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THE MEASUREMENT OF ENVIRONMENTAL AND RESOURCE PRODUCTIVITY IN THE GREEN ECONOMY

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POMIAR ŚRODOWISKOWEJ EFEKTYWNOŚCI PRODUKCJI W ZIELONEJ GOSPODARCE

STRESZCZENIE: Globalny kryzys gospodarczy z 2008 r. zmusił przywódców państw do poszukiwania nowych ścieżek rozwoju. Jedną z takich dróg może okazać się „zielony wzrost" prowadzący do osiągnięcia „zielonej gospodarki". Wymaga to jednak podejmowania działań polegających na zrównoważonym korzystaniu z kapitału przyrodniczego, zachowaniu zdolności ekosystemów do świadczenia określonych usług oraz zapewnieniu dobrej jakości elementów środowiska, niepowodujących negatywnych oddziaływań na zdrowie i życie ludzi. Działania te powinny umożliwić pogodzenie wzrostu gospodarczego z troską o środowisko.

W tej sytuacji niezbędne stało się monitorowanie skuteczności podejmowanych działań i stanu „zazielenienia gospodarki". Polska statystyka publiczna opracowała zestaw miar, które mogą być wykorzystane w procesie tego monitorowania.

Celem artykułu jest zaprezentowanie jednej z grup tych miar odnoszących się do środowiskowej efektywności produkcji. Artykuł podzielony został na dwie części. W pierwszej z nich przedstawiono zagadnienia teoretyczne dotyczące zielonej gospodarki oraz wskaźniki służące do jej pomiaru. Druga zaś poświęcona została zaprezentowaniu sytuacji Polski na tle krajów Unii Europejskiej w zakresie grupy wskaźników dotyczących środowiskowej efektywności produkcji.

SŁOWA KLUCZOWE: zielona gospodarka, środowiskowa efektywność produkcji, wskaźniki monitorowania.

Introduction

The global economic crisis of 2008 determined the perception of the environment, its condition, its diversity and its wealth as a basic element of the emerging prosperity of societies. It forced the world leaders to seek new development paths, taking into account the needs for environmental protection and the prevention of adverse effects of human activities. "Green growth" may be a good way to achieve "the green economy". However, it requires action to be taken to reconcile economic growth with care for the environment, sustainable use of natural resources, the maintaining of ecosystems' capacity to provide specific services and the provision of good-quality elements of the environment, avoiding adverse effects on the health and lives of the citizens.

Along with the increasingly wider use of this approach to growth, the need to develop solutions to measure progress in "greening" economies appeared.

The Central Statistical Office of Poland has developed a measurement methodology that can be used in the monitoring process. The aim of the article is to present one of the indicator groups relating to the environmental and resource productivity of the economy. The presentation of the indicators is preceded by a list of the theoretical issues relating to the green economy and the indicators used to measure it. Achieving this objective required a review of the literature, including international organisations' reports, and the study and selection of the statistical figures that describe the issues under discussion.

The range of presented indicators and values is drawn by the scope of issues subjected to monitoring and by the availability of valuable comparable statistical data from the Polish Statistical Office as well as from other domestic and international organisations.

The green economy – definition perspective and measurement methodology

The Central Statistical Office of Poland, learning from the achievements of the Organisation for Economic Co-operation and Development and other environmental organisations, like the United Nations Environment Programme (UNEP) and the European Environment Agency (EEA), has adapted

the definition of the green economy to Polish conditions, identified the areas where it is formed and developed a set of monitoring indicators.

"Green economy" defines an economy that promotes growth and economic development, along with maintaining the access to natural capital and ecosystem services on which human welfare depends[1].

An examination of the green economy in Poland mainly includes an assessment of the state of the natural environment and economic efficiency. However, the social aspect is recognised to a lesser extent – only the part that remains in direct relation to the environment or the economy[2].

The basis of the economy and society is in fact the environment and economic development. These elements (environment, economy and society) are related in a certain way, and that was used to define four areas to monitor the state of the green economy in Poland, namely[3]:

- the natural capital – including indicators describing the state of the natural environment;
- the environmental efficiency of production – including indicators of the relationship between the natural environment and the economy;
- the environmental QOL of the people – including indicators used to monitor the relationship between the natural environment and the society;
- economic policies and their consequences – including indicators characterising instruments of influence on the economy and society, giving rise to the desired directions of development aimed at greening the economy.

In this study the second of the listed indicator groups was analysed. It refers to the use of environmental resources, labour and capital to produce goods and services. Side effects of production are pollution and waste, which are absorbed and stored in the environment. The priority in the development of a green economy is to increase the effectiveness of the use of the environment. Its aim is to break the relationship between economic growth and increased use of natural resources.

Efficiency and its fluctuations over time are the most commonly used measures in the green economy; therefore, increased efficiency in the use of the environment is a prerequisite in the process of green economy development. Effective management of natural resources and waste should in fact lead to a reduction of the negative impact on the environment[4].

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1 *Towards Green Growth: Monitoring Progress OECD Indicators 2011*, Paryż 2011, p. 9.

2 Position not published: the report of the methodological work *Examination of Green Economy Status in Poland – Definition and Compilation a Set of Measure Indicators,* Białystok 2016, p. 10.

3 Ibidem, pp. 11–12.

4 *Wskaźniki zielonej gospodarki w Polsce,* (*Green Growth Indicators in Poland*), Białystok 2016, p. 54.

The sphere of production and its relationship with the natural environment were a starting point for the isolation of a group of indicators of the green economy illustrating the environmental efficiency of production, as shown in Table 1.

Table 1. Indicators of environmental efficiency of production

Issue	Group Indicator/Measure
Energy	Energy management 1. Productivity of primal energy 2. Final energy consumption Renewable energy 1. The share of renewable energy in the gross final energy consumption
Greenhouse gases	Greenhouse gas emissions 1. Greenhouse gas emissions 2. Greenhouse gas emissions according to source of emission
Resources	Domestic material consumption 2. Resource productivity (GDP/DMC) 3. Domestic material consumption per capita Waste management 1. Municipal waste produced per capita 2. Recycling of packaging waste Balances of nitrogen and phosphorus 1. Gross nitrogen balance 2. Gross phosphorus balance Water management 1. Water consumption for the needs of the national economy and population per capita 2. Water productivity[a] 3. Water absorption of industry[a] 4. Water absorption of households[a] 5. The water exploitation index (WEI)[b]

[a] Data available only at the national level.
[b] In the methodological work undertaken by the Statistical Office in Bialystok, this measure was classified in the area of natural capital as one of the indicators of renewable resources.

Source: own work in the context of the methodological work undertaken by the Statistical Office in Bialystok.

The greater part of the indicators listed in Table 1 can be presented not only for Poland but also for other countries of the European Union, enabling international data comparisons.

The environmental efficiency of production in Poland in the context of the European Union

To assess the effectiveness of the use of environmental resources in production processes, we should first examine the process of shaping a measure showing the energy management, the renewable and non-renewable natural resources and the issues concerning greenhouse gas emissions as the adverse effects of human activities.

Energy is used in production and in households. The effective use of energy stands as an important factor in shaping the production costs and the competitiveness of products in the international market. The irrational use of energy causes pollution problems (greenhouse gas emissions) and the depletion of energy resources. The demand for energy is constantly growing; therefore, an improvement in energy efficiency and the rational use of the existing energy resources should be among the main priorities of the green economy[5].

In 2014 the primary energy consumption in the EU countries reached 1,507.1 Mtoe.[6] Among the countries showing the highest consumption levels were Germany (291.8 Mtoe), France (234.5 Mtoe), the United Kingdom (182.4 Mtoe) and Italy (143.8 Mtoe), while the Polish consumption of 89.1 Mtoe was ranked in the sixth place among the 28 countries of the European Union.

Most often economic growth is accompanied by an increased demand for energy. It is certainly important that the energy consumption rate should rise at the lowest possible rate in relation to the GDP growth[7]. Accordingly, to assess the effectiveness of the energy policy in the EU, the indicator of energy productivity is used. This is the relationship between the GDP and the consumption rate of primal energy. A higher value indicates lesser use of energy to produce 1 GDP unit. According to data from Eurostat, for the 28 countries of the EU, the energy productivity ratio was 8.7 PPS/kgoe in 2014 (Figure 1).

According to the data presented in Figure 1, the leaders among the countries with the highest level of the analysed index are as follows: Ireland (12.5 PPS/kgoe), Denmark (11.4 PPS/kgoe) and Malta (11.4 PPS/kgoe). This value

5 *Green Growth Indicators* ..., p. 113.

6 Million tonnes of oil equivalent; toe – tonne of oil equivalent (contractual) is a measure unit of the energy of different types, using conversion factors. It is applicable in international balance sheets. It equals the amount of energy produced from the combustion of 1 metric ton of petroleum; 1 tonne of oil equivalent equals 41.868 GJ (11.63 MWh).

7 G. Łyś, *Poland is Still Too Energy-Consuming*, www.obserwatorfinansowy.pl [15/06/2016].

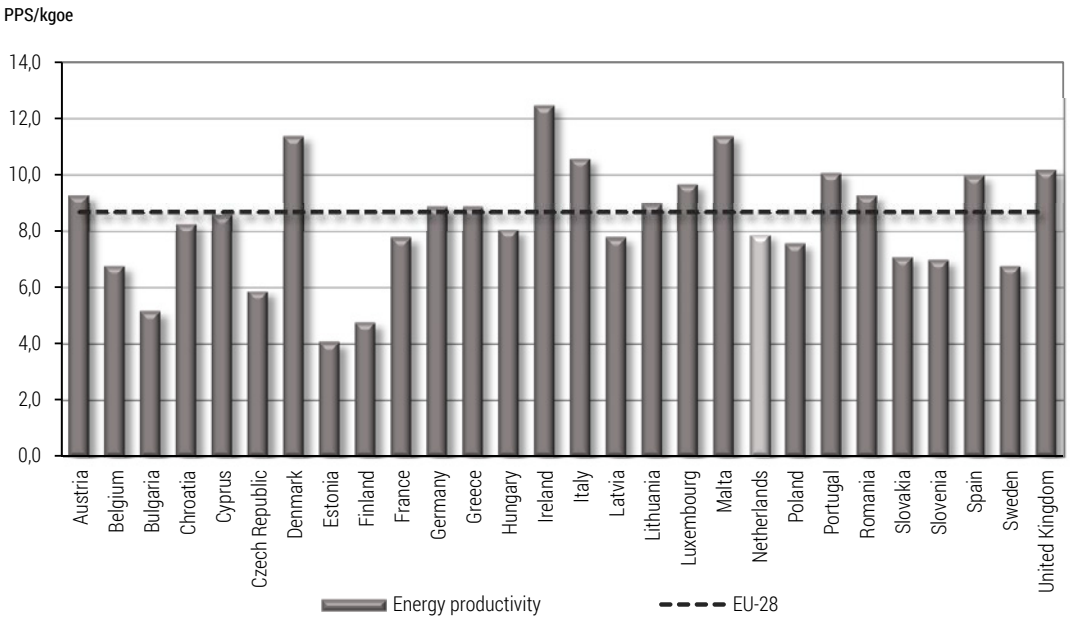

Figure 1. Energy productivity in 2014

Source: own calculations based on Eurostat data, www.ec.europa.eu [09-06–2016].

is relatively low in Poland – 7.6 PPS/kgoe, ranking Poland in the twentieth position among all the EU countries.

Another measure used to assess the effectiveness of the energy policy in the EU is the energy intensity value. It shows the relation between the final energy consumption in the economy and the GDP, indicating how much of the final energy was utilised to produce one GDP unit.

In 2014 the final energy consumption of the member states of the Community reached a level of 80.7 kgoe/1000 eur. In the analysed period the countries with low levels of energy consumption were, among others: Denmark (54.8 kgoe/1,000 euros), Ireland (59.1 kgoe/1,000 euros), the United Kingdom (66.0 kgoe/1,000 euros), France (68.5 kgoe/1,000 euros) and finally Poland, with total energy consumption of 152.7 kgoe/1,000 euros, ranking in the twenty-fourth place among the EU countries.

The rising energy demand, resulting from the development of civilisation and care for the environment, especially the air quality, the need to reduce the impact of climate change, the limitations on deposits and the increase in the price of conventional energy carriers have caused increased interest in the use of energy from renewable sources.

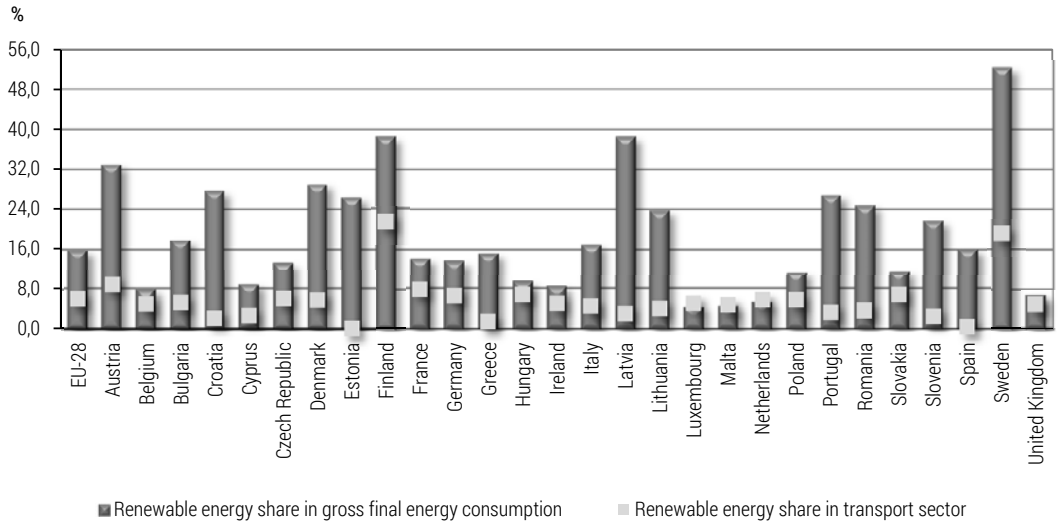

Figure 2. The shares of RESs in the gross final energy consumption and the transport sector in 2014
Source: own calculations based on Eurostat data, www.ec.europa.eu [09-06–2016].

Renewable energy sources (RESs) are an alternative to traditional primary non-renewable energy sources (fossil fuels). Fossil fuel deposits regenerate through natural processes over time, which practically allows them to be treated as inexhaustible. Moreover, obtaining energy from these sources is far more environment-friendly than the traditional (fossils) sources. The use of RESs significantly reduces the harmful impact of energy on the environment, mainly through the reduction of harmful emissions[8].

Increasing the share of energy from renewable sources in the final energy consumption is part of the EU energy policy. In line with the EU strategy for 2020, the respective states of the EU are to achieve their own national goals for renewables in their energy balances to achieve the average rate of 20% for the Community. The target level for Poland was set at 15%.[9] In 2014 significant differences were observed at the level of the member states in terms of the share of renewable energy in the gross final energy consumption (Figure 2).

8 *Energy from Renewable Sources in 2014,* Warsaw 2015.

9 *Bruksela przedstawia stan realizacji celu OZE na 2020 r. w krajach UE*, www.gramwzielone.pl [15/06/2016].

While in Sweden it reaches a level of 52.6%, Latvia and Finland 38.7% and Austria 33.1%, other countries, namely Luxembourg and Malta, do not exceed 5%.[10] Poland was in the twentieth position among the EU countries with a share of RESs in the gross final energy consumption at the level of 11.4%.

Increasing the share of renewable energy in the transport sector is also a challenge for the EU energy policy. The European Union emphasises the increasing importance of liquid biofuels in transportation. According to Directive 2009/28/EC,[11] all the member states are required to achieve a 10% share of energy from renewable sources in their final energy consumption in the transport sector by 2020. According to Eurostat data from 2014, the largest shares of this indicator were recorded in Finland (21.6%) and Sweden (19.2%) and the lowest in Estonia (0.2%) and Spain (0.5%) (Figure 2). Poland was ranked together with the Netherlands in ninth place among the EU countries with a share of 5.7%.

Applying the solutions from the scope of RESs should contribute to reducing greenhouse gas emissions, which are named one of the major problems of our times. It may contribute in the future to reducing the water resources of our planet and increasing the frequency of floods, melting glaciers and soil erosion and the intensification of tornadoes, hail, frost waves or excessive heat. To make these risks less probable, measures have been taken to reduce greenhouse gas emissions[12]. The United Nations Framework Convention on Climate Change (UNFCCC), signed in 1992 in Rio de Janeiro, which specified the establishment of an international cooperation on greenhouse gas emissions, was supplemented in 1997 by the Protocol signed at a conference in Kyoto[13]. This document obliges the states that opted for its ratification to reduce their emissions of greenhouse gases by 2012 in line with the agreed limits (at least 5% of the emission level of 1990). At the climate conference in Doha in 2012, an amendment to the Kyoto Protocol was adopted, establishing the second period relating to emission limits for the years 2013–2020. In line with this regulation, the European Union as a whole is obliged to reduce its emissions by 20% (compared with 1990) by 2020.

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10 E.E. Szekalska, *Kraje UE za wolno zwiększają swój udział OZE w zużyciu energii* (EU Countries Too Slowly Increase Their Share of Renewables in Energy Consumption), www.teraz-srodowisko.pl [15/06/2016].

11 Directive 98/34/EC of the European Parliament and of the Council 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources, amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (OJ No. L 140/16 of 5 June 2009).

12 *Zmiany klimatu* (*Climate Changes*), www.gios.gov.pl [15/06/2016].

13 The Kyoto Protocol to the United Nations Framework Convention on Climate Change (OJ 2005 No. 203, item. 1684).

Table 2 Greenhouse gas emissions in 2014

Countries	Total [Million tonnes of CO_2e]	[Base year ratio from Kyoto = 100%]
Austria	76,3	96,6
Belgium	113,9	78,1
Bulgaria	57,2	43,1
Croatia	24,5	78,2
Cyprus	8,4	(·)
Czech Republic	125,9	64,8
Denmark	51,2	73,8
Estonia	21,1	49,4
Finland	59,1	83,2
France	458,9	81,4
Greece	101,4	94,8
Spain	328,9	113,5
Netherlands	187,1	87,8
Ireland	58,3	104,8
Lithuania	19,0	38,5
Luxembourg	10,8	81,8
Latvia	11,3	43,6
Malta	3,0	(·)
Germany	900,2	73,0
Poland	**380,3**	**67,5**
Portugal	64,6	107,4
Romania	109,8	39,5
Slovakia	40,6	56,4
Slovenia	16,6	81,5
Sweden	54,4	75,4
Hungary	57,2	49,6
United Kingdom	527,2	67,9
Italy	418,6	81,0

The data exclude emissions and absorption rates from the "Land-use, land-use change and forestry" (LULUCF) sector
(.) No records in the Eurostat database

Source: own calculations based on Eurostat data, www.ec.europa.eu , www.ec.europa.eu [25-06-2016].

In 2014 the total greenhouse gas emissions in the 28 EU countries reached 4285,600000 tonnes CO_2e. Among the countries with the lowest emissions were Malta (3.0 million tonnes CO_2e) and Cyprus (8.4 million tonnes CO_2e), while the most greenhouse gases were emitted by Germany (900.2 million tonnes CO_2e), the United Kingdom (527.2 million tonnes CO_2e) and France (458.9 million tonnes CO_2e). Poland, with 380.3 million tonnes of CO_2e, was ranked in the fifth place among the highest-emission countries of the European Union.

The largest increases in greenhouse gas emissions in the EU compared with the base year[14] were recorded in Spain (13.5%), Portugal (7.4%) and Ireland (4.8%), and the deepest declines during this period were recorded in Lithuania (61.5%), Romania (60.6%), Bulgaria (56.9%) and Latvia (56.4%).

According to the classification developed by the Intergovernmental Panel on Climate Change (IPCC), throughout the European Union, the energy sector was mainly responsible for the emission of greenhouse gases (77.6% of the total emissions), and agriculture was responsible to a lesser extent (10.2%), followed by the industrial processes and use of products sector (8.7%) and the waste sector (3.4%). Among the countries of the EU, the largest emitter of greenhouse gases proved to be Germany, which is responsible for 21.0% of the emissions throughout the Union. In the second place was the United Kingdom, which emits 12.3% of gas. The third place went to France (10.7% of the emissions), and Italy was ranked fourth (9.8% of the emissions). Poland, which is responsible for 8.9% of the emissions in the EU, occupied fifth place. Given the sectoral structure of the greenhouse gas in the power industry, almost a quarter of the emissions in the EU correspond to Germany, the United Kingdom (12.9%), Italy (10.2%), France (9.6%) and Poland (9.3%). In the industry-related processes and use sector, the leader is Germany, with 16.3% of the emissions, followed by France (10.7% of the emissions), Spain (10.1% of the emissions), the United Kingdom (9.4% of the emissions), Italy (8.1% of the emissions) and Poland (8.0% of the emissions). On the other hand, the emissions in agriculture are mainly produced by France, Germany and the United Kingdom (i.e. 18.1%, 15.2% and 10.3% of the entire sector emission), and Poland, with 6.9% of the emissions, took sixth place in the ranking. In the category of waste management, the foremost emitters were France (13.3% of the emissions), the United Kingdom (13.1% of the emissions) and Italy (12.5% of the emissions). In the sector mentioned above, Poland and Germany were ranked in the fifth place of the greatest greenhouse gas emitters among the European Union countries.

[14] For most countries the year 1990 was set as the base year, and it was decided that for Poland and the central European countries the base year will be 1988.

Another aspect of the environmental efficiency of production is the use of material resources, which are the basis for the functioning of the economy and an important source of income and employment. However, both the extraction and processing and the use of the products exert pressure on all the components of the environment. Therefore, it is important that the process of resource management throughout the product life cycle is the least harmful and the most effective possible, providing access to the resources for future generations[15].

According to the Eurostat data, in 2014 the domestic material consumption (DMC) in the EU reached a volume of 6,641.7 million tonnes, which equals 13.1 tonnes of raw material consumed per resident per year. At the forefront of the countries with the highest consumption per person were Finland (31.1 tonnes), Estonia (29.3 tonnes) and Sweden (23.1 tonnes). In Poland the figure stood at 17.2 tonnes.

To measure the efficiency of the materials used in the economy, we use a resource productivity rate, expressed as the ratio of the GDP to the national consumption of materials. When this rate increases, the use of materials to produce one unit of GDP decreases. According to the Eurostat data in 2014, the resource productivity of the member states was 2.1 PPS/kg (Figure 3).

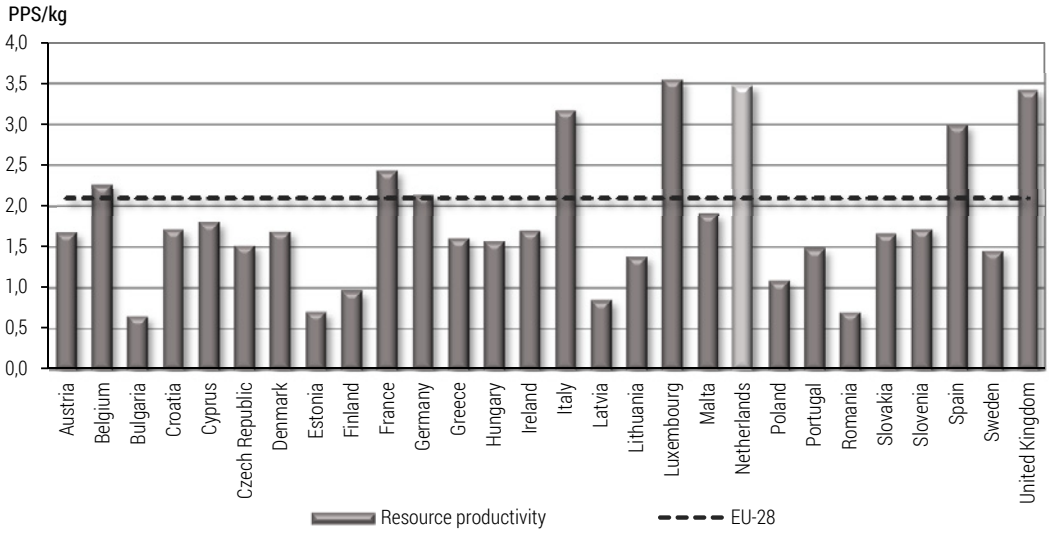

Figure 3. Resource productivity in 2014

Sources: own calculations based on Eurostat data, www.ec.europa.eu [09/06/2016].

15 *The State of the Environment in Poland–Report 2014*, Warsaw 2014.

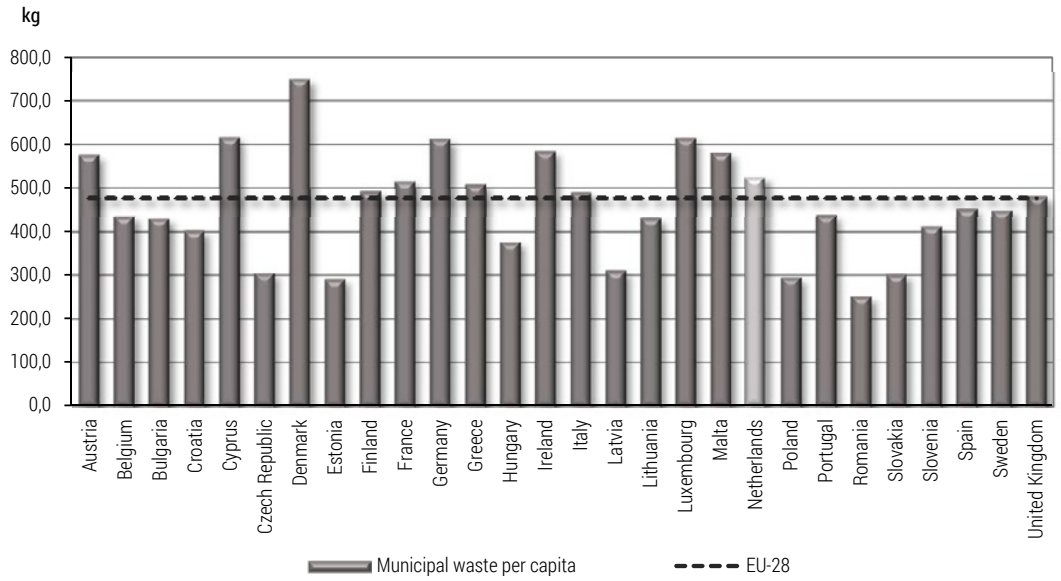

Figure 4. Municipal waste produced per capita in 2013

Source: own calculations based on Eurostat data, www.ec.europa.eu [09/06/2016].

The eight countries where the level of productivity was higher than the EU average were Luxembourg, the Netherlands, the United Kingdom, Italy, Spain, France, Belgium and Germany. In relation to the EU average, the value of the index in Poland was relatively low and reached 1.1 PPS/kg, which ranked our country in twenty-third place among the member states.

Thus, waste management can have a significant impact on the environment and human health. Limiting its production in times of increasing production and consumption is essential for reducing the adverse effect on the environment and one of the major challenges of the modern world. Disposal by storage is a sign of inefficient management of resources, resulting in additional emissions into the atmosphere, soil and water, loss of space in landfills and reduction of the aesthetic values of the landscape. Only reuse, recovery or recycling of waste can make it a potential resource, contributing to reducing the consumption of primary raw materials to produce products and thus to more effective management of resources.[16] According to data from Eurostat in 2012, the amount of municipal waste generated in the EU Member States reached 242.0 million tonnes. This means that the statistical inhabitant of the EU has contributed to the creation of 477 kg of waste (Figure 4).

16 *Green Growth Indicators* ..., p. 108.

According to the data presented in Figure 4, there is a considerable difference between countries in terms of the amount of waste produced. Among the countries producing the largest amount of waste are Denmark (752 kg), Cyprus (618 kg), Luxembourg (616 kg) and Germany (615 kg). Poland is one of the countries with the smallest amount of waste generated per capita (297 kg).

Of the total amount of municipal waste collected in the European Union, 30.6% was disposed of in landfill sites, 27.4% was recycled, 26.3% was thermally processed and 15.7% was composted. There are also significant differences between the countries of the EU in their methods of waste disposal. In 2013 the most waste went to landfill in Malta (85.6%), Croatia (84.6%), Cyprus (84.4%) and Latvia (83.1%). In Poland the figure was 63.1%. Incineration of waste is the most widespread in Estonia (63.7%), Denmark (54.8%) and Sweden (50.7%). In 11 other countries, including Poland, less than 10% of waste is burned. On the other hand, composting plays the biggest role in Austria, the Netherlands and Belgium (respectively: 34.3%, 26.0% and 20.6%). In Poland 13.0% of municipal waste is processed in this way. Recycling as a method of waste disposal has a significant role in Germany (46.6%), Slovenia (45.4%), Ireland and Belgium (34.0% each). This figure reached 15.8% in Poland.[17] Packaging waste constitutes a significant part of municipal waste. The amount of it increases in proportion to the growth of wealth of the EU societies. According to the Directive of the European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste,[18] the member states of the Community are obliged, inter alia, to achieve a certain level of recycling of packaging waste. It is monitored by the indicator presenting the percentage of packaging waste put on the market recycled in a given year. Among the EU countries, in 2013 the highest levels of packaging waste occurred in Belgium, Sweden and Germany (i.e., 78.7%, 71.9% and 71.8%).

In addition, modern agriculture has a significant influence on the environment. That is why it is important to maintain a balance between environmental protection and economic benefits to ensure the regeneration of the natural resources needed to continue production. Agricultural activities interfere with the cycle of the natural nutrients, which can create the risk of an imbalance of ecosystems.

The most serious threat caused by agriculture is nutrients like nitrogen and phosphorus, which can enter the groundwater and open water bodies or

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17 *Eurostat Examined Municipal Waste in the EU*, www.administrator24.info [15/06/2016].

18 Directive 94/62/EC of the European Parliament and the Council of 20 December 1994 on packaging and packaging waste (OJ L 365 of 31 December 1994, p. 10, as amended; EU Polish special edition, chapter. 13, t. 13, p. 349).

volatilise into the atmosphere if unused in the production. However, a deficit of those nutrients may lead to reduced productivity, infertility and soil degradation[19].

Today it is difficult to imagine contemporary agriculture without fertilisation. The use of fertilisers is a major factor in the growth of crops that determines the development of agricultural production[20]. The economic effects largely depend on the quantities used during the production. However, excessive or incompetent use of fertilisers leads to the accumulation of harmful compounds in the soil, which are easily carried to the food chain of animals and humans.

Eurostat estimates that nitrogen fertiliser use (with contents of pure N) amounted to 11.1 million tonnes in the 2014/2015 marketing year in 27 EU countries[21]. Among the countries where the consumption was highest are: France (19.9% of the total consumption of the EU–27), Germany (14.6%) and Poland (10.4%). In the case of phosphate fertilisers (with contents of pure P_2O_5), the use in the period amounted to 2.5 million tonnes. The leaders in terms of consumption of these fertilisers were: France (16.9% of the total consumption of the EU–27), Spain (15.4%) and Poland (14.3%).

The balances of nitrogen and phosphorus, as one of many agri-environment indicators, are a very important source of information on the impact of agriculture on the development of environmental conditions. With nitrogen fertilisation of plants, this balance is not sustained because of the inevitable leaks due to the volatilisation to the atmosphere or the leaching of nitrates into the deeper layers of the soil and groundwater. It is assumed that, due to the yield volume and quality of groundwater, the gross balance of nitrogen should be at the level of 30–70 kg per hectare of agricultural land.[22] The Eurostat data show that in 2012 only nine countries, including Poland, achieved this balance with safe amounts for the environment (Table 3).

The balance of phosphorus is the primary measure used to assess the effectiveness of crop production, the use of the scarce resources of phosphate rock as well as the environmental protection. It is assumed that the balance of phosphorus, with the average soil abundance of this component, should be

19 J. Kopiński, A. Tujaka, *Bilans azotu i fosforu w rolnictwie polskim*, "Woda–Środowisko–Obszary Wiejskie" 2009 No. 4(28), www.itp.edu.pl [15/06/2016].

20 J. Igras, J. Kopiński, *Zużycie nawozów mineralnych i naturalnych w układzie regionalnym,* in: *Sprawdzenie przydatności wskaźników do oceny zrównoważonego gospodarowania zasobami środowiska rolniczego w wybranych gospodarstwach, gminach i województwach*, "Studia i Raporty IUNG-PIB" 2007 No. 5, p. 108.

21 The reference area covers 27 European Union member states, excluding Malta.

22 J. Kopiński, *Określenie kryteriów do obliczenia sald głównych składników nawozowych w ujęciu wojewódzkim, ekspertyza*, Puławy 2008, p. 3.

Table 3 The gross nitrogen and phosphorus balance in 2012

Countries	Gross balance	
	Nitrogen	Phosphorus
Austria	22	–3
Belgium	121	6
Bulgaria	14	–5
Croatia	75	10
Cyprus	195	32
Czech Republic	89	–1
Denmark	72	5
Estonia	24	–9
Finland	45	4
France	44	1
Greece	51	–1
Spain	35	4
Netherlands	163	6
Ireland	(·)	(·)
Lithuania	2	0
Luxembourg	88	1
Latvia	1	–3
Malta	104	9
Germany	84	1
Poland	**43**	**1**
Portugal	13	2
Romania	2	–1
Slovakia	29	1
Slovenia	58	4
Sweden	44	0
Hungary	66	5
United Kingdom	48	–4

(.) No record in the Eurostat database.

Source: own calculations based on Eurostat data, www.ec.europa.eu [09-06-2016].

close to zero[23], with a low abundance of up to 5 kg per ha of agricultural land. Among the member states that have available and up-to-date data, only 13 countries (including Poland) achieved the balance of phosphorus within the range of 0 to 5 kg per ha of agricultural land.

Until recently, water was taken for granted as unlimited. Today we know that the water resources are limited, especially when we consider freshwater resources. Water is one of the most important resources on the planet, essential to all life forms. It plays a special role in the processes that take place in ecosystems, and it is an essential abiotic element of the environment. It is a highly valuable, specific and renewable natural time-varying resource. It has diverse functions in industry; therefore, it is crucial not only to keep it clean but to use it rationally and efficiently[24]. Across the country, water resources are subject to seasonal fluctuations over the year, enforcing the need to monitor their use[25].

In 2014 Poland used 10,243.7 hm water for the purposes of the national economy and the population, out of which 74.7% of the total consumption was used for production purposes, 15.0% for the operation of the water supply network and 10.3% for irrigation in agriculture and forestry as well as for watering fish ponds. In relation to 2004, positive changes were reported, namely a decrease in water consumption – 1.9%, including the operation of the water supply system – 3.9%, industry – 1.5% and agriculture and forestry – 1.4%. The amount of waste water recovered for the needs of the national economy and population per inhabitant has also reduced (from 273.5 m^3 in 2004 to 266.2 m^3 in 2014).

To measure the efficiency of water use, the productivity ratio was used, calculated as the ratio of GDP (in constant prices) to water consumption for the needs of the national economy and population. It expresses the GDP per unit of water consumption. Between 2004 and 2014, an increase in the productivity of water was reported. In 2014 it reached 167.08 zł/m^3, which means that it increased in both 2013 and 2004 to 2.4% and 96.2%, respectively.

Since 2004 a positive trend has been observed in Poland, namely a systematic decrease in the water consumption in industry (except for 2006, 2009 and 2011). In 2014 it reached the level of 20.1 m^3/thousand PLN, the same as a year ago, while in relation to 2004 it decreased by 47.9%. Much lower levels of water consumption are observed in the household sector, in

23 J. Kopiński, *Bilans składników nawozowych w gospodarstwach rolnych jako kryterium zrównoważonego gospodarowania*, in: J.St. Zegar (ed.), *Z badań nad rolnictwem społecznie zrównoważonym*, Warszawa 2006, p. 83.

24 T. Jakubowski, *Gospodarka wodno-ściekowa w wybranej gminie*, "Infrastruktura i ekologia terenów wiejskich" 2005 No. 4, p. 47, www.agro.icm.edu.pl [15/06/2016].

25 *Green Growth Indicators*..., p. 104.

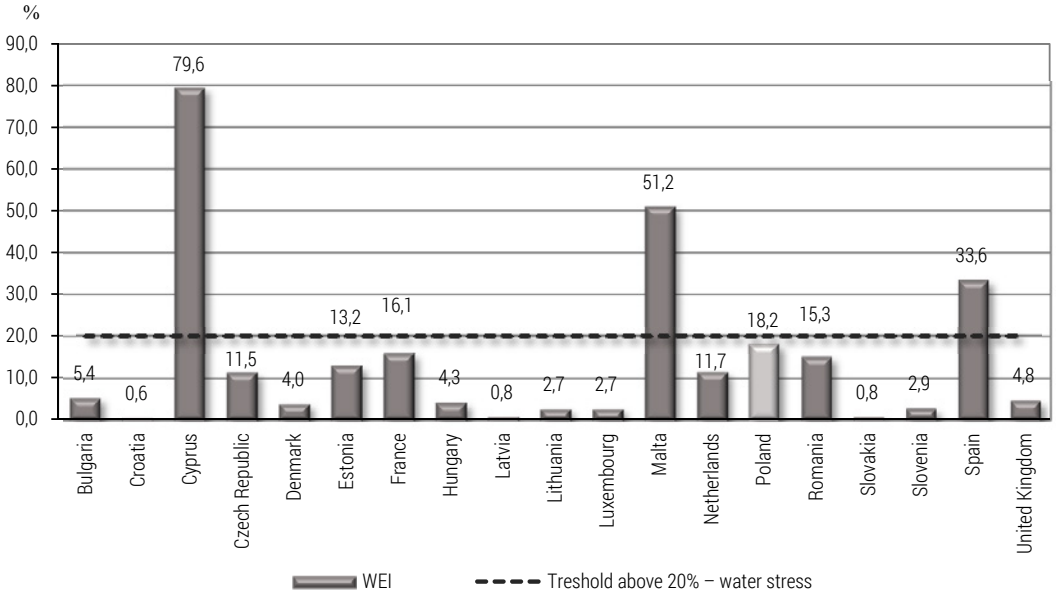

Figure 5. The water exploitation index (WEI) in 2012

Source: own calculations based on Eurostat data, www.ec.europa.eu [09-06–2016].

which a steady decline in the analysed indicator has been observed. In 2014 it amounted to 2.7 m^3/thousand PLN, so it did not change compared with 2013, while in relation to 2004 it decreased by 43.8%.

To depict the total demand for water for a country in relation to the volume of available water resources, the water exploitation index is used (WEI). It expresses the share of the average annual consumption of fresh water in the long-term average values of freshwater resources. A WEI value exceeding 20% is a symptom of water stress. The data on the WEI in the countries available in Eurostat's database in 2012 are presented in Figure 5.[26]

Analysing the data presented in Figure 5 in 2012, only three countries – Cyprus, Malta and Spain – were recognised as being "under the pressure of water", and the WEI value for those countries reached respectively 79.6%, 51.2% and 33.6%. In Poland the rate during this period was below 20%, reaching 18.2% in 2012, and did not change compared with 2004.

[26] Data available for 19 EU countries.

Conclusions

Increasing pressure on the use of environmental resources, especially non-renewable ones, forces different official entities to undertake measures to improve production efficiency in this regard. The implementation of these activities should be subjected to monitoring to assess their effectiveness. Monitoring the green economy also facilitates international comparisons and determines the current status of development of the green economy in the respective states.

After analysing the presented figures of the green economy in terms of environmental efficiency of production, we can conclude that Poland ranks quite unfavourably among the countries of the EU, especially when we consider resource productivity or energy productivity. We may also consider the share of renewable energy in the final use as unsatisfactory. Poland's performance is much better from the perspective of municipal waste generated per capita or the nitrogen and phosphorus gross balance.

It should be emphasised that the set of figures presented does not exhaust the topic, and it will be subjected to constant evaluation. Any change in the availability of data, as well as changes in the environment, will determine adjustments in a range of indicators applied for the evaluation of the environmental efficiency of production. It is essential that the indicators developed and summarised are used by various decisive groups (including scientific and public authorities at various levels) to assess the state of the green economy in Poland and take action to contribute to the rapid "green growth and development".

The contribution of the authors in the article

Dorota Wyszkowska, PhD – 50%
Helena Artemiuk, MSc – 50%

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