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Qualitative-environmental aspects of products improvement

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OFICYNA WYDAWNICZA
POLITECHNIKI RZESZOWSKIEJ

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CONTENTS

INTRODUCTION

In the long term, circular economy can become a key factor for the success of individual countries. In contemporary times, one of its essential components is sustainable development. This concept emphasizes the importance of respecting the environmental, economic and social needs, goals, and effects. Given that sustainable development encompasses numerous phenomena and processes, its formulation necessitates harmonization and systematic collaboration among entities shaping the regional economic system. The Visegrad Group countries can potentially serve as such a region.

Challenges arise in the practical implementation of the sustainable development concept. These challenges stem from the turbulent environment and are evident in the operations of manufacturing enterprises in the V4 countries. Recent major challenges, such as the SARS-CoV-2 pandemic and the war in Ukraine, have compelled production companies in the prominent electromechanical industry of the V4 countries to seek new avenues of support for pro-ecological product quality management.

A literature review indicates varying levels of achievement in sustainable production goals among V4 countries compared to other OECD nations. Consequently, it becomes intriguing to seek a scientific and practical answer to the question: Does the current approach of manufacturing enterprises in the V4 countries align with customer expectations and, simultaneously, promote a pro-ecological approach to product quality management? This question was addressed within the framework of the International Visegrad Fund project number 22230264, titled 'Qualitative-environmental aspects of products improvement'. The project aimed to compare the current strategies of electrical machinery industry enterprises in the V4 countries with those of their customers or potential customers in the realm of pro-environmental product quality management.

The findings of the conducted research are presented in this monograph. They can be particularly beneficial for enterprises striving to enhance their products in line with sustainable development principles, drawing insights from similar enterprises within the V4 group. Additionally, students and researchers interested in sustainable development and enterprise development may find valuable knowledge within this monograph. It is conceivable that this study may also be utilized by trainers, managers, and other enterprises beyond the V4 region.

Editors

CHAPTER 1

ANALYSIS OF THE USE OF QUALITY MANAGEMENT INSTRUMENTS IN SMEs FROM THE VISEGRAD GROUP COUNTRIES

Dominika SIWIEC, Andrzej PACANA, Beáta GAVUROVÁ

Adequate quality management benefits enterprises in meeting market requirements and maintaining a significant position in the long term. Therefore, the purpose of the research was to analyze the use of instruments supporting current actions in SMEs from V4 countries (Poland, Czech Republic, Slovakia, and Hungary) as part of sustainable quality management. These enterprises were SMEs from the electrical machinery industry (machine processing industry). The research method employed was survey research, with a sample consisting of 265 enterprises. The results were analyzed using the Mann-Whitney U test at the significance level of $\alpha = 0.05$. It was demonstrated that SMEs from V4 countries use quality management instruments and decision methods differently in the pro-environmental improvement of product quality. The originality lies in identifying the current level of using selected quality management instruments and the areas of these actions as part of quality management in SMEs from V4 countries. The research results may be useful for various types of companies striving to continuously improve product quality in accordance with the principles of sustainable development.

Keywords: production engineering, quality management instruments, SMEs, V4 countries, sustainable development

1. Introduction

Currently, the global market is experiencing competition and a saturated business environment creating pressure to achieve effective production processes. Enterprises try to meet the market requirements in various ways and maintain their position in the long term[1]. The adequate management of quality favours enterprises, referring to the development of proper practices, rules, and techniques concentrated on continuous improvement, teamwork, and product quality. This stems from the fact that adequate design actions and improvement

[1] A. Pacana, D. Siwiec, L. Bednárová, J. Petrovský, *Improving the Process of Product Design in a Phase of Life Cycle Assessment (LCA),* Processes, 2023, 11, 2579. https://doi.org/10.3390/pr11092579; A. Pacana, D. Siwiec, J. Pacana, *Fuzzy Method to Improve Products and Processes Considering the Approach of Sustainable Development (FQE-SD Method),* Sustainability, 2023, 15, 9927. https://doi.org/10.3390/ su15139927; D. Siwiec, A. Pacana, A. Gazda, *A New QFD-CE Method for Considering the Concept of Sustainable Development and Circular Economy,* Energies 2023, 16, 2474. https://doi.org/10.3390/en16052474.

management largely depend on customers' requirements, which should be analyzed and implemented continuously in new product solutions[2].

Quality management is an important element in the development of small and medium enterprises (SMEs), which play a key role in the development of the market and maintaining its good level in developing countries, e.g., countries of the Visegrad Group V4 (Poland, Slovakia, Hungary, Czech Republic). The V4 is an informal association of four countries from Central Europe with the goal of expanding cooperation between them to support spatial integration within the framework of joint investments and achieve harmony in the development of selected areas in these countries[3].

Efforts are being made in these countries, as well as around the world, to achieve newer approaches to business management, meet customer expectations, and face the challenges encountered by entrepreneurs as part of their sustainable development. However, these activities may have changed their nature as a result of the COVID-19 pandemic (caused by SARS-CoV-2, lasting from November 2019 to mid-2023).

Therefore, the purpose of the research was to analyze the use of instruments supporting current actions of SMEs from V4 countries as part of sustainable quality management. The surveyed SMEs belonged to the electrical machinery industry (machinery processing industry). The conducted research confirmed the thesis that SMEs from the V4 countries use quality management and decision support instruments to varying degrees in pro-environmental improvement of product quality. The originality of the article lies in the identification of the instruments currently most and least popular in use by SMEs from the V4 countries for quality management.

2. Characteristics of selected quality management instruments

Quality is synonymous with compliance with requirements. Each failure to meet specified standards is considered a nonconformity or defect. The occurrence of these nonconformities

[2] J. Martin, M. Elg, I. Gremyr, A. Wallo, *Towards a quality management competence framework: exploring needed competencies in quality management*, Total Quality Management & Business Excellence, 2021, 32(3-4), 359-378. Doi: https://doi.org/10.1080/14783363.2019.1576516; P. Ondra, *Managing Quality In Industrial Companies: The Empirical Study Of Quality Management Systems In The Czech Republic*, Serbian Journal of Management, 2021, 16(1), 251-266. Doi: 10.5937/sjm16-24507; A. Pacana, D. Siwiec, *Method of Fuzzy Analysis of Qualitative-Environmental Threat in Improving Products and Processes (Fuzzy QE-FMEA)*, Materials 2023, 16, 1651. https://doi.org/10.3390/ma16041651.

[3] S. Gałaś, A. Gałaś, M. Zeleňáková, L. Zvijáková, J. Fialová, H. Kubíčková, *Environmental Impact Assessment in the Visegrad Group Countries*, Environ Impact Assess Rev, 2015, 55, 11–20, doi:10.1016/j.eiar.2015.06.006; M. Sukiennik, K. Zybała, D. Fuksa, M. Kęsek, *The Role of Universities in Sustainable Development and Circular Economy Strategies*, Energies (Basel) 2021, 14, 5365, doi:10.3390/en14175365; J. Belas, B. Gavurova, L. Novotna, L. Smrcka, *Examination of Differences in Using Marketing Tools in the Management of SMEs in the Visegrġd Group Countries.* www.amfiteatrueconomic.ro 2022, 24, 447, doi:10.24818/EA/2022/60/447.

generates costs, necessitates repairs, or results in customer complaints. Such challenges pose problems for a company, prompting them to take actions to minimize the incidence of quality issues. These efforts are facilitated by quality management instruments, which encompass principles, tools, and methods.

High-quality tools can be employed individually, although other qualitative techniques are often combined for a more comprehensive analysis of a problem. Therefore, it is assumed that qualitative techniques have a broader application than tools. In general, quality tools are utilized for the collection and processing of data and information, as well as the analysis of errors, non-conformities, and problems in processes, products, or services. Their application allows for a graphical representation of the problem, the identification of correlations, and the determination of improvement actions. Selected quality management instruments will be briefly characterized according to their purpose later in the study.

Benchmarking

Benchmarking entails identifying the most advantageous solutions employed in a specific activity to gain a competitive advantage. This process involves comparing oneself with others to acquire their knowledge and best practices, aiming to achieve superior results that will result in a competitive edge. Various types of benchmarking exist based on different applications, such as strategic, external, internal, process, product, management methods, competitive, and functional benchmarking. A detailed description of these types can be found in works by authors like J. Materac[4].

Tree analysis

Event Tree Analysis (ETA) and Fault Tree Analysis (FTA) are quantitative analysis techniques. The event tree method (ETA) is employed for identifying output data, and if necessary, determining the probability of the event occurring. ETA is a technique for modeling success or failure, examining the relationships of individual initiating events and establishing a path for assessing the probability of outcomes and overall system analysis. On the other hand, FTA is systematically used to determine and graphically present logical connections of problems. Its application enables the analysis of incompatibilities among system elements and the identification of undesirable effects, thereby facilitating the implementation of appropriate improvement actions[5].

[4] J. Materac, *Benchmarking jako metoda zapożyczania najlepszych rozwiązań,* Zeszyty Naukowe ZPSB Firma i Rynek 2019, 2(56), 121-131.
[5] K. Knop, *The Use of Quality Tools to Reduce Surface Defects of Painted Steel Structures*, Manufacturing Technology, 2021, 21(6), 805-817. DOI: 10.21062/mft.2021.088

Techniques of acquiring customer expectations

The development of enterprises relies on obtaining and analyzing customer expectations. Techniques employed for this purpose include surveys, questionnaires, and interviews. Surveys and questionnaires involve direct or indirect client participation, while interviews are conducted face-to-face. These methods are utilized to gather specific information. Consequently, the questions incorporated into surveys or questionnaires are contingent on the nature of the research, aiming to acquire respondents' requirements in a given research field. Advantages of these techniques encompass ease of researching large societal groups, the feasibility of conducting pilot studies, ensuring triangulation procedures, maintaining anonymity and confidentiality, and the cost-effectiveness of research[6].

Quality management tools

Relatively frequently used tools to analyze quality problems in processes, products, or services include the Ishikawa diagram, Pareto-Lorenz analysis, and the 5Why method. These techniques can be applied independently, but employing them in combination allows for a more comprehensive verification of the problem.

When using a combination of tools, the process typically begins with a Pareto-Lorenz analysis. This analysis helps identify the 20% of causes that contribute to 80% of the effects. To utilize this method effectively, one must first determine the number of problems of a specific type, such as product non-compliance. The discrepancies are then scrutinized using the 20/80 rule. This approach facilitates the identification of the primary causes of the problem, pinpointing those with the most significant impact[7].

Subsequently, to delve into the primary causes of the problem, the Ishikawa diagram (also known as a fishbone diagram or chevron diagram) can be employed. This diagram serves to visually represent the problem and scrutinize potential causes. It is a valuable tool for analyzing the causes identified in the Pareto-Lorenz analysis and pinpointing potential root causes. In the traditional approach, potential causes are categorized using the 5M principle: man, method, machine, material, and management. Other categories, such as environment

[6] M. Jeziński, *Badanie ankietowe jako element ewaluacji jakości kształcenia na uczelniach wyższych,* Kultura i edukacja 2016, 3(113), pp. 213-227. DOI: 10.15804/kie.2016.03.12

[7] M. Zasadzień, *Using the Pareto diagram and FMEA (Failure Mode and Effects Analysis) to identify key defects in a product,* Management Systems in Production Engineering 2014, 4(16), pp. 153-156. DOI: 10.12914/MSPE-02-04-2014; A. Hoła, M. Sawicki, M. Szóstak, *Methodology of Classifying the Causes of Occupational Accidents Involving Construction Scaffolding Using Pareto-Lorenz Analysis,* Appl. Sci. 2018, 8, 48. https://doi.org/10.3390/app8010048.

or finances, may also be considered. From the list of identified causes, it becomes feasible to select the most probable contributors to the problem[8].

Following that, the 5Why (Why-Why) analysis can be applied. The 5Why method entails asking the question "Why?" five times. The initial query is directed at the primary problem, and subsequent questions aim to unveil the underlying causes. By the fifth iteration of the question "Why?" the root cause of the problem should be discerned. Subsequently, appropriate improvement actions can be implemented[9].

Multi-criteria decision support methods

In addition, there are multi-criteria decision-making methods (MCDM) and their counterparts designed for operation in a fuzzy decision-making environment, known as fuzzy multi-criteria decision-making methods (FMCDM). Examples include AHP (Analytic Hierarchy Process), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), and PROMETHEE (Preference ranking organization method for enrichment evaluation). These methodologies are employed for the analysis of multiple criteria and alternatives, facilitating the creation of rankings and compromises to determine a synthesis or conclusion. The analyses incorporate the numerical measurement of the criteria's importance. Employing these methods enables the resolution of various decision-making problems, reducing the likelihood of errors resulting from computational analyses[10].

3. Research subject and methods

The research focused on qualitative and environmental aspects of product improvement, conducted through surveys in SMEs from the Visegrad Group countries (Poland, Czech Republic, Slovakia, and Hungary), specifically those in the electromechanical industry (machine processing industry). The survey was conducted using both traditional paper surveys and an electronic survey created with MS FORMS.

[8] A. Pacana, D. Siwiec, *Method of Determining Sequence Actions of Products Improvement*, Materials 2022, 15, 6321. https://doi.org/10.3390/ma15186321; D. Siwiec, A. Pacana, *A New Model Supporting Stability Quality of Materials and Industrial Products*, Materials 2022, 15, 4440. https://doi.org/10.3390/ma15134440

[9] O. Serrat, The Five Whys Technique. In: Knowledge Solutions. Springer, 2017, Singapore. https://doi.org/10.1007/978-981-10-0983-9_32; D. Siwiec, A. Pacana, *Method of improve the level of product quality*, Production Engineering Archives, 2021, 27(1), pp. 1-7. Doi: https://doi.org/10.30657/pea.2021.27.1

[10] R.W. Saaty, *The analytic Hierarchy Process – what it is and how it is used*, Mathematical Modelling, 1987, 9(3-5), pp. 161-176. DOI: https://doi.org/10.1016/0270-0255(87)90473-8; E. Plebankiewicz, D. Kubek, *Zastosowanie metody AHP do wyboru dostawców materiałów budowlanych,* Gospodarka Materiałowa i Logistyka, 2014, 8, pp. 2-12; H.A. Effat, M.S. Ramadan, R.H. Ramadan, *A spatial model for assessment of urban vulnerability in the light of the UN New Urban Agenda guidelines: case study of Assiut City*, Egypt. Model. Earth Syst. Environ. 2021. https://doi.org/10.1007/s40808-021-01281-7.

The survey comprised information and fundamental questions developed through preliminary research, e.g.[11] and literature review on the subject, e.g.[12]. The survey instrument used in the research is detailed in the literature[13].

This study presents the results of the analysis of a selected survey question, investigating the current utilization of specific quality management instruments and decision support methods in SMEs from the V4 countries:

- benchmarking,
- tree analysis (e.g. event tree (ETA), fault tree (FTA)),
- machine learning methods,
- teamwork techniques (e.g. brainstorming, Delphi method, multiple voting),
- planning and quality control methods (e.g. APQP, PPAP, PC),
- methods of planning experiments (e.g. Shainin, Taguchi, 2-level/3-level plans),
- statistical tools (e.g. sampling, statistics, distributions, analyses of variance/ regression/ correlation),
- fuzzy multi-criteria decision support methods (e.g. FAHP, FTOPSIS, FANP),
- multi-criteria decision support methods (e.g. AHP, TOPSIS, PROMETHEE, ZAPROS, VIKOR),
- quality management tools (e.g. Ishikawa diagram, Pareto-Lorenz analysis, 5Why, control chart, histogram),
- quality management methods (e.g. FMEA, QFD, Kano, SPC),
- quality management principles (e.g. Deming, Kaizen, Poka Yoke, Zero Defects),
- techniques of acquiring customer expectations (e.g. survey, questionnaire, interview).

[11] M. Hajduk-Stelmachowicz, P. Bełch, D. Siwiec, L. Bednarova, A. Pacana, *Instruments used to improve the betterment of products quality*, Scientific Papers of Silesian University of Technology, Organization and Management Series, 2022, 157, 167-171. Doi: http://dx.doi.org/10.29119/1641-3466.2022.157.10; D. Siwiec, P. Bełch, M. Hajduk-Stelmachowicz, A. Pacana, L. Bednarova, *Determinants of making decisions in improving the quality of products*, Scientific Papers of Silesian University of Technology, Organization and Management Series, 2022, 157, 497-507. Doi: 10.29119/1641-3466.2022.157.31; D. Siwiec, A. Pacana, Z. Simkova, G. Metszősy, I. Vozňáková, *Current activities for quality and natural environment taken by selected enterprises belonging to SMES form the electromechanical industry,* Scientific Papers of Silesian University of Technology, Organization and Management Series, 2023, 172, 537-553. Doi: http://dx.doi.org/10.29119/1641-3466.2023.172.33

[12] Z. Saqib, L. Qin, R. Menhas, G. Lei, *Strategic Sustainability and Operational Initiatives in Small- and Medium-Sized Manufacturers: An Empirical Analysis*, Sustainability, 2023, 15, 6330. doi:10.3390/su15076330; J. Wysocki, *Działalność Proekologiczna Dużych Przedsiębiorstw Produkcyjnych w Polsce - Wyniki Badań Ankietowych.* In Nowe formy innowacji, 2018, 82–109; P. Bryła, *Znaczenie Marki Na Rynku Ekologicznych Produktów Żywnościowych.* In Strategie budowania marki i rozwoju handlu. Nowe trendy i wyzwania dla marketingu; Wydawnictwo Uniwersytetu Łódzkiego, 2020; M. Hudakova, M. Gabrysova, Z. Petrakova, K. Buganova, V. Krajcik, *The Perception of Market and Economic Risks by Owners and Managers of Enterprises in the V4 Countries*, Journal of Competitiveness 2021, 13, 60–77, doi:10.7441/joc.2021.04.04.

[13] QuEn – Research Questionnaire for enterprise. Online access: https://forms.gle/eDSLsZ2SuNBt7Fqx7 (19.10.2023)

The research aimed to validate the following thesis: SMEs from the V4 countries employ quality management and decision support instruments to different extents for pro-environmental enhancement of product quality. The verification of this thesis involved analyzing the variances and correlations among the scrutinized management instruments utilized in SMEs from the V4 countries. The relationships were tested using the Mann Whitney U-test, with analyses conducted at the significance level of $\alpha = 0.05$.

4. Results and discussion

The presented research results constitute a sample obtained in the period from March to July 2023 in the V4 countries (Poland, Czech Republic, Slovakia and Hungary). During this time period, the sample consisted of 265 SMEs in the electrical machinery industry.

The percentage of survey results obtained from V4 SMEs in the total number of responses is shown in Figure 1.

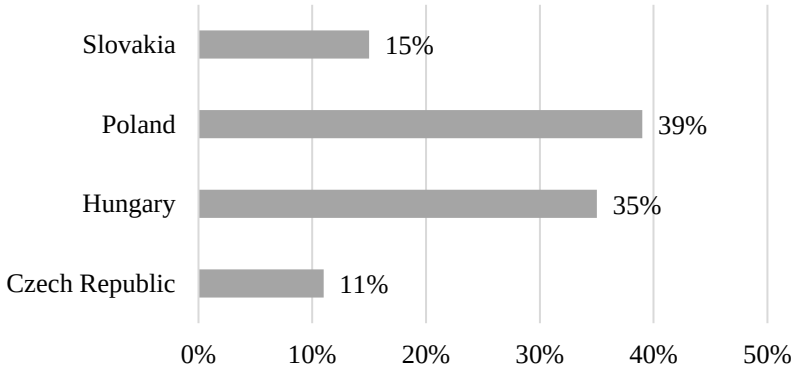

Figure 1. Country of the company`s registered office.
Source: own study.

During the analyzed period, the results for analysis were mostly SMEs from Poland (39%) and, relatively speaking, from Hungary (35%). A smaller number of surveys were collected from SMEs in Slovakia (15%), and the Czech Republic (11%).

Subsequently, the survey results regarding the birth certificate questions were analyzed. Initially, the location of SMEs from the V4 countries participating in the survey was analyzed (Figure 2).

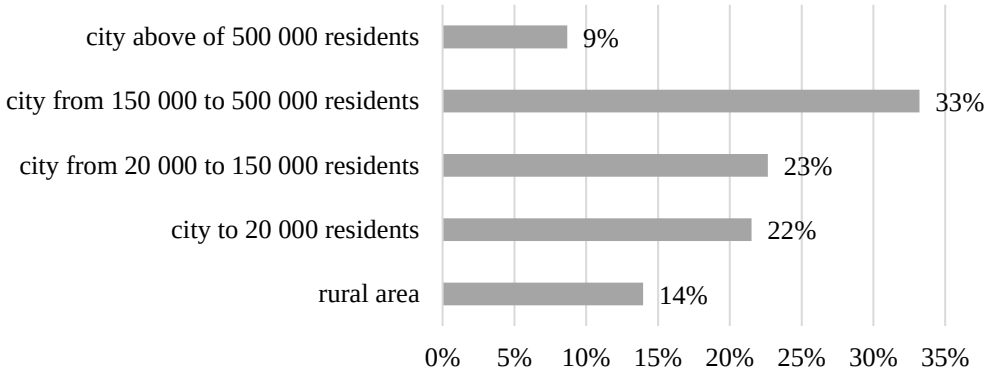

Figure 2. Company headquarters.
Source: own study.

Most of the surveyed SMEs from the V4 countries were located in cities with a population of 150,000 to 500,000 (33%). Fewer companies were those located in a city with a population of 20,000 to 150,000 (23%) and in a city with a population of up to 20,000 (22%). Next, these were V4 SMEs located in a rural area (14%) and a city with a population of up to 500,000 (9%).

Then, the type of enterprise from the V4 countries participating in the survey was analyzed (Figure 3).

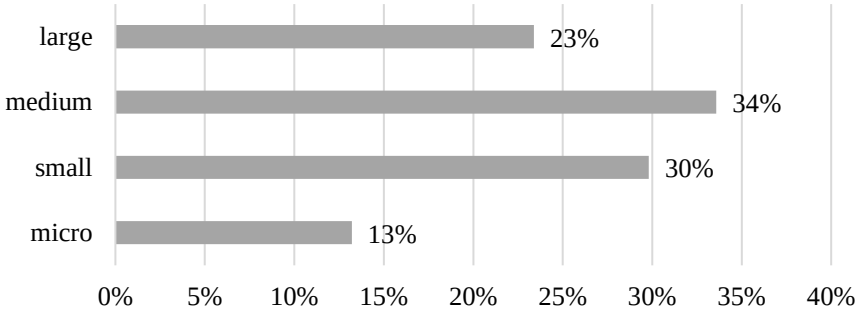

Figure 3. Enterprise type.
Source: own study.

It was observed that in the analyzed research period, the largest share was represented by medium-sized enterprises (34%), followed by small-sized enterprises (30%).

Later, the scope of activities of the surveyed SMEs from the V4 countries was analyzed. The result is shown in Figure 4.

It was shown that the overwhelming percentage of surveyed SMEs from the V4 countries were companies with an international reach (47%), and a significantly smaller share

of companies with a national reach (21%). The surveyed companies also included regional (15%) and local (17%) companies.

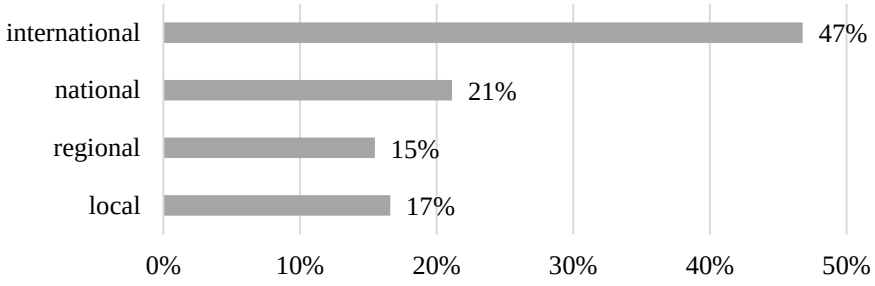

Figure 4. Range of activities.
Source: own study.

Another analysis concerned the implementation of environmental management systems or the EMAS system and the quality management system, as shown in Figure 5.

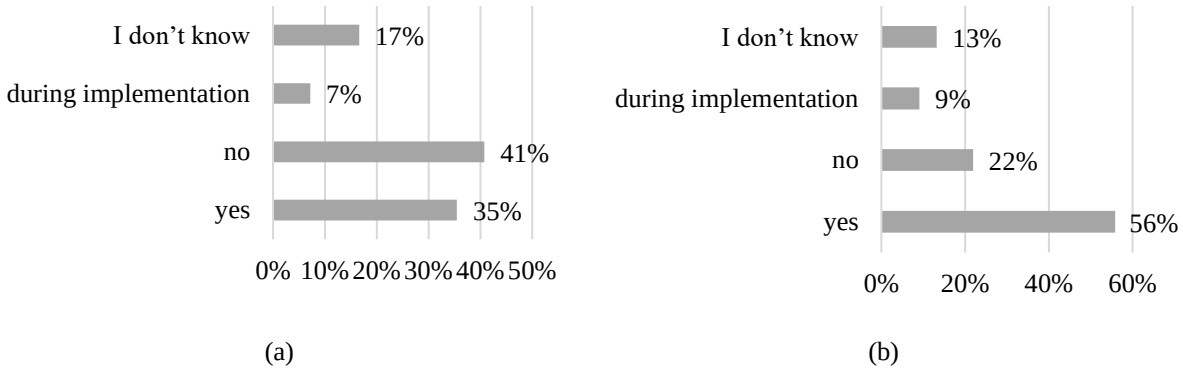

Figure 5. Implemented: (a) ISO 14001:2015 system or EMAS system, (b) ISO 9001:2015 system.
Source: own study.

In the given research period, the majority of the analyzed SMEs from the V4 countries declared that they did not have the ISO 14001:2015 or EMAS system implemented (41%). However, relatively slightly fewer SMEs from the V4 countries indicated that they had implemented such systems (35%). Some entrepreneurs did not know about such implementation (17%), while 7% of the surveyed companies were in the process of implementation. In turn, in the case of the ISO 9001:2015 system, more than half of the analyzed SMEs from the V4 countries indicated that they had implemented this system (56%).

No such implementation was declared by 22% of companies, while 9% were in the process of implementation. However, 13% of entrepreneurs indicated that they had no knowledge about such implementation.

Based on the survey results obtained for the presented research sample of SMEs from the V4 countries (Poland, Slovakia, Hungary and the Czech Republic), the research thesis was verified, i.e. SMEs from the V4 countries use quality management and decision support instruments in pro-environmental improvement to varying degrees quality of products. The frequency of use of individual instruments by entrepreneurs was assessed on a scale of 0-5, where 0 - no use, 5 - greatest use. The result is shown in Figure 6.

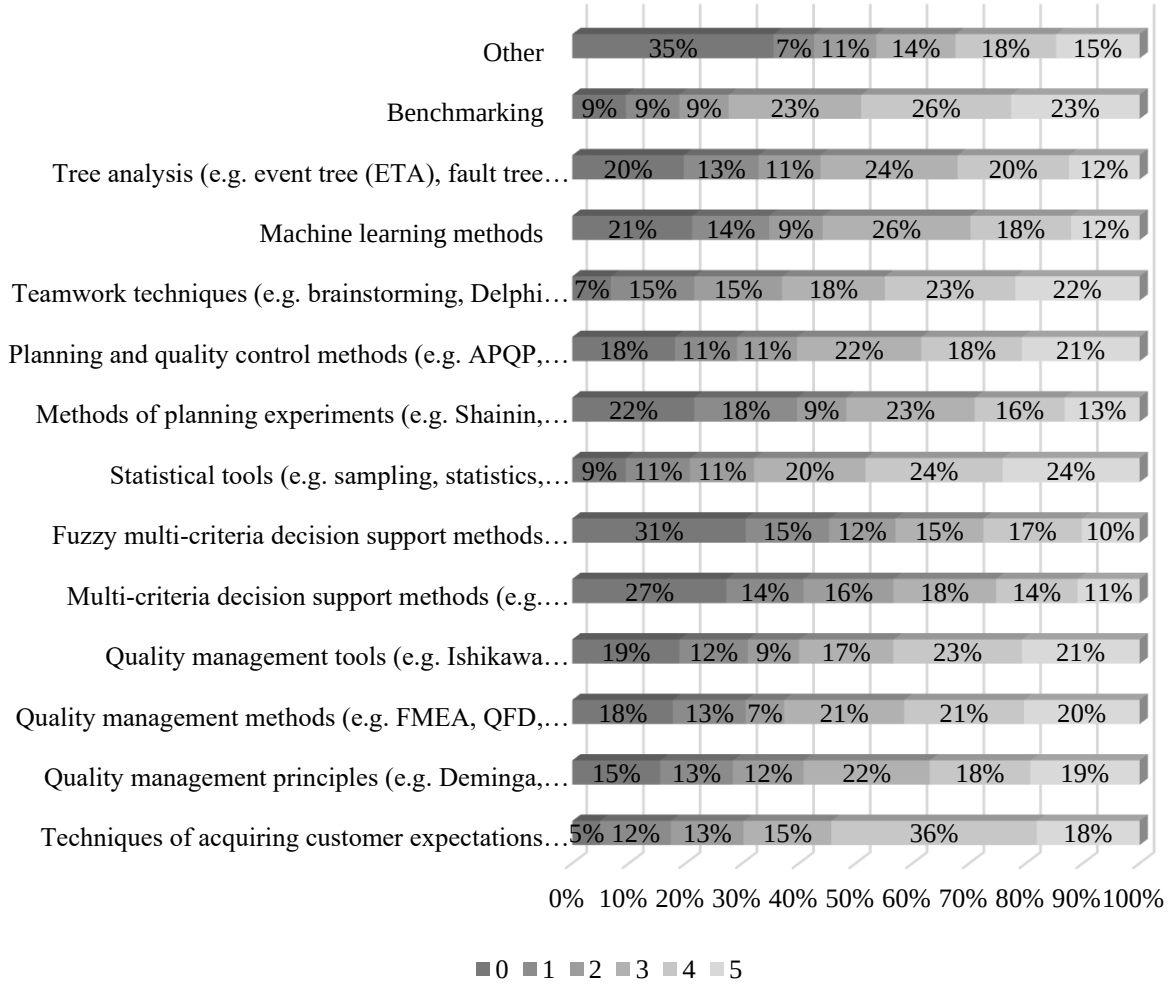

Figure 6. Frequency of use of individual management instruments by entrepreneurs.
Source: own study.

It has been shown that entrepreneurs are least likely to utilize fuzzy multi-criteria decision support methods (FMCDM) (31%) and multi-criteria decision support methods (MCDM) (27%). MCDM includes methods like AHP (Analytic Hierarchy Process), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), PROMETHEE (Preference ranking organization method for enrichment evaluation), ZAPROS, and VIKOR. On the other hand, FMCDM involves methods that support decision-making in a fuzzy decision-making environment, using triangular fuzzy numbers as a scale for assessing criteria. Examples of FMCDM methods include FAHP (Fuzzy Analytic Hierarchy Process), FTOPSIS (Fuzzy Technique for Order of Preference by Similarity to Ideal Solution), FANP (Fuzzy Analytic Network Process).

It was observed that SME entrepreneurs from the V4 countries often used certain instruments, such as techniques for acquiring customer expectations (36%). Additionally, relatively common practices included benchmarking (26%), statistical tools (24%), quality management tools (23%), teamwork techniques (23%), and quality management methods (21%). Techniques for acquiring customer expectations include surveys, questionnaires, and interviews. Benchmarking involves comparing an enterprise's processes and practices with those of other enterprises considered to be the best. Statistical tools, such as sampling, statistics, and distribution analyses, are used for research samples and statistical analyses. Quality management tools, like the Ishikawa diagram, Pareto-Lorenz analysis, 5Why, control chart, and histogram, are employed to analyze quality problems, non-conformities in products or processes, and take improvement actions. Despite this, quality management methods, such as FMEA (Failure Mode and Effect Analysis), QFD method (Quality Function Deployment), and the Kano model, are used for analyzing errors, identifying customer expectations, and transforming them into product or service criteria. Figure 7 displays the average assessment of the frequency of use of individual management instruments by SME entrepreneurs from the V4 countries.

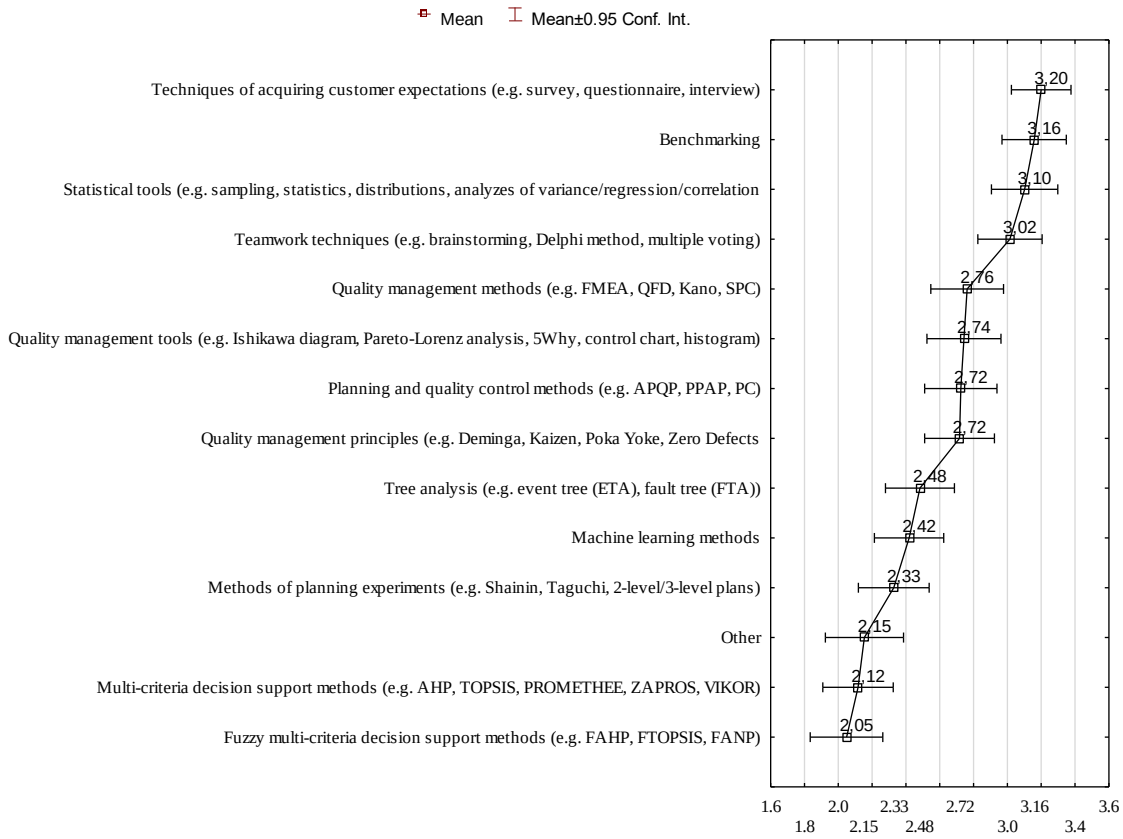

Figure 7. Average assessment of the frequency of use of individual management instruments. Source: own study.

Entrepreneurs commonly utilize techniques for acquiring customer expectations (e.g., surveys, questionnaires, interviews) and benchmarking, as indicated by their responses. These methods are considered relatively simple and are often employed in improvement processes. Acquiring customer expectations, for instance, is predominantly undertaken during the creation of new products or enhancements to existing products. Conversely, benchmarking serves as a foundation for improvement, involving the enhancement of an enterprise based on the best practices observed in other enterprises.

5. Summary and conclusions

Quality management in SMEs from the V4 countries is still a challenge. Therefore, companies use various instruments to support this process as part of continuous development and coping with the competitive production environment. Various aspects have an impact on the actions taken, e.g. the COVID-19 pandemic. For this reason, it was important to analyze the state of current instruments supporting quality management.

The aim of the research was to analyze the use of instruments supporting the current activities of SMEs from the V4 countries as part of sustainable quality management. These

enterprises were SMEs from the electrical machinery industry (machinery processing industry). The presented research analyzes were the result of surveys conducted in the V4 countries (Poland, Czech Republic, Slovakia and Hungary). The results represent a sample of 265 electrical machinery SMEs from the V4 countries. The research was obtained between March and July 2023.

The conducted research confirmed that SMEs from the V4 countries use quality management and decision support instruments in pro-environmental improvement of product quality to a varying extent. The main conclusions from the analysis indicate that SME entrepreneurs from the V4 countries:

- use it the least often fuzzy multi-criteria decision support methods and multi-criteria decision support methods,
- often exploit statistical tools, quality management tools, teamwork techniques, and quality management methods,
- most often use techniques of acquiring customer expectations (e.g. survey, questionnaire, interview) and benchmarking.

It was concluded that decision support methods are not popular in use by SMEs from the V4 countries. This means that decisions made in these enterprises are often not supported by preferred methods, including methods that allow for making adequate multi-criteria decisions. At the same time, more popular are methods for statistical calculations or simple methods for managing the quality of products or processes, which generally involve the analysis of nonconformities (the causes and effects of their occurrence). Additionally, the methods used support making more appropriate improvement decisions. In addition, it was observed that entrepreneurs willingly use methods to obtain customer expectations. Hence, it was concluded that SMEs from the V4 countries examine customer expectations in order to meet their satisfaction. At the same time, it has been shown that entrepreneurs improve their companies based on the examples of good practices of other companies. Most of them use benchmarking for this purpose.

The results and conclusions presented in the article may be useful for SMEs in the electrical machinery industry in the V4 countries in the selection of instruments supporting product quality management. In addition, the analyzes carried out can be used by other types of enterprises that strive to constantly improve the quality of products in accordance with the principles of sustainable development.

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CHAPTER 2

QUALITY OF LIFE INFLUENCED BY THE ENVIRONMENT

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The quality of life is one of the most important concepts in the European area, and extremely discussed in terms of content and quantification. It is primarily used as a target value for the economic development of society, but it has also become a new challenge for ensuring a dignified life EU resident. Last but not least, the quality of life is mentioned in connection with the promotion of the concept of sustainable development and sustainable consumption. A lot is written about the quality of life, as evidenced by a relatively large number of research studies and professional articles, in which the quality of life is discussed as an overall category, but it is also analyzed as a fragment in the sense of focusing only on individual or partial areas (domains) of human life. This broad view is the result of the fact that today the quality of life is the subject of study in several scientific fields, which analyze it from different aspects of a person's life and offer different definitions.

Keywords: quality of life, environment, waste management, waste audit

1. Introduction

An important role is played by the specification of economic indicators aimed at the real evaluation of direction in individual areas of the economy. Since the beginning of quality-of-life research, which dates back to the late 1960s, many approaches and procedures for its assessment have been created. At the beginning of the research, it was mainly about finding and determining indicators of well-being, while the quality of life expressed the degree of congruence of objective living conditions and their subjective evaluation by large groups of people – these were researches related to the state of society. The focus was on economic and social indicators of quality of life: income and material security, political freedom and independence, social justice, legal certainty, and health care. In the last two decades, the preferred approach is to quality of life as a concept that refers to the individual, not to his/her economic or social conditions. A significant part of quality-of-life research is focused on the area that is related to a person's health (HRQOL = Health-Related-Quality of Life). In this area, the concept of quality of life has acquired a special position in the evaluation of the results of medical procedures (how patients experience their health condition, how they manage their everyday life, and how they function in social relationships). A very wide range of instruments

is used to measure quality of life, many of which are available in extensive databases. For example, The Australian Center for Quality of Life[1] lists around 1000 instruments on its website that have an affinity for subjective assessment of quality of life. In addition to databases, there are dozens of monograph-oriented works that describe the basic characteristics of the measurement tools created so far for subjective quality of life.

Discussions about quality of life were held in Great Britain, but primarily in the USA, where the direction of the first research was set. In them, the researchers focused mainly on the content definition and definition of this term. Many opposing opinions and concepts have appeared. Most of them had a futuristic character, focused on models of future perspectives of the way of life. The trend of the 70s and 80s became the so-called post-materialism, which emphasized the value of the quality of life, where the priority was civil liberties, personality development, development of free time, and tourism. In the 90s of the last century, there was a further expansion of quality-of-life research, the reason being the effort to thoroughly define the theoretical foundations of quality of life, to create such indicators that would allow quantifying the quality of life in its complexity[2].

Discussions on defining the meaning of quality of life in the context of sustainable development have been renewed. Various theoretical concepts emerged, such as utilitarianism, i.e., a stream of thought that can be understood as a theoretical starting point for further considerations about the quality of life and well-being. The basis of this theory is the quality of life, which is primarily determined by the highest possible ways of satisfying the desires of individuals, achieving the maximum level of income, and utility[3]. Two basic problems are immediately connected with the practical use of the term quality of life. The first problem is the content definition of this term, where there is no consensus. This means that until now there has not been a definition of the quality of life that would be generally accepted. The second problem is the measurability of the quality of life. In this area, we have the absence of an indicator that would capture the quality of life in its complexity. So, what is quality of life and is it measurable? The answers to these two problems must be sought primarily in its

[1] N. Izdenczyová, Predstavujeme projekt APVV-0374-10 *„Subjektívne hodnotenie kvality života: reliabilita a validita merania",* Access online: http://napulze.unipo.sk/ univerzity/akcie-a-projekty/765-proijekt-kvalitazivota.html (25.10.2023); Act No. 290/2013 Coll., amending Act No. 223/2001 Coll. on waste and on the amendment and supplementing of certain laws as amended and supplementing Act no. 8/2009 Coll. on road traffic and on the amendment of certain laws, as amended;

[2] J. Drdoš, J. Oťaheľ, *Landscape as a research subject,* [in]: Landscape Ecology in Slovakia. Development, Current State and Perspectives. Chosen Chapters, edit. Kozová, M. et al., 2007. Minsitry of the Environment of the Slovak Republic, Slovak Association for Landscape Ecology, Bratislava, Williams, P. T. 2005, 91-97.

[3] S. Thirion, *Social cohesion indicators and the contribution of a solidarity – based economy*, [in]: Trends in social cohesion, 2004, 12, 49-69.

definition. The quality of life is the result of the interaction of social, health, economic, and environmental conditions related to human and social development. On the one hand, it represents the objective conditions for a good life, and on the other hand, the subjective experience of a good life. The objective side includes the fulfillment of social and cultural needs depending on the material availability, social acceptance, and physical health of the individual. The subjective experience of the quality of life includes a good feeling of life, well-being, and satisfaction of the individual with his own life.

2. The environment and the quality of life

The purpose of the chapter is to describe that the connection between quality of life and the environment is deep and interdependent. The quality of life of individuals and societies is significantly influenced by the state and quality of the environment in which they live. Overall, it can be said that the quality of life and the environment are interconnected, and their sustainable balance is key to the long-term and healthy development of society.

The environment and quality of life are concepts that are directly related to each other. From a qualitative point of view, these terms are mutually correlated. Thus, the state of landscape quality largely reflects the quality of the environment, which, in turn, affects the overall quality of life. If environmental indicators are negative, they also indicate a reduced quality of life. Our contribution is based on this idea, the goal of which is a methodological view of the acceptance of objective indicators of the quality of the landscape (environment) within the framework of the quality-of-life assessment. Simultaneously, we aim to highlight the methods used in the assessment of the quality of the landscape, employed in the framework of landscape ecological analyses and syntheses. According to Ira and Andrášek, it is currently possible to examine and characterize the concept of quality of life through three basic features[4]:

- inconsistency (terminological, within basic approaches and methods of measurement),
- multidisciplinary (quality of life is the subject of research from several scientific disciplines),
- multidimensionality (this statement is based on the assumption that the complexity and intricacy of human life are created by a number of its different dimensions, which can overlap each other, and there are various types of connections between them).

These three basic features apply to both subjective and objective quality of life indicators. While subjective characteristics are based on people's opinions, attitudes, and self-perception

[4] V. Ira, I. Andráško, *Kvalita života z pohľadu humánnej geografie,* Geografický časopis, 2007, 59(2), 159-179.

within the environment, objective indicators are based on measurable and quantifiable indicators.

The quality of life and the state of the environment are interconnected. The environment affects many aspects of the daily life of individuals and communities, and the quality of life can be substantially positive or negative.

The link between quality and the environment refers to the mutual relationship between the state of the environment and the quality of people's lives. This relationship can be quite complex, as the environment affects many aspects of human life, including health, economic development, social stability, and overall life satisfaction.

1. Health: The quality of air, water, and soil has a direct impact on the health of the population. A polluted environment can cause respiratory diseases, infections, and other health problems.
2. Economy: Pollution and the lack of sustainable use of natural resources can have a negative impact on the economy. At the same time, economic growth can lead to greater use of natural resources and pollution.
3. Social stability: Environmental problems can lead to conflicts between individual communities or states, especially over access to resources.
4. Quality of life: A clean environment, access to nature, and sustainable urban planning can contribute to the overall quality of life. Conversely, a polluted and degraded environment can have a negative impact on people's well-being and living conditions.
5. Climate change: Climate change is one of the most striking examples of the link between the quality of the environment and human life. Climate change influences weather patterns, disrupts food availability, raises sea levels, and impacts various other factors with direct consequences for people's lives.

To achieve sustainable development and improve the quality of life, it is essential to consider environmental factors in policy-making, urban planning, and decision-making at all levels, from individuals to international organizations. Introducing measures that minimize the negative impact of human activities on the environment and support a sustainable economy and living conditions is crucial. Waste management, a critical aspect of today's society, deals with a wide range of issues that must be addressed to ensure a greener, better, and healthier

future. Proper waste management ensures that waste is disposed of to minimize its effects on human health and the environment[5].

Before discussing waste management, it's important to understand what waste is, its types, and then delve into waste management. Municipal solid waste is often categorized into two major groups: organic and inorganic. Organic municipal solid waste can be further divided into three categories: putrescible, fermentable, and non-fermentable. Putrescible wastes include products such as foodstuff that decompose rapidly. Fermentable wastes decompose rapidly, but without the unpleasant accompaniments of putrefaction, while non-fermentable wastes tend to resist decomposition and break down very slowly. Inorganic solid waste includes articles like metals, plastics, and other non-biodegradable materials. In terms of toxicity, some solid wastes are classified as hazardous, including pesticides, medical waste, electrical waste, herbicides, fertilizers, and paints, and they are recommended to be disposed of in special ways, not to be mixed with general municipal waste[6].

Solid waste may be defined as all discarded solid materials resulting from households, industrial, healthcare, constructional, agricultural, commercial, and institutional sources[7]. Solid waste generated in a city is often referred to as municipal solid waste. Solid or municipal solid waste management refers to the planning, financing and implementation of programs for solid waste collection, transportation, treatment and final disposal in an environmentally and socially acceptable manner[8].

3. Waste management

Waste management plays a pivotal role in influencing the quality of life on multiple fronts. The primary objective of this chapter is to explore the significance of proper waste management and its positive impacts on the environment, public health, and overall well-being. The persistent challenges associated with waste generation and improper disposal, especially with regard to plastic pollution, continue to demand attention. Various initiatives are underway

[5] Rakesh Patel: 8 Solutions for Overcoming Common Waste Management Challenges. Access online: https://www.upperinc.com/blog/waste-management-challenges (17.09.2023)

[6] UNEP and CalRecovery Inc. Solid Waste Management. Tsurumi-ku: UNEP International Environmental Technology Centre (IETC) and California: CalRecovery, Inc., California, USA, 2005.

[7] Abdhalah K.Z., Tilahun N.H., Blessing M., A review and framework for understanding the potential impact of poor solid waste management on health in developing countries, Arch Public Health, 2016, 74:55. DOI: 10.1186/s13690-016-0166-4.

[8] Ziraba, A.K., Haregu, T.N., Mberu, B. A review and framework for understanding the potential impact of poor solid waste management on health in developing countries, Arch Public Health, 2016, 74, 55. DOI: https://doi.org/10.1186/s13690-016-0166-4.

globally to promote recycling, reduce single-use plastics, and enhance waste management infrastructure[9].

Adopting proper waste management practices is crucial to mitigating negative environmental effects. Inadequate or improper waste disposal can lead to severe ecological and health consequences. Achieving effective waste management requires a comprehensive, integrated approach involving collaboration among governments, industries, communities, and individuals. Sustainable waste management practices contribute to environmental protection, resource conservation, and the establishment of a circular economy.

Implementing proper waste management can result in the availability of valuable materials for reuse, offering potential cost savings and creating new job and business opportunities. Reducing, reusing, and recycling waste not only benefits the environment but also has economic advantages.

Contrary to the common perception of landfills as static repositories, they are dynamic environments where discarded materials gradually break down and settle over months and years through various decomposition processes. Waste collection management encompasses operations from the producer to the processing site or point of disposal. Collection and removal of waste constitute a significant portion, accounting for up to 70% of the total cost of waste removal[10].

Organic waste, such as food scraps, paper, and green waste, decomposes rapidly due to microbial activity. Yard trimmings also break down swiftly with oxygen circulation. Inorganic materials like glass, dense plastics, and metals remain intact for longer periods. Rotting organics in landfills release methane gas and contaminated leachate liquid, both of which are collected and treated in modern facilities. Methane is converted to energy, while leachate is cleaned at wastewater plants.

While full decomposition takes decades, landfills are engineered to contain waste and limit pollution risks. Clay or plastic liners, along with final covers, prevent contamination, and systems are in place to capture gases and liquids for treatment[11].

[9] L. Bednárová et al.: *Odpadové hospodárstvo v SR*, SPÚ Nitra, 2023.
[10] M. Stričík, *Udržateľné nakladanie s komunálnym odpadom,* Ostrava, 2019. ISBN: 978-80-248-4359-9.
[11] From Trash to Treasure: The Surprising Journey of Your Garbage. Access online: https://wedocs.unep.org/handle/20.500.11822/916https://www.vanellagroupmn.com/from-trash-to-treasure-the-surprising-journey-of-your-garbage (23.10.2023).

Here are key aspects of waste management:

1. Waste Collection:

Source Separation: Encouraging individuals and businesses to separate waste at the source into categories like recyclables, organic waste, and non-recyclables.

Curbside Collection: Regular collection of waste from households, typically organized into different bins for various types of waste.

2. Waste Transportation:

Transfer Stations: Intermediate facilities where waste from local collection points is transferred to larger vehicles for transport to disposal or recycling facilities.

Landfills: Final disposal sites for non-recyclable and non-compostable waste. Modern landfills incorporate environmental safeguards to minimize their impact.

3. Waste Disposal:

Incineration: Burning waste to reduce its volume and generate energy. Advanced incineration technologies include energy recovery to produce electricity or heat.

Landfilling: Disposing of waste in designated land areas. Proper landfill management is critical to prevent environmental contamination.

4. Recycling:

Material Recovery Facilities (MRFs): Facilities where recyclable materials are sorted, processed, and prepared for manufacturing new products.

Promoting Recycling Programs: Governments and organizations often implement programs to encourage recycling among the public.

5. Waste Reduction:

Waste Minimization: Encouraging practices that reduce the generation of waste, such as adopting reusable products and packaging.

Product Design: Designing products with minimal environmental impact, considering their entire life cycle, including disposal.

6. Electronic Waste (e-waste) Management:

Special Handling: Due to the hazardous materials present in electronic waste, proper disposal and recycling methods are crucial to prevent environmental contamination.

7. Regulations and Policies:

Waste Management Laws: Governments enact laws and regulations to govern waste management practices and ensure compliance with environmental standards.

Extended Producer Responsibility (EPR): Holding manufacturers responsible for the entire life cycle of their products, including disposal and recycling.

8. Public Awareness and Education:

Community Engagement: Raising awareness among the public about the importance of proper waste disposal and the benefits of recycling.

Education Programs: Informing individuals and businesses about waste reduction strategies and best practices.

Poor waste management not only impacts the environment but also poses a threat to public health. UN-Habitat found that in areas lacking sufficient waste management services, the incidence of diarrhea is twice as high, and acute respiratory infections occur six times more frequently than in areas with regular waste collection[12]. Improperly managed waste, especially excreta and other liquid and solid waste from households and communities, poses a serious health hazard and contributes to the spread of infectious diseases. Examples include skin and blood infections from direct contact with waste and infected wounds, eye and respiratory infections from exposure to infected dust (especially during landfill operations), various diseases from bites of animals feeding on waste, intestinal infections transmitted by flies feeding on waste, and exposure to certain untreated chemicals (e.g., cyanides, mercury, and polychlorinated biphenyls), which are highly toxic and can lead to disease or death[13].

If we want to improve the quality of life with regard to the volume of waste, it is very important to set up a proper collection system. the following figure shows the five main areas where improvement is possible and necessary.

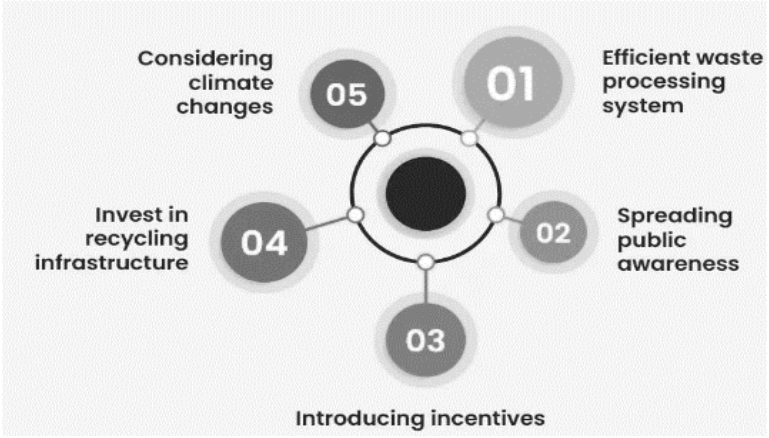

Figure 1. How to create a waste management business plan.
Source: https://www.upperinc.com/blog/waste-management-challenges/

[12] UN-Habitat, *Solid Waste Management in the World's Cities:* Water and Sanitation in the World's Cities, 2010.
[13] Auditing waste management. Access online: https://sisu.ut.ee/waste/book/13-problems-caused-mismanagement-waste (14.10.2023).

Efficient waste processing system

Effective collection and disposal methods can lead to a successful waste management system. Efficient systems ensure the secure and environmentally friendly collection and disposal of waste. Components of an efficient system include regular pick-ups, well-designed waste bins, and optimized routes that minimize the time and resources required for waste collection.

Spreading public awareness

To encourage sustainable trash management methods, education and awareness are extremely important. Strategies such as education campaigns, neighborhood gatherings, and media outreach can raise public awareness about trash management. Hence, it is crucial to educate the public about the adverse effects of trash on the environment and human health, motivating them to adopt more ecologically conscious lifestyles.

People can learn the importance of waste reduction, recycling, composting, and proper disposal from these activities. They can encourage individuals to adopt sustainable lifestyles and use reusable items in their daily lives.

Introducing incentives

There are various types of incentives, including monetary awards, tax credits, recognition programs, and other advantages. Conversely, the government can enforce rules and fines for those who neglect waste management policies. As a result, companies may be more likely to invest in waste management and reduction technology, contributing to a reduction in overall waste production and an enhancement of waste management system efficiency. This process can include the following:

- Incentives for people who dispose of their waste properly,
- Tax breaks for companies investing in composting and recycling infrastructure,
- A community can give incentives to homes that routinely take part in recycling or composting programs[14].

[14] Waste Management Technologies. Access online: https://www.upperinc.com/blog/waste-management-challenges/ (25.10.2023); Act No. 79/2015 Coll. on Waste and on the amendment to certain acts (the "Waste Act"); Business Waste. Access online: https://www.businesswaste.co.uk/waste-management-audit/ (23.10.2023); Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives. Access online: https://eur-lex.europa.eu/LexUriServ /LexUriServ.do?uri= OJ:L:2008:312:0003:0030:SK:PDF (14.10.2023); Gašparíková B., Gallovič P.: Nakladanie s odpadmi v SR., EPOS, Bratislava, ISBN 80-8057-691-2; Gürses A., Güneş K., Korucu M.E., Açikyildiz M. Industrial Waste, [in:] :Kirk-Othmer Encyclopedia of Chemical Technology, Seidel A., Bickford M., Editor, John Wiley & Sons, West Sussex, UK, NewYork,1-26, 2016; Ira V., Andráško I., Kvalita života z pohľadu humánnej geografie, Geografický časopis, 2007, 59(2), 159-179; Waste management line. Access online: https://safetyculture.com/topics/waste-management-system/e-waste-management/ (14.07.2023).

Invest in recycling infrastructure

A proper waste management system requires investment in composting and recycling infrastructure. It includes the construction of recycling, composting facilities, and other waste processing and disposal infrastructure. Investment also includes research and development into new and innovative methods for managing waste.

Investing in these facilities can also create new job opportunities in the composting and recycling s tors. Additionally, composting and recycling can lessen the need for virgin resources, resulting in a more sustainable economy.

Considering climate changes

Climate change has a substantial impact on waste management. It involves implementing sustainable methods in trash management facilities, contributing to lowering emissions, and boosting the use of renewable energy sources like solar and wind.

Additionally, the long-term effects on the environment must also be considered, which includes assessing landfills' viability and considering alternatives like recycling and composting that are less harmful to the environment. Another important part of the process of protecting human health and improving the quality of life is the application of waste management in society.

4. Waste audit

Waste management is a critical aspect of today's society. It is an industry dealing with a wide range of issues that need to be addressed to ensure a greener, better and healthier future. Proper waste management ensures the disposal of waste in such a way as to minimize its impact on human health or the environment. The World Bank predicts that 2.2 billion tons of solid waste will be produced worldwide by 2025. Therefore, proper waste management is essential for the health and safety of the community. The purpose of the chapter is to better know the process of waste audit to get higher quality of living, by eliminations of negative impact. Waste is usually produced from various sources namely institutional, commercial, industrial and households. In addition, improper waste disposal can lead to littering, illegal dumping and environmental pollution, which affects the ecosystem[15]. A waste audit is a process used to calculate the type and amount of waste produced by an organization. Any large organization

[15] Waste audit methodology. Access online: https://www.sprep.org/sites/default/files/documents/publications/waste-audit-methodology-common-approach.pdf (25.10.2023); Reduce, refuse, recycle. Access online: https://www.recycle-more.co.uk/how-to-recycle-and-reduce-waste/recycling-in-the-workplace/waste-management/waste-audits (14.09.2023); Waste treatment and disposal. Access online: https://download.e-bookshelf.de/download/0000/5677/91/L-G-0000567791-0015244104.pdf (14.07.2023).

can perform this type of audit. The data collected from the audit will determine the type of waste that the organization produces and how the organization disposes of this waste. An audit can also make an organization more efficient in reducing waste management costs by educating employees about proper waste disposal and better use of natural resources. When conducting a waste audit, the organization should not inform employees about the audit before the audit is completed. Notifying staff in advance can change waste disposal habits, leading to an inaccurate and counterproductive audit. A waste audit is a well-thought-out process that determines the amount and types of waste that a company produces. Completing a waste audit will provide valuable information that will benefit the company in many ways. A waste audit is the process of checking and analyzing the waste flow of an organization or the life cycle of the waste produced. Ensures compliance with regulatory requirements requires physical passage through waste to determine sources and types of waste produced. The movement of waste from its source to the end of its life, in which the waste is either disposed of or recycled, is also analyzed. In order to reduce the impact of waste on the environment, the main objectives of a waste audit include the detection of recycling possibilities and the improvement of waste management systems. You need a quick and easy checklist to help you outline your next steps so your team can get to work on what matters to make your company more effective. A waste audit is a survey of the normal flow of waste in a facility. Waste auditors go through bags of waste, sort items, record and analyze data. In doing so, they identify what is thrown away, what is recycled or otherwise diverted and the quantities of each type of waste by weight or volume[16].

4.1 What is the goal of a waste audit in a company

The main objective of the waste audit, as described above, is to evaluate the current state of the company's waste program while simultaneously identifying opportunities to diminish the volume of waste sent to landfills. This reduction can significantly enhance the quality of life and mitigate negative impacts on health.

[16] How to Do a Waste Audit for Your Company. Access online: https://recyclecoach.com/blog/how-to-do-a-waste-audit-for-your-company-quick-10-min-checklist/ 2023-06-11 (14.07.2023); Izdenczyová N., Predstavujeme projekt APVV-0374-10 „Subjektívne hodnotenie kvality života: reliabilita a validita merania", Access online: http://napulze.unipo.sk/ univerzity/akcie-a-projekty/765-proijektkvalitazivota.html (25.10.2023); Mannan S., Lees' loss prevention in the process industries (Hazard identification, assessment and control), USA Elsevier Butterworth – Heinemann, 2005, 1(3); Ministry of Natural Resources and Environment. National Environmental Status Report in 2016: Urban Environment. Access online: http://vnniosh.vn/Portals/0/ VT_Articles/2014/Baocao_tacdongMT_2016.pdf (17.09.2023); Theoretical and Practical Aspects of Forming Quality of Life in terms of Consumption. Access online: https://euba.sk/www_write/files/SK/ekonomicke-rozhlady/2019/er3_2019_holkova_veselkova_fulltext.pdf (10.11.2023)

From a general point of view, it is possible to divide the objectives of the waste audit into four basic groups:

1. Compare your company's current processes and environmental impact.
2. To understand where there are opportunities for our improvement.
3. Monitoring trends and developing new initiatives.
4. Reduce, reuse and recycle more waste for less landfill.

Determining what is recyclable and what is not poses common challenges that require resolution. In case you lack access to the web application, utilize an alternative guide during the audit that provides information on the types of recyclable and non-recyclable waste. Additionally, you can explore the collection requirements of your local authority through local information portals and relevant pages on the Ministry of the Environment and other associated portals. In conclusion, conducting a waste audit serves as an excellent starting point for establishing a high-performing recycling program. A waste audit is basically a process that gathers information about a company's waste management processes, such as:

- How waste is created,
- Types of generated waste,
- What containers are used to store waste,
- How the waste is prepared for collection,
- Total amount of produced waste.

This basic information is necessary to apply it in making waste management processes more efficient, ultimately leading to savings in both time and costs. To ensure the company's waste audit is conducted correctly, it is necessary to set partial goals for the waste audit, such as:

- Assessment of compliance with national and European regulations: some businesses must demonstrate that their waste management program complies with all relevant laws and regulations prior to certification,
- Identifying opportunities for cost savings: a waste audit can identify potential ways to reduce costs associated with waste disposal, such as reducing the number of collections or switching to a more efficient transport service,
- Increase environmental value: by pinpointing potential environmental risks and assessing the impact of a company's current waste program, you can gain valuable insight into how to reduce your environmental footprint,
- Partnership or incentive requirements: government incentives and other partnerships are often tied to meeting specific waste reduction goals, such as choosing a specific type

of recycling protocol or organic composting waste. Employees and customers consistently express their desire for businesses to improve their environmental performance, leading to increased satisfaction for all parties. With these goals in mind, it is possible to move on to a review of the company's activities and policies.

4.2 Review of company activities and policies

The waste assessment should encompass an analysis of the company's current policies and activities. The expert conducting the assessment will scrutinize documents, including orders and invoices related to waste disposal. Additionally, interviews with staff will be conducted to gain insights into current practices, and site tours will be undertaken to observe operations firsthand. This section is necessary for the following reasons:

- Understanding how the business works and what types of materials are used,
- To learn various management processes such as waste storage and disposal,
- Identifying the types of waste that the company creates, where it comes from and how it is managed,
- Know the types of materials that are disposed of, reused, recycled or composted,
- Assessing waste management programs and their effectiveness, including these policies and procedures,
- Review of the total costs of the current program, including collection, disposal and recycling[17],
- Estimate the size and composition of your waste streams for future needs,
- Identifying opportunities for improvement,
- Documenting findings and proposing recommendations for changes.

Once the review is complete, we should have a detailed overview of the waste management system, which will help managers identify potential areas for improvement and set practical, achievable waste reduction targets.

[17] Environmental Benefits and Impacts. Access online: https://www.in.gov/idem/waste/environmental-benefits-and-impacts/#:~:text=IDEM%20encourages%20the%203Rs%20of,or%20reduce%20expenses%20for%20disposal (14.09.2023); Erick Brent Francisco: What is a Waste Management System. Access online: https://safetyculture.com/topics/waste-management-system/e-waste-management/ (28.09.2023); European Commission, 2015. Circular economy package - Questions and answers. Available online: http://europa.eu/rapid/press-release_MEMO-15-6204_sk.htm (14.09.2023); European Commission. A European Strategy for Plastics in a Circular Economy. Available online: https://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy-brochure.pdf (15.09.2023); European Environmental Agency. The Road From Landfilling to Recycling: Common Destination, Different Routes. EE Copenhagen, 2007. Access online: https://wedocs.unep.org/handle/20.500.11822/916 (23.10.2023).

Internal versus external waste audit

The advantages of an in-house system are that it is more affordable, you can see the process first hand and it can be a great experience for the team. For smaller offices that are just trying to get some basic data, an internal audit will probably suffice. However, it probably won't be as thorough and you won't get the expert insight and suggestions you would get from an external waste specialist.

External audit

An external audit is especially suitable for large companies that have several operations and a large number of employees. If you decide to go the external audit route, find a reputable company that is willing to work with you to find solutions tailored to your organization. For waste audits with a specific goal, it is also recommended to use the expertise of experts. Larger organizations and those generating complex waste streams can benefit from professional waste audits as they can offer an experienced team that understands the complexities of waste management, regulatory requirements and industry best practice. It is also important to have your own internal audit team as part of an external review. Corporate waste solutions are ideal for every type of business at every level. Professional waste management consultants can assess current systems and processes, identify areas for improvement, develop tailored plans and help implement them. This can save time and money in the long run and ensure compliance with local regulations.

5. Conclusion

As per the literature, there is a clear linkage between poor solid waste management and adverse health outcomes. Various groups of individuals are at risk of ill-health due to inadequate solid waste management. With urbanization and industrialization, the volume and complexity of waste generated increase. For health, environment, and economic reasons, the management of solid waste is and should be a crucial undertaking in any setting. Policies and practices in solid waste management vary widely between regions, countries, large and smaller cities, and formal and informal areas within a city. As developing countries continue to grow economically, urbanization poses a challenge to solid waste management. Municipal solid waste is not only an environmental and health challenge but also an economic resource, providing livelihoods through picking, reusing, and recycling. While all urban centers face similar solid waste management challenges, the impact varies depending on how policies and practices are implemented. Despite the high risks of exposure to solid waste,

the corresponding burden of adverse health effects and mortality is not always clear due to knowledge gaps and unclear impact assessments.

The framework clarifies many linkages but is not exhaustive due to a lack of knowledge of causal relationships. In cases where the linkages are known, the burden of the impact is not clear, including to policymakers. However, existing evidence emphasizes the need to appreciate the health risks associated with various types of solid waste, providing a strong basis for drawing attention to improving solid waste management. There is compelling evidence to show that solid waste, especially medical and other biodegradable waste, can be potential sources of pathogenic organisms such as viruses, bacteria, and fungi, requiring strict management. Waste management is crucial for environmental protection, public health, and the quality of life for future generations. Individuals can contribute to waste management by supporting initiatives and programs, and organizations can invest in recycling infrastructure, helping build a better and more sustainable future.

As for waste management and sustainability, advanced software is essential to provide desired output efficiently. Sustainable waste management practices can mitigate negative effects and contribute to a healthier and more sustainable future. Natural resources play a crucial role in the quality of our life and overall standard of living, creating wealth and jobs. However, our current level of resource consumption jeopardizes the ability to secure these resources in the future. To ensure a high quality of life and standard of living, greening our economy is necessary and should be done as soon as possible. This involves more efficient resource use and waste reduction. The economy provides tools for estimating costs and damages, proposing the inclusion of environmental issues in economic decisions. It is crucial to promote more innovations, a long-term perspective, and a more efficient way of using resources. This long-term initiative is essential for sustainable development.

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CHAPTER 3

ECOLOGICAL, ECONOMIC AND TECHNICAL ASPECTS OF THE USE OF CARS WITH ALTERNATIVE DRIVES

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The aim of the paper is to describe the most important ecological, economic and operational technical aspects of the use of cars with alternative drives and to propose their evaluation by the method of pairwise comparison, since information about alternative drives is usually presented separately or in comparison with only one other drive. The access of motor vehicle users can then be influenced by a lot of contradictory information. The conclusion of the chapter indicates the possible further development of the use of alternative drives in vehicles and the young generation's approach to motoring.

Keywords: alternative drives, ecological aspects, economic aspect, technical aspects

1. Introduction

The development of the number of manufactured and operated cars has undergone major changes in the world in recent years. While there is a noticeable decline in production in Europe and America, production in Asian countries is rising. If we focus on the countries of Central Europe and especially the V4, approximately one in three cars produced within the EU today comes from the Czech Republic, Slovakia, Poland and Hungary, followed by Romania and Slovenia. The Czech Republic ranks 2nd behind Slovakia in the number of cars produced per capita. In terms of global production, automobile companies located in the Czech Republic contribute roughly 1.4 percent to global production, Slovakia roughly 1.1 percent[18].

By far the largest producer is now China, where over 25 percent of cars are produced. It is followed by the USA and Japan. These three countries together produce half of all cars. Fourth is Germany, the top ten also includes South Korea, India, Mexico, Brazil, Spain and Canada[19]. According to research by the Bernstein institution, there could be twice as many cars in the world in the next twenty years as there are now. In Europe, the number of cars is expected to increase to 273 million cars by 2025. After that, it will start to decline

[18] Automobilový průmysl v ČR a ve světě. Access online: https://www.oneindustry.cz/elektro/automobilovy-prumysl-v-cr-a-ve-svete-2-2/ (26.10. 2023).
[19] Ibidem.

due to sharing and the advent of autonomous cars. This follows from the Digital Auto Report study by the consulting company PwC Strategy&[20].

In the Czech Republic, the automotive industry is and will continue to be, despite the problems of recent years associated with the pandemic and the import of some components and the war in Ukraine, a promising branch of the Czech economy that significantly contributes to further growth and exports. What is changing fundamentally is the use of alternative fuels and alternative drives, in order to achieve a more ecological operation of cars and less burden on the environment. The support of alternative fuels is one of the pillars of sustainable transport towards environmentally and economically more advantageous solutions. The problem is that not only the general public, but also experts and politicians argue about which of these alternative fuels or alternative drives is the most suitable and sustainable.

The vast majority of motor vehicles in operation today are powered by internal combustion engines, which still use gasoline and diesel produced from fossil fuels, in this case oil, as an energy source, even though the amount of emissions produced by burning gasoline and diesel is decreasing. This development is significantly influenced by the increasingly tougher legislative regulations of the European Union of late, especially the need for manufacturers to comply with the provisions of the applicable Euro standards, which set the limit values of exhaust exhalations[21].

There are also various modifications of vehicles powered by classic internal combustion engines that are structurally modified to burn alternative fuels, which are:

- biodiesel (FAME), bioethanol (E85),
- propane - butane (LPG),
- natural gas (CNG, LNG),
- hydrogen (H2), possibly others.

Another possibility, which can be encountered more and more often in motor vehicle drives today and is expected to develop rapidly in the coming years, is the use of electric motors. There are also several variants of arrangement and design solutions, but the most common variants of drive with electric motors are:

[20] Počet aut v Evropě vzroste na 273 milionů, pak začne klesat. Tvrdí studie. Access online: https://www.auto.cz/pocet-aut-v-evrope-vzroste-na-273-milionu-pak-zacne-klesat-tvrdi-studie-132202/(accessed: October 26, 2023).

[21] 2009/28/ES. Směrnice evropského parlamentu a Rady 2009/28/ES ze dne 23. dubna 2009 o podpoře využívání energie z obnovitelných zdrojů a o změně a následném zrušení směrnic 2001/77/ES a 2003/30/ES. Lucemburk: 2009. Access online: https://eur-lex. europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016: 0062:cs:PDF (26.10.2023).

- vehicles with a hybrid drive,
- electric cars.

Each of the above-mentioned groups of motor vehicles, divided according to the fuel used and design, of course, has its own advantages and disadvantages[22].

The issue of alternative fuels is very often addressed, from different perspectives. The problem, however, is that each manufacturer, modifier or supplier especially praises its own drive concept, and the summary results of the comparison of all types of drives are presented rather marginally, superficially, or are intentionally distorted. The access of motor vehicle users can then be influenced by a lot of contradictory information.

2. Subject and research methods

2.1. The issue of alternative drives and fuels

Currently, there is an effort to withdraw from the use of fossil fuel vehicle drives and replace them with environmentally friendly vehicles, mainly for the following reasons:

- ecological (reducing the production of SO_3, NO_x, flying dust and other dangerous pollutants),
- economic (with decreasing supplies, the price of fuel increases),
- strategic (uneven distribution of fuel stocks between individual countries or regions and high dependence on imports)[23].

Environmentally friendly vehicles can be defined as vehicles with low production of greenhouse gas emissions and other limited pollutants. Vehicles that:

- they use an alternative drive:
    - — hybrid vehicles, i.e. vehicles combining an internal combustion engine and an electric motor,
    - — electric cars, i.e. vehicles using only an electric motor for their drive;
- use alternative fuels:
    - — LPG (Liquid Petroleum Gases - liquefied petroleum gas),
    - — CNG (Compressed Nature Gas – compressed natural gas),

[22] R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*, Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023)V. Adamec, V. *Doprava, zdraví a životní prostředí.* Grada, Praha 2008. ISBN 978-80-247-2156-9, pp. 4.
[23] *Ibidem*, pp. 9.

— hydrogen,

— biofuels (especially bioethanol, biodiesel, dimethyl ether)[24].

When solving the question regarding the use of alternative fuels, it is necessary to consider a number of criteria that accompany this issue, namely:

- impact on the environment – for most alternative fuels, there is always a certain compromise between positive and negative effects, while the positive ones should prevail,
- suitability for specific climatic conditions,
- safety,
- price – purchase value and economy of operation for users, but with alternative fuels, a certain form of subsidy is often necessary,
- availability and nature of raw materials for their production,
- radius of action (range),
- sufficient infrastructure – system, technology and technique of production and distribution of alternative fuels, as well as vehicle service,
- lifetime of vehicles and components,
- production technology, which must be efficient, effective, economical and not contradict the properties of the resulting fuel,
- efficiency, which if possible should be higher than that of conventional fuels, for example even ordinary gas compression is associated with a certain additional consumption of electrical energy, which must be considered when evaluating the fuel,
- applicability – where to apply preferably (in cities) and on which vehicles (with high fuel consumption),
- structural impacts on the vehicle – this includes not only power units, but also structural materials and vehicle acquisition costs, for several reasons these acquisition costs for vehicles powered by alternative fuels are usually significantly higher,
- availability of vehicles – especially in the initial phase of the implementation of alternative fuels, they are usually not available directly from the manufacturer, they have to be modified additionally, the manufacturer then does not want to take over the warranty for the vehicle after modification,
- legislation focused on all elements of the alternative fuel system, including setting the subsidy policy,

[24] Ministerstvo životního prostředí: Alternativní paliva v dopravě. Access online: http://www.mzp.cz/cz/alternativni_paliva_doprave (26.10.2023).

- creation of appropriate standards,
- coping with various lobbying pressures – it concerns not only politicians, but also, for example, operators on the fuel market, who may support the introduction of alternative fuels or, on the contrary, see them as a threat to existing trade,
- timing – for example, there are very different opinions about the appropriate period for the introduction of the hydrogen economy, it is also related to a certain impatience of governments to make ecological decisions regardless of the actual state of development of specific alternative fuels,
- marketing – estimation of users' abilities and willingness to purchase alternative fuel vehicles[25].

From these criteria, the most important criteria will be selected on the basis of theoretical starting points, the study of professional publications and also on the basis of experience, and in the following third subsection, an evaluation table will be compiled, where the criteria will be evaluated using the multi-criteria evaluation method.

2.2. Methods of researching the issue

Given that a relatively large part of the information presented is of a nature that does not allow clear conclusions to be drawn directly, research methods such as analysis will be used in the work, which will analyse the advantages and disadvantages of individual alternative drives and alternative fuels in their use, look for contradictory tendencies and separates material findings from non-material ones. Furthermore, synthesis, which allows combining the knowledge previously obtained through an analytical approach into a single whole, induction, which draws general conclusions based on all previously processed knowledge, deduction – based on already known and generally valid (verified) conclusions and enables their subsequent application to cases not yet investigated.

And above all, for the evaluation of individual variants, the methods of multi-criteria evaluation of variants will be used, namely Fuller's method or the method of pairwise comparison, because when applying it, weights are compiled using the so-called Fuller's triangle. With a larger number of criteria, it is advantageous to always compare only two criteria, which makes it easier to decide which is more important. The principle of pairwise comparison is that we always compare two criteria. For greater clarity when comparing, we compile the so-called Fuller's triangle. A triangle always has k–1 double line. In the first

[25] Magicacustic.cz: Co jsou alternativní paliva. Access online: https://www.magicacustic.cz/ alternativni-motorova-paliva/co-jsou-alternativni-paliva/ (26.10.2023).

line there are all combinations for comparison with the first criterion, in the second there are combinations for comparison with the second criterion, except for the one in the previous line, in each subsequent line there are combinations for comparison with the next criteria that are not in the previous lines. So each row has 1 member less than the previous row[26].

3. Results of comparing technical, ecological and economic criteria of alternative fuels

3.1. Ecological evaluation of alternative fuels

One of the main arguments for using alternative motor fuels is environmental reasons. The effects of the operation of classic car concepts on the air are relatively well known these days, including their consequences for human health and ecosystems. As far as alternative transport concepts are concerned, their impacts in operation will be clearly lower, with essentially no emissions in the case of electric motors and fuel cells. However, an increase in emissions during the production of individual concepts or the fuels they use can be a problem, especially with regard to the increase in the technical complexity of production[27].

When using alternative fuels in industrial transport according to the chosen drive, zero emissions of harmful substances and other ecological impacts, it is necessary to proceed according to the valid LCA (Life-Cycle Assessment) methodology, i.e. the life cycle assessment method, i.e. production of resources, production of fuel, its distribution to the consumer up to the stage of its consumption in the vehicle[28].

A simplified form of LCA called "well-to-wheels" analysis is used as the most appropriate tool for finding answers to questions about the environmental impact of fuels and biofuels. This is a specific type of LCA analysis, which is often used in connection with the evaluation of the impacts of fuels in the transport sector and various modes of transport, possibly types of vehicles and their drives. The analysis is usually divided into two basic parts – the first "from source to tank" (WTT – Well to Tank) – the second "from tank to wheels" (TTW – Tank to Wheels). Both of these parts then include the entire life cycle of vol. "from source to wheels" (WTW – Well to Wheels). The first of them evaluates the fuel from the extraction of basic raw

[26] R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*, Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023), pp. 81-82.

[27] Communication from the Commission to the European Council and the European Parliament - an energy policy for Europe {SEC(2007) 12}. EUR – Lex. Access online: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52007DC000 (26.10.2023).

[28] Ministerstvo životního prostředí: Alternativní paliva v dopravě. Access online: http://www.mzp.cz/cz/alternativni_paliva_doprave (26.10.2023).

materials through the entire processing chain to its delivery to the vehicle, or means of transport. The second part evaluates the actual use of fuel. Impacts are usually expressed in relation to the global warming impact category as CO_2 equivalents[29].

Alternative gaseous and liquid fuels, in comparison to classic petroleum-based fuels – gasoline and diesel fuel, generally represent a smaller burden on the air in the final phase of their consumption in the vehicle (TTW) both in terms of greenhouse gas (GHG) emissions and other inorganic and organic pollutants contained in the exhaust gases of combustion engines – carbon monoxide (CO), nitrogen oxides (NOx), total hydrocarbons (HC), particles (PM) and minor organic compounds with high risk potential (polyaromatic hydrocarbons, aldehydes, alkenes). The advantage of alternative gaseous fuels is the fact that they do not represent any burden on water resources and soil. Some liquid alternative fuels based on plant sources – biodiesel, bioethanol – have the advantage of better biological degradability compared to classic liquid motor fuels, gasoline and diesel. When assessing the environmental benefits of using alternative fuels, it is not enough to assess only the final phase of their consumption in vehicles (TTW), the entire "life cycle" including the previous phases, i.e. resource production, fuel production and its distribution to the consumer, and the final vehicle use (WTW). The production of almost every type of alternative fuel uses more or less energy from non-renewable sources. These are mainly electrical energy and motor fuels used in agriculture and transport. Therefore, only a comprehensive analysis is objective, which allows considering the fact that in some cases the production phase can be so ecologically and energetically demanding that the positive effect of the final fuel consumption in the vehicle (e.g. hydrogen) is completely negated in the overall balance. A comprehensive assessment of the impact of fuel on the environment (LCA – Life Cycle Assessment) is currently the subject of activity of a number of research workplaces worldwide. This is a very complex issue requiring the analysis of a large amount of various input data from a number of sectors of the national economy (agriculture, raw material extraction, energy, chemical industry, automotive industry, economy)[30].

The findings gained so far in solving this problem can be summarized in the following points:

- The key role in the production of GHG emissions and energy consumption is played not only by the nature of the motor fuel and its production method, but also by the efficiency

[29] V. Kočí, *Posuzování životního cyklu: Life Cycle Assessment - LCA*. Vodní zdroje - Ekomonitor, Chrudim 2009. ISBN 978-80-86832-42-5, pp. 263.

[30] Technicko-ekonomická analýza vhodných alternativních paliv v dopravě. Biom.cz. Access online:http://biom.cz/upload/6e01d6d4c4835ec93cda508772f3bf6e/technickoekonomicka_analyza_vhodnych_alternativnich_paliv_v_doprave.pdf. (26.10.2023).

of the drive unit in the vehicle. From a comparison of the production of alternative fuels based on targeted agricultural crops or the processing of waste biomass and wood, the balance of GHG gases is significantly more favorable for the second of the listed variants. The alternative of motor fuels from renewable sources can bring a significant reduction in GHG emissions, but generally at the cost of greater energy demands for their production and distribution.

- The positive balance of GHG gases when using liquid biofuels is not entirely clear-cut, due to difficult-to-quantify nitrogen oxide (N_2O) emissions from agricultural production (use of nitrogen fertilizers). Due to the growing consumption of motor fuels, the possibilities of using agricultural production for the production of liquid alternative fuels are limited on a pan-European scale. The potential of raw material sources for the production of alternative liquid fuels will therefore need to be extended to waste biomass or biomass from targeted uncultivated areas (straw, wood pulp, waste from paper production), the use of less valuable raw materials will also improve the economics of liquid biofuel production.
- The shift from fossil fuels to alternative fuels from renewable sources is currently very financially demanding. Reducing GHG emissions always results in increased costs. However, higher costs do not automatically mean greater reductions in GHG emissions. It can be generally stated that for practically all alternative motor fuels, with the exception of natural gas and LPG, the phase preceding their final consumption is very energy intensive. The energy consumption in the chain from mining to the transport of fuel to the vehicle tank (WTT) in the best case corresponds to the own usable energy content of the alternative fuel (synthetic liquid fuel, DME, hydrogen produced from natural gas or biomass), but in most cases the own usable energy content the fuel content exceeds 1.5 to 5 times (bioethanol, biodiesel, electrolytic hydrogen). It is confirmed that the energy contained in biomass or natural resources is very poorly concentrated and a larger part of the usable energy potential of renewable sources must be reserved for the production of alternative fuels and will not be able to be used effectively in the final consumption phase[31].

[31] R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*. Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023), pp. 53-59.

- As far as electric cars are concerned from an ecological point of view, they do not produce any exhalations during their operation and therefore do not burden the environment in this life cycle. However, it is necessary to consider the methods of producing electrical energy itself, the methods of storing it in cars in the form of large and heavy drive batteries, the production of which again means a significant consumption of energy and mineral resources, their extraction and processing with many risks and impacts on the environment, and last but not least also, for example, methods of ecological disposal of these batteries[32].

3.2. Economic assessment of the use of alternative fuels

The overall economy plays a big role in the development of the use of alternative fuels in transport, both the investment and operational demands of vehicles and the economics of gas stations. With high utilization of filling stations, it is possible to offer the customer a more favorable price for alternative fuels, which, assuming high utilization of vehicles, improves the return on funds invested in the purchase of a vehicle with an alternative drive.

Similar to the comparison of vehicles with different drive units in terms of ecology, or their impact on the environment, it is also very difficult to compare the advantages of these drives from the point of view of economy of operation. Anyone considering operating a vehicle (natural person) or vehicle (legal entity) powered by alternative fuels should be aware of what will affect the total operating costs and, as a result, the return on investment.

On the one hand, it is of course necessary to consider the consumption of which "fuel" to drive the chosen specific kilometer distance and the selling price of the fuel, which reflects a number of factors, the basic of which is certainly the cost of production and will depend on the type of fuel used[33].

The production price of most alternative fuels is higher than the price of an energetically comparable quantity of conventional liquid motor fuels of petroleum origin, despite the high current price of oil. The only exceptions are natural gas, bioethanol made from waste straw and also compressed hydrogen from the gasification of wood. Electrolytic hydrogen is the most expensive to produce. At lower prices of petroleum raw materials, it is necessary to favor alternative fuels in terms of price or tax[34].

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[32] V. Kočí, *Posuzování životního cyklu: Life Cycle Assessment -LCA*, Vodní zdroje Ekomonitor, Chrudim 2009. ISBN 978-80-86832-42-5, pp. 263.
[33] Price charts. Gasbuddy. Access online: http://www.gasbuddy.com/Charts. (26.10.2023).
[34] R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*. Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta

Another fact that will significantly affect the return on future investment is the purchase price of the vehicle, or rather the difference in the price of a vehicle with a classic drive and a vehicle with an alternative drive. It is not important whether, for example, gas-burning vehicles (LPG, CNG, etc.) are a vehicle supplied directly by the manufacturer or an additional conversion of a vehicle originally with conventional fuel combustion technology. In vehicles powered by electric energy, i.e. pure electric cars or hybrids, various types of drive batteries (accumulators) are used to store electric energy, which have a limited lifespan given the number of possible charge cycles. It is therefore likely that during the planned life of the car, which is kilometers longer than the life of the batteries themselves, the owner will have to count on their replacement, which represents a significant expense at current prices. The prices of service work are also directly related to the drive technology used, when a different price per normal hour of work can be assumed according to the difficulty of the work performed and also, for example, according to the requirements for the expertise of the service technician according to the manufacturer's regulations or valid standards and laws[35].

In addition to fuel prices, i.e. the energy required to operate the vehicle according to the selected drive unit, the purchase price of the vehicle and the costs of service and spare parts, a number of other factors can affect the resulting costs. Probably the most important thing is probably the state's willingness and ability to participate in the use of alternative fuels in the operation of motor vehicles and then, of course, the amount of such support. This can be provided, for example, in the form of lower or zero road tax for vehicles that meet the set rules, price support for selected alternative fuels in the form of lower consumption tax and other incentives, including subsidies for the purchase of a vehicle[36].

3.3. Technical, ecological and economic prerequisites for the application of alternative drives

The individual technical and structural solutions of vehicles with alternative drives and the specifics of the alternative fuels used today, respectively the types of energy, are so different that it is very difficult to compare them overall and say which of the alternative drives is the most advantageous.

On the basis of theoretical starting points, the study of professional publications and also on the basis of experience, an evaluation table is compiled that compares alternative fuels on the basis of technical – operational, economic and ecological criteria. The compared

metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023), pp. 68-74.

[35] *Ibidem*, pp. 68-74.

[36] *Ibidem*, pp. 68-74.

alternative fuels included gas fuels CNG and LPG, from biofuels - biodiesel and bioethanol, as well as vegetable oils, electricity and diesel with gasoline.

Some of the criteria listed in subsection 2.1., which need to be considered when solving the question regarding the use of alternative fuels, overlap with each other, so the 10 most important criteria were selected, and others will be discussed as part of the discussion of the results.

The evaluation criteria were divided into technical, economic and ecological. The technical criteria include parameters such as: number of gas stations, fuel storage issues, possibility of parking in garages, traffic safety, possibility of conversion, driving distance and performance. The price of the car was monitored in the economic criteria, and fuel production and emissions in the ecological criteria.

For clarity, these criteria were divided into two Tables 1 and 2, where the textual results of alternative fuels in individual criteria are presented[37].

Since the mentioned criteria are not equally important for the comparison, the weight of these criteria was determined by Fuller's method, i.e. the method of pairwise comparison, because when applying it, we compile the weights using the so-called Fuller's triangle. The comparison is shown in Table 3.

The individual numbers in the table are assigned statements related to the criteria in the previous Tables 1 and 2. Thus, under the numerical designation:

- 1 is the criterion: Gas station,
- 2 is the criterion: Fuel storage,
- 3 is the criterion: Parking in garages,
- 4 is the criterion: Fuel production,
- 5 is the criterion: Traffic safety,
- 6 is the criterion: Can be remodelled,
- 7 is the criterion: Price of the car,
- 8 is the criterion: Driving distance,
- 9 is the criterion: Performance,
- 10 is the criterion: Emissions.

[37] R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*. Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023), pp. 79-83.

Table 1. Evaluation criteria related to traffic

	Gas stations	**Fuel storage**	**Parking in garages**	**Fuel production**	**Safety of operation**
Benzine	Widely available	It does not require special conditions	Yes	It is obtained by fractional distillation of crude oil	Safe operation
Oil	Widely available	It does not require special conditions	Yes	It is obtained by distillation and refining of crude oil	Safe operation
Electricity	Limited	Cast iron batteries	Yes	Lithium production - high energy demand	Safe operation
CNG	Limited	Pressure cylinders	No parking in some garages	Dependence on natural gas supplies and its price	Safe operation
LPG	A large number	Pressure cylinders	No	Dependence on oil supply and its price	Less safe operation
Bioethanol	Widely available	It does not require any special storage conditions	Yes	Energy intensity of the entire production process	Safe operation
Biodiesel	Very limited availability	It does not require any special storage conditions	Yes	Energy intensity of the entire production process	Safe operation
Vegetable oils	Very limited availability	It does not require any special storage conditions	Yes	Commonly available	Less safe operation

Source: R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*. Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023), pp. 83-84

Table 2. Other evaluation criteria

	Can be remodeled	**The price of the car**	**Driving distance**	**Performance**	**Emission**
Benzine	x	Default	500-1000 km	Default	Default
Oil	x	Comparable	Comparable or slightly longer	Comparable	Higher emissions
Electricity	Exceptionally, very expensive conversion	High price of the vehicle	Low 200-300 km	Slightly reduced performance	None
CNG	Yes	Comparable to diesel engines	Comparable up to 1,000 km	Performance similar to a diesel engine	Low emissions
LPG	Yes	Conversion from gasoline engines, price approx. 1,000 EUR	Lower	Reduction of car performance	Lower emissions
Bioethanol	Yes	Can be rebuilt, price approx. 1,000 EUR	300-500 km	Increased performance	It burns better during the combustion process
Biodiesel	No	They can only use specified engine types	Comparable to default	Increased performance	It burns better during the combustion process
Vegetable oils	Yes	Can be rebuilt, price approx. 1,000 EUR	Comparable to diesel	Performance reduction	According to the engine design

Source: R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*. Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023), pp. 83-84

After performing the paired evaluation, the weight of the individual criteria was calculated and it is listed under the given criterion in Table 3. The criterion with the greatest weight is emissions, while fuel storage and parking in garages received the least weight. Subsequently, it was necessary to compare the fuels with each other not only textually, but also quantitatively. Therefore, a point scale from 1 to 10 points was proposed for each criterion. When one is the least points and ten is the most points. Thus, the text statements were converted into a numbered form through positive or negative impact.

The result is the sum of the points (score) of the individual fuels in relation to the weight of the criterion and the points it received for the given criterion. The point rating is shown in Table 4.

Table 3. Method of pairwise comparison of criteria (Fuller's method)

Criterion	1	2	3	4	5	6	7	8	9	10	Frequency	Weight in %
1		1	1	1.4	1.5	6	1.7	1.8	1.9	10.00	4.5	10
2			2.3	4	2.5	2.6	7	8	9	10.00	1.5	3
3				4	3.5	3.6	7	8	9	10.00	1.5	3
4					4	4.5	4.7	4.8	4.9	4.10	6.0	13
5						5.6	5.7	5.8	5.9	10.00	4.0	9
6							6.7	6.8	6.9	6.10	5.0	10
7								7.8	7.9	7.10	5.5	12
8									8.9	10.00	5.0	11
9										9.10	5.5	12
10											7.0	16
Total											45.0	100

Source: R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*. Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023), pp. 83-84

Table 4. Evaluation of technical, ecological and economic criteria of alternative fuels

Statement	1	2	3	4	5	6	7	8	9	10	Score
Weight in %	10	3	3	13	9	10	12	11	12	16	-
Benzine	10	9	10	3	10	8	9	9	10	3	7.5
Oil	10	9	10	2	10	8	8	10	9	2	7.1
Electricity	3	5	10	1	10	6	2	2	6	10	5.2
CNG	6	8	5	9	10	10	10	10	9	10	9.1
LPG	8	8	1	5	2	10	6	5	6	8	6.2
Bioethanol	7	8	10	4	10	10	8	9	10	9	8.3
Biodiesel	2	8	10	4	10	5	3	9	10	7	6.7
Vegetable oils	3	8	10	7	2	8	5	5	6	10	5.8

Source: R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*. Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023), pp. 83-84.

Based on the result of the pairwise comparison shown in Table 4, it can be stated that the alternative fuel CNG (natural gas) got the best rating, which received 9.1. Electricity and vegetable oils are the worst. The primacy of CNG is due not only to the positive effect on the environment and the associated emissions, but also to the favourable fuel price, operational safety, easy conversion, range and also the price of the car. Electricity fared the worst mainly because of the price of cars, driving distance and fuel production, which also includes the production and disposal of fuel cells themselves.

It should be added that the technical criteria are likely to differ greatly between individual types of cars, therefore it is advisable to focus on specific car models for a more detailed investigation[38].

4. Discussion

Based on the facts described in the previous subsections, it is evident that determining the degree of advantage of individual alternative drives and alternative fuels is very difficult. An example could be vehicles powered by electricity, which have been much discussed and publicly supported recently. While the price of electricity for the operation of an electric car is high despite its growth and the large price difference caused by power supply options, the overall cycle of producing batteries and electricity itself is energetically and ecologically very demanding.

Even when evaluating natural gas as the most advantageous fuel, there can be a lot of questions. The economic advantage of the drive, or the amount of savings resulting from the use of alternative fuels will vary over time and will depend mainly on the difference between the resulting market prices of so-called conventional fuels and alternative fuels.

To compare the operating costs of vehicles with different types of fuel, for example, information on the energy content of fuels can be used. If we compare natural gas with conventional fuels, it is generally true that 1 kg of CNG contains as much energy as is contained in 1.5 litters of gasoline or 1.3 litters of diesel. Opinions were commonly presented that using CNG can save up to 50% compared to gasoline and 35% for diesel fuel costs. It is clear, however, that with the currently changing global price of conventional fuels

[38] R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*. Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023), pp. 83-84.

and CNG, these differences no longer apply. While in 2019 the price of a kilogram of CNG at gas stations was around 20 crowns, today the average is much higher [39].

The development of energy and fuel prices was very turbulent in 2021 and was affected by many factors (the COVID-19 pandemic, speculation with emission allowances, decommissioning of nuclear power plants in Europe, unfavourable climatic conditions for power plants powered by renewable sources). This trend continues in the following years, when the main cause is the war in Ukraine and other events. Prices that had been stable for a long time reached previously unimaginable values. This is mainly due to the tension due to the Russian invasion of Ukraine. Russia, which is currently throttling gas supplies and whose future is uncertain to say the least, is the main supplier of natural gas to the EU. Therefore, determining the amount for any fuel is very theoretical today. When using a car, it will largely depend on the user's preferences. The very purchase of a CNG-powered car is comparable to the purchase of a conventionally powered car. Any reconstruction is also not financially demanding.

The ecological advantages of natural gas in transport result from its composition, especially the ratio of carbon and hydrogen atoms in the molecule. Natural gas consists of approximately 98% methane CH_4 with a favourable ratio of C:H = 1:4. It is not a classic alternative fuel, but its combustion has only a minimal impact on the environment and thus meets the current legislative requirements according to the Euro 6 specification. Natural gas is approximately 98% methane CH_4, which is a guarantee of zero production of sulphur dioxide (SO_2), a significant reduction in emissions of solid particles, a significant reduction in the content of hydrocarbons (H_xC_x), carbon monoxide (CO), nitrogen oxide (NO_x) and carbon dioxide (CO_2), which significantly contributes to the formation of the greenhouse effect.

Natural gas vehicles produce significantly less pollutants than vehicles with a conventional drive. This applies mainly to commonly monitored pollutants (nitrogen oxides NOx, carbon monoxide CO, carbon dioxide CO_2, and solid particles PM), but also to other health and ecologically risky hydrocarbons – emissions from the combustion of natural gas are clearly more acceptable than emissions from the combustion of automobile fuel gasoline, due to the lower content of aromatics, including benzene and unsaturated hydrocarbons with a high potential for the formation of photo-oxidative smog and ground-level ozone.

[39] R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*. Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023), pp. 87.

The production of emissions of volatile aldehydes and carcinogenic polyaromatic hydrocarbons is also significantly reduced.

When using natural gas, there is no loss of fuel, which is produced by evaporation during operation and refueling of liquid fuels. With natural gas, there is no risk of soil and groundwater contamination in accidents caused by fuel leaks.

Also, the influence on the greenhouse effect is lower for natural gas vehicles (compared to diesel or gasoline, it offers the potential for a 20-25% reduction in carbon dioxide emissions). The advantage of natural gas is its lower potential for the formation of photo-oxidation smog.

When comparing the technical operational criteria, the smaller gas station network is a significant disadvantage, however, it has grown considerably in recent years and due to sufficient driving distance, this risk can be reduced[40].

5. Conclusion

Comparing the technical, economic and ecological aspects of alternative drives and alternative fuels is very complex. If we look at it from the user's point of view, whether a natural person or a business entity, the most important aspect will be the economic criteria associated with the purchase of a car and its operation, as well as technical criteria such as performance, driving distance, the possibility of trouble-free refueling or recharging battery and of course safety. These criteria are not in line with ecological criteria, where the intervention and support of individual states will always be needed.

It is obvious that the use of alternative drives with the use of appropriate types of fuels or energies must be governed by fixed rules and it is not possible to leave everything solely to the immediate market demand, or to the activities of various groups exclusively promoting their own economic interests. These rules must be based on a thorough examination of the issue in its entirety and not try to highlight only the advantages of a specific solution, but also establish all the ensuing risks and, subsequently, ways of solving them.

It cannot be assumed that new possibilities of using alternative fuels to drive motor vehicles would be able to establish themselves in transport, especially if they mean increased costs for the acquisition of such a vehicle and the owner would not be sure that the funds spent in this way will be returned to him in lower fuel prices, which will for example, tax-advantaged.

[40] R. Šnita, *Technicko-ekonomické a ekologické aspekty využívání alternativních pohonů motorových vozidel v hutním podniku*. Vysoká škola báňská - Technická univerzita Ostrava, Ostrava 2017, Dissertation work, Fakulta metalurgie a materiálového inženýrství, Doc. Ing. Vozňáková Iveta, Ph.D. Online access: http://hdl.handle.net/10084/122042. (accessed: October 26, 2023), pp. 87-88.

The rules in the area of fuel use cannot be set by individual countries within the EU by themselves. The entire process of supporting the use of alternative fuels in transport on the European continent was taken over by the European Union at the end of the 20th century, the European Parliament and the European Commission began to adopt a number of legislative measures as early as 1993. This European legislation is then followed up in individual countries by various ways of supporting alternative fuels in transport, ranging from the reduction of consumption taxes on "ecological" fuels, financial support for the purchase of vehicles with reduced production of emissions or perhaps the support of mass transport with "clean" vehicles.

Recommendations and directives, as well as national government documents, are only one part of legislative documents. The second part, and even more important from the point of view of operating vehicles powered by alternative fuels, are technical standards, technical rules, laws, their implementing decrees and the like. Their implementation, and especially their observance, should be a guarantee that the necessary equipment will not only be safely designed, manufactured and built, but also safely operated in accordance with these regulations[41].

The current increase in energy prices and especially their availability and legislative requirements can significantly affect the economic comparison of an electric car and a car with a classic drive and other alternative drives.

It can be stated that electromobility supported by the European Union certainly has a future and it makes sense to deal with it. Many countries are already investing heavily in charging infrastructure, or are already preparing for a permanent transition to pure electric mobility. In the Czech Republic, however, this trend is not nearly as fast, and the most serious reason for car users is primarily the cost of acquisition and the short driving distance.

Unlike some other European countries, state support for the purchase of a vehicle with an alternative drive in the Czech Republic is not currently intended for natural persons. Likewise, the Ministry of the Environment does not yet provide subsidies for electric cars for companies or subsidies for electric cars for entrepreneurs. Currently, only self-government entities and some state organizations can apply for a contribution.

In the future, a new project should be launched to support clean mobility, where finance will be drawn from the Modernization Fund of the Czech Republic[42]. This should no longer

[41] 2009/28/ES. Směrnice evropského parlamentu a Rady 2009/28/ES ze dne 23. dubna 2009 o podpoře využívání energie z obnovitelných zdrojů a o změně a následném zrušení směrnic 2001/77/ES a 2003/30/ES. Lucemburk: 2009. Access online: https://eur-lex. europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016: 0062:cs:PDF (26.10.2023).

[42] Ministerstvo životního prostředí: Modernizační fond. Access online: https://www.mzp.cz/ cz/modernizacni_fond (26.10.2023).

be intended only for the public sector, but companies and individuals will probably also be able to apply for support. In addition, carsharing should also be supported as part of this challenge, which can greatly influence the approach to using cars in the future.

Last but not least, in the future it will depend primarily on the approach of the emerging young generation (Generation Z) to the topic of nature protection, for which it is a priority. According to the current World Economic Forum 2022 study, almost a third of the young generation is changing their consumer behavior in favor of companies with a positive impact on the environment. Young people are supporters of sharing means of transport – a car or bicycle with more people for more efficient use. They also often prefer those car-sharing providers that support green drives. In shared cars, hybrid drives are often used, which are the most ecological option in addition to electric cars, but also offer a certain range compared to electric cars[43].

Acknowledgements

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[43] Obnovitelně.cz. Access online: https://www.obnovitelne.cz/clanek/2030/mladi-davaji-prednost-zelene-doprave-a-trendem-je-pro-ne-i-udrzitelna-moda (26.10.2023).

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CHAPTER 4

PRO-ENVIRONMENTAL BEHAVIOUR OF HUNGARIAN COMPANIES IN THE ELECTROMECHANICAL INDUSTRY

Szabolcs NAGY, Gabriella METSZŐSY, Krisztina VARGA, László MOLNÁR

One of the causes of environmental problems is unsustainable business operations, particularly evident in companies operating within the Visegrad countries. In 2023, a questionnaire survey was conducted across four countries to explore, among other aspects, the characteristics of pro-environmental behavior in companies within the electromechanical industry in these nations. This chapter focuses on presenting the results for Hungary. Our research findings suggest that Hungarian companies do not engage in sustainable practices. The primary reason for this is the lack of resources and the higher costs associated with sustainable operations.

Keywords: pro-environmental behaviour, company, Hungary, electromechanical industry

1. Introduction and literature review

Today we live in the age of global environmental challenges. These worldwide environmental problems such as climate change, biodiversity loss, air pollution, etc. and their impacts are becoming more and more visible to everyone[1]. Environmental problems give rise to social and economic problems. And social and economic problems can backfire on environmental problems, amplifying them[2],[3]. We distinguish between three causes of environmental problems. The first is the government, the second is consumers and the third is businesses[4]. Environmental damage can result from the residues of the production process of products manufactured by companies, as well as from the residues of final products not consumed by consumers[5]. The role of companies in causing environmental problems

[1] D. Robinson, The Biggest Environmental Problems of 2021. Earth.Org. Access online: https://earth.org/the-biggest-environmental-problems-of-our-lifetime/ (10.10.2023).
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[5] R. Woodard, *Waste management in Small and Medium Enterprises (SMEs) – A barrier to developing circular cities*, Waste Management, 2020, 118, 369–379. DOI: https://doi.org/10.1016/j.wasman.2020.08.042

is indisputable[6]. This is particularly true for the Visegrad Group countries, which have never been on a sustainable development path[7]. Accounting for 99% of the total number of enterprises in the EU, SMEs are a dominant sector in the EU[8].

This makes it essential to examine the environmental performance of companies, especially SMEs in countries of the Visegrad Group and this project aims to fill this research gap. In this chapter, research findings on the environmental behavior of Hungarian companies are presented.

2. Research methodology

An online survey was conducted in 2023 in the Visegrad Group countries as part of the project entitled Qualitative-Environmental Aspects of Products Improvement (IVF 22230264), financed by the International Visegrad Fund. The aim of the research is to compare the current approach of the electromechanical industry companies in the V4 countries (Poland, Czech Republic, Hungary and Slovakia) with the approach of their customers or potential customers in the field of pro-environmental product quality management. In Hungary we received 94 responses from more than 300 companies.

In this chapter we analyzed the following closed-ended questions that are specifically related to pro-environmental behavior of companies:

- Q14: What is the degree of customers' expectations which have an impact on the pro-environmental improvement of products? Measured on a 5-point-scale from very low (1) to very high (5),
- Q15: How often actions to compare competing products in terms of their environmental impact are taken in the enterprise? Measured on a multiple choice closed ended question,
- Q16: To what extent do you agree with the following statements related to attitudes towards pro-environmental behavior of companies? Measured on a 5-point Likert-scale,

[6] Q. Zhang, Y. Ma, *The impact of environmental management on firm economic performance: The mediating effect of green innovation and the moderating effect of environmental leadership*, Journal of Cleaner Production, 2021, 292, 126057. DOI: https://doi.org/10.1016/j.jclepro.2021.126057

[7] S. Gałaś, A. Gałaś, M. Zeleňáková, L. Zvijáková, J. Fialová, H. Kubíčková, *Environmental Impact Assessment in the Visegrad Group Countries*, "Environ Impact Assess Rev", 2015, 55, 11–20. doi:10.1016/j.eiar.2015.06.006.

[8] A. Pinget, R. Bocquet, C. Mothe, *Barriers to Environmental Innovation in SMEs: Empirical Evidence from French Firms*, M@n@gement, 2015, 18(2), 132. DOI: https://doi.org/10.3917/mana.182.0132; C. Henriques, C. Viseu, M. Neves, A. Amaro, M Gouveia M., Trigo A., *How Efficiently Does the EU Support Research and Innovation in SMEs?* Journal of Open Innovation: Technology, Market and Complexity, 2022, 8(2),92. https://doi.org/10.3390/joitmc802009

- Q17.1. To what extent do you agree with the statements regarding the enterprise's activities? We are not interested in environmental problems. Measured on a 5-point Likert-scale,
- Q17.2. To what extent do you agree with the statements regarding the enterprise's activities? We are aware and have up-to-date knowledge of the impact of the enterprise on the environment (including the impact of the industry in which we operate). Measured on a 5-point Likert-scale,
- Q17.3. To what extent do you agree with the statements regarding the enterprise's activities? We take actions referring to the impact of our activities on the environment. Measured on a 5-point Likert-scale,
- Q17.4. We pay attention to the environmental issue in the following areas. Measured on a 5-point Likert-scale,
- Q17.5. Pro-environmental activities in our industry are important for. Measured on a 5-point Likert-scale,
- Q18. Which measures of environmental performance are used in your company? Measured on a multi select multiple choice question,
- Q19. Is the enterprise planning investment in pro-ecological solutions in the next three years? Measured on a dichotomous question (yes or no),
- Q20. What pro-environmental activities does your company implement? Measured on a multi select multiple choice question,
- Q21. What principles are used in the process of pro-ecological product design taking into account the product life cycle (LCA)? Measured on a multi select multiple choice question,
- Q23. Why do you not intend to invest in pro-ecological solutions? Indicate all that apply. Measured on a multi select multiple choice question,
- Q24. How do you assess the level of restrictiveness of legal regulations related to environmental protection in your country? Measured on a single select multiple-choice question,
- Q42. Imagine a hypothetical situation that the company has the funds for any pro-environmental investment. If so, what would the company invest in? Please indicate 5 the most important investments. Measured on a multi select multiple choice question.

3. Results and discussion

This chapter presents the research results of the survey related to the pro-environmental behavior of Hungarian manufacturing companies in the electromechanical industry.

As shown in Table 1, the level of perceived customer expectations regarding the environmental improvement of products is only average (mean=3.02). Approximately 20% of the companies experienced strong customer demand related to the environmental improvement of products.

Table 1. The degree of customers' expectations which have an impact on the pro-environmental improvement of products (Q14)

Answer	N	%
1 – very low	4	4.3%
2 – low	17	18.1%
3 – average	53	56.4%
4 – high	13	13.8%
5 – very high	7	7.4%
Total	94	100.0%

Source: own study.

One quarters (25.5%) of the companies have taken no actions to compare competing products in terms of their environmental impact (Table 2). It means, however, around three quarters of companies reported taking some kind of action in this area. As far as the frequency of the actions concerned, 16.0% of the companies reported actions less than once every three years, 11.7% once every two to three years, 33.0% once a year and 13.8% more than once year.

Table 2. How often actions to compare competing products in terms of their environmental impact are taken in the enterprise (Q15)

Answer	N	%
1 – they are not taken	24	25.5%
2 – less than once every three years	15	16.0%
3 – once every two to three years	11	11.7%
4 – once a year	31	33.0%
5 – more than once year	13	13.8%
Total	94	100.0%

Source: own study.

Attitudes towards pro-ecological products and actions were measured on a 5 scale Likert scale, where 1 means ‘I totally don't agree’ and 5 means ‘I totally agree’. Means were calculated to find out which statements respondents agree with the most and which statements they agree with the least. Figure 1 summarizes our research findings.

As shown in Figure 1, respondents mostly agreed with the statement that pro-ecological products have higher price (4.29), and the higher price of pro-ecological products significantly discourages customers from buying them (4.28). Our research results suggest that customers in this industry are price sensitive. However, respondents agreed that choosing a pro-ecological product can improve a customer's self-esteem (3.73), which may contribute to a stronger brand image. In their opinion, wealthy customers usually choose pro-ecological products (3.64), which suggests that greener products are more expensive.

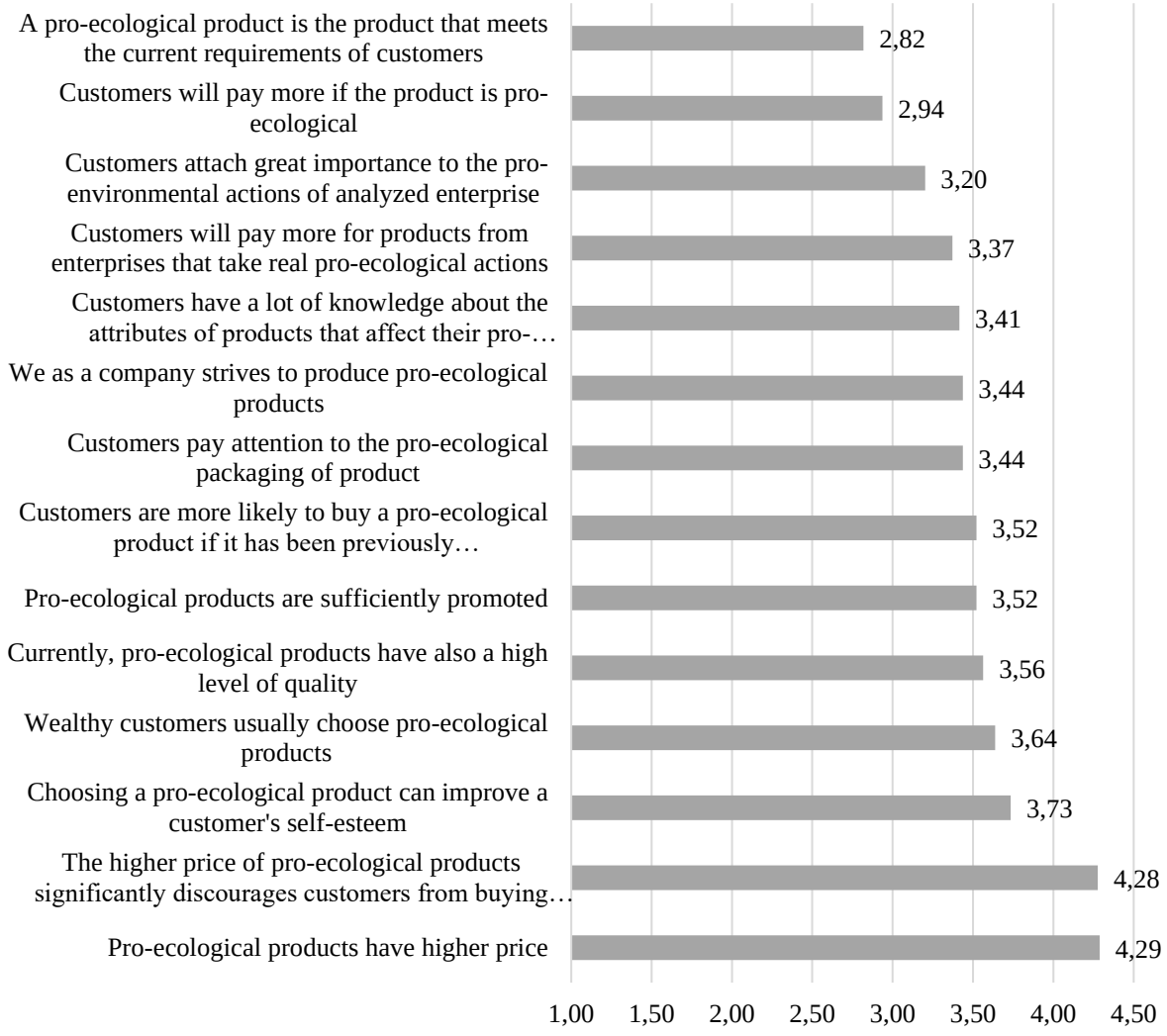

Figure 1. Attitudes towards pro-ecological products and actions (means, N=94), Q16
Source: own study.

As far as the relationship between the quality and the pro-ecological attributes of a product concerned, companies basically agreed that pro-ecological products have also a high level of quality (3.56). We also found that pro-ecological products are sufficiently promoted (3.52),

and customers are more likely to buy a pro-ecological product if it has been previously recommended/tested (3.52). It is also more common that customers pay attention to the pro-ecological packaging of the product (3.44) and that the responding companies strive to produce pro-ecological products (3.44).

In fact, there is a need for several awareness-raising campaigns among customers in this sector, as they do not have much knowledge about the characteristics of products that influence their pro-ecological characteristics (3.4). Companies are not very convinced that their customers would pay more for products from enterprises that take real pro-ecological actions (3.37). Also, they think that their customers do not attach great importance to their pro-environmental actions.

Hungarian companies rather disagree with the statements that ‘customers will pay more if the product is pro-ecological’ (2.94) and ‘a pro-ecological product is the product that meets the current requirements of customers’ (2.82), which implies that the more expensive pro-ecological products are not too attractive in the price sensitive Hungarian market where inflation skyrocketed in the past 12 months.

As Table 3 shows, the majority of companies (68.1%) were found to be somewhat interested in environmental issues. Only a small proportion (3.2%) of the companies, the dark browns, stated that they were not interested at all in environmental problems related to their activities. In total, 31.9% somewhat agreed with the statement 'We are not interested in environmental problems'.

Table 3. To what extent do you agree with the statements regarding the enterprise's activities?
We are not interested in environmental problems (Q17.1)

Answer	N	%
1 - I don't agree at all	16	17.0%
2 - I partly agree	48	51.1%
3 - I agree	8	8.5%
4 - I mostly agree	19	20.2%
5 - I totally agree	3	3.2%

Source: own study.

From a sustainability perspective, it is good news that most companies agreed to some extent with the statement that they are aware of and have up-to-date knowledge of the impact of their business on the environment, including the impact of the industry in which they operate. Only 2.1% said they had no idea of the environmental impact of their business (Table 4.).

Table 4. To what extent do you agree with the statements regarding the enterprise's activities? We are aware and have up-to-date knowledge of the impact of the enterprise on the environment (including the impact of the industry in which we operate) (Q17.2)

Answer	N	%
1 - I don't agree at all	2	2.1%
2 - I partly agree	24	25.5%
3 - I agree	27	28.7%
4 - I mostly agree	23	24.5%
5 - I totally agree	18	19.1%

Source: own study.

If we look more closely at the motives for taking action to reduce the impact on the environment (Figure 2), the strongest motive is fear, because they are doing it because of current legislation (penalties) (4.31). The second strongest, but much weaker motive is concern for the welfare of future generations (3.50), followed by market pressure (expectations of customers, investors, etc.) (3.33) and environmental awareness, i.e. we are aware of pollution and exploitation of the environment (3.17). The weakest motive is the realization of the development and/or pro-ecological strategy (3.03). It is not very common for companies not to have this type of activity, i.e. we do not take action (2.89).

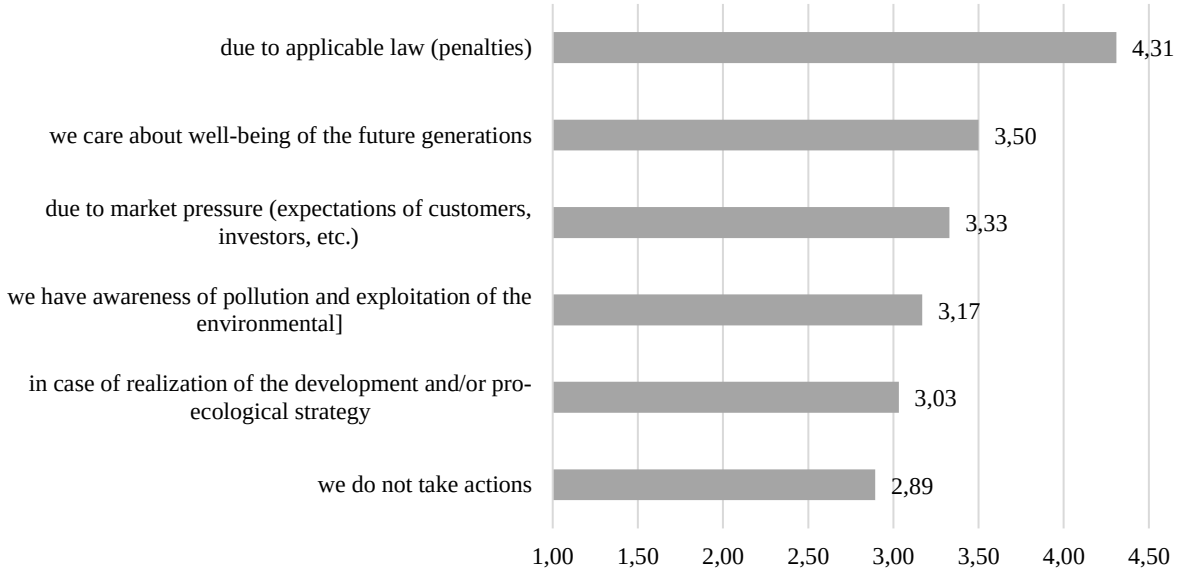

Figure 2. Motives of pro-ecological actions (means, N=94) (Q17.3)
Source: own study.

Enterprises pay the most attention to environmental issues when dealing with raw materials and their processing (supply processes) (3.68), followed by waste management (3.65), and manufacturing/production (3.57).

Consideration of environmental issues is also important, but far less important, in transport/logistics (3.33), purchasing (3.17) and modifying and/or purchasing equipment/machines/equipment (3.12). It has only an average importance in R&D (3.00) and an even lower influence in providing electronic customer services (e.g. e-invoicing, electronic customer service) (2.95) and in concluding contracts (2.87). However, companies pay the least attention to environmental issues in their warehousing and storage operations (2.83).

As far as the stakeholders concerned, pro-environmental activities in the responding company's industry are most important for customers (3.50). However, companies reported that it was much less important for local government units including public/local administration (2.9), government fiscal institutions (e.g. tax offices) (2.93), insurance companies (2.87), and banks/credit unions (2.66). It is also found that pro-environmental activities are least important for suppliers (2.79).

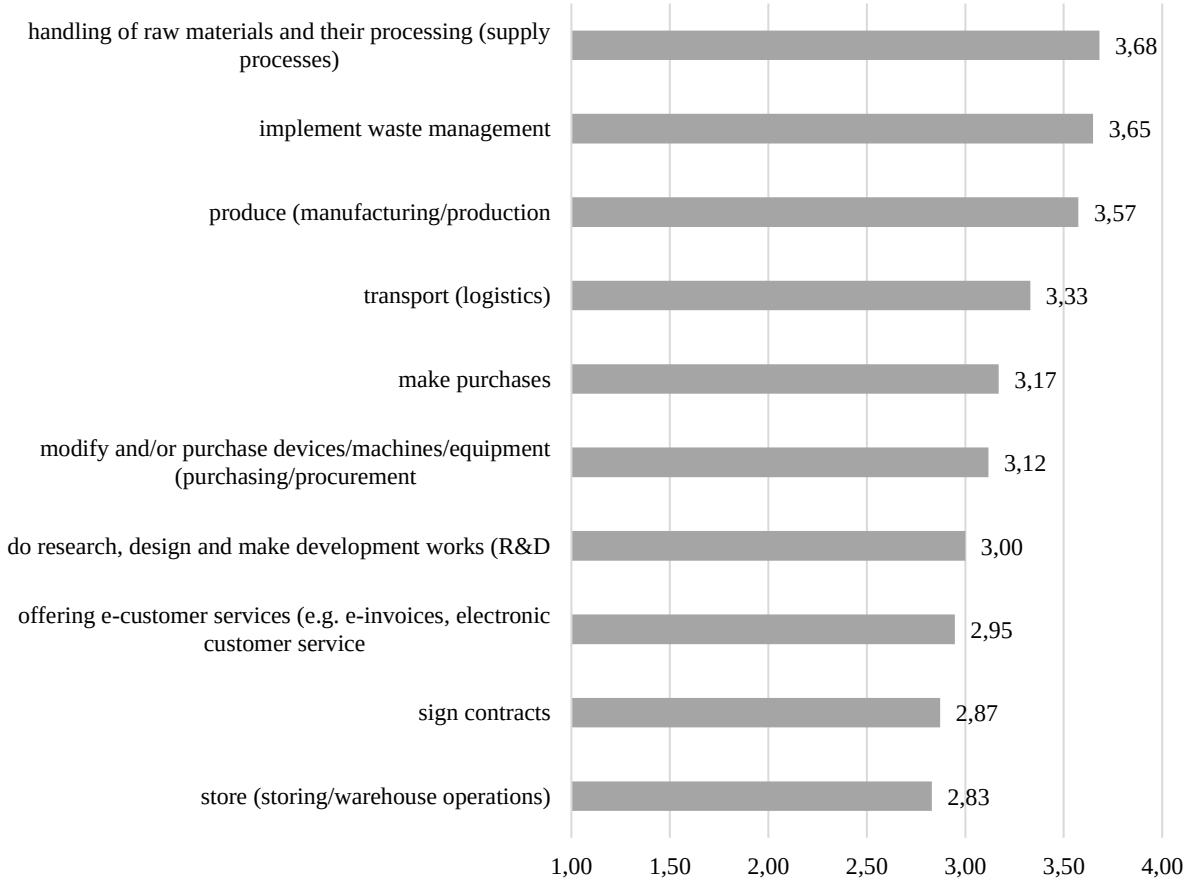

Figure 3. Importance of environmental issues in different company functions (means, N=94) (Q17.3)
Source: own study.

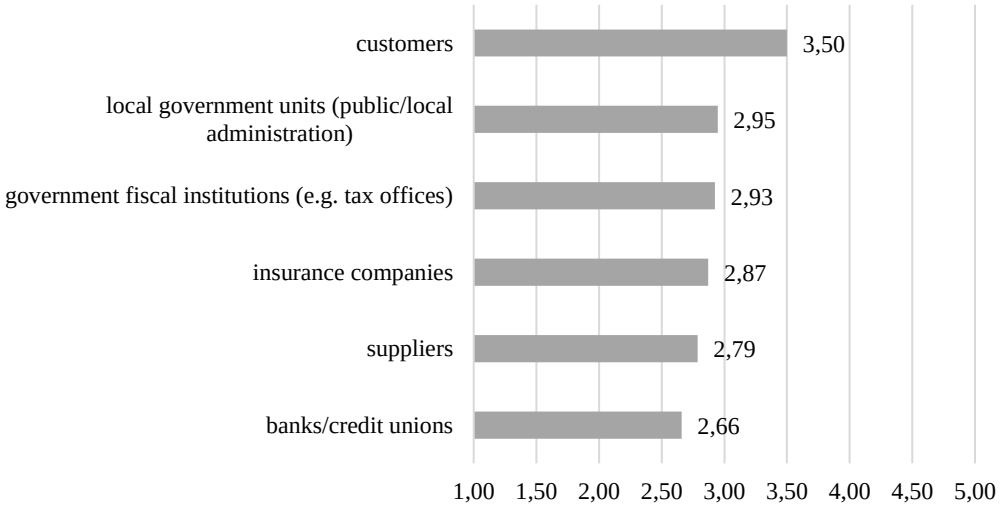

Figure 4. Importance of pro-environmental activities by stakeholders (means, N=94) (Q17.5)
Source: own study.

Regarding the measures of environmental performance used in Hungarian companies, the most commonly used measure was waste generated per unit of finished product, with 12.69% of all mentions (Figure 5). The number of incidents, environmental failures (e.g. exceeding set pollution limits) (12.07%) and the percentage of recycled waste (11.15%) were also very frequently mentioned. Around one in ten respondents had no knowledge of this area (10.53%). Official reports related to legal requirements were also mentioned more than 10% of the time (10.22%). Efficiency in the use of materials and energy (8.98%) and emissions (8.98%) were just under 9%. The number of investments in environmental protection (6.81%) and the number of vehicle kilometers travelled per production unit (6.81%) were mentioned even less frequently. The three least frequently used measures are the amount of specific pollutants emitted (e.g. NOx) (5.57%), the area of land around the company that is preserved as a natural environment (3.41%) and the number of allegations (2.79%).

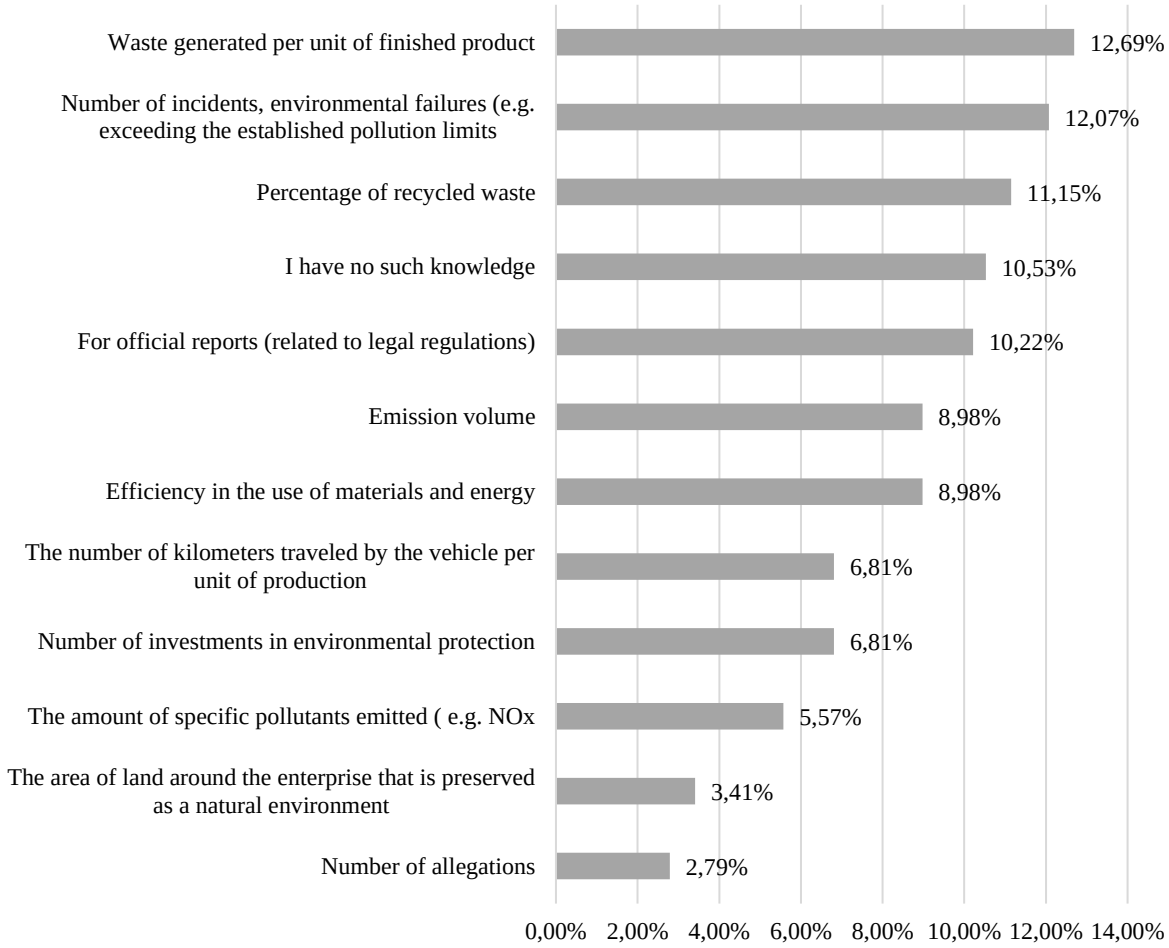

Figure 5. Measures of environmental performance used in Hungarian companies (frequency of mention, N=323) (Q18)
Source: own study.

More than half of the companies (53.2%) planned to invest in environmentally friendly solutions in the next three years. This compares to 46.8% of companies that had no such investment plans (Figure 6).

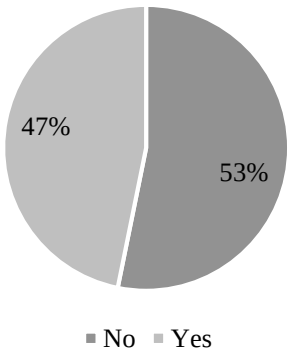

Figure 6. Is the enterprise planning investments in pro-ecological solutions in the next three years? (Q19)
Source: own study.

Based on 226 responses, as shown in Figure 7, the most common pro-environmental activity implemented by companies in Hungary is waste minimization in production processes (10.6%), followed by recycling (9.3%) and training, education, awareness raising (9.3%). The use of preventive environmental strategies (recycling or prevention strategies) and compliance with environmental principles as part of sustainable development (7.1%) are also popular (8.4%).

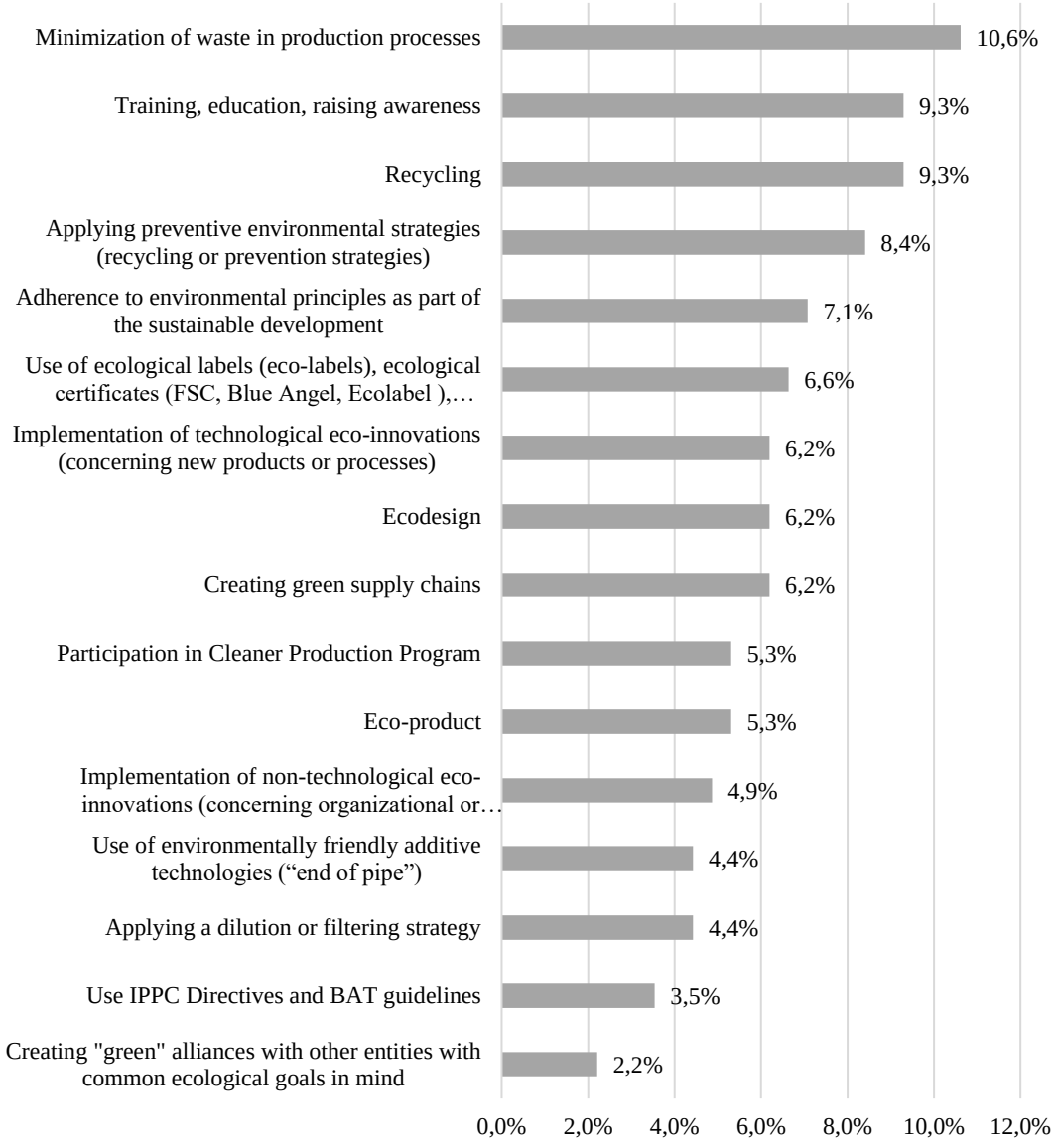

Figure 7. Pro-environmental activities implemented (frequency of mention, N=226) (Q20)
Source: own study.

6.6% of all mentions refer to the use of eco-labels, eco-certificates (FSC, Blue Angel, Ecolabel), environmental declarations on e.g. raw materials, materials, products, packaging. The creation of green supply chains (6.2%), eco-design (6.2%) and the implementation

of technological eco-innovations for new products or processes (6.2%) are slightly less frequently implemented actions. Developing and launching eco-products (5.3%), participating in cleaner production programs (5.3%) and implementing non-technological eco-innovations (organizational or marketing solutions) (4.9%) are even less common. Only a small fraction of companies apply a dilution or filtration strategy (4.4%) or use environmentally friendly additive technologies, i.e. end-of-pipe (4.4%). The use of IPPC directives and BAT guidelines (3.5%) and the formation of "green" alliances with other companies with common environmental objectives (2.2%) are the least frequently implemented measures in Hungary.

Based on 189 responses, the most frequently used principle in Hungary in the process of pro-ecological product design taking into account the product life cycle (LCA) is the minimization of harmful substances (14.29%). This is closely followed by saving resources and using available renewable resources (13.23%).

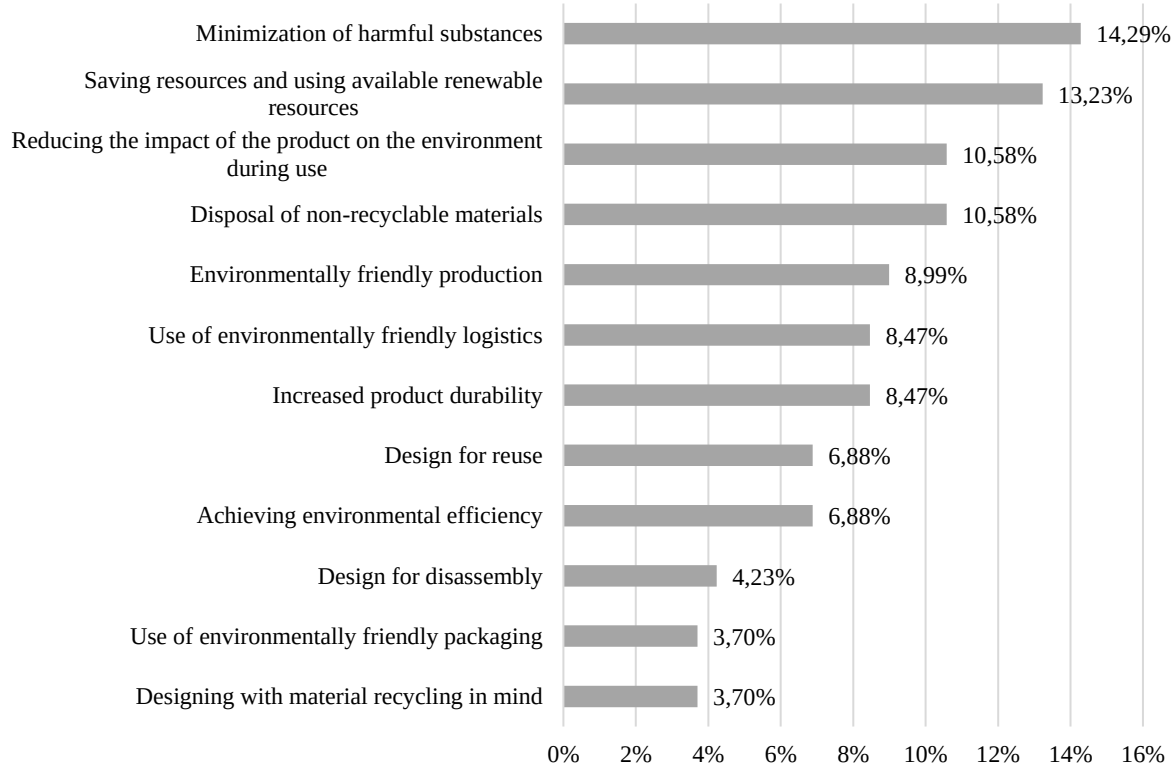

Figure 8. What principles are used in the process of pro-ecological product design taking into account the product life cycle (LCA)? (frequency of mention, N=189) (Q21)
Source: own study.

As Figure 8 shows, reducing the environmental impact of the product during use and disposing of non-recyclable materials (10.58% and 10.58% respectively) are equally important for Hungarian companies. Environmentally friendly production (8.99%), the use

of environmentally friendly logistics and increased product durability (8.47%) are somewhat less frequently considered. Achieving environmental efficiency and design for reuse are also considered equally (6.88%). The three least used principles in the process of pro-ecological product design are designing for disassembly (4.23%), designing for material recycling (3.70%) and using environmentally friendly packaging (3.70%).

Looking at the reasons why Hungarian enterprises are not willing to make environmentally friendly investments (Figure 9), we can say that the main reason is the lack of funds (43.6%). Several companies considered pro-ecological solutions as unprofitable investments (12.8%). The third most important barrier is lack of knowledge/know-how, experience (11.1%). Almost one in ten companies said they had already made such investments (9.4%). 6.0% were unable to say. 5.1% had already invested or intended to invest (2.6%). 3.4% said that the infrastructure (e.g. premises) was not owned by the enterprise. Size can also be a problem, e.g. the company is too small for pro-ecological activities (2.6%), and 1.7%-1.7% said that there is no place or simply no need for pro-ecological solutions in their business (1.7%).

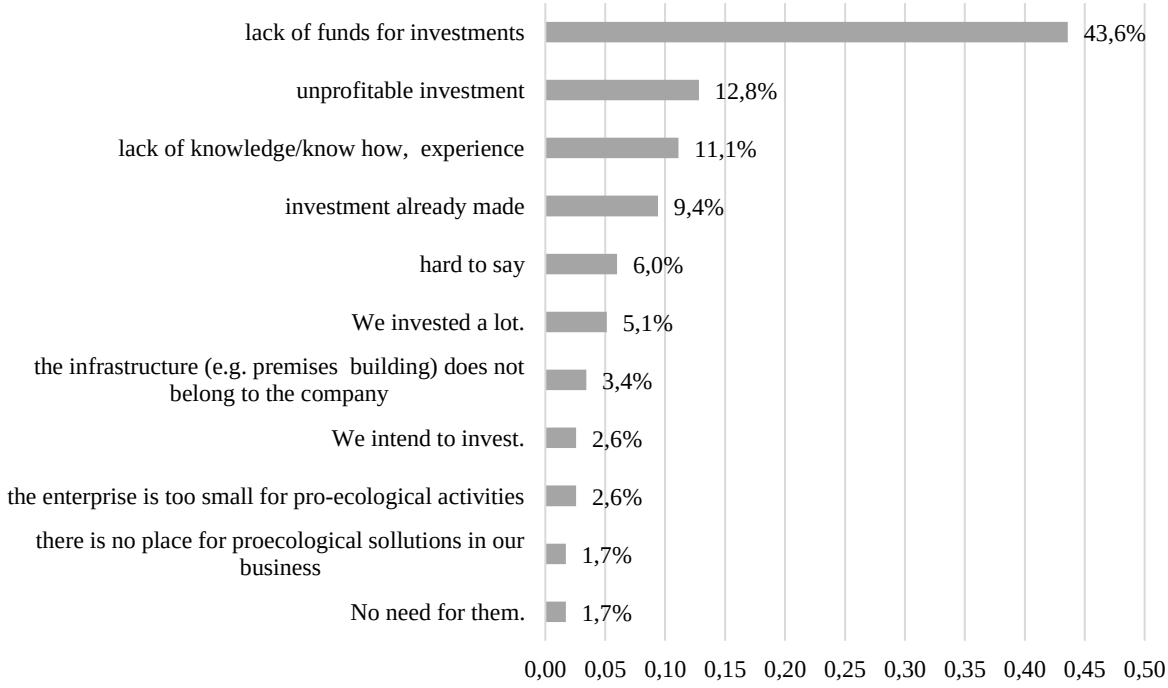

Figure 9. Why do you not intend to invest in pro-ecological solutions? (frequency of mention, N=117) (Q23)
Source: own study.

As shown in Table 5, most companies in Hungary are convinced that the level of restrictiveness of legal regulations related to environmental protection in Hungary is either restrictive (64.9%) or very restrictive (21.3%). Only around one in 10 companies feel that legal

regulations related to environmental protection in Hungary are not so restrictive. Less than 5% replied that it is hard for them to assess it.

Table 5. Perceived level of restrictiveness of legal regulations related to environmental protection in Hungary (Q24)

Assessment result	N	%
Hard to say	4	4.3%
They are not very restrictive	9	9.6%
They are restrictive	61	64.9%
They are very restrictive	20	21.3%
Total	94	100.0%

Source: own study.

In a hypothetical situation where Hungarian companies had the funds for any environmental investment, shown in Figure 10, they would most likely invest in reducing the use of materials and raw materials (13.13%). The second and third most preferred pro-environmental investments are thermo-modernization (12.88%) and implementation of modern energy-saving machines/devices (11.87%). Implementation of modern technologies (9.85%) and replacing lighting with energy-saving alternatives (8.84%) would also be popular among Hungarian companies. A significant number of respondents also mentioned the followings: replacement of window joinery (8.33%), replacing the car fleet with a newer or more ecological one (8.08%) and installing photovoltaic panels (7.83%). The three least planned forms of green investment are:

- Introduction of pro-ecological standards in the production process (6.31%),
- Replacement of old/ineffective energy or heating source (5.05%) , and
- Construction of wind turbines (4.55%).

Only very few companies replied that it was hard to say what green investment would they do (3.28%).

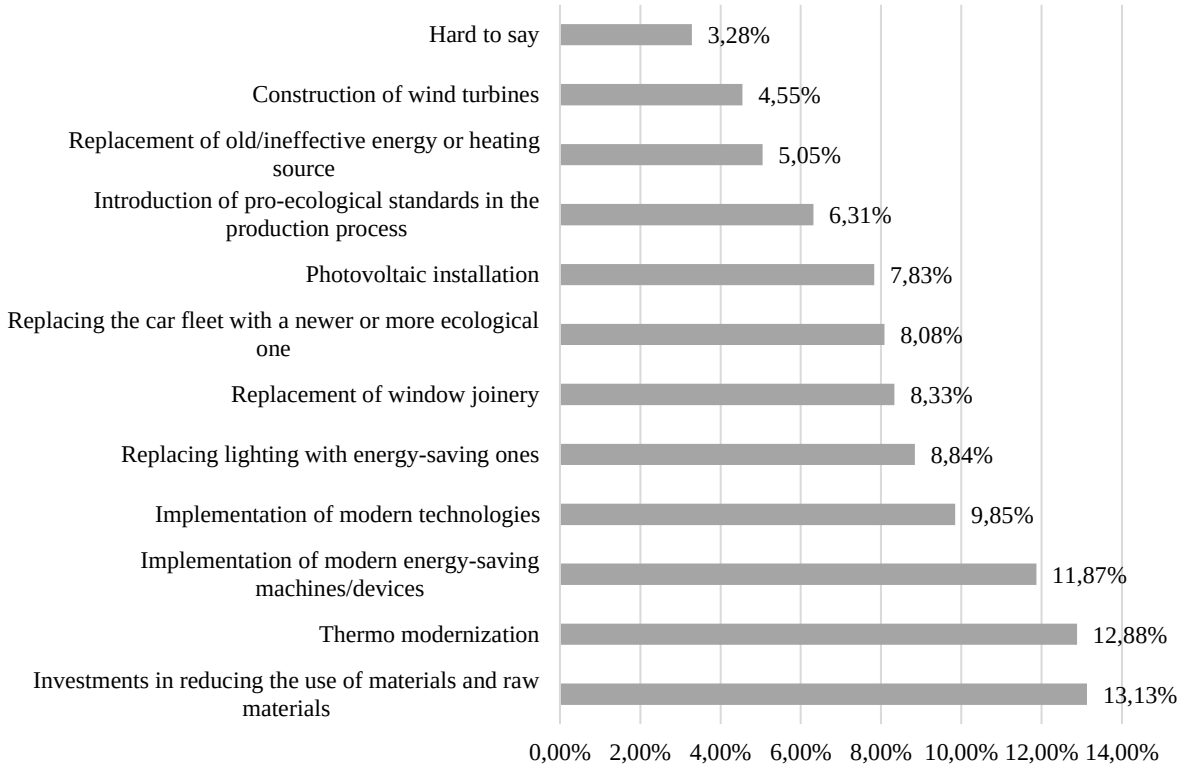

Figure 10. Hypothetical pro-environmental investments preferred by Hungarian companies (N=396) (Q42)
Source: own study.

4. Conclusion

In Hungary, the level of perceived customer expectations regarding the environmental improvement of products is not very high. Yet, customers are the main drivers of pro-environmental behavior. Several companies do not compare their products with competing products in terms of environmental impact. Pro-ecological products have a higher price and the higher price of pro-ecological products significantly discourages customers from buying them. However, pro-ecological products can improve a customer's self-esteem.

The majority of companies are somewhat interested in environmental issues. The strongest motive for pro-environmental behavior is the fear of penalties and lawsuits.

Companies pay the most attention to environmental issues when dealing with raw materials and their processing (supply processes), waste management and manufacturing/production. More than half of companies plan to invest in environmentally friendly solutions in the next three years. The most common pro-environmental activities in Hungary are related to cost savings and education: waste minimization in production processes, recycling and training, education, awareness raising. The main reason for not investing in environmental activities

is definitely the lack of funds. If they had funds, they would most likely invest in reducing the use of materials and raw materials in order to save money.

These results also suggest that there is still much work to be done in Hungary in the field of environmentally responsible business.

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CHAPTER 5

THE RELATIONSHIP BETWEEN QUALITY AND PRO-ENVIRONMENTAL OPERATION IN THE CASE OF HUNGARIAN COMPANIES

László MOLNÁR, Szabolcs NAGY, Gabriella METSZŐSY, Krisztina VARGA

This article explores the nuanced relationship between product quality and pro-environmental operations in Hungarian companies. Survey responses unveil diverse approaches, with varying levels of commitment and opportunities for enhanced focus on sustainable practices. The findings emphasize the need for further analysis to understand regional patterns and reasons behind disparities. The study delves into the balance between quality and environmental care, providing insights into sustainability practices and proposing further exploration of specific strategies. Companies recognize the importance of environmental considerations in product quality, but variations persist, necessitating exploration of specific strategies in different commitment categories. The study highlights diverse approaches to balancing product quality and environmental concerns, prompting further analysis into reasons and implications. Companies implement a range of activities, from prevalent customer satisfaction surveys to the use of environmental impact catalogs, emphasizing the need for further analysis to gauge effectiveness on product quality and environmental sustainability.

Keywords: quality, pro-environmental behaviour, Hungary, electromechanical industry

1. Introduction

In an era where sustainability has become a focal point for businesses worldwide, the interplay between quality management and pro-environmental initiatives stands as a critical nexus for organizational success. This article delves into the intricate dynamics shaping the relationship between quality and pro-environmental operations, with a specific focus on the practices and perspectives of companies within Hungary[1].

As industries strive to strike a delicate balance between meeting customer expectations for product excellence and navigating the ever-growing demand for environmentally responsible practices, Hungarian companies find themselves at the forefront of this complex intersection. The pursuit of quality, traditionally associated with customer satisfaction and compliance,

[1] S. Nagy, Környezettudatos marketing [Phd, Miskolci Egyetem]. 2005. http://real-phd.mtak.hu/94/.

is increasingly intertwined with the imperative to reduce ecological footprints and embrace sustainable methodologies[2].

The examination of Hungarian companies serves as an insightful case study, offering a microcosmic view into the broader global challenge of harmonizing business operations with environmental stewardship. With a spotlight on the unique economic landscape, industrial sectors, and regulatory frameworks shaping Hungary's business environment, this article seeks to unravel the strategies employed by companies to integrate quality enhancement and pro-environmental initiatives.

As we embark on this exploration, we will scrutinize survey data, industry practices, and company-specific approaches to understand the spectrum of engagements with environmental concerns within the context of product quality improvement. By dissecting the multifaceted relationship between quality and pro-environmental operations in Hungarian companies, we aim to contribute valuable insights that can inform global conversations on sustainable business practices.

Join us on this journey as we unravel the nuanced interplay between quality and environmental consciousness in the corporate realm, with Hungarian companies serving as a pertinent and illuminating case study in the ongoing pursuit of a harmonious and sustainable business landscape.

2. Research method and sample

In 2023, an online survey was carried out in the Visegrad Group nations as a component of the Qualitative-Environmental Aspects of Products Improvement project (IVF 22230264), funded by the International Visegrad Fund. The objective of the study is to assess and compare the prevailing practices of electromechanical industry companies in the V4 countries (Poland, Czech Republic, Hungary, and Slovakia) with the perspectives of their customers or potential customers regarding pro-environmental product quality management. In Hungary, the survey garnered 94 responses from a pool of over 300 companies.

In this chapter we analysed the following questions that are specifically related to the relationship between quality and pro-environmental operation in the case of Hungarian companies:

[2] A. Pinget, R. Bocquet, C. Mothe, Barriers to Environmental Innovation in SMEs: Empirical Evidence from French Firms, M@n@gement, 2015, 18(2), 132. DOI: https://doi.org/10.3917/mana.182.0132.
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- How often action to improve products' quality including its impact on the natural environment are taken in the enterprise? (Q13),
- How often does the company take steps to improve the quality of its products while taking care of the natural environment? (Q25),
- To what extent does the need to care for the natural environment affect the activities undertaken in the company when improving the quality of products? (Q26),
- To what extent does the need to care for the natural environment affect the activities undertaken in the company when improving the quality of products? (Q26),
- What quality and environmental measures are taken by the company to improve the quality of its products (Q28),
- Indicate only those activities that are implemented in the company as part of improving products in terms of quality and environment (Q29).

3. Research results

First, we looked at how often action to improve products' quality including its impact on the natural environment are taken in the enterprise? (Table 1).

Table 1. How often action to improve products' quality including its impact on the natural environment are taken in the enterprise? (Q13)

Answer	N	%
They are not taken	16	17.0%
Less than once every three years	10	10.6%
Once every two to three years	24	25.5%
Once a year	28	29.8%
More than once year	16	17.0%

Source: own study.

A short analysis of the responses to the survey question about the frequency of actions taken to improve product quality and their impact on the natural environment in the enterprise:

- **They are not taken (17.0%):** Approximately 17% of respondents indicated that actions to improve product quality and their environmental impact are not taken at all in their enterprise. This suggests a significant room for improvement in these areas in a notable portion of the surveyed organizations,
- **Less than once every three years (10.6%):** About 10.6% of respondents reported that such actions occur less frequently than once every three years. This indicates a relatively low level of commitment to quality and environmental improvement in a smaller subset of the organizations,

- **Once every two to three years (25.5%):** The most substantial percentage of respondents (25.5%) stated that actions are taken once every two to three years. This suggests a moderate level of commitment to quality and environmental initiatives, with some intermittent efforts,
- **Once a year (29.8%):** Nearly 30% of respondents reported that actions are taken once a year. This indicates a more frequent commitment to quality and environmental improvements, which could suggest that these aspects are more consistently addressed.
- **More than once a year (17.0%):** Approximately 17% of respondents mentioned that actions are taken more than once a year. This group shows a higher level of commitment to continuously improving product quality and their environmental impact.

In summary, these responses highlight a range of approaches to quality and environmental improvement across the surveyed enterprises. A significant portion takes actions at least annually, but there are also organizations with infrequent or nonexistent efforts. The results could indicate opportunities for increased focus on sustainable practices and product quality enhancements in some organizations. Further analysis could explore the reasons behind these different levels of commitment and whether specific industries or regions exhibit particular patterns.

In the next question we looked at how often does the company take steps to improve the quality of its products while taking care of the natural environment? (Table 2).

Table 2. How often does the company take steps to improve the quality of its products while taking care of the natural environment? (Q25)

Answer	N	%
Not at all	6	6.4%
Rarely	20	21.3%
Sometimes	26	27.7%
Often	35	37.2%
Very often	7	7.4%

Source: own study.

A short analysis of the responses to the second survey question about the frequency of a company's efforts to improve product quality while considering the natural environment:

- **Not at all (6.4%):** Approximately 6.4% of respondents stated that the company does not take any steps to improve product quality while caring for the natural environment. This indicates a small minority of companies that appear to have little to no commitment to environmentally conscious product quality improvements,

- **Rarely (21.3%):** About 21.3% of respondents mentioned that the company's efforts in this regard are rare. This suggests that a notable portion of the surveyed companies infrequently addresses both product quality and environmental concerns together,
- **Sometimes (27.7%):** The largest group of respondents, at 27.7%, reported that the company occasionally takes steps to improve product quality while caring for the natural environment. This signifies a moderate level of commitment, indicating that there is some effort but still room for more consistent actions in this area,
- **Often (37.2%):** Nearly 37.2% of respondents indicated that their companies often engage in efforts to enhance product quality while being environmentally conscious. This is a substantial proportion, suggesting a significant commitment to combining quality improvement with environmental considerations,
- **Very often (7.4%):** Approximately 7.4% of respondents mentioned that their companies very often prioritize improving product quality while taking care of the natural environment. While this group is smaller, they represent organizations with a particularly strong commitment to these dual objectives.

In summary, the responses reveal a range of approaches in companies when it comes to balancing product quality and environmental care. A significant portion of companies reports frequent or occasional efforts in this direction, but there is also a smaller group with less commitment or, conversely, very high commitment. This data can be used to assess the level of environmental responsibility and product quality emphasis in the surveyed companies, providing insights into their sustainability practices. Further analysis could delve into specific strategies and practices employed by companies falling into each category.

In the next question we looked at to what extent does the need to care for the natural environment affect the activities undertaken in the company when improving the quality of products? (Table 3).

Table 3. To what extent does the need to care for the natural environment affect the activities undertaken in the company when improving the quality of products? (Q26)

Answer	N	%
Very low	8	8.5%
Low	9	9.6%
Average	37	39.4%
High	34	36.2%
Very high	6	6.4%

Source: own study.

A short analysis of the responses to the question about the extent to which the need to care for the natural environment affects activities undertaken in the company when improving product quality:

- **Very low (8.5%):** Approximately 8.5% of respondents indicated that the need to care for the natural environment has a very low impact on the activities undertaken to improve product quality in their company. This suggests that, in this group, environmental considerations are not strongly integrated into the quality improvement processes,
- **Low (9.6%):** About 9.6% of respondents reported that the impact of environmental concerns is low on their company's activities aimed at improving product quality. While slightly higher than the "very low" category, this group still indicates a relatively weak connection between quality improvement and environmental considerations,
- **Average (39.4%):** The largest percentage of respondents, at 39.4%, noted that the impact of caring for the natural environment is average when it comes to improving product quality. This suggests that for a substantial portion of companies, environmental considerations play a moderate role in their quality improvement efforts,
- **High (36.2%):** Around 36.2% of respondents stated that the need to care for the natural environment has a high impact on their company's activities related to product quality improvement. This indicates a significant number of organizations that prioritize and integrate environmental concerns into their quality enhancement processes,
- **Very high (6.4%):** Approximately 6.4% of respondents mentioned that the impact of environmental considerations on their quality improvement activities is very high. This is a smaller group but represents companies with an exceptionally strong commitment to both quality and environmental sustainability.

In summary, the responses reveal that a majority of companies consider the need to care for the natural environment as an average or high factor influencing their product quality improvement activities. However, there are also organizations with low or very low levels of integration of environmental concerns in these processes, as well as a smaller segment with very high commitment. This data can provide insights into the extent to which environmental sustainability is integrated into quality improvement efforts across different companies. Further analysis could explore specific strategies and practices employed by organizations in each category.

In the next question we looked at to what extent does the need to care for the natural environment affect the activities undertaken in the company when improving the quality of products? (Table 4).

Table 4. To what extent does the need to care for the natural environment affect the activities undertaken in the company when improving the quality of products? (Q26)

Answer	N	%
Improving the quality of products is aimed at reducing the negative impact on the natural environment as well as at achieving the quality of products that satisfies customers.	18	19.1%
Improving the quality of products is definitely more focused on achieving the quality of products that satisfy customers than on reducing the negative impact on the natural environment.	44	46.8%
Improving the quality of products is definitely more focused on reducing the negative impact on the natural environment than on achieving the quality of products that satisfy customers.	32	34.0%

Source: own study.

A short analysis of the responses to the question regarding the company's current approach to actions aimed at improving the quality of products in terms of quality and the environment:

- **Improving the quality of products is aimed at reducing the negative impact on the natural environment as well as at achieving the quality of products that satisfies customers (19.1%):** Approximately 19.1% of respondents mentioned that their company's approach to improving product quality places equal importance on reducing the negative impact on the natural environment and satisfying customer needs. This indicates a balanced and integrated approach to quality and environmental considerations,
- **Improving the quality of products is definitely more focused on achieving the quality of products that satisfy customers than on reducing the negative impact on the natural environment (46.8%):** The largest group, at 46.8%, reported that their company's primary focus is on achieving product quality that satisfies customers, with less emphasis on reducing the negative impact on the environment. This suggests that for this group, customer satisfaction takes precedence over environmental concerns in their quality improvement efforts,
- **Improving the quality of products is definitely more focused on reducing the negative impact on the natural environment than on achieving the quality of products that satisfy customers (34.0%):** About 34.0% of respondents stated that their company's approach is primarily centered on reducing the negative impact on

the natural environment, with less emphasis on meeting customer quality expectations. This group indicates a stronger commitment to environmental sustainability in their quality improvement efforts.

In summary, the responses show a variety of approaches to balancing product quality and environmental considerations in the surveyed companies. While a significant portion places a stronger emphasis on customer satisfaction over environmental concerns, there is also a substantial group that prioritizes reducing the negative impact on the natural environment. Additionally, a smaller but noteworthy group takes a balanced approach, giving equal weight to both quality and environmental considerations. This data provides insights into how different organizations weigh these two critical aspects in their product quality improvement efforts, which can be important for understanding their sustainability strategies. Further analysis could explore the reasons and implications behind these different approaches.

In the next question we looked at what quality and environmental measures are taken by the company to improve the quality of its products.

Table 5. What quality and environmental measures are taken by the company to improve the quality of its products. (Q28)

Answer	N	%
Activities are undertaken separately, taking into account customer requirements as to the quality of products and taking into account the impact of products on the natural environment	33	35.1%
Activities are undertaken simultaneously taking into account customer requirements as to the quality of products and taking into account the impact of products on the natural environment	51	54.3%
No such environmental activities	3	3.2%
We do not have such things.	3	3.2%
We focus only on the quality	4	4.3%

Source: own study.

A short analysis of the responses to the question about the quality and environmental measures taken by the company to improve the quality of its products:

- **Activities are undertaken separately, taking into account customer requirements as to the quality of products and taking into account the impact of products on the natural environment (35.1%):** About 35.1% of respondents mentioned that their company undertakes activities separately, considering customer quality requirements and the environmental impact of their products. This suggests a bifurcated approach, where quality and environmental concerns are addressed as distinct processes,
- **Activities are undertaken simultaneously, taking into account customer requirements as to the quality of products and taking into account the impact**

of products on the natural environment (54.3%): The majority of respondents, at 54.3%, reported that their company integrates quality and environmental considerations by undertaking activities simultaneously. This indicates a more holistic approach where both customer quality requirements and environmental impact are considered in tandem during product improvement efforts,

- **No such environmental activities (3.2%):** A small percentage, 3.2%, indicated that their company does not engage in any specific environmental activities alongside product quality improvements. This suggests a lack of focus on environmental sustainability in this subset of companies,
- **We do not have such things (3.2%):** Similarly, another 3.2% of respondents reported that their company does not have environmental activities related to quality improvement, indicating a lack of integration or focus on environmental considerations,
- **We focus only on the quality (4.3%):** Approximately 4.3% of respondents mentioned that their company concentrates solely on product quality and does not consider environmental factors during the improvement process.

In summary, the responses reflect varying approaches to integrating environmental considerations with product quality improvement. While a significant portion of companies simultaneously addresses both customer quality requirements and environmental impact, there are also smaller groups that either focus solely on quality, treat these aspects separately, or have no environmental activities in place. These results provide insights into how different organizations balance quality and environmental concerns in their product improvement efforts. Further analysis could explore the reasons and outcomes associated with these different approaches. First, we looked at what activities that are implemented in the company as part of improving products in terms of quality and environment (Table 6).

Table 6. Indicate only those activities that are implemented in the company as part of improving products in terms of quality and environment. (Q29)

Answer	N	%
A catalog of activities aimed at improving the quality of products is kept	5	5.3%
Catalogs describing the impact of products on the natural environment are being developed	12	12.8%
Computer software is used to support making quality and/or environmental decisions as a part of the product improvement,	9	9.6%
Satisfaction surveys of customers and interested parties are conducted regarding the impact of products on the natural environment	13	13.8%
Specification of products catalogs are being developed	17	18.1%
Surveys of customer satisfaction with the quality of products are conducted	38	40.4%

Source: own study.

An analysis of the responses to the question about activities implemented by the company as part of improving products in terms of quality and the environment:

- **A catalog of activities aimed at improving the quality of products is kept (5.3%):** Approximately 5.3% of respondents reported that their company maintains a catalog of activities focused on improving product quality. This indicates a relatively small portion of companies with a structured approach to quality improvement,
- **Catalogs describing the impact of products on the natural environment are being developed (12.8%):** About 12.8% of respondents mentioned that their company is developing catalogs that describe the environmental impact of their products. This suggests a growing interest in documenting and communicating environmental aspects of products,
- **Computer software is used to support making quality and/or environmental decisions as a part of the product improvement (9.6%):** Approximately 9.6% of respondents reported using computer software to support decision-making related to product quality and environmental concerns. This indicates a moderate but not widespread use of technology in these areas,
- **Satisfaction surveys of customers and interested parties are conducted regarding the impact of products on the natural environment (13.8%):** About 13.8% of respondents conduct satisfaction surveys among customers and stakeholders to assess the impact of products on the environment. This reflects a level of engagement in understanding and addressing environmental concerns,
- **Specification of products catalogs are being developed (18.1%):** Nearly 18.1% of respondents mentioned that their company is developing catalogs specifying product details. While the question doesn't explicitly link this to environmental considerations, such catalogs may include environmental information as well,
- **Surveys of customer satisfaction with the quality of products are conducted (40.4%):** The majority of respondents, at 40.4%, conduct surveys to gauge customer satisfaction with the quality of their products. This is a commonly used approach to assess product quality and customer perception.

In summary, the responses indicate a range of activities implemented by companies to improve products in terms of quality and the environment. While customer satisfaction surveys are the most prevalent, other activities, such as developing environmental impact catalogs and using computer software, also play a role. These results provide insights into

the diversity of approaches used by companies to address both quality and environmental aspects in their product improvement efforts. Further analysis could explore the effectiveness and impact of these activities on product quality and environmental sustainability.

4. Summary

In summary, the survey responses reveal diverse approaches to quality and environmental improvement across surveyed companies. While a significant portion takes annual actions, there are also instances of infrequent or nonexistent efforts, suggesting opportunities for enhanced focus on sustainable practices. The data highlights variations in commitment levels and could indicate potential patterns in specific industries or regions. Further analysis is recommended to explore the reasons behind these disparities.

The findings indicate a spectrum of approaches among companies in balancing product quality and environmental care. While many report frequent or occasional efforts, a smaller group exhibits either lower or higher commitment levels. This data allows assessment of environmental responsibility and product quality emphasis, offering insights into sustainability practices. Further analysis could delve into specific strategies employed by companies falling into each category.

The responses underscore that a majority of companies view caring for the natural environment as a significant factor in product quality improvement. However, variations exist, with some organizations showing low integration of environmental concerns and others displaying high commitment. This data provides insights into the extent of environmental sustainability integration across different companies, warranting further exploration of specific strategies in each category.

The survey responses demonstrate a variety of approaches to balancing product quality and environmental considerations. While some emphasize customer satisfaction over environmental concerns, a substantial group prioritizes reducing negative environmental impact. A smaller yet noteworthy group takes a balanced approach. This data provides insights into how organizations weigh these critical aspects in product quality improvement, crucial for understanding sustainability strategies. Further analysis is needed to explore reasons and implications behind these different approaches.

The responses reveal varying approaches to integrating environmental considerations with product quality improvement. While many companies address both customer quality requirements and environmental impact, smaller groups focus solely on quality, treat these aspects separately, or lack environmental activities. The results provide insights into how

organizations balance quality and environmental concerns in product improvement efforts, prompting further analysis into reasons and outcomes associated with these approaches.

In summary, companies implement a range of activities to improve products in terms of quality and the environment. While customer satisfaction surveys are prevalent, other activities like developing environmental impact catalogs and using computer software also contribute. These results highlight the diversity of approaches used by companies to address both quality and environmental aspects in product improvement. Further analysis is recommended to explore the effectiveness and impact of these activities on product quality and environmental sustainability.

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CHAPTER 6

THE PERCEPTION OF QUALITY AMONG HUNGARIAN COMPANIES – INTRODUCTION TO A RESEARCH REPORT

Krisztina VARGA, László MOLNÁR, Szabolcs NAGY, Gabriella METSZŐSY

This research report presents some of the results of the Qualitative-Environmental Aspects of Products Improvement Project. The chapter summarizes the current approach of companies and their customers to environmental product quality management, based on the responses of the surveyed Hungarian companies in the electromechanical industry. The chapter is closely related to the other three chapters written by the Hungarian research team, which together form the research report on Hungarian companies. The main research question of the presented questionnaire survey is: Is the current approach of the V4 manufacturing companies in line with the customer expectations and at the same time with the pro-ecological approach to product quality management? The questionnaire examines a total of 44 closed questions, emphasizing quality and environmental awareness and the link between them. It uses scale questions that are suitable for measuring attitudes. The results are presented in the form of tables and graphs (94 responses). Our main finding is that the quality and development of products and customer expectations in terms of quality are very high priorities for the Hungarian companies surveyed.

Keywords: quality, environmental awareness, electromechanical industry, questionnaire

1. Introduction

This chapter presents, in the form of a research report, the results of one component of the Qualitative-Environmental Aspects of Products Improvement Project. The aim of the project is to compare the current approach of companies in the electromechanical industry in the V4 countries (Poland, Slovakia, Czech Republic, Hungary) with the approach of their customers and potential customers in the field of environmental product quality management. This chapter analyses the surveys among Hungarian SMEs in the electromechanical industry, one of the two planned studies. The chapter is closely linked to the other three chapters of the Hungarian research team, together with the Hungarian companies' responses to the questionnaire. Titles of other chapters:

- Pro-environmental behaviour of Hungarian companies in the electromechanical industry,
- The relationship between quality and pro-environmental operation in the case of Hungarian companies,

- Outlook for the future development of environmentally friendly activities among Hungarian companies).

This chapter examines the background and purpose of the research and presents the research questions. It describes the methodology used, the structure of the questionnaire and the composition of the sample. Together with the members of the Hungarian research team, the attitudes of Hungarian SMEs in the electromechanical industry towards quality and environmental awareness, attitudes towards the relationship between environmental awareness and quality and future perspectives in this area are examined.

2. Research subject and methods

As mentioned above, the general aim of the project is to compare the current approach of enterprises from the electromechanical industry of V4 (PL, SK, CZ, HU) with the approach of their clients and potential clients in the field of pro-environmental product quality management. The participants of the project:

- Rzeszow University of Technology (PL),
- Technical university in Košice (SK),
- Pan-European University (CZ),
- University of Miskolc (HU).

The methodology is two separate questionnaire surveys for these two groups in V4. There is a need to obtain new updated data in this research subject and discuss it. Target groups and stakeholders of the project:

- SMEs in the electromechanical industry (industrial manufacturing) of the consortium members, where the surveys are carried out respondents to the surveys in these companies are mainly concerned with the quality of products design and improvement of the products, also from an environmental point of view,
- Customers and potential customers of the V4 consortium countries. A customer is a person who is a customer of the companies selected for the survey, i.e. SMEs in the electromechanical industry (industrial manufacturing) products manufactured by the manufacturers of the electrical and mechanical industries. A potential customer is a person who is a customer of the enterprises, i.e. SMEs in the electromechanical industry (industrial manufacturing) (SMEs),
- Research representatives of the V4 countries.

This chapter presents the results of a survey of Hungarian manufacturing companies belonging to SMEs in the electromechanical industry.

Problems hindering sustainable production result from the turbulent environment and are visible in the functioning of production companies in the V4 countries, with a particular focus on the challenges facing the electromechanical industry. Applying the principles of sustainable development is a key element in addressing these challenges. The 1987 report of the United Nations World Commission on Environment and Development (WCED)[1], entitled "Our Common Future", irrevocably introduced the concept of sustainable development into the public discourse. Since then, sustainable development has been defined as development that meets the needs of the present without compromising the needs of future generations. Today, humanity has exceeded the ecological capacity of our planet, i.e. it has gone beyond its limits. According to the ecological footprint concept of Rees and Wackernagel[2], humanity is using one and a half of the Earth's ecological capacity. The challenges we face are not a cause for resignation and pessimism, but rather a call for considered action[3]. A prudence that invites us to take time for wise foresight, for reflection. This is all the more necessary because we cannot add to our mistakes, we cannot add to our existing problems. The survey presented in this chapter serves precisely this purpose, supporting the study of quality and environmental awareness in the context of sustainable development, based on the responses of the companies surveyed. Accordingly, the main research question is the follow:

- is the current approach of the V4 manufacturing companies in line with customer expectations and, simultaneously, with the pro-ecological approach to product quality management?

A further question is:

- mapping quality expectations,
- exploring issues of environmental awareness and sustainability,
- and outlining future development opportunities.

The results of the research will help determine the current level of activities in SMEs from the electromechanical industry in the V4countries in the field of pro-ecological product quality management and meeting customer expectations.

[1] World Commission on Environment and Development, *Our Common Future*, World Commission on Environment and Development, Oxford University Press 1987.
[2] M. Wackernegel, W.E. Rees, Our Ecological Footprint: Reducing Human Impact on the Earth. New Society Publishers. Gabriola Island, 1996.
[3] I. Gyulai, Fenntartható fejlődés és fenntartható növekedés (Sustainable development and sustainable growth), Statisztikai Szemle, 2013, 91(8-9), 797-822.

In each V4 country, two separate surveys were be carried out. The first questionnaire which is the subject of this research report was addressed to SME enterprises from the electromechanical industry. The results of this survey can provide a solution to the problem of the lack of new data on:

- activities of enterprises for the natural environment,
- the possibility of implementing in enterprises the good practices supporting environmentally friendly production.

This survey was conducted in an electronic and paper manner.

One of the most popular methods of primary data collection is questionnaires. The questionnaire is a written survey method and the most important tool for collecting large amounts of data. Data collection is usually classified as a quantitative method, which means that the basic unit of the associated analytical procedure is realized as a number, regardless of whether it is represented as such in the measurement process. Thanks to the numerical data, links and causal relationships are established between the data collected. When applied, it can be used to obtain answers in a variety of ways, due to the diversity of channels. The questionnaire can be delivered in written form, through a face-to-face meeting, by telephone or possibly through a web-based interface. The questionnaire is suitable for explanatory, descriptive and exploratory purposes. It is important that closed or open-ended questions are simply worded and easy for everyone to understand, and that numerical data can be provided. The original target for the questionnaire on companies was a minimum of 85 responses per country, which the Hungarian team exceeded by more than 10%, with a total of 94 questionnaires completed. The survey was conducted using an online questionnaire (Google Form) in August and September 2023. Following the distribution of the questionnaires, the main challenge was to find and motivate respondents who were able to answer the questions on the survey areas in the company on their own, which in some cases also meant visiting the contacts/representatives in person to encourage them to fill in the questionnaire at the company's premises. All this said, our work was effective, as we were able to base our analysis on 94 responses.

The questionnaire covered a total of 44 closed questions, with the following breakdown:

- the title of the questionnaire, the main purpose of the questionnaire, a brief summary of the relevant information,
- collection of data on the composition of the sample (questions 1-8),
- the subject area of quality (questions 9-12),

- environmental awareness (questions 14-18, 20-21, 23-24, 42),
- the relationship between environmental awareness and quality (questions 13, 25-31, 33-34, 43),
- future perspectives related to the theme: (questions 19, 22, 32, 35-36, 41, 44).

In terms of the structure of the questionnaire, the first part of the questionnaire contains a greeting to the respondent and the purpose of the survey. This, in our opinion, increased cooperation and responsible response. Here we informed respondents about the guarantee of anonymity and the voluntary nature of participation. In the introductory section, we informed the respondents about how to fill in the questionnaire, what to do, the deadline, the expected time needed to complete the questionnaire, who we were interviewing on behalf of and what would happen to the data collected. Also at this point, we have defined some of the terms that we require consistent use when completing the questionnaire.

In the next section we have included the questions and statements. Here, we first defined the introductory questions, which were related to the geographical location, type of company, area of activity, type of operation and the ISO systems (ISO 9001:2015 system; ISO 14001:2015 system or EMAS system) used by the respondent.

The questionnaire used closed questions (44 questions). For closed questions, we provided response options (pre-defined response options) and the respondent could select one or more of these (in line with the instructions for completion). We tried to use clear terms and also gave the option to answer 'don't know' or 'not understandable/not relevant'. We used scale questions (nominal scale, Likert scale), which are appropriate for measuring attitudes. For most questions, we graded the respondents on a scale of 1 to 5. Care was taken to ensure the symmetry of the scale, the number of scale points is therefore odd. For the Likert scale, the respondent was asked to express the degree of agreement with a statement or agreement with an opinion. Only the statement was specified in the questionnaire, the scale itself was always the same:

- I totally disagree,
- I partly agree,
- I agree / I don’t know,
- I mostly agree,
- I totally agree.

We have tried to keep the form short, clear and aesthetically pleasing. We provided an easy-to-use response interface (online mark-up) and, in addition to clarity, we were also concerned with language and vocabulary that was appropriate for the target group.

3. Results and discussion

To describe the composition of the sample, questions 1-8 of the questionnaire were analyzed.

A total of 94 responses were analyzed for Hungarian companies. Since only Hungarian companies were explicitly included in our study, the country of the company's registered office was Hungary in all cases. The headquarters of the surveyed companies were given by five types of headquarters, as shown in Table 1. About a third of the respondents were from companies with headquarters in cities from 150 000 to 500 000 inhabitants. About a quarter of the responses were from companies with headquarters in cities from 20 000 to 150 000 inhabitants. The lowest response (only 6.4%) was from companies of rural areas.

Table 1. Company headquarters

Answer	N	%
city above of 500 000 residents	14	14.9%
city from 150 000 to 500 000 residents	31	33.0%
city from 20 000 to 150 000 residents	25	26.6%
city to 20 000 residents	18	19.1%
rural area	6	6.4%
TOTAL	94	100.0%

Source: own study.

The distribution of companies by number of residents is shown in Figure 1.

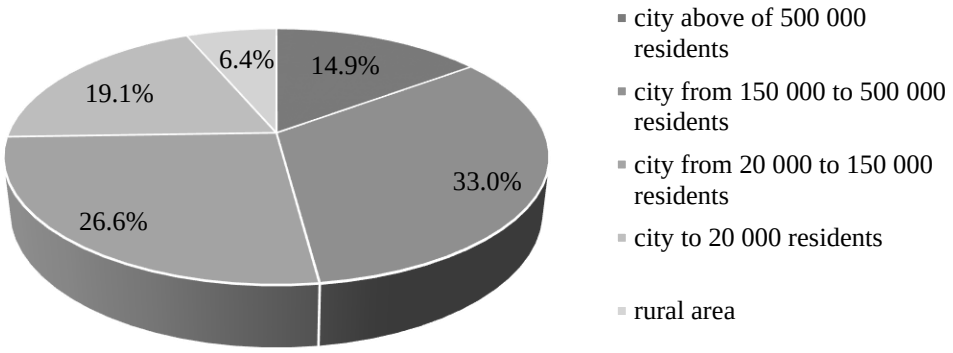

Figure 1. Distribution of surveyed enterprises by number of residents
Source: own study.

Based on the size of the company, the questionnaire offered a choice between the following types:

- Large,
- Medium,

- Micro,
- Small.

Based on the responses received from Hungarian companies, medium and small companies were equally represented in the sample (29.8%), while large companies were represented by 24.4%. The smallest proportion (16%) was made up of micro enterprises (Table 2).

Table 2. Enterprise type by size

Answer	N	%
large	23	24.4%
medium	28	29.8%
micro	15	16.0%
small	28	29.8%
TOTAL	94	100.0%

Source: own study.

The distribution of companies by size is shown in Figure 2.

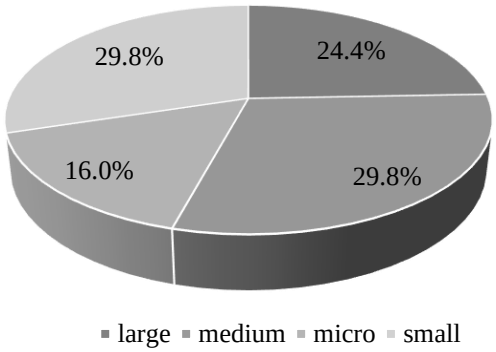

Figure 2. Distribution of surveyed enterprises by size
Source: own study.

In terms of corporate activity, we distinguish between international, local, national and regional level companies (Table 3).

Table 3. Range of corporate activity

Answer	N	%
international	39	41.5%
local	21	22.3%
national	22	23.4%
regional	12	12.8%
TOTAL	94	100.0%

Source: own study.

41.5% of respondents operate as international companies. The proportion of local and national companies is almost the same (22.3% and 23.4% respectively), while the lowest proportion is represented by regional companies (12.8%). The distribution of companies by range of activity is shown in Figure 3.

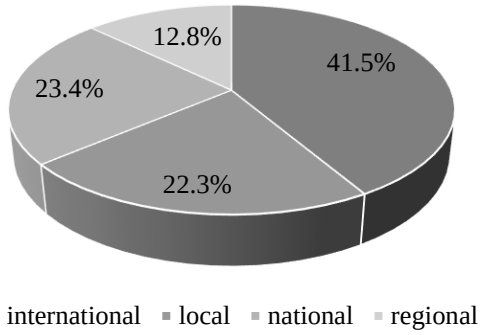

Figure 3. Distribution of surveyed enterprises by range of activity
Source: own study.

In the questionnaire, we paid particular attention to the question whether the company in question applied the following ISO or EMAS schemes (Table 4):

- ISO 9001:2015 system,
- ISO 9001:2000 system, ISO 14001:2015 system or EMAS system.

Table 4. Implementation of ISO or EMAS systems

	ISO 9001:2015 system		**ISO 14001:2015 system or EMAS system**	
	N	%	N	%
during implementation	12	12.8%	8	8.5%
not known	1	1.1%	3	3.2%
no	19	20.1%	54	57.4%
yes	62	66.0%	29	30.9%

Source: own study.

According to the answers, 66% of the companies surveyed apply ISO 9001:2015 system, while 30.9% apply ISO 14001:2015 system or EMAS system. 20.1% of the companies surveyed do not apply ISO 9001:2015 system, and this proportion is even more negative for ISO 14001:2015 system or EMAS system (57.4%). The implementation of these systems is underway in some of the companies surveyed (12.8% and 8.5% respectively).

In the questionnaire we also paid attention to the question "What area of the electromechanical industry does the company operate in? Around a third of respondents

are from the machine area, while the smallest proportion of respondents are received from the precise area (Table 5).

Table 5. Area of electromechanical industry of the enterprises

Answer	N	%
electrotechnical and electronic	18	19.1%
machine	34	36.2%
means of transport	21	22.3%
metal industry	12	12.8%
precise	9	9.6%
TOTAL	94	100.0%

Source: own study.

The distribution of companies by area of electromechanical industry is shown in Figure 4.

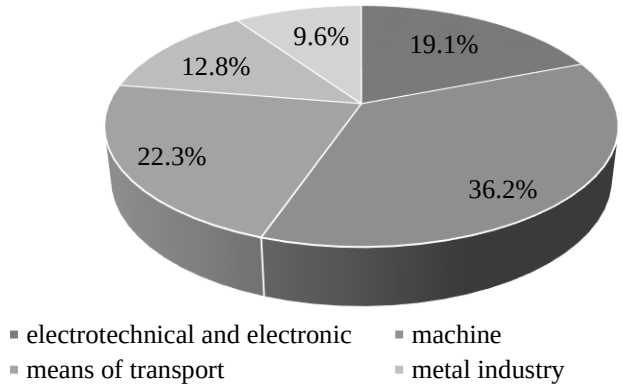

Figure 4. Distribution of surveyed enterprises by area of electromechanical industry
Source: own study.

As a final step, we analyzed the form of the companies included in the study in the following structure:

- Partnership,
- Capital Company.

In terms of Partnership (Table 6), almost half of the companies surveyed are Limited Partnerships, while only 5.3% are Limited Joint Stock Partnerships. In terms of Capital Company (Table 7), around 56.4% of the responses are Limited Liability Companies, while the lowest proportion is Joint Stock Companies (8.5%).

Table 6. Organizational and legal form - Partnership

Partnership	N	%
General Partnership	19	20.3%
Limited Joint Stock Partnership	5	5.3%
Limited Partnership	46	48.9%
Partnership	24	25.5%
TOTAL	94	100.0%

Source: own study.

Table 7. Organizational and legal form – Capital Company

Capital Company	N	%
Joint Stock Company	8	8.5%
Limited Liability Company	53	56.4%
Simple Joint	10	10.6%
Stock Company	23	24.5%
TOTAL	94	100.0%

Source: own study.

After the introductory questions, the first part of the questionnaire focuses on quality. This chapter provides an overview of the questions on quality, but the full analysis is also available in further chapters prepared with the co-authors.

The quality section of the questionnaire seeks answers to the following research sub-questions:

- How often actions to improve products' quality are taken in the enterprise?,
- How often action to improve products' quality, but considering customers' expectations are taken in the enterprise?,
- How often in the enterprise actions to compare the quality of products with the quality of the same types of competitive products are taken?,
- and asks respondents for their opinion on 14 statements focusing on the quality of the product and the behaviour and awareness of the customers (Likert scale).

For the three sub-questions on frequency, the possible answers on a rating scale were as follows:

- 1 – they are not taken,
- 2 – less than once every three years,
- 3 – once every two to three years,
- 4 – once a year,
- 5 – more than once year.

The frequency of actions taken to improve product quality is shown in Figure 5.34% of respondents (32 companies in total) said that their organization takes measures to improve the quality of its products several times a year. 26.6% of the companies surveyed (25 companies in total) take similar measures once a year, i.e. more than 60% of the respondents (57 companies in total) take quality improvement measures at least once a year. Only 1.1% of respondents (1 company in total) said that they do not take any measures to improve quality in their company.

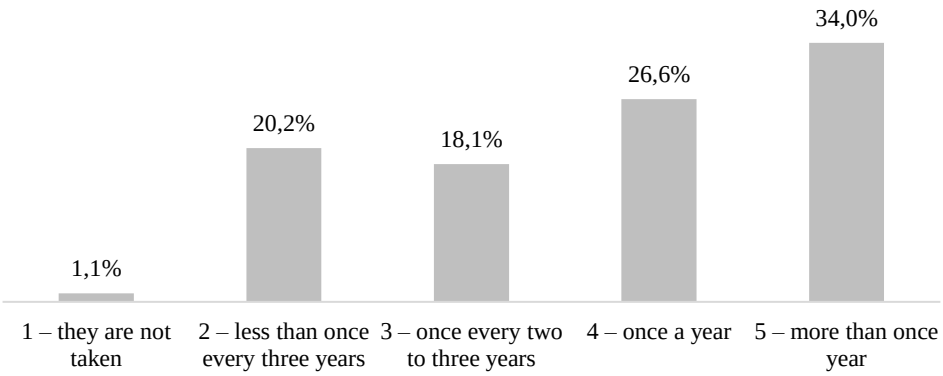

Figure 5. Frequency of actions taken to improve product quality
Source: own study.

The next question, in addition to the previous question, asked how often respondents carry out product development taking into account customer requirements (Figure 6). Almost 64% of the companies surveyed (60 companies in total) take customer requirements into account at least once a year, and only 1.1% (one company in total) said that their company does not take any action to improve quality based on customer requirements.

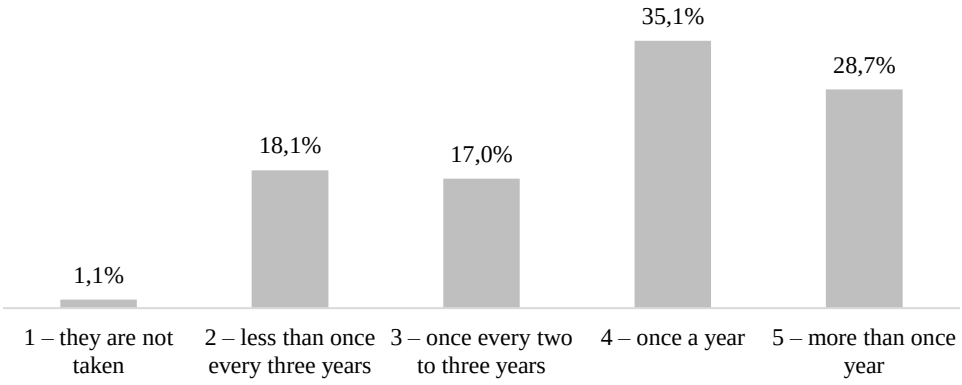

Figure 6. Frequency of actions taken to improve product quality based on customers' expectations
Source: own study.

The questionnaire also sought answers to the following question: how often in the enterprise actions to compare the quality of products with the quality of the same types of competitive products are taken? The answers to this question are presented in Figure 7. 54.3% of the companies surveyed (51 companies in total) carry out a comparison once a year and more than ¾ of the companies (71 companies in total) pay attention to this question at least once a year. Only 1.1% of companies (1 company in total) stated that their company does not take any action to improve quality by comparing with other similar products.

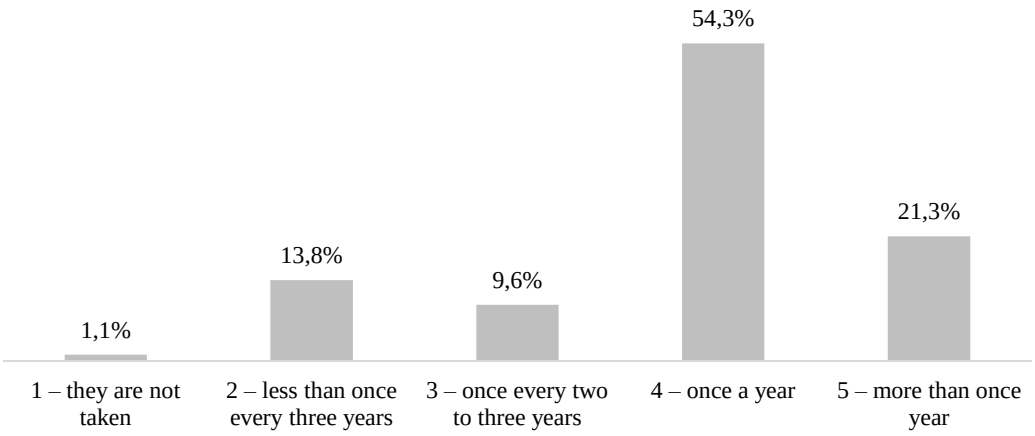

Figure 7. Frequency of actions taken to improve product quality compared to other competitive products
Source: own study.

In the final set of questions on quality, respondents expressed their views on 14 statements using a Likert scale. The possible responses, which indicate the level of agreement of respondents:

- 1 - I totally don't agree,
- 2 - I partly agree,
- 3 - I don’t know,
- 4 – I mostly agree,
- 5 - I totally agree.

The statements tested and their corresponding mean values are presented in Table 8. From the table it is clear that for 10 statements, respondents mostly agree, with the highest proportions agreeing on the following: the link between higher quality and higher price, higher price deterrence, and the importance of product quality by all actors in the supply chain.

Table 8. Likert scale statements on product quality and customer expectations

No.	Statement	Average of the point values of the responses	Evaluation
1	All customers in the supply chain attach great importance to the quality of products	4.05	Mostly agree
2	Customers will pay more if they get high quality product	3.29	Not known
3	A high-quality product is the product that meets the current requirements of customers	3.63	Mostly agree
4	Currently, high-quality products have also a high level of environmental friendliness	3.38	Not known
5	Wealthy customers usually choose high-quality products	3.71	Mostly agree
6	Choosing a high-quality product can improve a customer's self-esteem	3.64	Mostly agree
7	Customers pay attention to the high-quality of packaging of product	3.32	Not known
8	High-quality products are sufficiently promoted	3.64	Mostly agree
9	We as a company strive to continuously improve products' quality	3.97	Mostly agree
10	The higher price of high-quality products significantly discourages customers from buying them	4.13	Mostly agree
11	Customers are more likely to buy a high-quality product if it has been previously recommended/tested	3.39	Not known
12	Customers have a lot of knowledge about the attributes of products that affect their high quality	3.69	Mostly agree
13	Higher quality products have a higher price	4.19	Mostly agree
14	Customers will pay more for products from enterprises that are active in improving the quality of products	3.67	Mostly agree

Source: own study.

4. Conclusion

This chapter presents the results of a survey of Hungarian manufacturing SMEs in the electromechanical industry. Further results of the survey are presented in studies carried out with the co-authors. Based on the results, it can be concluded that the quality and development of products, as well as customer expectations in terms of quality, are of paramount importance for the Hungarian companies surveyed. For the project as a whole, it can be concluded that the presentation of the opinions of the V4 companies belonging to the SMEs of the electromechanical industry on product quality and environmental awareness allows new conclusions to be drawn. In addition, the project will provide new insights into product design in line with the rules of sustainable development, taking into account the current approach of V4 companies and customers to environmentally friendly product quality management. In the light of the results, it will be possible to develop a set of good practices that will be very useful for SMEs in the electromechanical sector in the V4 countries. In conclusion, the results of the survey and the overall project will provide desirable results for companies in the V4

countries and worldwide to establish an innovative and sustainable approach to the design and manufacture of environmentally friendly products.

Acknowledgements

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CHAPTER 7

OUTLOOK FOR THE FUTURE DEVELOPMENT OF ENVIRONMENTALLY FRIENDLY ACTIVITIES AMONG HUNGARIAN COMPANIES

Gabriella METSZŐSY, Krisztina VARGA, László MOLNÁR, Szabolcs NAGY

As Hungary continues to integrate into the global economy, the focus on environmentally friendly activities among Hungarian companies is growing. The shift towards sustainability is not only a moral imperative but also presents significant opportunities for innovation and a competitive advantage in the business landscape. In this chapter, we present the future-oriented perspectives of Hungarian organizations regarding pro-ecological solutions, with a primary focus on sustainability approaches, especially in terms of packaging. The chapter also explores product improvement while simultaneously minimizing the negative impact on the natural environment. Through the analysis, we aim to comprehend the current perceptions of Hungarian organizations concerning the relationship between quality and pro-ecological solutions, their future development opportunities, and the factors that play a crucial role in these organizations' implementation of pro-ecological activities.

Keywords: quality, environmental consciousness, electromechanical industry, Hungary, future development

1. Introduction

In recent years, there has been a growing awareness among Hungarian companies regarding the importance of environmental sustainability[1]. This trend is driven by various factors, including increasing regulatory requirements, evolving consumer preferences, and the escalating need to address global environmental challenges such as climate change and resource depletion[2]. Organizations are adopting more sustainable practices, aiming to reduce waste and enhance resource efficiency. However, the extent and nature of these practices vary significantly based on company size and geographical location[3]. Larger corporations, often equipped with more resources, have been able to implement more comprehensive environmental strategies, while smaller enterprises are progressively adopting

[1] A. Csizmafy, Z. Ferencz, L. Kőszeghy, G. Tóth, *Beyond the Energy Poor/Non Energy Poor Divide: Energy Vulnerability and Mindsets on Energy Generation Modes in Hungary*, Energies 2021, 14(20), 6487.
[2] A. Buzási, B.Sz. Jäger, *District-scale assessment of urban sustainability*, Sustainable Cities and Society, 2020, 62, 102388.
[3] V. Surman, E. Böcskei, *The SDG relevance-presence map of Hungarian SMEs - The relationship between the SDGs and the three pillar model*, Cleaner Environmental Systems, 2023, 11, 100144.

sustainable practices, albeit at a slower pace. As a result, Hungarian businesses are increasingly recognizing the value of incorporating environmentally friendly practices into their operations.

Companies are increasingly viewing sustainability as a driver of innovation and competitive advantage rather than just a compliance requirement. The adoption of ISO 9001:2015 has played a crucial role in this shift. This international standard for quality management systems has provided a framework for organizations to improve efficiency, reduce waste, and ensure quality, all of which contribute to broader sustainability goals. The adoption rates of ISO 9001:2015 vary, with larger companies and those in urban areas more likely to implement these practices, largely due to greater access to resources and expertise. Two-thirds of the organizations surveyed have already implemented ISO 9001:2015, and an additional 12.80% are in the process of introducing it. A less favorable ratio is observed in the case of the Environmental Management System (ISO 14001:2015), which is utilized by only about one-third (30.9%) of the respondents. With the implementation of an Environmental Management System, organizations can develop solutions that support the formulation of processes leading to environmental changes, aimed at enhancing innovativeness and competitiveness[4].

2. Research method

In 2023, two surveys were carried out in the Visegrad Group nations as a component of the Qualitative-Environmental Aspects of Products Improvement project (IVF 22230264), funded by the International Visegrad Fund. The first questionnaire was surveyed among electromechanical industry companies regarding their pro-ecological behavior, sustainability, and the quality provided to customers. The second questionnaire targeted potential customers, complementing the information received from the organizations. In this chapter, we present the responses to the first questionnaire, focusing specifically on views related to future-oriented questions:

- Is the enterprise planning investment in pro-ecological solutions in the next three years? (Q19),
- Evaluate the importance (on a scale of 1-5) of the motives inducing company managers to undertake pro-ecological activities (Q22),

[4] M. Urbaniec, *Implementation of International Standards for Environmental Management in Visegrad Countries: a Comparative Analysis*, Entrepreneurial Business and Economics Review, 2014, 2(2), pp. 65-76.

- To what extent (on a scale of 1-5) do you agree with the following statements concerning the importance of packaging features in the context of sustainability design of packaging for the Circular Economy (Q32),
- What is your opinion on the direction of the company's development? (Q35),
- During last 5 years determine whether the number of good quality and environmentally friendly products produced in the enterprise (Q36),
- Indicate what actions should be expected from the companies as the part of improving products and minimizing the negative impact on the natural environment (Q41),
- Which media are used to promote high-quality and environmentally friendly products on the market? (Q44).

3. Results and discussion

This subsection presents the research results of the survey related to the pro-environmental behavior of Hungarian manufacturing companies in the electromechanical industry, focusing on the future development of environmentally friendly activities.

At the beginning of the analysis, it is crucial to understand the plans of the analyzed organizations in terms of future investment in pro-ecological solutions. Figure 1 illustrates the distribution of these plans.

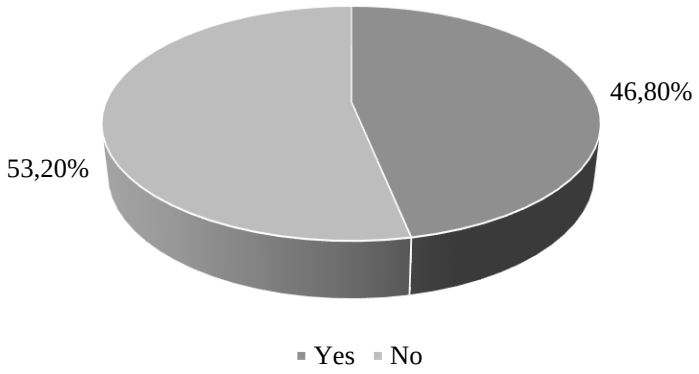

Figure 1. Future investment planning in pro-ecological solutions in the next three years (N=94)
Source: own study.

The distribution between organizations planning to invest (46.8%) and those not planning to invest (53.2%) in pro-ecological solutions is nearly equal. Although this concerns the short term, it appears insufficient given the rapidly changing environment and continuous environmental strain. There is a significant difference among organizations based on their location and range of activity. Proportionally, organizations headquartered in Budapest and engaging in international activities are planning to invest in pro-ecological solutions over

the next three years. They are followed by organizations conducting regional activities. Organizations operating at a national level, particularly those in small towns and localities, are the least likely to plan investments of this nature. There is also a correlation between organizations planning to implement ISO 9001:2015 and future investments. Specifically, those organizations currently in the implementation phase are more likely to plan investments in the coming years. In contrast, only 21% of the organizations that do not apply the standard plan such investments. Among those who have already implemented ISO 9001:2015, the ratio planning to invest is evenly split. The relationship becomes less clear in the case of ISO 14001:2015. All organizations who currently implementing this standard plan pro-ecological investments in the near future. However, a higher proportion (37%) of those that have not implemented the standard also plan such investments. Among organizations that already apply ISO 14001:2015, in this case, as well, the ratio planning to invest is evenly divided. Additionally, organizations that conduct quality improvement activities more frequently (once a year or more than once a year) are proportionally less likely to be planning investment in pro-ecological solutions in the near future.

The participants were asked to evaluate their motivation for implementing pro-ecological activities through 14 statements on a 1-5 Likert scale, where 1 represented “it is definitely not important” and 5 signified “it is definitely important.” 48 organizations did not complete this assessment, because they are not planning investment in pro-ecological solutions in the next three years thus the analysis in this matter is based on the responses of 46 organizations who are planning to invest in the near future. The evaluation of the responses is illustrated in Figure 2.

The participants considered the rational use of natural resources in production to be the most important, with this statement receiving the highest rating (a score of 5) from 19 respondents. Additionally, the statements regarding reducing the costs of negative environmental impact (e.g., compensation, penalties) and reducing the harmful impact of the product on the environment, taking into account Life Cycle Assessment (LCA) (noise, waste, sewage), were also marked as important. These findings suggest that both external and internal driving forces play a role in motivation. Factors related to financials generally received higher average ratings, while external societal pressure and national policy, as well as gaining new markets, although also receiving good scores, were ranked lower. It is interesting to note that although the statement regarding expansion into new markets was marked as “definitely important” by the highest proportion of participants, it still ranks among the lowest on average.

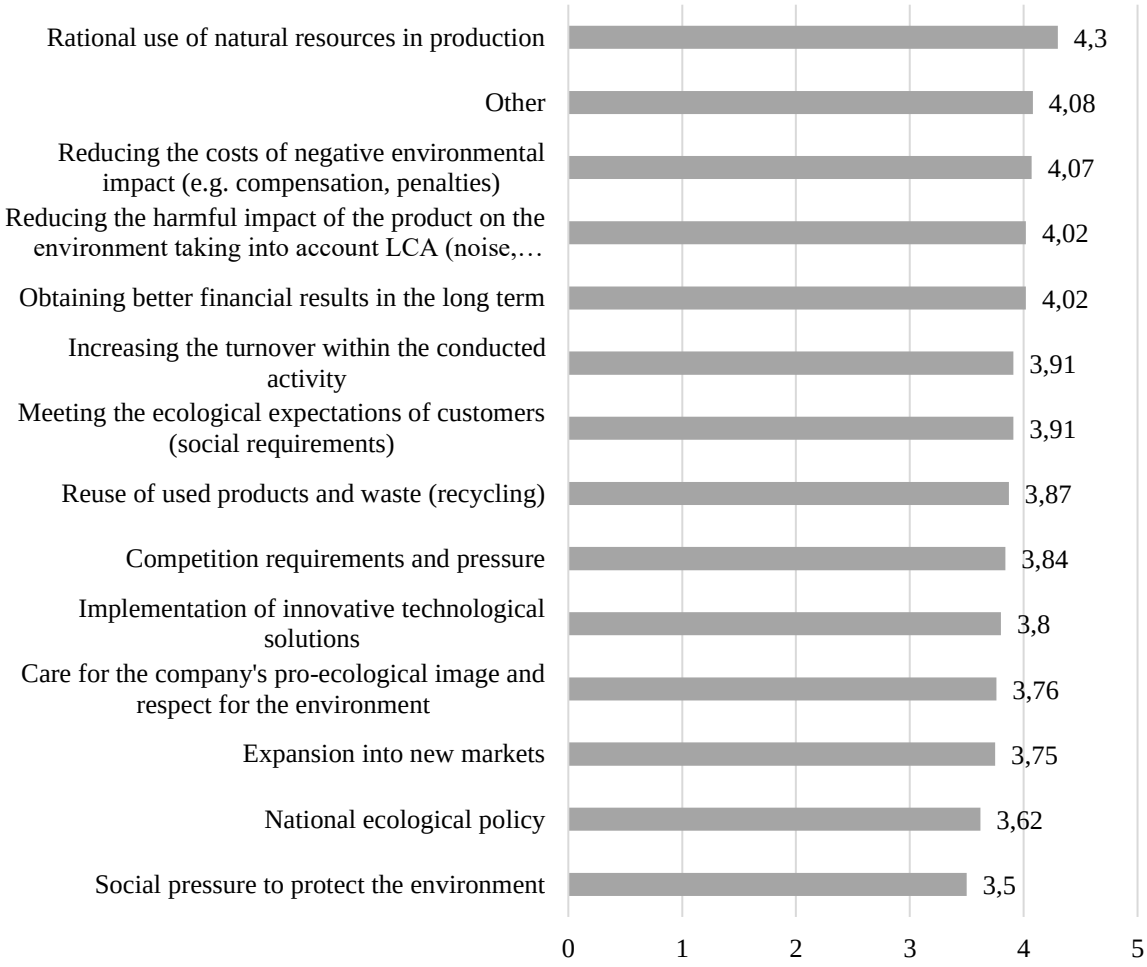

Figure 2. Importance of motives to undertake pro-ecological activities (means, N=46)
Source: own study.

Regarding the importance of packaging characteristics, the organizations were required to evaluate 20 statements on a scale ranging from 1 to 5. Each statement was related to the design of sustainable packaging. The evaluation of the responses is illustrated in Figure 3.

The topic of sustainable packaging is considered important by the responding organizations from the perspective of the circular economy. Based on the evaluations, there was a stronger agreement particularly with factors related to recycling and safety, as well as the higher production costs. In contrast, the statements related to savings received less agreement. However, even though these had the lowest averages, more than half of the respondents tend to view sustainable packaging merely as a marketing ploy without real value. Interestingly, although the focus of this section was on the sustainability design of packaging, there was not a strong consensus on the belief that the packaging should be ecological.

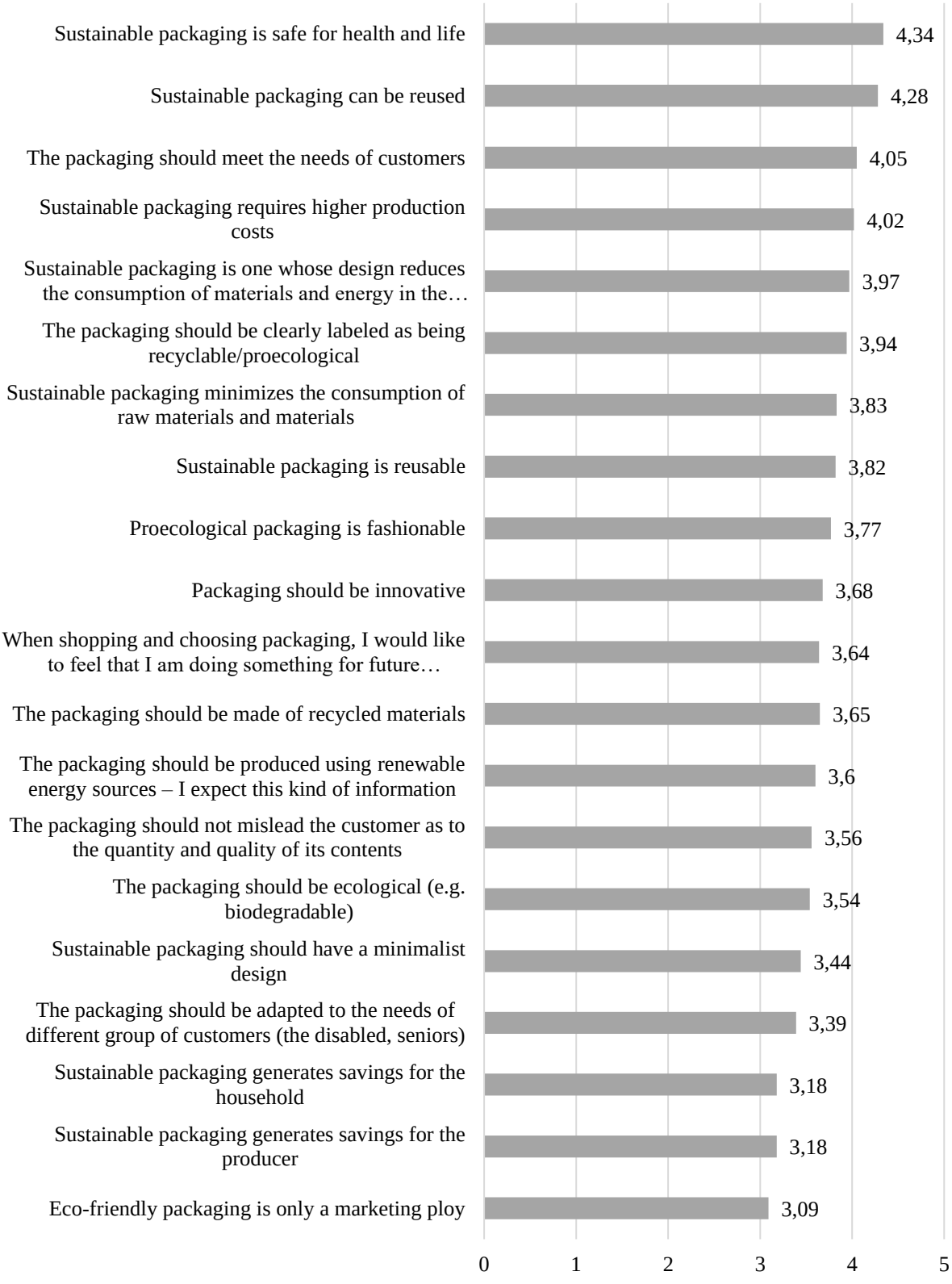

Figure 3. Importance of packaging features for sustainability (means, N=94)
Source: own study.

Regarding future directions, respondents were required to indicate how they expect their organization's performance to change in terms of product quality and environmentally friendly products. They were asked to specify whether they anticipate a decrease, increase, or stagnation in performance. The distribution of the received responses is presented in Table 1.

Table 1. Direction of the company's development (N=94)

Answer	N	%
It is hard to say	22	23.4%
The production of high-quality, but less environmentally friendly products is going to increase	20	21.3%
The production of more or less current quality but less and less environmentally friendly of products is going to increase	17	18.1%
The production of current quality & more and more environmentally friendly products is going to increase	14	14.9%
The production of more or less current quality but increasingly environmentally friendly products of is going to increase	21	22.3%

Source: own study.

The distribution of opinions is similar, with the largest proportion (23.4%) unable to express an opinion regarding the direction of development. However, the fewest (14.9%) stated that they could produce an increasing number of environmentally friendly products while maintaining the current quality. This suggests that organizations do not believe that maintaining or even improving quality would be compatible with the production of increasingly environmentally friendly products. This is supported by the opinions of those (21.3%) who expect to produce high-quality products in the future, but in a less environmentally friendly manner, indicating that in many cases, quality and environmentally friendly characteristics may have an inverse relationship.

This relates to a question that examines the change in the production of good quality and environmentally friendly products over the past five years. The rapid changes of recent decades and the negative impacts on the environment would suggest an increase in the number of environmentally friendly products. However, there is also the consumer expectation that good quality should not change but should evolve with technological advancements. The related opinions are presented in Figure 4.

According to the largest proportion of respondents (39.4%), there was no change in the production of good quality and environmentally friendly products in the past five years, and 31.9% were unsure whether there had been any change. The rates of increase and decrease appeared nearly identical in the responses, at 14.9% and 13.8% respectively. A correlation can be observed between the changes that occurred in the past five years and the direction

of the company's development. In cases where there was an observed increase in the production of good quality and environmentally friendly products in the past five years, there was a higher tendency to project an increase in the production of environmentally friendly products in the future. Conversely, in instances where there was a decrease in the past five years, there is a tendency to project a future decrease in the production of environmentally friendly products.

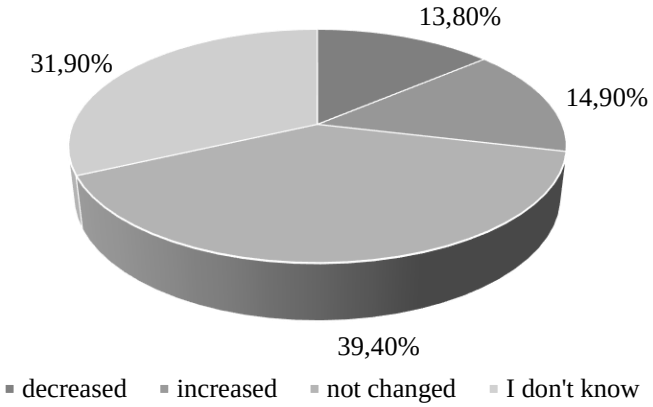

Figure 4. Changes in number of good quality and environmentally friendly products (N=94)
Source: own study.

In relation to the expected future actions, participants were required to evaluate 16 statements based on whether certain measures are anticipated and should be expected in order to improve products and minimize the negative impact on the natural environment. The results are thought-provoking, as in several cases, factors that should be considered fundamental were marked as not expected. The summary of the results is illustrated in Figure 5.

On average, actions requiring less investment received greater support, while those necessitating more organization and process transformation showed lagging support. "Compliance with the law" as an action was defined as the most expected by the participants, with 43.6% considering it "definitely can be expected," and not a single respondent considered it "cannot be expected." However, nearly a quarter of the respondents (23.4%) viewed the "implementation and functioning of an environmental management system" as not expected, and support was similarly low for a quality management system. This attitude was characteristic only of micro, small, and medium enterprises; none of the large enterprise representatives participating in the survey stated that these implementations "cannot be expected." In their case, "it can be expected" (a rating of 3) was the lowest. These differences are also evident on a geographical basis, with organizations based in small towns and localities showing a greater lack of support for the implementation of management systems.

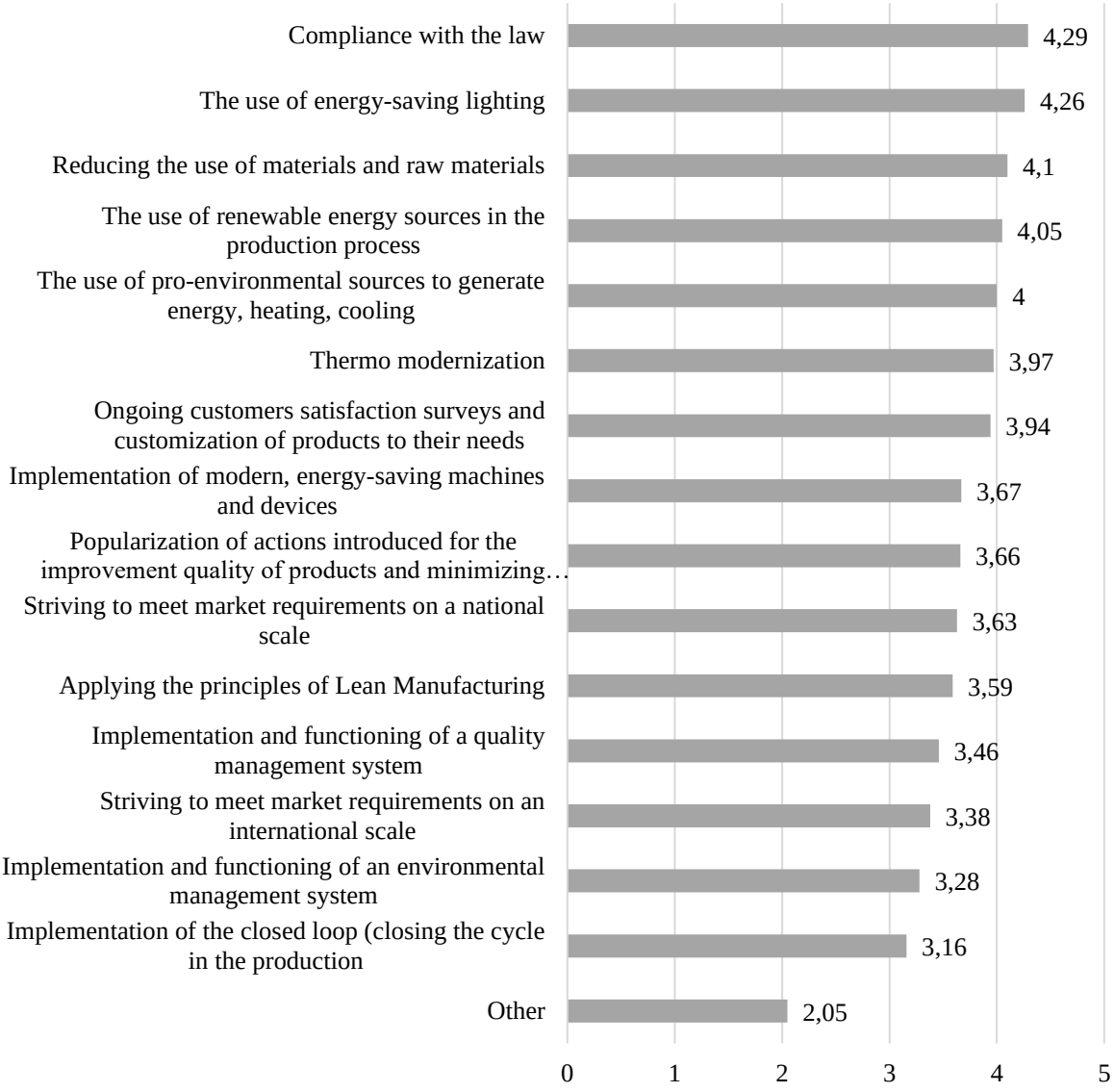

Figure 5. Actions should be taken for improving products and minimizing the negative impact on the natural environment (means, N=94)
Source: own study.

As the final question of the survey, organizations were asked about the advertising platforms they use to promote high-quality and environmentally friendly products. The responses received are illustrated in Table 2.

Nearly two-thirds of the responding organizations (63.8%) use only the internet as a tool for promotion, and only 19.1% utilize other media in addition to the internet. This shift in proportions is understandable, as nowadays people less frequently buy newspapers, listen to the radio, and many try to avoid television advertisements. Only 6.4% of the respondents considered satisfied customers as a suitable medium for this purpose. However, in the era

of online shopping and information gathering, the opinions shared by acquaintances about a product can be crucial in determining the outcome of a purchase.

Table 2. Media usage for promotion (N=94)

Answer	N	%
None of those listed	10	10.6%
Satisfied customers	6	6.4%
Television, the Internet	2	2.1%
Television, the Internet, newspapers / magazines	8	8.5%
Television, the Internet, newspapers / magazines, radio	2	2.1%
Television, the Internet, radio	1	1.1%
The Internet	60	63.8%
The Internet, newspapers / magazines	5	5.3%

Source: own study.

5. Conclusion

This chapter presents the results of the future perspective analysis based on a survey of Hungarian manufacturing companies belonging to SMEs in the electromechanical industry.

The analysis indicates that the opinions of the responding organizations are not uniform, with significant differences evident between organizations based on their location and range of activity. Generally, there is an awareness of sustainability issues, but maintaining the provided and perceived quality is a more crucial aspect in the life of these organizations than the introduction of pro-ecological solutions, which many believe could only be achieved at the expense of quality using their available resources. They tend to support actions that require less investment but create the appearance of environmental concern. Additionally, packaging issues are treated as a prominent aspect, an area that has become increasingly important in recent years, with the acquisition of necessary expertise and the initiation of professional training dating back to recent years. Therefore, it can be said that Hungarian organizations still have room for improvement in pro-ecological behavior, not by competing with quality, but by considering it as a complement that supports sustainability and encourages customers towards the market of environmentally friendly products.

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February 1, 2023 to March 31, 2024: Applicant: Politechnika Rzeszowska im. Ignacy Łukasiewicz. Rzeszow University of Technology, Rzeszów, PL.

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4. Urbaniec M., *Implementation of International Standards for Environmental Management in Visegrad Countries: a Comparative Analysis*, Entrepreneurial Business and Economics Review, 2014, 2(2), 65-76. DOI: https://doi.org/10.15678/eber.2014.020206.

CHAPTER 8

"DO FACTORS INFLUENCING SATISFACTION IN PURCHASING PRODUCTS IN THE ELECTROMECHANICAL INDUSTRY CONSIDER A PROECOLOGICAL APPROACH?"

Marzena HAJDUK-STELMACHOWICZ, Paulina BEŁCH,
Katarzyna CHUDY-LASKOWSKA, Gabriella METSZŐSY

The determination of factors influencing the level of satisfaction with the purchase of environmentally friendly products within the electromechanical industry, catering to both individual and business customers, is a multifaceted inquiry that demands a comprehensive investigation. A thorough analysis of the pertinent literature reveals several key determinants that warrant consideration: product performance and reliability; financial considerations; environmental consumer awareness; Corporate Social Responsibility (CSR) Initiatives and ESG, innovation and technological advancements; more than regulatory compliance; supply chain transparency; post-purchase support and services.

Keywords: factors, satisfaction in purchasing, electromechanical industry

1. Introduction

The latest rankings related to EU countries are intriguing, encompassing two composite indicators for the production and consumption domain. The first indicator pertains to production and consumption, utilized to measure the progress of the EU Action Plan for the Circular Economy. The second indicator involves responsible consumption and production, applied for monitoring advancements in achieving the sustainable development goals outlined in the UN Agenda 2030.The position of the Visegrad Group countries in the comparison of both indicators is presented in Table 1 and Table 2. Ranking 19th, considering variables from Goal 12 (Agenda 2030), are the Czech Republic, while the three bottom positions (25th to 27th) in the ranking are occupied by Hungary, Slovakia, and Poland (Table 1).

In the second ranking of the European Union countries concerning variables from production and consumption (CEAP) (Table 2), among the Visegrad Group countries, Slovakia secured the 4th position, Hungary the 6th position, Czechia the 15th position, and Poland the 25th position.

Table 1. Ranking of the European Union countries concerning variables from Goal 12 (Agenda 2030)

Country	Energy productivity	Raw material consumption 2019	Average CO2 emissions per km from new passenger cars	Circular material use rate	Generation of waste excluding major mineral wastes by hazardousness	Synthetic measure	Ranking
Netherlands	10	12	1	1	24	9.47	1
Denmark	2	14	3	15	16	10	2
Malta	26	1	7	14	1	10.17	3
France	7	26	5	3	14	10.75	4
Slovenia	15	4	16	9	9	10.89	5
Luxembourg	3	2	21	6	22	10.94	6
Croatia	17	7	12	20	3	12.03	7
Ireland	1	10	8	26	15	12.08	8
Italy	4	24	11	4	19	12.14	9
Spain	9	22	13	11	11	12.94	10
Belgium	14	13	10	2	26	12.97	11
Sweden	8	21	2	16	21	13.39	12.5
Portugal	12	18	4	25	8	13.39	12.5
Austria	6	20	14	10	18	13.42	14
Germany	5	27	15	7.5	17	13.93	15
Latvia	19	5	19	22	7	14.61	16
Finland	16	17	6	18	23	15.81	17
Lithuania	21	8	20	21	13	16.64	18
Czechia	24	19	22	7.5	12	16.82	19
Romania	18	23	17	27	2	17.22	20
Estonia	25	6	23	5	27	17.25	21
Bulgaria	27	15	27	24	25	18.02	22
Greece	13	11	9	19	6	18.41	23
Cyprus	11	3	25.5	23	5	18.80	24
Hungary	22	16	18	13	4	19.19	25
Slovakia	20	9	24	17	10	19.58	26
Poland	23	25	25.5	12	20	20.74	27

Source: A. Migała-Warchoł, B. Ziółkowski, P. Babiarz, *The circular economy vs the sustainable development approach to production and consumption: the case of the European Union Countries*, Humanities and Social Sciences, Research Journal 30, No. 2 (2023), pp 59-74, DOI: 10.7862/rz.2023.hss.15.

Table 2. Ranking of the European Union countries concerning variables from production and consumption (CEAP)

Country	Material footprint 2019	Resource productivity	Generation of municipal waste per capita	Generation of waste excluding major mineral wastes per GDP	Generation of waste excluding major mineral wastes per domestic material	Waste generation per capita	Generation of packaging waste per capita 2019	Generation of plastic packaging waste per capita 2019	Synthetic measure	Ranking
Croatia	8	19	5	19	12.5	1	1	1	8.31	1
Cyprus	19	16	21	4	2	9	4	2	9.63	2
Greece	4	13	15	15.5	19	6	3	3	9.81	3
Slovakia	**7**	**15**	**7**	**20**	**18**	**7**	**6**	**9**	**11.13**	**4**
Slovenia	10	14	13	13	16	13	7	6	11.44	5
Hungary	**11**	**22**	**4**	**17**	**6**	**4**	**13**	**18**	**11.88**	**6**
Sweden	22	11	6	5.5	9.5	25	10	7	12	7
Spain	2	8	9	11.5	23	5	19	20	12.19	8.5
Latvia	15	21	10	22.5	11	2	12	4	12.19	8.5
Malta	13	12	23	5.5	8	18	14	15	13.56	10
Netherlands	1	1	16	11.5	27	20	20	13	13.69	11
Lithuania	17	24	11	21	7	8	11	12	13.88	12
Ireland	21	4	19	2	3	10	27	27	14.13	13
Italy	3	3	13	14	25	11	24	21	14.19	14
Czechia	**14**	**18**	**18**	**18**	**14**	**14**	**8**	**10**	**14.25**	**15**
France	6	5	17	7	22	16	23	19	14.38	16
Denmark	20	9	26	3	5	12	18	23	14.5	17.5
Romania	26	27	1	24	1	21	5	11	14.5	17.5
Portugal	12	20	14	15.5	9.5	3	22	24	15	19
Finland	27	17	20	10	4	27	9	8	15.25	20
Belgium	5	6	24	22.5	26	19	16	14	16.56	22
Bulgaria	18	26	8	27	20.5	26	2	5	16.56	22
Germany	9	7	22	9	20.5	17	26	22	16.56	22
Austria	23	10	27	8	12.5	22	17	16	16.94	24
Poland	**16**	**23**	**2**	**25**	**17**	**15**	**21**	**17**	**17**	**25**
Luxembourg	24	2	25	1	15	24	25	25	17.63	26
Estonia	25	25	3	26	24	23	15	26	20.88	27

Source: A. Migała-Warchoł, B. Ziółkowski, P. Babiarz, *The circular economy vs the sustainable development approach to production and consumption: the case of the European Union Countries*, Humanities and Social Sciences, Research Journal 30, No. 2 (2023), pp. 59-74, DOI: 10.7862/rz.2023.hss.15.

The observation reveals that countries with higher levels of industrialization performed less favorably. This implies a necessity for these nations to allocate increased resources towards addressing environmental concerns, especially when analyzing data related to production and consumption[1].

This chapter constitutes another in a series of publications resulting from ongoing international scientific endeavors titled "Qualitative-environmental aspects of products improvement". The research conducted in Hungary, Poland, the Czech Republic, and Slovakia was financed by the International Visegrad Fund for the years 2023-2024 (grant number IVF 22230264).

2. Satisfaction Factors in Purchasing Eco-Friendly Products – Theoretical Approach

The determination of factors influencing the level of satisfaction with the purchase[2] of environmentally friendly products within the electromechanical industry, catering to both individual and business customers, is a multifaceted inquiry that demands a comprehensive investigation. A thorough analysis of the pertinent literature reveals several key determinants that warrant consideration: product performance and reliability; financial considerations; environmental consumer awareness; Corporate Social Responsibility (CSR)[3] Initiatives and ESG[4], innovation and technological advancements; more than regulatory compliance; supply chain transparency; post-purchase support and services.

Product Performance and Reliability[5]. Assessing the extent to which environmentally friendly products meet performance expectations and exhibit reliability is critical. Customer

[1] A. Migała-Warchoł, B. Ziółkowski, P. Babiarz, *The circular economy vs the sustainable development approach to production and consumption: the case of the European Union Countries*, Humanities and Social Sciences, Research Journal 30, No. 2 (2023), pp 59-74, DOI: 10.7862/rz.2023.hss.15.

[2] Additional information on factors influencing post-purchase satisfaction can be found, among others, in the following publications: A. Sreeram, A. Kesharwani and S. Desai, *Factors affecting satisfaction and loyalty in online grocery shopping: an integrated model*, Journal of Indian Business Research, Vol. 9 No. 2/2016, pp. 107-132. https://doi.org/10.1108/JIBR-01-2016-0001; S. Khan, Y. Liang and S. Shahzad, *An Empirical Study of Perceived Factors Affecting Customer Satisfaction to Re-Purchase Intention in Online Stores in China*, Journal of Service Science and Management, 8/2015, pp. 291-305. doi: 10.4236/jssm.2015.83032; J.M. Garcia, O.B.D.L Freire , E.B.A. Santos and J. Andrade, *Factors affecting satisfaction and loyalty to online group buying*, Revista de Gestão, Vol. 27 No. 3/2020, pp. 211-228, https://doi.org/10.1108/REGE-02-2018-0037.

[3] D. Matten, J. Moon, *Corporate social responsibility*, Journal of business Ethics, 54/2004, 323-337; A.B. Carroll, *Corporate social responsibility*, "Organizational dynamics", 44.2 (2015), pp. 87-96.

[4] A.A. Egorova, S.V. Grishunin, A. M. Karminsky, *The Impact of ESG factors on the performance of Information Technology Companies*, Procedia Computer Science, Volume 199, 2022, https://doi.org/10.1016/j.procs.2022.01.041

[5] See: Y.M. Tang, A.W.H. Ip, Y. Shan Au, K.L. Yung, *Product performance model for product innovation, reliability and development in high-tech industries and a case study on the space instrument industry*, [in:] K.L. Yung, A. W.H. Ip, F.Xhafa, K.K. Tseng (Eds.), *In Aerospace Engineering*, IoT and Spacecraft Informatics, Elsevier, 2022, Pages 255-283, https://doi.org/10.1016/B978-0-12-821051-2.00006-4.

satisfaction is intrinsically tied to the product's ability to fulfill its intended functions effectively. A comprehensive analysis of product performance necessitates a meticulous examination of the alignment between environmentally friendly features and the intended purpose of the product. This entails a detailed scrutiny of factors such as energy efficiency, durability, and overall functionality. Customers accord significant importance to products that not only contribute to sustainability objectives but also excel in fulfilling their primary functions. Reliability, conversely, pertains to the enduring and dependable performance of the product throughout its lifecycle. This facet encompasses considerations such as the longevity of eco-friendly attributes, resistance to wear and tear, and the capacity to withstand diverse environmental conditions. Products demonstrating reliability instill confidence in consumers, thereby fortifying trust in both the product and the associated brand. Furthermore, given the dynamic nature of consumer preferences, environmentally friendly products must not only meet prevailing performance standards but also demonstrate adaptability and innovation. This dual imperative ensures the ongoing relevance and effectiveness of such products in addressing the continually evolving needs of consumers.

Financial considerations. The cost factor remains pivotal in consumer decision-making[6]. Evaluating whether the price of environmentally friendly products aligns with perceived value and affordability is imperative. Discerning evaluation extends beyond mere numerical values and delves into the intricate interplay between the perceived worth of the product and its alignment with the financial capacities of the consumer[7]. In this intricate calculus, consumers weigh the tangible and intangible benefits offered by environmentally friendly products against the monetary outlay required for their acquisition. The perceived value encompasses not only the immediate utility but also the long-term implications, including environmental impact, sustainability and circular economy. Moreover, the accessibility of these products hinges on several elements, encompassing individual financial limitations and the current economic milieu. Examples: An individual may have a restricted budget for purchases due to a low income or financial obligations such as loans and housing expenses. Rising energy prices can

[6] M. Hajduk-Stelmachowicz, P. Bełch, D. Siwiec, L. Bednarova, A. Pacana, *The use of instruments aimed at improving the quality of products (research results)*, Scientific Papers of Silesian University of Technology – Organization and Management Series – Issue No. 157/2022, DOI: http://dx.doi.org/10.29119/1641-3466.2022.157.10; D. Siwiec, P. Bełch, M. Hajduk-Stelmachowicz, A. Pacana, L. Bednarova, *Determinants of making decisions in improving the quality of products*, Scientific Papers of Silesian University of Technology – Organization and Management Series – Issue No. 157/2022, DOI: http://dx.doi.org/10.29119/1641-3466.2022.157.31

[7] K. Indounas, *Making effective pricing decisions*, Business Horizons, Volume 49, Issue 5, 2006, Pages 415-424, https://doi.org/10.1016/j.bushor.2006.02.003.

impact production and transportation costs[8], subsequently affecting the prices of products, including environmentally friendly ones. Companies may face financial constraints due to unforeseen expenses, prompting them to opt for cheaper, less environmentally friendly options. Changes in government policy, such as the introduction of new taxes or regulations that can influence the prices and availability of environmentally friendly products. The occurrence of a pandemic or a war can lead to economic uncertainties, impacting both individual and business financial situations and influencing purchasing decisions[9]. Natural disasters can disrupt supply chains, leading to shortages and increased costs for businesses, potentially affecting the pricing of eco-friendly products. A high inflation rate can erode purchasing power, making environmentally friendly products relatively more expensive compared to less sustainable alternatives.

As consumers traverse the marketplace, achieving equilibrium between cost and value becomes pivotal in shaping the decision-making process and fostering a persistent preference for environmentally friendly alternatives.

Consumer awareness regarding the environmental impact of the purchased products is instrumental[10]. Investigating how well-informed customers are about the ecological footprint of their choices contributes to understanding satisfaction levels. Understanding the social consequences arising from the exclusion of ecological and social objectives alongside economic goals in production processes is crucial[11]. This comprehension plays a pivotal role in fostering

[8] More information on transportation aspects within companies: P. Bełch, *Management of a transport company during the Covid-19 pandemic*, Scientific Papers of Silesian University of Technology, Organization and Management, Modernity of Industry and Sciences, red. J. Pyka, R. Wolniak, B. Skotnicka-Zasadzień, no. 150, Wydawnictwo Politechniki Śląskiej, Gliwice 2021, s. 7-16; Bełch P., *Zarządzanie przedsiębiorstwem handlowo-transportowym z sektora paliw płynnych w warunkach kryzysu a jego konkurencyjność*, [in:] *Społeczne, ekonomiczne i organizacyjne dylematy współczesnego zarządzania. Księga jubileuszowa dedykowana Profesorowi Andrzejowi Gaździe*, red. G. Ostasz, T. Olejarz, B. Zatwarnicka-Madura, Oficyna Wydawnicza Politechniki Rzeszowskiej, Rzeszów 2021, s. 39-55; Bełch P., *Analiza kosztów procesów logistycznych,* Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, Rachunkowość a controlling, nr 472, Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu, Wrocław 2017, s. 23-31; K. Piszcz, M. Hajduk-Stelmachowicz, *Aspekt kosztowy wyboru jako paliwa w transporcie dalekobieżnym*, [in:] L*ogistyczne, ekonomiczne i organizacyjne aspekty współczesnego zarządzania,* P. Bełch (red.), Oficyna Wydawnicza Politechniki Rzeszowskiej, Rzeszów 2023.

[9] See: Shao J., Ünal E., *What do consumers value more in green purchasing? Assessing the sustainability practices from demand side of business*, Journal of Cleaner Production, Volume 209, 2019, Pages 1473-1483, https://doi.org/10.1016/j.jclepro.2018.11.022.

[10] M. Shen, J. Wang, *The Impact of Pro-environmental Awareness Components on Green Consumption Behavior: The Moderation Effect of Consumer Perceived Cost, Policy Incentives, and Face Culture*. Front. Psychology 2022, vol. 13:580823. doi: 10.3389/fpsyg.2022.580823; M. Barbaritano, E. Savelli, *How Consumer Environmental Responsibility Affects the Purchasing Intention of Design Furniture Products*, Sustainability, 2021, *13*, 6140. https://doi.org/10.3390/su13116140.

[11] Y. Bilan, K. Chudy-Laskowska, E. Szczygieł, T. Piecuch, *The changing of the living standard as an element of sustainable development - an example of the Carpathian Euroregion's inhabitants*, Acta Polytechnica Hungarica, 2021, Vol. 18 No. 2, s. 105-125, DOI: 10.12700/APH.18.2.2021.2.6.

appropriate pro-environmental attitudes and behaviors. The triad of objectives should align with SMARTER principles and maintain credibility, encompassing not only financial reporting but also integrating Environmental, Social, and Governance (ESG) considerations[12]. In both short and long-term perspectives, it is essential to grasp the implications of:

- the utilization of natural resources, emission of harmful substances, and waste generation[13],
- ensuring proper employment conditions, encompassing safety, fair labor practices, work-life balance, and redefining economic efficiency metrics towards a deeper understanding of economic development[14],
- employed eco-friendly technologies (current and future), the significance and cost-effectiveness of implementing best practices, and various types of eco-innovations[15],
- addressing issues of exclusion and discrimination stemming from educational deficiencies, environmental knowledge deficits, limited means for accurate information verification by organizations, and financial constraints affecting poverty, societal aging, and digital exclusion,
- the impact analysis (throughout the product life cycle) on local communities concerning issues such as community engagement and philanthropy (because of growing infertility, mental health problems, civilization diseases or environmental degradation).

A circular economy should be endorsed and economically viable. For its effectiveness, it must extend to households, diverse organizations, and countries, including their various relationships[16], e.g., within the EU framework. All endeavors to enhance awareness and promote proper behaviors must be coherent, credible, inclusive, and just at micro, meso,

[12] I. Taylor, *Responsible government and responsible business: the challenge of harnessing CSR in a new epoch*, Int J Corporate Soc Responsibility, 8, 7 (2023). https://doi.org/10.1186/s40991-023-00083-7; Hsu SC., Wu, KT., Wang, Q. *et al. Is capital structure associated with corporate social responsibility?*, *Int J Corporate Soc Responsibility*, 8, 6 (2023). https://doi.org/10.1186/s40991-023-00081-9.

[13] F. Doni, L. Johannsdottir, *Environmental Social and Governance (ESG) Ratings*. [In:] Leal Filho, W., Azul, A.M., Brandli, L., Özuyar, P.G., Wall, T. (eds) *Climate Action. Encyclopedia of the UN Sustainable Development Goals*. Springer 2020, Cham. https://doi.org/10.1007/978-3-319-95885-9_36; Y. Jiang, H. Ni, Yihan Ni, X. Guo, *Assessing environmental, social, and governance performance and natural resource management policies in China's dual carbon era for a green economy*, Resources Policy, Volume 85, Part B, 2023, https://doi.org/10.1016/j.resourpol.2023.104050.

[14] M.F. Alsayegh, R. Abdul Rahman, S., *Homayoun Corporate Economic, Environmental, and Social Sustainability Performance Transformation through ESG Disclosure*, Sustainability, 2020, 12, 3910. https://doi.org/10.3390/su12093910

[15] M. Pichlak, A. R. Szromek, *Eco-Innovation, Sustainability and Business Model Innovation by Open Innovation Dynamics*, Journal of Open Innovation: Technology, Market, and Complexity, Volume 7, Issue 2, 2021, 149,https://doi.org/10.3390/joitmc7020149.

[16] S. Tiwari, K.S. Mohammed, G. Mentel, S. Majewski, I. Shahzadi I., *Role of circular economy, energy transition, environmental policy stringency, and supply chain pressure on CO2 emissions in emerging economies*, Geoscience Frontiers, 2023, 101682, https://doi.org/10.1016/j.gsf.2023.101682.

and macroeconomic levels. Cultural specificity and variations in approaches to building environmental awareness across continents must be acknowledged, significantly influencing competitive advantages or disadvantages in different markets.

Corporate Social Responsibility[17] and Environmental, Social, and Governance Initiatives. Examining the influence of a company's commitment to environmental responsibility and sustainable practices on customer satisfaction is crucial. Customers increasingly value corporations that align with their own environmental values. The synchronization between corporations and customer environmental values constitutes a complex phenomenon propelled by ethical considerations, an evolving corporate responsibility ethos, heightened environmental consciousness, the nurturing of trust and loyalty, regulatory mandates, maturity[18], and an acknowledgment of sustained business viability. In the present-day, we observe a noticeable surge in ethical consumerism, with especially young people giving preference to businesses highlighting dedication to sustainable and eco-friendly approaches. This ethical transformation is grounded in a shared recognition of worldwide environmental issues. Companies that genuinely incorporate environmental principles into their fundamental identity and activities often earn elevated levels of trust from their customer base. This trust, in reciprocity, fosters customer loyalty, as individuals are more predisposed to stay devoted to brands that mirror their environmental beliefs. Advancing regulatory frameworks on a global scale accentuate the growing significance of corporate environmental accountability[19]. Cultural changes, particularly observed among younger demographics, highlight the value of sustainability, sharing economy, circular economy, leading consumers to prefer businesses aligning with these principles. Customers recognize that environmental stewardship is intertwined with long-term business viability[20]. Companies embracing sustainable practices are perceived as better positioned to confront upcoming challenges, enhancing their appeal to environmentally conscious customers[21].

[17] A. Lindgreen, V. Swaen, 2010, *Corporate social responsibility*, International journal of management reviews, 12(1), 1-7; D. Windsor, The future of corporate social responsibility, *The international journal of organizational analysis*, 2001, 9.3, 2001, pp. 225-256.

[18] A. Witek-Crabb, *CSR Maturity in Polish Listed Companies: A Qualitative Diagnosis Based on a Progression Model*, Sustainability, 2019, 11(6), 1736.

[19] L. Sołoducho-Pelc, A. Sulich, *Natural environment protection strategies and green management style: Literature review*, Sustainability, 2022, 14(17), 10595.

[20] S. Kakati,, A. Roy, *Financial sustainability: An annotated bibliography*, Economics and Business Review, 2021 ,7(3) 35-60. https://doi.org/10.18559/ebr.2021.3.4.

[21] T. Zhghenti, V. Chkareuli, M. Rios de Haro, V. M. Moreno, Dz. Atstaja, *How are businesses adopting circular practices – empirical study on the case of Georgia and selected Eastern European countries*, Agora International Journal of Economical Sciences, 2023 , Vol. 17 No. 1 https://doi.org/10.15837/aijes.v17i1.5771.

Environmental, Social, and Governance (ESG) is entwined with a notion of collective responsibility as it encapsulates a comprehensive approach to business methodologies. The "E" in ESG denotes environmental considerations, "S" encompasses social factors, and "G" pertains to governance[22]. ESG principles encourage resource efficiency and the adoption of cleaner technologies. In the electromachinery sector, this translates to designing and producing energy-efficient products, minimizing waste, and optimizing the use of raw materials. Firms embracing ESG principles acknowledge their obligations not solely to shareholders but also to the wider community, the environment, and ethical governance. Governance aspects center around the internal frameworks and processes guiding decision-making within a company. This entails promoting transparency, fostering ethical and pro-ecological leadership, and upholding accountability. ESG considerations have become integral to market competitiveness. Consumers, investors, and regulatory bodies increasingly favor companies that demonstrate a commitment to sustainable and socially responsible practices. Adopting ESG principles in the electromachinery industry can enhance a company's reputation and market position. It can help to stay ahead of regulatory changes, avoiding legal issues and potential fines. Proactively adopting ESG measures can position companies as leaders in rapidly changing business environment (models). ESG is going to be a strategic imperative because it attract investors, satisfy customers and contribute positively to society and the environment.

3. Materials and Methods

The research tool used for the preparation of this study was a questionnaire distributed among respondents in Poland, the Czech Republic, Slovakia, and Hungary in the first half of 2023. The scope included both current and potential customers/consumers, both individual and B2B. The geographical scope pertained to respondents from countries affiliated with the Visegrad Group. Examining the situation regarding the significance of environmentally qualitative priorities in products from the electromechanical industry in Central European countries is important in the context of deepening cooperation between these nations. Experience exchange is crucial not only for understanding the evolution of current models but also for shaping new/desired business models.

The aim of the conducted research was to answer the question: do factors influencing satisfaction in purchasing products in the electromechanical industry consider a proecological approach? To address this question, the following were established and indicated: satisfaction

[22] J. Wang, Z. Hong, H. Long, *Digital Transformation Empowers ESG Performance in the Manufacturing Industry: From ESG to DESG*, SAGE Open, 2023, 13(4). https://doi.org/10.1177/21582440231204158.

factors in purchasing eco-friendly products in the electromechanical industry. The results of the theoretical research were used to prepare a questionnaire for surveys. In the research process, efforts were made to determine:

- whether the respondents are satisfied with the quality of pro-ecological (pro-environmental) products currently available on the market,
- whether the country of origin influences satisfaction with the quality of proecological products,
- whether and what relationship exists between satisfaction with the quality of proecological products currently available on the market and gender,
- whether the level of satisfaction with the quality of pro-ecological products currently available on the market is associated with employment,
- whether and to what extent satisfaction with the quality of pro-ecological products currently available on the market is associated with marital status.

Verification of the research objective required the use of a diverse research toolkit, especially a comprehensive review of both national and international literature, as there are few publications considering the specificity of the electromechanical industry. Both inductive and deductive approaches were utilized in the research process. The research also employed reasoning by analogy, survey method, Delphi method, and statistical methods. The research objective determined the selection of the target group. This paper presents an analysis of customer satisfaction with the purchase of proecological products, focusing mainly on the choices made by young people (representatives of Generation Z). Many representatives of the Post-Millennials generation are characterized by their engagement in social and environmental issues. They see themselves as active participants in creating positive changes in society. They are particularly important in the face of challenges related to the transition from a linear economy model to a closed-loop economy model. It is worthwhile to compare declarations, attitudes, and purchasing behaviors/habits, taking into account the specificity of individual countries[23], as well as gender, education, employment, or factors such as marital status. There is a research gap in this area. Generation Z is a group with tremendous purchasing potential. This group is going to influence the shaping of attitudes, behaviors, and purchasing habits in the future. Understanding the determinants of satisfaction in acquiring eco-friendly products within the electromechanical industry is imperative

[23] J. Małkowska, E. Grela, M. Hajduk-Stelmachowicz, *Tygiel kulturowy a zarządzanie bezpieczeństwem produktu*, Problemy Jakości, 2022 R. 54, nr 2, s. 16-24, https://doi.org/10.15199/46.2022.2.2.

for companies seeking to align with the preferences of Generation Z, improve competitiveness, and establish enduring connections with environmentally aware consumers. Appropriately, utilized knowledge about the specifics of determinants influencing satisfaction with purchases translates into profits for companies. This knowledge will also influence the evolution of applied purchasing/selling strategies on both the manufacturer's and consumer's side.

Participants (consumers) were instructed to assess individual statements for agreement on a five-point Likert scale (where 1 indicated the respondent's disagreement with the proposed statement, and 5 indicated full agreement with the statement). Data for the survey were collected from individuals interested in participating, specifically representatives of Generation Z. The questionnaires were distributed via email, LinkedIn, WhatsApp, and Facebook, as well as collected through direct interviews. The questionnaire was developed in English (but was also translated into national languages). In total, 812 questionnaires were obtained, but after checking for completeness and data accuracy, 796 forms were considered for further analysis. Pilot tests were conducted on a total of 80 respondents (20 from each of the surveyed countries) to check the validity of the formulated questions and their proper interpretation (due to cultural and language differences, credibility of responses, correctness, and completeness of data for further analysis). In the context of validating the questionnaire, consultations were conducted

Table 1. Characteristics of respondents

Features	%(N)	Features	%(N)
Country		**Marital status**	
Poland	52%(415)	single	64%(508)
Czech Republik	17%(138)	married	6%(46)
Hungary	17%(133)	partners relationship	29% (229)
Slovakia	14%(110)	widow/divorced	1%(13)
Gender		**Education**	
Male	36%(285)	elementary	17%(134)
Female	61%(489)	medium	50 (397)
I don’t want to answer	3%(22%)	higher	33%(265)
Employment		**Number of people in the household**	
Student	82%(651)	one	3%(23)
Empoloyee	14%(109)	two	12%(98)
Other	4%(36)	three or four	26%(203)
		over 4	59%(472)
Place of living			
rural area (e.g. village)	35%(278)		
city up to 20,000 inhabitants	11%(86)		
a city of 20,000 to 150,000 inhabitants	14%(111)		
a city with over 150,000 to 500,000 inhabitants	36%(288)		
a city with over 500,000 inhabitants	4%(33)		

Source: own study.

with individuals specializing in marketing research and statistics. All respondents were adults. A detailed characteristic of respondents in terms of features such as country of origin, marital status, gender, education, employment, and household size is presented in Table 1.

4. Research results

In response to the question, "Are you satisfied with the quality of pro-ecological (pro-environmental) products currently available on the market?" more than half of the respondents stated that they have no opinion on this matter (59%). Twenty-three percent of the participants expressed satisfaction with the quality of pro-ecological products available on the market, while 13% conveyed a negative opinion on this topic (Figure1).

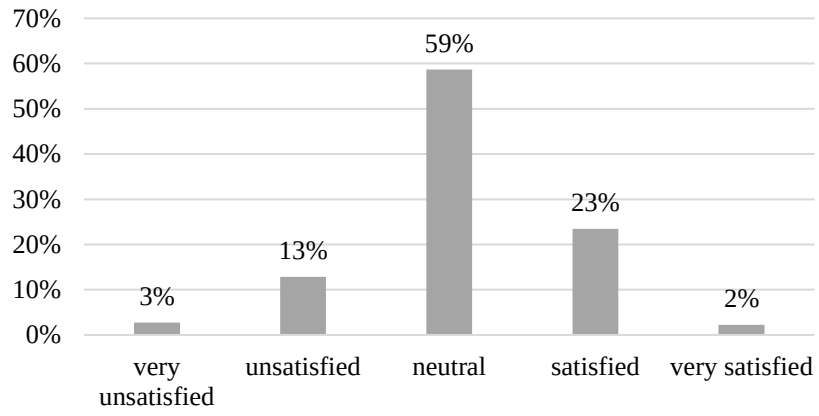

Figure 1. Are you satisfied with the quality of pro-ecological (pro-environmental) products currently available on the market?
Source: own study.

The data clearly indicates that the majority of respondents do not express a specific positive or negative opinion regarding the quality of available eco-friendly products. These individuals may lack prior experience with such products or harbor uncertainties regarding their efficacy and value. Therefore, further contextual studies are necessary to gain a deeper understanding of why such a substantial portion of respondents did not articulate a distinct opinion on the quality of environmentally friendly products within the electromachinery industry.

Examining the relationship between satisfaction with the quality of pro-environmental products available on the market and gender, employment status, marital status, and the number of individuals in the household is pivotal for several reasons:

- diversity in consumer preferences: analyzing the relationship between gender and satisfaction helps identify potential differences in consumer preferences between

genders, a significant factor influencing marketing strategies targeted at specific groups[24],

- impact of life context: relationships with variables such as employment, marital status, and household size aid in understanding how life context influences the level of satisfaction with pro-environmental products. This encompasses both financial and social aspects[25],
- guiding marketing campaigns: knowledge about how these factors are linked to satisfaction can be used to direct marketing campaigns in a more focused manner, tailored to different societal segments[26],
- enhancement of market segmentation: Analysis of these relationships can contribute to a better understanding of the pro-environmental product market by developing market segmentation based on demographic and socio-economic characteristics[27].

Therefore, it was checked whether the country of origin and socioeconomic characteristics have an impact on the declared satisfaction with the quality of pro-ecological products from the electromechanical industry (Table 2).

Table 2. Results of the Pearson's chi-squared test for independence. Satisfaction with the quality of pro-ecological (pro-environmental) products currently available on the market

Answer	**p-value**
Country	0.0776
Age	0.1622
Gender	0.0039**
Education	0.7446
Employment	0.0000***
Place of living	0.3648
Marital status	0.0024**
Number of people in the household?	0.0217*

Source: own study.

[24] B. Bembenek, M. Frankowska, J.M. Myszak, *National Strategic Documents on Cluster Policy as a Source of Challenges for Cluster Management in Poland*, European Research Studies Journal, 2020, vol. XXIII, special iss. 2, s. 182-199.

[25] J. Stec-Rusiecka, A. Warmińska, *Socially Responsible Management of Human Resources in SMEs during the COVID-19 Pandemic*, Zeszyty Naukowe: Cracov Review of Economics and Management, 2022, https://doi.org/10.15678/ZNUEK.2022.0996.0204.

[26] B. Zatwarnicka-Madura, R. Nowacki, I. Wojciechowska, *Influencer Marketing as a Tool in Modern Communication—Possibilities of Use in Green Energy Promotion amongst Poland's Generation Z*, Energies, 2022, 15, 6570, https://www.mdpi.com/1996-1073/15/18/6570/htm, doi.org/10.3390/en15186570.

[27] I. Cichocka, I. Oleniuch, *Food Conservatism and Consumer Ethnocentrism of Young Adults – Relations and References*, Intercathedra, 2019, 39/2, s. 185-193.

From the conducted analyses, it can be concluded that satisfaction with the quality of pro-ecological products is associated with gender ($p < \alpha$, $p = 0.0039$), employment ($p < \alpha$, $p = 0.0000$), marital status ($p < \alpha$, $p = 0.0024$), the number of people in the household ($p < \alpha$, $p = 0.0217$), and how often the respondent pays attention to the quality of products intended for long-term use ($p < \alpha$, $p = 0.0006$).

Another aspect was to analyze the declarations of respondents regarding the level of satisfaction with the quality of pro-ecological products currently available on the market vs. gender. The results of the conducted analyses are visualized in Figure 2.

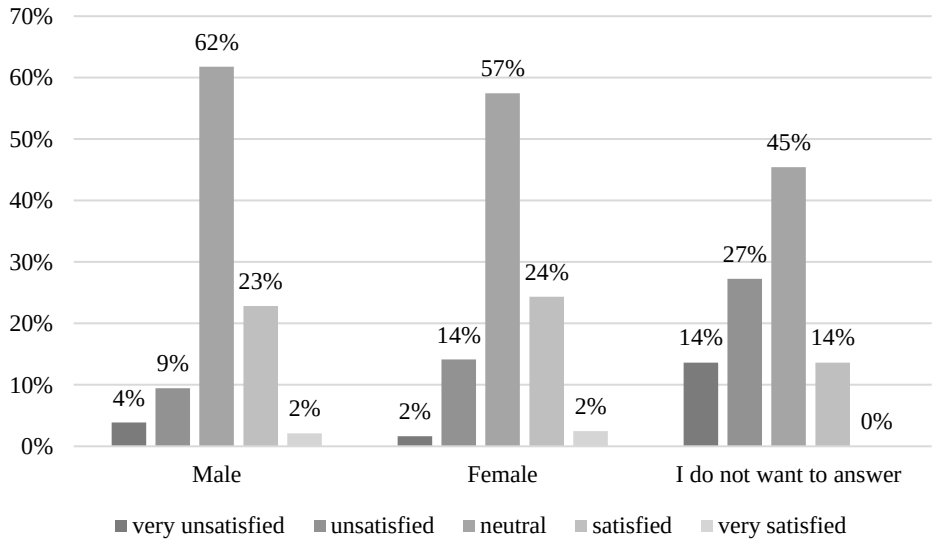

Figure 2. Satisfaction with the quality of pro-ecological (pro-environmental) products currently available on the market vs. gender
Source: own study.

Data analysis suggests that the least decisive in assessing the level of satisfaction with the quality of pro-ecological products were male respondents (62% had no opinion on the matter). The highest level of satisfaction with the quality of pro-ecological products was declared by female respondents (one in four of them stated that they were satisfied), and the worst evaluations of satisfaction with the quality of pro-ecological products were given by individuals who did not want to disclose their gender – 14% of them are very dissatisfied, and 27% are dissatisfied.

The correlation between satisfaction with the quality of pro-ecological products in electromachinery industry available on the market and employment status is subject to various influencing factors. This relationship is nuanced and can be shaped by several elements:

- financial capacity: the employment status may impact an individual's financial capacity to afford pro-environmental products, potentially leading to heightened satisfaction due to the perceived value of these products,
- awareness and education: employment can influence the level of awareness and education about environmental issues. Occupationally engaged individuals, particularly in specific professions or industries, may exhibit a greater understanding of the benefits of pro-environmental products, thereby influencing their satisfaction,
- workplace practices: individuals employed in environmentally conscious organizations may possess an elevated awareness and preference for pro-environmental products. Positive workplace practices can extend their influence into personal choices and satisfaction levels,
- time constraints: employment introduces time constraints that may impact the convenience and ease of incorporating pro-environmental products into one's lifestyle, consequently influencing satisfaction,
- social influence: the workplace environment and colleagues can exert an influence on attitudes and behaviors. Positive social influence toward pro-environmental choices in the workplace may contribute to higher satisfaction levels,
- conducting comprehensive research is imperative to comprehend the specific dynamics of the relationship between employment status and satisfaction with pro-environmental products within a particular context. The multifaceted nature of this relationship involves economic, social, and personal factors that need careful consideration in scientific exploration.

The results of our own research regarding satisfaction with the quality of pro-ecological products currently available on the market vs. employment are presented in Figure 3.

The most satisfied individuals with the quality of pro-ecological products were those who indicated a different type of employment. In this group of respondents, a significant 17% are very satisfied, and 19% are satisfied. However, in this group, there is also the highest percentage of dissatisfied individuals. In the group of employed individuals and students, the majority are those who do not have an opinion on the satisfaction with the quality of pro-ecological products.

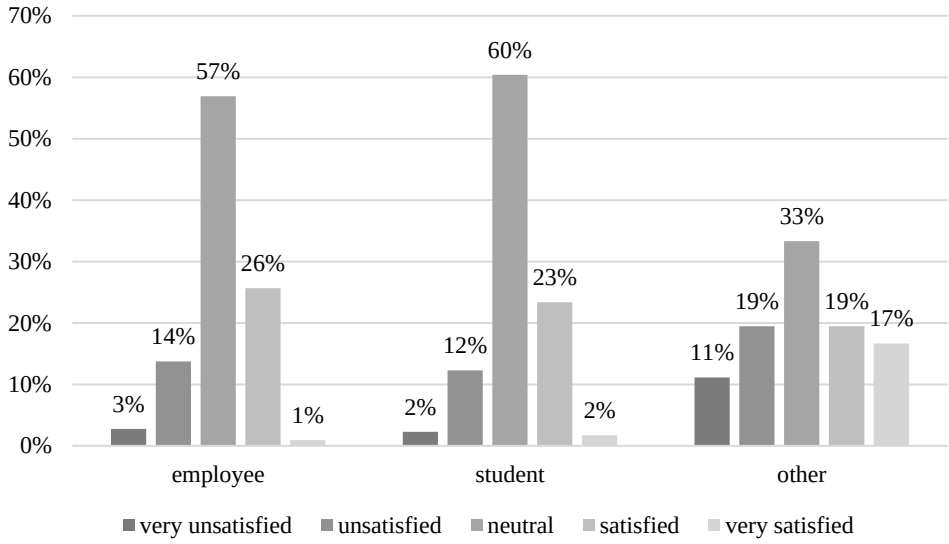

Figure 3. The level of satisfaction with the quality of pro-ecological (pro-environmental) products currently available on the market vs. employment.
Source: own study.

The impact of marital status on the satisfaction with the quality of pro-ecological products within the electromechanical industry, currently available on the market, is intricate and shaped by various factors. The following considerations highlight the potential dynamics of this relationship:

- shared values: Married individuals may collectively derive satisfaction from pro-environmental products, influenced by shared environmental values and lifestyle preferences. Joint decision-making in marital relationships can contribute to the overall satisfaction with such products,
- financial considerations: The financial capacity of individuals, influenced by marital status, can impact the affordability and satisfaction with pro-environmental products. Dual-income households, often associated with married couples, may exhibit greater financial resources for such purchases,
- social norms: Marital status is intertwined with societal expectations. Married individuals may be more likely to conform to pro-environmental practices in line with broader societal norms, influencing their satisfaction with environmentally friendly products,
- lifestyle choices: Marital status can shape lifestyle choices, including consumption patterns. Couples often engage in joint decision-making regarding product choices,

contributing to shared commitments to pro-environmental options and enhancing overall satisfaction,

- support system: Within a marital relationship, the presence of a spouse can serve as a support system for adopting and maintaining pro-environmental behaviors. Mutual encouragement and reinforcement can positively influence satisfaction levels,
- time allocation: Differences in time allocation for household activities, influenced by marital status, may impact the research, purchase, and use of pro-environmental products. Structured routines in married life may affect the time available for engaging with such products.

To comprehensively understand the interplay between marital status and satisfaction with pro-environmental products in the electromechanical industry, empirical research is essential.

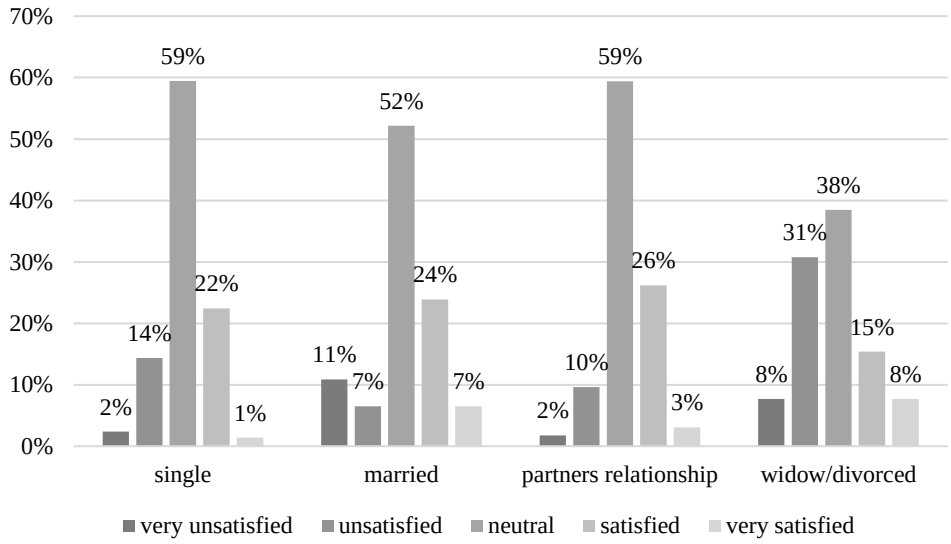

Figure 4. Satisfaction with the quality of pro-ecological (pro-environmental) products currently available on the market vs. marital status
Source: own study.

Investigating shared values, financial considerations, adherence to societal norms, lifestyle choices, support systems, and time allocation within the context of marital status will contribute to a nuanced understanding of this influence in scientific exploration.

Analyzing the comparison visualized in Figure 4, it can be generally stated that individuals who declare that they are not in relationships (unmarried women and men), those in marital relationships, and those in partnership relationships mostly declare a neutral attitude (an interpretation that is difficult to define unambiguously) regarding satisfaction with the quality of pro-ecological (pro-environmental) products currently available on the market.

5. Summary

Assessing the incorporation of cutting-edge technology and innovative features in environmentally friendly products is pertinent. Customers are likely to be more satisfied when products not only contribute to sustainability but also offer technological advancements. This heightened satisfaction stems from the dual benefits of environmental responsibility and innovative features, aligning with the evolving expectations and preferences of modern consumers in the electromachinery sector. Good examples of cutting-edge technology and ecoinnovative features in good quality products can be:

- energy-efficient home appliances, such as smart thermostats, lighting systems, and HVAC systems, that contribute to sustainability while offering advanced automation and control through technology[28],
- manufacturing equipment and machinery that focus on sustainability by reducing energy consumption and waste, coupled with Internet of Things (IoT[29]) integration for real-time monitoring, predictive maintenance, and enhanced efficiency,
- systems that contribute to sustainable energy distribution, incorporating smart grid technologies for better management, reduced losses, and improved reliability,
- sustainable energy storage solutions, such as advanced batteries and storage systems, that enhance the efficiency and reliability of renewable energy sources,
- data center solutions that prioritize sustainability through energy-efficient design, renewable energy sources, and advanced cooling technologies,
- electronics such as smartphones, laptops, and tablets designed with eco-friendly materials, recyclability, and energy-efficient components, combined with cutting-edge technological features,
- technologies in the electromachinery sector that contribute to sustainable water treatment, ensuring efficient purification processes while incorporating advanced monitoring and control mechanisms,

[28] D.R Mckoy, R.C. Tesiero, Y.T. Acquaah, B. Gokaraju, *Review of HVAC Systems History and Future Applications*, Energies, 2023**,** 16, 6109. https://doi.org/10.3390/en16176109; S. Saran, M. Gurjar, A. Baronia, V. Sivapurapu, PS Ghosh, GM Raju, I. Maurya, *Heating, ventilation and air conditioning (HVAC) in intensive care unit*, Crit Care. 2020 May 6;24(1):194. doi: 10.1186/s13054-020-02907-5. PMID: 32375844; PMCID: PMC7201115.

[29] T. Domínguez-Bolaño, O. Campos, V. Barral, C. J. Escudero, J.A. García-Naya, *An overview of IoT architectures, technologies, and existing open-source projects*, Internet of Things, 2022, Volume 20, https://doi.org/10.1016/j.iot.2022.100626; S. Nižetić, P, Šolić López-de-Ipiña, D. González-de-Artaza, L. Patrono *Internet of Things (IoT): Opportunities, issues and challenges towards a smart and sustainable future*, Journal Clean Production 2020;274:122877. doi: 10.1016/j.jclepro.2020.122877.

- heating, ventilation, and air conditioning (HVAC[30]) systems that focus on sustainability by minimizing energy consumption and emissions, coupled with smart features for optimal climate control,
- electric vehicles that are not only environmentally friendly but also integrate advanced battery technology, energy-efficient systems, and smart connectivity features[31].

Investigating and ensuring compliance with environmental regulations and standards is not only paramount, but it is a strategic imperative for electromachinery companies, encompassing legal, environmental, reputational, and competitive dimensions. Compliance with regulations helps mitigate the environmental impact of electromachinery products. It ensures that manufacturing processes and product lifecycles adhere to established standards, minimizing pollution, resource depletion, and other adverse effects. It often involves optimizing resource use, reducing waste, and improving overall resource efficiency. This can result in cost savings and operational efficiency for electromachinery manufacturers.

Non-compliance exposes organizations to various risks, encompassing financial, operational, and reputational dimensions. The thorough examination and assurance of compliance function as a proactive risk management strategy, preempting potential challenges and fortifying the overall stability of the company. Environmental regulations often drive innovation within industries. Standardization can be considered as a means of reinforcing innovation. Companies that proactively embrace and exceed environmental standards (certifications, ecolabels) can gain a competitive edge[32]. This fosters a culture of continuous improvement and positions the company as an industry leader. Products adhering to stringent eco-friendly guidelines may garner higher satisfaction levels.

Numerous markets impose stringent regulations on imported goods, with adherence to environmental standards frequently being a precondition for market entry. Moreover, consumers are progressively prioritizing products from companies demonstrating a robust commitment to sustainability, thereby positively influencing the brand's reputation[33].

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[30] J.C. Solano, E. Caamaño-Martín, L. Olivieri, D. Almeida-Galárraga, *HVAC systems and thermal comfort in buildings climate control: An experimental case study, Energy Reports*, Volume 7, Supplement 3, 2021, https://doi.org/10.1016/j.egyr.2021.06.045.

[31] S. Stec, *Assessment of the economic efficiency of the operation of low-emission and zero-emission vehicles in public transport in the countries of the Visegrad Group. Energy Supplies in the Countries from the Visegrad Group,* Energies, 2021. https://doi.org/10.3390/en14227706.

[32] U. Mentel, M. Hajduk-Stelmachowicz, *Does standardization have an impact on innovation activity in different countries?* Problems and Perspectives in Management, 2020, 18(4), 486-503. DOI: http:// dx.doi.org/10.21511/ppm.18(4).2020.39.

[33] P. Perz, *Efektywność inwestycji w spółki społecznie odpowiedzialne notowane na GPW w Warszawie*, Studia i Materiały Wydziału Zarządzania i Administracji Wyższej Szkoły Pedagogicznej im. Jana Kochanowskiego w Kielcach, R. 22, nr 4, t. 2. *Gospodarowanie zasobami organizacji*, pp. 273-281.

In today's interconnected world, supply chains span across various countries. Investigating compliance ensures that electromachinery products meet not only local but also international environmental standards, facilitating smooth global operations. The transparency of the global supply chain, including sourcing of raw materials and manufacturing processes, contributes significantly to customer satisfaction. A clear understanding of a product's lifecycle enhances consumer trust. In the electromachinery industry, it is imperative for companies to uphold ethical labor conditions throughout their supply chains, champion workplace diversity, and actively participate in the well-being of local communities in which they operate.

Exploring the quality of post-purchase support and services is essential. Customers' satisfaction is often contingent on the availability of effective customer service, warranties, insurance guarantees[34] and sustainable product life cycles. It can be an effective tool in combating planned product obsolescence. In the electromachinery industry, products should have extended life cycles. Robust post-purchase support ensures that these products continue to function optimally, promoting their longevity and reducing the need for premature replacements. Positive customer experiences contribute to brand loyalty and positive word-of-mouth marketing[35]. The electromachinery industry is highly competitive, and customer perceptions of post-purchase support play a significant role in shaping a company's reputation. A commitment to quality support services enhances the brand's image, fostering trust and loyalty among customers.

Comprehensive post-purchase support involves many practices such as recycling (also recyclable packaging), component refurbishment or responsible disposal not only of electronic components. This helps in creating circular economy[36]. Effective post-purchase support contributes to minimizing electronic waste. When customers receive prompt and reliable support, they are less likely to discard products prematurely due to minor issues. This aligns with sustainability goals by reducing the environmental impact of electronic waste. Post-

[34] R. Dankiewicz, *Insurance guarantees as a tool to support risk management procedures in an enterprise*, Nauki o Finansach (Financial Sciences), 4 (33), 2017, s. 51-61. https://dbc.wroc.pl/Content/40966/Dankiewicz_Insurance_Guarantees_As_A_Tool_To_Support_Risk.pdf

[35] L. Witek, *Zachowania nabywców wobec produktów ekologicznych, determinanty, model i implikacje dla marketingu*, Oficyna Wydawnicza Politechniki Rzeszowskiej, Rzeszów 2019.

[36] E.H. Arruda, R.A. Pita Brancalhão Melatto, W. Levy, D. de Melo Conti, *Circular economy: A brief literature review (2015–2020)*, Sustainable Operations and Computers, 2021, Volume 2, https://doi.org/10.1016/j.susoc.2021.05.001; J. Kirchherr, N-H N. Yang, F. Schulze-Spüntrup, M.J. Heerink, K. Hartley, *Conceptualizing the Circular Economy (Revisited): An Analysis of 221 Definitions*, Resources, Conservation and Recycling, 2023, Volume 194, https://doi.org/10.1016/j.resconrec.2023.107001; B. Baran, *The Circular Economy in EU Policy as a Response to Contemporary Ecological Challenges*, Gospodarka Narodowa. The Polish Journal of Economics, vol. 300, no. 4, 2019, pp. 31-51. doi:10.33119/GN/113064.

purchase support involves addressing issues and providing maintenance, contributing to resource efficiency. Instead of discarding a malfunctioning product, customers can benefit from repair services, extending the useful life of the electromachinery and optimizing resource utilization (end-of-life management).

Moreover, post-purchase support can include options for product upgradability. Instead of replacing an entire electromachinery product, customers may have the option to upgrade specific components or features (e. g. energy-efficient upgrades), aligning with sustainability principles. Providing regular software and firmware updates can optimize product performance, potentially extending its lifespan and reduce the need for new purchases. Offering remote diagnostic services to identify and resolve issues without the need for physical interventions is also recommended.

Support services provide an opportunity for customer education. Educated customers are more likely to use products efficiently, understand their environmental impact, and adopt sustainable practices in product usage and maintenance. High-quality post-purchase support can serve as a competitive differentiator in the electromachinery industry. Companies that excel in support services may gain a competitive advantage by offering a comprehensive and sustainable customer experience.

In conclusion, unraveling the intricate web of factors shaping customer satisfaction in the procurement of environmentally friendly products in the electromechanical industry necessitates a meticulous exploration of product performance, cost dynamics, environmental awareness, corporate responsibility (ESG), product, process, marketing and organizational ecoinnovations, regulatory compliance, supply chain transparency, and post-purchase support. This investigation aims to contribute valuable insights to the evolving discourse on sustainable consumption in both individual and business contexts.

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QUALITATIVE-ENVIRONMENTAL ASPECTS OF PRODUCTS IMPROVEMENT

Sustainable development is a key element in achieving the economic success of individual countries.. It combines pro-environmental and pro-quality activities, focusing on both environmental conservation and customer satisfaction. It is particularly important to carry out quality and environmental activities in developing countries, such as the countries of the Visegrad Group (V4). This is particularly significant for the predominant group of small and medium-sized enterprises (SMEs) within the electrical machinery industry. However, this is a difficult task and requires an appropriate approach and commitment. In recent years, the problems have been intensified by dynamic changes in customer requirements and the economic approach of these countries due to the SARS-CoV-2 pandemic and the war in Ukraine. The emerging challenges connect the V4 countries in a similar way, due to their similar direction of economic development, location, histories, and geopolitical ideas.

Research covering these issues was carried out as part of the International Visegrad Fund project no. 22230264 “Qualitative-environmental aspects of products improvement”. The aim of the project was to compare the current approach of the electrical machinery industry in V4 countries to that of their customers or potential customers in the field of quality management for pro-environmental products. The research sought to provide a scientific and utilitarian answer to the question: Is the current approach of manufacturing enterprises in the V4 countries consistent with customer expectations and, simultaneously, with a pro-ecological approach to product quality management?". The selected results of these studies are presented in the monograph.

The first chapter includes an analysis of the use of instruments supporting the current activities of SMEs from V4 countries as part of sustainable quality management. The second chapter presents an analysis of waste management in terms of the development of the mentioned countries, where the analysis focused on qualitative aspects. The third chapter presents an analysis of the main aspects of product development, i.e. environmental, economic, and quality. The subsequent chapters also include an analysis of selected aspects of pro-environmental and pro-quality product improvement, in particular examining approaches and relationships, including the mutual relationship between SME entrepreneurs and their clients. Special attention has been paid to factors determining customer satisfaction with the purchase of products from the electromechanical industry, considering the increasing demands of the circular economy and the pro-environmental awareness of buyers.

Research on customer satisfaction regarding environmental and quality aspects in the electromechanical industry constitutes a research gap and is highly significant in the context of achieving the goals of sustainable development, including ESG (Environmental, Social, and Governance) considerations.

The research results presented here can be particularly valuable for companies seeking to enhance their products in alignment with sustainable development practices, drawing insights from similar enterprises in the Visegrad Group countries.

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