Hapres | Journal of Sustainability Research

sustainability.hapres.com

Article

Corporate Social Responsibility as One of the Factors of Increasing Energy Efficiency: The Case of Energy Consumption at Industrial Companies of Ukraine

Fei Mei, Natalia Stanasiuk, Oleh Vysochan, Olexandr Yemelyanov, Vasyl Hyk *

Institute of Economics and Management, Lviv Polytechnic National University, Lviv 79013, Ukraine

* Correspondence: Vasyl Hyk, Email: vasiahyk@ukr.net.

ABSTRACT

One of the tasks of the concept of corporate social responsibility is to help solve social and environmental problems facing society. An important way of such a solution is the implementation of energy-saving projects at companies. In this regard, the purpose of this study was to assess the impact of corporate social responsibility on the energy efficiency of companies, and, accordingly, on the financial and economic results of these activities. In the research process, the following methods were used: economic and mathematical modeling (when developing a model of the influence of corporate social responsibility on the share of operating profit in the amount of operating income of companies), grouping and generalization (when grouping factors that have an impact on the energy efficiency of companies), statistical analysis (when determining the influence of factors on the change in the energy efficiency of companies), economic analysis. The place occupied by corporate social responsibility among the factors influencing the energy efficiency of companies is determined. A method of evaluating the specified impact has been developed. This method was tested on a sample of 150 industrial companies in Ukraine. To eliminate the influence of factors that determine the profitability of investing in energy-saving projects, 97 companies with a low basic level of efficiency in using natural gas were selected and analyzed among the studied companies. These companies included companies of three branches, namely, those that manufacture products from metal (29 companies), glass (36 companies), and clay (32 companies). The results of the empirical analysis showed that corporate social responsibility has a significant impact on the efficiency of natural gas use by companies and on the profitability of their products. At the same time, most of the studied companies have reservations regarding increasing the level of corporate social responsibility and, accordingly, increasing energy efficiency and profitability.

KEYWORDS: corporate social responsibility; energy efficiency; energy saving project; increase in profitability; natural gas

Received: 01 June 2024
Accepted: 30 August 2024
Published: 10 September 2024

INTRODUCTION

Excessive consumption of non-renewable energy resources is one of the most acute problems faced by many countries in the last decade. The acuteness of this problem is due to the simultaneous influence of several circumstances. First of all, large amounts of energy consumption do not provide an opportunity to ensure sustainable development, since the rapid depletion of reserves of natural gas, crude oil and other types of fossil energy resources provokes their future shortage for the next generations of people, which will negatively affect their standard of living. Also, the importance of reducing the use of non-renewable energy sources is caused by a difficult environmental situation, one of the causes of which is the emission of harmful substances caused by the consumption of these energy sources. In addition, significant volumes of energy consumption cause companies, the population, and other energy consumers to incur significant expenses related to the acquisition of the appropriate types of energy resources, which is especially felt in periods when the prices for these resources begin to rise. After all, large volumes of imports of certain energy resources, which are inherent in several countries, often result in increased risks for the economies of these countries due to both the possible increase in prices for such energy resources and possible disruptions in their supplies. The last circumstance is especially important at present, when military operations are taking place in Ukraine and other regions of the world, and relations between many countries have become much more complicated.

It should be noted that all the listed reasons, which determine the urgency of the problem of reducing energy consumption, concern the daily life of people and society as a whole. Therefore, this problem has, among other things, a social character. Therefore, its solution requires, in particular, consideration of the interests of people and society and awareness of the social significance of energy-saving measures.

Along with households, the biggest consumers of energy are companies. Therefore, reducing the consumption of fossil energy resources by companies should be recognized as one of the main directions for reducing the total volume of such consumption. At the same time, it is important that such a reduction does not lead to a decline in economic activity, which will lead to negative changes in macroeconomic indicators. In this regard, reducing the consumption of energy resources by companies should take place, first of all, based on increasing the energy efficiency of production processes and replacing non-renewable energy sources with renewable ones.

Management of energy saving at companies requires preliminary selection and analysis of factors that influence the scale of measures to save energy resources. There are quite a lot of these factors and their influence can be quite complex. This difficulty, among other things, is because when decisions are made by the owners and managers of companies regarding the implementation of certain energy-saving

projects, subjective factors can have a significant impact. These factors are, first of all, the personal preferences of owners and managers, in particular their propensity to risk, the desired level of profitability of investments made in the implementation of energy-saving projects.

Taking into account the social importance of reducing energy consumption at companies, one of the possible factors influencing the volume of consumption of energy resources by companies is the degree of awareness of the mentioned importance by the owners and managers of companies. This awareness can be reflected in the fact that when company managers make energy-saving decisions, not only the expected level of economic efficiency of the implementation of these decisions, but also the social consequences will be taken into account. The mentioned aspects of decision-making by owners and managers of companies regarding the implementation of certain measures aimed at reducing the consumption of non-renewable energy resources should be considered through the prism of the concept of corporate social responsibility. In this regard, the purpose of this study is to assess the impact of corporate social responsibility on the energy efficiency of companies, and, accordingly, on the financial and economic results of these activities. Achieving the set goal made it necessary to solve several tasks, the most important of which are the following: determining the place of corporate social responsibility among the factors that influence the energy efficiency of companies; development of a method for evaluating the specified impact; approbation of this method by a sample of industrial companies of Ukraine.

LITERATURE REVIEW

The problem of energy saving at companies is of interest to many scientists. At the same time, the researchers paid considerable attention to the issues of methodological support for the process of methodological support issues for companies. In particular, scientists proposed methods for evaluating the effectiveness of these projects (Szafranko, 2022) [1], formed an information base for such evaluation (Krones and Müller, 2014) [2], and determined criteria for selecting the best energy-saving projects (Krenn et al., 2015) [3], the theoretical and methodological principles of the formation of programs of energy-saving investment measures by companies have been developed (Richert, 2017) [4], the conditions under which these programs can be successfully implemented have been determined (Máša et al., 2018) [5].

Also, quite a lot of publications are devoted to establishing, evaluating, and managing obstacles that arise when business entities implement measures to increase the energy efficiency of economic activity (Trianni et al., 2013) [6]. Some scientists refer to such obstacles, first of all, obstacles of an economic nature. In particular, this was done by (Lesinskyi et al., 2021) [7]. A similar opinion is expressed in (Zhang et al., 2013) [8], where the lack of financial incentives is considered as a determining reason for inhibiting the implementation of energy-saving measures.

Also, several scientists, in particular the authors (Lopes et al., 2019) [9], highlight managerial obstacles on the way to energy saving at companies. At the same time, among these obstacles, information barriers (Kostka et al., 2013) [10], which largely arise as a result of the lack of knowledge and skills in the formation and processing of data necessary for making energy-saving decisions among enterprise managers, are singled out (Lesinskyi et al., 2020) [11]. In particular, this concerns the lack of competences in organizing financial support for the implementation of energy-saving projects at companies (Lesinskyi et al., 2021) [7]. Scientists have also developed several methods for assessing obstacles in the implementation of energy-saving projects at companies and proposed mechanisms for overcoming these obstacles. In particular, it is suggested to use qualitative analysis (Kangas et al., 2018) [12], processing of survey results (Herrera et al., 2017) [13], grapho-analytical models (Bhandari et al., 2019) [14] to assess the mentioned obstacles. As for the mechanisms for overcoming barriers on the way to increasing energy efficiency, they include the improvement of energy audit methods (Chiaroni et al., 2017) [15], improvement of information support of energy-saving projects (Yemelyanov et al., 2023) [16], increase competence of employees in matters of energy saving (Lesinskyi et al., 2020) [11], preferential lending (Yemelyanov et al., 2020) [17] and subsidies (Hui et al., 2017) [18].

Regarding the factors affecting the effectiveness of energy saving measures, one of such factors, which is studied in several scientific works, is the price of those energy resources, the consumption of which is supposed to be reduced. At the same time, the results of evaluating the impact of energy prices on the scale of energy saving among different researchers differ significantly. For example, in (Chen, 2017) [19], no such influence was found, which contradicts the results given in (Nesbakken, 1999) [20]. In addition, scientific works have proven the influence of such factors as the investment climate (Lesinskyi et al., 2021) [7], the capital intensity of projects (Lesinskyi et al., 2020) [11], their riskiness (Hilorme et al., 2019) [21].

There are also several publications that consider the impact of energy saving at companies on the conditions and results of their activities. In particular, scientists have considered the impact of energy-saving measures on the economic results of firms (Zhang et al., 2022) [22], prospects for their development (Wang, 2016 [23]; Vysochan et al., 2022 [24]; Vysochan et al., 2024 [25]), the market value of companies (Yemelyanov et al., 2022) [26].

Considering the factors that influence the scale of energy-saving measures at companies, it is also worth highlighting the awareness of the owners and managers of companies regarding the social significance of the implementation of energy-saving measures. Deepening this consideration, it is expedient to investigate the ability of enterprise managers to take into account the specified significance when they make final decisions regarding the implementation of energy-saving projects. In

other words, it is worth considering such a factor of influence on the energy-saving activities of companies as corporate social responsibility.

It should be noted that currently there are quite a few scientific publications devoted to the impact of corporate social responsibility on various properties and performance indicators of companies. In particular, scientists have considered the impact of such responsibility on the competitive advantages of companies (Barauskaite and Streimikiene, 2020) [27], their financial results and reputation (Vitezić, 2011 [28]; Vysochan et al., 2023 [29]; Hyk et al., 2023 [30]), the effectiveness of investments (Benlemlih and Bitar, 2018 [31]), the amount of intellectual capital of companies (Vo et al., 2023) [32], their value (Chintrakarn et al., 2017) [33]. At the same time, the majority of publications, based on the empirical analysis conducted by their authors, conclude that the impact of corporate social responsibility on the relevant properties and indicators of companies is mostly positive.

At the same time, several scientific studies were conducted to assess the impact of corporate social responsibility on energy consumption and energy-saving processes. Among the scientific works in which such research was carried out, it is worth noting, in particular, (Gezmen, 2021) [34], which analyzed corporate social responsibility projects to increase the level of awareness of young people in matters of efficient energy consumption. Interesting results were obtained by the authors of the work (Nurunnabi et al., 2019) [35], which claims that the principles of energy efficiency can be used as a tool of corporate social responsibility to achieve the goals of sustainable development in the UN agenda until 2030, thus meeting the requirements several stakeholders while increasing profitability. The authors (Hori et al., 2014) [36], who established that there is a positive relationship between the recognition of corporate social responsibility and energy saving, adhere to a similar point of view. This statement is supported by the results of research published by (Laguir et al., 2019) [37], which proved that active activity in the social, environmental, and economic aspects of corporate social responsibility is associated with high energy efficiency.

Several scientific works are also devoted to specific measures to increase energy efficiency within the framework of the implementation of the concept of corporate social responsibility by companies. In particular, as noted in (Tylżanowski et al., 2023) [38], in recent years, corporate social responsibility has gained popularity in Poland and this has led to the fact that Polish companies have begun to implement energy-efficient technologies and practices in order to reduce energy consumption, reduce operational costs and promote environmental sustainability. At the same time, (Strielkowski et al., 2021) [39] note the positive impact of corporate social responsibility on the development of renewable energy in the Baltic States. Similar conclusions regarding energy consumption in Romania are presented in (Bajda et al., 2022) [40]. As emphasized in (Andronie et al., 2019) [41], energy conservation is becoming part of the corporate social

responsibility strategy of many manufacturers and a marketing tool due to the growing awareness of consumers about the climate. At the same time, as noted in (Zhang et al., 2022) [42], which analyzed the energy-saving behavior of employees in the hospitality industry, corporate social responsibility has a tangible positive effect on such behavior.

However, at present, the place of corporate social responsibility among other factors that have an impact on energy efficiency and, accordingly, on the financial and economic results of companies, is not fully established in the scientific literature. At the same time, solving this problem could improve the methodology for evaluating the impact of corporate social responsibility on energy saving at companies. In turn, the use of such a methodology would make it possible to increase the accuracy of the obtained empirical results. Therefore, the issue of assessing the impact of corporate social responsibility on the implementation of energy-saving measures at companies is not yet definitively resolved and requires further research.

METHODOLOGY

Assessment of the impact of corporate social responsibility on the level of energy efficiency of companies and the change in financial and economic results should be based on the specified places, that hold corporate social responsibility among the factors that exert the specified influence. The analysis of literary sources, in particular works [1,5,8,11], as well as our own research, give reasons to assert that all factors that affect the scale of energy saving at companies should be divided into four main groups, namely (Table 1):

(1) Factors that consider economic efficiency and determine the expediency of implementing energy-saving projects of companies. These factors include those that have a direct impact on the expected level of profitability of investments in the enterprise's implementation of certain energy-saving measures, as well as on the value of the net present value of the corresponding energy-saving projects;

(2) Resource support for the implementation of energy-saving projects by companies. These factors are the volumes of various types of resources, some for such implementation, as well as consumer properties of these resources. additional conditions of resource provision of companies by energy-saving companies about the cost of assigning costs for attracting and other conditions for attracting certain resources by companies, as well as expenses related to increasing the quality level of resources available at companies;

(3) Existing competencies of the owners, managers, and specialists of companies in matters of resource management, necessary for the development and implementation of energy-saving projects. The mentioned competencies, in turn, can be divided according to the stages of the process of development and implementation of energy-saving measures;

(4) Personal preferences and beliefs of owners and managers of companies. In particular, these preferences and beliefs should include the maintenance of the concept of corporate social responsibility by the owners and managers of companies.

Table 1. Grouping of factors that influence the energy efficiency of companies.

Names of factors	Types of factors
1. Factors that determine economic efficiency and determine the expediency of implementing energy-saving projects of companies	1.1 Amounts of investment needed to implement energy-saving projects
	1.2 The expected change in the consumption norms of certain types of energy resources after the implementation of energy-saving projects
	1.3 The expected change in individual costs of companies (except for energy resource costs) due to the implementation of energy-saving projects
	1.4 Current and forecast level of prices for energy resources
	1.5 Discount rates for energy-saving projects
	1.6 Terms of implementation and operation of energy-saving projects
	1.7 Natural volumes of production of products under energy-saving projects
2. Resource support for the implementation of energy-saving projects by companies	2.1 Volumes and level of quality of available and possible information resources necessary for the development and implementation of energy-saving projects
	2.2 Volumes and level of quality of available and possible human resources necessary for the development and implementation of energy-saving projects
	2.3 Volumes and level of quality of available and possible material resources necessary for the development and implementation of energy-saving projects
	2.4 Volumes and level of quality of available and possible technical resources necessary for the development and implementation of energy-saving projects
	2.5 Volumes and level of quality of available and possible financial resources necessary for the development and implementation of energy-saving projects
	2.6 Costs for attraction and other conditions for attraction by companies of resources necessary for the development and implementation of energy-saving projects
	2.7 Expenditures related to improving the quality level of resources available to companies, necessary for the development and implementation of energy-saving projects

Table 1. *Cont.*

Names of factors	Types of factors
3. Existing competencies of the owners, managers, and specialists of companies in matters of resource management, necessary for the development and implementation of energy-saving projects	3.1 Owners, managers, and specialists of companies have the competence to collect input information necessary for the development and implementation of energy-saving projects
	3.2 Owners, managers, and specialists of companies have competencies in processing incoming information and forming an array of information necessary for making decisions on the implementation of energy-saving projects
	3.3 Owners, managers, and specialists of companies have the competence to choose the best options for the implementation of energy-saving projects
	3.4 Owners, managers, and specialists of companies have competencies in organizing resource support for the implementation of energy-saving projects
	3.5 Owners, managers, and specialists of companies have competencies in effective management of the operation of energy-saving projects
4. Personality preferences and beliefs of owners and managers of companies	4.1 Owners and managers of companies comply with the concept of corporate social responsibility
	4.2 The propensity of owners and managers of companies to risk
	4.3 The profitability of incurred investment costs is acceptable for owners and managers of companies
	4.4 The propensity to hoard and other preferences of owners and managers of companies

It should be noted that the influence presented in the Table 1 factor in the amount of energy savings at companies and the change in their financial and economic results have an indirect nature. In other words, this influence occurs due to a certain combination of other factors. A review of literary sources, particularly works [9,15,17,22], as well as our research, make it possible to model the mechanism of influence of the factors presented in the Table 1, for changes in the amount of energy consumption at companies and the amount of their profit. The specified mechanism is shown in Figure 1.

It follows from this figure that those listed in the Table 1, four groups of factors have a direct impact on the change in energy efficiency of activities. The impact of changes in energy efficiency on changes in energy consumption at companies, as well as on changes in profit, such an impact can be estimated, in particular, based on information about the forecast values of the relevant indicators. For example, the change in the amount of energy consumption is determined by the forecast natural volumes of production and the level of energy efficiency. At the same time, it is possible to have a so-called rebound effect on energy

consumption, in which an increase in energy efficiency can lead to an increase in the sales potential of companies, which, in turn, will lead to the need to increase their production of certain types of products. After all, the impact of changes in energy consumption on the company's profit is primarily due to changes in current costs for the purchase of energy resources. At the same time, the company's profit may be affected by changes in some other costs of the enterprise as a result of its implementation of energy-saving projects. For example, such implementation can lead to an increase in depreciation deductions (if new energy-saving equipment is expensive enough), an increase in costs for other types of energy resources (if some types of energy carriers are replaced by others).

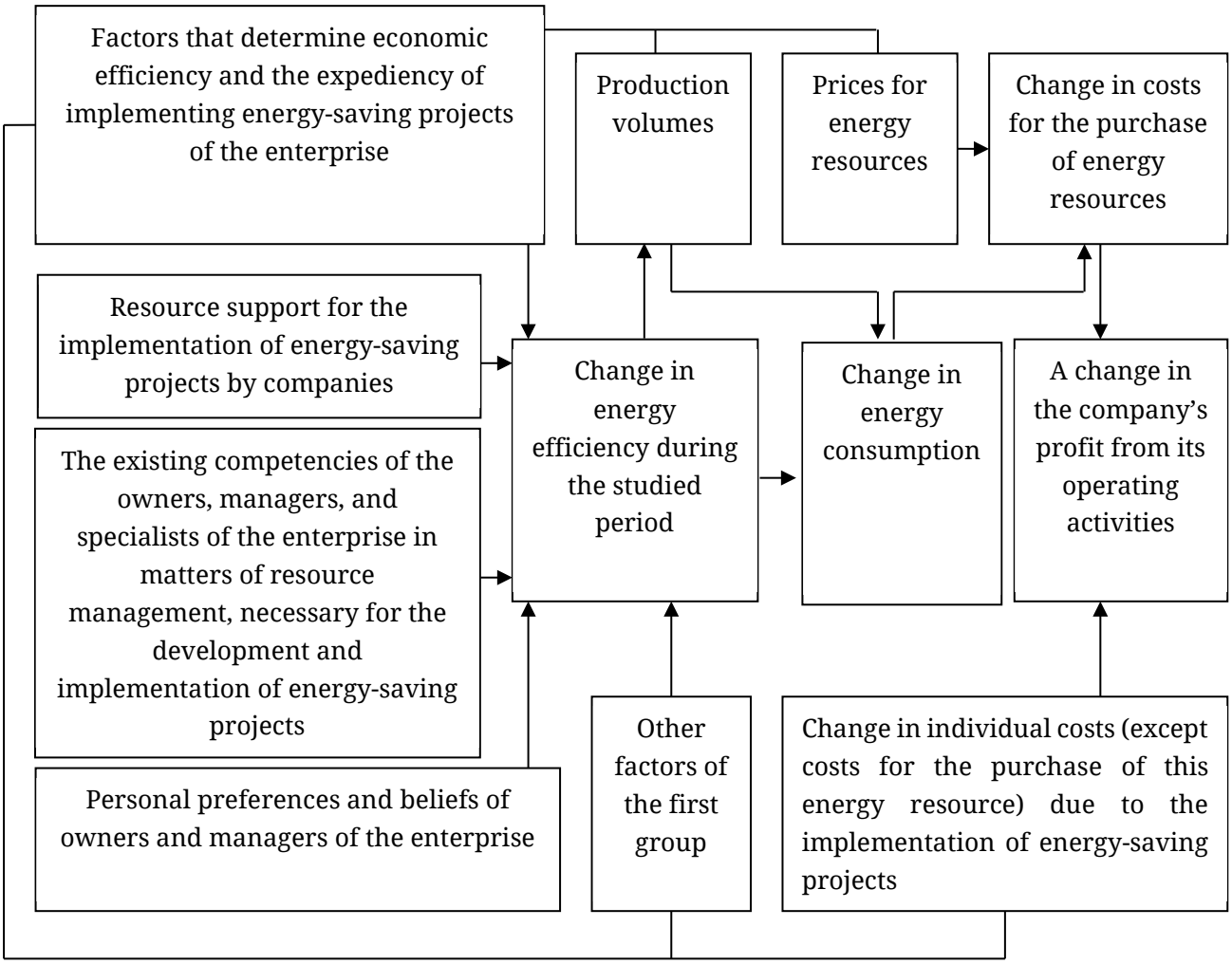

Figure 1. The mechanism of the influence of factors on the change in the amount of energy consumption at the enterprise and on the amount of profit from its operational activities. Source: formed by the authors.

In general, the sequence of assessing the impact of corporate social responsibility on the energy efficiency of companies, and, accordingly, on the change in their profit should include the following main stages of action:

Stage 1. Selection of the base and reporting periods, as well as the type of energy resources. Since the evaluation of the change of the studied indicators will be based on the comparison of their values, it is necessary that the period under consideration be sufficiently large. In particular, if the base and reporting periods are calendar years, then the duration of the time interval between these periods should not be less than one calendar year.

Stage 2. Formation of a sample of the investigated companies. Such formation should be carried out by types of economic activity while ensuring that companies with approximately the same level of energy efficiency fall into the sample (it is also possible to divide companies into groups according to the level of energy efficiency and perform all subsequent actions separately for each such group). Satisfying these conditions for a sample of companies makes it possible to eliminate the influence on energy efficiency of those factors that determine economic efficiency and determine the feasibility of implementing energy-saving projects.

Indeed, the economic efficiency of investing in any energy-saving measure is determined, first of all, by the expected change in energy resource consumption norms, the required energy-saving investment per unit of production, and the price of this energy resource. In turn, the change in energy consumption norms is the difference between the actual and expected values of these norms after the implementation of an energy-saving measure. Then, if companies with approximately the same level of energy efficiency in the base period are selected, it will mean that the norms of energy consumption of such companies in this period are also approximately the same. After all, if all the selected companies belong to the same type of economic activity, then the level of other factors that affect the economic efficiency of investing in energy saving will be the same at these companies. Therefore, the forecast level of such efficiency for all selected companies will be the same. Therefore, if such companies have different values of relative energy efficiency growth in the reporting period compared to the base period, then such differences cannot be caused by the impact of the economic efficiency of energy-saving projects. Thus, having formed a sample of companies of the same type of economic activity with approximately the same basic level of energy efficiency, it is possible to eliminate the influence of factors that determine profitability and determine the feasibility of implementing energy-saving projects.

Stage 3. Evaluation of changes in the energy efficiency of each of the companies in the reporting period compared to the base period. Since energy efficiency at the level of companies is determined, as a rule, by dividing the cost of manufactured products by the natural costs of energy resources, it is important that the specified products are measured at comparable prices. In addition, it is worth bringing energy efficiency to a dimensionless form (this makes it possible to make various comparisons,

in particular, according to different types of energy resources and different types of economic activity). For this purpose, it is proposed to use the relative energy efficiency indicator. This indicator should be calculated as the ratio of energy efficiency at a certain enterprise in a certain period to the maximum possible value of energy efficiency in the reporting period. This value can be taken, in particular, at the level of the enterprise in which it is the largest. Taking into account these considerations, the change in the relative energy efficiency of a certain enterprise in the reporting period compared to the base period will be determined by the following formula:

$$\Delta E = \frac{1}{E_m}\left(\frac{R_1}{C_1} - \frac{R_0 * P}{C_o}\right) \quad (1)$$

where ΔE—change in the low energy efficiency of the enterprise in the reporting period compared to the base period, particles; E_m—the maximum possible value of energy efficiency, monetary units per physical unit of energy consumption; R_1, R_0—the amount of production of the enterprise according to the reporting and base periods, monetary units; C_1, C_o—volumes of consumption by the enterprise of a certain type of energy resources, natural units; P—price index for the company's products in the reporting period compared to the base period, times.

Stage 4. Determination of the level of resource support for the implementation of energy-saving projects for each of the selected companies, the level of competence available to the owners, managers, and specialists of the enterprise in matters of managing this provision, and the level of compliance by the owners and managers of the companies with the concept of corporate social responsibility in the field of energy saving. As for other factors that characterize the personal preferences and beliefs of owners and managers, it is assumed that they are to some extent determined by the competencies available to owners and managers. At the same time, if the final results of the study are not statistically significant, then in this case it is advisable to add to the consideration other factors that characterize the personal preferences and beliefs of owners and managers.

It should be noted that the evaluation of the factors listed above can take place in points according to the evaluation scales presented in the Table 2. As can be seen from this table, for each factor, its level for a certain enterprise can take one of four possible values.

Table 2. The proposed point assessment of individual factors that have an impact on the energy efficiency of companies.

Levels of relevant factors	Resource support for the implementation of energy-saving projects by companies		Existing competencies of owners, managers, and specialists of companies in matters of resource management, necessary for the development and implementation of energy-saving projects		Compliance by owners and managers of companies with the concept of corporate social responsibility in the field of energy-saving	
	Characteristic	**points**	**Characteristic**	**points**	**Characteristic**	**points**
Zero	There is no resource support for the implementation of energy-saving projects by companies	0	Owners, managers and specialists of companies do not possess these competencies at all	0	The owners and managers do not follow the concept	0
Low	Resource provisioning makes it possible to implement only very small and isolated energy-saving projects	1	Owners, managers, and specialists of companies have only initial competencies	1	Owners and managers stick to the concept only sporadically	1
Average	Resource provision enables the implementation of only a certain number of energy-saving projects, but is insufficient for the implementation of large-scale energy-saving programs	2	Owners, managers, and specialists of companies in general have basic competencies	2	Owners and managers generally adhere to the concept	2
High	Resource provision is sufficient for the implementation of large-scale energy-saving programs	3	Owners, managers, and specialists of companies perfectly possess all competencies	3	The owners and managers are fully committed to the concept	3

Stage 5. Averaging the studied variables by companies in the base period. For this purpose, you should use the following formula:

$$I_{ai} = \sum_{j=1}^{n} I_{ij} * a_j \quad (2)$$

where I_{ai}—value of the i-variable averaged across companies; n—the number of companies; I_{ij}—the value of the i-th variable at the j-th enterprise in the base period; a_j—the share of consumption of this type of energy resource by the j-th enterprise in the total volume of consumption

of this energy resource by all studied companies in the base period, unit shares.

Stage 6. Analysis of the distribution of companies according to the studied variables according to the data of the base period. Such analysis should include, in particular, the division of companies into groups depending on the range in which the variables fall.

Stage 7. Construction of the correlation matrix for the studied variables, determination of the numerical values of the coefficients of the regression equation, and assessment of the statistical significance of the obtained dependence. At the same time, taking into account the selected variables, the specified equation will have the following general form:

$$\Delta E = \beta_0 + \beta_1 * L_1 + \beta_2 * L_2 + \beta_3 * L_3 \quad (3)$$

where β_0, β_1, β_2, β_3—parameters of the regression equation; L_1, L_2, L_3—the value, respectively, of resource support for the implementation of energy-saving projects, the level of competence available to the owners, managers, and specialists of the enterprise in matters of managing this support, and the level of compliance by the owners and managers of companies with the concept of corporate social responsibility in the field of energy saving, points.

Stage 8. Generalization of the obtained results. Such a generalization involves the formation of an array of data on the magnitude of the impact of corporate social responsibility on two main indicators based on the studied types of economic activity, namely:

(1) Relative efficiency of consumption by companies of a certain type of energy resource. The impact of corporate social responsibility on this efficiency is estimated by the β_3 indicator in equation (3);

(2) The share of operating profit in the amount of operating income of companies. The use of this indicator makes it possible to present the amount of profit in a relative expression, which facilitates the comparison of the obtained results for different types of economic activity. At the same time, the amount of influence of corporate social responsibility on the share of operating profit in the amount of operating income can be calculated using the following formula:

$$\gamma = \frac{\gamma_{ea} * L_{a3} * \beta_3}{E_m} - \gamma_{oa} \quad (4)$$

where γ—the amount of influence of corporate social responsibility on the share of operating profit in the amount of operating income of companies, share of units; γ_{ea}—the average share of expenses for the purchase of this type of energy resources in the operating income of the reporting period, unit shares; L_{a3}—the average value of the level of compliance with the concept of corporate social responsibility by companies, points; γ_{oa}—the average share of individual costs (except costs for the purchase of this energy resource) in operating income, caused by the implementation of energy-saving projects by companies during the studied period of time, unit share.

It should be noted that the transition to the eighth stage of the sequence of actions described above is possible only under the conditions of the statistical significance of equation (3) and the absence of the above-described rebound effect in energy consumption. If at least one of these conditions is not met, it is necessary to adjust the research process. Such an adjustment, in particular, may involve the introduction of additional variables into consideration, which was already mentioned above in the fourth stage of the proposed sequence of actions.

EMPIRICAL ANALYSIS

For many countries, the issue of reducing natural gas consumption is currently relevant. Ukraine belongs to such countries. Therefore, three branches of industry (types of economic activity) of Ukraine, which are characterized by sufficiently high specific consumption of natural gas, were considered. The list of these industries is presented in the Table 3. At the same time, 2019 and 2021 were chosen as the base and reporting periods, respectively.

Table 3. Average values of individual variables for the studied companies in the base year.

Variable names	Average values of variables by types of economic activity by companies		
	Production of metal products	**Production of glass and glass products**	**Production of bricks, tiles and other building materials from clay**
1. Relative efficiency of natural gas use, a fraction of a unit	0.524	0.475	0.598
2. The level of resource support for the implementation of energy-saving projects by companies, points	1.763	1.616	1.504
3. The level of competence of the owners, managers, and specialists of companies in matters of resource management, necessary for the development and implementation of energy-saving projects, points	1.987	1.564	1.707
4. The level of compliance by owners and managers of companies with the concept of corporate social responsibility in the field of energy-saving, points	1.520	1.432	1.643

For each type of economic activity, data were collected on 50 companies located in the western region of Ukraine. At the next stage of the research, the investigated companies for each branch were divided into groups with low, medium, and high efficiency of natural gas use in the base year. It was the companies of the first group (their total number is 87) that were chosen as the final objects of the study. Having estimated the value of the selected variables for each enterprise in the base year, formula (2) determined their averaged values. As can be seen from the data presented in the Table 3, the average values of all studied variables are not very high. In particular, the relative efficiency of using natural gas varies from 0.475 to 0.598 (i.e., from 47.5% to 59.8% of the maximum possible). As for the score of factors influencing this efficiency, in most cases, it is in the range of 1.5 to 2.0 (with the maximum possible value equal to 3.0).

At the next stage of the research, the values calculated according to formula (1) for each enterprise were divided into three groups: low (less than 0.05), medium (from 0.05 to 0.1), and high (greater than 0.1). As can be seen from the data in the Table 4 for all three types of economic activity, the majority of companies belong to the group with average values of changes in the relative efficiency of natural gas use.

Table 4. Distribution of the studied companies according to the major changes in the relative efficiency of the use of natural gas during 2019–2021.

Indicator names	**The value of indicators by types of economic activity**		
	Production of metal products	**Production of glass and glass products**	**Production of bricks, tiles and other building materials from clay**
1. Total number of companies	29	36	32
2. The number of companies with a change in the relative efficiency of natural gas use:			
2.1 low	8	10	8
2.2 average	16	19	17
2.3 High	5	7	7

Also, the studied companies were divided into groups by the level of factors influencing the energy efficiency of economic activity. For this purpose, three types of values of these factors were selected: low (less than 1.5), medium (from 1.5 to 2.5), and high (greater than 2.5). As can be seen from the data given in the Table 5 and Table 6, for all three factors and all studied types of economic activity, the values of these variables in most companies are average, that is, they are in the range from 1.5 to 2.5. In particular, regarding compliance by the owners and

managers of companies with the concept of corporate social responsibility in the field of energy saving, the share of companies with an average level of this factor was: for companies producing metal products—58.62%; for companies engaged in the production of glass and glass products—58.33%; for companies that produce bricks, tiles and other building materials from clay—65.63%. Therefore, it can be assumed that the existing level of the studied factors can contribute to a significant increase in the energy efficiency of the studied companies during 2019–2021.

Table 5. Distribution of the studied companies according to the level of individual factors that influence the energy efficiency of economic activity.

Names of factors	**Level of factors**	**Number of companies by types of economic activity**		
		Production of metal products	**Production of glass and glass products**	**Production of bricks, tiles and other building materials from clay**
Resource support for the implementation of energy-saving projects by companies	Zero	0	0	0
	Low	6	5	7
	Average	19	25	20
	High	4	6	5
Existing competencies of owners, managers, and specialists of companies in matters of resource management, necessary for the development and implementation of energy-saving projects	Zero	0	0	0
	Low	5	6	5
	Average	18	22	22
	High	6	8	5
Compliance by owners and managers of companies with the concept of corporate social responsibility in the field of energy-saving	Zero	0	0	0
	Low	7	8	7
	Average	17	21	21
	High	5	7	4

Table 6. Shares of the number of investigated companies by the level of individual factors that have an impact on the energy efficiency of economic activity.

Names of factors	Level of factors	Shares of the number of investigated companies by the level of individual factors that influence energy efficiency in the total number of these companies by types of economic activity, %		
		Production of metal products	Production of glass and glass products	Production of bricks, tiles and other building materials from clay
Resource support for the implementation of energy-saving projects by companies	Zero	0.00	0.00	0.00
	Low	20.69	13.89	21.88
	Average	65.52	69.44	62.50
	High	13.79	16.67	15.63
Existing competencies of owners, managers, and specialists of companies in matters of resource management, necessary for the development and implementation of energy-saving projects	Zero	0.00	0.00	0.00
	Low	17.24	16.67	15.63
	Average	62.07	61.11	68.75
	High	20.69	22.22	15.63
Compliance by owners and managers of companies with the concept of corporate social responsibility in the field of energy-saving	Zero	0.00	0.00	0.00
	Low	24.14	22.22	21.88
	Average	58.62	58.33	65.63
	High	17.24	19.44	12.50

Correlation-regression analysis methods were used to establish statistical dependence between the studied factors and the change in the relative efficiency of natural gas use by companies during 2019–2021. As follows from the data given in the Table 7, each of the three independent variables has a moderate effect on the resulting indicator. At the same time, there is no significant mutual influence between the independent variables. As for the regression model (3), as can be seen from the data in the Table 8, the parameterization of this model led to a statistically significant relationship between the selected influencing factors and the change in the efficiency of natural gas consumption by companies. At the same time, this conclusion is valid for all three types of economic activity that were considered.

Table 7. The value of the correlation coefficients between the studied variables.

Designation of variables	ΔE	L_1	L_2	L_3
ΔE	1.000			
L_1	0.535	1.000		
L_2	0.442	0.275	1.000	
L_3	0.486	0.230	0.187	1.000

Note: the designations of the variables correspond to their designations in equation (3).

Table 8. The results of the regression analysis of the dependence between the selected independent variables and the level of change in the relative efficiency of the use of natural gas by companies by type of economic activity.

Types of economic activity	Regression coefficients			R^2	*F-value*	*t-value*		
	β_1	β_2	β_3			t_{β_1}	t_{β_2}	t_{β_3}
1. Production of metal products	0.022	0.031	0.019	0.758	76.13	3.516	4.357	3.986
2. Production of glass and glass products	0.025	0.029	0.021	0.801	54.29	4.659	5.112	4.241
3. Production of bricks, tiles and other building materials from clay	0.031	0.024	0.018	0.716	60.86	3.687	4.421	4.074

The conducted analysis also showed that there is no rebound effect in the consumption of natural gas for all three types of economic activity. Therefore, formula (4) can be used to perform final calculations. The results of such application are presented in the Table 9.

Table 9. The results of assessing the impact of corporate social responsibility on the relative efficiency of natural gas consumption by companies and on the share of operating profit in the amount of operating income of these companies.

Types of economic activity	The average change in the relative efficiency of natural gas consumption when the level of compliance with the concept of corporate social responsibility changes by 1 point	The average change in the share of operating profit in the amount of operating income when the level of compliance with the concept of corporate social responsibility changes by 1 point
1. Production of metal products	0.019	0.006
2. Production of glass and glass products	0.021	0.007
3. Production of bricks, tiles, and other building materials from clay	0.018	0.005

So, as follows from the data in the Table 9 with an increase of one point in the level of compliance by owners and managers of companies with the concept of corporate social responsibility in the field of energy saving, the average change in the relative efficiency of natural gas consumption and the average change in the share of operating profit in the amount of operating income are, respectively: for companies that produce metal products—0.019 and 0.006; for companies producing glass and glass products—0.021 and 0.007; for companies that produce bricks, tiles and other building materials from clay—0.018 and 0.005.

DISCUSSION

Assessment of the impact of corporate social responsibility on the level of energy efficiency of companies and changes in their financial and economic results should be based on determining the place that corporate social responsibility occupies among the factors that exert the specified influence. In general, the factors affecting the scale of energy saving at companies should be divided into four main groups, namely: factors that determine economic efficiency and determine the feasibility of implementing energy-saving projects of companies; resource support for the implementation of energy-saving projects by companies; existing competences of the owners, managers, and specialists of companies in matters of resource management, necessary for the development and implementation of energy-saving projects; personal preferences and beliefs of owners and managers of companies. The last group of factors include, in particular, compliance by owners and managers of companies with the concept of corporate social responsibility in the field of energy saving. It should be noted that most of the considered groups of factors that influence the level of energy efficiency of companies and changes in their financial and economic results have already been considered separately for each group in the literature, in particular in works [1,5,8,11]. At the same time, the systematization of factors that influence the energy efficiency of companies, proposed in this article, was not previously carried out in the scientific literature. Accordingly, this made it possible to deepen the understanding of the mechanism of such an influence, compared to the studies performed, in particular, in works [9,15,17,22].

In order to assess the impact of corporate social responsibility on energy efficiency, and, accordingly, on the change in the company's profit, it is necessary to perform a certain sequence of actions, which include: the selection of the base and reporting periods, as well as the type of energy resources being studied; formation of a sample of investigated companies; assessment of changes in the energy efficiency of each of the companies in the reporting period compared to the baseline; determination for each of the selected companies of the level of resource provision for the implementation of energy-saving projects, the level of competences available to the owners, managers and specialists of the enterprise in matters of managing this provision, and the level of compliance by the

owners and managers of companies with the concept of corporate social responsibility in the field of energy conservation; averaging researched variables by companies in the base period; analysis of the distribution of companies according to the studied variables according to the data of the base period; building a correlation matrix for the studied variables, determining the numerical values of the coefficients of the regression equation and evaluating the statistical significance of the obtained dependence; generalization of the obtained results. The proposed sequence of actions, in contrast to the methods given in particular in works [34–36], makes it possible to consider a larger number of factors that can influence energy efficiency and energy saving and to more accurately establish the place that corporate social responsibility occupies among these factors.

The conducted empirical analysis based on the data of Ukrainian companies that are consumers of natural gas showed, in particular, that the relative efficiency of the use of this energy resource ranged from 0.475 to 0.598 (i.e., from 47.5% to 59.8% of the maximum possible). As for the score of factors influencing this efficiency, in most cases, it was in the range of 1.5 to 2.0 (with the maximum possible value equal to 3.0). It was also established that when the level of compliance by owners and managers of companies with the concept of corporate social responsibility in the field of energy saving is increased by one point, the average change in the relative efficiency of natural gas consumption and the average change in the share of operating profit in the amount of operating income are, respectively: for companies that manufacture products from metal—0.019 and 0.006; for companies producing glass and glass products—0.021 and 0.007; for companies that produce bricks, tiles and other building materials from clay—0.018 and 0.005. Therefore, corporate social responsibility has a significant impact on the efficiency of the use of natural gas by the studied companies and on the profitability of their products. At the same time, most of the investigated companies have reservations regarding the increase of corporate social responsibility and, accordingly, the growth of energy efficiency and profitability of economic activity.

Further research on this topic should include, on the one hand, an increase in the number of independent variables whose influence is investigated. In particular, it is possible to consider the level of risk appetite of owners and managers of companies and other personal preferences and beliefs of owners and managers of companies not considered in this study. On the other hand, it is worth expanding the number of resulting indicators, in particular, by adding to them those that characterize the efficiency of investment activities of companies.

It should be noted that the obtained empirical results are largely consistent with the results presented in works [37–42]. At the same time, there are differences between these results both in the choice of control variables and in terms of the objects of the research. In particular, the

impact of corporate social responsibility on energy consumption at companies in the western region of Ukraine, which belong to the three industries considered in this article, has not been studied before.

Thus, the results obtained in this article are characterized by scientific novelty and make it possible to deepen the understanding of the complex laws on which the influence of corporate social responsibility on energy efficiency in industrial companies is based.

CONCLUSIONS

In the process of this study, the impact of corporate social responsibility on the energy efficiency of industrial companies in Ukraine and, accordingly, on the financial and economic results of this activity was evaluated. for this, firstly, a theoretical analysis of the mechanism of influence of various factors on energy efficiency and energy saving at companies was carried out. This made it possible to establish the place occupied by corporate social responsibility among the factors that exert the specified influence.

Secondly, a method of assessing the impact of corporate social responsibility and energy saving in companies was developed. The specified method takes into account all other main factors of influence, allowing one to single out the influence of corporate social responsibility.

Thirdly, the developed method was tested on a sample of 150 industrial companies in Ukraine. At the same time, the existence of a statistically significant influence of corporate social responsibility on energy efficiency and energy saving in companies was proven and the quantitative measure of such influence was determined. To obtain these results, in particular, the influence of factors that determine the effectiveness of investing in energy-saving measures was eliminated, the factor of prices for energy resources, that is, the influence of one of the most important factors that determine the scale of energy saving at companies was eliminated.

According to the results of the conducted research, it is worth recommending to the owners and managers of companies, the level of energy efficiency of which is not high enough, to pay more attention to increasing the corporate social responsibility of those employees who participate in the development and implementation of energy-saving measures. Also, state and local authorities can play a significant role in this, implementing a policy of promoting corporate social responsibility and providing appropriate informational, methodical, organizational, and in some cases, financial support to companies.

It should be noted that the theoretical and methodological results obtained in this article can also be used by analysts when assessing the impact of corporate social responsibility on the energy efficiency of companies. In particular, this applies to the case of the evaluation, which is performed to analyze the investment potential of companies in the field of energy saving.

Ultimately, the results obtained in this article may be of interest to scientists working in the relevant fields of science, from the point of view of further development of these results. At the same time, further research on this topic should include, on the one hand, an increase in the number of independent variables, the influence of which is investigated. In particular, it is possible to take into consideration the size of product sales markets, as well as the level of risk appetite of enterprise owners and managers, and other personal preferences and beliefs of enterprise owners and managers not considered in this study. On the other hand, it is worth expanding the number of resulting indicators, in particular, by adding to them those that characterize the efficiency of investment activities of companies.

DATA AVAILABILITY

The dataset of the study is available from the authors upon reasonable request.

AUTHOR CONTRIBUTIONS

FM, NS, OV, OY—methodology; FM, OV, OY, VH—formal analysis, review and editing; FM, NS, OV, OY, VH—conceptualization, original draft preparation.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1. Szafranko E. Assessment of the economic efficiency of energy-saving projects, methodology based on simple and compound methods. Energy Sci Eng. 2022;10:423-38.
2. Krones M, Müller E. An Approach for Reducing Energy Consumption in Factories by Providing Suitable Energy Efficiency Measures. Proced CIRP. 2014;17:505-10.
3. Krenn C, Weichbold T, Korp G, Meixner E, Stockner H, Berger D, et al. Qualitative and quantitative modelling to build a conceptual framework to identify energy saving options: case study of a wire producing company. J Clean Prod. 2015;95:212-22.
4. Richert M. An energy management framework tailor-made for SMEs: Case study of a German car company. J Clean Prod. 2017;164:221-9.
5. Máša V, Stehlík P, Touš M, Vondra M. Key pillars of successful energy saving projects in small and medium industrial companies. Energy. 2018;158:293-304.
6. Trianni A, Cagno E, Worrell E, Pugliese G. Empirical investigation of energy efficiency barriers in Italian manufacturing SMEs. Energy. 2013;49:444-58.
7. Lesinskyi V, Yemelyanov O, Zarytska O, Symak A, Petrushka T. Devising a Toolset for Assessing the Potential of Loan Financing of Projects Aimed at

Implementing Energy-Saving Technologies. East Eur J Enterp Technol. 2021;4(13):15-33.
8. Zhang Z, Jin X, Yang Q, Zhang Y. An empirical study on the institutional factors of energy conservation and emissions reduction: Evidence from listed companies in China. Energ Policy. 2013;57:36-42.
9. Lopes JRN, de Araújo Kalid R, Rodríguez JLM, Ávila Filho S. A new model for assessing industrial worker behavior regarding energy saving considering the theory of planned behavior, norm activation model and human reliability. Resour Conserv Recy. 2019;145:268-78.
10. Kostka G, Moslener U, Andreas J. Barriers to increasing energy efficiency: Evidence from small-and medium-sized companies in China. J Clean Prod. 2013;57:59-68.
11. Lesinskyi V, Yemelyanov O, Zarytska O, Symak A, Petrushka T. Development of a toolkit for assessing and overcoming barriers to the implementation of energy saving projects. East Eur J Enterp Technol. 2020;5(3–107):24-38.
12. Kangas HL, Lazarevic D, Kivimaa P. Technical skills, disinterest and non-functional regulation: Barriers to building energy efficiency in Finland viewed by energy service companies. Energ Policy. 2018;114:63-76.
13. Herrera B, Amell A, Chejne F, Cacua K, Manrique R, Henao W, et al. Use of thermal energy and analysis of barriers to the implementation of thermal efficiency measures in cement production: Exploratory study in Colombia. Energy. 2017;140(1):1047-58.
14. Bhandari D, Singh RK, Garg SK. Prioritization and evaluation of barriers intensity for implementation of cleaner technologies: Framework for sustainable production. Resour Conserv Recy. 2019;146:156-67.
15. Chiaroni D, Chiesa V, Franzò S, Frattini F, Latilla VM. Overcoming internal barriers to industrial energy efficiency through energy audit: a case study of a large manufacturing company in the home appliances industry. Clean Technol Envir. 2017;19:1031-46.
16. Yemelyanov O, Petrushka I, Zahoretska O, Petrushka K, Havryliak A. Information support for managing energy-saving technological changes at companies. Proced Comput Sci. 2023;217:258-67.
17. Yemelyanov O, Petrushka T, Lesyk L, Symak A, Vovk O. Modelling and Information Support for the Development of Government Programs to Increase the Accessibility of Small Business Lending. Available from: https://doi.org/10.1109/CSIT49958.2020.9322040. Accessed on 30 Aug 2024.
18. Hui J, Cai W, Wang C, Ye M. Analyzing the penetration barriers of clean generation technologies in China's power sector using a multi-region optimization model. Appl Energ. 2017;185:1809-20.
19. Chen YT. The Factors Affecting Electricity Consumption and the Consumption Characteristics in the Residential Sector—A Case Example of Taiwan. Sustainability. 2017;9(8):1484.
20. Nesbakken R. Price sensitivity of residential energy consumption in Norway. Energ Econ. 1999;21:493-515.

21. Hilorme T, Zamazii O, Judina O, Korolenko R, Melnikova Y. Formation of risk mitigating strategies for the implementation of projects of energy saving technologies. Acad Strateg Manage J. 2019;18(3):1-6.
22. Zhang Y, Zhao X, Fu B. Impact of energy saving on the financial performance of industrial in China: An empirical analysis based on propensity score matching. J Environ Manage. 2022;317:115377.
23. Wang J, Li L. Sustainable energy development scenario forecasting and energy saving policy analysis of China. Renew Sustain Energ Rev. 2016;58:718-24.
24. Vysochan O, Stanasiuk N, Honchar M, Hyk V, Lytvynenko N, Vysochan O. Comparative Bibliometric Analysis of the Concepts of “Ecotourism” and “Agrotourism” in the Context of Sustainable Development Economy. J Environ Manage Tour. 2022;13(2):561-71.
25. Vysochan O, Hyk V, Vysochan O, Yasinska A. Accounting in the context of a circular economy for sustainable development: A systematic network study. J Sustain Res. 2024;6(1):e240005.
26. Yemelyanov O, Petrushka T, Symak A, Lesyk L, Musiiovska O. Modelling the Impact of Energy-Saving Technological Changes on the Market Capitalization of Companies. In: Zaporozhets A, editor. Systems, Decision and Control in Energy III. Cham (Switzerland): Springer; 2021. p. 89-106.
27. Barauskaite G, Streimikiene D. Corporate social responsibility and financial performance of companies: The puzzle of concepts, definitions and assessment methods. Corp Soc Resp Env Ma. 2020;28:278-87.
28. Vitezić N. Correlation between social responsibility and efficient performance in Croatian enterprises. Available from: https://hrcak.srce.hr/clanak/111663. Accessed on 30 Aug 2024.
29. Vysochan O, Hyk V, Vysochan O. The Impact of Corporate Governance, Financial Performance, Intellectual Capital and Enterprise Size on Integrated Reporting: Evidence from Ukraine. J Environ Account Manage. 2023;11(4):429-39.
30. Hyk V, Vysochan O, Vysochan O. Sustainability Reporting Trends: A Systematic Literature Network Analysis. Comp Econ Res Cent East Eur. 2023;26(2):7-31.
31. Benlemlih M, Bitar M. Corporate social responsibility and investment efficiency. J Bus Ethics. 2018;148(3):647-71.
32. Vo DH, Van LTH, Hoang HTT, Tran NP. The interrelationship between intellectual capital, corporate governance and corporate social responsibility. Soc Responsib J. 2023;19(6):1023-36.
33. Chintrakarn P, Jiraporn P, Jiraporn N, Davidson T. Estimating the effect of corporate social responsibility on firm value using geographic identification. Asia Pac J Financ Stud. 2017;46(2):276-304.
34. Gezmen B. Increasing Efficiency of Energy Saving Policies in the Future: Corporate Social Responsibility Projects. In: Yüksel S, Dinçer H, editors. Strategic Approaches to Energy Management—Contributions to Management Science. Cham (Switzerland): Springer; 2021. p. 127-39.

35. Nurunnabi M, Esquer J, Munguia N, Zepeda D, Perez R, Velazquez L. Reaching the sustainable development goals 2030: Energy efficiency as an approach to corporate social responsibility (CSR). GeoJournal. 2019;85(2):363-74.
36. Hori S, Shinozaki M, Nogata D, Fujita T. The role of CSR in promoting companies' energy-saving actions in two Asian cities. Energ Policy. 2014;69:116-21.
37. Laguir I, Stekelorum R, Elbaz J, Duchamp D. Getting into the energy efficiency scene: Does corporate social responsibility matter for energy efficiency in SMEs? Appl Econ. 2019;51:5191-204.
38. Tylżanowski R, Kazojć K, Miciuła I. Exploring the Link between Energy Efficiency and the Environmental Dimension of Corporate Social Responsibility: A Case Study of International Companies in Poland. Energies. 2023;16(16):6080.
39. Strielkowski W, Tarkhanova E, Baburina N, Streimikis J. Corporate Social Responsibility and the Renewable Energy Development in the Baltic States. Sustainability. 2021;13(17):9860.
40. Bajda M, Jurdziak L, Pactwa K, Woźniak J. Energy-Saving of Conveyor Belts in the Strategy and Reporting of Corporate Social Responsibility Initiatives of Producers. In: Batako A, Burduk A, Karyono K, Chen X, Wyczółkowski R, editors. Advances in Manufacturing Processes, Intelligent Methods and Systems in Production Engineering. Cham (Switzerland): Springer; 2022. p. 402-14.
41. Andronie M, Simion VE, Gurgu E, Dijmărescu A, Dijmărescu I. Social Responsibility of Firms and the Impact of Bio-Economy in Intelligent Use of Renewable Energy Source. Amfiteatru Econ. 2019;21:520-35.
42. Zhang H, Omhand K, Li H, Ahmad A, Samad S, Gavrilut D, et al. Corporate Social Responsibility and Energy-Related Pro-Environmental Behaviour of Employees in Hospitality Industry. Int J Env Res Pub He. 2022;19(23):16141.

How to cite this article:
Mei F, Stanasiuk N, Vysochan O, Yemelyanov O, Hyk V. Corporate Social Responsibility as One of the Factors of Increasing Energy Efficiency: The Case of Energy Consumption at Industrial Companies of Ukraine. J Sustain Res. 2024;6(3):e240056. https://doi.org/10.20900/jsr20240056