing;
Section B - Mining and quarrying;
Section C - Manufacturing;
Section D - Electricity, gas, steam, hot water and air conditioning supply;
Section E - Water supply; sewage and waste management and remediation activities;
Section F - Construction;
Section G - Wholesale and retail trade; repair of motor vehicles, including motorbikes;



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Section H - Transport and storage;
Section I - Accommodation and food service activities;
Section J - Information and communication;
Section K - Financial and insurance activities;
Section L - Real estate activities;
Section M - Professional, scientific and technical activities;
Section N - Administrative and support service activities;
Section O - Public administration and defense; compulsory social security;
Section P - Education;
Section Q - Health care and social assistance;
Section R - Arts, entertainment and recreation activities;
Section S - Other service activities;
Section T - Activities of households as employers; households producing goods and providing services for own use;
Section U - Extraterritorial organizations and teams.



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## 5.3. Central Registration and Information on Business database

Central Register and Information on Economic Activity (in Polish: Centralna Ewidencja i Informacja o Działalności Gospodarczej CEIDG) is the digital platform that enables access to the information collected about them business activities in Poland, free of charge.
The following are subject to enlisting in CEIDG:

- natural persons who are partners in a civil partnership or who carry out a non-agricultural sole proprietorship,
- other entities, including legal persons and organizational units without legal personality registered in the National Court Register.

The National Court Register is a centralized IT database consisting of three separate registers:

- Register of Entrepreneurs,
- register of associations, other social and professional organizations, foundations and public health care institutions,
- register of insolvent debtors.

🔔Remark: The method of data acquisition from BDO, PKD and CEIDG described above is a method that does not require any financial outlays. Another way to obtain data is to buy a ready-made database that will contain the information that interests us. Among the most popular database providers are:

1) Dun & Bradstreet https://www.dnb.com/pl-pl/
2) InfoBrokering https://www.infobrokering.com.pl/
3) Bazy Firmowe https://bazyfirmowe.pl/



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## 5.4. The Combined Nomenclature (CN)

The Combined Nomenclature (CN) is a tool for classifying goods, designed to meet the requirements of both the Common Customs Tariff and EU foreign trade statistics. The CN is also used in inter-EU trade statistics [98].
This is a further development (with special EU-specific subdivisions) of the Harmonized System nomenclature of the World Customs Organization. It is a systematic list of goods used by most trading countries (and also used in international trade negotiations). The Combined Nomenclature (CN) is the EU's eight-digit coding system and provides statistics on trade within the EU and between the EU and the rest of the world.

Together with the new matrix of VAT rates, from July 2020, the CN is used for classifying goods. It is the basic element of the Common Customs Tariff in the European Union and allows the classification of goods in international trade. Until 2020, the Polish Classification of Products and Services (issued in 2008) was used to classify goods for VAT purposes.
The 2008 product and service classification system (PKWiU) were not an optimal solution; hence the decision was made to change the method of identifying goods in the Combined Nomenclature. The transition to the new system made it possible to eliminate errors, e.g., similar products were classified differently and therefore subject to different VAT rates.
However, the Combined Nomenclature has one major limitation: it does not include services.

According to the provisions of the Act the services should be classified according to the PKWiU classification from 2015. The situation is different in the case of goods covered by the mandatory split-payment. In such cases, the PKWiU classification issued in 2008 applies.
To sum up, from April 1, 2020, we must check very carefully which of the three classifications should be used:

1) for goods - Combined Nomenclature (CN 2020).
2) for goods subject to mandatory split-payment - PKWiU of 2008.
3) for services - PKWiU of 2015.

Each subdivision of the nomenclature is referred to as a 'CN code'. It has an 8-digit code followed by a description and duty rate. Depending on the case, it may contain an additional unit. The subheadings of the CN are given in import and export declarations:

- what rate of duty applies to the goods and
- how goods are treated in statistics and regulations.

The Harmonized Commodity Description and Coding System (HS), commonly referred to as the Harmonized System, is an international commodity classification system developed by the World Customs Organization (WCO). This is a general classification system with approximately 5,000 six-digit product categories organized hierarchically by:

- sections
- chapters (2 digits)
- positions (4 digits)



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– subdivisions (6 digits)

The system is supported by a set of rules and explanatory notes.
Thanks to the HS, economic operators, customs officials and legislators from any country can identify the same product using a numeric code. The CN contains detailed information about the goods, such as their name, description, properties (Table 34).

*Table 34: An example of a product classification*

| CHAPTER HS | 2 DIGITS | 44 WOOD AND ARTICLES OF WOOD; CHARCOAL |
|---|---|---|
| Number SH | 4 digits | 4412 Plywood, veneered panels and similar laminated wood |
| Subnumper HS | 6 digits | 4412 31 With at least one outer layer of tropical wood |
| Subnumber CN | 8 digits | 4412 31 10 African Acacia, White Lauan, Sipo, Lime, obeche, Mahogany (Swietenia spp.), Dark Red Meranti, Light Red Meranti, Okoumé, Para Rosewood, Rio Rosewood, Rose Rosewood, Sapelli or Virola |

*Source: own compilation*

The nomenclature is updated annually and published in the Official Journal of the EU. The most popular tool for viewing the customs tariff in Poland is the Integrated Tariff Information System (ISZTAR4) www.ext-isztar4.mf.gov.pl/taryfa_celna/. (Figure 50).

There you will find CN codes, information on customs rates, restrictions on trade in goods, quotas as well as VAT and excise duty rates.

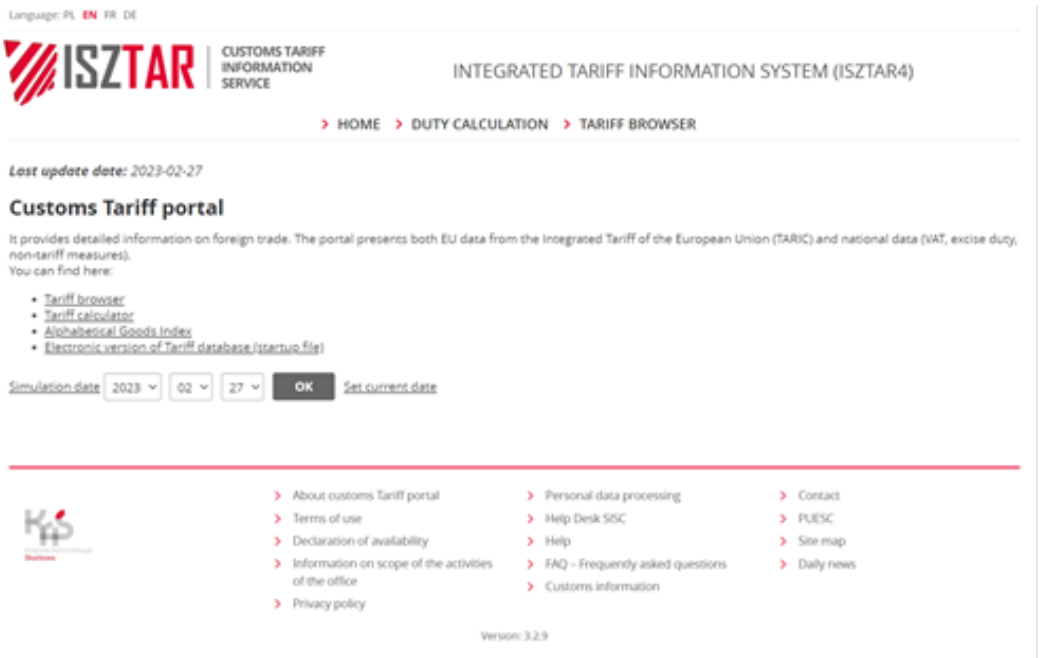


*Figure 50: Integrated customs tariff information system (ISZTAR4) website*



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ISZTAR4 is an IT system used in the Polish customs system, which enables the handling of processes related to the control and distribution of the flow of goods across country borders. ISZTAR4 enables e.g., registration of customs declarations, submitting applications for VAT exemption, keeping VAT records in import and export, handling customs controls, as well as communication between customs authorities in EU Member States and other entities involved in customs processes.
The aim of implementing the ISZTAR4 system was to facilitate and streamline the functioning of the Polish customs and tax system and to ensure greater efficiency of customs officers' activities. This system is also part of the European IT platform, which aims to enable the exchange of information between customs authorities in the EU and to ensure uniform standards in the field of customs and tax procedures throughout the European Union.

ISZTAR4 (Information System of the Integrated Customs Tariff) is based on the exchange of information between entrepreneurs, customs administration, customs, and tax authorities of EU Member States as well as external trade partners. All data and documents related to the customs and tax process are stored in a central database, which enables quick and effective processing of customs declarations and conducting customs controls.

ISZTAR4 also enables the automatic generation of customs documents and provides a wide range of information on customs procedures and legislation related to the import and export of goods in the European Union. The operation of the ISZTAR4 database is based on the principles of information security, which means that access to data is limited to individuals and institutions that are authorized to process the information. The system uses electronic certificates and encryption technology to ensure the confidentiality and integrity of data. ISZTAR4 is an integrated IT platform that enables the processing of customs declarations and other documents related to customs and fiscal procedures in the European Union, ensuring speed and efficiency in the customs process and the security of processed data. However, like any technology, ISZTAR4 has its drawbacks, and we outlined some of them below:

- Risk of system failure - ISZTAR4 is a sophisticated IT system that can fail or break down, which can lead to delays in the customs process and adverse consequences for businesses.
- Requires specialized knowledge - ISZTAR4 requires specialized knowledge and skills to be used properly, which can be a difficulty for small businesses that do not have access to such personnel or resources.
- Access restrictions - Access to the ISZTAR4 database is limited to individuals and institutions that are authorized to process customs data, which can make it difficult for some businesses and trading partners to access the information.



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- Requires constant updating - ISZTAR4 requires constant updating to consider changing customs regulations and to adapt to changing market conditions, which requires additional time and money.
- Potential for errors - Introducing errors in the processing of data and documents in ISZTAR4 can lead to problems related to delivery delays, errors in customs settlements and tax penalties.

In summary, ISZTAR4 is a high-tech database that enables the efficient processing of customs declarations and other documents related to customs and fiscal procedures in the EU. However, like any technology, ISZTAR4 has its drawbacks, which can lead to adverse consequences for traders and trading partners.

CN is a list of goods regulated in EU law, which allows the classification of goods for the purposes of international trade, foreign trade statistics of the European Union, and intra-Community trade. Toolkit, as a platform that develops and engages various stakeholder groups, shall use many data sources to meet various information needs.

Goods are classified based on their characteristics such as material, purpose, function, etc. The CN is used for various purposes, including:

- Customs - CN is used by Customs to calculate taxes and duties when importing and exporting goods.
- Statistical - CN allows you to collect and analyze statistical data on foreign trade between EU Member States.
- Commercial - CN facilitates trade between EU Member States and helps identify and classify goods during commercial transactions.

Therefore, the CN is an extremely important tool for entrepreneurs and companies operating in the European Union that import and export goods, as well as for customs services and statistical agencies.
One of the aims of the FRONTSH1P project is to create a more competitive business environment for companies involved in the circular economy. Combined Nomenclature as a unified list of goods for international trade meets the expectations as to the quality of data, i.e., usefulness, legitimacy and tailored to the profile of specific stakeholders.

Bearing in mind the main objective of WP2, the development of methodologies and toolkits supporting the regional transition to a circular economy, the use of CN is necessary.
The unification of nomenclature and the use of a defined code eliminates the likelihood of confusion and misunderstanding. RCBT, understood as a set of online tools for collecting data and publishing information about resources available in the region, shall use various



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databases. The raw material is understood very broadly. The term applies not only to waste or by-products, but also to marginalized land. The undeveloped administrative and social potential is also considered.

As in the case of data from the waste system (PL BDO), data obtained from Combined Nomenclature shall be the starting point for building full "tailor-made" information for RCBT users.

Summing up:

- CN is a commodity classification system that is used in the European Union for customs and statistical purposes. CN has its drawbacks, which should be minimized in the context of the project. Here are some of them:
- The complexity of the system - CN is a complex system that requires specialized knowledge and skills to use it properly. Some categories of goods can be difficult to classify, which can lead to errors and delays in the customs process.
- Requires constant updating - The CN is constantly updated to reflect changes in customs regulations and to adapt to changing market conditions. It requires constant tracking of changes and updates to ensure that goods are properly classified.
- Restrictions on international use - The CN is mainly used in the European Union and is not a universal system for classifying goods. Using the CN outside the EU can lead to problems related to differences in the classification of goods.
- Lack of flexibility - The CN is a rigid system of classifying goods that is unable to consider the unique characteristics and features of goods. This can sometimes lead to ambiguity and errors in the goods classification process.

Possibility of errors - CN is based on the classification of goods according to their name, description, and characteristics, which can lead to errors and ambiguities in the classification process. In case of incorrect classification of goods, there may be problems related to delays in delivery, errors in customs clearance and tax penalties.



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## 5.5. Local Data Bank of the Central Statistical Office

The Local Data Bank (in Polish: Bank Danych Lokalnych, BDL, https://bdl.stat.gov.pl/BDL/dane/podgrup/temat/9/223), is a collection of statistical information on the local economy in Poland. The BDL is maintained by the Central Statistical Office (GUS) and contains a wide variety of indicators related to production, employment, industry, services and other sectors of the economy as well as demographic data, such as population, population density, age structure, education level, unemployment, income, budget expenditure and many others.

The BDL enables data analysis at a local level, which allows better understanding of the economic situation in a given region or city. These data are used by various institutions and organizations, including local governments, entrepreneurs, researchers and experts to make decisions on the economic development of a region.
In the BDL, we can find information such as the number of companies, the number of employees, wages and salaries, industrial production rates, information on the service sector and data on infrastructure. This data can be compared with data from other regions or cities, which enables comparative analysis and the identification of a region's strengths and weaknesses.
When deciding to obtain information from the DBL, we can choose to use it as a logged-in user or as a guest of the service. Using the service as a logged-in user gives the possibility to remember search parameters, which is useful when logging in again.
The BDL is Poland's unique, largest database of local and regional data on the economy, society and the environment. The CSO makes available via API, as part of the MC project: Open Data - Access, Standard, Education, and the data collected in the BDL. Now anyone interested can use them free of charge and create any cross-sectional summaries, visualizations or analyses.
Making the data collected in the BDL available through the API opens unlimited possibilities of combining the largest and most thematically diverse sets of statistical data in Poland. It offers over 40 thousand statistical features grouped thematically by units of territorial division of Poland.

The potential of the BDL data is extremely important from the point of view of the data necessary for the RCBT. In particular, data quality and accessibility will be appreciated by analysts from the world of science, business and non-governmental organizations, and especially entrepreneurs who base their business on data. The database is also of particular value to administrative staff for policy-making purposes, as well as to the local government, scientific and academic communities. The opening up of the Local Data Bank data through the API fosters the development of civil society. Access to the API of the BDL is possible through the new CSO API Portal and directly through the bdl.stat.gov.pl website. The BDL database



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has been opened by API as part of the 'Open Data - Access Standard, Education' project implemented in the Ministry of Digitalization, co-financed by the Digital Poland Operational Program.

DBL is a tool for collecting and analyzing information about local communities and their needs. The BDL can be relevant to the Lodzkie Region in several ways:

- Regional development planning - The BDL can provide important data for local and regional authorities that are needed to plan the economic, social and cultural development of the Lodzkie Region.
- Monitoring the social situation - The BDL can provide information on the social conditions in the Lodzkie Region, such as the unemployment rate, education level, demographic structure or poverty level. This information is crucial for local authorities and NGOs dealing with social and economic problems in the region.
- Assessing the effectiveness of actions - The BDL can help assess the effectiveness of actions taken by local authorities and NGOs in the Lodzkie Region. By analyzing the data contained in the BDL, it is possible to assess whether strategic goals and objectives are being achieved, and to identify areas that require further work.
- Supporting scientific research - The BDL can serve as a source of data for scientists and researchers interested in topics related to the Lodzkie Region. With access to a rich collection of data, they can conduct research and analysis to better understand the problems and challenges facing the region.



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## 5.6. Local community data

The commune is the smallest territorial subdivision of the state, which serves the local community living in its area. It has numerous tasks and responsibilities, the proper performance of which undoubtedly makes life easier for the residents of the community. One such task is the organization of the entire municipal waste management system. This term covers a range of activities and actions aimed at sustainable management of the generated municipal waste, as safe for the environment and human and animal health and life as possible. These include, among others: collection, transport, utilization and disposal of waste, as well as supervision of the entire process and reporting to public administration authorities.

All obligations of a municipality in the field of municipal waste management are regulated by legal act. The Act has been amended several times since 1996 and this has mostly involved expanding the catalogue of activities necessary for the municipality to organize the entire waste management system.

It is the responsibility of the municipality to organize and include all its inhabitants in a municipal waste collection system which will ensure collection of all types of waste, starting from biodegradable (green) waste, through waste such as paper, glass, plastic etc., to dangerous waste, bulky waste or demolition waste.

When organizing the system, the municipality - by means of a tender - selects the companies or enterprises that will collect waste from residents on its behalf, planning the system of fees that will cover the costs of organizing the services, as well as the development of the necessary infrastructure (Figure 51).


*Figure 51: Diagram of the functioning of the municipal waste management system.*



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## Monitoring and reporting

Municipalities are obliged to constantly supervise the proper operation of the municipal waste management system, including, inter alia, the fulfilment of the tasks entrusted to entities collecting municipal waste from residents. Therefore, the mayor evaluates and approves the activity reports submitted by the entity collecting municipal waste from property owners, the entity operating the selective municipal waste collection point.
Also, the entity operating a municipal installation is obliged to provide the company collecting municipal waste from property owners or the municipality with which it has concluded agreements, with information on the waste transferred to it by this company or municipality, which it has subjected to the process of preparation for re-use, recycling or transferred for this purpose to another waste holder.

The municipal operator shall provide information on the waste he has subjected to the process of preparation for reuse, recycling or recovery by other methods or has transferred:

1) a company collecting municipal waste from property owners twice a year: for the first half of the year - by 15th July and for the second half of the year - by 15th January.
2) municipality once a year - by 15th January for the previous calendar year).

## Analysis of the state of municipal waste management

On the basis of reports submitted by entities collecting municipal waste from property owners, entities operating selective municipal waste collection points, entities collecting municipal waste, information provided by operators of municipal installations and on the basis of the annual report on the implementation of municipal waste management tasks and other available data on factors influencing the costs of the municipal waste management system, the head of the municipality, the mayor or the president of the city prepares an analysis of the state of municipal waste management including among others:

1) the volume to treat non-segregated (mixed) municipal waste, bio-waste that constitutes municipal waste and the residues from the sorting of municipal waste and residues from the mechanical-biological processing of non-segregated (mixed) municipal waste intended for landfilling.
2) investment needs related to municipal waste management.
3) the costs incurred in connection with the collection, recovery, recycling and disposal of municipal waste, broken down into receipts, expenses and surpluses from municipal waste management fees.
4) the number of inhabitants;
5) the amount of municipal waste generated in the municipality;
6) the amount of non-segregated (mixed) municipal waste and bio-waste constituting municipal waste collected from the municipality and the residues from the sorting of



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municipal waste and residues from the mechanical-biological processing of non-segregated (mixed) municipal waste intended for storage.

7) the levels of preparation for reuse and recycling of municipal waste achieved.
8) the weight of municipal waste generated in the municipality transferred for thermal treatment and the ratio of the weight of municipal waste transferred for thermal treatment to the weight of municipal waste generated in the municipality.

An analysis of the state of municipal waste management shall be drawn up by 30 April for the previous calendar year. The analysis of the state of municipal waste management shall be made publicly available on the subject page of the Public Information Bulletin of the municipal authority,

### Annual report on the implementation of municipal waste management task

The mayor (city mayor/president) is also obliged to prepare an annual report on the implementation of municipal waste management tasks, which is submitted to the provincial marshal and the provincial environmental protection inspector by 31st March for the previous calendar year. This report contains the following information:

1) the name of the municipality or inter-municipal association which has taken over the tasks of the municipality, the type of municipality and the number of inhabitants of the municipality or inter-municipal association.
2) information on the weight of the several types of municipal waste collected from the municipality and how they were managed, with an indication of the name and address of the facilities to which they were transferred.
3) information on selective municipal waste collection points operating in the municipality, the mass of waste collected in them and the manner of their management, with an indication of the name and address of the installation to which the collected municipal waste has been transferred.
4) information on the weight of products accepted by separate collection points for reuse and repair.
5) information on the weight of sorting residues and residues from mechanical-biological treatment sent to landfill generated from municipal waste collected and collected from the municipality.
6) information on the achieved levels of preparation for reuse and recycling of municipal waste and reduction of the mass of biodegradable municipal waste transferred to landfill and storage.
7) the number of property owners from whom municipal waste has been collected.
8) information on the weight of municipal waste generated in the municipality and waste generated from the treatment of municipal waste that has been sent for landfilling or thermal treatment, and information on the ratio of the weight of municipal waste sent for thermal treatment to the weight of municipal waste generated in the municipality.



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The report is submitted to the provincial marshal and the provincial environmental protection inspector via the Database on Products and Packaging and Waste Management (BDO database).

The provincial marshal shall be obliged to prepare an annual report on the implementation of municipal waste management tasks. This report shall be submitted to the minister responsible for climate matters by 15th July of the year following the year to which it relates.

1) the name of the province, the type and number of municipalities or inter-municipal associations that have taken over the tasks of the municipality, and the number of inhabitants of the province.
2) information on the weight of types of municipal waste collected from the province and the manner of their management, with an indication of the name and address of the facilities to which they were transferred.
3) information on the weight of products accepted by separate collection points for reuse and repair.
4) information on points of selective municipal waste collection operating in the province and entities collecting municipal waste.
5) information on the mass of sorting residues and residues from mechanical-biological treatment transferred for storage generated from municipal waste collected and collected from the province.
6) information on the levels of preparation for re-use and recycling of municipal waste, reduction of the mass of biodegradable municipal waste transferred for storage, storage, achieved by communes or intercommunal associations that have taken over the tasks of the commune, in the field of municipal waste management, from the territory of the province.
7) the number of property owners from whom municipal waste has been collected.
8) information on the weight of municipal waste generated in the province and waste resulting from the processing of municipal waste which has been transferred for storage or thermal processing, and information on the ratio of the weight of municipal waste transferred for thermal processing to the weight of municipal waste generated in the province.

The report is submitted to the minister responsible for climate affairs via the Database on Products and Packaging and Waste Management. (BDO database)

It is important to provide residents with information on waste management methods and principles, because on the one hand it makes it easier for municipal authorities to manage waste rationally and efficiently, and on the other hand it is educational. This information should be posted on the municipality's website, in the office and in the manner customarily accepted



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in the given area, e.g. on advertising poles or in shops, and should concern, among others: entities collecting municipal waste, entities collecting waste electrical and electronic equipment, points of selective municipal waste collection, including their addresses and opening hours, places of managing mixed municipal waste, green waste and residues from sorting municipal waste intended for storage, levels of recycling achieved by the municipality. Information and education activities can take the form of leaflets/folders with this information, activities for children in schools and kindergartens, actions to collect recyclable waste, e.g., wastepaper, bottle tops, or rewarding the most active residents in such actions.

In the context of the FRONTS1P project's activities, data on waste quantities and types of waste are important. This knowledge makes it possible to create a closed loop for a given type of waste by connecting the producer of a given waste with a potential recipient for whom it will become a raw material for a new good, a product. Therefore, a well-organized waste management system in each area, as well as reliable mandatory reports, can become a source of knowledge, a database which can directly contribute to limiting the mass of waste, implementing sustainable waste management and, above all, can serve the entire local community and help it implement the assumptions of a universally understood closed-circuit economy.

Municipalities, as organizers of the waste management system and holders of key knowledge about the quantity and quality of available raw materials from waste, are an essential link in the creation of circular waste management as a tool to reduce the mass of waste sent to landfill. This knowledge can contribute to the creation of a tool for exchanging information on the potential to use second-generation raw materials and thus reduce landfilling of valuable mass and lower the costs of organizing the municipal waste management system.

### Disadvantages of the system

Municipalities, which are the entities responsible for organizing the entire waste management system, have data on waste from the entire municipality. Companies involved in the waste collection and disposal process on behalf of the municipalities are obliged to submit monthly reports containing basic data on the waste collected in each period, i.e., its type (waste code) and quantity. On this basis, the municipalities produce the waste studies that the Act obliges them to produce. Unfortunately, this data is verified by the municipalities staff on an ad hoc basis by means of checks with the service contractor, which can create the potential for abuse and discrepancies between the actual and reported status, which is the biggest drawback of the existing system in terms of identifying the supply of waste as a second-generation raw material for the economy. The technical design of the system for reporting is unfortunately also flawed. Data is submitted to the regulators via the BDO system, the structure of which makes it impossible to generate a report on the amount and type of waste held. The lack of data in



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the form of a unique file makes it impossible to identify the potential held for raw materials from waste that could be reintroduced into the economy, allowing the waste cycle to be closed and the life cycle of a given raw material to be extended.

Another problem is the inconsistent designation of a given fraction. One waste can be classified under several codes and there are no specific regulations in this respect. The creation of precise guidelines for the qualification of waste into a specific group will undoubtedly be a key element in the creation of a system that will strengthen circularity and help to unambiguously identify the raw materials held for further action.

Undoubtedly, the knowledge and awareness of the participants in the system is insufficient regarding the closed-loop economy at every level of the social structure, and the topic of waste incorporation is still rarely addressed in local government unit educational campaigns, if municipalities conduct such campaigns at all.

Clear and simple information on how to deal with waste, how to use waste, how to put the zero-waste concept into practice, as well as knowledge about the specifics and quantities of waste that can be returned to the system and treated as raw materials for further production, thus reducing the amount of waste sent to landfill, is key to implementing purposeful circular solutions in both business and everyday life. Learning about these issues should be implemented at the earliest stages of education and continued for all ages and social groups. Raising people's awareness of waste, waste reduction and waste reuse at the local level can allow circular capacity building already at the municipal level, i.e., implementing solutions that are practical and useful for local people and therefore have the potential to escalate to a larger scale - region - country - continent - world.



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## 5.7. Review of available regional analysis of market and social analysis

Market and social analyses can come from different sources and be generated and published at different levels. Basically, we can distinguish analyzes created by public entities, scientific institutions, official statistics services, and industries. Analyzes can also be generated at different levels, from global, European (continental), national, and regional Figure 52.


*Figure 52: Sources and levels of analysis*

Social and market reports and analyzes are also available on the websites of public entities. Access to their websites and information published by them can be obtained through the Public Information Bulletin (Biuletyn Informacji Publicznej – BIP), which consists of websites where public entities and other entities performing public tasks (Ministry, Central Offices, Voivodeship Offices, Sanitary and Epidemiological Stations, foreign missions of the Republic of Poland Prosecutor's Office, State Fire Service, Hospitals) provide information required by Polish law (Table 35). As part of the Public Information Bulletin, it is possible to search for entities that are obliged to publish information, as well as the information itself. For this purpose, on the BIP home page, enter a phrase containing the name or part of the name of the institution in the search engine window. Information can be searched in this way on the websites of individual public entities. Materials on markets or social issues can be difficult to access because they are often included as part of or an appendix to legislation. Such materials are also available directly on the websites of public entities. For example, the Ministry of Family



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and Social Policy (Ministerstwo Rodziny i Polityki Społecznej) publishes reports on the labor market or living conditions (https://www.gov.pl/web/rodzina/analizy-i-raporty1).

On the website of the Lodzkie Region (https://www.lodzkie.pl) it is possible to search for this content in a browser using keywords

The European Commission is the executive body of the European Union, responsible for current policy, supervising the work of all its agencies, and managing its funds. The Commission has the sole legislative initiative in the field of EU law and is empowered to issue implementing regulations. The EC deals with all current issues related to the functioning of the EU, i.e., agricultural, economic, social, defense, and international policy, etc., and is the only EU body that has the right to the so-called direct legislative initiative. The EC also produces white and green papers. Green Papers are communications on certain policy areas, primarily aimed at participants in consultations and debates on a given topic. Sometimes, they provide an impulse to take legislative action. White Papers are documents proposing concrete actions by the Union, often drawn up after the publication of a Green Paper that opens a discussion on a given topic. Therefore, many documents are available on the EC website, e.g., reports and analyses concerning the EU as a whole but also individual countries and regions.

Eurostat allowed us to obtain information and data on topics related to the project. The datasets are accessible through themes and Categories inside each theme. The navigation tree presents data categorized by themes. Themes are organized into categories and subcategories, with datasets attached at the lowest category level. Each category and sub-category in a theme of the navigation tree can be expanded. There are three language choices: English, German, and French. All data sets maintained by Eurostat are identified by a unique code that is necessary to obtain statistical data.

Interesting from the point of view of the project may be the theme „Tables of EU policy" > category „Circular economy indicators" (code „cei") > menu subcategories: Production and consumption (cei_pc), Waste management (cei_wm), Secondary raw materials (cei_srm), Competitiveness and innovation (cei_cie). Sample subcategories: Waste generation per capita (cei_pc034), Recycling of biowaste (cei_wm030), Trade in recyclable raw materials (cei_srm020), Private investments, jobs and gross value added related to circular economy sectors (cei_cie010).

Another way to find interesting data or information is to search the database for keywords directly related to CSS1-CSS4. For "CSS1: The cruise of wood packaging residues: once a waste, now a resource" data in the theme agriculture, forestry and fisheries > subcategory forestry may be relevant. For example, if you enter Home > Data > Database for the word



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"wood" you will find data related to secondary wood products (for_secwp) and secondary paper products (for_secpp).
If you are considering the circular economy, waste and data in different European countries, please refer to the methodology and documents developed for EU countries in: https://ec.europa.eu/eurostat/web/circular-economy , https://ec.europa.eu/eurostat/web/waste
There is direct access to: Complete database, Selected tables, Indicators by topic, Information on data, Publications, Statistics Explained, Methodology, Legislation, Policy context, Targets, Reporting and Links to further information.

Statistics Poland is a central government administration office that collects and provides statistical information on most areas of public life and some aspects of private life (Table 35). The transfer of data is required by the relevant provisions of law (Act on public statistics and the Statistical Research Program published annually). Data may be made available only in aggregated (prepared) form, which prevents the identification of individual respondents (statistical confidentiality). Reports and analyzes are available on the CSO website in two tabs: Publications and SDG (indicators for global purposes). Publications can be filtered by topic by selecting the field from the drop-down list or alphabetically by going to the letter of the alphabet with which the title of the publication begins. In the SDg tab, the available indicators can be filtered by thematic areas corresponding to the goals of sustainable development.



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## 5.8. Review of available scientific publication

Searching scientific databases can be done on several platforms, e.g.: Springer, Wiley, EBSCO, Web of Science, Scopus. Not all, especially older publications, were included in these databases. In their case, Google Scholar search engine can be more useful.

Using the example of the Scopus database, you can follow the process of searching for publications on a given topic. A TITLE-ABS-KEY(circular AND economy) search will return more than 20,000 documents where the term circular economy appears in the title, abstract, or keywords. There are many of them. For this reason, the search of the database of scientific publications should be carried out gradually. By narrowing the search for the term circular economy only in TITLE (circular AND economy) titles, the database returns over 6,000 documents (of which nearly 3,000 have Open Access). Further conditions limiting the search may concern the date of publication (162 documents in 2023), document types (e.g.: article, conference paper, review, book, book chapter, editorial), name of the journal, keywords, affiliation of authors, sponsors, language of publication, and others. The possibility of using connections with other keywords repeated in publications is also interesting. For example, more than 6,000 publications with the title 'circular economy' are associated with more than 1,000 publications with Sustainable Development, Sustainability, or Recycling in keywords, and more than 700 with Waste Management. It is important that searching the publication database, you can also limit them by subject area. Publications will vary depending on the field, different in the area of social sciences, and others in: Energy, Computer Science, Environmental Science, Engineering, and five others.

The next stage of publication database search may concern the circular economy and exactly addressing CSS1, CSS2, CSS3 and CSS4 specific needs. Adding a condition that the title must contain, for example, the word 'wood' (TITLE (circular AND economy) AND TITLE (wood)) returns only 36 documents from the entire SCOPUS database. However, such a result may be too small. In this case, the scope of the search should be extended, and the word 'wood' should also be searched by keywords or abstract (TITLE (circular AND economy) AND TITLE-ABS-KEY (wood)). In this case, SCOPUS returned 95 documents. Even more - nearly 1000 publications - the database returned when All Fields are indicated in the query (TITLE (circular AND economy) AND ALL (wood)).
A similar pattern of searching for potentially important publications occurs in other databases of scientific journals, as they use SQL to create queries. These databases do not have disjoint resources and in each of them they can eliminate records that are in the others.

Reports and analyses can also be obtained from institutions and companies in many industries. Undoubtedly, the bank industry provides such resources (Table 35). The institution that provides many of these studies is the World Bank. The reports are available on the bank's



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website in the „Annual Report…" tab (https://www.worldbank.org/en/about/annual-report), and regional engagements are also highlighted in this section. Moreover, it is possible to search for other reports and analyses, for example, concerning demography, poverty, or other social matters through the search window on the Word Bank Web page. Materials can be filtered by key words.

National banks can also be a source of such information. Polish National Bank (Narodowy Bank Polski – NBP) periodically publishes analytical materials (Table 35). They are available on the bank's website in the "Publications" tab (https://www.nbp.pl/home.aspx?f=/publikacje/raporty_i_analizy.html). There are available analyzes and reports on the financial situation, inflation, investments, the situation of the enterprise sector, the real estate and credit markets, etc.

Market reports are also created and published by commercial banks. For example, Bank PKO BP provides sector analyzes on its website (https://www.pkobp.pl/centrum-analiz/), among which you can find industry reports and industry cross-sectional reports. The materials provided contain information not only on the current state but also forecasts.

*Table 35: Source of information*

| SOURCE TYPE | NAME | ADRESS | OPEN SOURCE |
|---|---|---|---|
| Public | European Commission | https://commission.europa.eu/index_pl | yes |
| | Biuletyn Informacji Publicznej | https://www.gov.pl/web/bip | yes |
| | Ministerstwo Rodziny i Polityki Społecznej | https://www.gov.pl/web/rodzina | yes |
| | Urząd Marszałkowski Województwa Łódzkiego | https://bip.lodzkie.pl/urzad-marszalkowski/informacje-ogolne | yes |
| Statistical | Eurostat | https://ec.europa.eu/eurostat | yes |
| | Główny Urząd Statystyczny | https://stat.gov.pl/ | yes |
| Scientific | Elsevier | https://www.elsevier.com | no |
| | Springer | https://link.springer.com/ | no |
| | Wiley | https://onlinelibrary.wiley.com/ | no |
| | EBSCO | https://www.ebsco.com | no |
| | Web of Science | https://access.clarivate.com | no |
| | Scopus | https://www.scopus.com/home.uri | no |
| | Google Scholar | https://scholar.google.com/ | partly |
| Industry | World Bank | https://www.worldbank.org/en/home | yes |
| | Narodowy Bank Polski | https://www.nbp.pl/ | yes |
| | PKO Bank Polski | https://www.pkobp.pl/ | partly |

*Source: own compilation*



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# 6. The readiness of the circular reality of Lodz Metropolitan Area for orchestration with RCBT

## Presentation of Lodz Metropolitan Area in the context of the economic megatrends: circular, collaborative, on-demand and app-driven economy

Association of Lodz Metropolitan Area (ALOM) is made up of 30 local government units in five districts: the City of Lodz, Brzezinski, Lodz -East, Pabianicki and Zgierski. The primary objective of the Association is to support the socio-economic development of the Lodz Metropolitan Area (LOM).

The Association acts as a so-called ITI Association (Integrated Territorial Investment) and implements the Development Strategy for the LOM, which is also the Strategy for Integrated Territorial Investments.

Within the framework of ITI instrument, local government units (LGUs) implement thematically and territorially integrated projects, focusing on development challenges that local authorities (forming the Functional Urban Area) decide to address jointly, at the stage of implementation and subsequent operation as well.

One of the development goals within the framework of LOM is to improve the quality of life of its citizens and sustainable management of space and resources. Considering visible climate changes, including the intensification of extreme phenomenon, and pollution, it is necessary to take coordinated actions to ensure rational and efficient management of space and valuable natural environment resources. Therefore, the efforts under functional area are focused on:

- creating more environmentally friendly space
- transformation towards low or zero emission economy
- reducing the consumption of fossil fuels
- green and blue investments
- circular economy
- climate changes and adaptation to them
- risk prevention and management
- protection of natural resources.

In addition, the authorities deploy Low-Emission Economy Plans, setting out the main goals and directions of activities in the field of improving air quality, energy efficiency, reducing emissions of pollutants, including greenhouse gases. Some of the LGUs have developed a Climate Change Adaptation Plan as a response to one of the most important environmental protection problems. Moreover, local authorities provide access to segregated waste containers and points for selective collection of municipal waste. On their websites, they



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conduct many educational programs, promoting environmental protection or waste segregation.

LGUs implement various projects in the field of environmental protection, co-financed from European funds (including the regional program), they also actively participate in programs co-financed from the following funds:

- Voivodship Fund for Environmental Protection and Water Management in Lodz concerning ecological education of residents, including kindergartens and schools, liquidation of asbestos-containing products, replacement of heat sources and improvement of energy efficiency of single-family residential buildings,
- National Fund for Environmental Protection and Water Management, for example "Clean Air", "My Electricity", "Stop Smog".

Association of the Lodz Metropolitan Area is co-responsible of the regional development policy. The following negative environmental factors, such as the poor condition of air and surface waters, low level of environmental awareness of citizens, low level of efficiency of waste management systems have been identified in the LOM. Adaptation to climate change is seen in particular in the implementation of technologies based on the potential of RES, improving the energy efficiency of buildings, eliminating non-ecological heat sources, the concept of the Circular Economy, supporting natural and landscape resources, creating new areas of green areas, building a system of blue and green infrastructure.

Therefore, the key directions of the Association's activities include:

- construction of a waste collection, segregation and processing system
- infrastructure development towards a circular economy
- development of sewage and wastewater treatment infrastructure
- increasing the ecological awareness of the inhabitants.

Thanks to joint initiatives for environmental protection and the exchange of experiences throughout the area of LOM, actions will be more coherent and effective. The Association performs the functions of the ITI Association, whose main goal is to: build partnership and cooperation within the functional area and support cooperation and exchange of experience between ITI Associations at the Lodzkie Region and national level.

In order to implement the partnership principle for the years 2021-2027, as part of an open recruitment process, ITI also invites representatives of civil society and representatives of socio-economic entities operating in the Lodz Metropolitan Area to submit Candidates for Members of the Advisory Committee of the ALOM for the years 2021-2027. Thanks to the cooperation, the prepared and implemented strategic documents for the LOM area (in



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particular the ITI Strategy and the supra-local strategy) will be consulted with stakeholders and representatives of the LOM community.

In 2021, Poland accounted for an average of 360 kg of municipal waste collected per capita, which means an increase of 16 kg compared to the previous year. Municipal waste in the area of LOM in kg slightly exceeds the national average, as shown in the Table 36 below.

*Table 36: Mass of municipal waste generated by one inhabitant of LOM by districts in 2020 and 2021*

| DISTRICTS LOM | MASS OF MUNICIPAL WASTE GENERATED BY ONE INHABITANT | |
|---|---|---|
| | 2020 | 2021 |
| | [kg] | [kg] |
| Lodzki East | 389 | 397 |
| Pabianicki | 416 | 428 |
| Zgierski | 454 | 455 |
| Brzezinski | 353 | 360 |
| Lodz | 389 | 395 |

*Source: BDL*

As part of all municipal waste in the area of LOM, a large part is mixed waste, which is presented in Table 37.

*Table 37: Mixed municipal waste collected from households per capita in 2020 and 2021 in kg*

| DISTRICTS LOM | 2020 | 2021 |
|---|---|---|
| Lodzki East | 142,7 | 131,1 |
| Pabianicki | 176,8 | 178 |
| Zgierski | 227 | 216 |
| Brzezinski | 175,5 | 181,8 |
| Lodz | 191,8 | 185,8 |

*Source: BDL*

Data on selectively collected municipal waste in relation to total municipal waste are presented in Table 38.



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*Table 38: Municipal waste collected selectively in relation to the total waste in the area of LOM*

| DISTRICTS LOM | TOTAL | | HOUSEHOLD | | PAPER AND CARDBOARD, METALS, GLASS AND PLASTICS | | BIODEGRADABLE | |
|---|---|---|---|---|---|---|---|---|
| | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 |
| | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| Lodzki East | 46,8 | 53,3 | 54,9 | 60,8 | 17,8 | 15,8 | 11,8 | 17,1 |
| Pabianicki | 42,7 | 42,0 | 49,2 | 48,7 | 9,3 | 9,6 | 17,7 | 17,6 |
| Zgierski | 40,8 | 41,2 | 44,3 | 45,1 | 10,5 | 14,3 | 16,3 | 18,1 |
| Brzeziński | 42,4 | 41,0 | 45,0 | 44,5 | 9,2 | 9,5 | 18,4 | 19,0 |
| Lodz | 37,5 | 38,8 | 32,4 | 36,3 | 8,8 | 15,6 | 16,8 | 13,8 |

*Source: BDL*

Based on the above data, in majority of LOM districts in 2021 there was an increase in waste segregation compared to 2020. The low efficiency of selective waste collection systems remains a problem in the Lodzkie Region. Despite the fact, that selectively collected municipal waste in the total mass of collected waste indicator and percentage of municipal waste intended for recycling constantly increase, the obtained values are still on unsatisfactory level (concerning region and country as well).

The predominant mass of the total waste generated is industrial waste (91.0%), therefore the problem lies in the high share of landfilled industrial waste in generated waste, with a simultaneous decrease in the share of recycled waste from 14.7% in 2010 to 5.4% in 2019 (against the average drop for Poland from 74.3% to 20.4%) [99]. The above data show the need to focus on the development of circular economy and intensified educational activities among the residents of LOM in the field of selective waste collection.

### On-line platforms for the development of circularity in Lodz Metropolitan Area

Units associated with LOM are actively involved in initiatives concerning broadly understood environmental protection. Several local government units have separate portals concerning this area (however, these are not pages limited to the topic of the circular economy).

The following websites addressing the environmental and circularity issues:

- https://uml.lodz.pl/ekoportal/
- https://www.facebook.com/Zielonalodz
- https://aleksandrow-lodzki.pl/eko-miasto/
- https://www.strykow.pl/654,srodowisko-i-rolnictwo
- https://rzgow.pl/srodowisko-t6
- http://www.ekologia.brzeziny.pl/
- http://www.ekologicznyzgierz.pl/o-projekcie/



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## Good practices in Lodz Metropolitan Area, with the companies, administration, society engagement

Members of LOM have implemented many projects of strategic importance, co-financed from EU funds (under the regional program for the Lodzkie Region, which have been identified in the Development Strategy of the LOM. These are, for example, projects in the field of environmental protection, including in particular: low-emission urban transport (7 projects), renewable energy sources (12 projects), thermal modernization of buildings (50 projects), air protection (14 projects), and water and sewage management (6 projects).
The synergy effect of these projects is the improvement of the environment in the area of LOM, which benefits the residents, entrepreneurs and administration.

The Commune Water and Sewage Plant in Rzgów, as part of projects co-financed by the EU, has expanded the sewage treatment plant. A second, twin purification sequence was built. The final product of wastewater treatment is granulated, which is used in agriculture. The fertilizer obtained from the s plant fosters the formation of humus in the soil.
Social consultations are a process of dialogue between representatives of the authorities and residents, non-governmental organizations, representatives of various environments, aimed at collecting their voices and based on them, making optimal decisions by the authorities in public matters. Local government units are obliged to ensure public participation in making environmental decisions in connection with the implementation of investments. They carry out an environmental impact assessment in order to determine the extent of the planned investment project's interference with the environment and human health. The subject of the project's environmental impact analysis is its direct and indirect impact on particular aspects of the environment.
The city of Lodz uses an innovative tool, VoXPopuli platform (https://vox.uml.lodz.pl/), which enables local e-referenda to be carried out, supports the construction of a modern civil society, and encourages residents to actively participate in the decision-making process. The consultations cover various areas, including environmental ones.
Local governments of LOM organize competitions, in particular dedicated to children and youth in the field of environmental protection, including circular economy (https://uml.lodz.pl/panel-obywatelski/ii-lodzki-panel-obywatelski/). Moreover, they conduct eco-education for residents and all other stakeholders. They also cooperate with NGOs and companies, working together to protect the environment, for example cleaning together on Earth Day.
In particular, the city of Lodz leads the way in the above-mentioned activities. The city of Lodz runs an Ecoportal (https://uml.lodz.pl/ekoportal/). Ecoportal contains information related to broadly understood environmental protection, including circular economy. The portal is addressed to a wide range of stakeholders, starting from residents, through communities, businesses and NGOs. In terms of circular economy, the portal provides knowledge on how to segregate waste, how to apply the 9R principle, and on waste management.



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## Regional clusters in area of circular development

The Lodz Wave Energy Cluster was initiated to ensure local energy security, improve the natural environment and increase the competitiveness and economic efficiency of the local economy. The cluster will operate in the Lodz administrative borders.

Bioenergy for the Region Cluster is an open cooperation initiative, bringing together over 80 enterprises, research institutes, local government units and business environment institutions operating in the field of renewable energy sources. The aim of the Cluster is to act for the sustainable bioenergy development of Central Poland in the context of the integrated package of actions of the European Commission in the field of energy and climate change to reduce emissions in the 21st century.

The LODZistics - Logistics Business Network of Central Poland cluster associates' companies from the logistics branch, local governments, research and development units, business environment institutions, as well as other entities operating in the logistics sector. Lodz Special Economic Zone S.A. is one of the initiators of the establishment of a logistics cluster due to the strong logistics potential of the Lodz region, its location in the center of a transport hub in Poland and Europe, a large number of entities providing logistics and transport services, the supply of warehouse space and extensive road infrastructure.
The main objectives of the Cluster are to increase the competitiveness of companies by stimulating innovation in the logistics industry, including technology transfer, development of good practices, common projects, the use of modern transport solutions such as intermodal transport, RFS system in air transport or eco-driving.

The energy cluster of the Pabianice district is a project pointed at reducing low emission through investments in renewable energy sources and to increase energy security through the diversification of energy sources. The cluster will also contribute to the development of distributed prosumer energy, environmental education in the field of RES, and will support innovative technologies in the field of effective energy management.

Bio2materials Sp. z o. o. B2M - a brand in the sector of ecological and sustainable textiles - operates in the Parzeczew commune. They deal with the creation of materials of organic origin. The current product is an alternative to animal and synthetic leather. Bio2Materials leather is 100% biodegradable and free of harmful substances. The business model and production process are based on the circular economy. Owing to this, a more efficient production process was introduced.

Business for the Environment Initiative Business increasingly concentrates on the concept of CSR (corporate social responsibility). According to it, companies, in addition to achieving profit-



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oriented goals, also invest in human resources and environmental protection. Thanks to the CSR concept, Lodz opens a new chapter in relations with business.

As part of the initiative, cooperation was concluded in the form of an ECOPACT (Figure 53), allowing to support the efforts of the city in building a more environmentally friendly environment. The stakeholders of ECOPACT include the public and private sectors, NGOs and other organizations, universities and the media.

Possible forms of cooperation within ECOPACT:

- Support for the City in the implementation of its initiatives (e.g., in the form of a donation or sponsorship).
- Implementation of a joint initiative with the city (e.g., in the form of barter).
- Declaration of the company to implement a pro-ecological project or initiative in its enterprise.
- Other forms proposed by entrepreneurs.
- ECO certificates issued by the City to the companies involved in the EC initiative climate neutral and smart cities.

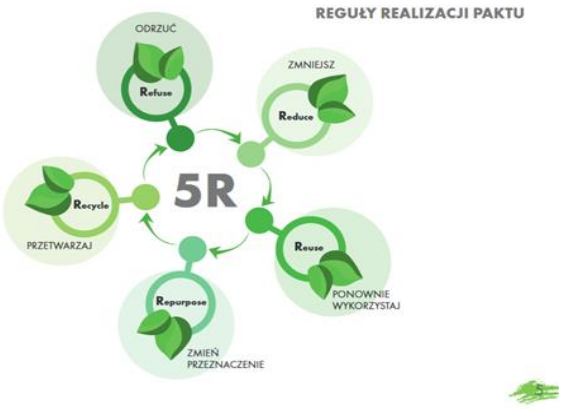


*Figure 53: ECOPACT rules*

The list of eco-pact partners is available at: https://uml.lodz.pl/ekoportal/eko-wiedza/wlacz-sie/partnerzy-ekopaktu/

### Climate-neutral and smart cities program

The city of Lodz is among the 100 European cities that will receive EU support in environmental protection activities.

## Available LOM databases, useful for circularity development

### Environmental NGO database



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The City of Lodz has a database of non-governmental organizations whose statutory activities and categories of public activities fall into, among others, in the field of environmental protection and ecology. Currently, the database includes 269 associations and foundations from the city of Lodz.
The list of partners of the above-mentioned Ecopakt is available at: https://uml.lodz.pl/ekoportal/eko-wiedza/wlacz-sie/partnerzy-ekopaktu/

Lodz Schools for Climate. Competences of the future is a pilot project dedicated to the development of an innovative methodology of teaching through experience, which will lead to a permanent change in the attitudes of recipients (students, teachers, parents) in terms of self-respect, other people and the environment. The whole is complemented by an investment element - the creation of green educational gardens. The project partners are the Centre for Ecological Activities Źródła - NGO and Echo Investment - company. The current list of schools participating in the project can be found at: https://uml.lodz.pl/ekoportal/eko-wiedza/edukacja/lodzkie-szkoly-dla-klimatu/



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# 7. Operational model of data value circle within the RCBT

The essence of the operational model for the RCBT is to integrate and visualize four different technological, business, social and institutional perspectives and four different circular solutions in the entire value cycle, created within the FRONTSH1P project.
We have embedded the operational model of RCBT on four development megatrends: circular, on-demand, collaborative and app-driven economy. Additionally, as the FRONTSH1P project is a circular stakeholder community - oriented, the idea of mass personalization is implemented.
Mass personalization is formally defined as “the act of tailoring a product or service based on what customers’ desire.” An example of a modern mass personalization company is Take Care Of [100], a vitamin brand that has customers answer questions based on their values, goals, and lifestyle to create a custom daily plan involving vitamins, proteins and/or collagens. The name of the customer is printed on each daily package as well.

In the RCBT case, personalization applies specifically to information and to information sharing. RCBT, being the owner and data processor, includes rules of mass personalization of information that responders/FRONTSH1P community stakeholders can use to build their circular profile. RCBT is going to be able to collect, process, visualize and archive large amounts of raw data and add personalization to tailored range of responders. In the heart of RCBT is mass personalization of information that is in line with the on-demand economy paradigm, but it focuses its attention exactly on data. Data transfers will be specially tailored to the needs of exact stakeholders, but the idea of RCBT is to provide information that is certainly useful, however without strictly defining its use direct use. For example: RCBT will inform potential recipients A1, A2, A3 in a given region, searched by keywords from the list of classification of activities about raw materials available at the moment (by-products), produced by manufacturer A. What is more, the given information will provide the amount and place where this resource is available, and this shall be shown on the FRONTSH1P mapping tool as well.

Designing the RCBT as a tool for mass personalization of information is, on the one hand, a response to the information needs of individual recipients, but on the other hand, it requires the use of much more advanced, comprehensive data processing algorithms to obtain not only a value chain effect, but a value circle effect. RCBT introduces a new approach called "value circle" instead of "value chain". The circle of values suggests a circular approach to material resources, social awareness, local policy and – first of all to information. We assume that thanks to access to RCBT, FRONTSH1P stakeholder community will permanently notice individual needs and offers. Moreover, they will understand their particular role as a member



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of the quadruple helix in the transition process – from linear to circular economy. Clear information about individual values and the benefits resulting from participation in regional value circles are of the greatest importance.
The practical implementation of the above challenging assumptions and the expected impact of RCBT on the actual development of local circularity will be only possible due to engagement of IT technologies.

The operational model of the RCBT reflects the principles that govern holds practical management of mass personalization of information. Therefore, it considers three main issues:

1) WHO?
2) TYPES OF INFORMATION
3) METHOD OF PROCESSING AND TRANSFER OF INFORMATION

Within the RCBT base of users/ beneficiary's key parameters for indicating them are layout and criteria for creation, expansion and archiving of the users database, including email addresses, and specific profiles in context of data needs. It also considers the aspects of sensitive data protection and sensitive data security procedures.
The range of IT tools, a set of algorithms and IT cloud solutions will be developed and tested on the FRONTSH1P platform with the participation of all project partners, including partners from replication regions.
Any feedback, comments and remarks will be used in the feedback loop to improve not only the IT tools, but also the operation model of RCBT.
The RCBT operational model is to manage the following two basic groups of information: horizontal information and current, on-demand information.

## Horizontal information

The
horizontal information consists of information on regional policies, regulatory information, as well as useful market reports and scientific articles selected from databases of scientific publications. Horizontal, cross-sectional and up-to-date information over a relatively long period of time will be collected and published on The Overarching Circularity Booster Toolkit platform (Figure 20).
Database search algorithms will be developed conferring to a set of keywords, according to the needs of the FRONTSH1P stakeholder community, including project partners: companies, local and regional administration offices, NGOs and academia. Such algorithms consist of two advanced programming tools: Watchdog, which constantly monitors the emergence of new information of a horizontal nature as well, searches for information tailored to the needs of the FRONTSH1P stakeholder community and (....as a real dog used to do....) "brings" the given



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information to the Circularity broker. Then, the Circularity broker (see 4.6 sub point of the Report:
Circular Economy Brokers) makes more detail selections for appropriate matching information to avoid frustratingly bombarding users of the RCBT with unnecessary, redundant information. Hence, the Circular Broker and Watch-dog algorithms will be developed for transferring information.

We assume that the following information of a horizontal character will be relevant and useful in the transition processes towards circularity for the FRONTSH1P stakeholder community, including all project partners:

1) Regional and local official guidelines as well as national and EU law acts, like regulations, directives, decisions, recommendations and opinions in scope of circularity development.

🔔Remark: It remains to be decided in the next stages of work on the RCBT IT tools, which law acts should be considered essential, and which should be treated as redundant and excluded from further processing.

2) Selected current market analysis e.g.,
   - market reports, prepared by marketing agencies,
   - reports on the state of the environment prepared by governmental agencies, foundation or scientific institutions,
   - reports on the human resources and labor market,
   - reports of social awareness in scope of practical requirements of circular economy and acceptance for regional circularity development.

🔔Remark: It remains to be decided in the next stages of work on the RCBT IT tools, which market analysis should be considered essential, and which should be treated as redundant and excluded from further processing.

3) Knowledge base: selection of scientific and popular science articles, books and websites. Databases of scientific publications such as Springer, Wiley, EBSCO, Web of Science, Scopus will be reviewed periodically and selected articles, presenting results of research in terms of circularity in general and in particular, respectively to interest of individual CSS.

Hence, we presume that scientific articles will be sent to all RCBT users with the hope of creating and obtaining a synergy effect because of applying knowledge to the every-day practice. For example, articles on circular social innovations could stimulate local communities or regional authorities to undertake new circular initiatives. Just as an example, the described



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research investigation in the field of i.e., plastic waste management technology can be inspiring not only for CSS4, but also for CSS2 or CSS1.
We appreciate the good examples and circular lighthouses presented on the websites. Thus, the close co-relationship will be established and maintained between the RCBT and selected websites like www.circularbenchmarktool.eu or www.obec.ecta.si. Up-dated information and news will be automatically transferred to RCBT from these platforms and published.
🔔Remark: It remains to be decided in the next stages of work on the RCBT IT tools, which scientific publications and websites should be considered essential, and which should be treated as redundant and excluded from further processing.

4) Monitoring system: The system of monitoring the progress of implementing CSSs within FRONTSH1P project will be fully in line with the EC rules.

We will monitor the pace of progress of circular economy development in following four thematic areas:

- Production and supply of raw materials for CSSs technologies;
- Waste management in entire FRONTSH1P stakeholder: companies, local communities and households;
- By-products management in order to avoid them to become waste;
- Competitiveness and innovation, cooperation networks and circular symbiosis creation.

We presume that the monitoring system will include about 30 indicators (see 4.2. Circular economy monitoring system model for the Lodzkie Region), distributed more or less equally between the four main categories mentioned above. As an added value of the project, innovative indicators for assessing qualitative issues in such aspects as social acceptance or the involvement of local authorities in the development of circularity will be considered too.
Additionally, a self-assessment tool for monitoring the progress of implementation of the circular economy paradigms in companies will be elaborated as an integral instrument of the system for monitoring. The self-assessment monitoring tool will be shared on the RCBT.
The monitoring system will be elaborated in month 24. We expect several challenges related to e.g., lack of necessary data or difficult access to information, etc.
🔔Remark: It remains to be decided in the next stages of work on the RCBT IT tools, which issues should be considered essential for on-going monitoring, and which should be treated as redundant and excluded from further processing.

5) VER Concept: The VER will be proposed and tested within the RCBT as a tool to manage and to reduce $CO_2$ emissions. The VER solutions have a horizontal character. However, on the basis of the VER concept, an IT tool for ongoing management of $CO_2$ emissions will be elaborated and shared. In the case of industry, the practical, tailored guideline on how to reduce $CO_2$ will result from the life cycle assessment analysis (LCA) of company products and by-products.



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🔔Remark: It remains to be decided within the WP3, WP4, WP5, WP6 (CSSs studied), particularly in tasks related to tasks LCA how the VER concept can be used to support the development of circularity. The VER IT tools will be developed in the FRONSTH1P project and then shared via the RCBT.

6) Social engagement boostering data: Considering the social impact to the development of local circularity, the following groups of information are planned to be analyzed:
   - in the area of the labor market: databases on available employees, characteristics of available competencies in the region, average wages, as well as regional labor market observatory analysis.
   - in the field of education: databases on the situation of pro-environmental education, including vocational education in school forms and adult education, as well as databases on academic education, e.g., the number of students participating in university courses on the circular economy, the number of scientists working in projects on the circular economy, etc.
   - in the area of social engagement in regional circularity development: compiling examples of good practices of local society involvement in environmentally friendly activities. The watch-dog will be permanently analyzing internet portals presenting social initiatives in this area and the circular broker will share them with FRONTSH1P stakeholder community.
   - in the area of circular project-driven cooperation: downloading information about open or incoming calls for proposals on EC and national and local portals and creating the project partner search room on the FRONTSH1P platform.

### On-demand fast information

RCBT is to ensure that current information needs of companies developing circular technologies are met. It is worth to stress that the role of RCBT is to increase awareness among companies not developing circular technologies yet. The information needs of enterprises are seen in two dimensions: firstly - in the area of meeting current purchasing needs in relation to raw materials supply and secondly – in sales needs in relation to own by-products and final products of the company.

At the current stage of work on RCBT, we are limited to analyzing only on-demand fast information in the field of raw material supply and possible sale of by-products by CSSs. However, we are aware that other important raw material issues should be considered, e.g., electricity and heat supply, water management and wastewater generation, etc.

Social aspects, such as ad-hoc searching for employees with specific qualifications or local social engagement actions, important for the development of the circular economy will be also addressed by RCBT.



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## Data processing model in relation to raw material supply

The CSSs information needs in terms of the supply of raw materials for production are varied. Two main databases will be under on-going watching: databases of waste and databases of regional producers, potential deliverers of their by-products, useful for CSSs production.

The project assumed that the CSSs technology would use waste for the generation. Hence, for each CSS, a database of appropriate waste codes has been prepared (Table 9, Table 15, Table 25).

Consequently, a database of waste owners, having given type of waste, interesting for CSS technology at their disposal has been elaborated in the tables connected to each CSS technology. The database of recyclers contains detailed contact information (an address, and e-mail, telephone number) important for making business decisions.
The watch-dog interface will follow not only tailored regional recyclers' databases, but also the waste-oriented trade platforms, like e.g., www.mamodpad.wastemaster.pl, offering such waste “raw-materials”.

Waste databases tailored to CSSs’ needs are described in detail in chapter 4.1. Knowing the waste code and the contact details of the waste management company - the identified recyclers, RCBT via the watch-dog IT tool and the RCBT will reach the potential waste supplier, the owner of the specific waste, ordered by the production company of CSS1, CSS2, CSS3 or CSS4.
The inquiry Table 39 will specify waste code, required amount of waste, delivery date, place of delivery. As RCBT is not a purchasing platform, the full specification of business terms and the finalization of the transaction will take place outside RCBT.

The RCBT's capabilities allow for more than only access to waste databases. As a source of raw material for CSSs technology, RCBT considers substances and items which are simultaneously/ parallelly produced as valuable raw material. Substances and items can be reported as waste or can be defined as by-products and offered to the market. According to the paradigm of the circular economy, commercial and environmental orientation in industry should be constantly "on" in relation to all substances and objects accompanying the production cycle. The terms “substances and items”, “by-products” and “waste” have their own specific definitions [4], however, physically, they are identical (Figure 54).



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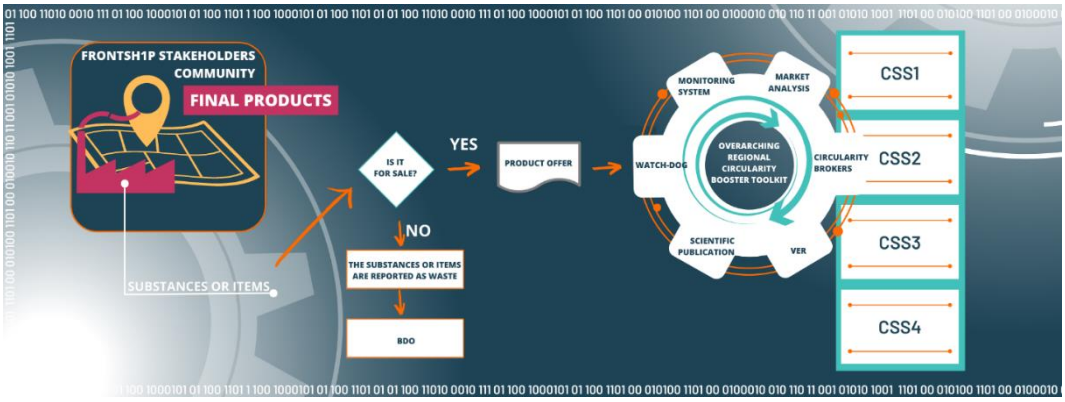


*Figure 54: The differences between "substances or items" accompanying the production cycle, "by-products" and "waste"*

Finally, the place where the by-products or waste could be obtained is completely different. Waste owners are recyclers, while the by-products owners are producers.

The key moment to be caught by RCBT is just before reporting the given by-products as a waste. An entrepreneur reporting a by-product as a waste must pay a fee for its collection, utilization, recycling or possible disposal. However, if an owner of by-products finds a buyer via RCBT, any price offered by the contractor/ CSS company, even null, will be beneficial. Therefore, manufacturing and wholesale activities were selected that produce by-products, useful as raw material for CSS1, CSS2 and CSS4.

### Data processing model in relation to by-products and final products sale

Industrial companies and other entities such as wholesalers, large stores or supermarkets, restaurants or transport carriers, and others economic entities whose economic activity is burdened with the generation of by-products, which are reported as waste, will be invited to use the RCBT. For the circular stakeholder community, it will be of particular interest to reduce operating costs by eliminating cost/ fees for collecting such waste as wooden, plastic packaging or bio-waste. Of course, in order to reach information about RCBT's possibilities to the FRONTSH1P stakeholder community, appropriately tailored dissemination activities will be necessary.

Elaboration and testing of RCBT in scope of data processing in relation to by-products and final products sale of CSSs will be carried out within WP7. The RCBT will enable 0-waste or nearly zero-waste production activities of industrial partners of FRONTSH1P project.
All by-products manufactured at different stages of the entire production process should be on-going reported to the RCBT. Development of IT algorithms dealing with this issue should be considered: information about by-products should be generated automatically and after meeting the set conditions, e.g., accumulated quantity, it should be subjected to LCA and ecodesign analysis. Within the LCA, the profitability of a given by-product will be analyzed



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and the most advantageous application for it will be indicated. For example, by-products generated in the process of algae cultivation, such as biostimulants can be offered as substrates for the production of fertilizers, biofuels or go to the pharmaceutical industry. The profitability of each of the above-mentioned applications is different. Therefore, RCBT will look for the most cost-effective and zero-waste option for the CSSs (Figure 55).

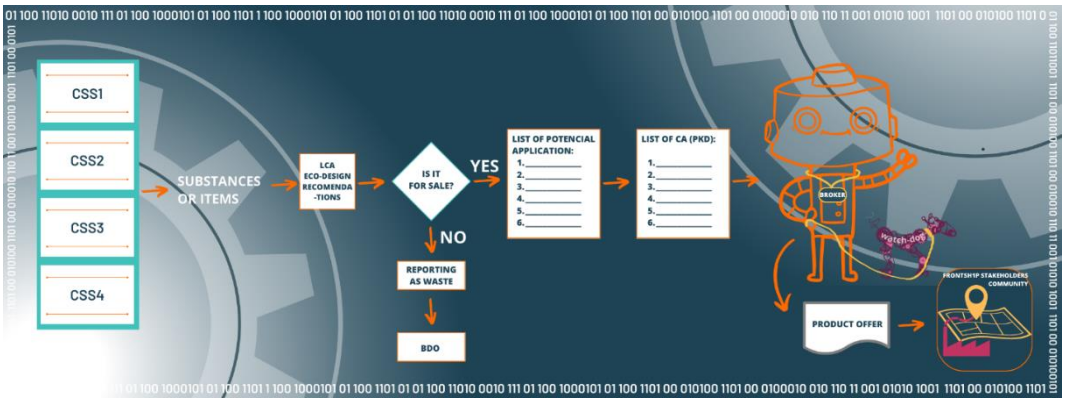


*Figure 55: Zero-waste CSSs technologies scheme*

As was mentioned above, the list of the most profitable applications for CSS's by-products will be created, and in relation to the list - economic activity codes of the potential buyers and their activity codes will be identified. Knowing the activity codes, RCBT watch-dog will search for potential contractors for a given by-product. Contractors will be ranked according to two key parameters: firstly – to the highest profitability and secondly – to the distance from the place of production of by-products. The second parameter will give information regarding transport costs which impact profitability.
In the next step, the Circular broker will send an offer for a given by-product to selected potential contractors.

At the next stages of the project, the details of the technology as well as production scale will be developed. Industrial partners will specify what by-products are manufactured, when, in what quantities and how quickly they should be transferred for further processing. The last parameter - "the best-before date" is of particular importance in the case of by-products of organic character, coming e.g., from food processing or restaurants.

*Table 39: Questionnaire for CSS by-products offer*

| No. | Name of by-product | Technical features (quantitative if possible) | Date of production | Amount/ volume | Pick-up place address and link to mapping geolocation | The-best-before-date |
|---|---|---|---|---|---|---|
| 1 | ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... | ... |



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Summing up, at the moment the following question arises why, if such a solution is so simple and mutually advantageous for the owner of by-products and producer interested in them, it is not widely used in practice. Indeed, it was only in the last decade, together with the circular economy paradigm dissemination and the development of on-line tools, that the conditions for implementing the above solutions appeared.

This approach is:

- pro-environmental - not only we will use local waste for production, but we will also prevent its creation and burdening the natural environment;

- pro-economic - we will build effective, shorter and cheaper raw material supply circles (by-product from production of company A -> production company B), omitting the phase of transforming the by-product into waste (we will avoid laborious reporting in company A) and collecting by-products that have been reported to the waste management companies as waste;

- pro-social - we will motivate local industrial partners to cooperate, we will build natural cooperation networks and industrial ad-hoc symbiosis, based on ad-hoc specific benefits. Companies will save money and time. In addition, enterprises using the RCBT will improve their digital competences. RCBT should contribute to the creation of start-ups, social cooperatives or micro-enterprises, cooperating with larger companies, supplying them with raw materials, i.e., with locally available by-products. Being part of the on-demand, collaborative and app-driven economy, their economic activity can only take place in virtual space.



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# 8. Conclusions for replications regions

One of the main ambitions of the FRONTSH1P project is the development of a comprehensive strategy for the replication of the four CSSs in the four replication territories: the Friesland province in the Netherlands, the Campagna region in Italy, the municipality of Livadia in Central Greece, and the North Region of Portugal. The strategy will include the definition of a business model, as well as methodologies, measures, and guidelines for replication, along with engagement tools and best practices to be deployed as a service portfolio to local and regional authorities of the regions in their territories.
In the operational level, the main value chains in the territorial clusters have been identified: North Portugal region will focus on CSS2, Campania region in Italy in CSS2 and CSS3, the region of Central Greece and the municipality of Livadia in CSS1 and CSS2; and Norther Netherlands, the Province of Friesland, will work mainly in CSS2, CSS3, and CSS4. The goal is to translate the lessons learnt from the Polish Lodzkie Region to the 4 EU regions, and beyond to the EU. FRONTSH1P will integrate the technical solutions from all the CSSs adapted to the local conditions, involving local stakeholders, while supporting the development of Circular Economic Action Plans.

The Regional Circularity Booster Kit comprises a robust tool for knowledge transfer to support the replication strategy. It provides an efficient methodology and several instruments, such as available platforms, networks, initiatives and projects currently available which will serve as basis for replication, scalability and visibility of CSSs in the replication regions. The booster kit enables cross-regional collaboration schemes to be reproduced on multilevel, from knowledge exchange, technology transfer and institutional cooperation.

This section provides a brief introduction of each of the replication regions, followed by examples of currently available regional platforms, maps, good practices and databases from each of the territories.

## 8.1. Province of Friesland, the Netherlands

Fryslan is a province in the north of the Netherlands. Friesland has approximately 650 000 inhabitants. The capital is Leeuwarden, which was the European Capital of Culture in 2018. In addition to Dutch, Frisian has the status of national language in the province. Fryslân also has a high level of welfare by Dutch standards. Fryslân scores low nationally on various economic indicators, but high on numerous welfare indicators. This is also known as the Frisian paradox. The gross added value of the Frisian economy amounted to €17.8 billion in 2018. We distinguish five themes in which we are (internationally) distinctive: water technology, agrifood,



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high-tech systems & materials (HTSM), maritime technology and circular materials (plastics, chemicals, construction, etc.). Together, these five themes are the driving force behind our employment and added value. In the economic domain, Fryslan works closely with the neighboring provinces Groningen and Drenthe (North Netherlands). Jointly, the RIS3 was drawn up in which the transition to a circular economy was identified as an important opportunity for new economic developments in the region. Together with quadruple helix partners, the province is a member of the Circular Friesland Association. Together we are on the road to becoming a European frontrunner in the transition to a circular economy.

For several years, initiatives to create a more circular economy in Fryslân have been launched across the province. It is mainly companies and organizations that are taking the initiative. Together, those companies and organizations founded the *Circular Friesland Association* in 2016. The province of Fryslân thinks, works and invests along with this association. Increasingly, the circular economy is being put on the map. Others are also noticing this and in 2017, the province of Fryslân was named Most Circular Region of the Netherlands. Currently the association consists of 140+ members (2023).

### Examples of on-line platforms for the development of circularity in Friesland region

Website Circular Friesland Association: The Association Circular Friesland plays the central role in our region for connecting education, business, government and civil society organizations around circular economy. The association's website is therefore the central platform for this movement. Through this platform, members, potential members and other stakeholders are informed about the development of circular economy in Fryslan. News and highlights are shared via monthly newsletters. In addition, there is a public online membership database so that members of the association can easily find each other to start new circular projects. The online platform thus provides online support for an active association program in which the various stakeholders are actively brought together through periodic meetings.
Homepage - Vereniging Circulair Friesland

Circular procurement platform: Circular procurement is an important enabler of the transition to a circular economy. The Frisian public sector purchases over €4 billion annually: a great opportunity to accelerate the transition to a circular economy. To learn and monitor together, twenty Frisian public organizations have expressed a joint ambition to procure as much as possible in a circular way. Knowledge and best practices are shared on an online platform.
Win Kopen Circulair - Wij Kopen Circulair

Circular education: The Frisian education system is working together to make circular economy a part of education as much as possible. They are doing this through a joint initiative called Spark the Movement. This movement is supported by an online platform where education



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makers, students, administrators, companies and other stakeholders meet and exchange best practices ('Sparks').
Home - Be a Spark - Join the movement (sparkthemovement.nl)

## Examples of on-line of Friesland regional maps, supported the development of circularity and CSSs technologies

Regional map of material flows – 2016

What enters Fryslân? What goes out of the province? Where is energy in and where do we drain energy? These questions were extensively pondered, critically examined and clearly mapped by Metabolic and Urgenda. They compiled this valuable information - sometimes confronting, often encouraging - into a material flow analysis report [101]. During the presentation of this report, including the raw material flow analysis, about a hundred entrepreneurs, knowledge institutions, (social) organizations and public authorities were inspired. By the numerous circular possibilities, Frisian opportunities and promising cycles that became known. And so, in 2016, Vereniging Circulair Friesland was formed.

Regional map of material flows – 2018

In 2018, a follow-up survey was conducted at the scale of the Northern Netherlands. This is an area comprising the provinces of Friesland, Groningen and Drenthe with a total population of 1.2 million. Through this material flow analysis, raw material flows were mapped with the aim of identifying circular opportunities, for chains within clusters and between clusters. The following were identified as strategic clusters: Chemistry, Agriculture (biomass, arable and livestock farming), Waste (household and business) and Construction (infra, utility, residential construction).
Noord-Nederland Circulair - Metabolic

## Examples of good practices of Friesland region, supporting the circular economy development with the strong social inclusion

Circular plastics

The National Circular Plastics Test Centre (NTCP) in Heerenveen is a major boost towards new life for plastic waste. This research center for improving plastic packaging sorting and recycling offers new and necessary opportunities for knowledge, cooperation and innovations within the plastics chain. The NTCP's ambition: to close the plastic cycle 100%. This means sustainable reuse of plastic in its original application and a sharp increase in the proportion of recycled plastics in packaging, for example.
The independent test center is open to the entire sector. Education, companies and other organizations can collaborate on plastic solutions and innovations in the test lab. The NTCP also has a public function, to transfer knowledge about plastics, circularity and recycling.



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Water technology for a circular economy

A large number of educational and research institutions, research facilities and water technology companies make the Frisian capital Leeuwarden a true water city: Capital of Water Technology.

WaterCampus is the hub of the Dutch water technology sector and fulfils a sector-connecting role within Europe. WaterCampus organizes and encourages cooperation between national and international companies, knowledge institutes and governments in the water technology sector. This creates synergy for innovations, education and entrepreneurship and strengthens the position of European water technology. With its unique research infrastructure, WaterCampus is also an exciting and inspiring meeting place for scientists and companies from all over Europe.

Circular society

Companies, municipalities, the province of Fryslân and all major educational institutions in Fryslân have started the movement towards a circular economy and a sustainable world. Spark the Movement, an initiative of the Vereniging Circulair Friesland, stimulates and strengthens this movement in and from education.

Spark the Movement is there for teachers, directors, caretakers, teaching assistants, policymakers and administrators. In short, for everyone who makes education. They are invited and encouraged to help young people find sustainable solutions to the great challenges of our time in a local context. All steps in the right direction (sparks) can be linked to the UN's Sustainable Development Goals.

## Sources of information – databases available in Friesland region to feed the RBCT

Monitoring waste

Waste policy in the Netherlands is monitored and analyzed at municipal and national level. Rijkswaterstaat manages the Netherlands' waste monitoring data. The government uses the data when evaluating and further developing waste policy.

How much waste is offered, what does the waste consist of, how is it processed, what are the costs for citizens? Much of this data is readily available via an online database Swing. Here, Rijkswaterstaat keeps track of collected waste data at municipal and national level.

In cooperation with the Dutch Cleaning Services Association (NVRD), Rijkswaterstaat organizes the Household Waste Benchmark. With this benchmark, municipalities and public collectors can compare these waste figures and steer policy.

From Waste to Resources - Rijkswaterstaat Environment (rwsenvironment.eu)



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## 8.2. Campania, Italy

The Campania Region, with its 6 million inhabitants, is one of the most densely populated regions in Southern Italy. The region is renowned globally for its long and fascinating history, the ancient ruins, and the key position occupied in the Italian cultural panorama. Napoli, the regional capital, is a city of remarkable beauty, highly animated and surrounded by an extraordinary natural environment, with the famous volcanic cone of Mount Vesuvius and the deep blue waters of the Gulf of Naples flanked by spectacular coast lines such as the Amalfi coast (Positano, Amalfi and Ravello) and dotted with islands including Capri, Ischia and Procida with their villages and small towns, nestled between the rocks and the sea. While the coastal areas are well known for tourism, the inner areas of the region have a very important value for agriculture and the environment. There are several regional areas of excellence that will play a decisive role for investments related to green and digital transition and the Campania Region can offer a strong focus on innovative content, particularly related to sustainability.
Campania is building its green transition on its focal areas: an ecosystem of innovation, the agri-food sector, the maritime economy, the aerospace district and tourism.

To develop its Smart Specialization Strategy, the Campania Region has proposed an Entrepreneurial Discovery Process (EDP) involving regional SMEs, start-ups, spin-off, Large Enterprises, RTOs, Universities, Research Clusters, High Technology Districts (STRESS is among them with the focus on Sustainable Construction), and Digital Innovation Hubs.

Through the Open Innovation platform of the Campania Region, it has received over 700 contributions to address the future innovation needs for the Region's economic development and has defined various technological trajectories, some of them are specifically dedicated to circularity (and some inspired by the FRONTSH1P CSSs):

1) Development and adoption of Nature Based Solutions for urban and territorial resilience against extreme climatic events.
2) Wastewater treatment using sustainable technologies; Innovative models and advanced technologies for waste treatment and recycling; Development of advanced digital technologies to support "industrial symbiosis".
3) Materials and components from CSSs for green cities.
4) Enhancement of organic waste and sludge for the production of bioplastics and biochemicals.
5) Models and systems for assessing the sustainability and energy and environmental efficiency of production chains.
6) Development of biosensors and nanostructured materials for the analysis of water pollution and the construction of hydraulic works.
7) Models, innovative processes and advanced technologies for the treatment and productive reuse of industrial and urban waste.



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8) Biotechnological systems and processes for the degradation of plastics and bioplastics and the phyto and bioremediation of environmental matrices.

From a regulatory point of view, the Campania Region promulgated Regional Law n.14/2016 to establish an active undertaking geared towards the implementation of a model of circular economy, with associated aims of sustainable development and realization of the principles of a bioeconomy. The Regional Law N°14/2016 states that: *"Campania Region assumes as a reference for its actions in the field of waste treatment the priorities established at European and National regulation:*
*a) prevention, as a set of interventions aimed at reducing the production of waste at the source;*
*b) preparation for reuse, aimed at promoting the reuse of products or components not to be considered waste;*
*c) recovery, for purposes other than recycling, including energy production;*
*d) disposal, as a residual and minimal system for non-treatable waste*
*The Campania Region recognizes the validity of the principles of the circular economy, whereby waste from a production and consumption process circulates as a new entry into the same or a different process, giving rise to a new model of production and consumption which aims at eliminating waste, through high-level innovative design of materials, reuse of goods, reconditioning of the product, regeneration of components." And it also declares that: "it pursues the creation of a circular economy model through concrete actions and supports, also with reward criteria in the allocation of European, state and regional resources, scientific research aimed at the design and production of reusable, repairable and recyclable goods and research on materials used in production cycles in order to minimize the environmental effects of their production and their post-consumption management, helping to encourage the reduction of the use of virgin raw materials and the maintenance of resources within the production cycle as much as possible as long as possible, to offer consumers durable and innovative products capable of generating savings and improving the quality of life."*

Within the same law, the Region *sets the following objectives:*
1) at least 65% of separate waste collection
2) for each separated fraction, at least 70 % of material actually recovered.

The law encourages information and education activities concerning circular economy measures aimed at reducing waste, reusing, recycling and recovering secondary raw materials also through the establishment of the *Regional information and education system for environmental sustainability* (SIESARC), as a network organization involving a plurality of public and private subjects of the regional territory and the Campania Regional Agency for Prevention and Environment (ARPAC) with the aim of promoting socio-economic sustainability education activities. The Regional Law also establishes the Regional Observatory on Waste



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Management - ORGR - and provides that ARPAC takes care of the regional section of the waste register (SRCR) in collaboration with the Regional Observatory on Waste Management.

The correct management of waste databases allows the representation and the monitoring of the regional reality relating to the production and management of waste (urban and special) and effectively supports the planning and design of future activities by the institutions in charge. The Regional Section of the Waste Cadastre carries out the collection, remediation (understood as correction of errors found) and processing of all the data required by current regulations.

### Examples of on-line platforms for the development of circularity in Campania region

There are some on-line platforms for the development of circularity at National level in Italy that include specific sections referred, or linked, to the Campania Region.

Progetto ECONOMIA CIRCOLARE, is an online Platform, developed by CONFINDUSTRIA the Italian National Industrial Federation with the support of research institutions (ENEA, LUISS Business School) and energy providers ( ENEL X, ENI), to promote Circular economy through ad hoc information, updating and sharing of experiences and good practices, aimed at companies and management, through targeted actions that aim to bring out the opportunities linked to the circular economic model, to activate knowledge dynamics -sharing and to disseminate the best practices available in the country.
https://economiacircolare.confindustria.it/

Another example is the ZEROSPRECHI (Zero Waste) Platform, developed by Gli Amici della Terra Association and supported by the Italian Ministry of Environment, which provides access to Best Practices, Documentation and, in general, Support for the development of Circularity.
https://www.zerosprechi.eu/

This platform is also linked to the 100% Campania rete per il packaging sostenibile (Network for sustainable packaging) that focuses on paper and cardboard and provides consulting services and support for their recovery and recycling to produce sustainable and circular packaging.
https://www.packagingsostenibile.com/

eLoop is a small consulting enterprise founded by Campania by young researchers specialized in sustainability services to small and medium-sized enterprises, large multinational companies and research projects.
https://www.eloop.consulting/



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## Examples of on-line of Campania regional maps, supported the development of circularity and CSSs technologies

The Campania region has its own specific Cartographic Portal, not specifically dedicated to circularity development that gives access to all the accessible Regional data Maps.
https://sit2.regione.campania.it/node

## Examples of good practices of Campania region, supporting the circular economy development with the strong social inclusion

The "FABU.LA- Financial And Business Activities Learning" project (Co-funded by the Erasmus+ Program of the European Union) intends to engage, motivate and stimulate young people of Primary Schools in entrepreneurship and financial literacy Financial And Business Learning Activities
https://fabula.conform.it/the-project/

The "FABU.LA- C-PLUS" Project builds on the Good Practice created by the "FABU.LA" and expands its scope and range of action, experimenting with innovative forms of interactive, gamified and laboratory teaching to develop consciousness, knowledge and ability to adopt behaviors oriented to the circular economy, experimenting and, at the same time, producing new creative and inventive ideas for an early entrepreneurial vision in the field of re-use and recycling of resources and materials.
https://fabula.conform.it/fabula-cplus/

Progetto Campania Green, is a Project funded by the Campania Region and the EU under the POR 2014-2020 and ESF programs to promote Circular Economy and Sustainable development in the Region.
The project includes various stages:

1) Green Meet – local animation and scouting carried out through 4 workshops on the Challenges of the Green Economy (Green Meets);
2) Business Ideation – selection of the best 20 innovative ideas on circular economy and sustainable development, presented by entrepreneurs, workers (including self-employed), students and unemployed (including long-term unemployed). The ideas will be supported by mentoring services, supported by experts in administrative, economic and managerial matters, as well as in the field of technological assessment to develop the business idea into a business plan; C) Business acceleration – 10 of the previous 20 Business plans will receive additional support and mentoring services to drive them to the start-up phase.

https://campaniagreen.it/



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## Sources of information – databases available in the Campania region to feed the RBCT

The databases managed by the Regional Section of the Waste Cadastre consist of:

O.R.SO. (Supra-regional Waste Observatory): it is a web-based application (i.e., functioning entirely through the internet) which collects production and management data of municipal waste in Campania municipalities (550 subjects) and waste treatment plants located in our region (about 1,000). Thanks to the processing carried out on this data. And it is possible to know the production, management and flows of urban waste and the data concerning the recovery and disposal of waste carried out in the plants.

MUD database: the collection of data on special waste takes place through MUD declarations that are presented every year by the obliged parties at the Chamber of Commerce territorially competent. The Chamber of Commerce subsequently transmits the declarations of our Region to the Regional Section of the Land Registry at ARPA (approximately 25,000 declarations a year). The data contained in the MUDs are not immediately usable, but they require of a substantial reclamation work (understood as correction of the errors found) to eliminate and/or reduce the main errors often due to the use of paper forms; the data on the production of special waste derive from the processing of this information.

CGR – Georeferenced Waste Cadastre: it is a database that contains administrative information and technical aspects of waste treatment plants in the Campania Region regardless of the procedure with which they were authorized (Ordinary, simplified or AIA); operational since the beginning of 2008, it is updated annually on the basis of available information;

Inventory of equipment containing PCBs: required by Legislative Decree. 209/1999, contains the information on equipment contaminated by PCBs (polychlorinated biphenyls, for example transformers and capacitors) and their disposal, recorded through declarations every two years carried out by the holders of the equipment themselves.



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## 8.3. Sterea Ellada, Greece

### Presentation of Sterea Ellada Region

The region of Sterea Ellada is located in central Greece, just above Peloponnese. The ancient oracle of Delphi is the most famous place in Sterea. The region of Sterea is also known as Central Greece, as truly it covers the central part of the country. Central Greece is the most populous geographical region of Greece, with a population of 4 591 568 inhabitants, and covers an area of 24 818.3 km$^2$, making it the second largest of the country.
Although it has lovely beaches and interesting historical sites, this region is not much popular.

### Brief description of the Municipality of Levadia

The Municipality of Levadia (Figure 56) is a municipality of Boeotia (regional unity) of the Prefecture of Central Greece. It was established by the amalgamation of the pre-existing Municipalities of Levadia, Davlia, Koroneia and Chaironea and the Community of Kyriaki according to the Act of Kallikratis Program (Administrative reorganization of Greece). The area of the new Municipality is 698.79 km$^2$ and its population is 31 035 inhabitants according to the census of 2021. The city of Livadia was designated to be the seat of the new municipality.


*Figure 56: Location of Municipality of Levadia*

The area is bordered to the north and west by the Municipality of Arachova – Distomo – Antikyra, to the south by the Gulf of Corinth, to the southeast by the Municipality of Thebes and to the southeast by the Municipalities of Aliartos – Thespies and Orchomenos.
The center of the Municipality is about 7 km away; road distance from the Sanitary Waste Landfill (in Livadia), to which all mixed waste is transported.
The Municipality of Levadia consists of the Municipal Unities of Levadia, Koroneia, Davlia, Chaironia, and Kyriaki. The total population of the Municipality amounts to 31 035 permanent residents (Source: Hellenic Statistical Authority 2021). It should be noted that the total number of households in the Municipality of Levadea is 11 700 households, while the average household size is 2.4 members/household (Source: Hellenic Statistical Authority 2021).



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## Current Situation of solid wastes management in the municipality of Levadia

The quantities of urban solid wastes to be disposed/buried at the Levadia Landfill for 2022 are 11 377.77 t. The quantities of packaging waste that are collected separately and taken to the Recyclable Material Sorting Center (RMSC) for the year 2022 are 684 t. In the Municipality of Levadea, no study has been carried out to ascertain the quality of the USW. For the purposes of this plan, elements of the quality recommendation are used according to the approved study of the Revision of the National Solid Waste Management Plan (July 2014), which is as follows:

*Table 40: Qualitative composition of MSW of the Municipality of Levadia*

| MATERIAL | % (PER WEIGHT) |
|---|---|
| Organic | 44.30% |
| Paper – Cardboard | 22.20% |
| Plastic | 13.90% |
| Metal | 3.90% |
| Glass | 4.30% |
| Wood | 4.60% |
| Others | 6.80% |
| **TOTAL** | **100.00%** |

*Source: own compilation*

## Current Infrastructures and Management Systems USW

The Municipality of Levadia is responsible for the collection of solid waste of M.U. Levadia, Koroneia, Davlias, Chaironea and Kyriaki. The urban solid waste for final disposal is transported and ends up in the Sanitary Waste Landfills of Levadia. According to data of Municipality, the Collection Service has 12 garbage trucks with a capacity of 8m$^3$, 12m$^3$, 14m$^3$, 16m$^3$, and 2 of them serve the collection of recyclable materials. The characteristics of garbage tracks of the Municipality and the number of existing mixed bins are shown below.

*Table 41: Characteristics of garbage tracks*

| TYPE OF GARGAGE TRUCKS | NUMBER |
|---|---|
| Wrecker | 7 |
| Closed Tracks | 4 |
| Recycling Wrecker | 1 |
| TOTAL | 12 |



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*Source: own compilation*

*Table 42: Mixed and recyclable waste bins of the Municipality of Levadia*

| BIN CAPACITY | NUMBER |
|---|---|
| Green bins (mixed waste) 1100 L | 1.387 |
| Blue bins (recyclable) 1100 L | 709 |
| Green bins 240 L | 20 |
| **TOTAL** | **2.116** |

*Source: own compilation*

The collection of mixed waste and transport to the Livadeia Landfill takes place 6 times a week in Livadeia, 5 times a week in Koroneia, 5 times a week in Davlia, 5 times a week in Chaironia and 5 times a week in Kyriaki.

Additionally, the Municipality of Levadia has entered into a cooperation agreement with the Hellenic Company of Utilization - Recycling SA for the alternative management of municipal packaging waste (paper, plastic, and glass, metal). In the current phase, the recycling program is implemented with 709 recycling bins (blue bins) of 1100 lt. The Hellenic Company of Utilization - Recycling SA has supplied the Municipality with 2 recycling vehicles of 16 m3. From the analysis of the data presented in the following table, it appears that the Municipality of Levadia has 1 recycling bin per 55 permanent residents.

*Table 43: Network of Recycling Bins*

| NAME OF NETWORK | PERMANENT POPULATION (2011) | RECYCLING BINS IN TOTAL | RESIDENTS PER BIN |
|---|---|---|---|
| M.U. LEVADIA | 21.932 | 555 | 40 |
| M.U. KYRIAKI | 2.085 | 41 | 51 |
| M.U. KORONEIA | 3.552 | 57 | 62 |
| M.U. DAVLIA | 1.851 | 26 | 71 |
| M.U. CHAIRONIA | 1.615 | 30 | 54 |
| **TOTAL** | **31.035** | **709** | **55** |

*Source: own compilation*

Regarding the alternative management of municipal packaging waste, the Municipality makes an average of 2 routes per day to collect it from the blue bin. After their collection, the packaging waste, after being weighed, is collected in a 10-ton container, and then forwarded in accordance with the legislation to a Recyclable Materials Sorting Center in Schimatari, Boeotia. There, after their sorting, the separated streams are bundled and the outgoing



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materials, which are characterized by greater purity, are promoted to the materials recycling industry. From the amount of recyclables that has been achieved by the Municipality, the Hellenic Company of Utilization - Recycling SA as a return finance it with the amount of €10/tn. As regards green waste (Pruning), this is collected separately from mixed waste and its total amount amounts to approximately 150tn per year. According to the Cleanliness Regulation of the Municipality of Levadia, the collection, transport and disposal of green waste takes place within 4 days from the notification of the competent cleaning service of the Municipality. In this case, green waste is collected by the cleaning service without charge. Part of the green waste (logs, etc.) is available free of charge from the Municipality to needy citizens for their heating.

### The regional program of transition to a circular economy

One of the Special Objectives of the Operational Development Program for the Region of Central Greece is the transition to a circular economy.

This is currently achieved through a series of actions implemented by PSTE. Specifically:

- Sustainable Resource Management, which concerns:
  - in the Management of solid and liquid waste, the support of environmentally friendly production processes & efficient use of resources, with the main objectives of increasing their efficiency.
  - in rethinking value chains.
  - in the reuse of buildings and the reuse of water or the collection of rain and spring water.
  - A District Waste Register has been created.
  - the implementation of successful practices in scope of water resource management and energy saving.
- Reinforcement of Circular Entrepreneurship, which concerns:
  - encouraging the idea of ecodesign, the production of long-life products, repair, renovation, reuse, restoration.
  - the promotion of innovative entrepreneurship models.
  - support of the biological economy.
  - the promotion of green and circular public procurement.
  - supporting the use of secondary materials.
- Circular Consumption, which concerns:
  - fully informing citizens.
  - in the utilization of Ecolabel and other incentives.
  - in education with the main objectives of sustainable food consumption (waste prevention, urban farming).
  - to prevent excessive use of resources (food, drinks, clothing, packaging, EEE).
  - in the prevention of waste generation through preparation for reuse, repair and remediation.



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- Creation of urban spaces as "creative centers of reuse", by exploiting the Green Points and transforming them into "Green Centers".
  Green Centers encourage repair, reuse, swapping, repair training as part of the local community. They are broader structures based on the Green Points. Meeting point for consumers and producers to get feedback on design, shaping so that urban areas encourage ecodesign. The action includes, among others:
  - mapping of existing reuse initiatives and consideration of the possibility of establishing a common framework for the establishment of social education/repair centers.
  - compilation of a specific list of incoming waste.
  - connection of green centers with waste treatment structures.
  - separation and sorting of incoming waste with a focus on re-use and hazardous waste.
- Promotion of use of waste as secondary fuel in industry.
- Management, utilization and reuse of waste products. The action concerns the use or redistribution of products, such as clothes, furniture, appliances, etc., which are no longer useful to citizens or families, to other people for whom it may be necessary. PSTE developed this initiative: collecting everyday items/ products that are unnecessary for some and can be used by needy or low-income citizens.
- Promoting citizens' information, education and awareness, with the aim of forming a new consumer culture oriented more towards the use than the acquisition of goods, the interest in energy efficiency and the life span of products, as well as the use of innovative consumer applications.

### Examples of good practices of circularity development in Sterea Ellada

The Material Reuse Center (MRC) is a facility of the Integrated Waste Management System (IWMS) of PSTE that aims to prevent the production of waste and its reuse. It is a space where there is attendance and interaction of citizens, in order to prevent the production of waste through the exchange of objects and to give these objects a second chance to be reused. Citizens give and receive books, household items, clothes, shoes, furniture, rugs, toys and similar items.

MRC has, among other things, an informative and educational role. Also, various events for the exchange of materials, themed celebrations/bazaars of materials to be reused should be organized in these areas.

In the context of the operation of MRC, the Waste Management Company of the Region of Central Greece has started cooperation with social and solidarity economy bodies, with local educational institutions as well as with the Social Structures of the Municipalities (such as Welfare and Help at Home).



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The Circular Economy Park (Figure 57) is developed in an area of 270 hectares and consists of existing facilities to be modernized as well as new infrastructures, on the one hand greenery, walking, recreation and on the other reuse, sorting at the source, recycling, and recovery of solid waste, research-innovation and energy efficiency.
The master plan drawn up by the Unified Association of Waste Management of the Region of Central Greece foresees the implementation of the park gradually in discrete projects which, in their full development, are expected to create 250 new jobs in 2025, while it will be open and accessible to citizens, schools, educational institutions and productive bodies, thus combining sound circular environmental management with information, education, innovation as well as recreation.

*Figure 57: Circular Economy Park*

## 8.4. North Region, Portugal

The North Region of Portugal concentrates almost 35% of the resident population of Portugal, with 3.6 million inhabitants. It is the region responsible for 39% of the national exportation and represents around 29% of the GDP of the national economy. In administrative terms, the North of Portugal is made up of 86 municipalities and 1 426 parishes. Municipalities are organized into eight Inter-Municipal Communities (CIM), which constitute NUTS III.

The Northern Regional Coordination and Development Commission (CCDR-N) is the agency that coordinates environmental policies, land use planning, cities and global development in this region, supporting local governments and associations. In 2019 CCDR-N promoted a study about the regional metabolism, which presented an in-depth characterization of the region´s metabolism, adopting a breakdown at the level of its NUTS III sub-regions. The study integrates a territorial framing presentation and productive specialization of the region, as well as the analysis of the direct entry of materials and their internal consumption.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Following an innovative methodological approach, the results of this study contributed to the deepening knowledge about the resource consumption in the North of Portugal. It supported the application of more effectively public policies, as well as in the focus of economically attractive opportunities for exploitation by private agents. The eight inter-municipality communities composing the North Region demonstrated a great diversity of existing contexts and patterns of expertise. It contributed to strengthening the performance of public and private agents regarding the consumption management of materials and waste, especially due to the great diversity of activities performed in the region. In contrast, the existence of clusters of activities concentrated in the territory allows the development of efficient logistics solutions in the management of waste and by-products, as well as the exploration of opportunities for symbiosis industries. Hence, allowing to reduce the direct entry of materials into some territories of the North region and providing a better use of the non-productive consumption of resources by the companies.

The construction sector and extractive industries are those showing a greater amount of non-productive consumption of materials. This is mainly due to the type of materials used. Although, the food and beverages, and the wood and cork industries also present a high degree of consumption of non-productive materials. Deepening the management of specific flows of sectorial waste and its effective control must be a priority for the region. However, the significant consumption of materials by the final consumption also requires the prioritization of (in) training and awareness of the final consumer. Especially concerning the increasing of the selectivity in the generation and collection of waste. Due to the strong relevance of the main industries generating non-productive consumption, which lead to higher consumption per inhabitant, practices of circularity and increase of material productivity should be fostered in the North Region.

Around 36% of material resources consumed in the North Region are absorbed by companies as non-productive consumption (i.e., consumed materials that do not result directly on products, including stocks accumulated in the year of analysis, but also accumulated waste). These values are a mirror of the current standard of regional metabolism, showing the way to go in terms of efficiency in the use of resources, potential for symbioses industries and deepening of the Circular Economy.

The resource productivity (economic value per consumed resource unit) in the different sub-regions varies. The high consumption of materials per inhabitant or per worker, associated with the manufacturing industries, nor always results in a high weight in the volume of business, depending largely on the value added to manufactured goods. In addition to the cost implications, this fact also affects environmental issues, as far as products with lower added value, but which involve large amounts of material (e.g., metallic works) demand more from the environment and ecosystems per unit of value economical obtained than products with



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greater added value (e.g., machines or vehicles automobiles). Thus, moving up the value chain can, under certain circumstances and standards of production, have an environmental value.

The Norte Smart Specialization Strategy (NORTE S3) constitutes an ex-ante conditionality of the Program NORTE2030, as a basis for prioritizing research and innovation investments under cohesion policy and has been taken as an enabling condition in the 2021-2027 programming period. The NORTE S3 is currently being revised, based on a democratic and participated discussion with a wide range of regional stakeholders. For the programming period 2021-2027, this strategy maintains its focus on the "food and agro-environmental systems" domain (including the agro-industrial industry). CCDR-N has also recently approved the NORTE2030 Strategy. This will be the basis upon which priorities for the North Region have been established for the 2021-2027 programming period. The abovementioned priority of the revised version of the NORTE S3 on agro-food systems is also a priority of the NORTE2030 Strategy.

### Examples of on-line platforms for the development of circularity in North Portugal region

The Materials Repository is a platform that ensures the recovery of materials and leftover components of construction and demolishing/rehabilitation works with reuse potential. It is an innovative tool that looks to gather and centralize the relationships between the materials proprietors and buyers.
http://repositoriodemateriais.pt/

Fibrenamics Green is an international and multidisciplinary platform for the development of innovative products by incorporating and valuing waste from various industries. Fibrenamics Green is being developed by the International Fibrenamics Platform of the University of Minho (Braga, Portugal), in partnership with the Center for the Valorization of Waste, with the main mission of the valorization of waste as a source of value creation for product development through the incorporation of design, engineering and creativity, resulting from university-industry involvement and synergies. It intends to bring together in a common space the various players from the entire value chain of the waste generation and recovery process, enhancing the transfer of interdisciplinary and multisectoral knowledge, in the development of products based on waste, driven by scientific and technological knowledge.
http://green.fibrenamics.com/

Collection, treatment and recovery of by-products is an initiative by SAVINOR UTS, responsible for the collection of by-products from over 250 locations in Portugal and Spain. The service is recognized as a service of public utility by local and community entities. It is



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responsible for the sustainable treatment of these types of by-products, and hundreds of economic units depend on it for their production activities.
https://savinoruts.pt/en/empresa/sustainability_1280/



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

# 9. References


[1] European Parliament, Circular economy: definition, importance and benefits, Eur. Parliam. Website. (2022). https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits.

[2] ISM Waste & Recycling, What is the Waste Hierarchy?, (2022). https://ismwaste.co.uk/help/what-is-the-waste-hierarchy.

[3] D.P. Clemen Rasmussen, Dorte Vigsø, Frank Ackerman, Richard Porter, ReThinking the Waste Hierarchy, Environmen, nvironmental Assessment Institute, Copenhagen, 2005. https://dors.dk/files/media/graphics/Synkron-Library/Publikationer/IMV/2005/waste_hierarchy.pdf.

[4] European Commission, Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, Off. J. Eur. Union. 312/3 (2020) 3–30.

[5] S. Sihvonen, T. Ritola, Conceptualizing ReX for Aggregating End-of-life Strategies in Product Development, Procedia CIRP. 29 (2015) 639–644. https://doi.org/10.1016/j.procir.2015.01.026.

[6] N. van Buren, M. Demmers, R. van der Heijden, F. Witlox, Towards a Circular Economy: The Role of Dutch Logistics Industries and Governments, Sustainability. 8 (2016) 647. https://doi.org/10.3390/su8070647.

[7] European Commission, Guidance on Innovation Procurement, 2021. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:C:2021:267:FULL&from=EN.

[8] PeoplePerHour, The Evolution of the On-Demand Economy, 2015.

[9] E. Kochanska, K. Wozniak, A. Nowaczyk, P.J. Piedade, M.L. de Almeida Lavorato, A.M. Almeida, A.R.C. Morais, R.M. Lukasik, Global Ban on Plastic and What Next? Are Consumers Ready to Replace Plastic with the Second-Generation Bioplastic? Results of the Snowball Sample Consumer Research in China, Western and Eastern Europe, North America and Brazil, Int. J. Environ. Res. Public Health. 19 (2022) 13970. https://doi.org/10.3390/ijerph192113970.

[10] E. Kochańska, R.M. Łukasik, M. Dzikuć, New circular challenges in the development of take-away food packaging in the covid-19 period, Energies. 14 (2021). https://doi.org/10.3390/en14154705.

[11] Petropoulo Georgios, An economic review on the Collaborative Economy, Brussels, Belgium, 2016. https://www.europarl.europa.eu/RegData/etudes/IDAN/2016/595358/IPOL_IDA(2016)595358_EN.pdf.

[12] Frankenfield Jake, Collaborative economy, Investopedia. (2021). https://www.investopedia.com/terms/c/collaborative-economy.asp.

[13] H. Bruyninckx, Summer 2022: Living in a state of multiple crises, Eur. Environ. Agency. (2022). https://www.eea.europa.eu/articles/summer-2022-living-in-a.

[14] H.J. Vaughan Robert, The sharing economy: how will it disrupt your business? Megatrends: the collisions, London, 2014. https://pwc.blogs.com/files/sharing-economy-final_0814.pdf.

[15] Laury Veronique, Collaborative consumtion, (2014).




This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

https://pwc.blogs.com/files/sharing-economy-final_0814.pdf.
[16] J. Hamari, M. Sjöklint, A. Ukkonen, The sharing economy: Why people participate in collaborative consumption, J. Assoc. Inf. Sci. Technol. 67 (2016) 2047–2059. https://doi.org/10.1002/asi.23552.
[17] A. Menor-Campos, M. de los B. García-Moreno, T. López-Guzmán, A. Hidalgo-Fernández, Effects of Collaborative Economy: A Reflection, Soc. Sci. 8 (2019) 142. https://doi.org/10.3390/socsci8050142.
[18] S. Carlin, K. Curran, Cloud Computing Technologies, Int. J. Cloud Comput. Serv. Sci. 1 (2012). https://doi.org/10.11591/closer.v1i2.486.
[19] R. Kurzweil, Technology and the New, Improved You, Wall Str. J. (2014). https://www.wsj.com/articles/technology-and-the-new-improved-you-1..
[20] A. Pluta-Zaremba, A. Szelągowska, Transformation of the economy. Towards era 5.0, in: Econ. Sustain. Transform., Routledge, London, 2021: pp. 12–56. https://doi.org/10.4324/9781003219958-3.
[21] Circular Benchmark Tool Team, The Circular Benchmark Tool, 2023.
[22] Europe Interreg, Replace: REgional PoLicy Actions for Circular Economy, (2023). https://projects2014-2020.interregeurope.eu/replace/.
[23] K. Jugdev, Learning from Lessons Learned: Project Management Research Program, Am. J. Econ. Bus. Adm. 4 (2012) 13–22.
[24] A. Calatayud, J. Mangan, M. Christopher, The self-thinking supply chain, Supply Chain Manag. An Int. J. 24 (2019) 22–38. https://doi.org/10.1108/SCM-03-2018-0136.
[25] S. Iaconesi, O. Persico, Digital urban acupuncture: Human ecosystems and the life of cities in the age of communication, information and knowledge, Springer International Publishing, Cham, 2016. https://doi.org/10.1007/978-3-319-43403-2.
[26] 'The App Economy'No Title, OECD Digit. Econ. Pap. (2013).
[27] D.M. Gidi Navon, David Melman, Moti Nisim, The Role of Network Visibility in the Borderless Enterprise., (2020).
[28] E.H. Klijn, V. Sierra, T. Ysa, E. Berman, J. Edelenbos, D.Y. Chen, The Influence of Trust on Network Performance in Taiwan, Spain, and the Netherlands: A Cross-Country Comparison, Int. Public Manag. J. 19 (2016) 111–139. https://doi.org/10.1080/10967494.2015.1115790.
[29] European Parliament and of the Council of the European Union, Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), 2007. https://inspire.ec.europa.eu/documents/directive-20072ec-european-parliament-and-council-14-march-2007-establishing.
[30] J. Cetl, V., Nunes de Lima, M., Tomas, R., Lutz, M., D'eugenio, J., Nagy, A., & Robbrecht, Summary Report on Status of implementation of the INSPIRE Directive in EU., 2018. https://doi.org/10.2760/143502.
[31] M.A. Lacayo-Emery, Interoperable Workflows for Ecosystem Service Assessments: Applications in Science, Policy, and Education, Universite de Geneve, 2022. https://doi.org/10.5281/zenodo.3470897.
[32] M. Lacayo, D. Rodila, G. Giuliani, A. Lehmann, A framework for ecosystem service assessment using GIS interoperability standards, Comput. Geosci. 154 (2021) 104821. https://doi.org/10.1016/j.cageo.2021.104821.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

[33] G. Cho, J. Crompvoets, The INSPIRE directive: some observations on the legal framework and implementation, Surv. Rev. 51 (2019) 310–317. https://doi.org/10.1080/00396265.2018.1454686.
[34] F. Huang, Data Processing, in: Encycl. Big Data, Springer International Publishing, Cham, 2019: pp. 1–4. https://doi.org/10.1007/978-3-319-32001-4_314-1.
[35] E. Kochańska, Language of benefits for digital sharing of knowledge on the Open Access interactive platform, Acta Innov. (2016) 31–42.
[36] Stefan Nowak, Metodologia badań społecznych, Wydawnictwo PWN, 2011.
[37] D. Frankfort-Nachmias, Chava & Nachmias, Metody badawcze w naukach społecznych, Zysk i S-ka Wydawnictwo, 1996.
[38] Earl Babbie, Badania społeczne w praktyce, Wydawnictwo Naukowe PWN, 2004.
[39] I. Przybysławska, Wywiad swobodny ze standaryzowaną listą poszukiwanych informacji i możliwości jego zastosowania w badaniach socjologicznych, Przegląd Socjol. Sociol. Rev. (1978) 53–68.
[40] S. Kvale, Prowadzenie wywiadów, Wydawnictwo Naukowe PWN, 2010.
[41] J. von Thienen, C. Meinel, C. Nicolai, How design thinking tools help to solve wicked problems, in: Des. Think. Res. Build. Innov. Eco-Systems, Springer International Publishing, Cham, 2014: pp. 97–102. https://doi.org/10.1007/978-3-319-01303-9_7.
[42] G.G.J. Katherine Adams, Komunikacja w grupach, Wydawnictwo Naukowe PWN, 2008.
[43] U. Baer, Gry dyskusyjne: materiały pomocnicze do pracy z grupą, Polskie Stowarzyszenie Pedagogów i Animatorów (2000) Klanza, 2000.
[44] Z. Okraj, Design thinking. Inspiracje dla dydaktyki, DIFIN, 2020.
[45] Howard S. Becker, Triki badawcze w socjologii. Jak w pełni wykorzystać potencjał badań społecznych, Wydawnictwo Naukowe PWN, 2018.
[46] Uwe Flick, Projektowanie badania jakościowego, 2023.
[47] Graham Gibbs, Analizowanie danych jakościowych, Wydawnictwo Naukowe PWN, 2011.
[48] D. Jemielniak, Badania jakościowe Tom 1, Wydawnictwo Naukowe PWN, 2012.
[49] Dariusz Jemielniak, Badania jakościowe Tom 2, Wydawnictwo Naukowe PWN, 2012.
[50] C. Claramunt, Ontologies for geospatial information: Progress and challenges ahead, J. Spat. Inf. Sci. (2020). https://doi.org/10.5311/JOSIS.2020.20.666.
[51] R. Bill, J. Blankenbach, M. Breunig, J.H. Haunert, C. Heipke, S. Herle, H.G. Maas, H. Mayer, L. Meng, F. Rottensteiner, J. Schiewe, M. Sester, U. Sörgel, M. Werner, Geospatial Information Research: State of the Art, Case Studies and Future Perspectives, PFG - J. Photogramm. Remote Sens. Geoinf. Sci. 90 (2022) 349–389. https://doi.org/10.1007/s41064-022-00217-9.
[52] I. Environmental Systems Research Institute, ArcGIS, (2023).
[53] GISCO statistical unit dataset, (2023).
[54] C. Zhang, Ontology for Geospatial Semantic Interoperability, Geogr. Inf. Sci. Technol. Body Knowl. 2019 (2019). https://doi.org/10.22224/gistbok/2019.4.9.
[55] B. Volkers, A Roadmap for Building Circular Value Chains: A Guideline for regional research and identifying synergies, Synergic Circular Economy across European Regions (SCREEN) Project. Deliverable 3.1, n.d.
[56] E. Mossali, M. Diani, M. Colledani, DigiPrime: Digital Platform for Circular Economy in Cross-Sectorial Sustainable Value Networks, in: 8th Annu. Int. Sustain. Places Conf.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Proc., MDPI, Basel Switzerland, 2020: p. 1. https://doi.org/10.3390/proceedings2020065001.
[57] M. Hirschmugl, C. Sobe, C. Khawaja, R. Janssen, L. Traverso, Pan-European Mapping of Underutilized Land for Bioenergy Production, Land. 10 (2021) 102. https://doi.org/10.3390/land10020102.
[58] C. Khawaja, R. Janssen, R. Mergner, D. Rutz, M. Colangeli, L. Traverso, M.M. Morese, M. Hirschmugl, C. Sobe, A. Calera, D. Cifuentes, S. Fabiani, G. Pulighe, T. Pirelli, G. Bonati, O. Tryboi, O. Haidai, R. Köhler, D. Knoche, R. Schlepphorst, P. Gyuris, Viability and Sustainability Assessment of Bioenergy Value Chains on Underutilised Lands in the EU and Ukraine, Energies. 14 (2021) 1566. https://doi.org/10.3390/en14061566.
[59] L. Amenta, A. van Timmeren, Beyond Wastescapes: Towards Circular Landscapes. Addressing the Spatial Dimension of Circularity through the Regeneration of Wastescapes, Sustainability. 10 (2018) 4740. https://doi.org/10.3390/su10124740.
[60] M. Abreu, A. Reis, P. Moura, A.L. Fernando, A. Luís, L. Quental, P. Patinha, F. Gírio, Evaluation of the Potential of Biomass to Energy in Portugal—Conclusions from the CONVERTE Project, Energies. 13 (2020) 937. https://doi.org/10.3390/en13040937.
[61] The European environment – state and outlook 2010, (2010).
[62] P. Manzanares, The role of biorefinering research in the development of a modern bioeconomy, Acta Innov. 37 (2020) 47–56. https://doi.org/10.32933/actainnovations.37.4.
[63] European Bioplastics e.V, EN 13432 CERTIFIED BIOPLASTICS PERFORMANCE IN INDUSTRIAL COMPOSTING, 2015.
[64] P.R. Yaashikaa, P. Senthil Kumar, S. Varjani, Valorization of agro-industrial wastes for biorefinery process and circular bioeconomy: A critical review, Bioresour. Technol. 343 (2022). https://doi.org/10.1016/j.biortech.2021.126126.
[65] Sustainability Report 2021, (2021). https://doi.org/https://www.novamont.com/public/Bilancio di sostenibilit%C3%A0/Novamont_Sustainability Report 2021 (NFS).pdf.
[66] J. Salimon, N. Salih, E. Yousif, Biolubricants: Raw materials, chemical modifications and environmental benefits, Eur. J. Lipid Sci. Technol. 112 (2010) 519–530. https://doi.org/10.1002/ejlt.200900205.
[67] E. de Jong, IEA Bioenergy - Task 42: Biorefineries: adding value to the sustainable utilisation of biomass, Implementing Agreement on Bioenergy, Amsterdam, The Netherlands, 2009.
[68] Mississippi Department of Agriculture and Commerce, Definition of Specialty Crops, (2023).
[69] Eurostat European Union, Circular economy – Overview, (2023).
[70] Eurostat European Union, Circular Economy Monitoring Framework, (2023).
[71] A. Avdiushchenko, P. Zając, Circular Economy Indicators as a Supporting Tool for European Regional Development Policies, Sustainability. 11 (2019) 3025. https://doi.org/10.3390/su11113025.
[72] OECD, The OECD Inventory of Circular Economy indicators, 2021.
[73] European Commission, Fit for 55 revision, (2021).
[74] World Bank Group, State and Trends of Carbon Pricing 2020, Washington, 2020. https://doi.org/10.1596/978-1-4648-1586-7.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

[75] World Bank. 2022. State and Trends of Carbon Pricing 2022. State and Trends of Carbon Pricing, World Bank, Washington DC (USA), 2022.
[76] UNICEF, What is the clean development mechanism?, Www.Cdm.Unfccc.Int. (2023). https://cdm.unfccc.int/about/index.html.
[77] A. Schulte, D. Maga, N. Thonemann, Combining Life Cycle Assessment and Circularity Assessment to Analyze Environmental Impacts of the Medical Remanufacturing of Electrophysiology Catheters, Sustainability. 13 (2021) 898. https://doi.org/10.3390/su13020898.
[78] A. Torresan, MAKE IT CIRCULAR. The results of the CIRCE2020 project, 2020. https://drive.google.com/file/d/1nI4biApCbpg1dT9XVjxVCRd7bOUOOBXK/view.
[79] K. Joachimiak-Lechman, D. Garstecki, M. Konopczyński, A. Lewandowska, Implementation of Life Cycle Based Tools in the Circular Economy Context—Case Study of Plastic Waste, Sustainability. 12 (2020) 9938. https://doi.org/10.3390/su12239938.
[80] Ellen MacArthur Foundation, Life Cycle Assessment for the circular economy, (2023). https://ellenmacarthurfoundation.org/life-cycle-assessment-for-the-circular-economy.
[81] A.C.M. Pontes, A. T.; Angelo, Use of life cycle assessment in the context of circular economy: a literature review, Syst. Manag. 14 (2019) 424–434. file:///C:/Users/inspiron 15/Downloads/1576-Article Text-10316-1-10-20200125-1.pdf.
[82] L. Sokka, S. Lehtoranta, A. Nissinen, M. Melanen, Analyzing the Environmental Benefits of Industrial Symbiosis, J. Ind. Ecol. 15 (2011) 137–155. https://doi.org/10.1111/j.1530-9290.2010.00276.x.
[83] The Circle Economy, The Circularity Gap Report 2023, Amsterdam, 2023. https://assets.website-files.com/5e185aa4d27bcf348400ed82/63ecb3ad94e12d3e5599cf54_CGR 2023 - Report.pdf.
[84] J. Schmidt, K., Bundgaard, A., Hirsbak, S., Rocha, C. S., Camocho, D., & Alexandre, Introduction to the circular economy, LNEG - Laboratório Nacional de Energia e Geologia, I.P., Lisbon, 2020. https://ecology.at/files/pr889_2.pdf.
[85] European Environment Agency, Circular by design: Products in the circular economy., 2017. https://www.eea.europa.eu/publications/circular-by-design.
[86] British Standards Institute, Framework for implementing the principles of the circular economy in organizations, 2017.
[87] Board of Innovation, Circular Economy business models, Www.Boardofinnovation.Com. (2022). https://www.boardofinnovation.com/circular-economy-business-models-explained/ (accessed 27 February 2023).
[88] the International Organization for Standardization, ISO/DIS 59020 Circular economy — Measuring and assessing circularity, (n.d.).
[89] D.J. Watts, Networks, Dynamics, and the Small-World Phenomenon, Am. J. Sociol. 105 (1999) 493–527. https://doi.org/10.1086/210318.
[90] Mark S. Granovetter, The Strenth of Weak Ties, Am. J. Sociol. 78 (1973) 1360–1380. https://snap.stanford.edu/class/cs224w-readings/granovetter73weakties.pdf.
[91] R.S. Burt, Structural Holes and Good Ideas, Am. J. Sociol. 110 (2004) 349–399. https://doi.org/10.1086/421787.
[92] E.L. Lingo, S. O'Mahony, Nexus Work: Brokerage on Creative Projects, Adm. Sci. Q. 55 (2010) 47–81. https://doi.org/10.2189/asqu.2010.55.1.47.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

[93] J. Howells, Intermediation and the role of intermediaries in innovation, Res. Policy. 35 (2006) 715–728. https://doi.org/10.1016/j.respol.2006.03.005.
[94] P.D. Gluckman, A. Bardsley, M. Kaiser, Brokerage at the science–policy interface: from conceptual framework to practical guidance, Humanit. Soc. Sci. Commun. 8 (2021) 84. https://doi.org/10.1057/s41599-021-00756-3.
[95] Eurostat, Guidance on classification of waste according to EWC-Stat categories, 2010. https://ec.europa.eu/eurostat/documents/342366/351806/Guidance-on-EWCStat-categories-2010.pdf/0e7cd3fc-c05c-47a7-818f-1c2421e55604.
[96] Obwieszczenie Marszałka Sejmu Rzeczypospolitej Polskiej z dnia 3 marca 2022 r. w sprawie ogłoszenia jednolitego tekstu ustawy o odpadach, (2022).
[97] Klasyfikacja PKD - podstawowe informacje, (2022).
[98] European Commission, Council Regulation (EEC) No 2658/87 of 23 July 1987 on the tariff and statistical nomenclature and on the Common Customs Tariff, (1987).
[99] Strategia Rozwoju Województwa Łódzkiego 2030, 2020.
[100] Take Care Off, The path to health looks different for everyone, (2023). https://www.takecareof.com/articles.
[101] S. van Odijk, Marjan Minnesma, Christiaan Kuipers, Gerard Roemers, circulair Fryslân, 2015.



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# 10. List of Figures





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# 11. List of Tables





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