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ECO-INNOVATIONS IN POLAND – THE EXTENT OF CHANGES, DEVELOPMENT AND BARRIERS

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Abstract: Competitiveness and innovation are indicators of the strength of the circular economy (CE). Eco-innovations are highly important because they lead to the reduction of energy consumption and to lowered CO_2 emissions. They also contribute to effective waste management and the use of materials that are less polluting or dangerous to the environment. These investments will increase Europe's economic competitiveness through environmental protection, the creation of new jobs and the promotion of entrepreneurship. The article indicates the scope and directions of changes in the implementation of eco-innovations in Poland and the obstacles that slow down the process of their activation. The presented ecological innovations were divided into: process, product, organizational and marketing. The data analysis was based on reports from the European Union (Eurostat), the Central Statistical Office (Polish: GUS) and the Polish Agency for Enterprise Development (Polish: PARP). In the summary, attention was drawn to the biggest barriers to the putting into place eco-innovations. Among these are the lack of financial resources, too high costs of eco-innovation implementation, legal obstacles and bureaucracy. The benefits for the environment are obvious, but investment costs often outweigh the financial possibilities of manufacturing or service, and, therefore, they are a factor slowing down the introduction of CE in Poland.

Keywords: circular economy, recycling waste, reduce energy consumption, innovation.

1. Introduction

For many years, European Union (EU) countries have been striving to practice the principles and goals of the idea of sustainable development. This can, however, be achieved through a real combination of three components, i.e. economic development with environmental protection and social justice. This development seeks to continuously improve

the quality of life and to achieve the well-being of present and future generations. Recognizing the anthropogenic threats from the excessive production and consumption of European society, the European Commission has developed documents (directives, communications) aimed at limiting this trend. Starting from 2008, the priority task of the EU countries has been to lead to the so-called *Recycling societies* (Directive 2008/98/EC), then to: *A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy* (COM/2011/21), improving products and improving production efficiency, transforming waste into resources, supporting research and innovation in the pursuit of a resource-efficient society and for rational consumption (COM/2011/571; COM/2014/398).

'A concept aimed at the rational use of resources and limiting the negative environmental impact of manufactured products, which – like materials and raw materials – should remain in the economy for as long as possible, and waste production should be minimized as much as possible' is the **circular economy** concept (CE) (Ministry of the Environment, 2019). The CE concept when put into practice allows to keep the added value of products for as long as possible and to completely eliminate waste and thus to save raw materials. It consists in closing the life cycle of products (so-called *Cradle to Cradle – C2C*), in which the product does not end up in the bin and landfill after its use, but is reused through recovery and recycling (also in the form of in-product recycling, industrial symbiosis and the so-called 'Waste markets') (Zarębska, 2019, p. 31). This concept is impossible to achieve without the actualization of innovations, especially eco-innovations. That is why the ability of the EU to put into place such endeavors is one of the CE indicators of success, alongside: (1) production and consumption, (2) waste management, (3) secondary raw material, and also (4) competitiveness and innovation.

The aim of the article is, at the EU level / background, to characterize the directions of changes in the realization of eco-innovation in Poland, and to indicate the obstacles faced by enterprises during their implementation. In the description and analysis of the data, European Union (Eurostat), Central Statistical Office (Polish: GUS) and the Polish Agency for Enterprise Development (Polish: PARP) reports were used. Eco-innovations are a particularly important issue because in addition to the benefits achieved by the enterprises that put these into play, there are also so-called 'external benefits', which their inventor cannot completely own. The external benefits in this case are related to social benefits related to the improvement of the natural environment, the company's environment and the general quality of life of the society.

2. Types and extent of eco-innovations

Eco-innovation can be understood very broadly because of its semantic volume, and therefore there are many definitions and classifications of this concept. This is discussed in

depth in publications from J.A. Schumpeter (1960), through C. Fussler (1996), OECD (2009), also: M. Bukowski, A. Szpor, A. Śniegocki (2012), K. Olejniczak (2015, pp 54-62), J. Zarębska and M. Michalska (2016, pp. 49-64) or I. Żabińska and E. Sujova (2016, pp. 1531-1536).

In the European Commission's Communication *Innovation for a sustainable Future – The Eco-innovation Action Plan (Eco-AP)*, we say that **eco-innovation** is 'innovation in any form whose outcome or goal is significant and visible progress towards achieving sustainable development by reducing the negative environmental impact, increasing resilience to environmental burdens or achieving more efficient and responsible use of natural resources' (COM/2011/0899 final). The Polish Agency for Enterprise Development defines ecological innovations in more detail as 'any innovation, implemented in accordance with applicable law, which brings environmental benefits, in particular in the form of minimizing the consumption of natural resources per unit of product produced and minimizing the release of hazardous substances into the environment during the manufacture and use of the product' (Woźniak, Strojny, Wojnicka, 2010, p. 9).

The European Commission has always been supportive of research and development projects in the field of eco-innovation via support through: research and technological development, competitiveness and innovation (CIP – Competitiveness and Innovation Framework Programme), support for first time eco-innovations and their market replication, the European eco-innovation platform and the environmental part of the LIFE + program. Together with these programs, Member States and regions can also benefit from cohesion policy support for the further implementation and replication of eco-innovation. The Community Innovation Survey (CIS) was also created, which forms the basis of statistical surveys according to the 'Oslo methodology' and a source of information on innovative activities in the European Economic Area (EEA). Based on the systematics contained in *the Oslo Manual* (OECD / Eurostat 2005), eco-innovations can be seen in: product, process, organizational and marketing. R. Kemp and P. Pearson (2007) in *the final report MEI* project, propose a similar typology of eco-innovation, namely: environmental technologies, organizational innovations, product and service innovations (from product and service innovations) and 'green' system innovations. Moreover, M.M. Anderson (2002, pp. 103-119) proposes an interesting typology of eco-innovation, according to which research should focus on the analysis of their integration in the economic process and should be their: add-on eco-innovations and integration (from integrated eco-innovations).

The authors of the study, using the Database – Eurostat, have compiled eco-innovation indicators in Table 1. Due to the limited volume of the study, the article presents only a few sets of eco-innovation indicators. These reveal Poland's place compared to other European countries.

Table 1.
The comparison of certain indicators eco-innovations

<table>
<tr><th colspan="4">Indicators eco-innovations:</th></tr>
<tr><th colspan="2">Indicators sustainable development:</th><th colspan="2">Indicators circular economy:</th></tr>
<tr><td>Goal 1:
…
Goal 8:</td><td>…</td><td>1) Production and consumption:</td><td>…</td></tr>
<tr><td rowspan="3">Goal 9: Industry, innovation and infrastructure:</td><td rowspan="3">a) Gross domestic expenditure on R&D by sector
b) Employment in high- and medium-high technology manufacturing and knowledge-intensive services
c) R&D personnel by sector
d) Patent applications to the European Patent Office (source: EPO)
e) Share of busses and trains in total passenger transport
f) Share of rail and inland waterways in total freight transport
g) Average CO2 emissions per km from new passenger cars (source: EEA, DG CLIMA)</td><td>2) Waste management:</td><td>…</td></tr>
<tr><td>3) Secondary raw materials:</td><td>…</td></tr>
<tr><td rowspan="2">4) Competitiveness and innovation:</td><td rowspan="2">a) Private investments, jobs and gross value added related to circular economy
b) Patents related to recycling and secondary raw materials</td></tr>
<tr><td>Goal 10:
…
Goal 17:</td><td>…</td></tr>
</table>

Source: own study on the basis of Database – Eurostat 2019.

3. Tendencies of changes in eco-innovation implementation in the context of sustainable development and circular economy

In Database – Eurostat, the **sustainability indicators (SD)** have been divided into 17 goals, of which goal 9 is called: 'industry, innovation and infrastructure'. Goal 9 is itself divided into 7 indicators (also compiled in Table 1):

a) gross domestic expenditure on R&D by sector,
b) employment in high- and medium-high technology manufacturing and knowledge-intensive services,
c) R&D personnel by sector,
d) patent applications to the European Patent Office,
e) share of busses and trains in total passenger transport,
f) share of rail and inland waterways in total freight transport,
g) average CO_2 emissions per km from new passenger cars.

According to Figure 1, for many years, Poland has been investing in new solutions (expenditures are growing), but in spite of this, it ranks as the low fifth position from the end among European countries in terms of *gross domestic expenditure on R&D by sector*. Poland

(in 2017 – 1% of GDP), together with Romania, Latvia, Slovakia, Lithuania, Spain, Hungary, Italy and Portugal is well below the European average, oscillating around 2% of GDP.

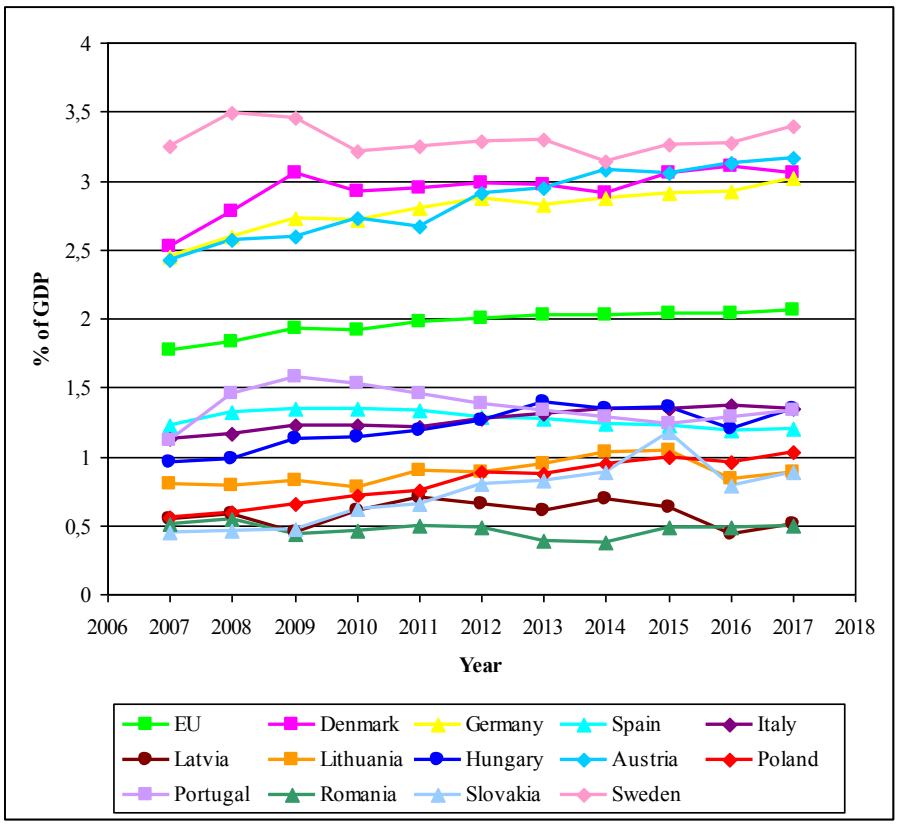

Figure 1. Gross domestic expenditure on R&D by sector [% of GDP] in years 2007-2017 (own work on the basis of Database – Eurostat 2019).

According to Figure 2, in the scope of *R&D personnel by sector* [% of active population], Poland, as in domestic expenditures on the R&D sector, is in the fifth place from the end. People employed in the R&D sector in Poland constitute only 0.85% of the active population, the EU average is 1.28%. Denmark, Sweden, Austria and Germany are the countries with the highest number of people employed in the R&D sector and probably therefore belong to the countries with the highest number of patents. These countries far outstrip the EU average in statistics. Figure 3 presents a list of European countries in the field of *Patent applications to the European Patent Office* [per million inhabitants].

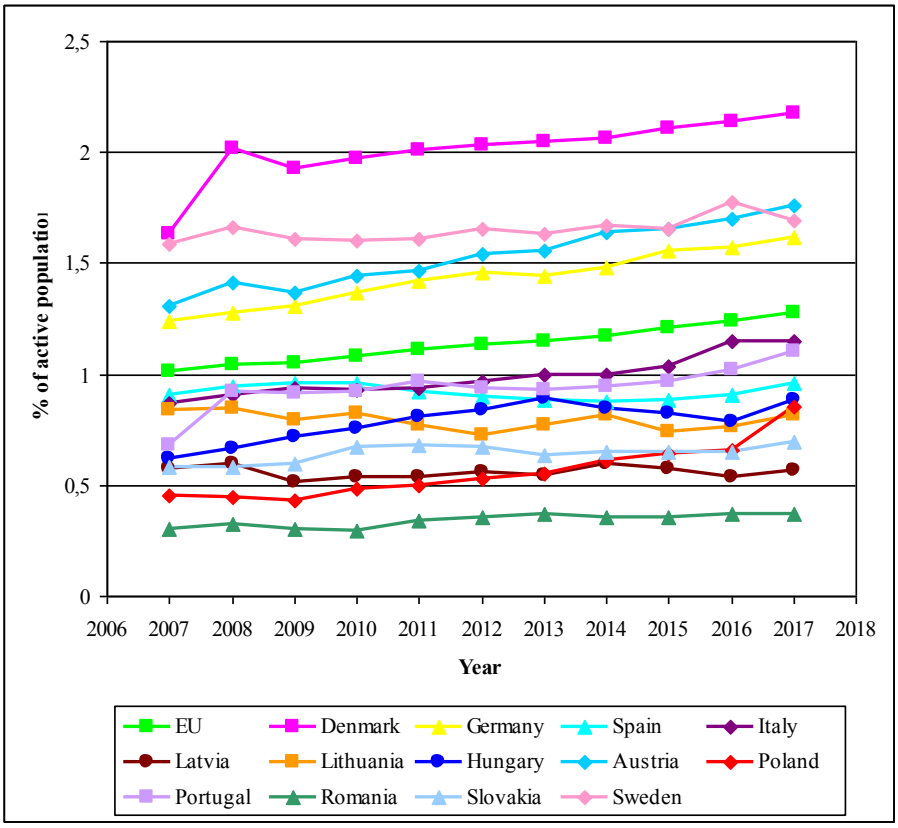

Figure 2. *R&D personnel by sector* [% of active population] (own study on the basis of Database – Eurostat 2019).

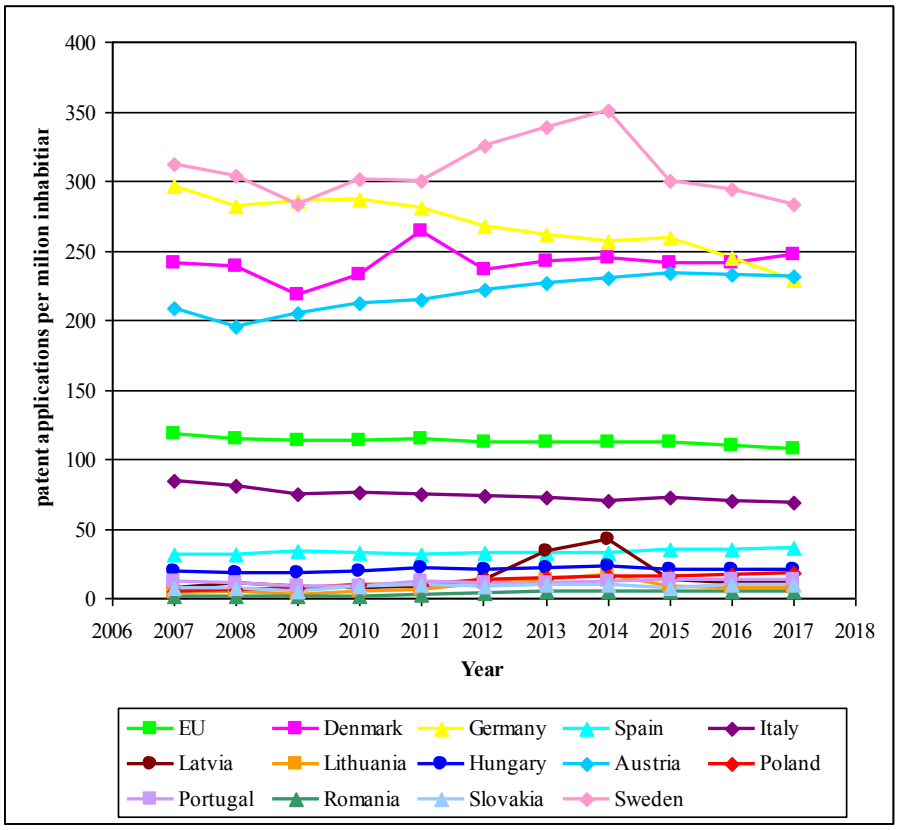

Figure 3. Patent applications to the European Patent Office [per million inhabitants] (own study on the basis of Database – Eurostat 2019).

In Database – Eurostat, the innovation indicators relating to the **circular economy** (CE) are summarized in two categories (cf. Table 1): a) *Private investment, jobs and related costs to circular economy sectors* and b) *Patents related to recycling and secondary raw material*. Figure 4 is a listing of countries whose data for all categories were complete in the period 2008-2016. Poland ranks fourth among fourteen, as the country investing not all 1000 Miles Euro per year in circular economy sectors. The most prominent and the greatest investor in the CE sector are countries such as Germany and Italy, and the least: Latvia, Lithuania, Hungary, Slovakia, Portugal and Denmark.

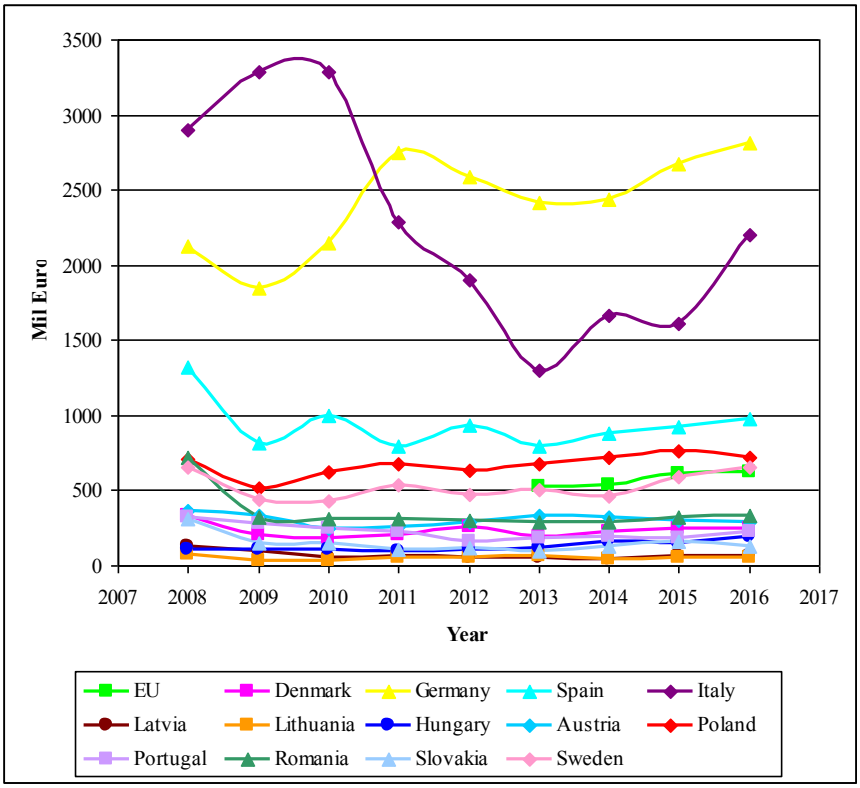

Figure 4. Private investments, jobs and gross value added related to circular economy sectors in the years 2008-2016 for certain European countries (own study on the basis of Database – Eurostat 2019).

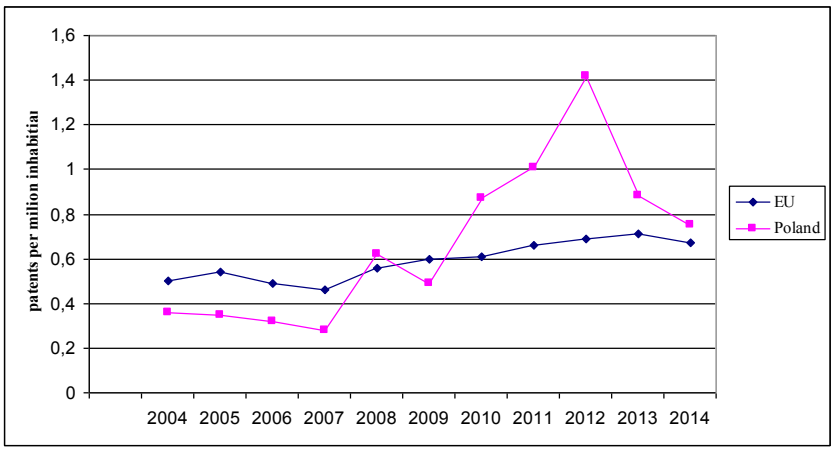

Figure 5. Patents related to recycling and secondary raw materials in years 2004-2014 (own study on the basis of Database – Eurostat 2019).

Index b) *patents related to recycling and secondary raw material* for CE is shown in Figure 5. Accordingly, Poland had the largest number of registered patents in 2012 (1.4 patents per million inhabitants) and then this rate dropped to 0.88 in 2013 and 0.75 in 2014. The subsequent years are not, unfortunately, included in the Eurostat database. Since 2010, the CE patent rate in Poland has been higher than the European average. The most stable countries in the field of patents, above the European average, are Germany and Austria (Database – Eurostat 2019).

4. Eco-innovations in Poland

In Poland, the Central Statistical Office (GUS) has the responsibility of compiling the results of innovation research according to the systematics of the Oslo Manual. Lately, GUS has revealed the share of Polish enterprises (industrial and service) that have introduced innovations (including eco-innovations) resulting from their specific types: product, process, organizational and service. The list includes three-year periods, namely, the years: 2012-2014, 2014-2016 and 2015-2017 (GUS 2015, GUS 2017, GUS 2018). The article compares the extreme periods, namely the years 2012-2014 and 2015-2017. In 2015-2017, compared to 2012-2014, there was a marked increase in innovation in the industrial and service enterprises sector (Figure 6). Herein, the growth in the sector of industrial enterprises (average value for all types of innovations) amounted to around 9%, in the sector of service enterprises – around 7%. The largest increase was observed in the sector of industrial enterprises in the group of process innovations – by 11.2%, the smallest in the sector of service enterprises in the group of product innovations – by 3.7%. Taking into account the size classes of enterprises, in all years, the highest percentage of innovation active entities was among large entities employing 250 people and more.

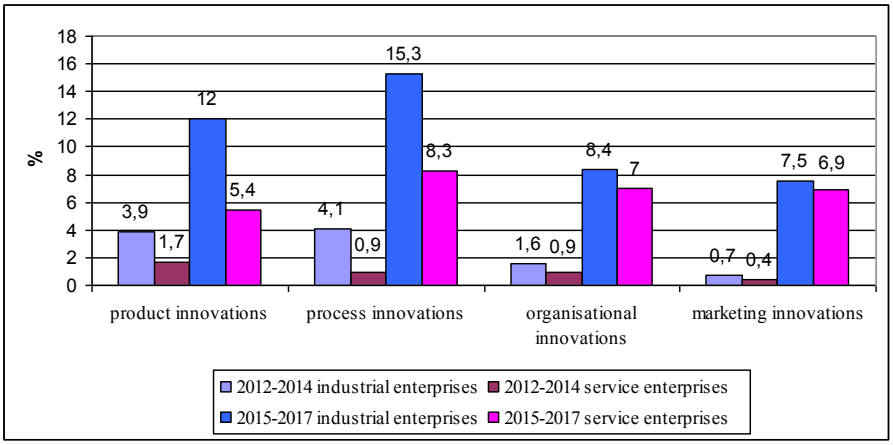

Figure 6. Innovation of Polish manufacturing and service enterprises [in %] (own study based on GUS 2015, p. 125; GUS 2018, p. 26-48).

Furthermore, the largest number of eco-innovations are introduced every year by manufacturing companies regardless of the categories and type of innovation. A comparison of the share of enterprises that introduced eco-innovations that bring environmental benefits in the production phase of a product or service by type of benefits is presented in Figure 7, while the benefits that bring benefits in the phase of use of a product or service by end users are presented in Figure 8.

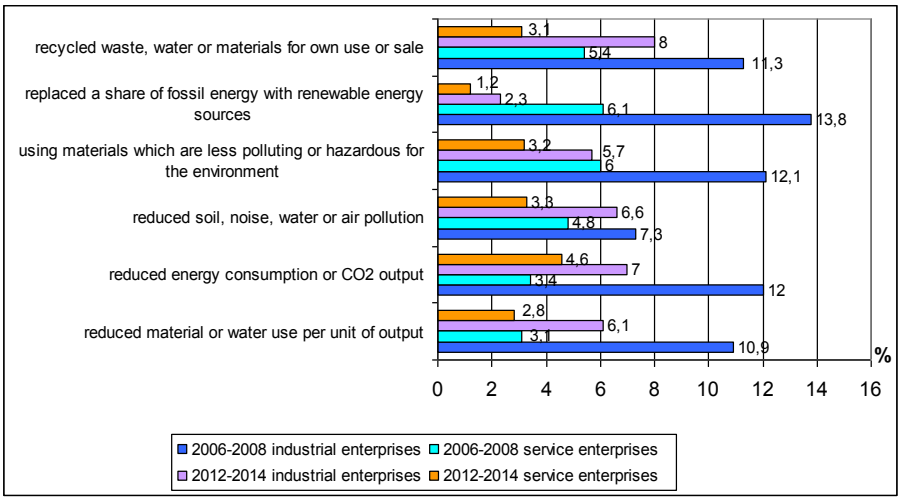

Figure 7. Eco-innovations that bring benefits to enterprises in the phase of manufacturing goods or services [in%] (Zarębska and Michalska, 2016).

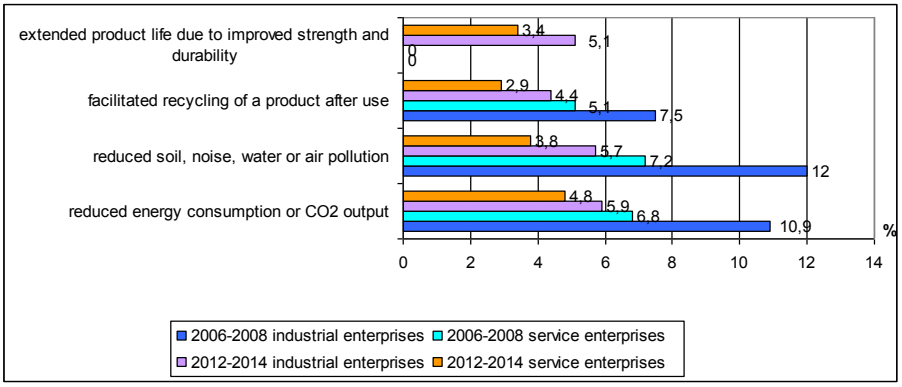

Figure 8. Eco-innovations that bring benefits to enterprises in the phase of use of a product or service by end users [in%] (Zarębska and Michalska 2016).

The most eco-innovations that bring benefits to enterprises in the phase of production of goods or services were submitted for patent in 2006-2008, and this concerned: replacement of fuels with renewable energy sources – 13.8%, using materials which are less polluting – 12.1%, reduced energy consumption or CO_2 output – 11.3%, for companies in the use phase of the product or service by end users – reduced soil, noise, water or air pollution – 12%. In 2012-2014, there was a significant decline in eco-innovations. In subsequent years, GUS ceased to distinguish eco-innovations in the compilations. In the summary for the years 2015-2017, eco-innovations were described among other sections of the Polish Classification of Activities (PKD) by section (GUS, 2018, p. 22):

- electricity, gas, steam and air conditioning supply – 33.4%,
- sewerage – 21.4%,
- water collection, treatment and supply – 20.4%,
- waste collection, treatment and disposal activities; materials recovery – 13.8%,
- remediation activities – 10%.

The change in the GUS formulas from 2015-2017 makes it impossible to compare them with previous years.

5. Summary

The need to implement the sustainable development and circular economy principles by popularizing eco-innovation is an important goal of present and future generations. The European Union supports such activities, which is reflected, inter alia, in the adopted "Europe 2020 strategy".

Despite the fact that Poland has a large innovation potential, it does not even reach the European average. For many years, the implementation of solutions classified as the ecological innovations has been observed to a greater or lesser extent. However, because statistics are not always complete (for example, the obligation to submit data on costs incurred on R&D in the companies' reports was removed), we generally do not fall out optimistically against other EU countries (Figure 2). In addition, the lack of financial resources of own enterprises (especially micro and small ones), too high costs of eco-innovation implementation, legal and tax obstacles and bureaucracy are the key barriers that slow down the implementation and dissemination of eco-innovation in the country.

References

1. Andersen, M.M. (2002). Organising Interfirm Learning – as the Market Begins to Turn Green. In T.J. De Bruijn, and A. Tukker (Eds.), *Partnership and Leadership – Building Alliances for a Sustainable Future* (pp. 103-119). Dordrecht: Kluwer Academic Publishers.
2. Bukowski, M., Szpor, A., and Śniegocki A. (2012). *Potencjał i bariery polskiej innowacyjności*. Warszawa: Instytut Badań Strukturalnych.
3. COM/2011/0899 final, Innovation for a sustainable Future – The Eco-innovation Action Plan (Eco-AP). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions (2011).

4. COM/2011/21, A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy. European Commission (2011).
5. COM/2011/571, Roadmap to a Resource Efficient Europe. European Commission (2011).
6. COM/2014/398, Towards a circular economy: A zero waste programme for Europe. European Commission (2014).
7. *Database – Eurostat*. (2019). Available online: https://ec.europa.eu/eurostat/data/ database, 27.06.2019.
8. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. European Commission (2008).
9. Fussler, C. (1996). *Driving Eco-innovation: A Breakthrough Discipline for Innovation and Sustainability*. Pitman Publishing.
10. Główny Urząd Statystyczny (2015). *Działalność innowacyjna przedsiębiorstw w latach 2012-2014*. Warszawa-Szczecin: Urząd Statystyczny w Szczecinie. Available online: https://stat.gov.pl/obszary-tematyczne/nauka-i-technika-spoleczenstwo-informacyjne/ nauka-i-technika/dzialalnosc-innowacyjna-przedsiebiorstw-w-latach-2012-2014,2,13.html, 20.06.2019.
11. Główny Urząd Statystyczny (2018). *Działalność innowacyjna przedsiębiorstw w latach 2015-2017*. Warszawa-Szczecin: Urząd Statystyczny w Szczecinie. Available online: https://stat.gov.pl/obszary-tematyczne/nauka-i-technika-spoleczenstwo-informacyjne/nauka-i-technika/, 20.06.2019.
12. Kemp, R., and Pearson, P. (2007). *Final report MEI project about measuring eco-innovation (Report No 044513)*. Retrieved from https://www.oecd.org/env/consumption-innovation/43960830.pdf, 30.06.2019.
13. *Ministerstwo Środowiska*. Available online: https://www.gov.pl/web/srodowisko/goz, 20.06.2019.
14. OECD (2009). *Eco-Innovation in Industry Enabling Green Growth*. Publisher OECD.
15. OECD/Eurostat (2005). *Podręcznik Oslo. Zasady gromadzenia i interpretacji danych dotyczących innowacji. Pomiar działalności naukowej i technicznej*. Warszawa: Ministerstwo Nauki i Szkolnictwa Wyższego. Retrieved from http://rpo.podkarpackie.pl/ images/dok/OS_I/2015/1_4_1/Inne_Przyd_dok/Podrecznik-OSLO-MANUAL.pdf, 20.06.2019.
16. Olejniczak, K. (2015). Innowacje ekologiczne jako narzędzie wspierania zrównoważonego rozwoju. *Zeszyty Naukowe Politechniki Częstochowskiej. Zarządzanie, 19*, 54-62. Retrieved from: http://www.zim.pcz.czest.pl/znwz/files/Innowacje-ekologiczne-jako-narz-dzie-wspierania-zrownowa-onego-rozwoju.pdf, 20.02.2019.
17. Schumpeter, J.A. (1960). *Teoria rozwoju gospodarczego*. Warszawa: PWN.
18. Woźniak, L., Strojny, J., and Wojnicka E. (2010), *Jak budować przewagę konkurencyjną dzięki ekoinnowacyjności?* Warszawa: Polska Agencja Rozwoju Przedsiębiorczości.

19. Zarębska, J. (2019). *Zagospodarowanie odpadów opakowaniowych w kontekście gospodarki o obiegu zamkniętym – istota, narzędzia, komunikacja środowiskowa.* Zielona Góra: Oficyna Wydawnicza Uniwersytetu Zielonogórskiego.
20. Zarębska, J., and Michalska, M. (2016). Ecological innovations as a chance for sustainable development – directions and obstacles in their implementation. *Management, 20, 2,* 49-64. DOI: 10.1515/manment-2015-0050.
21. Żabińska, I., Sujova, E. (2016). Policy of innovation development at the wood sector in Poland. *Science Journal, 6,* 1531-1536. DOI: 10.17973/MMSJ.2016_12_201696.