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Effects of Pro-Ecological Investments on an Example of the Heating Industry—Case Study

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Abstract: This paper presents problems connected with the effects of pro-ecological investment on the example of the heating industry. The aim of the publication, resulting from the identified gap, is to analyze pro-ecological investments on the example of a Polish heating company—Miejska Energetyka Cieplna Ltd. in Koszalin. In particular, the pro-environmental activities in which the examined company engaged over the period 2017–2020 were analyzed. On the basis of existing models in the literature, the authors' cause–effect model for analyzing pro-ecological investments was proposed and investments were realized by the analyzed organization using this model. Combining the presented causes and effects of ecological investments, it is possible to propose a cause–effect model of pro-ecological investments undertaken in organizations consisting of three causes and five effects. All causes that cause organizations to realize pro-ecological investments can be divided into three groups: low requirements, economical requirements, and image requirements, all of which lead to the implementation of environmental corporate social responsibility.

Keywords: pro-ecological investment; pro-ecological technology; emission reduction; heating plant; heating industry

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1. Introduction

Issues concerning pro-ecological investments and their impact on limiting the operation of an organization are very important in today's economy. In European Union countries, increasingly strict requirements have been introduced for compliance with standards on the emission of harmful substances into the atmosphere. This issue finds an important place in European law. Current trends associated with the pursuit of a significant reduction in CO_2 emissions into the atmosphere and the reduced use of coal as fuel force organizations operating in the European Union to adjust their activities and applied technologies.

The EU Emission Trading System (ETS) has been introduced in the European Union. It aims to reduce carbon emissions in industry by requiring companies to hold a permit for every ton of carbon dioxide emitted [1–4]. Companies are required to purchase permits through an auction system. This type of policy is aimed not only at reducing emissions, but at indirectly stimulating investment in new, environmentally friendly technologies in EU member states [5–7].

In particular, the regulation regarding the reduction in CO_2 emissions introduced by the European Union has resulted in a high increase in prices of emission allowances, which creates strong economic pressure on the reduction in emissions of all types by organizations, including heating plants [8–11]. This change represents a huge cost to the Polish power industry, which risks losing its competitiveness if new technological solutions are not introduced [12,13]. In particular, the problem concerns small municipal and regional heating plants and electrical power and heating stations which, if they do not invest in new, more environmentally friendly technologies, are threatened with bankruptcy due to the growing costs of emissions.

A reduction in CO_2 emissions in the coming years in Poland can be achieved by, among others, increasing the efficiency of coal-fired power plants, increasing the share of natural gas and energy from renewable sources—including wind, solar, and biomass energy—in electricity production, and increasing the share of co-generation of electricity and heat in this production, as well as in the longer term, by the share of nuclear energy in electricity production. Combined heat and power generation allows one to save primary energy, thus reducing CO_2 emissions and total generation costs compared to separate generation [14–16].

Therefore, there is strong pressure in the Polish heating industry to implement modern, pro-ecological solutions [17–20]. These trends also meet the implementation of the overall concept of environmental corporate social responsibility (ECSR) [21–26]. The introduction of these technologies should become an important element in realizing an ECSR strategy by a given organization [27–31].

The Polish heating sector has many problems related to the combustion of harmful substances, which lead to poor air quality. When analyzing the Polish heating sector, it should be noted that as much as 76% of heat is generated in individual heating installations, while only 24% is generated in district heating systems. It is worth noting, however, that the Polish district heating network is one of the best developed in Europe. At present, in Poland, despite the expansion of the district heating network and the growing area of heated buildings, the amount of heat sold is not increasing in the long term. This is due to systematic improvements in the energy efficiency of buildings [32–35].

A significant problem in the Polish heating sector is the fact that the main raw material used in Poland for heat production is still hard coal. Diversification of fuels used to produce heat in Poland is progressing very slowly. This is unfavorable due to the decarbonization policy pursued by the European Union. As a result, Poland must limit its use of hard coal and switch to pro-environmental energy sources [36–38].

In particular, attention should be paid to the necessity of adjusting heating installations to best available techniques (BAT). The deadline for adjustment is 1 January 2023. Issues related to the rising costs of CO_2 emission allowances are also important. The rapidly rising price of emission allowances leads to an increasing cost of heat production.

In this context, the Polish district heating sector must undergo rapid modernization to become more environmentally friendly. Only in this way will it be possible to ensure that the legislation is implemented and heat costs kept at a moderate level. In Poland, there are problems associated with the modernization of inefficient district heating systems due to the fact that there are legal restrictions on state aid. This makes it difficult to modernize the district heating industry and move to low-emission systems [39,40].

The implementation of investments in new technologies is also important from the point of view of the following transition to so-called Industry 4.0 [41–43]. In the conditions of Industry 4.0, it is necessary to introduce technologies that will not only allow the achievement of positive environmental effects but also enable the digitalization of processes [44–47]. This will improve their management and allow industries to adapt to the conditions of Industry 4.0 [48,49].

Analyzing the literature on the subject, we have identified a cognitive gap in the analysis of the implementation of new technologies in the heating sector, in particular in the context of the technologies used and their impact on the environment—emission of harmful substances.

The aim of this publication, resulting from the identified gap, is to analyze pro-ecological investments on an example of a Polish heating company—Miejska Energetyka Cieplna Ltd. in Koszalin. In particular, we analyzed the pro-environmental activities in which the examined company engaged over the period 2017–2020.

The paper poses the following research questions:

- What pro-ecological investments have been implemented by MEC Koszalin between 2016 and 2020?
- What was the impact of these investments on the emission of harmful substances into the atmosphere by the analyzed organization?
- Did the implementation of new technological solutions also result in positive economic effects?

On the basis of existing models in the literature, the author's cause–effect model for analyzing pro-ecological investments was proposed, and investments realized by the analyzed organization were analyzed using this model.

2. Literature Review

As part of a country's development policy, strategies are implemented aimed at environmental protection through the creation of sustainable cities, green cities, or eco-cities. In the literature, it is difficult to find an unambiguous classification of groups of pro-ecological investment activities. However, an analysis of the literature shows that the scope of investment as part of various activities and forms of financing is large [50–52]; however, the most frequently classified activities are related to:

- Changes in lighting methods (led) and energy creation (photovoltaics, wind turbines, nuclear power plants) [53–56];
- Building infrastructure for the creation and use of electric vehicles [57–59];
- Creating green areas [60];
- Appropriate waste management (including the use of increasing recycling methods) and water [51];
- Changes to heating systems.

The investment process consists of a thoughtful, responsible action to abandon current consumption and to use these funds for a specific purpose, one that is intended to bring certain benefits in the future [60–63]. All investments must be of a long-term nature and involve a certain rate of return. Green investments fit perfectly into this assumption. Currently, all green activities are socially justified [64–70] but the level of capital invested in this area is evidence of a company's development. It should be remembered that an investment process depends on the specificity of a business and the type of investment. [71–73]. In the case of district heating companies, green investments are most often the result of an adopted strategy for the development of organizations, statutory requirements, or specific future economic benefits [74–80].

Heating companies must constantly analyze and implement solutions that improve the quality of residents' life under the pressure of industrial and commercial entities located in their area and the natural environment [81]. Therefore, all investment activities are mainly aimed at [82–84]:

- Building pro-ecological awareness;
- Reducing exhaust emissions (greenhouse gases);
- The effective use of alternative methods of heat extraction.

This allows for changes in the production process through broad scientific research to seek or develop new technical and technological solutions in applied production that increase environmental impact (e.g., minimization of CO_2, use of recycling, or other components for heat production) and improve the quality of services offered (e.g., use of standardized management systems in the ISO standard family) [64,68,85–87]. All investment activities undertaken by district heating companies are intended, on the one hand, to increase the value of an organization by generating more profit and capital for the company and, on the other hand, to increase the level of satisfaction of stakeholders by developing appropriate relationships, acting within the ECSR, and improving the quality of life of customers [63,88–90]

Risk analysis is an important area in the implementation of green investments. Investment risk means the possibility of events that may, in some cases, have negative effects [91–95]. That is why it is important to identify and assess sources of internal and external risk (including particularly ecological risks) and eliminate and minimize irrational activities, expectations, or behaviors [73,96]. This allows one to make decisions with the planned investment, as its profitability will depend on the degree of success [97–99]. The effectiveness of green investments should generate positive cash flows over a certain period of time and reduce negative environmental impacts. From an economic point of view, indicators such as the return on investment or the rate of return are important for an organization. This approach allows for the identification and analysis of factors for new investments [68,77,78,100–103].

3. Materials and Methods

3.1. The Research Conception and Research Plan

A case study method was used to conduct this analysis. The research was conducted in relation to a heating company operating in northwestern Poland—Miejska Energetyka Cieplna (MEC) Koszalin. The research used reports on pro-ecological technologies implemented in the company in 2016–2020. The collected reports and internal documents were analyzed from the point of view of the studied years and implemented technologies.

The analysis covers years 2016–2020. The reason for this choice of years is that, in 2017, the company implemented the ISO 14001:2015 standard. The preparation for its implementation started in 2016. After this year, the company did not conduct pro-ecological investments and used old technology. The process of implementation of the ISO 14001:2015 standard was the impulse for the company to implement new environmental technological solutions. In our paper, we use qualitative and quantitative methods. We use quantitative methods in the case of data regarding pro-ecological investments in MEC Koszlain in years 2016–2020. We use the qualitative data regarding the costs of particular environment investments. To analyze the environmental effects of the investigation, we compared the data pertaining to a reduction in pollutants achieved by the modernization of a WR type of boiler.

In Figure 1, we show the scheme of the research design; this figure shows the steps of our research. In the first stage of our research, we analyzed the literature about pro-ecological investments in the heating industry. On this basis, we selected an organization and the period of the research.

In the next stage, we conducted a preliminary analysis of all ecological investments in the analyzed organization with the data related to the costs of the investment. Next, we analyzed particular investments point by point and tried to find the ecological effects connected with particular investments. Notably, we concentrated on the reduction in pollutants achieved by particular investigations. In the following stage of the research, we compared our achieved results with the international literature about the effects of pro-ecological investments. On the basis of the research, we prepared a cause-effect model of pro-ecological investment, and used this model to analyze and compare all investments in the analyzed company.

3.2. Information about Analyzed Organization

Miejska Energetyka Cieplna, a limited liability company in Koszalin, is an energy company with licensed business activity consisting of the generation, transmission, and distribution of heat. It provides its services in the area of the city of Koszalin, satisfying about 60% of heating needs of all objects located in the city, and in Sianów, where it secures about one fourth of the demand for heating energy.

MEC Koszalin has been present on the market for over ten years. It continues good traditions and a long experience of the heating sector in Koszalin, which previously operated in other organizational and ownership forms; since 1970, it has operated as Miejskie Przedsiębiorstwo Energetyki Cieplnej in Koszalin, which was created on the basis of Zakład Gospodarki Cieplnej MZBM in Koszalin.

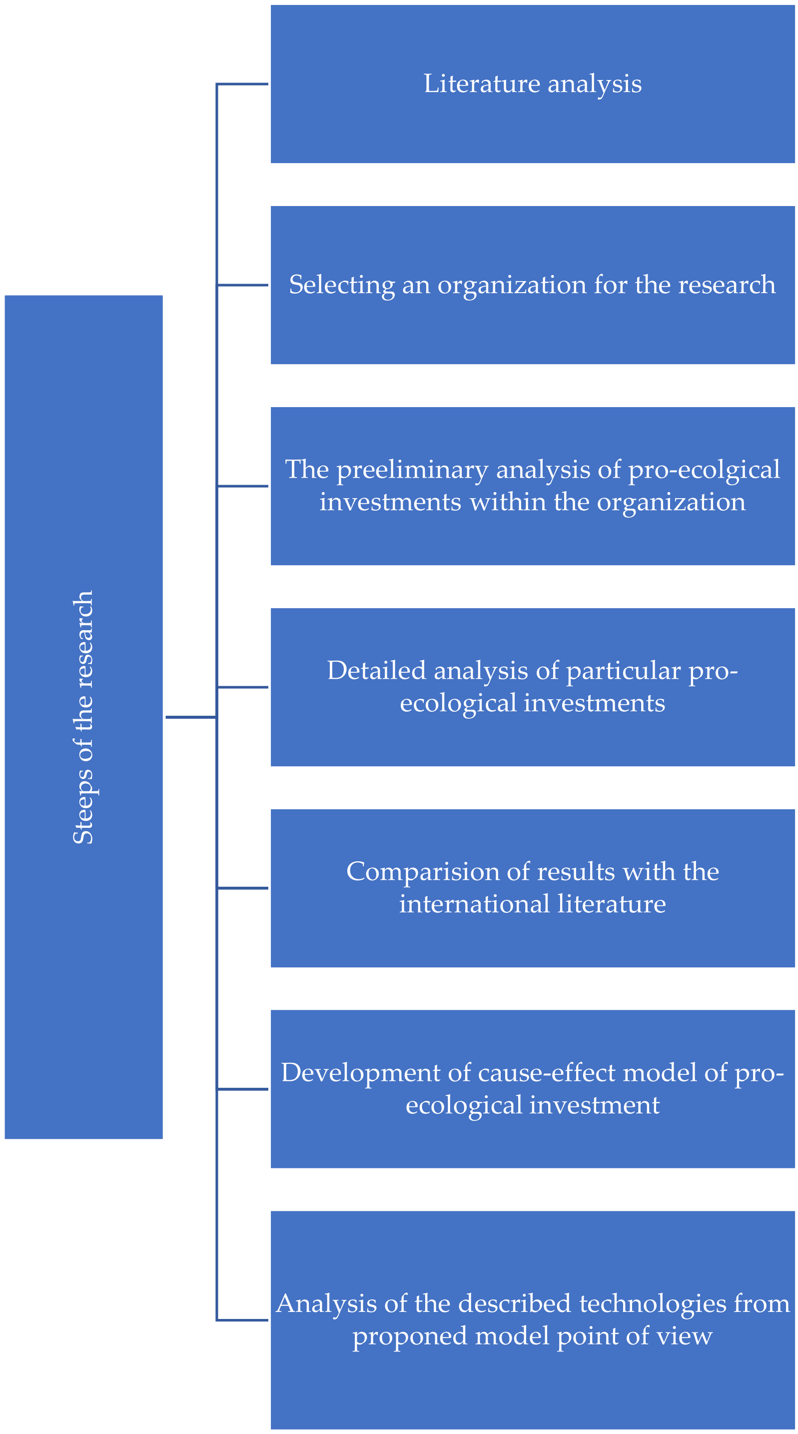

Figure 1. The steps of the conducted research.

At present, the entire Polish heating sector faces the same problem, i.e., dynamically changing regulations related to climate protection in a broad sense. Moreover, taking all possible strategic decisions would mean incurring disproportionately high investment outlays in relation to the assumed effects. The uncertainty related to the availability of selected fuels on the market and, above all, to what can conventionally be described as the end customer's endurance limit, should also be taken into account. These expenses will be reflected in the tariff for heat buyers [11,104].

Compared to the industry, MEC Koszalin is still in a stable situation and has no problems with financial liquidity. At the same time, it is not uncommon for many Polish heating companies to fall behind with their payments—a phenomenon that has already become noticeable [105].

The basic activities of Miejska Energetyka Cieplna Ltd. in Koszalin are generation, transmission, and distribution of heat energy; construction, development, modernization, and repairs of heating networks and power equipment and their operation; carrying out investment service activities and providing advisory, consulting, and engineering services in the field of district heating.

Moreover, the laboratory of Miejska Energetyki Cieplnej in Koszalin provides services in the scope of chemical analyses of boiler water quality, analyses of solid fuels—dust, coal, coke (calorific value, ash, sulfur), analyses of solid biofuels—wood chips, energy willow, straw briquette (calorific value, ash, sulfur), and determination of combustible parts in slag.

MEC has implemented an ISO 14001:2015 certified environmental management system to provide better control over the environmental impact of the organization, the products it produces, and the services it provides. The basic requirement of an environmental management system is to systematically reduce impacts on the environment.

In recent years, this organization has undertaken the following environmental activities: thanks to the promotion of a reduction in heat demand (through thermorenovation, automation), MEC led to the actual elimination of air pollution. As a result of these actions, it reduced fuel consumption; improvements in fuel quality (good quality fuel is burnt, with low ash and sulfur content); a reduction in fuel consumption by increasing the efficiency of boilers (modernization of the first boilers showed an increase in their efficiency by about 5 percent); a reduction in total fuel consumption by almost 10–15 percent due to the higher energy efficiency of large boiler units; a reduction in heat losses of district heating networks; a reduction in electricity consumption (by installing frequency converters for smooth control of pumps and fans); modernization of district heating substations; liquidation of its own local coal-fired boiler houses; liquidation of district heating substations (resulting in increased safety of the system and reduced heat consumption by about 17 percent).

The company's planned and implemented modernization and development projects, which are detailed in the Development, Modernization, and Environmental Investment Plan for the years 2010–2021, are aimed primarily at increasing the sales of heat energy, with a particular focus on increasing the sales of energy for domestic hot water needs, reducing the costs of operations, reducing emissions of dust and gases into the atmosphere, and ensuring safe heat production and transmission. The company achieves these goals through the following actions: connecting new facilities to the municipal heating network and existing ones in revitalized areas; acquiring new opportunities to sell heat energy for domestic water heating, ventilation, air conditioning, and technology; liquidation of group heat substations with a simultaneous increase in the sale of thermal energy for the supply of usable hot water; modernization of flue gas cleaning installation at DPM and FUB boiler houses in 2019–2020; modernization of coal-fired boilers made with traditional technology to boilers in sheet piles (boilers WR 10 No. 4, WR 25 No. 5 at the DOM boiler house, and WR 25 No. 7 and 5 at the FUB boiler house)—2013/2018; modernization of the boiler WR 25 No. 7 installed in the FUB boiler house for a boiler fired with natural gas GZ50 in order to diversify the fuel used for heat production and reduce harmful emissions into the atmosphere—2020/2021; continuation in 2020–2021 of the construction of an intelligent heating network consisting of modernized telemetry and the construction of a remote heat reading system—2016/2020; continuation of the project to increase cooling in the company's district heating substations aimed at the efficient use of district heating systems.

4. Results

4.1. Basic Description of Pro-Ecological Investments in MEC Koszalin

The investigated heating plant in the period 2016–2020 focused on numerous investments involving the introduction of pro-ecological innovations. Table 1 collects information about the discussed investments along with the most important data about each of them. In Figure 2 we present the comparison of costs of analyzed in five pro-ecological investments by MEC Koszalin. In the following points of the chapter, we will conduct a detailed analysis of the particular investments.

Table 1. Pro-ecological investments in MEC Koszalin—years 2016–2020.

No.	Year	Investment	Costs without VAT (PLN)	Effects
1	2016/2017	Modernization of the boiler type WR 25 No. 6 with heavy refractory, installed in FUB boiler house at in Koszalin for a boiler with sheet piling technology.	3,715,400.00	• increase in boiler energy efficiency • reduction in the amount of solid waste generated in the process of solid fuel combustion • increasing the energy security of Koszalin
2	2018	Modernization of the boiler type WR 25 No. 5 with heavy refractory, installed in the DPM boiler house in Koszalin into a boiler with sheet piling technology with nominal capacity of 11.63 MW.	2,900,000.00	• increase the trouble-free operation of the heat source • increase the efficiency of the heat generation process • reduction in pollutant emissions to the environment • adjustment of thermal power to the power demanded by consumers
3	2019	The construction of a video control system of the waste storage site produced within the activities of the company MEC boiler house FUB in Koszalin.	104,099.59	• adjusting to changes in legal requirements
4	2019/2020	New flue gas cleaning system.	13,400,000.00	• adjustment to changes in legal requirements • reduction in pollutant emissions into the environment
5	2020	Modernization of the boiler WR 25 no. 7 installed in FUB boiler house to a boiler fired by natural gas GZ 5.	5,200,000.00	• reduction in pollutant emissions into the environment • diversification of fuel types used for heat production
		Suma	25,319,500.00	–

In general, tax incentives and subsidies exist in Poland in the case of ecological investment, but, in practice, taking advantage of them depends on meeting a number of specific requirements. This is especially difficult for companies the size of MEC Koszalin, which are “too small” to become efficient district heating systems (in Poland, efficient district heating systems are systems in which at least 50% of energy from renewable sources is used to produce heat or cold, or 50% of waste heat, or 75% of heat from cogeneration, or 50% of a combination of the abovementioned energy and heat—in Polish practice only the largest energy facilities are such systems) or “too large” to take advantage of aid programs intended for so-called excluded cities. MEC Koszalin is also ineligible for the district heating program, as only heating companies with up to 50 MW of installed capacity are eligible. MEC, meanwhile, has 170 MW of installed capacity [106].

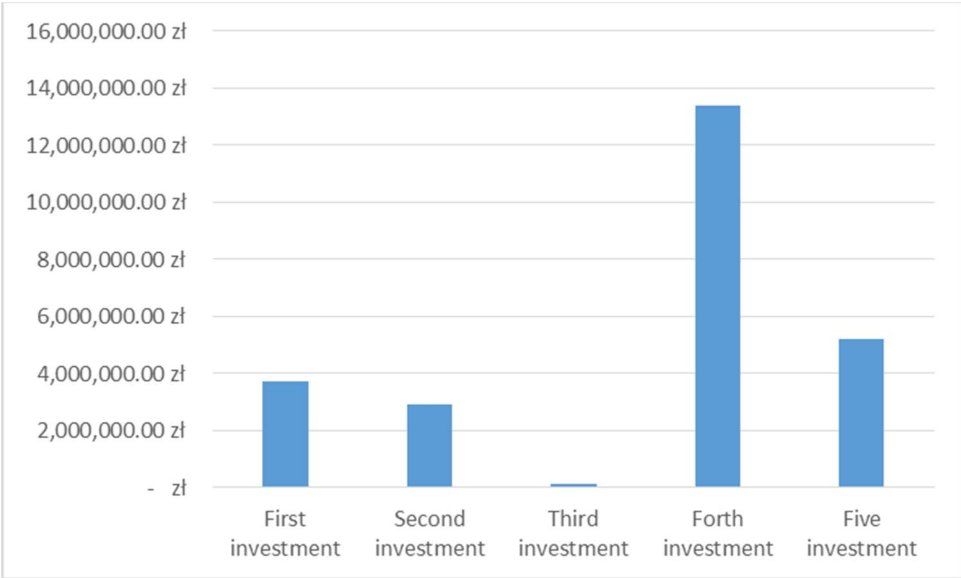

Figure 2. Costs of the pro-ecological investments in MEC Koszalin in years 2016–2020.

An additional uncertainty is the rules for the next EU financial perspective: European Funds for Infrastructure, Climate, Environment 2021–2027 program; consultations are currently ongoing (it is estimated that the final rules may not be ready until 2023). The only certainty is that investments related to the use of fossil fuels, so not only coal but also gas, will not be subsidized. Whether there will be subsidies (and if so, to what extent) for modernizing existing systems remains to be seen [107].

4.2. First Pro-Ecological Investment—Modernization of Boiler WR 25 No. 6

The first pro-ecological investment was undertaken in 2016/2017 and it concerned the modernization of boiler WR 25 No. 6 with a heavy refractory, installed in a FUB boiler house at ul Słowiańska 8 in Koszalin as a boiler with sheet piling technology. The total cost of the investment was PLN 3,715,400.00 + 23%VAT for the investment received funding—a loan from WFOŚ and GW in Szczecin PLN 3,690,000.00.

Many years of operation of the WR-25 No. 6 boiler caused significant wear and tear of its elements. The need to ensure a reliable heat supply to customers in Koszalin made it necessary to repair the boiler and increase its energy efficiency. Reconstruction of the WR 25 No. 6 boiler consisted in introducing structural changes and replacing the existing combustion chamber screens of the La Monta system with sheet piling screens. This solution made it possible to eliminate the previous traditional refractory and supporting structure. The boiler was constructed in a three-pass system. Sheet piling of the boiler made up the space of the furnace chamber and the second pass. An additional water heater bundle (III thrust) consists of coils built in the flue gas duct, formed by a free-standing steel structure and external armoring plates. The use of membrane walls made it possible to obtain tightness in flue gas ducts and allowed for the use of lightweight thermal insulation made of mineral wool plates covered with external armoring sheets.

The heating surface of the boiler consists of bundles of coils of water heater III line and bundles of coils of convection water heater II line, a boiler rear screen, a furnace chamber rear screen, a front screen, and side screens. The boiler is equipped with a new mechanical 7-zone, scale-type, heavy duty grate for burning fine coal. The grate was equipped with a coal basket with an arc gate and a stratifier with an electric drive. The inflow of air under the grate is ensured by ducts equipped with control valves actuated by electric actuators. The speed of the grate feed is regulated by the rotational speed of drive motors through frequency converters. The front and back of the grate are covered with a refractory lining, which, in the front part, is also an ignition vault. Slag and ash and fly ash transfers are discharged via the existing scraper slag traps onto the existing central slag conveyor belt.

Primary and secondary air fans were installed at the slagging level and equipped with frequency converters.

To clean the heated surfaces of the convection water heaters of II and III thrust, electromagnetic beaters were installed. All external elements of the boiler were properly thermally insulated with mineral wool covered with external protection. Boiler WR 25 No. 6 was equipped with a new switchgear RK, power supply systems for fans of flue gas exhaust, blowing, and secondary air, a grate drive, a slag trap, and a water heater pump behind the boiler. A basic and emergency lighting system for the boiler was installed. In the scope of AKPiA (control and measurement instruments and automation), we installed systems of fluent rotation regulation on the frequency converters of the fans of the flue gas exhaust, air blast, secondary air, and grate drive.

The scope of modernization of boiler type WR-25 No. 6 included the execution of the following works:

- Development of project documentation for the planned boiler modernization scope.
- Boiler modernization in the scope of: replacement of the whole boiler piping with the application of sheet piling screening of the combustion chamber in the first line, installation of two convective banks in the second line, and an economizer in the third line, with the application of a solution reducing outlet loss (reduction in flue gas temperature); dismantling of the existing mechanical grate and installation of a belt grate with reversible carriage type RTP 2570; the speed of the grate feed is regulated by the rotational speed of the drive motor using a frequency converter; modernization of blowing air and secondary air installation, together with the replacement of blowing air box and fans, as well as application of control valves, separately, in each of the seven grate zones; primary air fan type WWOax63 +K, secondary air fan type WP25/0.75, and fans will be equipped with frequency converters with manual and automatic air volume control; supply and installation of a mechanical system for cleaning the convective bank with the use of electromechanical beaters type OP–2; building of a refractory of the front and back parts of the boiler, together with an ignition vault made of wedge-shaped pieces of andalusite type material; a refractory of the back part of the boiler made of chamotte mortars and perlite; execution of thermal insulation and armoring of the boiler body from steel sheets; renovation of ash and slag hoppers with lining made of chamotte bricks; replacement of the coal hopper equipped with an arc gate valve and automatic and manual control stratifier; replacement of stop valves and boiler protection fittings; installation of platforms for service personnel and connections to passageways to other boilers; testing, pressure tests, and acceptance of pressure part by UDT.
- Execution of electrical works and control and measurement instruments and automation: preparation of design documentation for electrical and control and measurement instruments and automation branch; assembly of a new RK switchboard for boiler WR 25 No. 6; assembling of power supply systems for flue gas exhaust fan, blowing air, and secondary air, as well as grate drive, slag trap, and water heater pump behind the boiler; assembly of the systems for fluent rotation regulation on the frequency converters of the flue gas exhaust fan, air blast, and secondary air fan, as well as grate drive; installation of basic and emergency lighting for the boiler; carrying out tests and checking measurements of all machines, devices, and measurement lines included in the modernization process.

As a result of the project's implementation, an energy effect was obtained related to the increase in the K-6 boiler's energy efficiency, meaning a reduction in consumption of primary energy contained in the fuel in the FUB boiler house in relation to the initial state. As a result of the reduction in fuel consumption, there was also reduction in solid waste produced in the process of solid fuel burning, i.e., slag.

A very important result of the project is also the increase in the energy security of Koszalin resulting from the increase in the reliability of heat generation in the FUB boiler house; this is as a result of carrying out the renovation of the worn-out boiler house in a technically and economically justified manner while maintaining the requirements of environmental protection.

A detailed characterization of the effects obtained in the modernization process for each type of pollutant is presented in Table 2. In Figure 3, we present a comparison of the reductions achieved in particular pollutants in percentages (%).

Table 2. Reduction in pollutants achieved by modernization of WR type boiler.

Type of Pollutants	Dust (Mg)	NO_x (Mg)	SO_2 (Mg)	CO(Mg)	CO_2 (Mg)
Condition before modernization	67.370	119.768	305.408	149.710	65,872.400
Condition after modernization	63.754	110.684	288.276	138.355	60,876.200
Achieved pollution reduction (Mg/year)	3.616	9.084	17.132	11.355	4996.200
Reduction of pollutants planned in the funding agreement	1.849	3.288	8.384	4.11	1808.4
Achieved pollution reduction in (%)	5.37%	7.58%	5.61%	7.58%	7.58%

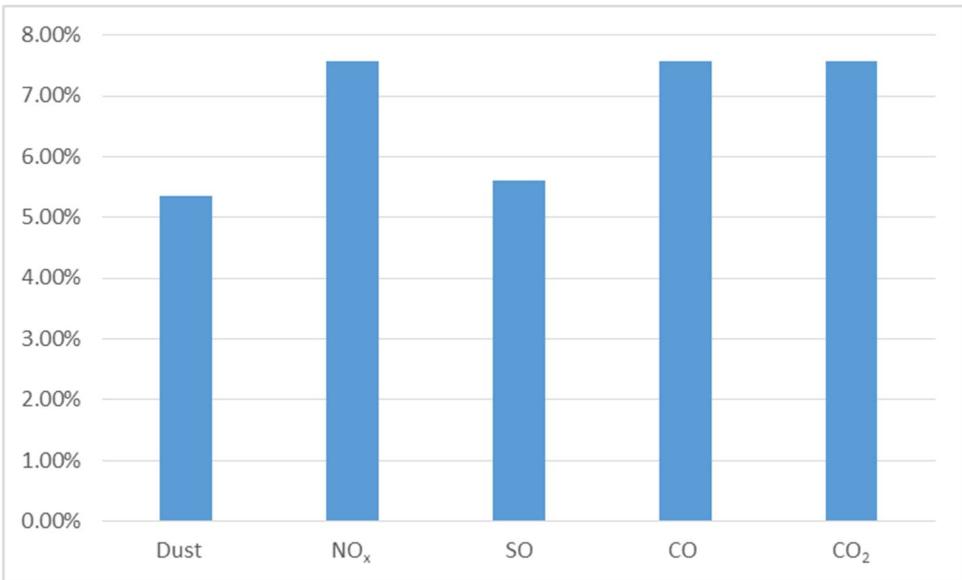

Figure 3. Achieved pollution reduction in particular pollutants in percentages. SO_2.

The new bag dust collection system currently in operation ensures a 99 percent reduction in the dust produced during coal combustion and dust emitted into the atmosphere. The annual fee for using the environment amounts to approximately PLN 360,000. Taking into account the volume of dust reduction achieved thanks to the new system, the saving on the annual fee for using the environment amounted to approximately PLN 16,000.

Apart from dust, other chemical compounds (SO_2, NO_x) are not reduced. The system does not affect the emission of carbon dioxide either. The emission of the latter compound will be reduced only after the gas boiler is put into operation, which will take place in October this year; in the future, it will be reduced because of the implementation of biomass-fueled or co-fueled boilers.

In principle, biomass may be used, provided that the existing coal-fired boilers are modernized to co-fire biomass with coal or replace coal completely. In the case of MEC Koszalin, which has a modern bag dedusting system, it is also necessary to install appropriate safeguards to protect the bag filters from being destroyed by unburned particles rising from the furnace. A completely new logistics system for biomass delivery would also have to be developed. Taking into account that biomass has, on average, half the calorific value of coal, twice as much biomass as coal would be needed to maintain the assumed volume of heat production. A switch to biomass would also require the construction of a so-called day store, i.e., a roofed place where fuel is placed just before burning and where biomass could be dried [108,109].

MEC Koszalin currently has one coal-fired boiler adapted for co-firing biomass in the amount of 10% of the total fuel per year. However, in order to take advantage of the opportunities offered by this boiler, it is imperative that the bag filters are protected from damage first [110,111].

Implementation of the boiler modernization project resulted in achieving the following effects in the reduction in pollutant emissions over a period of 12 months: an increase in heat generation efficiency in WR-25 No. 6 boiler from the value before modernization of ηG = 81.0% to the value after modernization ηG = 87.6%; an increase in heat generation efficiency in the FUB boiler house in Koszalin from the value before modernization of ηG = 82.6% to the value after modernization of ηG = 88.1%; a reduction in fuel consumption burnt in boiler WR-25 No. 6 from the amount of 18,612.00 Mg/year before modernization to the amount of 16,943.00 Mg/year after modernization, i.e., 1669.00 Mg/year, with the amount of generated heat being 343,344.00 GJ/year; a reduction in the emission of pollutants into the atmosphere in an amount higher than expected at the stage of concluding the contract for co-financing.

As can be seen from the data presented in Table 2, the investment can be regarded as successful. A significant reduction in pollutants was achieved with respect to all basic types of emitted substances. Noteworthy is the fact that, in all studied areas, the investment project brought about better effects in comparison with those assumed in the grant application. In the case of NO_x and CO_2 emissions, the achieved effect was almost three times higher than that assumed. For the remaining substances (dust, SO_2, and CO_2), the actual reduction in pollutants was about two times higher than assumed. The investment also created positive economic effects as a result of the improved efficiency of heat generation and reduced the amount of fuel burned in the boiler. This kind of pro-ecological investment is therefore beneficial from both ecological and economic points of view.

4.3. Second Pro-Ecological Investment—Modernization of Boiler WR 25 No. 5

The second investment carried out in MEC Koszalin was the modernization of boiler type WR 25 No. 5 with heavy refractory lining, installed in the DPM boiler house in Koszalin into a boiler with sheet piling technology with a nominal capacity of 11.63 MW. The investment was carried out in 2018. The boiler's modernization consisted of replacing the existing furnace chamber screens of the La Monta system with new screens with sheet piling technology, together with reducing the nominal capacity of the boiler from 29.07 MW to 11.63 MW. The cost of implementation was PLN 2,900,000.00 + 23%VAT.

To ensure the security of heat supplies to consumers in Koszalin, replacement investments in production units were necessary. Therefore, taking into account the poor technical condition of the piping in the pressure part of WR 25 No. 5 boiler in the DPM boiler plant (numerous failures), and given the existing overcapacity, it was justifiable to upgrade the WR 25 No. 5 boiler in the DPM boiler plant to a boiler with the application of sheet piling technology with a simultaneous reduction in the nominal thermal power of the boiler to 11.63 MW. The reduction in nominal thermal power of the WR 25 No. 5 boiler to 11.63 MW was a continuation (second stage) of the measures implemented in 2016, which led to a reduction in the nominal thermal power of the boiler from 29.075 MW to 23.26 MW.

Modernization of the boiler was carried out in 2018 and consisted of replacing the existing heavily technically worn furnace chamber screens with new screens with sheet piling technology. Replacement of the boiler piping, together with modernization of the boiler walls with sheet piling technology, secured and ensured failure-free operation of the boiler and increased the level of energy safety of the DPM boiler plant. In addition, the rebuilt and modernized WR 25 No. 5 boiler with a capacity of 11.63 MW is characterized by a high efficiency of over 85% and flat operating characteristics, allowing it to achieve the same efficiency of the boiler at both 100% and 50% efficiency. The boiler's modernization also allowed us to extend inter-renovation periods, reduce operating costs, and improve working conditions for the service staff.

The purpose of this investment task was to increase the failure-free operation of the heat source, increase the efficiency of the heat production process, reduce the emission of pollutants into the environment as part of the company's operations, and adjust the heat capacity of the sources to the capacity demanded by customers.

As a result of modernization, an energy effect connected with the increase in K-5 boiler's energy efficiency was obtained, which means a reduction in primary energy consumption contained in fuel in the DPM boiler house in relation to the initial state. As a result of the reduction in fuel consumption, there was an additional reduction in solid waste generated in the process of solid fuel combustion, i.e., slag. Additionally, in the case of this investment, the data show that it was possible to combine positive environmental and economic effects.

4.4. Third Pro-Ecological Investment—The Construction of a Video Control System of Waste Storage

The third ecological investment of the analyzed organization was the construction of a video control system of the waste storage site produced within the activities of the company MEC boiler house FUB in Koszalin. The investment took place in 2019 and was largely due to the need to adjust operations to changes due to legal requirements. The total cost of the investment was PLN 104,099.59 + 23% VAT.

In 2019, pursuant to Article 14 (1) of the Act of 20 July 2018 amending the Act on Waste and certain other acts (*Journal of Laws 2018*, item 1592), MEC proceeded to amend its waste collection permit in order to bring the permit into compliance with the requirements of the amendments to this Act.

The vision control system installed at MEC Koszalin meets the requirements for vision monitoring in the provisions of Article 25.6a–6c of the Act of 14 December 2012 on waste (*Journal of Laws 2019*, item 701, as amended) for the existing conditions of installation.

After the completion of the investment, the waste storage site was then located in a separate part of the warehouse in Koszalin. The warehouse structure is steel, and its walls and roof are made of corrugated metal sheets. The entire facility is divided into two parts separated by a metal mesh. The height of the building is 6.51 m. A video control system was built to monitor the storage area of waste produced at the FUB Koszalin boiler house.

The main cabinet with a video recorder, a network switcher, and a UPS unit was installed in a technical room under the staircase in a social part of the boiler room WLM 5. From this room, routed cables were installed to the waste storage area. Four indoor cameras have been installed in the corners of the waste storage area. Outside, in front of the entrance gate, there is one external camera. From the cabinet in boiler hall control room WR 25, a fiber optic route has been installed to the main cabinet in the technical room under the staircase. This ensures communication of the video system with the MEC Internet network at the FUB boiler house. Access codes to the system were provided to the Voivodeship Inspectorate of Environment Protection.

The technical parameters of the devices, equipment, and cabling used are in accordance with PN-EN 62616-4:2015-06: Video surveillance systems used for security purposes—Part 4. The following devices were purchased and installed as part of the investment: Camera type IPC-HFW4431S-0280B. The IR bullet camera provides 4 Mpx resolution with a 2.8 mm fixed lens. H.265+ compression ensures high image quality without excessive network load. Built-in intelligent video analytics allows for more efficient detection and analysis of moving objects for better video surveillance through network video recorder NVR5416-4KS2 with a WD60PURZ hard drive. The network recorder by Dahua Technology is dedicated to systems that require high-performance and -quality recordings. Thanks to its efficient processor, it is possible to record in 4K resolution (3840 × 2160), which provides high quality and great detail; a 6TB hard drive was designed specifically for these video surveillance systems. Caching algorithms are tailored to meet the requirements of surveillance environments characterized by high write-intensity, low bit rates, and a large number of simultaneous streams; power adapter APC Smart-UPS X 750VA Rack/Tower LCD 230V SMX750I UPS; Cisco SF302-08PP-K9-EU Network Switch.

4.5. Forth Pro-Ecological Investment—Installation of a New Flue Gas Cleaning System

The next investment was undertaken by MEC Koszalin in 2019/2020 and concerned the construction of a new flue gas cleaning installation. MEC Ltd. in Koszalin, with financial support from the Provincial Fund for Environmental Protection and Water Management in Szczecin, installed a flue gas cleaning installation in its facilities, thanks to which more than 250 tons of pollutants, including dust and sulfur dioxide, will not enter the atmosphere annually.

The investment was financed within the project "Adaptation of existing heat sources of MEC Koszalin to emission requirements of MCP Directive. Modernization of flue gas cleaning installation for WR 25 No. 6, WR 25/10-M No. 5, and WR 10 No. 4 installed in boiler house DPM Mieszka I-go 20 A in Koszalin, and for WR 25 No. 6 boiler installed in boiler house FUB, Słowiańska 8 in Koszalin". The objective of the project was to obtain an environmental effect in terms of coal dust emissions into the atmosphere, resulting from the combustion of solid fuels in WR 25 and WR 10 boilers, by adjusting dedusting installations in operation regarding the requirements of the Environment Protection Law Act. The investment will allow the company to comply with new standards that are in force from 1 January 2023. The FUB and DPM boiler plants must then meet the requirements set out in the Regulation of the Minister of the Environment of 24 September 2020 on emission standards for certain types of installations, fuel combustion sources, and waste combustion or co-incineration equipment (*Journal of Laws 2020*, item 1860), and the flue gas cleaning systems must ensure that dust emissions to the atmosphere in the outlet flue gas are limited: $\leq$50 mg/Nm3 and limitation of sulfur dioxide SO_2 emissions to $\leq$1100 mg/Nm3.

For the implementation of this project, the company received financial support from WFOŚiGW in Szczecin in the amount of PLN 10.4 million in the form of a loan. The total gross value of the project amounted to PLN 13.4 million + 23% VAT. As a result of the project's implementation, its environmental effects in the form of a reduction in dust emission should be discernable by 132,130 Mg/year and by 119,650 Mg/year for SO_2 emissions.

Until modernization, flue gas cleaning in each boiler house was ensured by a two-stage dedusting system based on dust separation under inertial forces (cyclone principle), which ensured that dust concentrations in flue gases met the level required by law by the end of 2022, i.e., $\leq$400 mg/Nm3 and $SO_2 \leq$ 1500 mg/Nm3.

In order to reduce the content of dust and SO_2 in flue gases, an upgrade of the existing flue gas cleaning systems at the FUB and DPM boiler plants was planned and executed in the following scope: the flue gas dedusting installation was made as a two-stage installation consisting of a pass-through multicyclone MOS preliminary dedusting unit (first filtration stage) and a main dedusting unit in the form of a vertical bag filter (second filtration stage); in order to reduce the content of SO_2 in flue gases, a complete installation for the reduction in sulfur dioxide based on the automatic liming of bag filters was implemented.

Dust removal systems for water boilers fired with coal dust of WR 25 type comprised three sets and a WR 10 type-one set, both of which were modernized. Bag filters are used where highly efficient dust recovery is important. The dedusting installation will not introduce additional substances into the air in comparison to the existing state and, due to higher dedusting efficiency, it will reduce dust loads introduced into the air by approximately 132,130 Mg/year.

Designed and manufactured bag filters have an increased surface area to ensure the proper operation of a desulfurization plant using sorbent. The desulfurization method uses dry technology with hydrated lime sorbent. The flue gases are mixed intensively with the sorbent flow to the fabric filter, where the main process of sulfur dioxide removal takes place. A filter cake located on the bag and consisting of a mixture of sorbent, dust, and post-reaction product constitutes a layer in which the main desulphurization process takes place. The post-reaction product and dust retained in the fabric dust collectors are discharged by pneumatic transport to waste silos, from which they will be collected by a truck.

As part of dust removal system modernization, we initiated a complete installation for the collection and transport of ash dusts precipitated in the installed devices, as well as the production and preparation of compressed air and air conditioning station necessary for proper operation of the entire dedusting system. New flue gas exhaust fans were applied together with frequency converters with parameters adjusted to requirements of the flue gas cleaning installation, thus ensuring the correct operation of boilers.

The investment was the biggest pro-ecological investment of MEC Koszalin in the years under research, and it also generated the greatest pro-ecological effects. At present, it is not possible to precisely determine the overall effect, as it will be known only after a year from the completion of the investment, at the end of 2021.

4.6. Fifth Pro-Ecological Investment—Modernization of Boiler WR 25 No. 7

The latest pro-ecological investment in MEC Koszalin was the modernization of WR 25 boiler no. 7 installed in the FUB boiler house to a boiler fired by natural gas GZ 50. The investment is in progress and has been planned for 2020–2021. Its total planned cost is PLN 2,200,200.00 + 23% VAT.

In 2020, the organization began the implementation of an investment task entitled "Modernization of WR 25 No. 7 boiler installed in the FUB boiler house to a boiler fired by natural gas GZ 50", and this was continued in 2021. The investment consisted of the modernization of existing coal-fired boiler WR 25 No. 7 with a power output of 29.07 MW, installed in the FUB boiler house and made with the use of sheet piling technology, into a gas-fired boiler with a power output of 36 MW, fired with GZ 50 gas. Start-up of the gas-fired boiler is planned for the middle of 2021. Expected annual gas consumption is approximately 1.5 million m3.

The need to upgrade WR 25 boiler no. 7 to a gas-fired boiler results from the adopted development directions of MEC for the coming years, all of which are related to the aim of diversifying the type of fuel used in heat production, using fuels that allow for a reduction in CO_2, NO_x, and SO_2 emissions to the atmosphere, and reducing the amount of waste associated with the production of heat from coal, i.e., slag, in the context of changing environmental and waste management regulations. Planned emission reductions are: dust = 99.4% (about 3133.00 kg), CO_2 = 37.3% (about 1798.00 kg), and SO_2 = 99.99% (about 12,669.00 kg).

The following work is planned as part of the investment:

- Disassembly: disassembly of the existing boiler flue gas dedusting system together with the flue gas exhaust fans; disassembly of the existing installation for transportation of smoke floor dusts of the boiler (tubular chain conveyor fulmar) and dust sprinkler foka; disassembly of the boiler fuel hopper, grate deck, blower air system, and parts of the boiler elements, systems, and equipment; disassembly of the boiler electrical system.
- Assembly work: rebuilding of boiler WR 25 No. 7 from coal fuel to gas fuel; construction of a gas connection from the gas reduction and measurement station to the boiler house building; execution of an internal gas installation from the gas connection's entrance to the boiler house to the boiler's gas burners, according to a description of the subject of the contract and the elaborated project documentation; execution of an independent system for flue gas discharge from the boiler together with construction of a new chimney; execution of control and measurement instruments and automation, power supply, control, and visualization installations necessary for proper and failure-free boiler operation; execution of construction works in the FUB boiler house facility in the scope of fire protection of the facility connected with the adaptation of

the boiler house facility to the fire protection requirements; execution of fire protection monitoring installation in the FUB boiler house facility related to the adaptation of the boiler house facility to fire safety requirements.

The solution proposed during modernization to adapt the coal boiler to gas fuel allowed for the use of existing boiler pressure parts, with the introduction of some modifications to adapt the boiler to burn natural gas. The elements of the existing boiler that were planned to be used during the reconstruction of this boiler included a whole boiler pressure part made with sheet piling technology, pipelines, boiler accessories, and working platforms. These components stayed in place and became part of the new boiler addition. The new part of the boiler increased the value of the existing boiler. As a result of removing the grate and installation of gas burners, necessary changes were made in the lower part of the boiler combustion chamber. New elements of the boiler pressure part, with the use of sheet piling technology, were designed and installed. They were functionally connected with the existing boiler pressure part with the use of sheet piling technology.

The pressure part and the supporting structure of the boiler were placed on a reinforced concrete foundation. In the "tub" of the foundation, in the place behind the dismantled ash and slag hoppers, there is a concrete floor and, under the burners, there is a removable steel platform (e.g., for the service works), from which there is service access to the burners. Two gas burners were installed in a suitably shaped and modified part of the boiler furnace chamber. Two ELCO burners—RPD70G-EU duoblock, low-emission, stepless electronically modulated gas burners—with 19.6 MW maximum output were installed in the bottom of the boiler furnace chamber. The burners were directed vertically upwards in the furnace chamber, which, given the structures of the boiler and furnace chamber, was the best solution for the proper operation of the burners and boiler. The flame of each burner has the correspondingly required flame length. On the side of the furnace chamber within the burners, a refractory wall was made. Sealing boxes were filled with insulating materials. Each burner has a louvre control valve and an individual primary air fan. The air for combustion is supplied by existing air intakes from above the boiler or from outside the boiler room. It is assumed to maintain a constant negative pressure of the combustion gases in the furnace chamber.

Access to fittings and accessories and other places requiring permanent or periodic service is provided by service platforms. Appropriate manholes and sight windows enable the observation of the boiler interior while it is in operation, as well as for entering it after it has been put out of service in order to perform an inspection or repair.

The rest of the boiler pressure part, such as water piping (inlet/outlet), was not changed and was completely used during the adaptation. The support structure, platforms, insulation, and armoring of the boiler were also unchanged.

Carrying out the conversion of the gas-fired boiler in 2020 allows for the following: Improving controllability and flexibility of the boiler's operation, as well as its reliability and availability; improving the combustion process, leading to a reduction in dust and gas emissions and, consequently, to an improvement in environmental indicators and a significant improvement in boiler operation and maintenance conditions.

The presented changes and additional changes in the type of applied automatics will also cause a significant change in the boiler operation method, which creates the necessity for developing new operating and OHS manuals.

At present, the investment is not yet complete. However, after its completion, it should have positive pro-ecological and economical effects.

5. Discussion

In the previous section, we presented a description of the effects of five ecological investments undertaken by the researched organization over the years 2016–2020. The sum of investments implemented by MEC Koszalin over the researched years amounted to PLN 25319500.0 + 23% VAT. These were significant ecological investments that resulted in a large modernization of the plant and much better adaptation to the requirements of the modern economy.

In particular, an important effect resulting from the investments undertaken was the reduction in emissions of harmful substances into the atmosphere. Detailed data have been presented for investment project no. 1—the modernization of a WR type boiler. In this case, all the toxic substances examined were reduced, in each case above the values planned in the grant application. Reductions concerned substances such as: NO_2—a reduction in emissions by 9084 Mg; SO_2—a reduction of emissions by 17,132 Mg; CO—a reduction in emissions by 11,355 Mg; CO_2—a reduction in emissions by 1808.4 Mg; and dust—a reduction in emissions by 3616Mg. The importance of reducing gas emissions, especially CO_2, in the heating industry is emphasized by Buryn and Hnydiuk-Stefan, who note the importance of carbon dioxide reduction in the production planning process in the heating industry [1]. Additionally, other Polish reports on the heating industry and its functioning emphasize the importance of new technologies that enable carbon dioxide emission reductions [112].

Even greater emission reductions will occur after the completion of investments in technology changing coal to gas. In this case, huge reductions in the generated waste are planned to occur at the level of approximately 99.4 for dust, 37.3% for CO_2, and 99.99% for SO_2. This type of technology change is in line with trends in the European Union and around the world that place an emphasis on reducing carbon dioxide emissions and moving away from coal-burning technologies. Polish analyses emphasize the importance of using gas technology in district heating [113]. For example, in Vienna, the use of coal-based technologies in district heating has now been completely abandoned. In the case of other large European cities, coal-based technologies are slowly being replaced by those based on gas, fuel oils, or biomass [114].

Additionally, in other countries, both at the macroeconomic level and at the micro level, individual heat plants are taking measures to reduce harmful emissions into the atmosphere. Lin and Lin conducted this kind of analysis for China from a macroeconomic perspective. In their view, the use of new technologies in the district heating industry is necessary to reduce the number of harmful substances being emitted into the atmosphere, particularly CO_2, but also other harmful substances [115]. Their analysis shows that the rapid growth of the district heating industry in China has been accompanied by a large increase in carbon dioxide emissions. This process can only be halted by using modern technologies to reduce harmful emissions [116,117].

Chinese authors note the need to optimize the operation of the heat industry, especially in terms of modernizing plants and implementing heat recovery technologies [118–120]. It is also worth introducing new technologies in heat production plants and implementing technologies based on clean energy sources [121,122]. It is also assumed to move towards application of the so-called energy mix, i.e., not relying only on hard coal but using other energy sources [123,124]. Such investments were introduced in the presented case of MEC Koszalin.

As far as the reasons for pro-ecological investments are concerned, an important factor is the need to comply with legal requirements. In the case of some pro-ecological investments undertaken by MEC Koszalin, decisions such as the construction of a video control system for the storage of waste generated within the company's operations or the purchase of a new flue gas cleaning installation, these actions resulted directly from the change in legal regulations to more restrictive ones. Other reasons include economic reasons for cost reduction and issues related to environmental corporate social responsibility (ECSR) and building a positive image of the organization in society.

The ecological investments discussed in the publication also fit into the model of implementation of the environmental corporate social responsibility strategy by organizations. Gunther [125] and Lean and Moon [126] described, in their publications, the model of ECSR strategy implementation consisting of ecological activities and pro-ecological expenses. Considering the described issues from this perspective, individual investments presented in our publication are pro-ecological activities, while the cost of implementing these activities is a pro-ecological expenditure [127–133]. However, the two-stage model alone is not sufficient. Analyzing the presented pro-ecological investments, their effects can also be approached from the perspective of four areas of pro-ecological activity: social, economic, technological, and physical.

All the described activities fit into this model. They are technological investments, so they are clearly included in the technological area. As far as the effects of new technologies are concerned, it is also worth mentioning the improved digitalization of the processes carried out in the heat plant under study as a result of their introduction. This allows us to adjust the applied technologies to the contemporary requirements of Industry 4.0. The importance of digitalization, in this respect, is often emphasized in the literature [41–46].

Additionally, many of the actions for which it was possible to calculate the financial effects of their implementation, such as boiler modernization, generated positive financial effects resulting from the reduced consumption of fuel burned in the boiler after modernization and increased boiler efficiency. The physical effects resulted mainly from a reduction in process waste in the form of slag. Social effects result from a reduction in the number of harmful substances emitted. Additionally, the implementation of pro-ecological investments builds a socially positive image of the organization as an environmentally friendly company. In addition, as a result of the realization of pro-ecological investments, we can adjust more suitably to current and future legal requirements.

Combining the presented causes and effects of ecological investments, it is possible to propose a cause–effect model of pro-ecological investments undertaken in organizations consisting of three causes and five effects. The proposal of the model is shown in Figure 4. All causes that cause organizations to realize pro-ecological investments can be divided into three groups:

- low requirements;
- economical requirements;
- image requirements—implementation of environmental corporate social responsibility.

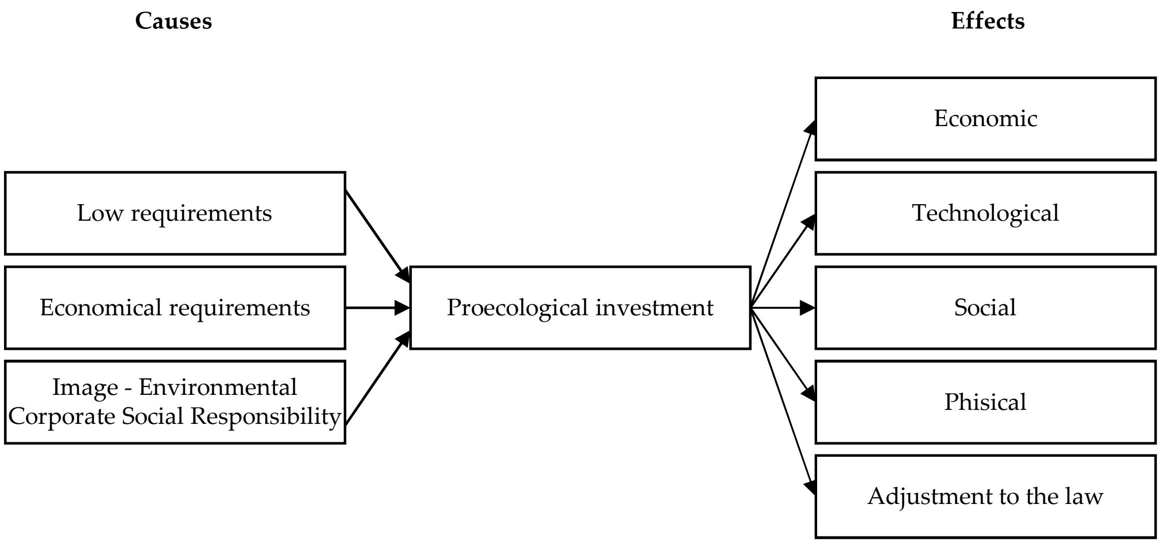

Figure 4. Cause–effect model of pro-ecological investments.

In the case of the effects of pro-ecological activities, the proposed model is a modification of the models previously used in the literature [125–133]. The proposed model can be used to analyze the five previously presented pro-ecological investments. Table 3 presents the previously discussed investments in the proposed system, specifying for each implemented technology the reasons for its implementation and the resulting effects.

Table 3. Implemented technologies from cause–effect model point of view.

Pro-Ecological Investment	Cause	Effects
First investment	Economical requirements Image	Economical Technological Social Physical
Second investment	Economical requirements Image	Economical Technological Social Physical
Third investment	Low	Technological Adjustment to low
Fourth investment	Low Economical requirements Image	Economical Technological Social Physical
Fifth investment	Economical requirements Image	Economical Technological Social Physical

6. Conclusions

In our paper, we have analyzed all pro-ecological investment conducted by MEC Koszalin in the years 2016–2020. We analyzed those investment in detailed way from the perspectives of cost, environmental impact, and technicality. This paper contains information regarding the impact of our conducted investments on the emission of harmful substances into the atmosphere. We also provide information regarding the positive economic effects of the conducted research. The proposed objective was achieved and, in our paper, we responded to three research questions formulated in our introduction. In the future, as far as slag is concerned, it is worth thinking not only about implementing new technological solutions for reducing the amount of this waste but also developing a means of recycling it [134,135]. There are positive examples of such actions in the world, which show significant possibilities regarding the use of slag in other areas. Slag as a waste product can be used [136–143] in the production of construction materials, in geotechnical applications, in backfilling opencast workings, in the fertilization of agricultural land, as a cement additive, as a part of bricks, etc.

It is also worth introducing new pro-ecological investments aimed at further reducing gas emissions, specifically CO_2. It is also worth introducing annual plans for reducing harmful substances and analyzing their implementation. The need to reduce harmful substances should also be directly included in the ECSR strategy implemented by a given organization.

The results presented in the paper are unique because an analysis of pro-ecological investments in the heating industry has been heretofore unavailable in the scientific literature. This is an important industry for the current economy, and an analysis of how various types of pro-economical investment can have a positive impact on the environment should be important for scholars and institutions involved in the heating industry. Additionally, the developed model for the analysis of pro-ecological investments (cause–effect model) can be useful in analyzing pro-ecological investments in other organizations and countries. From an academic point of view, our results are important, and they could represent part of a larger meta-analysis. From an investment point of view, the results of our study are proof that pro-ecological investment can bring positive results for the environment and companies. Managers of heat industry companies can use our results and descriptions as examples of good practice for implementation in their own companies.

The main limitation of the conducted research is the use of the case study method, which limited our analysis through the use of one example of one district heating organization from one country. This study can serve only as a single reference and other companies can achieve different results. However, it seems that the proposed modified cause–effect model of pro-ecological investments makes it possible to use our model for the analysis of organizations from the district heating sector and related sectors all over the world.

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