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Facing Environmental Goals for Energy-Efficiency Improvements in Micro and Small Enterprises Operating in the Age of Industry 4.0

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Abstract: One of the biggest challenges of a modern enterprise is finding a balance between achieving environmental goals and being competitive in the era of Industry 4.0 requirements. The digital revolution is forcing companies to overcome various challenges that contribute to reducing energy consumption. Micro and small enterprises carry out activities in the field of energy efficiency by implementing measures to save energy and reduce total energy consumption. However, these activities are limited by many barriers to resources, which means that these activities are much smaller than those in large companies. The purpose of this study was to assess the performance of micro and small enterprises following environmental objectives in improving energy efficiency. The research study, based on a structured and standardized survey questionnaire, was conducted with the use of the CATI technique between April and May 2022 among the owners of micro and small enterprises operating in Poland. The study showed that: (a) the activities of Polish micro- and small-sized companies were aimed at improving energy efficiency through the implementation of environmental objectives; (b) the operation of enterprises in accordance with contemporary environmental requirements improved energy efficiency; and (c) Polish micro- and small-scale enterprises took actions in compliance with environmental requirements.

Keywords: environmental objectives; micro and small enterprises; Industry 4.0; sustainability; energy efficiency

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1. Introduction

Industry 4.0 significantly influences the activities of micro and small enterprises, especially in the manufacturing environment, through the modification of traditional production operations and the optimisation of relatively new ones, the computerisation of processes, the intelligent interconnection of equipment via networks to increase production efficiency and encouraging innovation [1]; better risk management in the supply chain, traffic monitoring and infrastructure utilisation aimed at reducing waste [2]; support of pro-product and process quality by, among other things, enabling real-time troubleshooting and advanced process control, as well as increased labour productivity by reducing waiting times between different steps in the production process or speeding up the research and development process [3]. In addition to technical solutions, Industry 4.0 significantly impacts the functioning of the entire enterprise by combining technical and business processes, which is why it is essential to analyse this topic through the prism of a management process aimed at reconfiguring the strategy and often changing the business model.

In the age of Industry 4.0, the time for new enabling technologies [4–9] and smart solutions, there is a strong emphasis on socially and environmentally responsible sustainability and the role of environmental protection through increased energy efficiency in business [10,11]. In these times of significant climate change, companies increasingly demand to engage in activities that lead to environmental protection by redirecting capital from environmentally damaging investments to greener alternatives. Every company, regardless of size, should consider environmental and social issues in its business objectives. Achieving these goals represents opportunities for business and the economy, opening up new markets and securing the long-term development of individual economic sectors.

A sustainability policy improves energy efficiency by using less energy input to provide the same service or product. Energy efficiency is one of the major challenges that the EU faces due to its dependence on electricity imports, limited energy resources and the need to mitigate climate change. In this area, there are many motivations to improve energy efficiency in companies. One of the main drivers of change is the rapidly rising prices, especially electricity. The benefits of energy efficiency could effectively reduce the price of energy per unit, and as a result, total energy consumption could increase the partial reduction in the impact of productivity gains [12]. Changing how enterprises save energy in their operations has been enforced by new standards that guide sustainable production, contributing to sustainable goals with real business benefits [13].

Studies conducted so far show that SMEs (micro, small and medium enterprises), due to insufficient financial resources, tend to use simple technologies based on old solutions that lack the ability to improve energy efficiency [14]. The Flash Eurobarometer Survey 426 indicated that European SMEs use RES (renewable energy sources) quite rarely [15], while they most often use solutions such as replacing lighting in and thermally insulating buildings, using energy-efficient electric motors, recovering heat from production processes or reducing the indoor air temperature. In this context, it is possible to draw attention to the phenomenon described in the literature called the "energy efficiency gap", denoting the discrepancy between the potential for energy efficiency and the solutions implemented, resulting from barriers of various types encountered in the implementation process [12,16].

Micro and small enterprises are not as active in implementing all environmental requirements as large entities, and if they do take such action, they do not communicate it, even in a promotional context. It is mainly due to insufficient resources: financial, human, organisational, etc. Micro and small businesses often focus on their core business, using simply available technologies based on old but proven solutions, although unfortunately outdated in terms of improving energy efficiency [14]. In this context, the energy-efficiency gap described above arises. It is against this background that the concept of the presented research study was developed. It focused on two research problems. Because the economies of developed countries are overwhelmingly made up of entities belonging to the SME sector—mainly those classified as micro and small—the question then becomes relevant: to what extent are these enterprises adapting to environmental objectives by striving to improve energy efficiency? A further question that arises from this problem is whether the size of the company is essential in achieving environmental objectives. Do such enterprises close the energy-efficiency gap similarly or differently? These research questions determined the aim of the study, which was to assess the performance of micro and small enterprises following environmental objectives in improving energy efficiency.

The work consists of five parts. The first presents the research problems we develop during the paper, based on the micro and small companies in the light of energy efficiency. The second is the analysis of research concentrating on the current challenges derived from adopting the Smart World in the age of Industry 4.0. The third covers the methodology used, including the statistical models applied to the acquired data derived from quantitative research data. The fourth part presents the results of the research study related to the decision of micro and small firms in the area of innovation and energy efficiency. The last includes the discussion and conclusions, as well as the limitations of the results.

2. Challenges of the Smart World in the Age of Industry 4.0

Over the years, the development of new technologies has seen the world go through successive industrial eras that have fundamentally changed the game rules necessary for operating different types of business. The first revolution used water and steam propulsion, the second electricity, and the third introduced microelectronics and IT innovations to support automation. We now have the age of Industry 4.0 (Industry 4.0; German: Industrie 4.0), which is a collective term for technical innovations and a new concept (era) of value chain organisation that enables a revolutionary change in industrial production [17]. The term Industry 4.0 is understood as the unification of the real world of production machinery with the virtual world of the Internet and information technology [18]. In the process, that is, in the course of production, there is an automatic exchange of information among people, machines and IT systems, among separate factories and different IT systems operating in disparate industries. Therefore, the various peculiarities of production systems operating in different industries do not allow for a generalisation of the term Industry 4.0 [19–25]. It means that the scope of the given definitions has to be considered individually for the different functional areas of the respective company. Managers are, therefore, constantly looking for new and innovative production systems that motivate the creation of new business models focused on extracting a high degree of economic benefit while improving existing models. Conducted by Arnold, Kiel and Voigt, the research study identifies only some of the most critical areas that are directly related and important for business, in line with the idea of Industry 4.0. These areas include proposals for data-driven value creation, the transition process from product to system offerings, improved personalisation, intensified customer relationships, IT and software know-how as key resources, increased interconnectivity and collaboration with key partners [26].

In contrast with previous revolutions, Industry 4.0 creates a so-called Industry 4.0 environment to support the enterprise in creating extensive value networks that enable the exchange of and access to virtually any helpful information, anytime, from anywhere. It makes it possible to economically produce customised products for specific customer needs and so-called short runs (so-called Mass Customisation) [27]. Therefore, Industry 4.0 does not aim to create mechanised factories in which robots take the place of humans, but factories in which the employee is the most valuable asset of the enterprise [28]. In this process, man, machine and process are closely integrated. It is based on the cooperation of separate control units capable of autonomous decision making, managing the assigned technological unit and, in particular, becoming an independent and full member of complex production units [29,30].

Therefore, this concept requires continuous innovation and education, which depend on people's skills and the enterprise's strategy in question. To this end, it is necessary to understand internal and external changes to adapt strategy, structures and processes, as well as people and technologies, to the requirements of the "new wave" of the 4.0 concept.

One of the essential change elements in line with the age of Industry 4.0 is the introduction of a smart working environment related to machine production, technological processes, systems, products and the supply chain [31,32]. In this case, the term smart is one of the critical elements for creating a new vision of the industry based on the tenets of Industry 4.0. The term generally refers to aspirations and capabilities entirely dependent on an individual perspective based on strategy, conditions, environment, organisational culture and the values the individual represents. Being smart is about being smart, aspirational and focused on implementing innovative goals and solutions to achieve the desired future. One of the main components of a Smart World is smart future thinking, which moves toward innovations that help to support intelligent solutions to complex problems and safeguard the human environment. The most important thing, therefore, is to create a shared vision of the future based on people who, despite very rapid technological development, do not forget to protect heritage and the environment.

On the one hand, today's Smart World is becoming a challenge and an everyday reality in which modern businesses must operate. It requires the introduction of new

methods of communication and digitalisation to create a new space based on integrated cyber–physical–social thinking. The main idea of Smart World is to create a hyperspace containing all possible connections and to develop the intelligence of physical perception, social correlation and cognitive thinking concerning all aspects of everyday life in terms of the latest technological developments [8,33]. The essential stakeholders of life in a Smart World are the people who create and participate in all innovative processes, simultaneously co-creating the smart economy [34].

The listed Smart World assets generated by the development conditions of the age of Industry 4.0 are essential for enterprises to make informed investment decisions towards environmentally friendly activities [35,36]. Qualifying for sustainable economic activity must provide a significant contribution to at least one of the six environmental objectives of Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, as well as amending Regulation (EU) 2019/2088, defined as [37]:

1. Climate-change mitigation;
2. Climate-change adaptation;
3. Sustainable use and protection of water and marine resources;
4. Transition to a circular economy;
5. Pollution prevention and control;
6. Protection and restoration of biodiversity and ecosystems.

The same regulation (Article 17) sets out the DNSH (do no significant harm) principle relating to these environmental objectives. Significant harm to the environment in the activities of economic operators is considered as follows [37]:

1. In terms of climate-change mitigation, the company's activities lead to significant greenhouse gas emissions;
2. In climate-change adaptation, the enterprise's activities lead to an exacerbation of adverse climate impacts;
3. In the sustainable use and protection of water and marine resources, the enterprise's activities harm the good status or good potential of surface water and groundwater or the good environmental status of marine waters;
4. In a circular economy, the activity leads to (i) significant inefficiencies in the use of materials and natural resources, such as non-renewable energy sources; (ii) significant increases in waste generation, incineration or disposal; and (iii) long-term waste disposal;
5. In the prevention and control of pollution, the activities of the enterprise lead to a significant increase in the emissions of pollutants into the air, water or land compared with the situation before the start of these activities;
6. In the protection and restoration of biodiversity and ecosystems, the activity (i) significantly harms the health and resilience of ecosystems and (ii) is detrimental to the conservation status of habitats and species, including habitats and species of Union interest.

The current lines of action for achieving the environmental objectives are set out in European Union documents such as the European Green Deal [38], the "Fit for 55" package [39] and the provisions of the Glasgow COP26 Climate Summit of 2021 [40].

The efficiency of energy-related environmental measures, such as carbon reduction, is effective when imposed by legislation or when companies see economic and financial benefits from its application [16]. Energy efficiency is defined in EU Directive 2012/27/EU (Article 2) as "the ratio of outputs, services, goods or energy produced to energy input." The same directive also defines the concept of energy-efficiency improvement, taking it to be "an increase in energy efficiency as a result of technological, behavioural, and economic change" [41].

Although the design and implementation of various policies to encourage energy efficiency and the use of renewable energy take place at governmental levels (European,

national, regional and local), sustainable energy measures are still rarely implemented by European micro and small enterprises [15]. Energy-efficiency strategies are more dependent on cost savings and compliance with energy-efficiency regulations, while renewable-energy strategies are more linked to public support and environmental awareness [12].

With new technologies at their disposal, companies are learning to increase efficiency, develop new products and services, and use smart technology solutions that make managing and maintaining energy efficiency easier [42]. It applies to companies in the energy sector and all actors, including micro and small ones. Implementing energy-efficiency solutions is a complex process and depends on several factors that vary depending on the enterprise, the industry in which it operates, the environment and, above all, legal regulations [12]. Many proposed and applied energy-efficiency policies have wide acceptance among different stakeholders and are often referred to as win–win policies to emphasize the double benefit of environmental effects and increased enterprise energy efficiency [43]. An effective way to achieve positive energy-efficiency results is to implement an energy-efficiency measure (EEM) (taking specific actions to improve the efficient use of energy following the adopted energy management system), to implement energy management (EM) (systematic monitoring and control of energy use activities) and to implement an energy management system (EnMS) (implementation of strategies, standards or procedures to achieve efficient energy management) [16]. However, the manager must view energy as an asset that can be managed rather than a service that only needs to be paid for [12].

Improving energy efficiency is also significantly influenced by implementing closed-circuit economy-oriented solutions in enterprises, leading to the reduction, reuse and recycling of materials in production, distribution and consumption processes. A circular economy at the enterprise level requires a change in the business model aimed at reducing material consumption, increasing resource efficiency, and reducing emissions associated with the production process through "green" technologies, making better use of available resources [44].

The literature review determined the main hypothesis relating to the theoretical consideration of business investment and its analysis in improving energy efficiency. As research shows, it is repeatedly stated that the activities of enterprises in this area are ineffective due to the different characteristics of the purpose of enterprises' operation, i.e., generating profits and reducing operating costs versus spending more capital on energy-efficient investments. However, this does not mean that such activities are not carried out. As research shows, enterprises that are committed to environmentally friendly activities (e.g., those that are environmentally certified for their operations) are much more determined to make investments that reduce environmental damage as a result and improve their energy efficiency at the same time [45]. Given the positive aspect of such research, the below main hypothesis, directed at a different research group, i.e., micro and small enterprises, was defined.

Hypothesis 0 (H0). *The activities of Polish micro- and small-sized companies are directed toward improving energy efficiency by achieving environmental goals.*

The analysis of the main hypothesis allowed several exciting research threads to emerge, assuming that if companies meet the basic environmental objectives set by EU directives, their activities lead to improvements in energy efficiency [46]. Another issue is the gap in research on micro and small enterprises implementing measures to improve energy efficiency in European economies [47]. This analysis allowed two specific hypotheses to be formulated.

Hypothesis 1 (H1). *The operation of enterprises in line with current environmental requirements improves energy efficiency.*

Hypothesis 2 (H2). *Polish micro and small enterprises are committed to operating in compliance with environmental requirements.*

When evaluating the functioning of companies in the context of meeting environmental objectives, attention should also be paid to the different needs and approaches to this issue of entities of different sizes. Typically, the most visible and spectacular activities are those of large, often global entities, which not only can spend significant amounts on environmental investments but also appropriately promote them [48]. It is also apparent that there is a variation in the environmental solutions also used in micro and small enterprises [49], which allowed the third specific hypothesis to be formulated.

Hypothesis 3 (H3). *The size of the company matters for the degree to which environmental objectives are met.*

The hypotheses formulated delineated the framework of the research study, which is presented in the next section of the paper.

3. Research Methodology

Based on a structured and standardized survey questionnaire, the research study was carried out using the CATI technique between April and May 2022 among the owners of small and micro enterprises operating in Poland. The research study carried out assumed the acquisition of a representative sample so that it was possible to generalise the results obtained to the entire general population from which it was taken. The sample size was determined on the basis of a formula based on the estimation of the stratum weight and simple random sampling.

$$n = 0.25 \times u\alpha 2 \times N/[0.25 \times u\alpha 2 + N \times d2], \quad (1)$$

where n is the minimum sample size, N is the size of the analysed population, d is the maximum allowable error of the estimate and $u\alpha$ is the value of the random variable u with a standardized normal distribution for which the confidence interval CI $(-u\alpha/2 < U < u\alpha/2) = 1 - \alpha$.

The following were adopted for the calculations: $d = 0.05$, $\alpha = 0.05$, $1 - \alpha = 0.95$, $u\alpha = 1.96$, N = 4,804,685 (as of the end of 2020) [50]. On this basis, a minimum sample size of 384 business entities was calculated. The entities met the condition of belonging to a group of domestic micro and small enterprises (employing up to 49 persons) operating in various industries. The sampling frame was the database of the REGON Register of National Economy, considered a complete sampling frame of companies operating in Poland. The sample size was set at 1750 companies (400 in the basic sample and 1350 in the reserve sample). The substituted sample was used due to the refusal of respondents to participate in the study and the outdated records in the database. Finally, 407 completed questionnaires were obtained, of which 400 remained after verification due to inconsistency in the data.

Due to the large disparities in the number of micro and small companies in Poland, an overrepresentation of small companies was assumed (see Table 1). Due to disproportional sampling, the analyses used post-stratification weighting to adapt the structure of the sample to the population structure from the point of view of employment size. These ex post weights also included an uneven response rate within the sample. Thanks to the post-stratification weights applied, generalisations for micro and small business populations were carried out with a risk of type I error of less than 5%.

In terms of the type of dominant activity, service and commercial enterprises dominated, accounting for 59% and 22.7%, respectively. Taking into account the range of the company's market operations, which dominated in terms of turnover, almost 79% of the surveyed entities operated in the domestic and regional markets (41% and 38%, respectively) and only 6.2% in the international market.

Table 1. Population and sample structure of enterprises by employment size.

Description	Number of Companies		Percentage of Enterprises	
	Poland	Sample	Poland	Sample
Micro (up to 9 employees)	4,670,749	300	97.2	75
Small (10–49 employees)	133,936	100	2.8	25
Total	4,804,685	400	100	100

Source: own elaboration based on Local Data Bank (www.stat.gov.pl, accessed on 15 July 2022).

Respondents also evaluated the stage of development of their companies at the time. The analysis of the results obtained showed that more than 78.4% of the entities surveyed indicated the maturity phase characterised by a good reputation and market position of the company and a constant level of economic and financial results. Only 19.5% of the companies were in the dynamic growth phase, while start-up companies recorded the lowest share, 0.3%. The structure of the micro enterprises was almost the same as that of the entire population. On the other hand, in the case of small businesses related to the population, there were considerably fewer entities in the phase of dynamic growth and many more in the phase of decline and renewal.

Descriptive statistics and contingency are the methods used to analyse the research findings demonstrated later in the article.

4. Results

The first research area was to assess the degree of compliance of the enterprises' activities with contemporary environmental requirements resulting from the Regulation of the European Parliament and the Council EU described in detail in the first part of the study. Respondents were assessed on a scale of 1 to 5, where 1—no compliance; 2—compliance to a small extent; 3—medium degree of compliance; 4—compliance to a large extent; and 5—compliance to a very large extent (see Table 2). Interpreting the obtained evaluation results, it could be assumed that the activities of the surveyed micro and small enterprises were the most compatible with the following environmental goals: climate-change mitigation (assessed by respondents—22.2% as compatible to a very large extent and 15.2% as compatible to a large extent), pollution prevention and control (assessed by respondents—17.3% as compatible to a very large extent and 30% as compatible to a large extent) and the transition to a circular economy (assessed by respondents—17.5% as compatible to a very large extent and 18.5% as compatible to a large extent). On the other hand, the least compatible with environmental objectives were the activities of micro and small enterprises in the areas of the sustainable use and protection of water and marine resources (respondents' assessment—36.3% as not compatible and 28.5% as compatible to a small extent) and the protection and restoration of biodiversity and ecosystems (respondents' assessment—26.2% as not compatible and 18.3% as compatible to a small extent).

Table 2. Assessment of the degree of conformity of the activities of the enterprises with environmental objectives.

Environmental Objective	Assessment *				
	1	2	3	4	5
Climate-change mitigation	22.8%	16%	23.8%	15.2%	22.2%
Climate-change adaptation	20.2%	18.2%	30.3%	18.5%	12.8%
Sustainable use and protection of water and marine resources	36.3%	28.5%	26.5%	8.2%	0.5%
Transition to a circular economy	12.2%	18.3%	33.5%	18.5%	17.5%
Pollution prevention and control	7.2%	16.8%	28.7%	30.0%	17.3%
Protection and restoration of biodiversity and ecosystems	26.2%	18.3%	46%	9%	0.5%

* Respondents evaluated dynamic capabilities on a scale of 1–5, where 1—no compliance; 2—compliance to a small extent; 3—compliance to a medium extent; 4—compliance to a large extent; and 5—compliance to a very large extent. Source: own elaboration

In the next step of the analysis, an attempt was made to answer whether there were any dependencies among variables describing the degree of compliance of the enterprise's activities with current environmental requirements and the size of the company (measured using the number of employees). A chi-squared independence test was used to assess the statistical significance of these dependencies. The condition for applying the chi-squared independence test was met since all theoretical counts were greater than 5. The test results showed statistically significant dependencies only in the case of one grouping variable, a type of dominant activity. The results of the analysis, that is, the chi-squared statistics, the test probability (p) and the measure of correlation (Kendall Tau-C), are included in Table 3. Based on the results obtained, it could be concluded that the dependencies between the assessment of the degree of compliance of the enterprises' activities with environmental objectives and the size of the company were statistically significant. However, the strength of these dependencies was weak. The research study allowed us to conclude that small enterprises' activities were, to a much greater extent, in line with environmental objectives, especially in the case of three objectives: climate-change mitigation, the transition to a circular economy and pollution prevention and control. Significantly higher assessments provided by small enterprises evidenced the compliance of the enterprises' activities with these environmental objectives, defined as high and very high compliance. In the case of micro enterprises, these assessments were at the level of non-compliance of their activities with environmental objectives or compliance to a small extent. Different evaluations of the surveyed entities may have been due to their financial, technological and human resources, which can simultaneously impede business activities in compliance with environmental objectives.

Table 3. Results of the chi-squared test for the relationship between the assessment of the degree of compliance of an enterprise's activities with environmental objectives and the size of the enterprise.

Environmental Objective	Chi-Squared Statistic	*p*-Value *	Kendall Tau-C
Climate-change mitigation	73.701	<0.01	0.298
Climate-change adaptation	33.973	<0.01	0.094
Sustainable use and protection of water and marine resources	26.478	<0.01	0.060
Transition to a circular economy	65.133	<0.01	0.223
Pollution prevention and control	49.095	<0.01	0.240
Protection and restoration of biodiversity and ecosystems	36.340	<0.01	0.069

* Level of statistical significance. Source: own elaboration.

When assessing the degree of compliance of the entities surveyed with environmental objectives, it was also essential to answer the question of the state of implementation of solutions that respond to these objectives in the company, which was the next stage of the analysis. The research study carried out allowed the conclusion to be drawn that the surveyed enterprises implemented several measures, mainly resulting from the four environmental objectives, i.e., climate-change mitigation, climate-change adaptation, the transition to a circular economy, and pollution prevention and control (see Table 4), such as energy-efficient machinery and equipment, selective waste collection at the stage of their production and moving away from paper documentation to electronic documentation. These solutions were mainly related to reducing environmental pollution, changes in the production process, efficient use of resources and waste management.

Table 4. Status of the enterprises' implementation of solutions arising from environmental objectives.

Activity in Line with Environmental Objectives	Implemented	Planned	Not Implemented and Not Planned
Energy-efficient machinery and equipment	82.0%	5.5%	12.5%
Renewable-energy generation	17%	21.2%	61.8%
Implementation of energy management systems	12.8%	28.7%	58.5%
Eco-design contributing to a broadly understood reduction in demand for raw materials	5.8%	19.8%	74.4%
Moving away from paper to electronic documentation	50.7%	36%	13.3%
Increased use of secondary raw materials	9%	37.2%	53.8%
Use of reusable packaging	15.8%	42%	42.2%
Optimisation of transport/delivery	43%	47.5%	9.5%
Use of hybrid/electric cars	1.2%	14.8%	84%
Savings on water consumption	17.5%	58.5%	24%
Selective waste collection at the manufacturing stage	74,2%	19.3%	6.5%

Source: own elaboration.

The surveyed entities also had several pro-environmental measures in mind, such as reducing water consumption, optimizing transport/supply and increasing the use of secondary raw materials. On the other hand, according to the respondents' declarations, among the measures that had not been introduced and were not planned were the following, with the highest numbers of indications: the use of hybrid/electric cars, the generation of energy from renewable sources and the implementation of energy management systems.

In the next step of the analysis, an attempt was made to answer whether there were dependencies between the variables that describe the state of implementation of solutions resulting from environmental objectives in the enterprise and the size of the enterprise (measured using the number of employees). The chi-squared test described above was also used to assess this relationship. Based on the results obtained, it could be concluded that the relationships studied were statistically significant, but the strength of these relationships was weak and moderate (see Table 5).

Table 5. Results of a chi-squared test for the relationship between the status of implementation of measures in an enterprise in line with environmental objectives and the size of the enterprise.

Activity in Line with Environmental Objectives	Chi-Squared Statistic	*p*-Value *	Cramer's V
Energy-efficient machinery and equipment	40.247	<0.01	0.302
Renewable-energy generation	90.082	<0.01	0.442
Implementation of energy management systems	71.367	<0.01	0.389
Eco-design contributing to a broadly understood reduction in demand for raw materials	0.580	0.748	-
Moving away from paper to electronic documentation	39.910	<0.01	0.301
Increased use of secondary raw materials	6.031	0.49	-
Use of reusable packaging	49.682	<0.01	0.332
Optimisation of transport/delivery	105.884	<0.01	0.457
Use of hybrid/electric cars	6.536	0.058	-
Saving on water consumption	35.967	<0.01	0.287
Selective waste collection at the manufacturing stage	45.872	<0.01	0.321

* Level of statistical significance. Source: own elaboration.

The research procedure allowed us to conclude that small enterprises were much more likely to introduce essential solutions, as well as advanced solutions resulting from environmental objectives, while micro enterprises were at the stage of planning these solutions or were not planning them soon at all. In the case of micro enterprises, undertaking pro-environmental activities was limited both by the necessity to engage financial resources and by the lack of appropriately qualified personnel. This led us to the conclusion that the enterprises in the research study were not as active as bigger companies in the area

of improving energy efficiency. However, the micro and small firms generally performed some activities in the area, which partly fulfilled our research assumptions—the direction of the decisions corresponded with the hypothesis but the size of the relation was weaker than we expected.

5. Discussion and Conclusions

Today's environmental requirements define the scope of activities that enterprises wishing to conduct their business in compliance with environmental objectives should undertake. One of the essential elements of the change that must take place in this sense is the introduction of smart actions into the working environment associated with production, services and trade. It is a form of the new vision for industry based on the tenets of Industry 4.0. Being smart means making intelligent, aspirational decisions and focusing on implementing innovative goals and solutions to achieve the expected future. They must also be directed towards environmentally friendly actions. In this view, they should make a significant contribution to one or more of the six environmental objectives, taken as (1) climate-change mitigation, (2) climate-change adaptation, (3) sustainable use and protection of water and marine resources, (4) transition to a circular economy, (5) pollution prevention and control and (6) protection and restoration of biodiversity and ecosystems.

What does this offer businesses? By committing to be smart and meeting environmental targets, actors, including those of the small and medium-sized enterprise sector, are offered various benefits. In addition to the obvious environmental benefits, companies can develop their technologies and be more innovative, and as a result, this can directly or indirectly lead to a reduction in their operating costs. As the results of our research study show, this also applies to the smallest economic entities, classified as micro and small enterprises. The results of the investigation presented positively verified the hypotheses.

Based on the above analyses, it should be pointed out that the research study presented in this text was primarily aimed at identifying and assessing activities undertaken by micro and small enterprises to achieve environmental goals in the field of energy-efficiency improvement. The hypotheses were positively verified. This mainly applied to the directions of actions taken to improve energy efficiency through the implementation of environmental measures performed by these entities. However, the sheer scale of the actions taken raises doubts and does not allow final conclusions regarding the full positive verification of the hypotheses to be drawn. In other words, the companies declared that they were willing to make certain decisions, but the very execution of those decisions was not so obvious. Various reasons for the lack of environmental activity were indicated, the main of which were two: problems related to the costs of such activities and staff shortages; below are more extensive considerations regarding the indicated conclusions.

First of all, it should be stated that the activities of Polish micro and small enterprises were aimed at improving energy efficiency through the implementation of environmental objectives. This hypothesis was positively verified, as the entities surveyed indicated in their responses the implementation of activities related to environmental requirements. As EU recommendations show, implementing even one of the set objectives contributes to the existence of environmental benefits and, as a result of the decisions taken, to the improvement of energy efficiency. Examples of this were the following, indicated to the greatest extent by survey respondents: climate-change mitigation, pollution prevention and control, and transition to a circular economy. However, it should be constantly borne in mind that this applies to the smallest business entities that in their declarations first mention cost efficiency and then realise other goals. It can be said to be the implementation of a win–win strategy, where both sides, the enterprises and the environment, ultimately benefit. As micro and small businesses grow, they engage their resources in investments that indirectly result in gains in energy efficiency and directly in gains in cost efficiency by reducing expenses to the maximum. It is similar to the realization of the idea of efficiency in the Pareto sense, whereby an action that improves one area must not harm another. It is the case in an ideal sense, whereas in the real world, it is a second-best solution. In fact, the

companies that participated in the study could not afford to implement the most favourable solutions for themselves and the environment due to their limited resources. However, the implementation of even single projects that take into account the fulfilment of one of the environmental requirements concerning, among other things, energy efficiency brings the actions taken closer to the best solutions in the context of a win–win strategy.

The results of the literature analysis on the subject and of the research study undertaken also verified the auxiliary hypothesis relating to all enterprises operating in the economy: the operation of enterprises in accordance with contemporary environmental requirements improves energy efficiency. According to theory and research, companies that invest in modern technologies operating in the field of Industry 4.0 and apply smart solutions follow contemporary environmental requirements that improve energy efficiency. It can be observed in several essential areas. First, such actors try to overcome various barriers that limit the possibilities of using technology to improve energy efficiency. One of such barriers is the cost-effectiveness issue. Typically, new technologies, particularly those aimed at improving energy efficiency, are more expensive to purchase or produce than those already known and proven. The decision to implement environmentally friendly solutions is associated with higher costs. However, as research shows, many businesses take such decisions, even though they seem irrational from a cost-effectiveness point of view.

Another element related to energy efficiency is energy management. Such measures, carried out primarily by company management, result from the strategies adopted and the achievement of specific objectives. Adopting predetermined investment models that consider environmental requirements is an essential element of the strategies implemented by managers. By acting predeterminedly to achieve significant environmental objectives, specific decisions can be made according to environmental requirements. Then, it is in line with the action priorities adopted within the enterprises.

The next element is action conditioned by top-down energy policies promoted by states. These regulations are independent of the company's decisions but can significantly influence the investments made. In the case of the European Union and its members, specific directives (listed, among others, in the literature section of this thesis) indicate the directions and scope of the actors' actions in compliance with the environmental requirements set by law. Two main areas can be distinguished here in which enterprises should operate, namely, the formal one, that is, compliance with specific legal requirements for certain investments and extensive promotional activities regarding the energy efficiency of existing and new technologies. On the one hand, enterprises are encouraged to make confident investment decisions, while on the other, they are pushed in this direction by the need to fulfil specific legal provisions.

Interestingly, referring to the micro and small enterprises surveyed, the above directions were also considered and chosen. It showed the positive verification of the third hypothesis, in that Polish micro- and small-scale enterprises reported to take action in compliance with environmental requirements. Research was carried out in two main directions: compliance of the actions of companies with environmental requirements specified in the EU directives and the specific status of implementation of these solutions in individual companies. As mentioned earlier, micro and small businesses should not be expected to look primarily at environmental objectives rather than cost objectives in their decision making. Such an approach provides a different perspective on these enterprises and their functioning. According to the survey, these companies indicated in both areas that their activities complied with a certain proportion of environmental requirements and that they already had investments that fit such areas. These included the implementation of environmental requirements such as mitigation, adaptation, transition to a circular economy, and prevention and control of pollution. The main measures were the purchase of energy-efficient machinery and equipment, the separate collection of waste, and the switch from paper to electronic documentation. These solutions were primarily related to reducing environmental pollutants, changes in the production process, efficient use of resources, and waste management. When assessing these measures from a different perspective, it is essential to

point out their overall effect on the environment, not just the individual measures themselves. If we focus on individual economic operators' decisions, we see little. After all, how much of a contribution to environmental protection can be made by switching from paper to electronic documentation at the micro enterprise level? In principle, this contribution is relatively negligible, almost none. However, the effect of scale is clearly visible if one looks at it from the perspective of the entire economy and the number of micro- and small-sized entities operating within it. If even a minimal, negligible pro-environmental measure is multiplied by the number of viable businesses that can undertake it, then the overall result appears on a scale far more significant than expected. As a result, even the most minor measures to improve energy efficiency resulting from environmentally compatible business decisions are positive. It is because they positively affect not only the companies themselves and the way they operate but also the environment, especially on an overall scale. It can also be assumed that the declarations of compliance with environmental requirements and the implementation of specific measures simultaneously demonstrate that companies of this size can cope with the problem of cost effectiveness. As indicated above, the most crucial investment objective for small- and micro-sized enterprises is cost efficiency, not energy efficiency. Thus, if enterprises declare that they comply with environmental requirements, they can act favourably on both efficiencies with their investments. The effect is directed toward meeting environmental requirements and indirectly improving energy efficiency. It is an example of a win–win strategy.

An important question related to enterprises' operation and development concerns the scale of their operations and the extent of environmental requirements undertaken. Indeed, it can be assumed that the size of an enterprise (compared to micro and small enterprises) is relevant to the degree to which environmental objectives are met. There is a colloquial saying that big can do more. It can also be related to the scale of operation of the company and the scope of activities undertaken in pursuit of environmental goals. In simple terms, this means that the larger the enterprise is, the more activities it undertakes. In particular, this can be seen by comparing the smallest entities with the largest ones. Large enterprises are much more likely to burden the environment but also invest much more and show that they are investing in its protection. Our study's comparative scale was much smaller, as we compared micro entities with small entities. The two types of enterprises showed many similarities, mainly due to their relatively small scale of operation. However, they already differed in terms of turnover, number of employees or level of assets. The study was carried out in two areas of comparison for both types of companies: compliance with environmental requirements and implementation of appropriate solutions for their operations. In both cases, the hypothesis posed was positively verified. The correlations studied were statistically significant, but the strength of the correlations was weak and moderate. It means that it was possible to notice a difference between enterprises classified as micro and small. It was not easy to verify the strength and size of these differences unambiguously. However, in a certain simplification, it can be said that larger companies take more measures to conduct their business in compliance with environmental requirements and implement such solutions to a greater extent. One reason for this variation may be that as the scale of the enterprise increases, its investment capacity increases, and at the same time, the possibility of choosing between environmentally friendly investments and those that do not have such an effect increases. It may also mean that the smaller the enterprise, the more it is oriented towards achieving cost efficiency. The attitude of decision-makers towards the investment process itself is also probably necessary. In larger enterprises with more significant financial resources and capabilities, additional alternative opportunities open up for investments that are not only cost efficient but also energy efficient at the same time. Perhaps, the perspective of the owners or managers themselves also changes in this case, as they find it easier to make decisions in line with their environmental convictions.

To sum up the above considerations, it should be stated that micro and small enterprises in Poland make many decisions related to implementing environmental requirements.

These decisions are probably not easy, especially with respect to the financial expenses incurred. However, these entities are not going backward, but are moving in the direction of improving energy efficiency. In particular, it can be seen from a broader perspective when considering the number of actors in the economy and the potential scale of their combined efforts.

The results presented here have some limitations that may set new directions for research. We can identify some key areas that limit the interpretability of the indicated results and provide room for further analysis.

First, the research study was carried out under Polish conditions only, and conclusions can be formulated only with respect to them. In addition, only small and micro enterprises were surveyed, further narrowing the research group. Therefore, conducting research on a broader international scale would make sense. It would be fascinating to find out what actions enterprises in other countries take regarding the fulfilment of environmental requirements, especially in the context of enterprise size [51,52].

Another limitation is the static nature of the research study, which made it impossible to compare the changes that occur for micro and small enterprises to meet the environmental objectives. This is because it is known that environmental measures extend over many years and entail a variety of investments. Research that considers the passage of time and changes in the business, social and economic environment would be significant from the point of view of the actual needs to implement environmental requirements. Only such an approach would allow for a broader perspective from the point of view of the dynamics of such processes to be obtained [43,49].

A critical constraint, and at the same time a direction for research, is the issue of digitalisation. It is a supporting factor for the EE activities of SMEs. In addition to its applications directly in operational activities, actors can also use it in connection with energy-efficiency measures, such as measuring energy consumption or energy production in RES systems. This trend is expected to gain additional importance in the coming years, especially if we consider the problems with energy sources (gas, oil and electricity) resulting from Russia's aggression against Ukraine and various sanctions. In the area of the digitalisation of the use of different energy sources, it is essential to carry out further research on the interconnections and interactions among stakeholders, the evolution of digital platforms and the strength of indirect network effects [12,53,54].

The research method adopted, i.e., only quantitative studies, which did not allow us to obtain a more profound recognition of the relationships analysed, should also be pointed out as a research limitation. They provided many possible interpretations of behaviour on a scale representative of the study group. However, they did not allow us to realise a deeper and more accurate view of the problems. In this case, it would be worthwhile to conduct a qualitative study, e.g., in-depth interviews with micro and small enterprises, which would allow more precise statements to be obtained from entrepreneurs [55–57].

Further constraints related to decisions made by individuals, here responsible for the operation of enterprises. It is very often stated that a company has made some crucial decisions. However, it should always be borne in mind that this is the domain of individuals who, under certain economic conditions, with a certain level of knowledge and experience, have to make certain decisions. It is particularly evident in the case of micro and small enterprises. Their owners and, at the same time, usually their managers are the only people who have to make such decisions. Consequently, facts related to their motivation become very important. The behavioural approach, i.e., the assessment of people's attitudes toward certain events, circumstances or desired goals, is very relevant here [58]. Therefore, more research could be directed to extend existing research to include the underlying motivations for making decisions related to energy-efficiency improvements [53]. Behavioural aspects very often determine how decisions are made and the choice of specific possible solutions [59,60].

It would be interesting to use an interdisciplinary approach that was not present in the presented research study. It would be worthwhile to include analyses from other scientific

fields, e.g., psychological aspects of decision making or biological aspects, such as genetic determinants of behaviour [57,61]. It would allow a broad perspective on the problem to be obtained, and it would broaden the possibilities for interpreting decision makers' behaviour. Such a study conducted on a large sample of international-scale respondents would allow many exciting comparisons and new interpretations of entrepreneurial behaviour to be performed [62–64].

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