ECO-INNOVATIONS IN THE SPHERE OF MUNICIPAL WASTE MANAGEMENT IN A POLISH CONTEXT

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Abstract

Despite many of the actions taken by the European Union, the mass of municipal waste deposited in Member States' landfills is too large. One of the solutions to this problem is the use of eco-innovation in the management of municipal waste. Poland is a country which has made a lot of progress, and brought its landfill waste indicator down from 53% in 2014 to 44% in 2015. This paper allows us to answer the following questions: What is the attitude of Polish entities involved in waste management to eco-innovation and what are the environmental and financial implications of the ecological solutions used? Therefore, the main purpose of this article is to answer these questions based on the research conducted.

In order to illustrate the situation, this article begins with an overview of the literature and with a presentation of the condition and level of eco-innovations in Poland, as compared with other countries of the European Union. The presented data are based on secondary results. Later parts include examples of Polish eco-innovations in the sphere of handling municipal waste. Results of the survey and the results of the questionnaire are also presented, which indicate the direction of the necessary actions leading to increasing the number and efficiency of eco-innovation.

Key words: eco-innovation, municipal waste management, ecological innovation in Poland

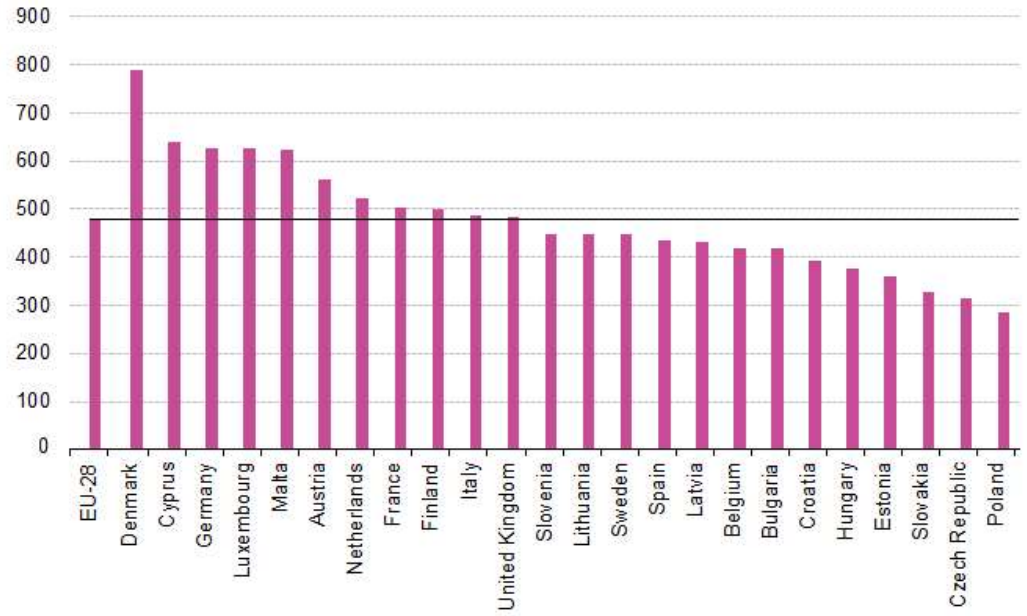
1. INTRODUCTION

Municipal waste management is a complex and multidisciplinary process which deals with managing waste from the moment it is generated until its time of neutralization. Its scope covers collecting, accepting, moving, transporting, disposal, as well as storing (Das & Bhattacharyya, 2015, pg. 9). A good and effective waste management system should take the relations and inter-links between the above elements into account, in consideration of their costs and negative effects on the environment (Singh, Gupta & Chaudhary, 2014, pg. 347). Moreover, it should allow implementing European Union policy, which imposes on its Member States the obligation to reduce the number of municipal waste produced, and to organize a procedure for collecting and managing the produced waste that is in accordance with the adopted hierarchy.

Numerous European Union countries still struggle with the problem of excessive amounts of municipal waste. According to Eurostat data, the average EU

figure for the year 2015 was 477 kg per single resident. The most waste, as much as 789 kg per capita, was produced by the citizens of Denmark; they are followed by the residents of Cyprus, Germany, Luxembourg, who exceeded 600 kg per person. Among the countries that generate the least amount of municipal waste are Poland (less than 300 kg per resident), the Czech Republic, and Slovakia (slightly over 300 kg per resident) (Eurostat, access May 12, 2017). The number of generated municipal waste in the year 2015 by European Union Member States is presented in Figure 1.

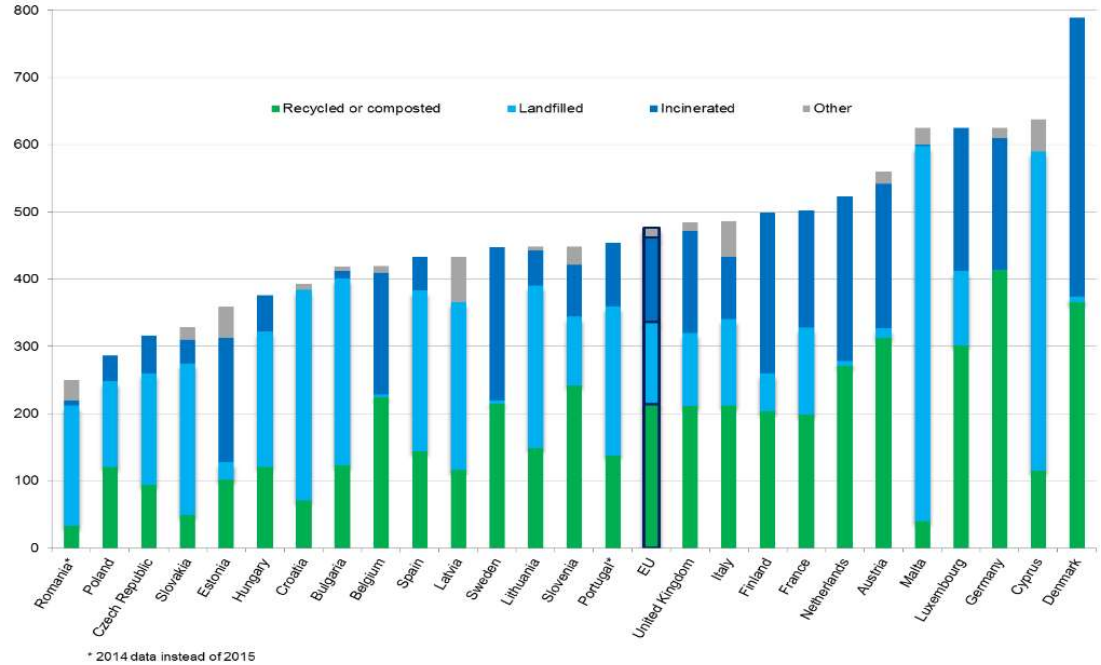
Figure 1. Municipal waste generated by European Union Member States in 2015



Source: Municipal Waste Statistic, Eurostat Statistic Explain, (2017) [available at: www.ec.europa.eu/eurostat/statistics-explained/index.php/Municipal_waste_statistics, access May 12, 2017]

The most popular method for managing municipal waste by European Union countries in 2015 was recycling (29%). However, a worrying fact is that as much as 28% of waste still ends up in landfills. Among the largest producers of municipal waste are countries that may pride themselves with the most effective ways of waste neutralization. High waste recycling and composting indicators can be seen in Germany - 68% (recycling + composting), Austria and Slovenia, 58% each (recycling + composting). Moreover, Germany is the European leader in landfilling municipal waste on dumps - only 1%. The ways of neutralizing waste by European Union Member States are presented in Figure 2.

Figure 2. Municipal waste generated by European Union Member States in 2015



Source: Municipal Waste Statistic, Eurostat Statistic Explain, (2017) [available at: www.ec.europa.eu/eurostat/statistics-explained/index.php/Municipal_waste_statistics, access May 12, 2017]

From the above, it may be concluded that huge amounts of precious resources are wasted in Europe, and many countries are at risk of not fulfilling their obligations related to the specified recycling quotas. One of the methods for improving the situation may be enhancing the waste handling system by implementing eco-innovations at individual stages of proceeding with municipal waste. This paper focuses on the analysis of eco-innovations as an effective tool of supporting the municipal waste management processes.

The aim of this article is to present the attitude of Polish entities engaged in waste management, i.e. companies dealing with segregation, transport, receiving, processing and disposal of municipal waste, as well as landfill operators, to eco-innovations. Moreover, it examines the possibilities and limitations of implementation and the use of eco-innovations. The first section presents the idea and definitions of eco-innovations, and a comparative analysis of eco-innovation-related data for Poland and other members of the European Union. The second part contains a presentation of the Polish eco-innovations in terms of waste management. The third part indicates the directions of necessary actions for increasing the number of eco-innovations in Poland, based on a survey.

2. ECO-INNOVATIONS - BASIC INFORMATION

Literature on the subject includes numerous definitions of the phrase *eco-innovations*; one of the early ones was proposed by C. Fussler and P. James in 1996,

who claimed that "eco-innovation is a unique application of breakthrough changes that will work for satisfying the future needs" (Fussler & James, 1996, pg. 354). The following year, P. James offered a more specific characterization, and provided a classical definition of an eco-investment: "new products and processes which provide customer and business value but significantly decrease environmental impacts" (James, 1997, pgs. 52-57). In the subsequent years, this subject was touched upon by a number of researchers who formed their own understanding of the concept. Analysing the above definitions, it may be concluded that they lack a certain systematization, and that it is apparently justified to add the prefix "eco" to any innovation that is less dangerous to the environment than its alternative. An attempt to crystallize the idea was made by R. Kemp and P. Pearson, who saw eco-innovations as "products, production methods, procedures of exploitation of resources, ways of providing services, management methods that are new to the organization, and which ensure reduced environmental risk, emit less pollutions, consume more resources and cause less harm to the environment than the alternative solutions" (Kemp & Pearson, 2007, pg. 34).

This area has also become the focus of other entities, such as: the European Committee and the Organisation for Economic Co-operation and Development (OECD). The position of the European Union is particularly interesting, since it treats eco-innovations as any form of innovation in production processes, providing services and management methods leading to significant progress in the direction of implementing sustainable development principles. At the same time, such innovation is to lead to a reduced environmental footprint through preventing and reducing pollution, and to responsibly utilize natural resources (Report European Commission, 2008).

The above literary examples may be greatly summarized by the definition proposed by the OECD, which describes eco-innovations as "creating or introducing new, significantly improved products, processes, marketing methods, organizational structures and institutional solutions aiming at improving the condition of the natural environment, compared to the respective alternative solutions." (OECD, 2009)

Literature on the subject proposes numerous types of ecological innovations. In the report from surveys commissioned by the European Union as part of the Measuring Eco-Innovation (MEI) project, the following classification is employed (Kemp, 2010, pgs. 398-401):

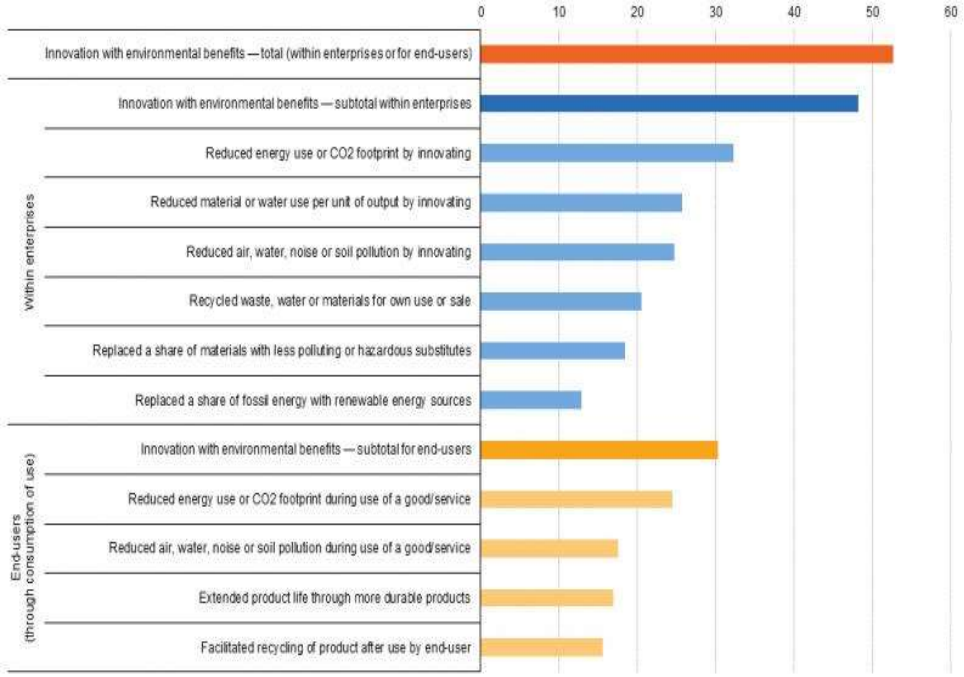
- environmental technologies,
- organizational innovation,
- product and service innovation,
- green system innovations.

In recent years a growing trend has be seen in research aimed at eco-innovation concerning production processes, new products or services. However, after analysing these innovative processes, it may be concluded that these are mostly growth-related innovations resulting from improvements to the production processes - rarely are they radical innovations. (Pujari, 2006, pg. 77) Defining the range between these types of innovations is very difficult, and the dividing criterion may be assumed to be the volume of knowledge and financial outlays on implementing the innovation, as well

as the resulting economic effects and consequences to the economy and enterprises introducing the new solutions (Forés & Camisón, 2016, pgs. 832-838).

The present state of environmental innovations can be found in European statistics. In years 2012-2014, nearly half of the enterprises operating within countries belonging to the European Union exhibited innovative activity (49.1%) in the scope of product, process, organizational and marketing solutions. The largest indicator was observed in Germany (67%), and the lowest in Poland (21%) and Romania (12.8%). Figure 3 presents the types of environmental benefits for enterprises and end-user, i.e., consumers, that result from implementing innovations.

Figure 3. Share of innovative enterprises that introduced innovations with environmental benefits within enterprises or for end-users in European Union, 2012–2014



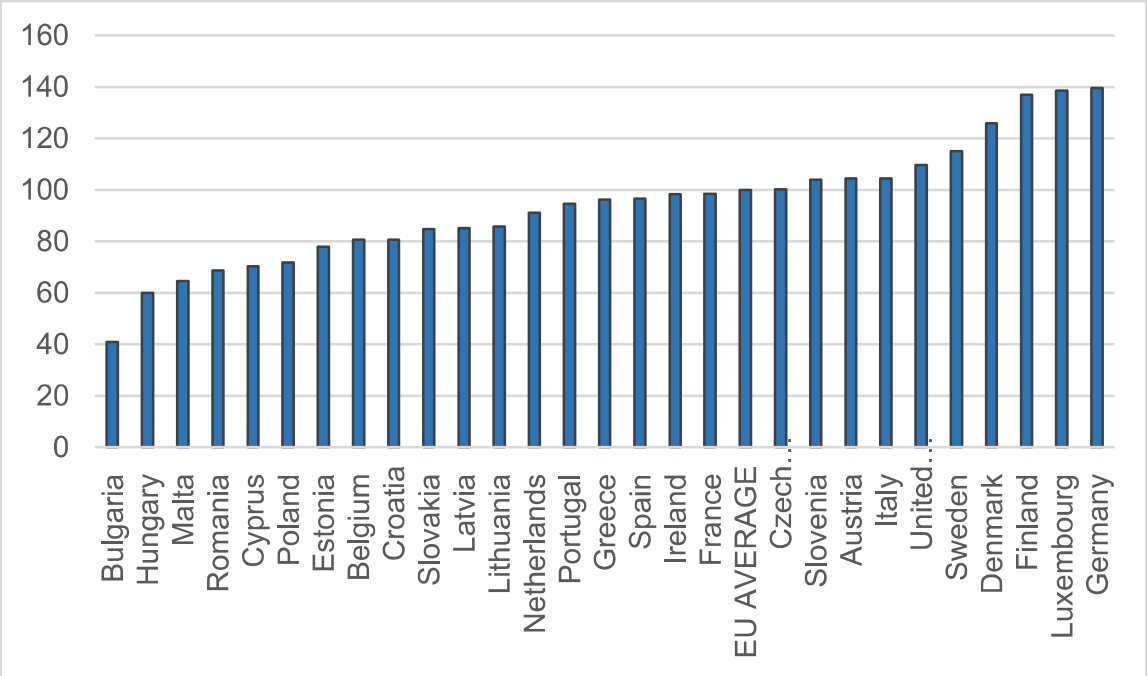
Source: Eurostat, Innovation statistics [available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Innovation_statistics, access May 12, 2017]

Nearly half (48.2%) of the innovative enterprises in the European Union introduced solutions providing environmental benefits. Almost one third (30.3%) of the countries implemented innovations bringing environmental benefits related to consumption or use of products and services. The most frequent benefits to the environment were limiting the consumption of energy and CO_2 emission - 32.3%, reducing the volume of water and materials for producing a single unit - 25.7%, reducing noise and air pollution, water and soil contamination - 24.7%, use of waste sourced from recycling for own purposes or for further resale - 20.6%. Among the most frequently seen environmental benefits obtained during final consumption or through the use of the products and services are: limiting power consumption and CO_2 emission - 24.5%, reducing noise and air pollution, water and soil contamination -

17.6%, facilitating recycling of the product after use - 15.6%, increased product life - 17.1%.

One of the tools increasing the level of ecological innovations in Europe is the Eco-Innovation Scoreboard (Eco-IS). This index, through the use of 16 indicators divided into five subgroups (i.e., outlays on eco-innovation, actions related to ecological innovations, products for ecological innovations, effectiveness of the use of resources and social and economic performance), allows to identify strong and weak areas of ecological innovations in individual European Union countries (Arundel et al., 2009, pgs. 5-6). Figure 4 presents the eco-innovativeness indicator of each EU-28 economy in 2016. The leaders in this area are Germany, which reached a score of 140, and Luxembourg with 139 and Finland with 137. Poland is ranked 23rd, with its result of 72; this is due to the fact that in the sphere of eco-innovations, the country is poorly developing. However, it has made significant progress compared to its 27th place in the year 2015. One of the reasons for this was eco-innovation in the sphere of waste management.

Figure 4. Eco-innovation Index 2016 in the European Union



Source: Giljum, Lieber & Doranova, (2017), European Union Eco-Innovation Index 2016-report [available at: https://ec.europa.eu/environment/ecoap/sites/ecoap_stayconnected/files/eio _brief_eco-innovation_index_2016_final.pdf, access May 17, 2017]

3. POLISH ECO-INNOVATIONS IN THE SCOPE OF WASTE MANAGEMENT

Technological, organizational and social eco-innovations can also be seen in municipal waste management processes (Rennings, 2000, pgs. 322-323). This paper will later discuss the above forms of eco-innovations, including examples of the solutions implemented in Poland.

Technological eco-innovations concern the use of a new technology or technique during the provision of municipal services, as well as during recycling, recovery and dumping of waste. An example of this type of innovation may be the use of a depolymerisation method, i.e. conversion of waste from plastics into liquid energy sources (oil, boiler fuel), which allows to obtain 80-85% of energy. This process is less harmful to the environment than burning waste which results in huge numbers of harmful substances, e.g. nitrogen oxides, phosgene, dioxides (Wołosiewicz-Głąb et al., 2016, pgs. 5-6).

Another example of an innovation used in the process of composting municipal waste is the use of aerated disposable foil sleeves in which an enclosed stabilization process takes place. This mechanical and biological procedure significantly reduces the release of methane to the atmosphere, and, thanks to the use of a system of pipes for distributing air into a bio-filter, it reduces the emission of undesirable odours. Moreover, thanks to its cycle time of about 8 weeks, it allows to save approximately 80% of the surface area, compared to the more frequently used bio-stabilization in prisms. This system has been successfully implemented in a dozen Polish cities (EIO, 2014-2015, pg. 9).

A very interesting and innovative solution bringing positive environmental and economic effects is the technology developed by the company Bioelektra, which consists of subjecting the waste to sterilization in specially designed hermetic containers. The waste content, under high temperature and pressure, decreases its mass, volume, as well as bacteria and parasite cultures. The process allows to separate raw materials, such as: glass, metal, plastic. Moreover, this fully ecological technology allows to obtain 99% effectiveness in recovering recycled resources in the sorting plant, reducing the waste processing plant size, investment outlays, and lowering operating costs per 1 MG of waste, as well as providing the possibility of processing unsegregated waste (Miller, 2016, pgs. 3-13).

The eco-innovative organizational solutions consist of providing waste management services in consideration of ecological aspects, as well the environmental footprint. One example of such solutions is the use of Geographical Information Systems (GIS) for making decisions relating to handling waste. This tool, based on computer technologies, allows to create, manage and analyse data in geographical space. The use of GIS provides the possibility of effectively managing the entire chain of deliveries, reducing waste volumes, while storing and processing them in a proper manner. It may be used for planning and defining waste management regions, optimizing collection times and waste truck routes (Gaska, Generowicz, 2014, pgs. 20-22). Another issue worth mentioning is an EU project named BURBA (Bottom-up selection, collection and management of URBAn waste), which was implemented, among others, in one Polish city. The project employs low-budget RFiD (Radio-frequency identification) technology and an LBS location system, which are integrated with an innovative IWAC waste container. It allows verifying the correctness of segregation, and removal of waste in the place of its occurrence. Through the use of residents' access cards allowing to open the bin lid, the inspecting authority receives information on the correctness of removing waste. Through a phone app, the same data are also received by users. Thanks to the use of these technologies,

it is possible to introduce motivating waste handling programs, e.g. lowering payments for waste disposal (UK, 2015).

Social eco-innovations consist of including human capital in the environmental goals, and shaping and introducing pro-ecological patterns of behaviour (Miklińska & Klopott, 2016). In the scope of municipal waste disposal, an example of this may be local sorting plants in specially constructed pavilions for such purpose. According to the hierarchy of waste treatment, it managed at an early stage of its generation and acceptance. The EKO AB system, which is innovative and attractive from the point of view of environmental protection and the economy, is a solution used in two Polish cities (Płock, Bytom Odrzański). It provides very good results, e.g. recovery and sale of recycled resources, and recovery of waste directed for segregation - at a level of 75-80%, reducing the volume of waste directed for sorting to 20-25%. This system also ensures the fulfilment of the European Union Directive within the specified timeframe, lower payment for solid waste disposal per resident, new workplaces for persons with low occupational qualifications, as well as ones having problems with supplementing their labour history for retirement purposes (Bartoszkiewicz, 2013).

In Poland, there is a growing interest in new solutions with regard to ecological innovations. This can be seen in the amount of scientific research devoted to environmentally-friendly implementations. Many of them are aimed at efficient and ecological management of municipal waste. In addition, Polish companies are increasingly eager to use ecological innovations in the area of transport, collection and storage services for municipal waste.

4. SURVEY FINDINGS

4.1. Survey purpose and methodology

In order to accomplish the purpose of this article, the decision was made to conduct a survey among enterprises collecting waste, dealing with its segregation, recycling, processing, disposal, and managing dumps. Regionalization is the basis of the waste management system in Poland. The country is divided into 81 regions with 172 regional municipal waste treatment facilities. The study selected the 75 largest in terms of the weight of treated waste from regional processing plants and 75 companies involved in the collection and transportation of waste to these points.

The survey aimed at verifying the use of eco-innovations in performing the process of handling waste, and at showing the attitude of these entities to eco-innovations. A questionnaire was created with the use of a template provided by Google. In order to unify the concept of eco-innovation by respondents, the questionnaire started with a definition and classification. It consisted of 10 questions on the causes and types of eco-innovation and barriers and further plans to implement these solutions in the companies surveyed.

The questionnaire was sent to 150 companies dealing with municipal waste in Poland, and the response rate was 50%.

4.2. Survey result

The survey finding was as follows:

- 67% of respondents use at least a single eco-innovative solution in providing their services related to handling municipal waste; the majority of recipients specified that these are technological and/or organizational innovations (92%),
- another inquiry was the reason for introducing the eco-innovation (multiple choice answer) - as many as 89% respondents pointed out that the main reason was the European Union's legal regulations relating to, among others, the means of transport (5 or 6 EUR standard in vehicles), and the necessity to increase recycling levels; moreover, 25 respondents specified pressure from an administrative commune as a reason - the communes want to present themselves as an eco-friendly region; 30 enterprises acted with the idea of lowering costs; 28 respondents introduced the new methods for the purpose of minimizing their environmental footprint,
- the eco-innovations used by the respondents only originate from European Union countries (about 32%), only from the domestic market (about 16%), outside Europe (4%), whilst 36% of the employed solutions come from the domestic and/or EU and/ or external EU market,
- 72% of the respondents notice economic benefits from the use of eco-innovations; this mostly applies to transportation companies which, thanks to the use of carriage route optimization tools, reduced their fuel consumption,
- environmental benefits are identified by 48 of the surveyed enterprises, and 75% of them are regional waste handling stations which point out that the implemented eco-innovations cause a year-to-year reduction in the number of deposited waste, and an increase in the fractions submitted to recycling.

Concerning the willingness to implement further eco-innovations in the service-providing processes, the responses were as follows:

- a little over two-thirds of the respondents would willingly introduce new solutions on the condition of receiving subsidies, financial incentives, or external co-funding of their purchase,
- 52% of the respondents claim that eco-innovations may strengthen the competitiveness of their companies on the market,
- among the largest barriers are: excessive costs of technological investments (85%), too few purchase-financing programs (73%), current regulations and structures that fail to provide sufficient incentive to eco-innovation (60%), unsure return on investment, or too long a return period (48%),
- from the respondents' perspective, the most important parameters that should characterize new eco-innovations are: shortening the duration of transportation, collection, segregation, utilization process times - 72%, lowering the costs of these processes - 92%, reducing the negative impact on the environment - 45%, reduction in employment - 15%.

The respondents' answers also included claims that, despite increased financial outlays from the Innovative Economy Operating Program in years 2007-2011, the effects of the carried out actions will only be noticeable to a limited extent. However, the respondents are seeing large possibilities in the "Europe 2020" program, which puts a lot of emphasis on eco-friendly technologies.

Even though the entrepreneurs participating in the process of waste management in Poland currently use modern and eco-innovative solutions, the main reason for their implementation is the imposed European Union regulations. In their opinion, the important barriers include a lack of sufficient co-financing, and excessive costs of purchasing technologies. Despite these barriers, the Polish companies are still interested in implementing new solutions, on the condition of external subsidization. In their opinion, eco-innovations must, most of all, generate cost and time savings - the ecological factor is of secondary importance. Eco-innovations are to be deemed an important issue, especially since the respondents see significant environmental and financial benefits from the solutions implemented so far. Modernization of the Polish process of managing municipal waste must be continued, so that the required levels of recycling and preparing of paper, metals, plastics and glass to re-use are achieved by 2020.

Poland has already taken a big step towards achieving these limits. The decreasing annual volume of generated municipal waste as well as the amount of waste entering landfills are evidence of this process. Thus, the experience resulting from the development of eco-innovation in Poland may undoubtedly constitute an example to follow for other countries. The solutions applied in Poland can be transferred directly to them and they could become an inspiration and determine the desirable course of development.

5. CONCLUSION

Eco-innovation aims not only at reducing the environmental impact, but also at increasing competitiveness and growth through more efficient use of natural resources. The use of eco-innovation in the area of waste management fosters the development of new processes, technologies and services that make businesses more environmentally-friendly and reduces operating costs. The EU has launched a number of programs that support eco-innovation but should speed up the process of practical implementation of good ideas. According to the survey conducted, Polish companies are willing to implement new ecological solutions provided financial support in their purchase is available. The next step will be to expand the research by increasing the number of respondents and covering the other cells involved in the waste management process in Poland, i.e., resellers and dealers in waste management.

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