

Investment outlays on environmental protection in Polish coal mining

Romuald Ogrodnik^{1,*}

¹ AGH University of Science and Technology, Faculty of Mining and Geoengineering,
Al. Mickiewicza 30, 30-059 Kraków, Poland

Abstract. Nowadays, the functioning of mining companies is conditional not only on the market situation, but also on the good relations with stakeholders. Good relations with recipients, suppliers, employees as well as with local communities and environmental organisations are of crucial importance. Social acceptance is becoming one of the primary conditions for mining operations. The main complaint faced by mining companies is their negative impact on the environment. It is, therefore, important to determine not only the measures aimed at reducing the negative impact of mining on the environment, but also the amount of expenditures allocated for this purpose. The main aim of this study is to analyse the investment outlays allocated for environmental protection. In order to support the aim of the study, a statistical analysis of data from 2003-2016 was carried out in terms of the structure of outlays for environmental protection: air and climate protection, water and sewage management, and soil protection, as well as protection against noise and vibration.

1 Introduction

Mining is a distinctive type of activity associated with environmental impact unprecedented in other industries. Mining is perceived negatively by society due to the scale of the transformations it causes [1]. The impact of mining is direct, consisting of the exclusion of natural areas used by a specific mining company, as well as indirect, resulting in changes in environmental compartments.

Coal extraction, as any extraction of natural resources, has a negative impact on the environment, and consequently, harmful or onerous effects on the population. In most cases, it is, however, necessary to conduct business activities in a precisely defined production area, which necessitates the transformation of the environment. In the case of hard coal and lignite mining, this necessity is to ensure the energy security of the country. The energy security of the country must not, however, justify mining which abandons environmental protection. The amount of investment outlays on environmental protection can serve as a measure indicating the level of measures taken to mitigate the negative impact of mining on the environment in its broad sense.

* Corresponding author: rogrod@agh.edu.pl

The implementation of environmental management systems is aimed at limiting the negative impact of mining on the environment. Issues related to environmental management systems and identification of environmental aspects are addressed in the following articles [2, 3].

2 Coal as the fundamental energy carrier

Coal is an important source of primary energy in the world, second only to oil. At present, the share of coal in primary energy balance worldwide amounts to nearly 27.6%, while in Asia Pacific, it is the dominant fuel with a share of 48.4% [4].

In Poland, most primary energy comes from hard coal (41.1%), oil (24.4%) and lignite (10.9%) [5, 6]. Table 1 presents the primary energy consumption balance in 2007-2016.

Table 1. The primary energy consumption balance in 2007-2016 by carrier [PJ], Source: [5, 6]

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Hard coal	2015	1961	1783	2008	1956	1788	1862	1726	1698	1843
Lignite	500	533	510	485	524	532	550	520	514	490
Oil	851	894	862	971	1027	1069	1029	1026	1110	1095
Methane-rich natural gas	492	440	418	448	444	475	479	467	482	521
Nitrogen rich natural gas	89	85	86	88	93	97	96	95	92	90
Water, wind, geothermal and solar energy	11	11	13	17	21	26	32	37	47	56
Wood	136	153	167	180	193	201	211	201	201	204
Waste fuels and other raw materials	87	91	101	141	169	198	170	178	178	181
Total: primary energy	4118	4168	3941	4338	4428	4387	4429	4250	4323	4482

Coal tops the structure of primary energy generation in Poland. In 2016, its share amounted to nearly 78%, of which 60.5% was hard coal and 17.4% was lignite. As regards electricity production mix in Poland, in the last decade, the share of coal has decreased from 90% to 78% in favour of other energy carriers. Table 2 presents data concerning electricity production in 2007-2016 by energy carriers.

In Poland, coal is an accessible raw material and at the same time the source of the cheapest electrical and thermal energy. It is safe to transport and store. Apart from rich reserves of coal, Poland also has well-developed infrastructure for mining it [8].

The global mining industry, particularly its coal sector, has been experiencing a difficult period recently. Businesses have been grappling with low prices on the global market which tend to drop below mining costs. The world's mining industry is now increasingly on the look-out for organizational solutions to allow cost reductions in the mining and processing of fossil fuels. The on-going reorganization and restructuring of the Polish mining sector must aim for reduced mining costs and greater flexibility as their strategic goals [9].

Table 2. Electricity production in 2007-2016 by energy carriers [GWh], Source: [6, 7]

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Hard coal	93047	85671	83154	87863	87229	80519	81568	76155	77694	79400
Lignite	50962	53224	50234	48651	52529	54054	56150	53365	52825	50920
Natural gas	4483	4679	4787	4798	5821	6260	5270	5328	6387	7831
Biomass and gas	2556	3619	5223	6303	7600	10094	8622	9977	9932	7957
Wind	522	837	1077	1664	3205	4747	6004	7676	10858	12588
Water	2939	2747	2974	3488	2761	2465	2997	2734	2435	2621
Other	4839	4528	4271	4890	4403	4000	3969	3824	4813	5317
Total	159 348	155 305	151 720	157 657	163 548	162 139	164 580	159 059	164 944	166 634

3 Investment outlays on environmental protection

Outlays on environmental protection include investment outlays and current cost of protection measures, which are usually covered in their entirety from the own funds of enterprises.

The main objective for incurring current costs is to prevent, mitigate, neutralise or eliminate pollution and all other environmental damage resulting from the entity's current activities. These include the cost of own actions, including the costs associated with the operation and maintenance of environmental protection equipment as well as the costs of services provided by third parties, costs of utilities (sewage treatment and waste collection), environmental fees and the costs of control, monitoring, laboratory tests, etc. [10].

Investment outlays are financial or material outlays aimed at creating new fixed assets or improving (redeveloping, extending, reconstructing or upgrading) the existing ones, as well as outlays on so-called initial equipment [11].

Investment outlays include outlays on fixed assets and on so-called initial equipment, as well as other costs connected with project implementation. These outlays do not increase the value of fixed assets [11].

Outlays on fixed assets are outlays on [10]:

- land purchase (including perpetual usufruct),
- buildings, premises and civil engineering facilities,
- technical equipment and machines,
- means of transport,
- tools, devices and equipment,
- other fixed assets aimed to achieve protective effects or effects in water management.

Figure 1 presents outlays on fixed assets used for environmental protection in industry at large and for the Mining and quarrying section, including Mining of coal and lignite between 2003 and 2016.

For 2003-2016 an increase can be observed in the amount of outlays on fixed assets used for environmental protection in industry at large from PLN 2.1 bn to 4.3 bn. In the period in

question, the amount of investment outlays allocated by the mining industry to environmental protection displayed a downward trend. For the Mining and quarrying section, total outlays in the analysed period amounted to PLN 1.3 bn, of which PLN 0.8 bn was incurred by Mining of coal and lignite, which amounts to 62% of all expenditures in the mining industry on fixed assets aimed at environmental protection. The highest expenditures in the coal mining industry were incurred in 2005 (PLN 86.7 million), in 2007 (PLN 83 million) and in 2013 (PLN 84.1 million). The average annual outlays for mining at large amounted to nearly PLN 93 million, while for coal mining to PLN 57.6 million. The record share of investment outlays on environmental protection in coal mining in the outlays incurred by the mining industry at large amounted to over 75%. This was the case for 2004, 2007, 2012 and 2013.

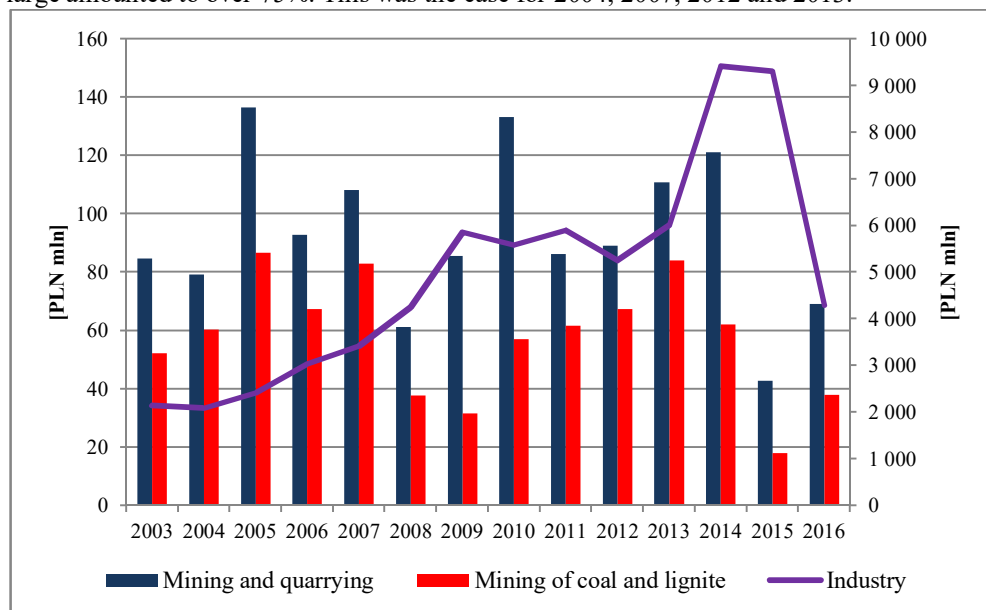


Fig. 1. Outlays on fixed assets aimed at environmental protection Source: own elaboration on the basis of [11]

When determining the amount of investment outlays aimed at environmental protection in the statistical reports of Statistics Poland (GUS), the following division of investment targets is applied [10]:

- air and climate protection,
- wastewater management and water protection,
- waste management, protection of soil, groundwater and surface water,
- protection against noise and vibration.

In order to increase the extent to which conclusions can be drawn, an indicator was created, taking into account the quality of the extracted resource. The indicator which took into consideration only unit outlays per tonne of extracted resource did not meet the desired expectations, as the obtained data on outlays were ascribed to one group, for both hard coal and lignite. Due to considerable qualitative differences between these energy carriers, a decision was made to consider their calorific value in the designed indicator.

$$E_H = \frac{E}{\text{Calorific value of extracted coal}} \quad (1)$$

where:

E_H – outlays on environmental protection per 1GJ of consumed coal-based primary energy

E – outlays on environmental protection incurred by the coal mining industry in a given year

The aforementioned indicator facilitates the comparison of actual outlays incurred for environmental protection per 1GJ of consumed coal-based primary energy.

Figure 2 presents outlays on environmental protection per 1GJ of consumed coal-based primary energy by investment target

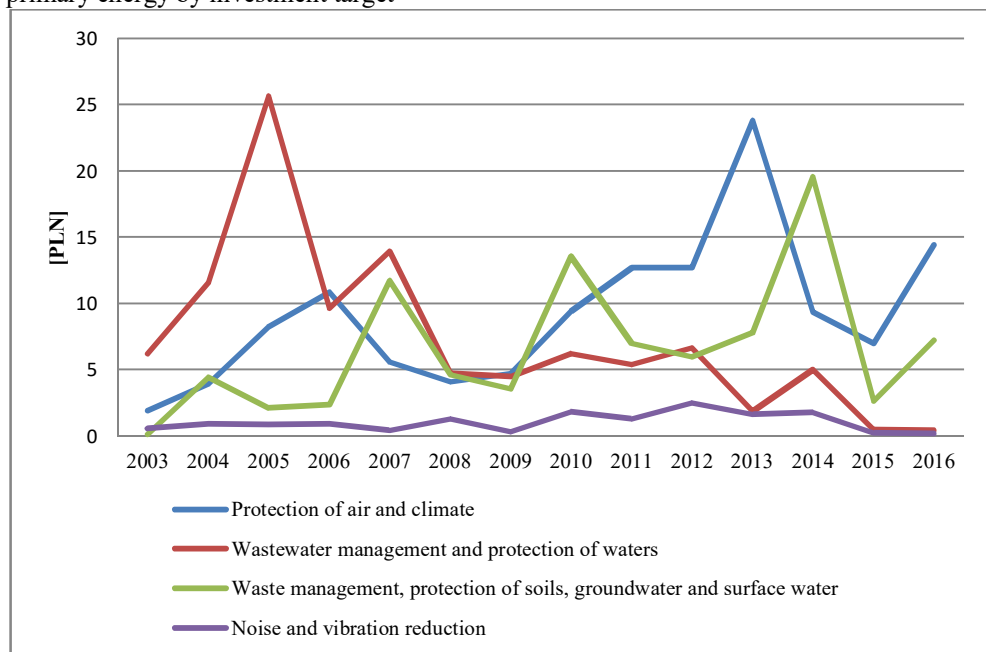


Fig. 2. Outlays on environmental protection per 1GJ of consumed coal-based primary energy by investment target, Source: own elaboration on the basis of [11]

3.1 Air and climate protection

Air and climate protection includes investments in purification and deodorising (dust removal and gaseous pollutant reduction and neutralisation) installations and installations which apply chemical transformation reactions to substances less harmful to the environment, along with complete equipment and a system of necessary auxiliary equipment ensuring the correct operation of the installations, as well as equipment and apparatuses used to limit the amounts or concentrations of generated or emitted pollutants, as well as tasks related to retrofitting facilities with air pollution control and measurement devices. In addition, the area in question also includes investments in new fuel combustion techniques and technologies, the modernisation of boiler plants and heat generating plants to reduce the amount of pollutants discharged into the air and resulting from the combustion process, unconventional energy sources (e.g. wind farms, utilisation of geothermal water) and the adaptation of engines to gas fuels [11].

The outlays incurred by the coal mining industry in 2003-2016 displayed a clear upward trend. In the analysed period, the sum of all investment outlays on air and climate protection incurred by the coal mining industry amounted to PLN 291 million. Average annual expenditures on this investment target equalled PLN 37.3, which translated into PLN 9.2 per 1 GJ of coal-based primary energy. The record-breaking amount of such outlays (PLN 57 million – 23.8 PLN/GJ) was recorded in 2013.

3.2 Wastewater management and water protection

Investments in wastewater management and water protection include equipment for the treatment and purification of industrial wastewater, municipal wastewater, stormwater and contaminated mine wastewater discharged directly into surface water and the soil. Investments in this area include wastewater treatment plants and their elements, devices for the economic use of wastewater, for the disposal, collection and transport of saline water, for the collection of wastewater, and equipping wastewater treatment plants with control and measurement devices. In addition, investments in wastewater management and water protection include the construction of sewage systems, sewage slurry treatment and disposal equipment, water circuit systems, protection measures against infiltration into rivers, creating water source and intake protection zones [11].

The amount of outlays incurred by the coal mining industry in 2003-2016 displayed a clear downward trend. In the analysed period, the sum of all investment outlays on wastewater management and water protection incurred by the mining industry amounted to PLN 253.8 million. The average annual expenditures of the coal mining industry on this investment target equalled PLN 32.5, which translated into PLN 7.3 per 1 GJ of coal-based primary energy. The record-breaking amount of such outlays (PLN 60.2 million – 25.7 PLN/GJ) was recorded in 2005. In 2015-2016 the coal mining industry allocated only PLN 0.45 per 1 GJ of coal-based energy for wastewater management and water protection.

3.3 Waste management, protection of soil, groundwater and surface water

This group of investments includes [11]:

- measures related to pollution prevention through the modification of technological processes, including new low-waste and waste-free techniques and technologies,
- collection (including selective collection) of waste and its transport,
- measures related to waste recycling,
- sewage slurry treatment and disposal equipment,
- devices for the economic use of waste,
- waste disposal,
- reclamation of landfills, heaps, landfill sites and settling ponds and other devastated and degraded areas,
- measures related to preventing soil degradation and devastation,
- provisions of control and measurement devices for waste management, protection of soil, groundwater and surface water.

The total amount of outlays incurred by the coal mining industry in 2003-2016 was PLN 201 million. Average annual expenditures on this investment target equalled PLN 25.8, which translated into PLN 6.6 per 1 GJ of coal-based primary energy. The record-breaking amount of such outlays (PLN 34 million – 19.5 PLN/GJ) was recorded in 2014, (PLN 25 million – 13.6 PLN/GJ) in 2010 and (PLN 30.7 million – 11.7 PLN/GJ) in 2007. In the analysed period, an upward trend in investment outlays on waste management, protection of soil, groundwater and surface water can be noted.

3.4 Protection against noise and vibration

Investments related to noise and vibration abatement include [11]

- equipment, or purchase thereof, resulting in reduced noise levels near its source or on the “recipient’s” premises,

- the construction of noise-reducing structures (walls, barriers, embankments, hedges and soundproof windows, etc.) measures reducing the noise nuisance of road and rail traffic,
- equipment, or purchase thereof, for the measurement of noise and vibration levels (not including tasks related to OHS – noise mitigation in the workplace).

In the analysed period, the sum of all investment outlays on protection against noise and vibration incurred by the hard coal and lignite mining industry amounted to PLN 34.3 million. Average annual expenditures on this investment target equalled PLN 4.4 million, which translated into PLN 1.1 per 1GJ of coal-based primary energy. The investment target in question is characterised by the highest share of outlays incurred by the coal mining industry in relation to outlays incurred by the entire mining industry. In 2007, the aforementioned share amounted to 100%, and in 2013 to 96%.

4 The analysis of the structure of investment outlays on environmental protection

Figure 3 presents the volume and structure of outlays on fixed assets aimed at environmental protection for the hard coal and lignite mining industry.

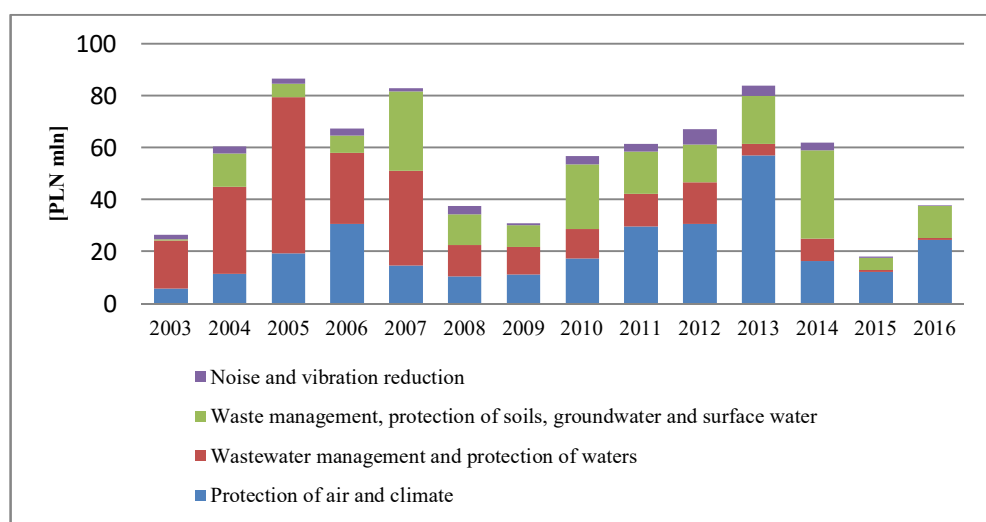


Fig. 3. The structure of outlays on fixed assets aimed at environmental protection by investment target, Source: own elaboration on the basis of [11]

In 2003-2016 the highest expenditures in the coal mining industry were incurred on air protection – PLN 291 million (37.3%). PLN 253 million (32.5%) was spent on wastewater management and water protection, PLN 201 million (25.8%) on waste management, protection of soil, groundwater and surface water, and PLN 34 million (4.4%) on protection against noise and vibration.

In percentage terms, the structure of investment outlays on environmental protection incurred by the coal mining industry changed significantly between 2003 and 2016, which is illustrated in Figure 4.

Initially, it was wastewater management and water protection which accounted for the highest share in outlays on fixed assets (70.6%), with the remaining shares being as follows: air and climate protection (21.7%), protection against noise and vibration (6.3%), waste management, protection of soil, groundwater and surface water (1.4%). On the other hand,

in 2016 the highest share in outlays on fixed assets aimed at environmental protection, incurred by the coal mining industry, was attributable to air and climate protection (64.8%) and waste management, protection of soil, groundwater and surface water (32.4%). The total of other shares was 2.8%.

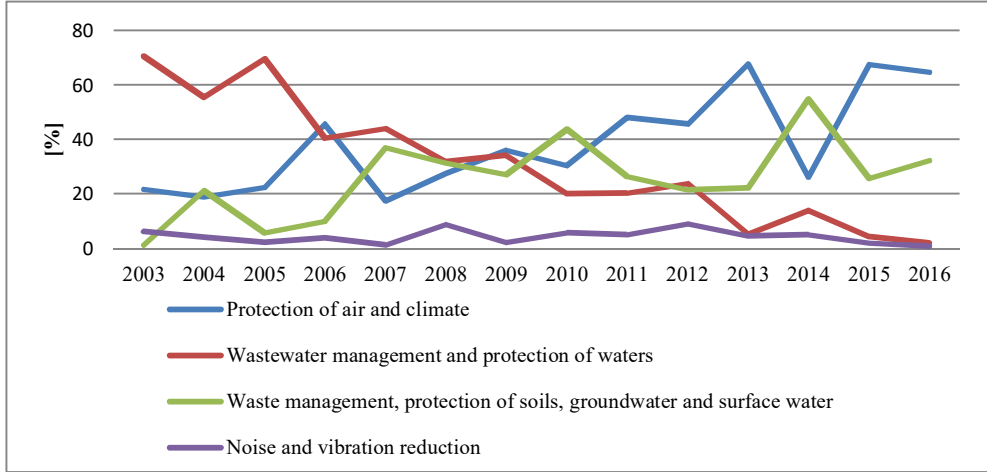


Fig. 4. The structure of outlays on fixed assets aimed at environmental protection by investment target, in percentage terms, Source: own elaboration on the basis of [11]

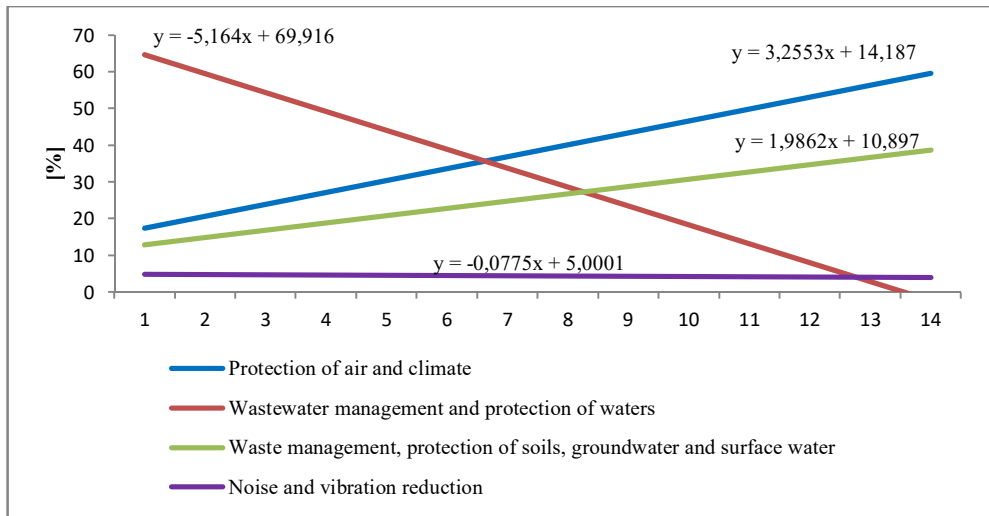


Fig. 5. Outlay share trend lines for individual investment targets, Source: own elaboration on the basis of [11]

A linear regression model was used to determine the graphs of linear functions of individual types of outlays incurred on environmental protection. Regression coefficients, corresponding to the slope of the linear function, and intercepts were calculated. In the case in question, it was assumed that values of individual outlay shares would be the dependent variables, and the subsequent years of analysis would be the independent variables. The results are presented in Figure 5.

In the case of outlays on air and climate protection, their share in the structure of outlays on environmental protection incurred by the coal mining industry displayed, in the analysed period, a clear upward trend. In statistical terms, each year saw an increase of 3.25 percentage points. Between 2003 and 2016, this increase amounted to 43 percentage points.

The evolution of the share of outlays on waste management, protection of soil, groundwater and surface water was less spectacular. Their share in the structure of outlays on environmental protection incurred by the coal mining industry displayed an upward trend. In statistical terms, each year saw an increase by nearly 2 percentage points. In the entire analysed period, this increase amounted to almost 31 percentage points. The percentage share of outlays on wastewater management and water protection in the hard coal and lignite mining industry differed from those discussed above. This share displayed a clear downward trend. The average annual decrease in their share in outlays on environmental protection exceeded 5 percentage points. In the analysed period, the drop amounted to 68.6 percentage points.

5 Conclusions

On the basis of the conducted analysis of data from Statistics Poland on outlays on fixed assets aimed at environmental protection, the following conclusions can be drawn:

1. Between 2003 and 2016 Polish industry saw a more than twofold increase in the amount of outlays on environmental protection. For the coal mining industry, the situation was different, and investment outlays dropped by 27.5%. The average annual outlays for mining at large amounted to nearly PLN 93 million, while for coal mining to PLN 57.6 million.
2. Taking into account the breakdown of outlays by investment target, most resources in the mining industry were allocated to air and climate protection (37.3%), wastewater management and water protection (32.5%) and waste management and protection of soil (25.8%). The least resources were allocated for fixed assets aimed at protection against noise and vibration (4.4%).
3. The greatest decrease in the amount of incurred outlays was recorded in relation to investments in wastewater management and water protection. In the coal mining industry, the amount of outlays in the analysed period dropped by 96%. The lack of measures in this field can be alarming given the fact that one of the main ecological problems of hard coal mining is the discharge of saline water.
4. The share of the coal mining industry in the outlays on environmental protection of mining at large is the highest for investments in protection against noise and vibration. On average, in the period in question, this share was 75%.
5. 2016 saw a marked increase in investments for all the analysed investment targets. The coal mining industry, in 2016, doubled resources on investments aimed at environmental protection when compared to 2015.
6. In 2003–2016 there was a clear change in the structure of outlays on environmental protection. In the period in question, the share of outlays on air and climate protection and on waste management, protection of soil, groundwater and surface water, increased at the expense of the share of outlays on wastewater management and water protection.

The application of an indicator which took into account the volume of outlays on environmental protection per 1 GJ of consumed coal-based primary energy facilitates the analysis of the incurred outlays irrespective of fluctuations in the amount and structure of extracted coal.

As the analysed data concern the hard coal and lignite mining section, it is difficult to unambiguously determine whether the decreased expenditures on environmental protection resulted from the restructuring of the hard coal industry or from the situation in the lignite mining sector. It appears reasonable to conduct more extensive studies on the interrelation

between the outlays incurred and the effects in minimising the negative impact of mining on the environment.

References

1. J.Król-Korczak, E. Brzywczy, Archives of Mining Sciences, *Fuzzy System For Decision Support Of Post-Mining Regions Reclamation*, **64**, 1, 35-50 (2019)
2. R. Ogrodnik, IOP Conference Series: Earth and Environmental Science, *Environmental performance indicators of hard coal mine*, **214**, (2019)
3. B. Kowal, D. Kowal, Polish Journal Of Environmental Studies, *The sustainable development management system of hard coal mining enterprises*, **20**, 4A, 145-150 (2011).
4. BP Statistical Review of World Energy 2018, 67th edition.
5. Bilans energii pierwotnej w latach 2001-2016. Agencja Rynku Energii. S.A.
6. Program dla sektora górnictwa węgla kamiennego w Polsce. Ministerstwo Energii, Warszawa 2018.
7. Energy 2018. Główny Urząd Statystyczny, Central Statistical Office, Warsaw, (2018).
8. R. Ogrodnik, Polish Journal Of Environmental Studies, *Mining companies' activities in the context of a sustainable development policy*, **23**, 3A, 89-94 (2014).
9. M. Kęsek, P. Bogacz, M. Migza, IOP Conference Series: Earth and Environmental Science, *The application of Lean Management and Six Sigma tools in globalmining enterprises*, **214**, (2019)
10. Environment 2017. Central Statistical Office, Warsaw (2017).
11. Statistical Yearbook Of Industry – Poland 2004 ... 2017. Central Statistical Office, Warsaw 2004 ... 2017.