REPAiR

REsource Management in Peri-urban AReas: Going Beyond Urban Metabolism

D.5.6. Eco-innovative solutions Łódź

Version 2.0

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Publishable Summary

The Deliverable D5.6 “Eco-innovative solutions Łódź” presents a catalogue of Eco-Innovative Solutions (EIS) which aims to transform material and territorial waste into resources. More specifically, EIS aim to prevent the generation of waste, within the contexts of the Łódź Metropolitan Area, one of the four follow-up cases of REPAiR.

Each of the EIS has been developed based on the research explored within Łódź pilot Peri-Urban Living Lab (PULL), following the five-step methodology, which includes the phases: Co-Exploring, Co-Design, Co-Production, Co-Decision, Co-Governance. This methodology is further explained in the Deliverable 5.4 “Handbook: how to run a PULL”.

This report presents a catalogue divided into EIS developed during the Łódź PULL and EIS from literature or practice.

Most of the presented solutions are characterized by a relatively basic principle of the idea of a circular economy. These are not very complex and sophisticated ideas, but rather specific actions, due to the level of development of the idea of circular economy in Poland, which is in its initial phase. Therefore, all kinds of ideas that are applicable in Western European countries will be difficult for immediate implementation in Poland.

1. Introduction

The Deliverable D5.6 "Eco-innovative solutions Łódź" presents a catalogue of Eco-Innovative Solutions (EIS) which aim to transform material and territorial waste into resources. More specifically, EIS aim to prevent the generation of waste, within the contexts of the Łódź Metropolitan Area, one of the four follow-up cases of REPAiR.

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For an effective identification of challenges and objectives towards the definition of preferred, feasible and transferable EIS, a challenge-tree based methodology for defining the EIS was developed by the WP5 team in collaboration with WP6 and WP7.

In collaboration with WP3, the focus area was identified. Within WP3, wastescapes have been identified and mapped (see more details in Deliverable 3.5). The specific target locations for developing EIS were defined as enabling contexts or possibility context. The enabling contexts were produced, combining several layers of spatial, socio-economic and material flow information in an interactive and discursive process by the consortium members. Therefore, these contexts are sensitive to different actors and interests in the territory, and their meaning depends greatly on the precision with which data was processed, maps were generated, and perspectives of stakeholders and experts were employed.

2. Eco-innovative solutions: definition and research methodology

2.1 EIS definition

This deliverable assumes the same definition of Eco-innovative solution presented within the catalogues of eco-innovative solutions for PULL Amsterdam (see Deliverable 5.2) and Naples (Deliverable 5.3).

The awareness to move towards circularity has raised the necessity to change and renew existing technological production and socio-political, environmental and economic behavioural patterns. At best, such awareness may produce different types of responses, the so-called solutions and strategies, to make the shift towards circularity. This consciousness for change has led to increasing application of the term 'eco-innovation' in environmental, technological, economic management, urban planning and policymaking. Many kinds of innovation can be defined as eco-innovations. This raises the importance of a common understanding across the different disciplines and roles involved in REPAiR on what eco-innovation and eco-innovative solutions exactly mean.

In literature, several attempts have been made to define eco-innovation. However, a common understanding is still missing (Kiefer et al. 2017; Carillo-Hermosilla, Könnölä 2010). As stated in the REPAiR Deliverable 5.4 (REPAiR 2018a), the definition included in the Eco-Innovation Action Plan of 2011 is shared between the different partners of REPAiR.

"*Eco-innovation refers to all forms of innovation – technological and non-technological – that create business opportunities and benefit the environment by preventing or reducing their impact, or by optimizing the use of resources. Eco-innovation is closely linked to the way we use our natural resources, to how we produce and consume and also to the concepts of eco-efficiency and eco-industries. It encourages a shift among manufacturing firms from "end-of-pipe" solutions to "closed-loop" approaches that minimize material and energy flows by changing products and production methods – bringing a competitive advantage across many businesses and sectors*" [EC 2011].

Moreover, the Horizon 2020 REPAiR call "WASTE-6a-2015" stated that eco-innovative solutions are:

"*demonstration, at an appropriate pilot scale, and market replication, of integrated eco-innovative cost and energy-efficient TECHNOLOGIES, PROCESSES and/or SERVICES for waste prevention, treatment, enhanced collection, recycling and recovery of high- grade valuable materials from waste.*"

The REPAiR team, with the support of the user board members, aims at developing Eco-Innovative Solutions (EIS) and integrate them into systemic and territorial Eco-Innovative Strategies. Eco-Innovative Strategies and Solutions can be defined as follows:

Eco-Innovative Strategy is an alternative course of action aimed at addressing both the objectives and challenges identified within a PULL and develop a more Circular Economy in peri-urban areas (REPAiR 2018a, p.10).

The Strategy can be composed of a systemic integration of two or more actions, namely EIS. According to the REPAiR Grant Agreement 688920, the "*Eco-innovative solutions developed will improve the capacity of urban environments to deal with future resource management challenges, while triggering positive transformations in spatial qualities, sustainability and urban metabolism. These shifts will together enhance the quality of life*" (EC 2016, p.157).

EIS will encompass decisions on the following aspects:

- Development and implementation of new materials, technologies or processes in connection with initiation of sustainable economic activities, or adding new activities in value chains with the modification of the status of the current waste management systems, and the resource flows, also capable of modifying the spatial configuration of peri-urban areas (also from an environmental perspective);
- Modification of existing policies and governance, or new policy/governance development;
- Definition of spatial and environmental design proposals.

These solutions will potentially lead to the modification of existing flows of materials, development of new flows and processes and/or change in the spatial design of areas, and will generate change in the behaviour of stakeholders and inhabitants in the case study areas.

REPAiR's attempt to conceptualize solutions towards eco-innovation arises through a systemic process that refers to the interconnectedness and dynamic interaction between different actors, waste flows, policy and governance factors influencing the innovation process in the built environment. These premises invite us to explore the wide array of eco-innovations and to examine the occurred changes in several dimensions of eco-innovations. In other words, EIS are creative and smart ideas aimed to innovate and improve a specific and fixed process in relation to the management of waste and wastescapes as a resource (Figure 2).

More specifically, EIS:

- Are elementary responses to case-specific problems, in a contextual approach towards innovation, where real innovation is the process to achieve the result. EIS derives from situated case-specific problems, but their final configuration is such that they can be used all over the cases. Their transferability is obtained by abstracting how they function, trimming their structure from site-specific features. For example, in the MAN one example can be the EIS referred to the hemp plantations that can be used for the remediation of polluted soils. More generally, hemp has to be intended as a "traditional cultivation" to be defined, case by case;
- Depend on local/regional/national policies/resources (managerial, economic/financial, administrative capacity, etc.);
- Are the result of a co-creation process implemented in the PULL environments, which means that their content depends on the needs of multiple stakeholders involved in the PULLs;
- Cross various scales, different dimensions, characteristics and densities of the peri-urban territories investigated;
- Assure reciprocities between the natural and the built environment (EC 2016, p.153). EIS are not just changes in current technologies, but also process innovations (Dente and Coletti, 2011) "contributing to the EU's ambition of a paradigm shift towards Circular Economy and a near-zero waste society" (EC 2016, p.153);
- Are based on the key environmental principle "Reduce-Reuse-Recycle-Recover".

Furthermore, through EIS, a new level of creativity is reached. Such creativity is needed to face the crisis of waste management and resource scarcity in the context of transition to circular economy as well as the problems related to the process of regenerating wastescapes.

To facilitate application and testing the EIS in the GDSE, EIS are classified according to the PESTEL framework following the dimensions that they can take, as:

- Political/organizational (P),

- Economic (E),
- Social (S),
- Technical (T),
- Environmental (E),
- and Legal (L).

2.2 EIS – research methodology

The first four PULL meetings (Peri-Urban Living Labs) were organized in Łódź at the premises of Łódź Regional Development Agency (ŁARR) and this seems the most neutral place for future gatherings. Participants represented different institutions: municipality, waste management, universities, research and consulting institutions, national/regional government and the REPAiR-team.

EVENT TYPE	DATE	N. OF PARTICIPANTS	DURATION
1st PULL meeting	01.02.2017	18	4h
2nd PULL meeting	14.05.2018	27	5h
3rd PULL meeting	27.11.2018	23	5h
4th PULL meeting	17.05.2019	15	4h

Identification of potential participants for the PULL meetings was initiated once the REPAiR project commenced - several target groups were recognized at that time, characterized by necessary knowledge and tools for implementing developed solutions. The basic groups of participants included: representatives of local and regional self-government institutions, waste collection companies, non-governmental organizations (NGO's), academia and research communities as well as environmental agencies. At the preliminary stage, about 40 institutions were selected. At the subsequent phase of the project, the contact database was enriched by means of face-to-face conversations, suggestions made by individuals with whom in-depth interviews were conducted, participation in important regional events (e.g. the European Economic Forum Łódzkie 2017 or European Bioeconomy Congress Łódź 2017) and promotion of the REPAiR project in the region. A crucial role in this activity was played by the Pheno Horizon company, who has established contacts with local stakeholders of diverse fields prior to project commencement. Selection of individuals invited to the meetings results directly from their interest in the subject considered within the REPAiR project. In both cases, the meeting participants were invited by sending traditional postal letters, e-mails (double reminder) and by phone.

During the first PULL meeting, there was a discussion on the main problems in the field of waste management in the Łódź Agglomeration. The discussion was carried out in a manner that allowed all participants to contribute, not only the most active ones. As a result, a collection of over 30 examples of problems and challenges related to waste

management in the Łódź Agglomeration was successfully compiled. At the end of the workshop, the discussed issues were grouped into five main blocks - (1) Social Attitudes, (2) Spatial Planning, (3) Technology, (4) Legislation, and (5) Finance. At the subsequent stage of the meeting, each participant received five voting cards and could freely distribute them within a given category – beginning with the most egalitarian variant (sticking one voting card to each of the five thematic blocks) to the most elite option (giving all votes to one category). Due to the fact that prioritization of problems and challenges took place within the framework of the same workshops as their collection, it was not possible to rank individual challenges and thus the organizers decided to indicate groups of problems. A group of specific issues was to be selected for the next PULL meeting with intention of in-depth evaluation. Problems and challenges identified by the meeting's participants within the five main groups are listed below.

Group of problems and challenges "Social Attitudes" - 37 votes

- Low social awareness, including decision-makers regarding the need to support waste management processes;
- Lack of social acceptance for local-use solutions, for instance concerning the construction of micro-incineration plants;
- Often the constraint is the lack of acceptance for the necessity of incurring the costs of the waste collection since they potentially are a valuable resource - for further commercial use;
- There have been registered numerous illegal incinerations of household waste;
- There is still a problem of attitude towards waste segregation (as a challenge) in contrast to the societies of Western Europe, where waste segregation has become a standard;
- It is necessary to conduct educational, pro-environmental activities;
- Lack of social courage to counteract undesirable behavior;

Group of problems and challenges "Finance" - 22 votes

- Limited financing possibility for waste management processes implementation;
- Lack of business models allowing for improving waste management processes;
- It is necessary to enforce new economic approach towards waste - as an actual resource that can be re-used for the production of goods;
- Inappropriate use of waste management funds (e.g. too low product subsidies) - business models to be verified;

Group of problems and challenges "Legislation" - 17 votes

- Lack of reliable analyzes/simulations regarding actual needs in terms of providing waste management infrastructure;
- Lack of responsibility in terms of organic waste management;
- Lack of possibility for rational sewage sludge management;
- Existing legislative solutions in the field of environmental protection, maintaining cleanliness and waste management are not respected;
- Unregulated legal conditions affecting difficulties regarding arranging space for activities related to waste management;

- Lack of effective control methods for processes being conducted;
- Lack of a well-functioning, effective flow monitoring system (this system should consider large-scale processes);
- Lack of transparent waste management system in the Łódź Agglomeration (division into sub-regions); the Agglomeration does not have a dedicated Regional Municipal Waste Treatment Plant (so-called RIPOK)

Group of problems and challenges "Spatial Planning" - 15 votes

- The problem lies in the lack of ensuring the development of infrastructure related to waste management in the planning documents (areas explicitly indicated for the location of facilities such as waste sorting plant accepted by local community have not been included);
- The process of suburbanization in the Łódź Agglomeration significantly affects the increase of costs related to waste management (e.g. costs of waste collection) which is a factor hampering the functioning of enterprises in this sector;
- The problem in the Łódź Agglomeration - especially in areas of high environmental assets - are the effects of "dispersed tourism" – significant pollution of green areas (e.g. landscape parks). Illegal waste often becomes a deadly trap for wild animals living in the area;
- Dramatic contamination of waters (e.g. retention reservoirs) resulting from the uncontrolled location of zoonotic (animal) waste;
- Pollution of river valleys – resulting from agricultural activity in the region;
- In the areas of downtown development (Łódź inner-city) or central parts of small towns - difficulties in finding sufficient space for collecting waste;

Group of problems and challenges "Technology" - 11 votes

- Individual studies on processes related to the management of municipal and industrial waste should be considered;
- Lack of technological lines allowing for improvement of waste management processes;
- Not entirely harnessed opportunities resulting from energetic potential of waste – in these cases regulations at the state level are required (use of waste in the energy sector);
- The use of central heating systems by the means of waste incineration processes is worth considering;
- An attempt must be made to enforce the method of controlled waste incineration, thus avoiding the cases of "uncontrolled fires";
- There is a need to limit the use and thus the production of non-recyclable materials (e.g. certain types of plastics);
- Lack of commercial biogas plants that could contribute to solving the problem of organic waste management;
- Post-production waste problem related to zoonotic waste.

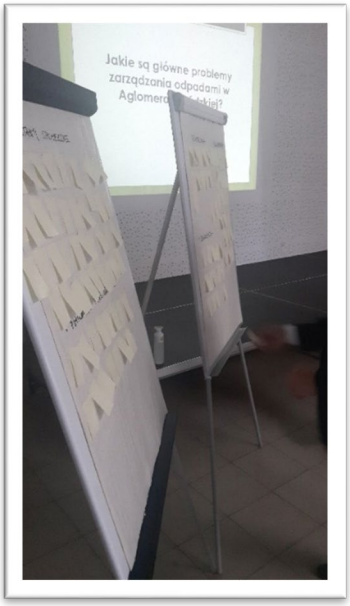


Photo 1-3: Participants during the PULL workshop. Source: PHH, IGiPZ PAN

During the 2nd PULL Meeting, more than thirty problems and challenges in the field of waste management in the Łódź Agglomeration were identified. Subsequently, these were divided into five main groups, which were subjected to voting and ranking by the workshop participants. As decided by gathered stakeholders, the largest number of votes was assigned to problems and challenges within the groups "Social Attitudes" and "Finance". Workshop participants were randomly divided in half, sat at tables and discussed problems and challenges from these two groups attempting to find solutions to them. A set of "eco-innovative cards" was given to each group that participants or the moderator could fill in. Due to the common consent for concentrating research efforts upon municipal solid waste, individual types of waste were not discussed. Instead, participants focused on the two most important groups of indicated problems and challenges. This part of the PULL workshop ended with a gathering in a dozen or so ideas:

- Establishing a financial system in which fees for waste disposal are directed to the general budget;
- Simplification of actions related to the recycling process, then gradual expansion in this field;
- Conducting educational activities among the youth;
- Applying subsidies to products using re-used resources;
- Waste co-incineration;
- Increasing the use of recovered resources;
- Extension of product warranty;
- Establishing a flexible waste collection system (giving away waste by phone);
- Allowing re-use of objects (e.g. clothing) in a systemic manner;
- Establishing a system of returning packaging at points of purchase - "bottle return machines" rewarding with the issuance of a lottery ticket (attractive prize randomly, for example, once a year - a car);
- Developing socially accepted methods of informing on improper behaviour regarding handling of raw materials (e.g. acceptance for informing the services about illegal landfills);
- Pointing out the benefits of selective collection - rewarding local communities for desired attitudes (e.g. awarding them in the form of an attractive development of common space);
- Implementing energy and waste management system in the city with significant public participation (including the use of online tools);
- Establishing a system-based solution for the education of children, thus developing desired habits in future adults, indirect involvement of whole families;
- Change of legislative conditions and attitude of individuals responsible for planning documents, basing decisions upon balance sheets and forecasts of needs in the field of waste management infrastructure, obligation to appoint places of infrastructure related to waste management;
- Dissemination of the idea related to waste incineration, construction of incinerators in commune's areas
- Raising the level of social awareness regarding the possibilities of waste management.

Detailed identification of Eco-Innovative solutions appropriate for the Łódź Metropolitan Area was carried out basing on discussion during the 3rd and 4th PULL Meetings as well as subject literature overview along with selection of best practices from Poland.

3. Catalogue of Eco-Innovative Solutions

3.1 UBER WASTE: Proposal for an eco-innovative solution in the circular economy of green municipal waste

Source: based upon internal REPAiR team and PULL stakeholders discussion
Type of waste: biodegradable

According to art. 3 par. 3 point 8b of the Waste Act of 2012, green waste, encoded 20 02 01, is defined as "*municipal waste being part of plants from the care of green areas and marketplaces, with the exception of waste coming from cleaning streets and squares*". Therefore, municipal green waste, with the code 20 02 01, is "*waste generated as a result of care and cultivation of public and private green areas and selectively collected plant waste from marketplaces, cemeteries, parks, public gardens*".
It is worth noting that such a defined group of waste is to a certain extent specific. In the case of green waste, it is relatively easy to re-introduce it to the circular waste management within individual households. There is only a necessity to meet a simple requirement that such a household has the basic equipment capability and the need to use such waste by composting and fertilizing the soil, for example in home gardens. Considering conditions of a typical single-family housing, which prevails in the vicinity of Łódź, as well as relatively common low-scale self-supply agricultural production, these conditions are met by a significant part of households. Although in this case, the Act on maintaining cleanliness and order in municipalities allows for the possibility of managing green waste coming from the household on its own. Individuals that do not possess such a need or possibility are obliged to transfer it to the Regional Municipal Waste Treatment Plant (RIPOK). Therefore, there is a potential for recycling this waste as part of a circular economy and transferring it using currently functioning transport system as a compostable resource to be used by households. The key element needed to achieve the desired effect is the efficient management regarding the flow of current information on the existing demand in individual households for the collection and delivery of green waste.

The technology used to optimize on-line logistics (the so-called rideshare technology) has already been implemented in for instance "car-sharing" on-line application. Moreover, specific solutions employing this innovative type of waste management have been developed. The example is the RTS (Recycle Track Systems) commonly known as "uber for trash" initiated by the CNBC company. This technology, introduced in 2014 by Greg Lettieri and Adam Pasquale as a *start-up* company, enables the flow of on-line information between waste-generating firms and independent carriers dealing with its collection and transport to recycling, utilization or storage sites. Initially, this invention was used to optimize management of waste generated by registered companies from around New

York by a common fleet of trucks. In June 2017, the company owning and developing this technology was registered, with initial capital of USD 11.7 million. The company's ideology strongly focused on pro-environmental objectives. Currently, agricultural holdings are common in this system, playing an important role, as they take away certain waste fractions for processing into fertilizer or purification and recycling for their own use. However, the company specializes in transportation of food waste, serving the network of restaurants, schools, hotels, stadiums and retail establishment, particularly large-format stores, in New York, Washington, Philadelphia, Baltimore and Chicago.

The benefits of implementing the proposed solution can be considered with respect to three various aspects: individual, ecological and legal-administrative. As regards the first element, the advantage seems obvious. Individual households can avoid bearing part of the cost as the green waste fraction collected from them does not have to be stored. However, taking over waste from a given individual, and even the readiness of the company serving the area to receive it, as well as possible transport are associated with certain costs. On the other hand, there are some savings related to the shortening of average transport distance of such waste as well as reducing demand for space in vehicles transporting waste, which might enable lowering the frequency of courses on selected routes. Probably, the greatest savings in the costs of waste collection result from reduction of demand for storage area.

The fundamental element constituting the idea of a circular economy is a holistic approach towards all generated expenses, including those related to the impact exerted upon the natural environment. Therefore, the aforementioned savings resulting from the reduction of waste transport costs have in fact a considerably broader dimension. Waste management may be also considered from a holistic and global point of view, going far beyond the mere flow of green waste fractions taking place at the local or regional scale. At least two basic ecological benefits resulting from the application of the described solution are apparent. First of all, a significant advantage is the reduction of pollutant emissions generated by transport of waste and its negative impact on the natural environment. Secondly, a detailed registration by electronic devices of the sources of individual waste fractions, including their location, emission intensity, its cyclicality over time, allows to better adjust, increase the purposefulness and effectiveness of lectures, trainings and workshops organized by experts in the field of environmental protection for the staff responsible for waste management in individual companies.

Drop-off places can be both – private owners that don't produce enough compost and need more or organized public places supervised by local self-government or NGO. Costs of the activity is shared by self-government and owners registered in the system.

Possible benefits of legal and administrative nature related to implementing this EIS seem to be the most complex. In general, considering provisions of the currently binding legal acts, the introduction of the proposed solution should foster accomplishing objectives in the field of green waste circular economy. This lies within responsibility of both local and central government. According to the Act on maintaining cleanliness and order in the commune, local authorities are obliged to limit - by July 16, 2020 - the weight of biodegradable municipal waste transferred to storage to a level not exceeding 35% of

the total mass of this type of waste disposed in 1995. This provision is challenging primarily due to the fact that a stable historical reference level has been adopted. Therefore, composting municipal green waste by individual households does not contribute to improving commune's indicators if such waste has not been previously transferred to storage. In fact, increasing composting of municipal green waste often does not enhance reduction of selective waste collection. Undoubtedly, composting of green waste that is currently subject to separate collection is much more effective considering improving mentioned indicators and achieving the assumed goals. The proposed solution certainly fosters accomplishing desired figures related to waste management.

3.2 Relooping Fashion Initiative – a model of circular economy in textiles

Source: based on best practice from Finland. Łódź is a Polish centre of fashion. Development of this city was based on textile industry starting from the second half of the 19th century until 1990s.

Type of waste: textile

Background

For a number of years, Łódź had been the most important textile industry centre in Poland. Among the employees of this sector, the number of women massively migrating to the city largely exceeded men. After the collapse of the centrally-planned socialist economic system, the majority of state-owned textile factories in Łódź were liquidated. Only a few entities have remained, although these engage a relatively high share of about 25% of the employed. The clothing and textile industry has also developed in other urban areas of ŁOM. It employs the largest percentage of population working in the industrial sector; depending on the town, it is 11% in Rzgów up to 36% in Zgierz. Nowadays many post-industrial buildings are abandoned.

The average U.S. citizen generates over 90 pounds of textile waste each year. According to Greenpeace, Americans in 2016 bought 60% more items of clothing than 15 years earlier and utilize clothes for a considerably shorter period of time (Cobbing, Yannick, 2016).

From an ecological perspective, the textile industry is considered as one of the most polluting in the world due to the use of harmful chemicals, high consumption of water and energy, generation of large quantities of solid and gaseous waste, huge fuel consumption for transportation and large scale use of non-biodegradable packaging materials (Choudhury, 2014). The majority of textile waste still ends up being incinerated or landfilled (Oakdene Hollins, 2016).

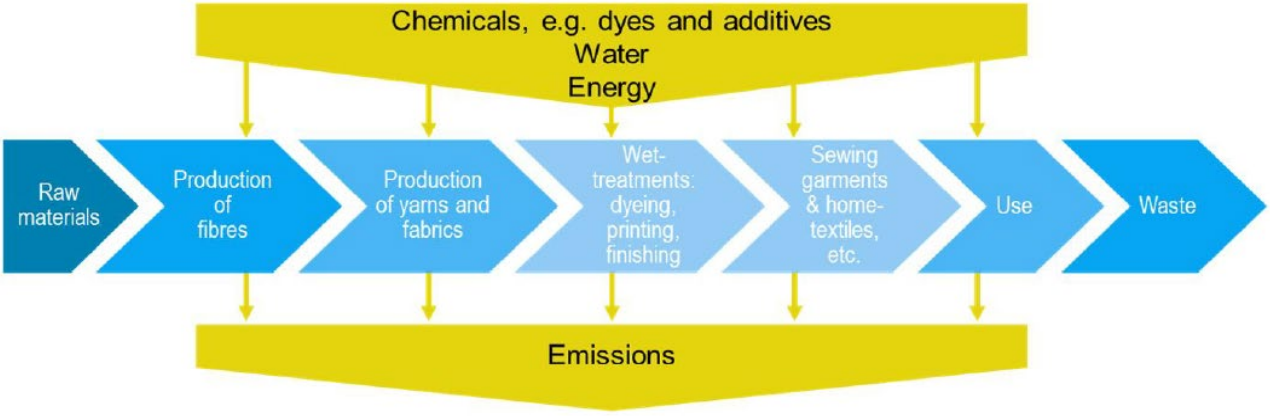


Fig. 1. A simplified linear model for textile production

Source: Choudhury, 2014

Circular business ecosystem for textiles

While considering a circular economy in the context of textiles, it is necessary to examine the possible key material flows, types of actors along the value cycles from end-user back to end-user, or interfaces between the different processes. The circular business ecosystem for textiles aims to keep most post-consumed textile materials in the re-use cycles or recycle them (depending on their quality) instead of textile waste being incinerated or ending up in the landfill. The key objective should be to use recycled textile materials for purposes that regenerate maximum value (Fontell and Heikkilä, 2017).

Basic information on the project

The Relooping Fashion Initiative created a pilot closed-loop model for textiles based on the principles of the circular economy. The objective of the project was to produce business opportunities and shared value for all parties within the chain (Fontell and Heikkilä, 2017). The main themes of the project cover service, production, design, and business.

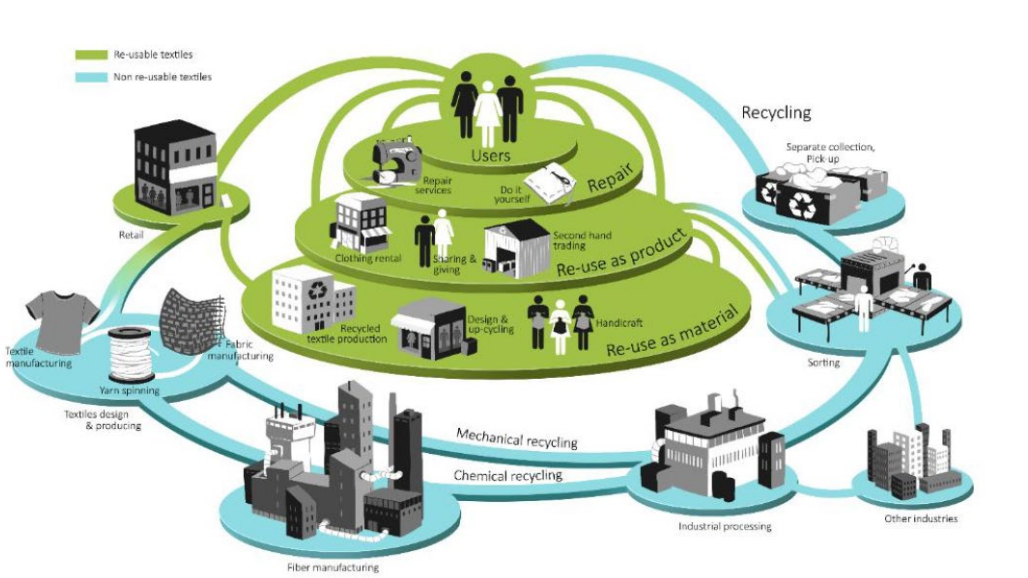
In the pilot research, The Helsinki Metropolitan Area Reuse Centre collected post-consumer textiles from the textile donation feed and sorted out cotton materials not suitable for reuse. The materials were then ground and delivered to the Technical Research Centre (VTT) for processing into new cellulosic fibres. Seppälä's partner role was to design and produce a clothing line using the novel fibres in cooperation with Pure Waste Textiles. Reusable packaging by RePack enabled delivery of new clothes and return of used clothing from the consumer back to the cycle, thus closing the loop. Other project partners included Ethica, Touchpoint and Lindström.

The idea of the circular fashion in this initiative beyond the reuse and return of old garments, is to describe new, high-quality clothes made of chemically recycled post-consumer cotton (Fontell and Heikkilä, 2017). The terms "relooped" and "remanufactured" garments are also used in the literature. The overall goal is to maintain

the high value of materials with minimum environmental impact (www.reloopingfashion.org).

Customer's contribution to the chain

The idea of Relooping Fashion Initiative is to make customers part of the chain. The figure below presents how customers could contribute to the model along the value cycles from end-user back to end-user. The initiative focused on circular material flows by demonstrating closed loop recycling for discarded textiles. The user, including customers and professional textile users, has a central role in creating closed loops.



Source: Fontell and Heikkilä, 2017

Relooping initiative covers the following four (technical) value cycles of a circular economy:

- repair and maintenance,
- re-use as product,
- re-use as material, and
- recycling-related activities, and business models for post-consumer/user textiles along the entire value chain.

Source: Ellen MacArthur Foundation, 2017a

All these processes need to work seamlessly together for the circular business ecosystem to function effectively. The simplified model describes the main material flows from one actor to another along the value chain.

Role of maintenance and repair, re-use as a product, and re-use as material-related functions.

The project presents several strategies aiming at designing for durability. The key motivation of the Relooping Fashion Initiative and related research activities is to recycle or up-cycle this major textile material flow to new higher value products instead of using it for energy generation or disposing it in landfills.

The role of several project's partners in the Relooping Fashion Initiative

- **The Helsinki Metropolitan Area Reuse Centre**

The Centre accepts donations of re-usable clothes, textiles, and other products, which are then either sold at their stores or donated to other collaboration partners or users. The centre raises awareness for more sustainable use of textiles by for example organizing handicraft workshops or producing training materials to recognize good-quality fabrics and learn to maintain the quality with good care. The centre spreads the idea that good quality is a starting point for a successful re-use.

In the Relooping Fashion initiative, the Centre's role was to collect, sort and process discarded textile materials. The Centre also tested and developed the sorting of textile materials (www.kierratyskeskus.fi).

- **Touchpoint**

Touchpoint designs and produces ecological work wear and corporate gifts. Their main idea is to re-use materials which are otherwise obsolete. The company's goal is to use 100% ecological materials by 2020.

Touchpoint participated in the project to find new connections, collaboration partners, and circular business opportunities, as well as to exchange information on the new technologies and solutions related to recycled fabrics (www.touchpoint.fi).

- **Lindström Group**

Lindström offers textile rental services, and its rental work wear is used by over a million people every day. Rental textiles provide a completely waste-free solution for the user, as the responsibility for the ecological footprint of their use and responsible disposal is shouldered by Lindström. The company manufactures textiles only for need. The fabric loss is minimized and the products are designed to be easy to repair and durable in terms of use and maintenance. The garments are also recycled from one user to another until they are ultimately unusable.

Lindström participated in the project to support the development of new technology innovations which enable recycling of worn-out textile waste, which is no-longer suitable for re-use.

Example: The Lindström company supplies Stormie Poodle (another Swedish company) with disposed terry cloth and bedding, which Stormie Poodle then uses to make children's clothes, terry cloth products and linen. Bedding and terry cloth products are used in hotels at the beginning of their life cycle (www.lindstromgroup.com).

- **VTT**

VTT Technical Research Centre of Finland Ltd. is the leading research and technology company in the Nordic countries. VTT has a large role in development of a cellulose carbamate (CCA) technology based recycling method for cotton.

CCA technology enables production of cellulosic man-made fibers with a process similar to viscose, but utilizing chemistry without harmful CS_2 needed for viscose. In cellulose carbamate technology dissolved pulp, which can be obtained from wood, but just as well from used paper, cardboard or cotton textiles, is made soluble to a water-NaOH system using urea. Mechanical properties of fibers are similar to viscose, and thus fibers can be used for a wide range of textile applications from fashion to home textiles and to technical applications (www.vttresearch.fi).

- **Pure Waste Textiles**

Pure Waste Textiles is a Finnish clothing company that produces 100% recycled yarns, fabrics and ready-made garments in India. The company uses pre-consumer textile waste as raw material. The textile waste is collected from nearby factories and comes in the form of cutting clips and spinning waste. After sourcing the materials, it is then sorted by color and quality, and carefully spread apart without weakening the fibers. The cotton is then spun into yarns, and finally turned into a 100% recycled high-quality textile.

In the Relooping Fashion Initiative, Pure Waste Textiles' role is to test the spinning of fibers into yarn and manufacturing of the fabrics and clothing (www.purewaste.org).

- **Seppälä**

Seppälä is a Finnish fashion chain with over 100 stores in Finland. As part of the Relooping Fashion initiative, Seppälä collected over 2600 kg of worn-out textiles from customers at Seppälä stores. The role of the company in the project was also to design the prototypes and a clothing line made of the new fiber, and to test the characteristics and possibilities of the obtained material together with Pure Waste Textiles Ltd (www.seppala.fi).

- **RePack**

RePack is a Finland-based start-up company, which provides reusable packaging options for online retailers and shoppers. The RePack delivery packages can be conveniently and easily returned, and then reused. Shoppers pay a small deposit for the RePack shipping option and get reimbursed after the bag or box finds its way back to the company via any post office around the world. Currently, 70% of the packages are returned for re-use (www.originalrepack.com).

3.3 Composting of waste by individual households

Source: based on best practice from other regions in Poland.

Type of waste: green and kitchen waste

Location of the EIS: certain communes and cities in Poland, i.a.: Wrocław, Pieszyce, Dzierżoniów (Dolnośląskie Voivodship), Sieradz (Łódzkie Voivodship), Legionowo (Mazowieckie Voivodship), Długołęka (Wielkopolskie Voivodship), Bestwina, Bielsko-Biała, Czechowice-Dziedzice (Śląskie Voivodship).

Initiator of the EIS: local authorities

Involved actors: local authorities (self-government) and residents (individual households

Objectives of operating this eco-innovative solution:

- promoting a pro-environmental attitude of residents towards proper management of biodegradable waste, including green waste;
- promoting of waste composting for own needs;
- increasing the amount of biodegradable waste subjected to recovery, and thus reducing the overall mass of municipal waste deposited in a landfill.

Current green waste management

Green waste is all waste generated from plant care (e.g. mowed grass, leaves, small branches, flowers, plant remains, weeds). They are formed from early spring to late autumn.

Green waste is collected from property owners and green areas by specialized waste collection companies, employed by local authorities. Green waste collected in a selective manner is transported to the Regional Municipal Waste Treatment Plant (RIPOK), where the first stage of its recycling is purification (i.a. by tearing and removing plastic bags in which they were stored). Subsequently, waste is subjected to a composting process. This procedure takes place in heaps as a result of oxygen decomposition of biomass, which means that the waste must be periodically flipped over mechanically to ensure adequate oxygenation. As a result of composting, a fertilizer is obtained, which is used for the recovery of damaged areas, urban greenery, forests and parks.

However, a considerable quantity of green waste is not processed nor properly disposed. A large share of green waste is not handed over by residents to mechanical and biological waste treatment installations. In fact, this waste is usually burned by individuals on their own property, contrary to regulations on waste management. Pursuant to Article 30

paragraph 1 of the Act of December 14, 2012, it is forbidden to process waste (including thermal treatment) outside installations.

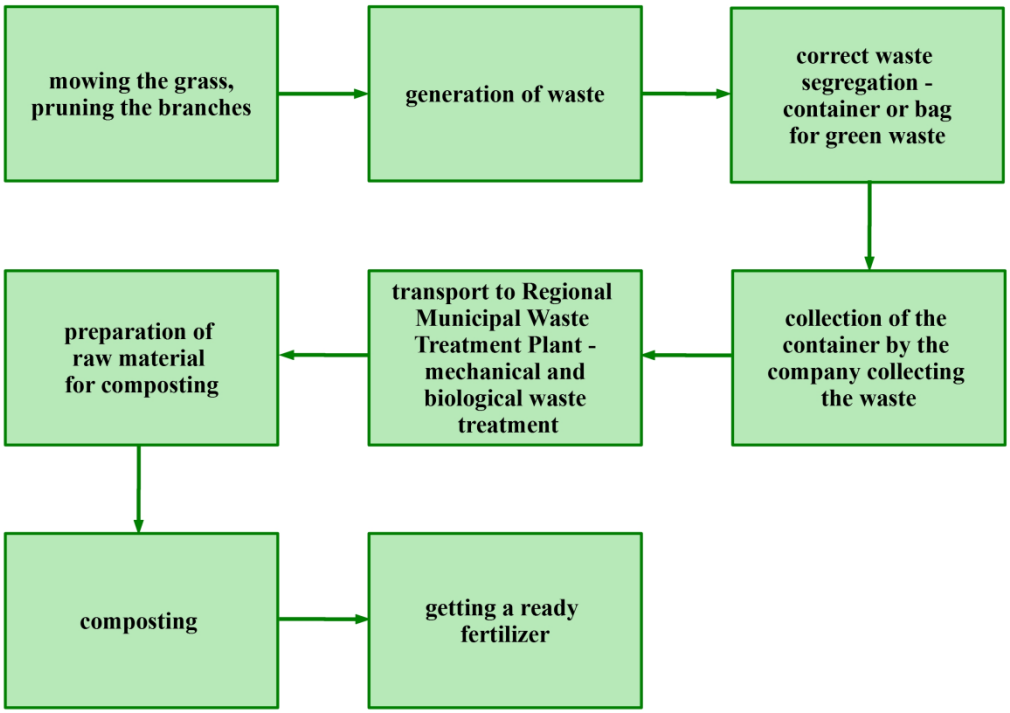


Fig. Current green waste path

Source: own compilation based on: https://lublin.eu/mieszkancy/srodowisko/odpady-i-recykling/recykling-odpadow/odpady-zielone/

Proposed Eco-innovative solution

Green waste is one of the basic waste fractions that is collected from households by dedicated companies. Collection and management of this type of waste generate costs. It is estimated that transportation and treatment of 1 ton of biodegradable waste costs about PLN 400 (about 95€). In order to reduce expense associated with exporting and managing biodegradable waste, as well as increase the mass of waste treated according to pro-environmental regulations being in force, many communes in Poland have implemented a program encouraging residents to manage biodegradable waste (green waste and biodegradable kitchen waste) in their households through composting. For this purpose, local authorities distribute free composters to all interested property owners producing green waste to be used in gardens. The purpose of using composters is to constrain the common habit of spring and autumn burning of plant residues. By providing composters to individual households, local authorities intend to educate residents and promote waste composting for their own needs, while reducing the overall mass of waste. Individuals using home composters are partly exempt from of municipal waste management fees. Individual composting of waste brings numerous benefits.

Tab. Advantages resulting from composting of waste by individual households

	Composting of green waste by residents	**Collecting green waste by the municipality/city**
Costs	Minimal: - marginal work input (filling the composter with green waste)	Considerable: - transport costs - administrative costs - waste disposal fees
Impact on the environment	Positive: - proper composting is a natural process of oxygen decomposition, being neutral and odourless to the environment	Negatywny - transport na znaczne odległości zanieczyszcza powietrze - instalacje do przemysłowego przetwarzania odpadów zielonych szkodzą środowisku Negative: - waste transport over long distances results in air pollution - installations for the industrial processing of green waste harm the environment (possible odor, soil, air and water pollution)
Benefits for the local community	Considerable: - compost can be used in the garden (reduced expense for garden soil and fertilizers) - compost is the only ecological, safe and full-value fertilizer for versatile use	None

Source: https://legionowo.pl/pl/a/kompostowniki

Many communes and towns in Poland have successfully implemented the program of distributing free composters to residents. In some of them (e.g. Wrocław) composting of green waste has been widespread for several years. By observing the good practice, an increasing number of local authorities also intends to reduce the amount of waste transported to waste treatment and implements this program it in its own commune area (e.g. the city of Sieradz).

3.4 Nesting boxes and bird feeders from bulky waste

Source: based on best practice from Kraków (Poland).

Type of waste: large-sized bulky waste

Location of the EIS: Kraków (Małopolskie Voivodship)

Initiator of the EIS: Association of the Joyful Bird Promoters (*Asocjacja Promotorów Radosnego Ptaka*)

Involved actors: Municipal Cleaning Service in Kraków, Association of the Joyful Bird Promoters, Association of Property Managers and Administrators, residents

Objectives of operating this eco-innovative solution:

- recovery of wood obtained from the bulky waste and its use for construction of bird feeders and nesting boxes

Large-sized waste management:

Bulky waste (old furniture, beds, armchairs, sofas, wardrobes) are collected from residents by the Municipal Cleaning Service in Kraków. Some inhabitants deliver this type of waste individually to *Lamusownia* company or the Selective Municipal Waste Collection Point. Subsequently, the waste is transported to a dedicated plant, where it is initially processed and analyzed in terms of type of raw materials from which they are built. Then they are dismantled. Their components are divided into particular fractions of raw materials: metals, plastics, textiles, wood, electronic and electrical elements. After separation, they are transported to the recycler of individual raw materials. Part of them is also used for the production of alternative fuel, because in the vast majority the raw materials of large-size waste has a high energetic value.

The raw material that is recovered in large quantities from bulky waste is wood. It is mostly post-consumer wood, i.e. products and elements made of wood and wood materials that are not suitable for further use, or wood waste resulting from processing and production of wooden products. Both types of wood are subjected to recycling and recovery processes, which is beneficial for the environment, because secondary wood can replace natural wood in a series of production processes, and thus possibly reduce deforestation.

The most valuable elements are selected from collected wood to be immediately reused. Other mixed elements are mechanically grinded and transported to furniture companies that manufacture furniture boards. Fractions that are not suitable for other uses (small parts, wood chips) become part of alternative fuel, which replaces coal in cement plants. The main idea behind such actions is to save raw materials.

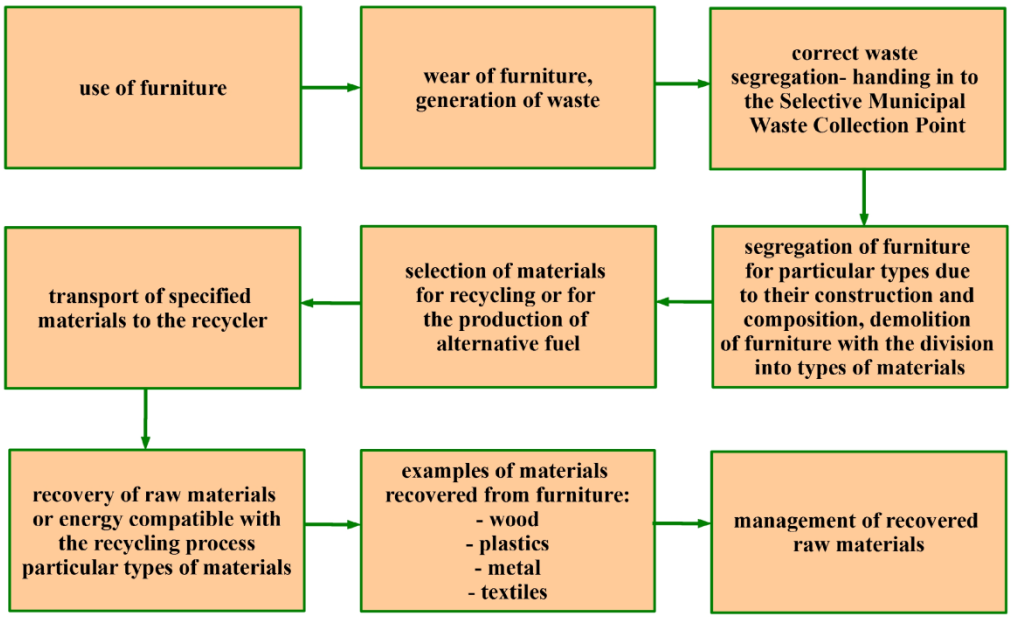


Fig. Path presenting raw materials recovery from large-size waste on the example of furniture

Source: own compilation based on: https://lublin.eu/mieszkancy/srodowisko/odpady-i-recykling/recykling-odpadow/odpady-wielkogabarytowe

Innovative use of wood waste:

An interesting solution for utilizing wood obtained from large-size waste is its use for the construction of nesting boxes and bird feeders. Their production takes place at the carpentry of the Municipal Cleaning Service in Kraków, while the initiator was the Association of the Joyful Bird Promoters.

Construction of bird shelters uses pieces of wood from the disassembled frames of beds, pallets and furniture. Feeders and nesting boxes are handed over to the Association of Property Managers and Administrators, who assemble them on administered buildings. Their recipients are also individual residents who wish to install a bird shelter on their property. Every year, about 800-1000 bird feeders and nesting boxes are distributed among the residents of Kraków, as well they can be installed in the parks. Such an initiative couls be also important from the social point of view – it could involve citizens and associations in co-management of commons and public areas.

This initiative is aimed at providing new "houses" for birds, mainly the common swift (*Apus apus*) which is steadily less numerous in Kraków. The place of breeding for these

birds are usually corners within buildings, wall hollows, niches under roof tiles, which during renovation and thermo-modernization are being filled in. These birds are especially useful because they clean the city of mosquitoes, flies and other insects. The action is an example of good practice in the field of waste management promoting the reuse of raw materials.

Nesting boxes and bird feeders produced from bulky waste. Photo by A. Wiśniewski.

Source:https://dziennikpolski24.pl/budki-legowe-i-karmniki-ze-smieci-zdjecia wideo/ga/3749563/zd/4886945

3.5 Aluminium can recycling machines

Source: based on best practices from other regions in Poland.

Type of waste: aluminium beverage cans

Location of the EIS: Małopolskie and Śląskie Voivodship

Initiator of the EIS: CP Recycling

Involved actors: CP Recycling, shops, public/private institutions, residents

Objectives of operating this eco-innovative solution:

- reducing the overall mass of waste deposited in landfills;
- implementing assumptions of circular economy by collecting aluminium cans and recycling them;
- pro-environmental education on packaging waste management.

Packaging waste management

Used beverage cans are transported to collection centres where they are properly sorted, cleaned and prepared for recycling plants. There, the material is recycled into new aluminium for further production purposes.
Aluminium is a raw material that can be processed a considerable number of times, obtaining new products. Processed aluminium does not lose its initial psychical properties. Its chemical composition is the same as material produced from bauxite. However, it is cheaper and more ecological - production of secondary aluminium is 60% less costly than processing bauxite. Each recycled can saves up to 95% of the energy needed to produce a can made of new aluminium.

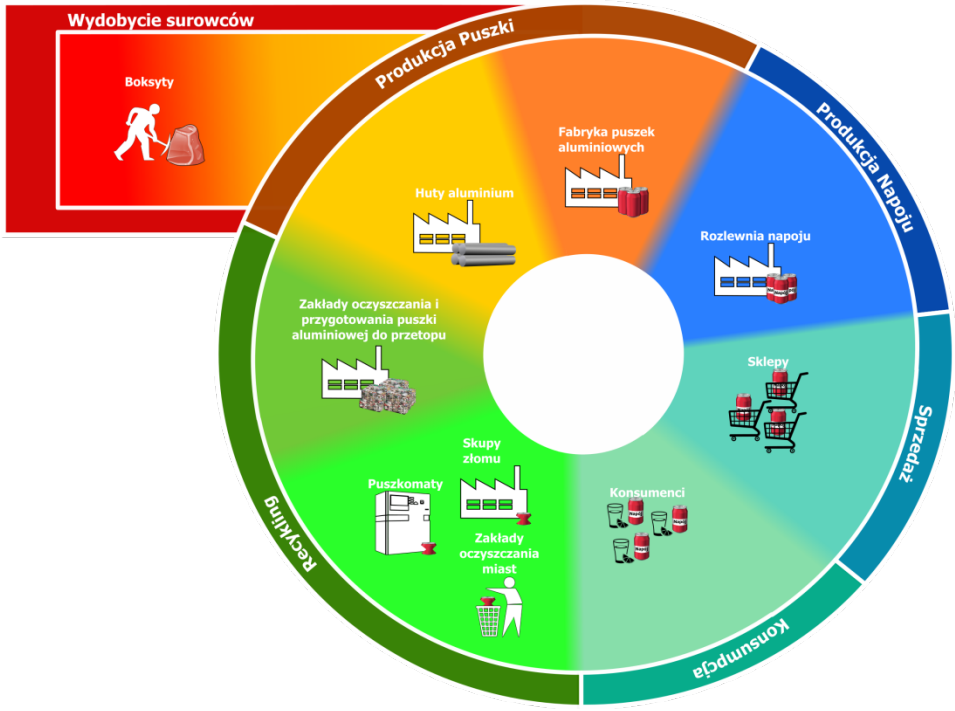
Proposed Eco-innovative solution for increased recycling of aluminium cans:

CP Recycling is part of the Can-Pack Group specializing in recycling of used aluminium cans. CP Recycling has established a network of can recycling machines, being devices for collecting used aluminium cans. It is an innovative solution in Poland, which aims to encourage local communities to segregate packaging waste at source. People inserting cans into machines are being rewarded in different ways. Aluminium can recycling machines have been installed in various institutions, stores, universities, multi-family housing communities and sports facilities. These machines operate in a simple manner: the user puts aluminium cans into device and in return receives a voucher for use in a given store the recycler was placed. In case of some machines, the individuals can also make a charitable donation instead of receiving the voucher. The system of advanced sensors enables inserting used aluminium cans of all sizes, both crushed and unchanged. The machines only accept aluminium cans. Other packaging is rejected and hence recycling of collected material is very effective. The idea behind such devices is to face

the challenge of constantly growing consumption of canned beverages in Poland and worldwide.

Fig. Aluminium can recycling machines by CP Recycling Packaging Recovery Company Inc. at supermarkets. These devices are part of a cycle, during which the same material is repeatedly processed to be re-used as an aluminium can. Source: http://cprecycling.eu/organizacja-odzysku-opakowan/puszkomaty

The aluminium can begins its life cycle as a metal sheet manufactured in aluminium smelter specializing in producing material for aluminium cans. Subsequently, it goes to the aluminium can factory, the largest producer in Poland and one of the largest in the world being the Can Pack Group, part of which is the CP Recycling Packaging Recovery Company Inc. Then, produced aluminium cans are transported to goes to beverage producer, where they are being filled at bottling plant. Ready drinks go to stores to be purchased by consumers. Used aluminium cans are then collected by various types of entities and are sent to the waste collection plants run by the CP Recycling Packaging Recovery Company Inc. to be to purified and assembled for remelting in aluminum smelter. After melting, the entire process can be repeated an infinite number of times as aluminium does not lose its properties after processing.



Recycling aluminium cans as part of circular economy

Source: http://cprecycling.eu/skup-puszki-aluminiowej/recykling

On the next stages that idea can be improved. Such can collectors can be located into eco-districts areas, where there are for examples more machines for recycling of different materials + reuse of textiles + reuse of woods.
Eco-point could be also a place in a public building where all people can go and recycle aluminium but also plastic or find small composting machines. In these areas it would be also possible to reuse aluminium itself, producing other objects.
Furthermore, the overall process could be managed by associations that can help simple citizens to recycle and then to reuse aluminium to produce other things.

3.6 Using waste for producing objects appealing to the imagination of the local community and raising awareness of the need for waste management

Source: based on best practices from other regions in Poland and Europe.

Type of waste: municipal waste.

Objectives of operating this eco-innovative solution:

This EIS aims at transferring educational values by using products made of waste. The overriding idea is to develop good habits related to waste management among youth. Objects being created often take the form of artworks, making the local community aware of the need for segregation and proper management of waste.

Fig. The "installation" is to make aware of dangers resulting from pollution of the Baltic Sea waters

Schools organize contests, during which children and youth present products made of waste or ideas for waste management. Such events, apart from educational values, increase awareness among young people concerning threats resulting from environmental pollution and the need of undertaking measures to counteract them. Created objects are often intended for everyday use.

<u>Example 1.</u> An opportunity for a creative look at everyday waste is a contest under the slogan *Art of recycling - second life of waste* organized for the first time at the Eco-Fairs in Brzezna (Małopolskie Voivodship).

- We encourage the fourth, fifth and sixth grade primary school students from Nowy Sącz and the Nowy Sącz county to artistic competition. It is an effective way to disseminate knowledge on waste recycling, also making children aware of how to reduce waste production through their reuse – as explains Joanna Olchawa from the Sądecka Foundation organizing Eco-Fairs in Brzezna.

Fig. Examples of toys made from waste

<u>Example 2</u>. Project implemented at Middle School No. 1 in Gostynin (Mazowieckie Voivodship) - *Waste is our problem.*

The aim of the project was to attract the attention of young people - who in the future will be responsible for running own households - on issues related to the production and recovery of waste. Thanks to numerous actions carried out as part of this undertaking, youth and their families have learned how considerable their impact on the surrounding environment can be.

As part of the *Waste is our problem project* participants carried out a series of activities that in a practical way showed how important environmental protection is, but also how to encourage youngsters to recycle waste in a modern and attractive way. At the workshops, among others, the City of Birds installation and a model of hydroelectric plant were built. Many educational mock-ups were constructed. There was also a contest for creating usable objects made of recyclable materials. Students measured the amount of waste produced in a household and proposed principles for their segregation. Youth designed informative leaflets on harmfulness of burning garbage in households' ovens.

Example 3. Art work and functional objects made of waste

Waste can also be used as a material for creating works of art and functional everyday use objects that increase the attractiveness of urban landscape.

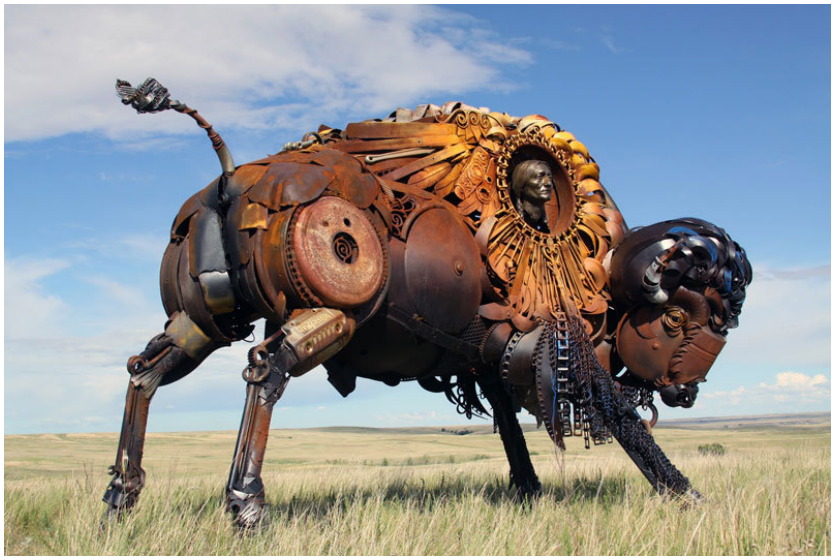


Fig. Sculpture made of metal waste by J. Lopez

Fig. Elephant made of plastic buckets

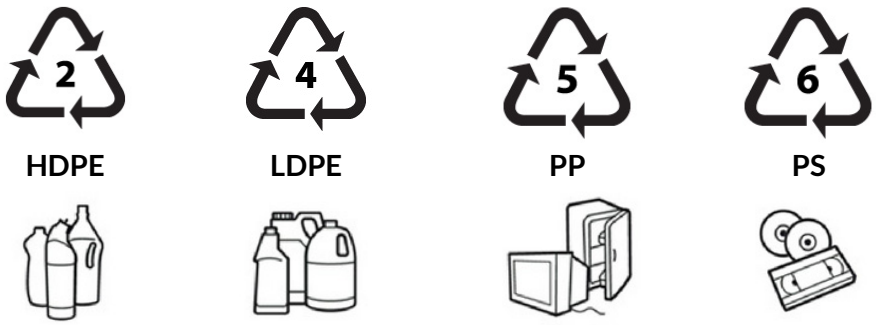
Fig. Troll made of waste at the playground in the city of Horsens (Denmark)

3.7 Production of ready-to-use engine fuels from plastic waste

Source: Haderek Technologies (handerek-technologies.com) – a stakeholder contributing to PULL Łódź.

Type of waste: long chain polymers (plastics)

Handerek Technologies has patented a technology that enables efficient recycling of mixed polymer waste (plastics) - in particular polyolefins (polyethylene PE, polypropylene PP and polystyrene PS). After recycling, the end product is compliant with the EU standardized fuels: EN590 diesel, EN228 gasoline and air fuel fractions. The technology processes plastic waste that is not suitable for recycling, such as: dirty plastic foil, multi-material packaging, all kinds of consumer packaging, as well as industrial waste, excluding polyvinylchloride (PVC) and polyurethane (PU).
Types of processed plastic waste:

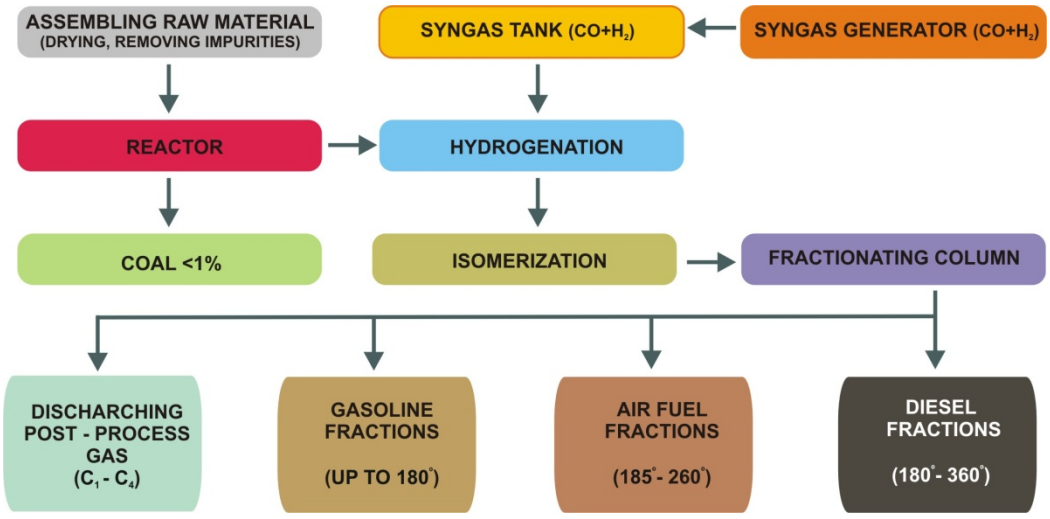


High-density polyethylene (HDPE)	Low-density polyethylene (LDPE)	Polypropylene (PP)	Polystyrene (PS)

At the waste sorting plants, there have been attempts to determine the capability of separating required types of plastics from mixed municipal waste and establish proper cooperation between the waste sorting plant and the Handerek Technologies installation processing it into fuel. These actions confirmed the ability to obtain raw material and the possibility of feeding the installation for processing directly after waste segregation. The process is not disturbed by the use of raw material, in which acceptable amounts of other fractions are contained, such as PET.

Main advantages of the EIS:

- mixed and unwashed polyolefin used as a raw material;
- high recycling efficiency reaching 83-90% (depending on the composition of mixed plastics);
- a minimal share of by-product 1-2% - dry coal coke (energetic material that can be sold);
- the process is scheduled for continuous operation;
- the process runs at atmospheric pressure and low temperature, thus the running costs are reduced;
- the process is self-sufficient in energy, providing gas and fuel used for its running;
- end products – engine fuels and emissions are tested by the PIMOT Automotive Industry Institute (subordinated to the Ministry of Entrepreneurship and Technology);
- Handerek Technologies patented in 2017, another patent submitted,
- Grand Prix and gold medals awarded at the largest innovation and technology fairs in Europe: IENA, INNOVA, ARCHIMEDES and INTARG.



Simplified scheme of plastic waste processing installation

3.8 Processing of used tires into rubber granules

Source: recykl.pl – good practice from Poland.

Type of waste: worn tiers

Involved actor: Grupa Recykl S.A. (Recycle Group Inc.), Śrem, Wielkopolskie Voivodship.

This eco-innovative solution aims at enhancing the management of post-consumer waste - used tires and their recycling. In addition, implementation of this EIS takes over the obligation of recovery and recycling as part of product charge.

The main area of Recycle Group Inc activity is running entity in the field of waste management, which are worn tires. Companies being part of Recycle Group Inc collect used tires, offer recycling and recovery services for used tires and produce rubber granules. These can be used for numerous purposes, for instance as a sound-absorbing layer in building insulation or making soft and safe surfaces often found on modern playgrounds. In addition, Recycle Group Inc provides payment for product charges on behalf of producers and importers.

The company collects used tires of various types, sourced from passenger cars trucks, agricultural and industrial vehicles. The tires are assembled by special containers. Worn tires are collected in the majority of regions (voivodships) in Poland. The collection network covers about 2,000 facilities, starting from tire replacement services, transport companies and car workshops, to waste treatment plants.


Tires are deposited to be recycled


Processing of used tires


Fine rubber GreenGran granules

Source: www.recykl.pl

As an outcome of tire processing GreenGran rubber granules are produced. Depending on the further purpose of use, the fractions vary from 0.5 to 6.0 mm. The method of mechanical granulation involves cold mechanical grinding. Inconsiderable amount of dusting is being produced thus making GreenGran is not burdensome to employees nor environment. Highly developed rubber surface supports adherence thus this material is suitable for building e.g. durable sports surfaces and other rubber products. Green Gran granulate from car tires is the most widespread and available rubber granulate on the market. It guarantees repeatability and homogeneity of the chemical composition, which is not indifferent to the producers of finished products. The products gained hygienic approval and Building Research Institute Recommendation and the ISA SPORT Sports Laboratory certificate. It can be used in all kind of public spaces – especially in creation of kids playgrounds or outdoor sports fields.

A playground in Ustroń, Śląskie Voivodship. Example of using material obtained from worn tires.

Source: www.atrakcjedzieciece.pl

3.9 Textile recycling. Wholesale and retail sale of sorted and unsorted second-hand clothing and raw material processing for industrial cleaning cloth.

Source: vivetextilerecycling.pl – good practice from Poland.

Type of waste: textile

Closing the life cycle of textile materials (used clothing, footwear, household appliances) - depending on the structure of material and degree of wear:

- re-entering the clothing market (second-hand stores);
- production of industrial cleaning cloth;
- production of alternative fuels;
- production of a composite board.

The process involves recycling of textile waste (used clothes) conducted in several stages:

1. delivery of raw material - used: clothing, footwear, accessories made of textile;
2. process of initial segregation, the raw material is transported for further segregation;
3. transport of raw material to the second phase of sorting, to which only clothes are delivered;
4. grouping clothing into various types, separating it into individual chute chambers;
5. transfer of clothing to the third phase of sorting where specific groups of textiles are divided into types, adapted to the quality requirements of customers - here clothing is classified individually and if it does not meet requirements, it is transported to the processing department for industrial clothing, alternative fuels or composite board;

6. segregated products are packed in bags or compressed into bales;
7. packaging of textiles, weighing and marking with a bar code;
8. clothing - a finished product is transported to storage halls or immediately goes to the loading (1500 tons of complete products per week);
9. non-compliant textiles intended for industrial clothing go to cutting room;
10. textiles that cannot be used as a cleaning cloth go to further processing - they are intended for alternative fuels, PE granules or composite board.

VIVE Textile Recycling is the main company within the VIVE Group, which has been operating for 26 years and has become a leader in the textile recycling industry in Poland and Europe. The company has technologically most advanced, fully computerized clothing sorting lines in Poland, which enable processing of 500 tons of raw material per day, maintaining the highest quality ISO 9001 and 14001 standards. Every day, over 990-person crew in a 3-shift system sorts and packs complete products from 700 different assortment groups. Products are transported to over 70 countries worldwide and to the VIVE Profit retail chain in Poland. The company also produces industrial cleaning cloths used by enterprises of various industries.

Sorting clothes to be reused. Source: www.vivetextilerecycling.pl

3.10 System for servicing installations producing bio-fuels and bio-energy

Source: based on internal REPAiR team and PULL stakeholders discussion

Type of waste: biodegradable

Eco-innovative solutions in the field of bio-waste processing for energy purposes and production of ethyl alcohol comprise a high technological potential of the Łódzkie Voivodship. Due to the growing interest in this type of technology, it is important to identify the supply market for this type of installations. Moreover, one ought to ensure adequate amount of raw material and design an appropriate delivery system. The primary raw material for this type of installation is waste generated during agricultural

production and agri-food processing. However, the technology employed in these installations enables the use of other types of raw materials. Due to the fact that the main issue in the Łódź agglomeration is segregation and management of green waste, it is important to combine the collection system for this type of waste and its management (including re-use). Current technological capabilities allow to take advantage of bio-waste for production of bio-energy or bio-ethanol, but the potential of this waste remains unused. The solution may be to ensure properly organized selection and collection of waste as well as transport of this raw material to installations. Producers of this waste are largely residents of the Łódź agglomeration area, and thus selective collection is carried out through facilities for selective collection of municipal waste (so-called PSZOK) and Regional Municipal Waste Treatment Installations (RIPOK's). As green waste is segregated and transported to appropriate RIPOK, these installations can act as intermediary recipient of the raw material, which will then be transported to plants producing bio-ethanol.

The Łódź agglomeration is to a large extent agricultural area (Figure 1). Therefore, the agri-food industry in this area is relatively well developed. Part of the waste, as raw material, can thus be directly transferred from food producers to installations producing bio-ethanol or other biofuels. However, remaining bio-waste produced in the agglomeration (municipal waste) must first be collected and transported to installations dealing with treatment of this type of waste (see figure 2, designation lfw. 1.9).

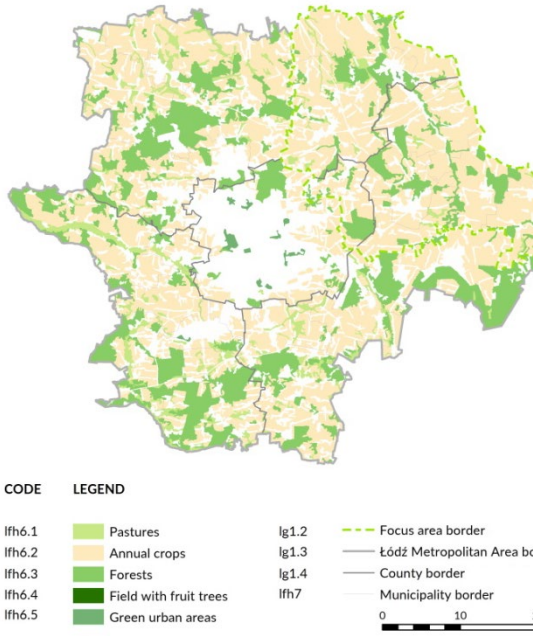


Fig. 1 Land use in Łódź agglomeration area

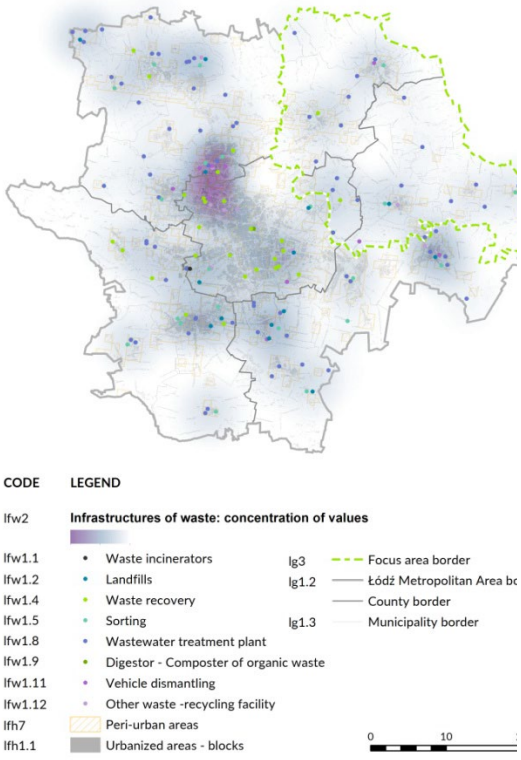


Fig. 2. Operating waste treatment installations in Łódź agglomeration area

In the Łódzkie Voivodship there are currently 6 installations receiving and managing green municipal waste (Table 1, Figure 3). However, their capacity is insufficient (Waste

management plan for the Łódzkie Voivodship for 2016-2022 with extension of 2023-2028). Therefore, it is necessary to expand the already operating and construct new installations. Location of such facilities is crucial in this regard when aiming at achieving an effective waste management system.

Tab. 1 Regional Municipal Waste Treatment Installations (RIPOK's) in the Łódzkie Voivodship

Installation	Capacity Megatons/year	Number of inhabitants served
Composting plant in Krzyżanówek	7,000	458,870
Composting plant for green waste in Łódź	19,000	1,300,098
Composting plant for green waste in Dylów A	20,000	
Composting plant in Płoszów	6,000	691,546
Composting plant in Pukinin	10,000	
Composting plant in Julków	10,000	

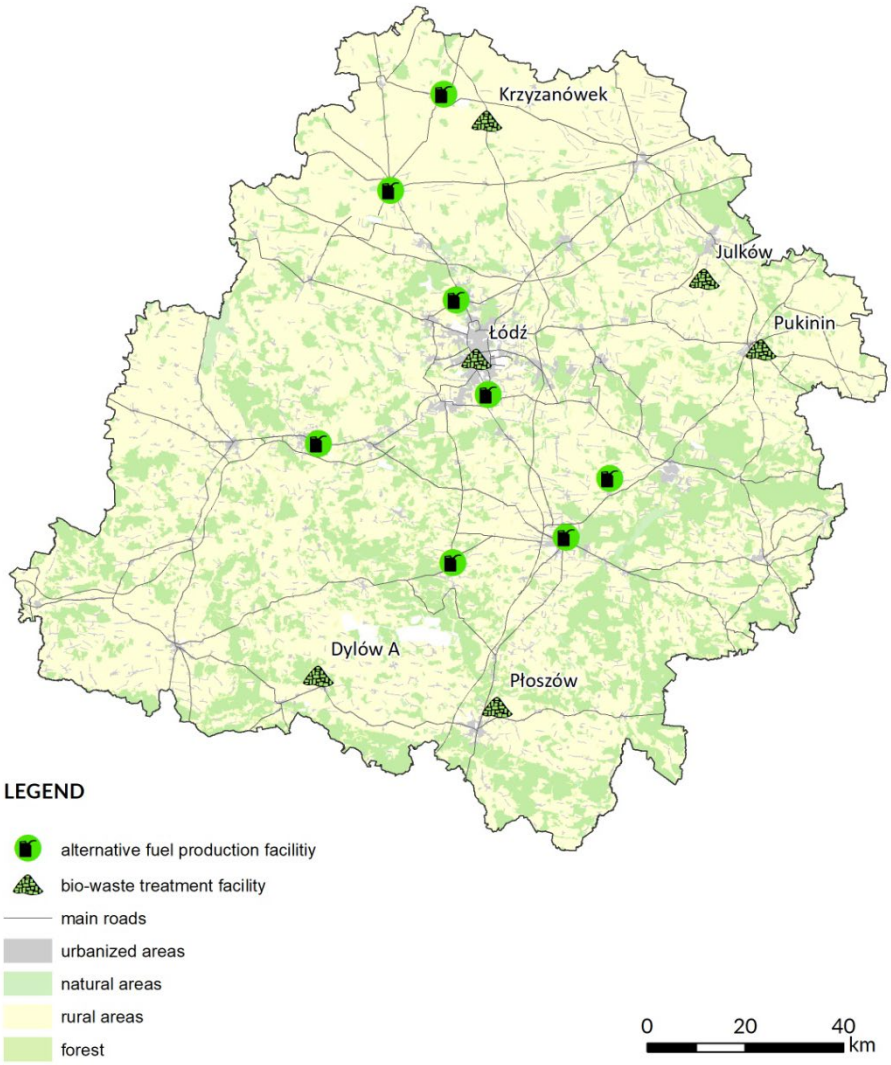


Fig. 3. Green waste processing installations and bio-fuels producing plants in relation to the road network and land use of Łódź agglomeration

Appropriate delimitation of areas, so-called "wastesheds" of installations receiving green waste coming from residents to installations processing them for biofuels or bio-ethanol would improve the system of circular processing of this resource. Figure 4 presents such exemplary areas defined using the Voronoi diagram method of polygons. This method consists in determining borders of areas with equal distances from reference points, in this case installations producing biofuels. The presented analysis shows that in Łódź agglomeration there are four areas lacking installations receiving and processing green municipal waste. Therefore, in order to stimulate the potential of green municipal waste, it is necessary to invest in installations receiving bio-waste, which will transfer them to existing installations dealing with the production of bio-energy and bio-fuels. It should be noted that already operating installations use agricultural raw material, but recent technologies allow simultaneous treatment of other resources. However, increasing the supply of raw materials may result in depleting the processing capacity of installations producing bio-fuels and bio-energy. Therefore it might be necessary to implement described technology in newly constructed installations.

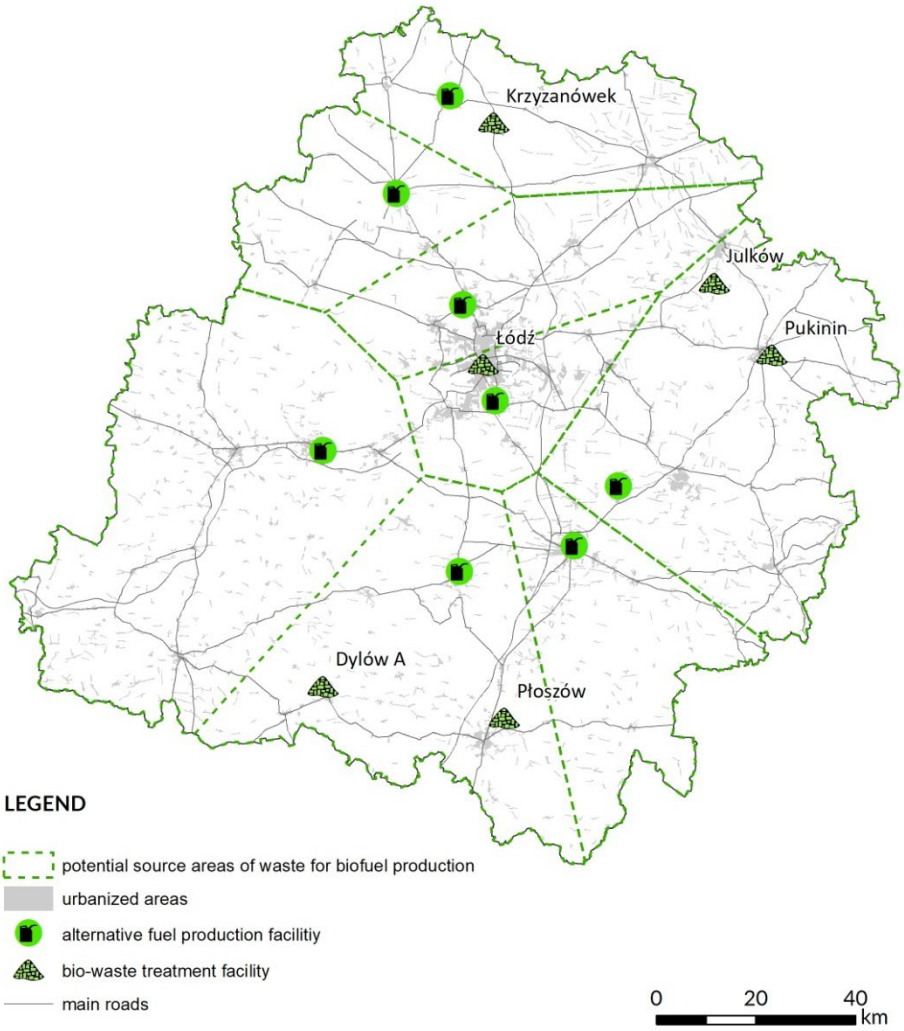


Fig. 4. Exemplary delimitation of operating areas for installations producing bio-fuels

Rozwój rozwiązań eko-innwacyjnych w zakresie biogospodarki ma szczególne znaczenie w Regionalnej Strategii Innowacji Województwa Łódzkiego (2015). Według danych zawartych w Wykazie… (2015) władze regionu upatrują szans rozwojowych w innowacyjnym przemyśle spożywczym i rolnictwie (Mazurek 2017) oraz odnawialnych źródłach energii (Bański i Mazurek 2018). W związku ze zidentyfikowanymi w ramach prac nad specjalizacjami inteligentnymi potencjałami województwa łódzkiego zasadny jest rozwój eko-innwacyjnych rozwiązań w zakresie przetwarzania odpadów pochodzenia rolniczego jak również odpadów zielonych pochodzących z gospodarstw domowych. Zarówno opisane rozwiązania eko-innowacyjne w pkt. 1 jak i propozycja uzupełnienia systemu instalacji gospodarowania odpadami opisana w pkt. 2 wpisują się w politykę innowacyjnego rozwoju całego regionu.

Development of eco-innovative solutions related to bioeconomy is of particular importance in the Regional Innovation Strategy of the Łódzkie Voivodship (2015). According to data included in the Registry... (2015), the region's authorities see development opportunities in the innovative food industry and agriculture (Mazurek

2017) as well as renewable energy sources (Bański, Mazurek 2018). Regarding identified intelligent specializations in potentials of the Łódzkie Voivodship, expanding eco-innovative solutions in the field of processing households' agricultural and green waste is reasonable.

3.11 Process of transforming residual biomass into clean energy. Production of transportation biofuel and chemicals from organic waste.

Source: based on internal REPAiR team and PULL stakeholders discussion

Type of waste: biodegradable

A non-recyclable waste contains carbon-based organic compounds, whose value can be captured when it is chemically recycled to produce clean transportation fuel and advanced chemicals instead of being landfilled.

Canadian firm Enerkem has developed a patented technology of biomass treatment that cannot be recycled and thus ends up in landfills. By the means of this eco-innovative solution, carbon is being extracted from organic waste (biomass). The carbon is then converted through a short chemical process into a gas. In turn, this product can be used to make biofuels like methanol and ethanol, as well as chemicals to be employed in production of numerous everyday products. Particularly methanol is a chemical compound used for the production of secondary chemicals, such as olefins, acrylic acid, n-Propanol and n-Butanol, which can then be employed in further processing to obtain plastics and solvents. These are conventionally made of petroleum.

This eco-innovative solution has already been implemented in the city of Edmonton in Alberta, Canada, which now reuses 90% of its waste, saving more than 100,000 metric tons of landfill a year. Enerkem's ethanol is a renewable, non-toxic, water-soluble, highly biodegradable and clean-burning fuel, used as a high octane oxygenate in gasoline.

Thermo-chemical procedure (Fig.1.) of converting non-recyclable waste into biofuels and other usable organic compounds is as follows:

Step 1. Non-recyclable waste is sorted and shredded into fine material that can pass through further process and be converted into useful products.

Step 2. The carbon-rich material enters the gasification system, where it is transformed from solid into gas. The material decomposes due to specific heat and pressure conditions carefully controlled by the operator. However, it does not burn as there is not enough oxygen. This process is called partial oxidation. The procedure is designed to protect carbon molecules within the biomass and is conducted in enclosed vessels. The carbon molecules, which were initially in the waste are now in a gas, called *syn-gas*, mostly composes of carbon monoxide and hydrogen. This reaction can be expressed as follows:

$$C_nH_m + \frac{n}{2}O_2 \rightarrow nCO + \frac{m}{2}H_2$$

Step 3. The *syn-gas* is purified with water in a closed circuit, thus the water itself is recycled in line with the concept of a circular economy. The purpose of this process is to discard side-products and other molecules not desired for further procedure. The gas is now a raw material that can be compared to natural gas.

Step 4. The process of catalytic synthesis takes place, in which the *syn-gas* is being converted into liquids that can be used as transportation fuels and chemicals. Catalysts split and rearrange the molecules, producing methanol (CH_3OH) and ethanol (C_2H_5OH) for fuel and other organic compounds such as olefins (C_xH_{2x}), acrylic acid ($C_4H_{10}O$), n-Propanol ($CH_3CH_2CH_2OH$) and n-Butanol ($C_4H_{10}O$), which can then be employed in further processing to obtain plastics and solvents.

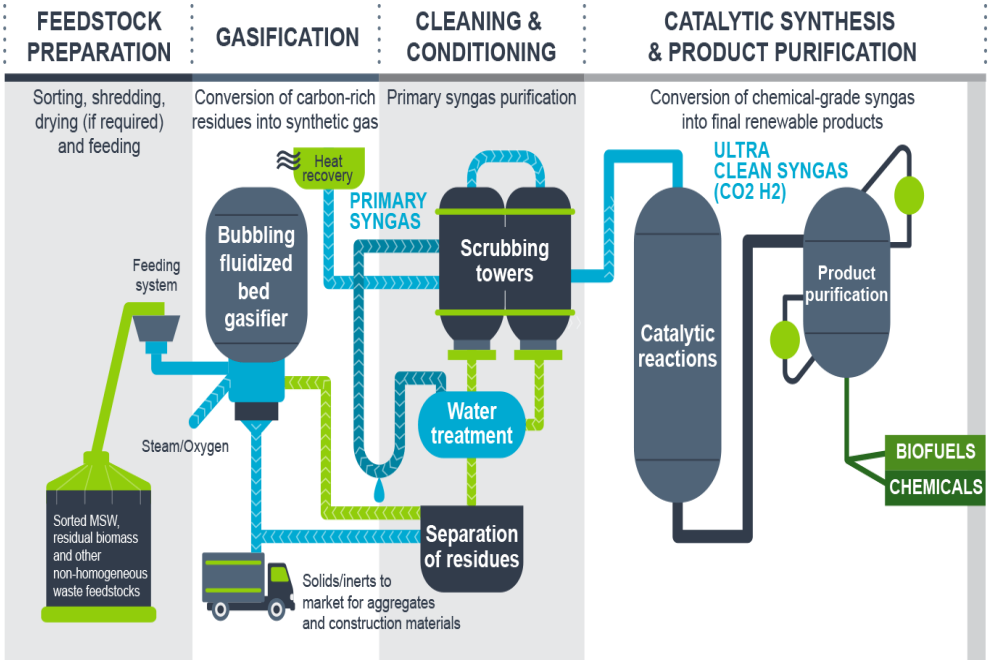


Fig. 1. Enerkem's 4-step thermochemical process. Source: enerkem.com

The process developed by Enerkem is environmentally sound, requiring relatively low temperatures and pressures, hence reducing energy consumption and costs. This eco-innovative technology was rigorously scaled up from pilot to demonstration to the commercial stage during an unprecedented period of 10 years of disciplined efforts. By displacing petroleum and reducing landfilling, this eco-innovative solution contributes to reducing greenhouse emission. This procedure goes in line with the concept of circular economy as waste that would be landfilled are employed.

Currently, in the Łódź Metropolitan Area the non-recyclable waste is transported to landfills or waste incineration plants. However, illegal landfills in this area are an important social and environmental issue as evidence in the REPAiR Deliverable D3.5 Process model for the follow-up cases: Łódź of 2018. This is a serious problem for Poland in general though. In the social awareness, the "easiest", "cheapest" and lest time-

consuming way to get rid of unwanted waste is to burn it. In the first six months of 2018, nearly 80 fires broke out in Poland in various waste disposal sites. The police have registered 1809 waste storing sites of different types in Poland: dumps, landfills, sorting plants and warehouses. 492 of them, according to the police, are particularly at risk of fire, this is especially dangerous for to the environment and the people.

Landfilling (both legal and illegal) is a serious and steadily increasing issue in the Łódź Agglomeration area. The share of waste being landfilled is considerable higher than Poland's average (fig. 2.).

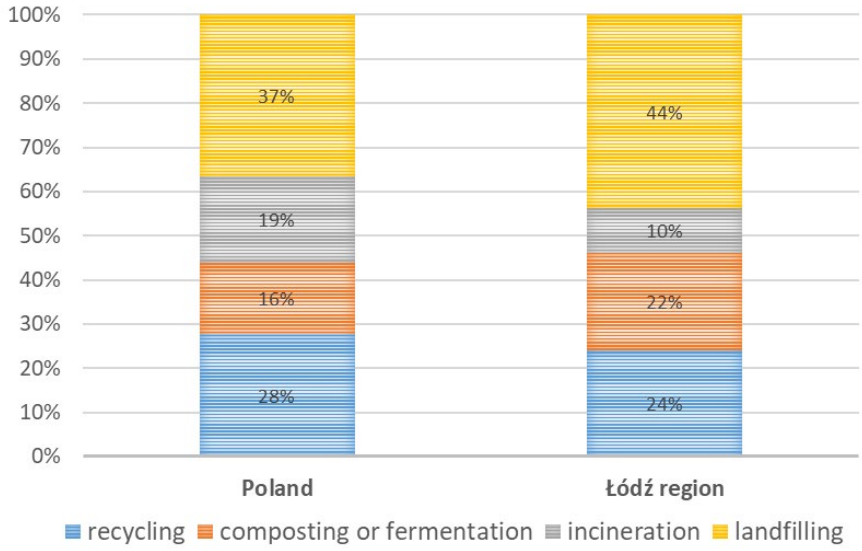


Fig.2. Municipal waste collected by treatment operations in Poland and the region of Łódź, 2016. Source: REPAiR Deliverable D3.5 Process model for the follow-up cases: Łódź of 2018.

Today's non-recyclable biomass waste flow in the Łódź Metropolitan Area (fig.3.) is not economically efficient nor environmentally friendly. A considerable amount of waste that could have been transformed into biofuels or raw materials is being landfilled. Merely a slight percentage of waste that undergoes the process of incineration is being transformed into heat and electricity for households' use.

Another alarming process that occurs in Poland mainly in winter time is air pollution, as especially in areas with no central heating, old type furnaces are still in use. These, when low quality fuels are burned (coal, but often old furniture and even plastics) highly contribute to air pollution and smog.

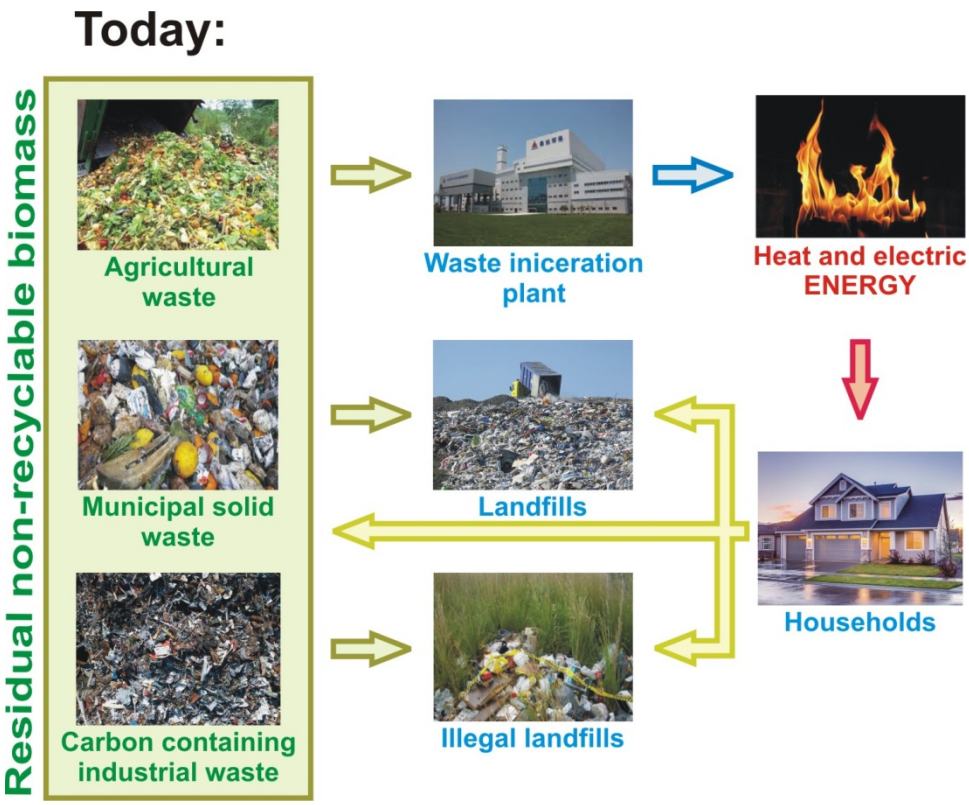


Fig. 3. A simplified non-recyclable biomass waste flow in the Łódź Metropolitan Area.

Source: own work

When the eco-innovative solution developed by a Canadian company Enerkem is implemented, the issue of landfilling and air pollution are expected to be inhibited as:

- Producing biofuels for the local need for **municipal transportation** (ethanol-run buses) will contribute to reducing costs in comparison to conventional fuel. **Local farmers** will be provided with biofuels for agricultural machinery and eventually the costs of production are expected to decrease. Apart from financial benefits, shifting from conventional (petroleum-based) fuels to biofuels contributes to **reducing air pollution** as no harmful combustion products are being exhausted (nitrogen oxides: NO_X, fine particulate matter, PMs) and only carbon dioxide is being produced.
- Providing households with produced locally (thus expected to be relatively cheap) biofuels for combustion in furnaces to **reduce air pollution**.
- As the prices of locally produced biofuels used for public transportation and households' heating will be relatively cheaper than conventional fuels, the amount of landfilled non-recyclable waste is expected to be reducing over time, with the changing **social awareness on perceiving waste as resource and saving costs.**
- Producing organic compound as: olefins acrylic acid, n-Propanol and n-Butanol to be further processed into plastics and solvents is expected to **diversify the local**

economy and contribute to providing self-sufficiency for these products considering local demands.

- Implementation of thermo-chemical biomass treatment shall contribute to **establishing new jobs** at the local scale (managing and operating such plant).

This undertaking will **enhance social awareness** considering waste and perceiving waste as a resource. A crucial aspect that needs to be emphasized is the **knowledge transfer** with implementation of new technology. This eco-innovative solution is thus expected to generate a **socio-economic development** at local or possibly regional scale**, enhancing life quality.**

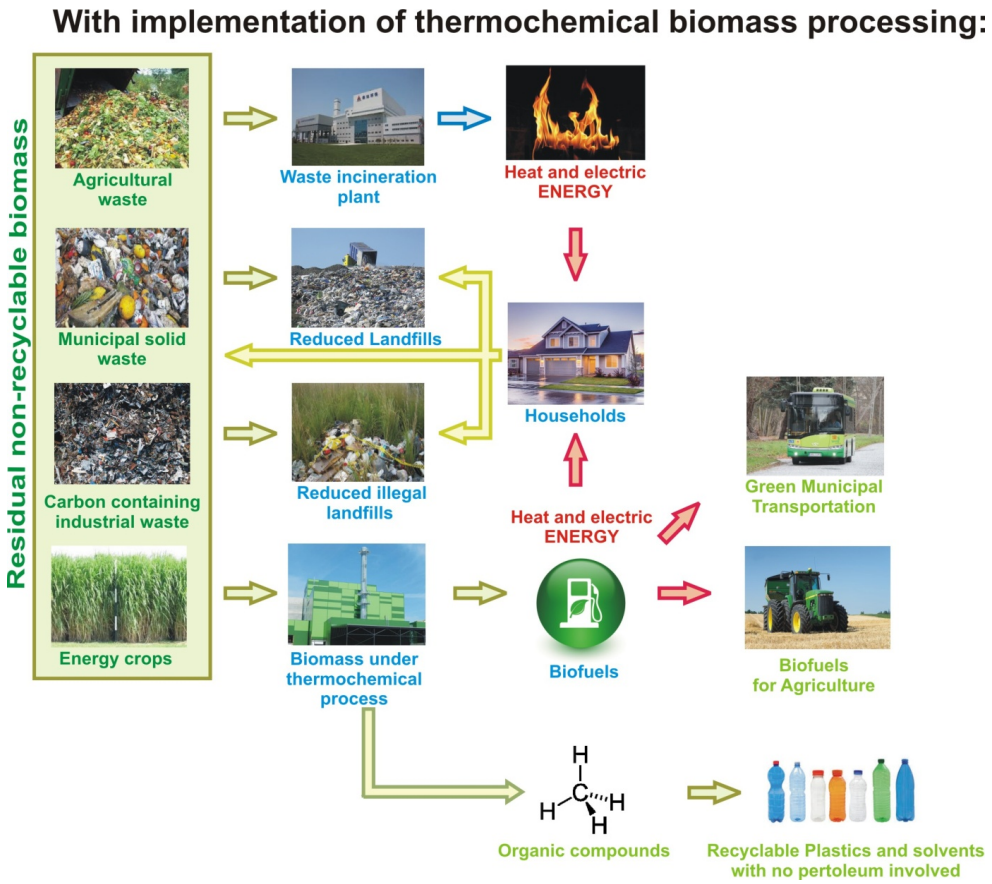


Fig. 4. A non-recyclable biomass waste flow in the Łódź Metropolitan Area with the implementation of the proposed eco-innovative solution. Source: own work

Although the implementation of extracting biofuels and organic compounds for non-recyclable waste is costly at the initial stage, the overall financial balance will be positive. However, the major advantage will be of environmental and social nature. Firstly, the amount of landfilled waste is to be reduced by reusing it to produce biofuels and other organic compounds. Secondly, implementation of this eco-innovative solution is likely to alter social attitude towards waste. The people will ascertain themselves that waste is a resource that can be re-used. Therefore, their perception of the unwanted material is to

be changed with successful implementation of this eco-innovative solution. Producing biofuels within the Łódź Metropolitan Area shall contribute to decreasing the fuel prices at local market. This is will enhance the self-sufficiency for biofuels and other organic compounds.

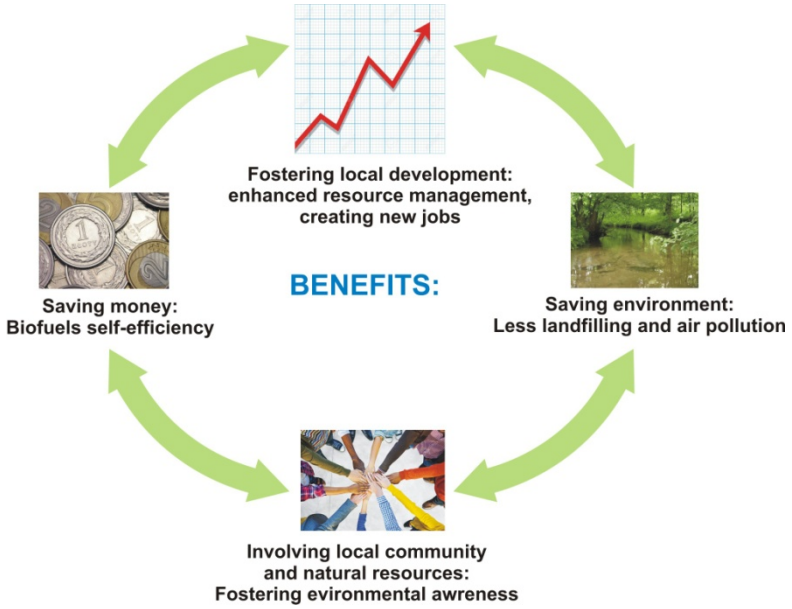


Fig. 5. Projected benefits in the Łodź Metropolitan Area (at the local scale) after implementing thermo-chemical biomass processing

The biofuels are already being produced in Poland (e.g. from corn). However, the proposed eco-innovative solution is less costly in this respect as no cultivation is needed (this employs soil, fertilizer and water consumption) for the purpose of producing biofuels. The process of biofuels production from raw material, that is being obtained with absolutely no costs (as waste) is innovative indeed.

Is this Eco-innovative solution realistic to be implemented in the Łódź Metropolitan Area?

It is relatively difficult to estimate the actual amount of waste that could potentially be converted into biofuels and raw materials in the analysed region. The structure of municipal solid waste by fraction in Łódź Agglomeration Area. As provided by municipal reports for 2016 the non-biodegradable municipal waste segregated and collected selectively amounted to 4,6% of all municipal waste. However, raw material could possibly largely be extracted from unsorted (mixed) waste comprising as much as 71.8% of municipal waste (REPAiR Deliverable D3.5 Process model for the follow-up cases: Łódź of 2018). Therefore, there is an excessive share of mixed municipal waste in the overall municipal waste flow and this would not foster application of the proposed eco-innovative solution.

Despite these, the major obstacle for the implementation of the proposed eco-innovative solution is of financial nature. Establishing sophisticated facilities and transferring the know-how from the Enerkem company is costly and time-consuming. However, local

authorities could apply for partial re-funding of the undertaking by the EU. Moreover, few communes can join their budgets to establish a shared biomass residual transformation plant that would operate raw material, fostering the entire process. On the other hand, local communities in Poland are often against such investments, leading to the common NIMBY-(Not in My Background) type conflicts, as they are reluctant towards waste processing in general (due to possible nuisances such as odour, noise, etc.). It difficult to predict how the local community would react towards such investment.

3.12 Food sharing centres in urban communes of the Łódź Metropolitan Area

Source: based on best practices from Łódź

Type of waste: biodegradable

Objectives: Reduction of food waste, diminish the overall amount of waste for enhanced waste management, sharing food with those in need.

Fig. 1. Food-sharing centre in Łódź. Source: lodz.wyborcza.pl

According to a survey conducted by the Federation of Polish Food Banks, about 9 million tons of food is wasted every year in Poland. An average Pole throws in bin 235 kg of food per annum. Sadly, these statistics position Poland fifth among the countries wasting most food in the EU. This has become a serious social issue, with the growing consumption and raising the living standard in Poland.

The idea of a food-sharing centre is to reduce the amount of waste being generated. In such place, everyone can come and take the food they need from the shelves or fridges. In the case of food brought in, limitations may apply to products, for which it is difficult to determine their shelf life (e.g. raw meat, eggs, unpasteurized milk)

In Poland, the first food sharing centre was established in May 2016 in Warsaw, followed by in Toruń, Krakow in Wrocław. The food sharing centre in Łódź was established in 2017 (fig. 1.) at the Faculty of Economics and Sociology, University of Łódź.

The eco-innovative solution will be to establish at least one food sharing centre in each urban and urban-rural commune of the Łódź Metropolitan Area. These include urban communes of:

- Brzeziny
- Głowno
- Konsnatynów Łódzki
- Ozorków
- Pabianice
- Zgierz

As well as the following urban-rural communes:

- Aleksandrów Łódzki
- Koluszki
- Rzgów
- Stryków
- Tuszyn

It has been assumed that establishing a food-sharing centre in rural communes would be to certain extent inefficient, considering much lower number of inhabitants and thus lower food exchange rate. Moreover, in rural areas, farmers waste considerably less food, as it is often fed to animals.

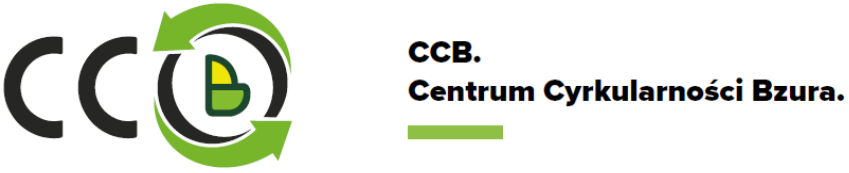
The network of food sharing centres operating the Łódź Metropolitan Area would considerably contribute to reducing the overall amount of municipal solid waste generated. As aftermath, this is expected to enhance municipal waste management. Considering that averagely 200 kg of food is wasted per capita, and the overall population of region being examined is 1 million, the total mass of food being wasted is potentially as much as 200,000 tons per year. If only 10% of this food would have been shared there would already be significant reduction of costs associated with waste management as well as saving time.

Apart from the aspect of waste management, this eco-innovative solution is aimed to help the people in need. Instead of wasting food, it is better to share it.

3.13 Circularity Center Bzura – CCB

Source: CBB idea – one of the PULL Łódź stakholder

Type of waste: recyclable waste



The "Bzura" inter-communal union was founded in 2009 to create and implement a comprehensive, sealed municipal waste management system, including the selective collection of raw materials, recovery, recycling and disposal. Currently, the Union consists of 19 municipalities - 146 224 inhabitants. These tasks will be carried out by creating convenient conditions for cooperation on the „Self-government – Entrepreneur" line as part of waste management in accordance with the idea of circular economy under the name Circularity Center Bzura - CCB, as well as through the construction of the "heart of the centre", a modern Regional Installation of Municipal Waste Processing units planned in the Waste Management Plan for the Lodzkie Voivodship, with the possibility of processing about 50-60,000 tonnes of waste per year.

The "Bzura" Inter-communal Association brings together 19 communes from the northern part of the Łódzkie Region:

1. Municipality Aleksandrów Łódzki
2. City of Głowno
3. Municipality Stryków
4. Municipality Bielawa
5. Municipality Brzeziny
6. Municipality Budziszewice
7. Municipality Chąśno
8. Municipality Dmosin
9. Municipality Domaniewice
10. Municipality Kiernozia
11. Municipality Kocierzew Południowy
12. Municipality Łyszkowice
13. Municipality Łowicz
14. Municipality Nieborów
15. Municipality Parzęczew
16. Municipality Piątek
17. Municipality Ujazd
18. Municipality Wartkowice
19. Municipality Zduny

It was founded in 2009 to create and implement a comprehensive municipal waste management system covering selective waste collection, recovery, recycling and disposal. The main objective of the association is to improve the environment through the proper management of municipal waste of communes belonging to the Union, as well as the level of prices for receiving municipal waste.

The association has 23 ha of land designated for waste management, on which it started the construction of a modern waste management installation. With 13 ha designated for the Regional Installation of Municipal Waste Processing, while the remaining 10 ha create opportunities for locating in the immediate vicinity of many organizations cooperating together as part of the Bzura Circularity Center. More than PLN 10 million has already been invested by arming and stabilizing the construction site.

During the implementation of the project, the association decided to take into account the changes that it has made about the circular economy.

In the European perspective, the December 2, 2015, the European Commission adopted the Circular Economy Package, which aims to boost competitiveness, create jobs and support sustainable economic growth.

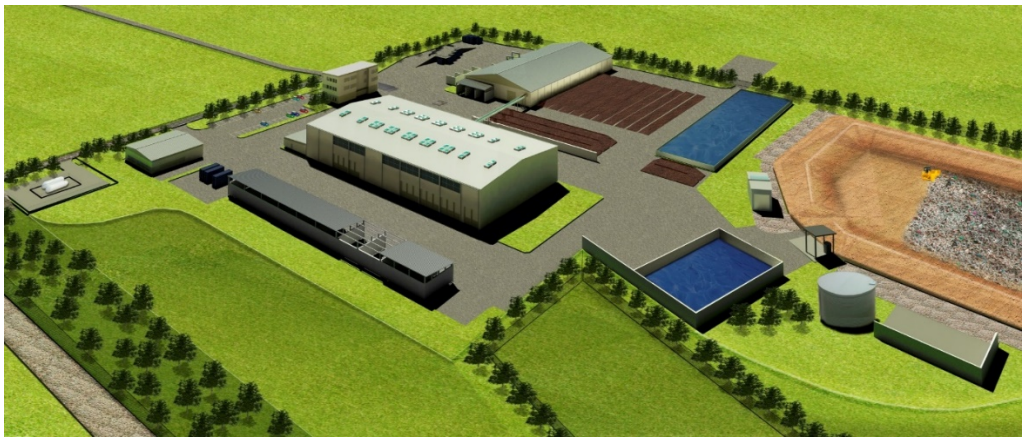
The most important goals of the package, planned to be achieved in 2030 include:

1. In the field of municipal waste recycling level of 65 per cent.

2. For the recycling of packaging waste level 75 per cent.

3. For the reduction of waste storage to a maximum of 10 per cent.

4. No storage of segregated waste.



It consists of the basic 4 components:

1. REUSE + RECYCLE component = a system of selective waste collection aiming at separating raw materials from the stream clean enough, as required by the requirements of production processes - companies - processors that produce products with high final value.
Actions:
a. cooperation between the Union and private capital;
b. educational and promotional activities among residents;
c. new rubbish sorting regulations that reduce costs;
d. acquiring investors in the perspective of long-term partnerships.

2. REUSE + REDUCE component = in the implementation of the new regulation concerning households, the quality and stabilization of the morphology of bio-raw material will increase. It will allow fully acquire a rich composition for reuse. The implementation of technologies available in Poland under the Bzura Circularity Centre will become a vector of growth of the entire undertaking, enabling also to obtain a "0" level of environmental impact of the entire installation together with cooperating companies.

3. component RESARCH + INNOVATION = technology development centre and entrepreneurship will be implemented in one building, managed by Bzura Circularity Centre as part of which scientific-research-implementation work will be carried out.

Actions:
a. partnerships with research institutes;
b. international projects using the potential of Bzura Circularity Centre;
c. use of local and national finances.

4. component of EDUCATION + COMMUNICATION. This is the key to success on the one hand and on the other hand the most difficult and arduous element that will be responsible for shaping awareness and changing attitudes of society. This is the key to achieve reduction of consumption and reduction of costs and pressure on the environment in the long run. The final form should be cantered between two vectors: community and education.

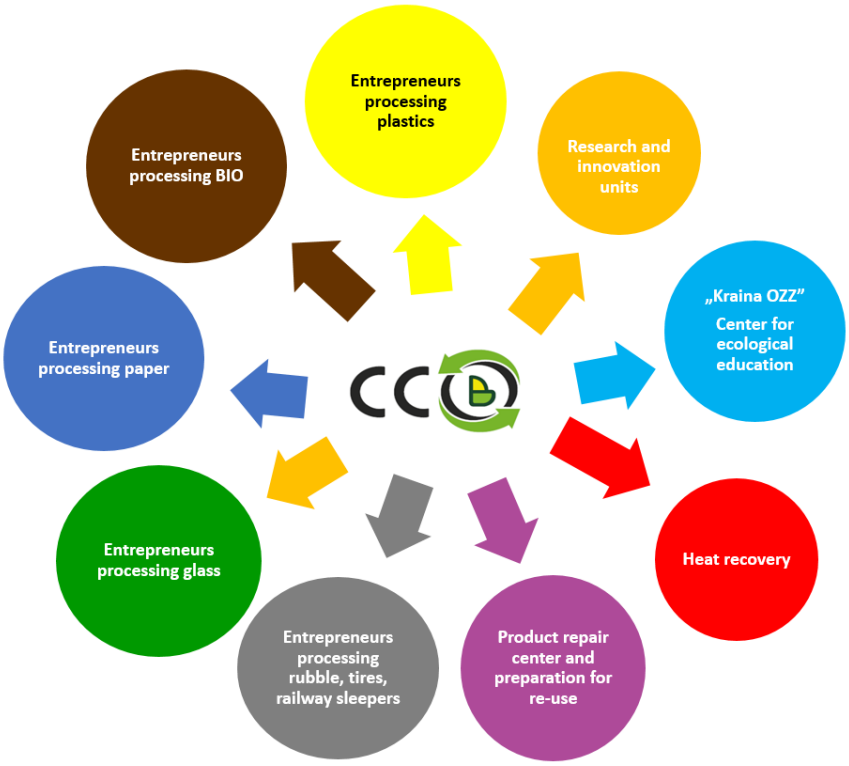
Actions:

a. establishing an educational centre called “Kraina Obiegów Zabawą Zamkniętych” (Land of Fun and Education of Circular Economy);
b. launching programs for education;
c. c. support for residents' initiatives in the BZURY area.

These tasks will be implemented by removing administrative barriers and creating favourable conditions for cooperation between the local government and companies. The undertaking is implemented in accordance with the assumptions and ideas of circular economy, combating climate change and further European integration.

Modern Regional Municipal Waste Treatment Plant fulfilling in full compliance with EU and national regulations, planned in the Waste Management Plan for the Lodzkie

Voivodship, with the possibility of processing about 50-60,000 tonnes of waste per year is nowadays vision of heart this project.



The main assumptions of the Circularity Centre Bzura operation are:

- reuse of all raw materials, products and waste, obtaining the maximum value,
- from production and consumption to waste management and create new market,
- saving energy and reducing gas emissions,
- secondary raw materials,
- limiting food waste,
- activities for the reuse of water,
- eco-design including repair and modernization options, durability and the ability to recycle products,
- implementation of best practices in the field of waste management and resource
- efficiency in the industrial sector,
- Increase employment in the region in accordance with European standards,
- creates solutions defining the impact of products on the environment,
- introduction of requirements and goals related to waste management and circular economy
- creating solutions defining quality standards for secondary raw materials,
- innovative solutions for plastics, food waste, critical raw materials, construction and demolition waste, biomass and bioproducts.

The "Bzura" Inter-communal Association is ready to commence subsequent construction works in order to create a new model - Circularity Centre Bzura (CCB).

The work carried out included in the purchase and conversion of land, isolation of the area, construction of water and energy connection, reconstruction of the installation and obtaining the necessary administrative decisions.

Unfortunately, co-financing available at the national and regional level does not allow financing the ambitious objectives. The allocation in POIŚ (https://www.pois.gov.pl/nabory/vii-nabor-dla-dzialania-22-gospodarka-odpadami-komunalnymi/) competitions is PLN 10 million, which can which can exclude our project. Also the project evaluation criteria limit the possibility of obtaining funds from European funds for our purpose.

4. Summary

The Deliverable D.5.6 presents Eco-Innovative Solutions (EIS) in which innovations works both from the technological side, and from the side of the process - by which they were being conceived and thanks to which they will act.

Solutions were developed based on the knowledge, ideas and experience of stakeholders present at PULL Łódź meetings, as well as as a result of searching for good examples from Poland and the world that can be implemented in the Łódź Metropolitan Area. Most solutions focus on the region's key problem, so municipal solid waste, especially biodegradable waste (EIS numbers: 1) UBER WASTE, 3) Composting, 10) Bio-fuels and bio-energy, 11) Biomass to clean energy, 12) Food sharing). The list also includes four additional solutions based on other categories of municipal solid waste (EIS numbers: 4) Nesting boxes, 5) Can recycling machines, 7) Engine fuels from plastic waste, 8) Rubber granules). Due to the great importance of the textile industry in the Łódź Metropolitan Area, two solutions in this field have been proposed - EIS numbers: 2) Relooping Fashion Initiative and 9) Textile recycling. Although no detailed analysis was carried out in the field of textile waste, but in the opinion of stakeholders at the subsequent stages of circular economy development in the region this industry branch should be further explored. Finally, one solution was proposed to make residents aware of the problem of managing, i.e. EIS number 6) Raising awareness of the need for waste management and one solution for a holistic way of organizing the waste collection point with simultaneous recycling on-site, i.e. EIS number 13) Circularity Center Bzura.

Most of the presented solutions are characterized by a relatively basic principle of the idea of circular economy. These are not very complex and sophisticated ideas, but rather specific actions, due to the level of development of the idea of circular economy in Poland, which is in its initial phase. Therefore, all kinds of ideas that are applicable in Western European countries will be difficult for immediate implementation in Poland. This was demonstrated, among others, by one of the PULL workshops, during which the possibility of EIS transfer from Amsterdam to Łódź was discussed. Most ideas have seemed too far to the local stakeholders - more on this issue in the deliverables developed under WP7.

Most PULL participants are constantly emphasizing that the first step should be taken effectively to realistically think about the full implementation of the circular economy principles. This stage is to make residents aware of pro-ecological behaviour. Awareness of the population is the key to seeing all solutions developed. Another element is the perception of the economic benefit of the solutions used, because, as one of the PULL participants said, "*when recycling is profitable there is no waste*".

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