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This study investigates the process that assesses the impact of energy-saving technological changes on the financial condition of enterprises. The principal hypothesis of this study assumes such an impact on a significant number of companies.

The research has made it possible to contribute to solving the task of improving the financial condition of business entities. In particular, the components of the impact of energy-saving technological changes on the financial condition of companies have been identified. A procedure for assessing the impact of energy-saving technological changes on this condition was devised. This procedure makes it possible to identify dependences between the level of energy-saving technological changes and indicators of the financial condition of enterprises. An integrated indicator of such a condition has been proposed.

The designed toolkit was validated on a sample of 105 enterprises in three industries. A statistically significant relationship was found between the level of energy-saving technological changes and the average values of the integrated indicator of the financial condition of the studied companies. It was established that the implementation of large-scale energy-saving technological changes by enterprises with low energy efficiency would allow these enterprises to increase the average value of the integrated indicator of the financial condition, depending on the industry, by 42–62%. It was found that energy-saving technological changes have the greatest impact on such a characteristic of the financial condition of enterprises as their profitability. This, in turn, provides more than 60% of the total increase in the value of the integrated indicator of the financial condition of companies.

The designed toolkit could be applied both at the level of an individual company and at the industry level. This would allow owners and managers of companies to increase the validity of technological renewal strategies

Keywords: *technological change, financial condition of an enterprise, investing in energy saving, financial stability*

ASSESSING THE IMPACT OF ENERGY-SAVING TECHNOLOGICAL CHANGES ON THE FINANCIAL CONDITION OF ENTERPRISES

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1. Introduction

The governments of many countries face the task of accelerating the pace of economic growth and improving the stability of economies given aggravating geopolitical situation [1]. The solution to these issues should emerge, first of all, at the level of companies, since their activities ultimately determine the processes that occur at the macroeconomic level. In addition, the economic development of companies largely determines the technical and technological, resource-saving and other types of development that occur in the sectors of the economy [2]. At the same time, the eco-

nom development of business entities often requires significant amounts of investment resources. In turn, the receipt of these resources by enterprises is largely determined by how good the financial condition of these companies is. First of all, this concerns their profitability and financial stability as the current level of these characteristics affects the ability of enterprises to receive investment resources from internal and external sources of funds, respectively. Therefore, managing the financial condition of firms in order to improve it is an important direction for ensuring long-term economic development of companies and increasing the sustainability of the economy as a whole [3].

On the other hand, the financial condition of enterprises depends on a significant number of various factors. In particular, such factors include the scale of investment and innovation activities of companies [4]. In turn, an important direction of such activities for many enterprises is the introduction of progressive technological processes for manufacturing products. Among these processes, energy-saving technologies occupy an important place. The introduction of these technologies under conditions of high energy prices and their significant volatility can be quite appropriately considered as an effective tool for improving the financial condition of enterprises.

Therefore, the financial condition is not only one of the factors in the formation of investment opportunities for the development of companies but also represents a resulting characteristic of such development, in particular development on the basis of energy-saving technological changes. Regarding these changes, their impact on the financial condition of business entities is likely to be particularly strong for those enterprises whose energy efficiency level was low before the implementation of energy-saving technological changes. Since quite a few enterprises have reserves to increase their energy efficiency, the issue of considering energy-saving technological changes as a possible tool for improving the financial condition of enterprises is relevant.

2. Literature review and problem statement

In modern scientific literature, the issue of managing the financial condition of enterprises is considered, in particular, through the prism of solving the problems of preventing the onset of a financial crisis or quickly overcoming this crisis if it does occur. Scientists, among other things, consider the impact on the occurrence of financial crises in companies of an unsatisfactory level of such parameters of their financial condition as solvency [5] and profitability [6]. At the same time, the authors of [5, 6] paid less attention to such a component of the financial condition of firms as their financial stability. However, the features of managing this component are considered in other papers, in particular [7]. However, in it, the task of establishing the main factors that lead to the deterioration of certain parameters of the financial condition of firms was not set. At the same time, this task was solved by other scientists. In particular, in work [8], scientists attributed the deterioration of the financial condition of firms to the deterioration of the market conditions for products manufactured by enterprises and other factors of their external environment. However, these factors, as a rule, are not subject to management by the management of enterprises. Therefore, it is important to identify internal factors that cause the deterioration of the financial condition of business entities. In particular, the authors of [9] attributed excessive amounts of debt financing of companies to these factors. Since this factor is predominantly internal in nature, regulation of the amount of debt financing is recognized by scientists, in particular the authors of [10], as one of the main tools for managing the financial condition of enterprises. However, in [9, 10], the task was not set to study in detail the economic consequences of debt financing of companies' activities, in particular the effects inherent in such financing.

In the context of debt financing management of economic activities, the effect of financial leverage deserves special attention. This effect reflects the influence of one of the

parameters of the financial condition of companies, namely the structure of the sources of financing of their assets, on another parameter, which is the profitability of the firms. At the same time, different scientists interpret the action of this effect differently. Thus, in [11] it is noted that the effect of financial leverage is positive, while the authors of [12] revealed negative consequences that can be caused by this effect for the financial condition of business entities. At the same time, there are publications, in particular [13], in which the influence of this effect on the financial condition of companies is not revealed at all. At the same time, the authors of some other papers, in particular [14], consider financial leverage as an important means of managing the financial condition of firms, justifying the need to apply an optimization approach for this purpose. However, it is worth considering the possible risks associated with the management of the activities of firms, which are considered, in particular, in [15].

However, in [11–15], the goal was not to perform a comprehensive study of the instruments for managing the financial condition of enterprises. At the same time, such a study was carried out in [16], the authors of which showed the existence of a fairly wide range of instruments for managing the financial condition of enterprises, instruments of both tactical and strategic nature. Also worthy of attention is study [17], which proves that an important role in improving the financial condition of enterprises can be played by their investment activities. However, as found out in work [18], the possibilities of such activities, especially in firms with an unsatisfactory financial condition, are always limited. At the same time, as established in [19], companies whose assets are relatively small face greater problems when trying to obtain investment resources from external sources than larger firms. However, the authors of [16–19] did not pay sufficient attention to energy-saving technological changes as a tool for improving the financial condition of enterprises.

One of the areas of investment activity, the relevance of which has recently increased significantly, is the investment by enterprises in the implementation of energy-saving technological changes. Such implementation makes it possible to reduce the energy intensity of enterprise products and reduce the consumption of non-renewable energy sources [20]. At the same time, as established in numerous studies, when implementing energy-saving measures, various barriers quite often arise [21], in particular, obstacles of a financial nature [22]. However, in most works that consider assessing the economic consequences of implementing energy-saving technological changes at enterprises, in particular [20–22], the issue of assessing the impact of such implementation on the financial condition of companies is not considered. At the same time, as proven in [23], the implementation of energy-saving projects by enterprises can significantly improve the financial stability of such enterprises. However, as found in work [24], this requires designing effective mechanisms, in particular financial and organizational ones. For this purpose, it is worth using the mechanisms proposed in the scientific literature to improve the perception of energy-saving technologies by firms [25], ensure their energy-saving development [26], and optimize the management of financial and investment activities of enterprises [27]. This, in turn, has a positive impact on the level of financial barriers that arise when enterprises attempt to carry out energy-saving investment measures. This statement is confirmed, in particular, by the results of the study of these barriers, reported in [28]. At the same time, in the reviewed papers [24–28] the issue of

assessing the impact of energy saving on the financial condition of companies is considered fragmentarily, in particular, insufficient attention is paid to the impact of energy-saving measures on the business activity of firms. This is due to the fact that a comprehensive assessment of the impact of energy saving on the financial condition of companies went beyond the research established in [24–28].

Among the characteristics of the financial condition of enterprises, which can be significantly affected by the introduction of energy-saving technologies, the greatest attention of researchers is paid to the profitability of economic activity. This is due to the undeniable positive impact of such implementation on reducing enterprises' expenses for the purchase of energy carriers. At the same time, it is possible to note such a characteristic of the financial condition of firms, the impact of energy-saving technological changes on which is not so obvious. We are talking about the business activity of companies, the increase of which is in principle possible if the competitiveness of firms increases as a result of their introduction of energy-saving technologies. The consequence of these processes is the so-called rebound effect in energy consumption, in which an increase in energy efficiency leads to an increase in energy consumption since the volume of production increases significantly [29]. However, the effect of the specified effect is not always present, as evidenced by the results reported in [30]. In any case, the rebound effect, if it manifests itself, affects only one of the components of the financial condition of enterprises, namely, their business activity. Therefore, studies that consider this effect do not provide a complete description of the mechanism of the impact of energy-saving measures, in particular energy-saving technological changes, on the financial condition of business entities.

Therefore, despite the existence of a number of scientific works that directly or indirectly study the impact of energy-saving technological changes on the financial condition of enterprises, the issue of such impact has not been considered in detail. Most of the studies in this field concern only individual characteristics of the financial condition. In addition, the issue of the impact of the introduction of energy-saving technologies on the integrated level of the financial condition of business entities has not been sufficiently studied.

3. The aim and objectives of the study

The purpose of our study is to establish the level of impact of energy-saving technological changes on the financial condition of enterprises. The results of such establishment should provide owners and managers of enterprises with information about the effectiveness of these changes as a possible tool for improving the financial condition of these enterprises.

To achieve the goal, the following tasks were set:

- to identify the main components of the mechanism of impact of energy-saving technological changes on the financial condition of companies;
- to devise a procedure for assessing the impact of energy-saving technological changes on the financial condition of companies that implement these changes;
- to test the designed toolkit for establishing the measure of the impact of energy-saving technological changes on the financial condition of enterprises based on a sample of industrial companies.

4. The study materials and methods

In our study, the object is the process of assessing the impact of energy-saving technological changes on the financial condition of enterprises. The principal hypothesis of this study is the assumption that a significant number of companies have such an impact. This hypothesis was based on a number of partial assumptions, namely:

- 1) the presence of a positive impact of implementing energy-saving technological changes on the profitability of enterprises;
- 2) the possibility of an increase in the level of financial dependence of enterprises as a result of their investment in the implementation of energy-saving technologies;
- 3) the generally positive impact of implementing energy-saving technological changes on the generalized level of the financial condition of companies.

At the same time, a number of simplifications were adopted in the process of the study, namely:

- 1) when testing the designed toolkit, a limited number of types of economic activity were considered;
- 2) within each type of economic activity, not the entire set of enterprises was studied but only their sample;
- 3) only enterprises whose net financial result during 2022–2024 was positive were considered.

The theoretical basis for this study included works that consider methodological and applied aspects of assessing technological changes at enterprises, analyzing the financial condition of companies, and establishing the influence of various factors on it. To form an array of input information necessary for conducting empirical analysis, statistical, management, and accounting data from a number of pre-selected industrial enterprises were collected. The specified data were collected in two ways: using publicly available databases on the economic activities of enterprises (primarily, the Opendatobot database (<https://opendatobot.ua/c/>)) and by directly surveying enterprises (the list of indicators for which data was collected is given in Table 1). The selected companies belong to three very energy-intensive industries, namely the manufacture of glass, metal, and clay products. For each of these industries, a sample of 50 randomly selected firms located in the western region of Ukraine was initially formed. Taking into account the completeness of the information collected and the willingness of the selected firms to provide it, a total sample of 105 companies was finally formed. This sample included 35 enterprises that manufacture glass products, 36 enterprises that manufacture metal products, and 34 enterprises that manufacture clay products.

In the process of carrying out this research, a wide arsenal of scientific knowledge methods was applied. In particular, such general scientific research methods as modeling, analysis, induction, etc. were used.

Thus, when devising and substantiating the procedure for assessing the impact of energy-saving technological changes on enterprises on their financial condition, economic and mathematical modeling was used. Its necessity in this case is due to both the complexity of the integrated assessment of the financial condition of companies and the presence of a rather complex mechanism of influence on this condition of measures to introduce energy-saving technologies. This, in turn, necessitates the need for appropriate formalization of the procedure for assessing the impact of energy-saving technological changes on the financial condition of business entities.

Table 1

List of indicators, the data on which formed the information base of our research

Names of performance indicators of the studied enterprises	Time periods over which data was collected
1. Total assets at the beginning of the year according to the balance sheet, UAH thousand*	2020–2024
2. Equity at the beginning of the year according to the balance sheet, UAH thousand	2023–2025
3. Debt at the beginning of the year according to the balance sheet, UAH thousand	2023–2025
4. Annual total income, UAH thousand	2020–2024
5. Annual net profit, UAH thousand	2020–2024
6. Annual value of marketable products, UAH thousand	2023–2024
7. Annual value of marketable products for the production of which energy-saving technologies were used, UAH thousand	2023–2024
8. Number of energy-saving technologies that were introduced into the production process, units	2020–2024
9. Amount of investment costs incurred for the implementation of energy-saving technological changes, UAH thousand	2020–2024

Note: * – the official exchange rate of the US dollar to the hryvnia, set by the National Bank of Ukraine, as of 10/15/2025 was 41.7514 UAH (<https://bank.gov.ua/>).

When studying the mechanism of influence of energy-saving technological changes on the financial condition of companies, the methods of system analysis and induction were applied. Their use allowed us to establish connections between the results of the implementation of projects for the introduction of energy-saving technologies and the corresponding parameters of the financial condition of enterprises.

In the process of carrying out empirical research on the impact of energy-saving technological changes on the financial condition of enterprises, such methods as economic analysis and feasibility studies were used. In addition, the questionnaire method was used to collect input data. When processing input information and further interpreting the results, one-way analysis of variance and other methods of statistical analysis were used. In addition, the implementation of empirical research is also based on the tools designed in this work. In order to visually display the results, graphical and tabular methods were used.

5. Results of investigating the impact of energy-saving technological changes on the financial condition of enterprises

5.1. Components of the impact of energy-saving technological changes on the financial condition of companies

When considering the impact of energy-saving technological changes on the financial condition of companies, it is worth highlighting three main components of the general mechanism behind such impact, namely:

1. The impact caused by the reduction of the specific cost of the company's products due to the implementation of energy-saving technological changes. The size of such a reduction is determined by the production cost standards of the relevant energy carriers before and after the implementation of energy-saving technological changes, the level of prices for energy resources, the size of additional current costs with the introduction of energy-saving technological changes by the company. Such additional costs include, for example, the costs of purchasing some other types of energy resources in the event that technological changes involve the full or partial replacement of one type of energy resources by others. The mechanism of the specified impact is reflected in the increase in the company's profit due to the reduction of the specific cost, while prices and physical production volumes remain unchanged. This naturally

leads to an increase in the profitability of the enterprise's products. In addition, a reduction in the specific cost can allow the company to slightly reduce product prices and, thanks to price competition, increase the sales volumes of its products. Then the amount of profit from sales of the entire volume of products will increase, which will lead to an increase in overall profitability. As for the profitability of assets and capital of the enterprise, in this case their degree can both increase and decrease. This depends on the value of the profitability of the company's assets before the introduction of energy-saving technologies and on the profitability of investments in projects for such implementation.

2. The impact caused by an increase in physical volumes of product sales due to the introduction of energy-saving technological changes by the company. In turn, this increase can be due to the action of two key factors. First, the introduction of energy-saving technologies by the enterprise may involve an increase in its production capabilities. Second, an increase in physical volumes of sales due to the introduction of energy-saving technological processes at the enterprise may cause the above-described effect of an increase in demand for the company's products after a decrease in prices for these products. In the case when the company had a reserve of production capabilities before the increase in demand for its products, then after such an increase it will be possible to use the specified reserve in full or in part. At the same time, the increase in sales volumes due to the implementation of energy-saving technological change projects by the company can lead to both an increase and a decrease in business activity and the profitability of the company's assets. This will depend on the initial capital intensity of the product (i.e., its level before the implementation of energy-saving technological changes), as well as on the volume of growth in the company's operating income due to the introduction of energy-saving technologies and on the amount of investment in such implementation.

3. The impact caused by the increase in the company's capital as a result of its implementation of energy-saving technological changes. Such an increase is a consequence of the investment costs incurred by the enterprise to implement the relevant measures. In this case, the investment of investment resources should be considered as a basic factor in changing the company's financial condition. This is due to the fact that the specified investment ultimately leads to both a reduction in the cost of production due to a decrease in the specific costs of energy carriers and an increase in sales of these products. It is also necessary to take into account the

structure of investment sources directed to the implementation of energy-saving technologies. This is due to the fact that the structure of sources of financing for the implementation of energy-saving technological changes may be a factor in further changing the structure of sources of financing for all the company's property, which it will own after such implementation. The level of influence of the specified factor will be the stronger, the more the initial structure of sources of financing for the company's assets and the structure of sources of financing for the implementation of energy-saving changes differ from each other. The volume of investment in these changes is also important. Thus, both the volume and the structure of sources of financing for measures to implement energy-saving technological processes at an enterprise can significantly affect its financial stability.

Therefore, the above-described mechanisms of the impact of investments in the implementation of energy-saving technological changes at an enterprise on the level of its business activity, profitability, and financial stability are interconnected. Given this, these mechanisms can be combined into one general mechanism for the impact of the company's implementation of energy-saving technological changes on its financial condition (Fig. 1).

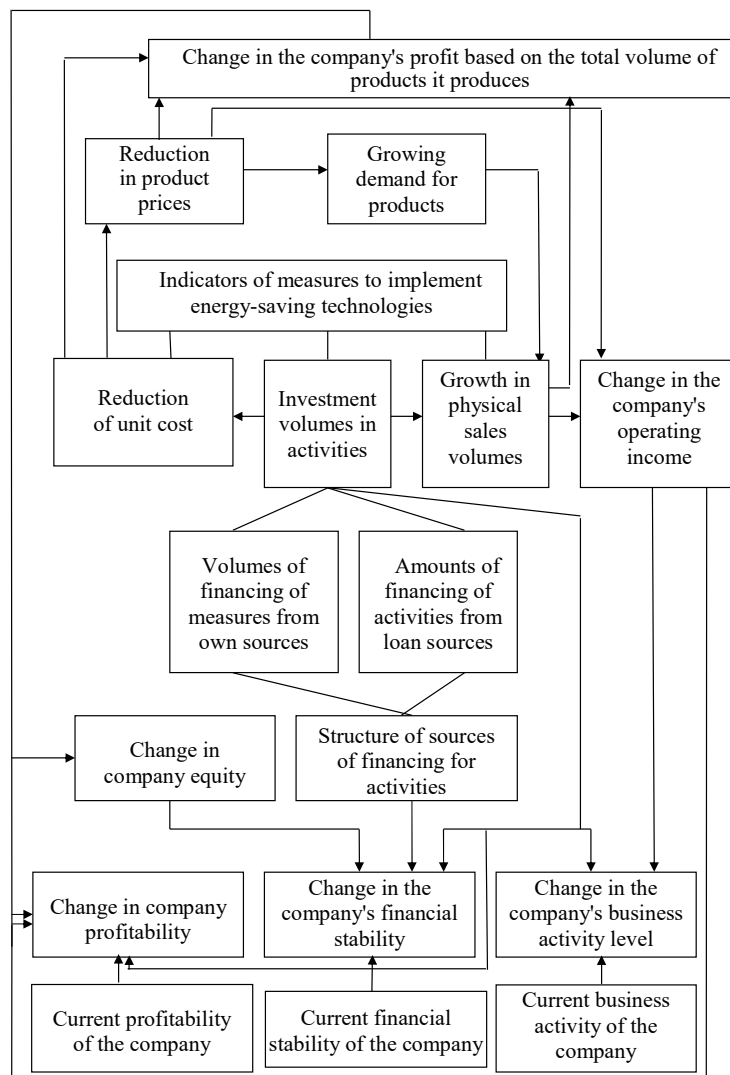


Fig. 1. Model for determining the impact of energy-saving technological changes on the financial condition of a company

It is also worth noting that the increase in the company's profit as a result of implementing measures to introduce energy-saving technologies can also have an impact on the level of financial stability of this enterprise. This impact is due to the fact that the increase in the profit of firms at a constant rate of its capitalization leads to an increase in the market value of the companies' equity. This, in turn, has a positive impact on the level of its financial stability.

5.2. Devising a procedure for assessing the impact of energy-saving technological changes on the financial condition of enterprises

When assessing the impact of energy-saving technological changes on the financial condition of enterprises, it is important to pre-select indicators that will characterize this condition. In addition to the well-known partial indicators for assessing individual components of the financial condition of firms, it is important to construct an integrated (generalizing) indicator of this condition.

In order to construct an indicator of the integrated level of the financial condition of enterprises, it is worth using the ratio between the market value of the equity of a particular company and the value of this value, which is indicated in the balance sheet

$$I = \frac{V_m}{V_b} \quad (1)$$

where I – integrated level of financial condition of the enterprise; V_m , V_b – respectively, market and balance sheet value of the enterprise's equity capital, monetary units.

Formula (1) is based on the fact that the ratio between the market and balance sheet value of the enterprise's equity capital is one of the fundamental criteria of the economic efficiency of the companies' functioning. At the same time, in order for this efficiency to be considered sufficiently high, the value of this ratio must exceed unity.

If the market value of the enterprise is estimated by the capitalization method, then expression (1) can be transformed into the following one

$$I = \left(\frac{P}{r} - V_c \right) \cdot \frac{1}{V_b} = \frac{P}{r \cdot V_b} - \frac{V_c}{V_b}, \quad (2)$$

where P is the average annual expected net profit of the enterprise, monetary units; r is the annual capitalization rate in fractions of a unit; V_c is the amount of loan capital of the enterprise, monetary units.

Expression (2) can be represented in the following equivalent form

$$\begin{aligned} I &= \frac{P \cdot R}{r \cdot R \cdot V_b} - \frac{V_c}{V_b} = \\ &= \frac{1}{r} \cdot \left(\frac{P}{R} \right) \cdot \left(\frac{R}{V_b} \right) - \frac{V_c}{V_b} = \frac{\alpha \cdot \beta}{r} - \gamma, \end{aligned} \quad (3)$$

where R is the average annual expected value of the enterprise's total income, monetary units; α is the level of profitability of the enterprise, which in this case is calculated as the ratio of net profit to total income; β is the turnover of the company's

equity, the value of which in this case is calculated according to the balance sheet data; γ is the level of financial dependence of the company, which in this case is calculated as the ratio of the balance sheet values of the enterprise's debt and equity.

Thus, indicator (3) is indeed integrated in nature. This is explained by the fact that it contains three partial indicators that characterize the three main components of the financial condition of companies, namely: profitability (indicator α), business activity (indicator β), and financial stability (indicator γ).

Regarding the assessment of the impact of energy-saving technological changes on the financial condition of enterprises, which is characterized by both partial indicators and the integrated indicator (3), the sequence of such assessment is shown in Fig. 2.

As follows from Fig. 2, one of the key points in assessing the impact of energy-saving technological changes on the financial condition of enterprises is the division of selected companies by the level of these changes. In turn, this level can be estimated, in particular, by the share of products manufactured using energy-saving technologies. For this purpose, the division of enterprises into three classes can be carried out according to the scale presented in Table 2.

It should be noted that the increase in the value of indicator (3) when moving from one class of enterprises by the level of energy-saving technological changes to another such class is subject to decomposition. For this purpose, it is necessary to assume that every two of the three averaged values of partial indicators (α , β , γ) contained in expression (3) are the same for both compared classes. In particular, they can be taken at the level of averaged values for the class of companies with a smaller number. Then it is necessary to recalculate the average value of indicator (3) for the class of companies with a larger number and subtract from this value the average value of indicator (3) for the class of companies with a smaller number. The described procedure will make it possible to establish which factors have the greatest impact on the differences in the average values of the integrated indicator of the financial condition of companies of different classes by the level of energy-saving technological changes.

Classes of companies by level of energy-saving technological changes

Class numbers	Class names	Signs of company class affiliation
1	Companies characterized by a low level of energy-saving technological changes	The share of companies manufacturing products using energy-saving technologies in the total volume of such manufacturing does not exceed 30%
2	Companies with a medium level of energy-saving technological change	The share of companies manufacturing products using energy-saving technologies in the total volume of such manufacturing is in the range from 30% to 70%
3	Companies with a high level of energy-saving technological change	The share of companies manufacturing products using energy-saving technologies in the total volume of such manufacturing exceeds 70%

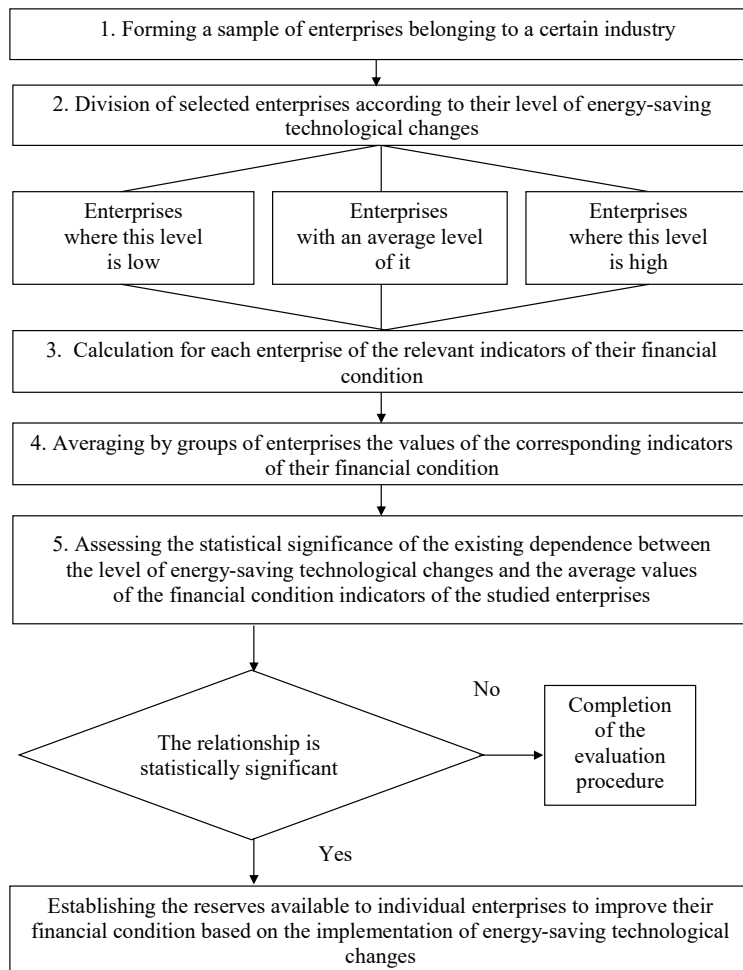


Fig. 2. Algorithm for assessing the impact of energy-saving technological changes on financial condition

5. 3. Testing the toolkit for assessing the impact of energy-saving technological changes on the financial condition of enterprises

Analysis of energy-saving technological changes at the studied enterprises belonging to three industrial sectors of Ukraine revealed that the scale of such changes at these enterprises in recent years was not very high (Table 3). In particular, the share of enterprises that made the specified changes during 2020–2024 ranges from 30.56% to 38.24% by type of economic activity. The average level of investment costs for implementing energy-saving technological changes was also quite low. This level, which was calculated as the ratio of investments in energy-saving technologies to the average value of total assets of enterprises, ranged from 0.03 to 0.06 by type of economic activity.

As follows from the data in Table 4, the vast majority of the studied enterprises belong to the class of companies that, as of the beginning of 2025, are characterized by low and medium levels of energy-saving technological changes. In particular, the share of enterprises with a low level of these changes by type of economic activity ranges from 29.41% to 36.11%.

In the course of our research, the impact of energy-saving technological changes on the values of partial indicators of the financial condition of the studied firms was assessed (Table 5). We are talking

about those indicators that are contained in formula (3). The calculations performed showed the presence of a statistically significant such impact for indicators α and γ , as well as the absence of the specified impact for indicator β . This conclusion follows from the fact that the actual values of the F -criterion for indicators α and γ are greater than the critical ones, and for indicator β – less. At the same time, this applies to all three types of economic activity under consideration, as well as to the entire set of studied enterprises in general.

Table 3

Individual indicators of the implementation of energy-saving technological changes at the studied enterprises during 2020–2024

Indicator names	The value of indicators for the studied enterprises that manufacture articles			Indicator values for all enterprises
	Glass	Metal	Clay	
1. Total number of enterprises	35	36	34	105
2. Number of enterprises that implemented energy-saving technological changes during 2020–2024	12	11	14	37
3. Share of enterprises that implemented energy-saving technological changes during 2020–2024 in the total number of companies studied, %	34.29	30.56	38.24	35.24
4. Average level of investment costs incurred for implementing energy-saving technological changes during 2020–2024	0.04	0.03	0.06	0.04

Table 4

Distribution of the studied enterprises by the level of energy-saving technological changes

Enterprise classes	Number of enterprises of the corresponding class that manufacture articles			Share of enterprises of the corresponding class that manufacture articles		
	Glass	Metal	Clay	Glass, %	Metal, %	Clay, %
Companies with low levels of energy-saving technological change	11	13	10	31.43	36.11	29.41
Companies with medium levels of energy-saving technological change	13	14	15	37.14	38.89	44.12
Companies with high levels of energy-saving technological change	11	9	9	31.43	25.00	26.47
Total	35	36	34	100.00	100.00	100.00

At the same time, for all types of economic activity under consideration there is a statistically significant relationship between the level of energy-saving technological changes and the average values of the integrated level of the financial condition of the companies under study. This conclusion follows from the data given in Table 6. As can be seen from Table 6, with the increase in the level of energy-saving technological changes, there is a clear increase in the average values of the integrated level of the financial condition of the companies under study. At the same time, for all three industries and for the entire set

of companies under study, the actual values of the F -criterion for indicator (3) are greater than the critical ones.

Table 5

Average values of partial indicators of the financial condition of the studied enterprises depending on the level of energy-saving technological changes

Names of financial condition indicators	Level of energy-saving technological changes	Average values of indicators for the studied enterprises that manufacture articles			Average values of indicators for all enterprises
		Glass	Metal	Clay	
1. Net profit to total revenue	1. 1. Low	0.02	0.03	0.02	0.02
	1. 2. Medium	0.05	0.05	0.04	0.05
	1.3. High	0.07	0.08	0.07	0.07
2. Equity turnover	2. 1. Low	3.01	2.97	4.76	3.21
	2. 2. Medium	3.69	3.23	4.21	3.44
	2. 3. High	3.41	3.50	5.03	3.62
3. Net profit to total revenue	3. 1. Low	1.19	1.27	1.45	1.25
	3. 2. Medium	1.58	1.64	1.79	1.67
	3. 3. High	1.82	2.09	2.16	2.07

Table 6

Results of variance analysis of the impact of the level of energy-saving technological changes on the integrated level of the financial condition of the studied enterprises

Level of energy-saving technological changes	The value of the integral level of financial condition for the studied enterprises that manufacture articles			The value of the integral level of financial condition for the entire set of studied enterprises
	Glass	Metal	Clay	
Low	0.78	0.66	0.83	0.76
Medium	0.93	0.89	1.04	0.94
High	1.17	1.07	1.18	1.12
Actual F-test values	6.54	5.89	7.21	5.65

A decomposition of the increase in the value of indicator (3) was also performed when moving from one class of the studied enterprises in terms of the level of energy-saving technological changes to another such class. The relative indicators that describe the results of such decomposition are given in Table 7.

As shown in Table 7, the main reason for the higher integrated level of the financial condition of enterprises with a higher level of energy-saving technological changes is the higher value of the ratio of net profit to total income. The degree of influence of this reason for all types of economic activity and for the entire set of enterprises under study exceeds 60%. Therefore, energy-saving technological changes have the greatest impact on such a characteristic of the financial condition of enterprises as their profitability. At the same time, the impact of equity turnover and financial dependence on the higher value of the integrated level of the financial condition of enterprises with a higher level of energy-saving technological changes is moderate. It should be noted that the sum of the values of the influences of the factors given in Table 7 is not equal to 100%, since there is also a joint influence of the first two factors. This, in turn, is explained by the fact that expression (3) in relation to these two factors has a multiplicative nature.

Based on the data given in Tables 5, 6, an assessment of the forecast impact of implementing energy-saving techno-

logical changes on the change in the values of partial and general indicators of the financial condition of the studied enterprises was performed. The results of such an assessment are given in Table 8.

Table 7
Results of decomposition of the increase in the value of indicator (3) when moving from one class of the studied enterprises in terms of the level of energy-saving technological changes to another such class

Comparable enterprise classes	Influencing factors	Relative level of influence of factors for the studied enterprises that manufacture articles			Relative level of influence of factors for the entire set of studied enterprises, %
		Glass, %	Metal, %	Clay, %	
1 and 2	1. Net profit to total revenue ratio	67.11	63.07	71.65	66.82
	2. Equity turnover	26.39	30.05	27.12	27.05
	3. Level of financial dependence	-17.87	-16.54	-14.76	-16.38
2 and 3	1. Net profit to total revenue ratio	63.76	62.98	70.48	64.13
	2. Equity turnover	27.65	32.71	29.65	29.48
	3. Level of financial dependence	-19.31	-17.32	-15.52	-17.54

Table 8
Assessing the forecast impact of implementing energy-saving technological changes on change in the values of partial and general indicators of the financial condition of the studied enterprises

Comparable enterprise classes	Names of financial condition indicators	Forecasted absolute average increases in indicator values				Forecasted relative average increases in indicator values, %			
		For companies that manufacture articles			For all enterprises	For companies that manufacture articles			For all enterprises
		Glass	Metal	Clay		Glass	Metal	Clay	
2 to 1	Net profit to total revenue ratio	0.03	0.02	0.02	0.03	150.00	66.67	100.00	150.00
	Equity turnover	0.68	0.26	-0.55	0.23	22.59	8.75	-11.55	7.17
	Level of financial dependence	0.39	0.37	0.34	0.42	32.77	29.13	23.45	33.60
	Integral level of financial condition	0.15	0.23	0.21	0.18	19.23	34.85	25.30	23.68
3 to 1	Net profit to total revenue ratio	0.05	0.05	0.05	0.05	250.00	166.67	250.00	250.00
	Equity turnover	0.4	0.53	0.27	0.41	13.29	17.85	5.67	12.77
	Level of financial dependence	0.63	0.82	0.71	0.82	52.94	64.57	48.97	65.60
	Integral level of financial condition	0.39	0.41	0.35	0.36	50.00	62.12	42.17	47.37

As can be seen from Table 8, the implementation of energy-saving technological changes at those enterprises under study, in which the level of such changes is low or medium, can lead to a significant increase in the profitability of these enterprises. In most cases, such an increase exceeds 100%. In contrast, the expected impact of energy-saving technological changes on the turnover of equity of the studied firms, although in most cases positive, is reflected in an increase in this turnover of no more than 23%. At the same time, for all groups of enterprises under study, energy-saving technological changes, according to forecast estimates, lead to an increase in the level of financial dependence of these enterprises. It is also worth noting the rather significant positive forecast impact of the implementation of energy-saving technological changes by the companies studied

on the increase in the value of the integrated indicator of the financial condition of these companies. Thus, for enterprises with low energy efficiency, the implementation of large-scale energy-saving technological changes, according to forecast

Table 7

estimates, should provide an increase in the integrated indicator of the financial condition, depending on the type of economic activity, by 42–62%.

6. The designed toolkit for assessing the impact of energy-saving technological changes on the financial condition of enterprises: discussion

Our research showed that the assessment of the impact of technological changes on the financial condition of enterprises should be based on the application of the appropriate tool. This tool, in turn, should be based on the model for determining the impact of energy-saving technological changes on the financial condition of the company, built in this work, shown in Fig. 1. This model, which is based on the preliminary identification of the three main components of the specified impact, among other things, considers the impact caused by the reduction in the specific cost of the company's products due to its implementation of projects for the introduction of energy-saving technological changes. The magnitude of such a reduction is determined by the production cost standards of the relevant energy carriers before and after the implementation of energy-saving technological changes, the level of prices for energy resources, the size of additional current costs with the introduction of energy-saving technological changes by the company. Such additional costs include, for example, the costs of purchasing some other types of energy resources in the event that technological changes involve the full or partial replacement of one type of energy resources by others. The mechanism of

this impact is reflected in the increase in the company's profit due to a reduction in the unit cost, while prices and physical production volumes remain unchanged. This naturally leads to an increase in the profitability of the company's products. It is also worth noting the fact that the increase in the company's profit as a result of implementing measures to introduce energy-saving technologies can also have an impact on the level of financial stability of this enterprise. This impact is due to the fact that the increase in the company's profit at a constant rate of its capitalization leads to an increase in the market value of the companies' equity. This, in turn, has a positive impact on the level of their financial stability.

When assessing the impact of energy-saving technological changes on the financial condition of enterprises, it is important to pre-select indicators that will characterize this

condition. In addition to the well-known partial indicators for assessing individual components of the financial condition of firms, it is important to construct an integrated (generalizing) indicator of this condition. In order to construct such an indicator, it is worth using the ratio between the market value of the equity of a particular company and the value of this value, which is indicated in the balance sheet. The corresponding indicator is represented by expression (3). Based on the indicated indicator, we have devised a procedure for assessing the impact of energy-saving technological changes on the financial condition of enterprises, shown in Fig. 2. At the same time, one of the key points of such an assessment is the division of selected companies by the level of the specified changes. This level can be estimated, in particular, by the share of products manufactured using energy-saving technologies.

The designed toolkit for assessing the impact of energy-saving technological changes on the financial condition of companies can be used to establish the presence and determine the extent of such impact both at the level of an individual company and at the industry level. The practical value of this tool is due to a number of aspects. First, using the proposed generalized indicator for assessing the financial condition of enterprises, their owners and managers will receive a fairly complete picture of the integrated level of this condition. Second, using the built model of the impact of energy-saving technological changes on the financial condition of the company, owners and managers of enterprises will be able to better understand the mechanism of such impact, which will increase the validity of decisions regarding the implementation of these changes. Third, enterprises with high energy intensity of products, using the procedure devised in this study, will be able to predict a possible improvement in their financial condition if energy-saving technologies are implemented. To this end, these enterprises should collect data on their competitors, including those in which the energy intensity of products is lower. This will enable business owners and managers to increase the validity of their businesses' technological renewal strategies.

The effectiveness of the designed toolkit was established during its testing on a sample of industrial enterprises belonging to three industries. This testing, the results of which are given in Tables 3–8, showed, in particular, the existence of a statistically significant relationship between the increase in the level of energy-saving technological changes and the growth of the integrated level of the financial condition of the companies under study. In particular, our calculations showed that the implementation of energy-saving technological changes at those enterprises in which the level of such changes is low or medium can lead to a significant increase in the profitability of these enterprises. In most cases, such an increase exceeds 100%. In contrast, the expected impact of energy-saving technological changes on the turnover of the equity of the companies under study, although in most cases positive, is reflected in an increase in this turnover of no more than 23%. At the same time, for all groups of the enterprises under study, energy-saving technological changes, according to forecast estimates, lead to an increase in the level of financial dependence of these enterprises. It is also worth noting the rather significant positive predictive impact of the implementation of energy-saving technological changes by the studied companies on the increase in the value of the integrated indicator of the financial condition of these companies. Thus, for enterprises with low energy efficiency,

the implementation of large-scale energy-saving technological changes, according to predictive estimates, should ensure an increase in the integrated indicator of the financial condition, depending on the type of economic activity, by 42–62%.

Thus, in this work, the system of indicators for assessing the financial condition of enterprises was expanded compared to those indicators used in particular in [6–17]. Also, in comparison with the results reported in [18–31], the degree of formalization of the process of assessing the impact of energy-saving technological changes on the financial condition of firms was increased. In general, the designed toolkit quite fully covers the issue of assessing the impact of energy-saving technological changes occurring at enterprises on the level of their financial condition. This is achieved due to the fact that the use of such tools allows the specified assessment to be carried out completely and with due accuracy. Therefore, the information obtained as a result of using the specified tools makes it possible to substantiate ways to realize the potential for improving the financial condition of companies based on the implementation of energy-saving technological changes in them.

This toolkit will be especially useful after the end of martial law in Ukraine and the start of large-scale reconstruction of its economy since technological renewal should be an important component of such reconstruction. Martial law and military activity do not allow for the full realization of the potential of such renewal.

At the same time, a limitation of this study is that it does not take into account the possibility of implementing other types of technological changes at enterprises, in particular labor-saving ones. Another limitation is the consideration of enterprises with only three types of economic activity. Eliminating these limitations should be the area of further research.

It is also worth noting a certain drawback of this study, namely, the difficulty of absolutely accurately assessing the capitalization rate, which appears in expressions (2) and (3). At the same time, the introduction of this rate into consideration made it possible to combine the main parameters of the financial condition of enterprises in one formalized model. This allowed us to construct an integrated indicator for assessing this condition. However, it is possible to use other such indicators, which would make it possible to obtain additional results of assessing the impact of energy-saving technological changes on the financial condition of companies. Therefore, the indicated application may represent a further advancement of our study.

7. Conclusions

1. Three main components of the mechanism of the impact of energy-saving technological changes on the financial condition of companies have been identified. The first of them is due to a reduction in the specific cost of the company's products due to its implementation of projects for the introduction of energy-saving technological changes. The second component of the impact is caused by an increase in the physical volume of product sales due to the introduction of energy-saving technologies by the company. In turn, this increase can be caused by the action of two key factors. First, the introduction of energy-saving technologies by an enterprise may involve an increase in its production capabilities. Second, an increase in physical sales due to the introduction of energy-saving technological processes at the enterprise may cause the effect of an increase in demand for the compa-

ny's products after a decrease in prices for them. Finally, the third component of the impact of energy-saving technological changes on the financial condition of companies is caused by an increase in the company's capital as a result of its implementation of energy-saving technological changes. Such an increase is a consequence of the investment costs incurred by the enterprise to implement the relevant measures. At the same time, the investment of investment resources should be considered as a basic factor in changing the financial condition of the company. This is explained by the fact that the specified investment ultimately leads to both a reduction in the cost of production due to a decrease in the specific costs of energy carriers and an increase in sales of these products.

2. A procedure for assessing the impact of energy-saving technological changes on the financial condition of companies implementing these changes has been devised. The procedure provides, in particular, for dividing selected companies by the level of energy-saving technological changes. This makes it possible to assess the statistical significance of existing dependence that exists between the level of energy-saving technological changes and the average values of the financial condition indicators of the studied enterprises. At the same time, an integrated (generalizing) indicator of such a condition was proposed and substantiated. Its integrated nature is manifested in the fact that it contains partial indicators that characterize the three main components of the financial condition of companies, namely: profitability, business activity, and financial stability.

3. Our analysis of energy-saving technological changes at the studied enterprises belonging to three industrial sectors of Ukraine revealed that the scale of such changes at these enterprises in recent years has not been very high. In particular, the share of enterprises that implemented the mentioned changes during 2020–2024 ranges from 30.56% to 38.24% by type of economic activity. The average level of investment costs for implementing energy-saving technological changes was also quite low. This level, which was calculated as the ratio of investments in energy-saving technologies to the average value of total assets of enterprises, ranged from 0.03 to 0.06 by type of economic activity. At the same time, for all considered types of economic activity, a statistically significant relationship was established between the level of energy-saving technological changes and the average values of the integrated level of the financial condi-

tion of the studied companies. This dependence is manifested in the fact that with the increase in the level of energy-saving technological changes, there is a clearly pronounced increase in the average values of the integrated level of the financial condition of the studied enterprises. Calculations have shown that the implementation of large-scale energy-saving technological changes by enterprises with low energy efficiency will allow them to increase the average value of the integrated indicator of the financial condition for these enterprises, depending on the industry, by 42–62%. At the same time, energy-saving technological changes have the greatest impact on such a characteristic of the financial condition of enterprises as their profitability. This, in turn, provides more than 60% of the total increase in the value of the integrated indicator of the financial condition of companies. Therefore, energy-saving technological changes should be considered as an effective tool for improving the financial condition of enterprises.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study, as well as the results reported in this paper.

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Data availability

All data are available, either in numerical or graphical form, in the main text of the manuscript.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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