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*This work assesses the financial and investment potential of enterprises for implementing energy-saving measures. The task addressed is to design an effective toolset for such an assessment. This study has made it possible to contribute to solving this task.*

*Specifically, components in the financial and investment potential of enterprises in implementing energy-saving measures have been identified. Indicators for assessing the specified potential and its components were constructed. It was proposed to carry out such an assessment in several stages using an optimization approach.*

*The designed toolset was tested on a sample of 105 enterprises belonging to three energy-intensive industries. The financial and investment potential of the studied enterprises in implementing energy-saving measures was assessed. It was established that the main limiting factor of the magnitude of this potential is its financial component. The level of use of this potential by the studied companies was calculated. It was found that this level for enterprises with high energy intensity of production varies by industry from 37.19% to 44.29%. It was found that with increasing energy efficiency, the size of the financial and investment potential of the studied enterprises for their implementation of energy-saving measures decreases but the level of realization of this potential increases.*

*The proposed toolkit is suitable for use both at the level of individual companies and at the industry level. Its application could allow company managers to more reasonably approach the development of financial and investment strategies for implementing energy-saving measures*

*Keywords: financial and investment potential, energy saving at the enterprise, personnel competence, energy-saving project*

# DESIGNING A TOOLKIT FOR ASSESSING THE FINANCIAL AND INVESTMENT POTENTIAL OF ENTERPRISES FOR THE IMPLEMENTATION OF ENERGY SAVING MEASURES

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## 1. Introduction

Among the goals of sustainable development, ensuring long-term economic growth occupies an important place. Such growth is impossible without investing investment resources. It is also necessary to improve the quality of economic growth on the basis of introducing new progressive technologies and other innovations into the activities of business entities. This implementation, as well as ensuring long-term growth in production volumes, requires enterprises to incur investment costs [1].

At the same time, drawing up investment programs for their development by enterprises requires that owners and managers of companies have up-to-date and complete information about the size of their investment opportunities. The significance of this information is especially high under current business conditions, which are characterized by significant price volatility and destabilization of logistics chains [2]. To obtain this information, it is necessary to assess the financial and investment potential of business entities. The results of this assessment should form the basis on which owners and managers of enterprises will make informed management decisions on investment [3].

However, assessing the financial and investment potential of companies is a difficult task. Solving it is complicated by the presence of different types of the specified potential. In particular, the financial and investment potential of firms can be assessed both in the short-term and in the long-term periods. It is also necessary to note the complexity of the mechanism of formation of financial and investment potential, primarily the presence of a significant number of exogenous and endogenous factors that take a direct or indirect part in the process of such formation [4]. After all, the financial and investment potential of enterprises contains a number of components that correspond to different areas of investment. Each of these components has a certain specificity, which should be reflected in the tools used for its assessment [5].

The most important areas of investment include investments in resource-saving measures at enterprises. Among other things, this concerns energy-saving measures, the implementation of which is a necessary condition for ensuring competitiveness, economic sustainability, and adaptability of business entities [6].

Despite the obvious need to reduce the energy intensity of products by many companies, a significant part of them demonstrates inertia in carrying out active energy-saving activities. This is due to the existence of a number of critical obstacles of an informational, institutional, and other nature [7]. Financial constraints also play a significant role among these obstacles. The high capital intensity of projects for the modernization of energy equipment, long payback periods, and limited access to cheap credit resources can lead to a significant slowdown in the energy-saving process at enterprises. As a result, enterprises are forced to postpone the implementation of energy-efficient technologies, which leads to further technological lag and an increase in the energy intensity of products.

However, business experience shows that not all barriers to the implementation of energy-saving projects at enterprises are of an exclusively objective external nature. Often, a subjective factor becomes a deterrent, primarily the lack of special competencies among owners and top management, in particular in assessing the financial and investment potential of enterprises for the implementation of energy-saving measures. At the same time, such an assessment should be based on the use of scientifically sound tools, with the help of which it would be possible to estimate the magnitude of the specified potential. Therefore, it is a relevant task to design tools for assessing the financial and investment potential of enterprises for the implementation of energy-saving measures.

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## 2. Literature review and problem statement

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The issues of formation and assessment of various types of economic potential of business entities have been studied in a significant number of works. Thus, in [8], the regularities of formation of investment potential of companies were established and means of realization of this potential were singled out. However, in [8], the issue of assessment of investment potential of firms was not considered in detail. At the same time, scientifically substantiated tools for assessment of innovation potential available in firms on the basis of mathematical modeling were proposed in [9]. However, insufficient attention was paid to the technological component of innovation potential. This issue is addressed in [10], which studied and assessed

the ability of companies to carry out advanced technological changes. However, the specified ability was not closely connected with the ability of companies to develop. In contrast, in [11], the ability of firms to their economic development on the basis of diversification of activities was determined. However, in it, as in the above-mentioned papers [8–10], insufficient attention was paid to the potential for energy saving at enterprises. This can be explained by the fact that the study of this potential went beyond the scope of those studies.

At the same time, the potential for energy saving and increasing the energy efficiency of companies has been studied in sufficient detail in other scientific papers. In particular, the author of [12] assessed this potential using the example of the US economy, showing that there are enough economically justified options for increasing energy efficiency to reduce the US energy needs by half. However, the study concerned only one country. Although the US consumes significant amounts of energy, there are also other states that consume significant amounts of energy resources, primarily China. Therefore, work [13] is of interest, which assesses the potential for increasing energy efficiency using the example of the industrial sector of China and, in particular, reveals the importance of technological progress for ensuring such an increase. At the same time, energy consumption was considered only in the Chinese industry. Therefore, the results reported in [14], in which the object of the study was the construction sector of China, for which a significant potential for increasing energy efficiency was established, are also of great importance. At the same time, in [14], as in [11–13], insufficient attention was paid to the issue of financial support for the implementation of the potential for increasing energy efficiency. This can be explained by the fact that consideration of the specified issue was not included in the list of tasks set by the authors of [11–14].

Special attention should be paid to studies that investigate the reasons that determine the insufficient level of realization of the potential of enterprises for implementing energy-saving measures. Thus, a number of scientists, in particular the authors of [15], attribute to such reasons the shortcomings in the information support of the decision-making process on the implementation of energy-saving measures at enterprises. However, the results reported in [15] are characterized by the lack of a sufficiently detailed assessment of the impact of the implementation of energy-saving measures on the economic performance of companies. This gap is to some extent closed by [16], the authors of which investigate the patterns of information support for managing energy-saving economic development of firms. At the same time, [16] does not consider the impact of the aforementioned support on the scale and speed of energy-saving changes. Work [17] addressed this issue but its authors did not pay sufficient attention to the issue of the competence of owners and managers of enterprises in the field of energy saving. At the same time, [18] points out the importance of appropriate competencies for realizing the potential for increasing energy efficiency in the manufacturing sector. However, paper [18] does not pay enough attention to green competencies. Therefore, work [19] deserves attention, which found that investing in the development of key green competencies is beneficial for business as it leads to improved environmental innovations and the green image of companies. However, the study does not consider the functions of sustainable energy management in sufficient detail. At the same time, paper [20] establishes the importance of environmental awareness as a condition for the implementation of these functions at enterprises, although the impact of such awareness on

energy efficiency has not been studied. Therefore, work [21] deserves attention. Its authors, along with other driving forces for energy efficiency growth, also highlighted the increase in awareness of organizational personnel in energy issues. However, in [21], as in [15–20], the financial capabilities of business entities were not considered as one of the factors that inhibit energy saving at enterprises. This can be explained by the fact that the authors of those papers provided a detailed description of the action of other factors that cause such inhibition.

At the same time, the issue of assessing the financial capabilities of enterprises was considered in a number of other papers. Special attention is paid to external sources of financing of companies' activities, primarily to bank loans. Thus, the results of the analysis of the activities of small European firms given in [22] proved the presence of significant difficulties in the access of these firms to banking services. However, insufficient attention was paid to the impact of bank lending on the development of companies. The presence of such an influence, in particular for countries with a transition economy, was established in [23]. However, in it, the factor of firm size is not sufficiently taken into account, as it is done in [24]. At the same time, it was established in [24] that companies with smaller assets are forced to limit themselves mainly to internal sources of funds, while larger enterprises, in addition to internal sources, also turn to external sources of funds. However, in [24], as well as in papers [22, 23], the specificity of assessing the financial capabilities of enterprises regarding the financing of energy-saving investment projects were not considered. This is caused by the fact that the authors of those papers considered a more general case, that is, the financing of any projects. At the same time, energy-saving projects have their own specificity that must be taken into account.

Taking into account the specificity of energy-saving investment projects when justifying financial support was considered in a significant number of studies. In particular, in [25], the feasibility of crediting projects of energy-saving technologies is considered and its availability is evaluated as a tool for overcoming obstacles that arise during the implementation of these projects. However, the scale factor of energy-saving projects of enterprises is not sufficiently taken into account. Therefore, the results reported in [26] are of scientific interest; it is specifically noted that investments in these projects may be too large, which inhibits the introduction of energy-saving technological processes. At the same time, paper [26], as well as other studies reviewed above, did not set the task of a comprehensive assessment of the financial and investment potential of enterprises in relation to the implementation of energy-saving projects.

Thus, the scientific literature has not solved the task of designing a toolset for assessing the financial and investment potential of companies in the field of energy saving. At the same time, there are reasonable grounds to consider increasing the level of realization of this potential as an important way to accelerate the implementation of energy-saving measures at enterprises. All this allows us to argue that it is advisable to conduct a study aimed at designing and testing a toolset for assessing the financial and investment potential of enterprises in implementing energy-saving measures.

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### 3. The aim and objectives of the study

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The purpose of our study is to design a toolkit for assessing the financial and investment potential of enterprises

for implementing energy-saving measures. The use of this toolkit could allow company managers to substantiate their approaches to devising financial and investment strategies for implementing energy-saving measures.

To achieve the goal, the following tasks were set:

- to identify basic components and factors in the formation of the financial and investment potential of enterprises for implementing energy-saving measures;
- to build indicators and establish a sequence for assessing this potential and its components;
- to test the toolkit being designed on a sample of industrial companies.

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### 4. The study materials and methods

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In our study, the object is the process of assessing the financial and investment potential of enterprises in terms of their implementation of energy-saving measures. The principal hypothesis assumes that there is a significant part of the unrealized component of this potential.

At the same time, some assumptions were adopted in the process of the study, namely:

- 1) the possibility of dividing the financial and investment potential of enterprises into its individual components;
- 2) the possibility of obtaining information about the level of competence of company personnel in the issues of assessing and implementing the financial and investment potential for implementing energy-saving measures.

Also, a number of simplifications were accepted during the study, namely:

- 1) consideration of only those energy-saving measures, the implementation of which involves saving natural gas;
- 2) limited number of firms studied;
- 3) limited types of economic activity that were considered.

The theoretical basis of our study is the scientific literature on the issues of assessing the potential of enterprises, substantiating energy-saving investment measures, and financial support for economic activity.

Statistical, management, and accounting data on selected industrial enterprises served as an array of input information for empirical analysis. These data were collected both using publicly available databases (primarily the Opendatabot database (<https://opendatabot.ua/c>)) and by surveying enterprises. The selected companies were enterprises of three energy-intensive industries (manufacturing of products from glass, metal, and clay, respectively). At the same time, for each type of economic activity, a sample of 50 firms was initially formed, randomly selected from those located in the western oblasts of Ukraine. Since it was not possible to collect a sufficient amount of input information for all selected firms, and some companies did not express a desire to provide it, the final sample consisted of 105 companies. This sample included 35 enterprises – manufacturers of glass products, 34 enterprises that produce building materials from clay, as well as 36 enterprises whose main economic activity is the manufacture of metal products.

The implementation of this study necessitated the use of a wide range of scientific methods. In particular, a number of general scientific research methods were used.

Thus, when designing a toolkit for assessing the financial and investment potential of enterprises in implementing energy-saving measures, economic and mathematical modeling was used. Its necessity was due to the complexity of the pro-

cesses of forming and assessing the specified potential, which necessitated the need for their formalization.

When studying the components and factors of forming the financial and investment potential of enterprises in implementing energy-saving measures, the methods of system analysis and induction were used. That made it possible to establish connections between the components of the specified potential, as well as to investigate the mechanism of the influence of factors on it.

In the process of testing the designed toolset for assessing the financial and investment potential of enterprises in implementing energy-saving measures, the methods of economic analysis and technical and economic calculations were used. In addition, the collection of input data necessitated the use of the questionnaire method. Processing of input information and further interpretation of the obtained results required the use of statistical analysis methods.

To ensure a visual representation of our results, graphical and tabular methods were used.

**5. Results of designing a toolkit for assessing the financial and investment potential of enterprises for their implementation of energy-saving measures**

**5.1. Components and factors for assessing the financial and investment potential of enterprises for their implementation of energy-saving measures**

Since any modernization is associated with significant capital investments, there was a need to identify a special economic category that would integrate the financial capabilities of the enterprise with its investment goals. Such a category for the case of an enterprise implementing energy-saving activities should be the concept of financial and investment potential for implementing energy-saving projects. The specified potential is a comprehensive ability of a business entity to mobilize and effectively transform internal and external financial resources into investments for the implementation of energy-efficient measures aimed at strategically reducing the energy intensity of production and achieving certain parameters of economic performance.

The process of forming the financial and investment potential of enterprises in the field of energy saving is a multi-level procedure of coordinating the strategic goals of modernization with the real resource capabilities of the business entity over a certain time interval. This process is characterized by the interaction of two key vectors, namely, the investment request and the sources of its financial coverage. The formation of the investment component should begin with the identification and selection of energy-saving projects that are characterized by a sufficiently high level of economic efficiency. An important aspect at this stage is the rejection of those projects whose profitability is lower than the cost of

capital raised or alternative investment options in other areas of the enterprise's activity.

Defining investment needs for the implementation of energy-saving measures is coordinated with the process of forming the financial component of the financial and investment potential of enterprises in the field of energy saving. Such formation is justified, first of all, by establishing the possibilities of mobilizing internal sources of funds, primarily the part of the profit that the owners of the firms would agree to reinvest in energy saving, as well as depreciation deductions and unused funds of special funds of previous periods. However, the formation of the full volume of the financial component is impossible without assessing the potential of external financing, that is, the ability of the enterprise to obtain borrowed funds (in particular, bank loans) and attracted resources (in particular, contributions of third parties to the authorized capital).

The key feature in the formation of a financial component of the financial and investment potential of enterprises in the field of energy saving is the consideration of strict financial restrictions. In particular, it is necessary to deduct from the total volume of formed resources investments of a mandatory nature to maintain the vital activity of the enterprise, as well as funds directed to alternative projects, the efficiency of which is higher than the indicators of energy saving measures (Fig. 1).

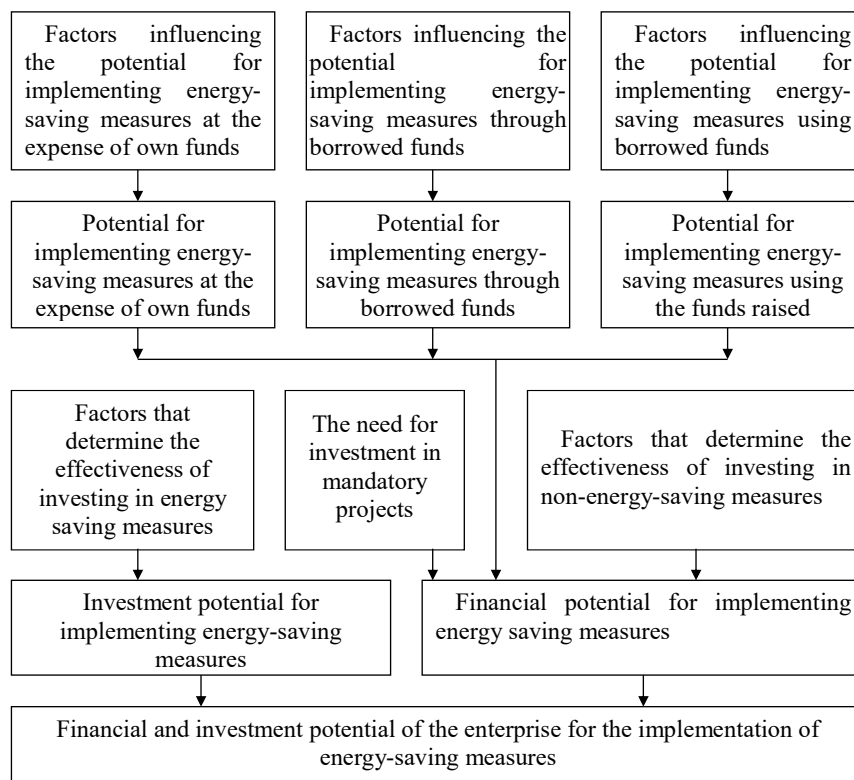


Fig. 1. Model to form the financial and investment potential of enterprises for implementing their energy-saving measures

The final formation of the financial and investment potential of enterprises for the implementation of energy-saving measures is determined by the dynamic balance between financial capacity and the selected portfolio of investment energy-saving projects. At the same time, each component of the specified potential is formed under the influence of a set of factors (Table 1).

Table 1

Factors forming the components of the financial and investment potential of enterprises regarding their implementation of energy-saving measures

Components of potential	Key factors of formation	Description of the influence of factors
1. Investment (resource needs)	Level of technological obsolescence; energy intensity of production; profitability of projects	Determines the amount of capital needed to implement projects that exceed the cut-off threshold
2. Own financial (internal resources)	Dividend policy; depreciation volume; owners' propensity to reinvest	Determines the share of net profit and funds that the owners are ready to direct specifically to energy conservation
3. Loan (credit resources)	Current debt; forecasted cash flow; interest rate	Defines the limit of safe borrowing of loans that can be repaid through cost savings
4. Attracted (authorized capital)	Investment transparency; control strategy (share of authorized capital owned by current owners); expected increase in the company's value	Determines the amount of external investment that the company can receive in exchange for a share in the capital

Thus, the formation of the financial and investment potential of companies for the implementation of energy-saving projects is possible only under the condition of harmonization of all four components, where the investment component is supported by a balanced set of financial resources obtained from own, borrowed, and attracted sources of funds.

**5. 2. Construction of indicators and establishment of the sequence of assessment of the financial and investment potential of enterprises regarding the implementation of energy-saving measures**

Based on the above, the value of the financial and investment potential of the enterprise in terms of its implementation of energy-saving measures in this study was estimated using the following expression

$$W = \max\{I, F\}, \tag{1}$$

where  $W$  is the value of the financial and investment potential of the enterprise for the implementation of energy-saving measures, monetary units;

$I$  – value of the investment potential of the enterprise for the implementation of energy-saving measures, monetary units;

$F$  – value of the financial potential of the enterprise for the implementation of energy-saving measures, monetary units.

In turn, the value of the investment component of the financial and investment potential of the enterprise for the implementation of energy-saving measures is proposed to be estimated using the following formula

$$I = \sum_{j=1}^n I_j \cdot k_j, \tag{2}$$

where  $n$  is the total number of investment energy-saving measures that can be implemented at the enterprise in the considered time period;

$I_j$  is the required investment in the implementation of the  $j$ -th investment energy-saving measure, monetary units;

$k_j$  is a dimensionless variable that takes one of two values, namely: 0, if the  $j$ -th measure is not feasible, or 1, if the implementation of the  $j$ -th measure is feasible.

In this case, the selected energy-saving investment projects must meet the following condition

$$V_j = P_{1j} + P_{2j} - C_j - I_j \geq 0, \tag{3}$$

where  $V_j$  – net present value of net cash flow for the  $j$ -th investment energy-saving measure, monetary units;

$P_{1j}$  – discounted value of the increase in the enterprise's profit due to the reduction in energy costs under the condition of implementing the  $j$ -th investment energy-saving measure, monetary units;

$P_{2j}$  – discounted value of the increase in the enterprise's net cash flow due to other positive consequences of implementing the  $j$ -th investment energy-saving measure (in particular, due to an increase in product sales volumes, if its competitiveness increases), monetary units;

$C_j$  – discounted value of the increase in the enterprise's current expenses associated with the implementation of the  $j$ -th investment energy-saving measure, monetary units.

Regarding the financial component of the enterprise's financial and investment potential for implementing energy-saving measures, the value of this component in this study was estimated using the following expression

$$F = \sum_{j=1}^n I_j \cdot l_j, \tag{4}$$

where  $l_j$  is a dimensionless variable that takes one of two values, namely: 0, if the  $j$ -th measure is impractical or impossible to implement (due to lack of sufficient funds), or 1, if the implementation of the  $j$ -th measure is feasible and possible.

In order to perform calculations according to formula (4), it is necessary to solve the optimization problem regarding the formation of the investment program of the enterprise under study. The objective function of this problem is formalized in the following form

$$Z = \sum_{j=1}^n V_j \cdot l_j + \sum_{s=1}^m V_s \cdot l_s \rightarrow \max, \tag{5}$$

where  $Z$  is the criterion for optimizing the investment program – the total net present value of the projects that will be included in this program, monetary units;

$m$  – total number of investment projects that are not of an energy-saving nature that can be implemented at the enterprise in the considered time period;

$V_s$  – net present value of the net cash flow for the  $s$ -th investment project that is not of an energy-saving nature, monetary units;

$l_s$  – a dimensionless variable that takes on one of two values, namely: 0, if the  $s$ -th project that is not of an energy-saving nature is impractical or impossible to implement (due to a lack of sufficient funds), or 1, if the implementation of the  $s$ -th project is feasible and possible.

The optimization model for forming the investment program of the enterprise under study, in addition to the above objective function, also includes a restriction on the amount of financial resources. The specified restriction is formalized in the following form

$$\sum_{j=1}^n I_j \cdot l_j + \sum_{s=1}^m I_s \cdot l_s \leq F_1 + F_2 + F_3 - I_n, \quad (6)$$

where  $I_s$  – required investments in the implementation of the  $s$ -th investment project, which is not of an investment nature, monetary units;

$F_1, F_2, F_3$  – potential for financial support of the enterprise's implementation of the investment program at the expense of its own borrowed and attracted funds, monetary units;

$I_n$  – required investment volumes that the enterprise must invest in investment projects, the implementation of which is mandatory, monetary units during the period under review.

At the same time, the types of financial potential of the enterprise, which appear in expression (6), were estimated in this study using the following formulae:

$$F_1 = R \cdot \alpha_1 + N \cdot \alpha_2; \quad (7)$$

$$F_2 = O / (\beta_1 + \beta_2); \quad (8)$$

$$F_3 = C \cdot \min\{\gamma_1, \gamma_2\}, \quad (9)$$

where  $R$  is the amount of the enterprise's financial reserves at the beginning of the period under consideration, monetary units;

$\alpha_1$  – the share of the enterprise's financial reserves at the beginning of the period under consideration, which the owners of the enterprise will agree to invest in the investment program of this period, fractions of a unit;

$N$  – expected amount of the enterprise's net cash flow in the period under consideration, monetary units;

$\alpha_2$  – share of the enterprise's net cash flow in the period under consideration, which the owners of the enterprise will agree to invest in the investment program of this period, fractions of a unit;

$O$  – forecast average annual amount of the enterprise's net cash flow, which can be used to service and repay the loans taken by the enterprise, according to a moderately pessimistic scenario of receiving this flow, monetary units;

$\beta_1$  – average annual interest rate on loans taken by the enterprise, fractions of a unit;

$\beta_2$  – annual rate of return of the principal amount of loans taken by the enterprise, fractions of a unit;

$C$  – amount of the authorized capital of the enterprise at the beginning of the period under consideration, monetary units;

$\gamma_1$  – maximum possible growth rate of its authorized capital acceptable to the owners of the enterprise during the period under consideration, fractions of a unit;

$\gamma_2$  – economically justified growth rate of the authorized capital of the enterprise during the period under consideration (in particular, such that the maximum possible growth of the market value of the enterprise is ensured in the part that will correspond to the future share of the current owners), fractions of a unit.

In order to compare the size of the financial and investment potential for the implementation of energy-saving measures between different enterprises, the specified potential

was also estimated in this study in relative terms using the following formulae:

$$d_i = I / A; \quad (10)$$

$$d_f = F / A; \quad (11)$$

$$d_w = W / A, \quad (12)$$

where  $d_i, d_f, d_w$  is the relative level of the investment, financial and financial-investment potential of the enterprise for the implementation of energy-saving measures, fractions of a unit;

$A$  – average value of the enterprise's total assets during the period under consideration, monetary units.

Thus, formulae (10) to (12) are intended for estimating values of the corresponding types of potential, which are determined from formulae (2), (4), and (1), relative to the value of the enterprise's total assets.

An assessment of the enterprise's financial-investment potential for the implementation of energy-saving measures is possible both for the forecast and for past periods. In the second case, it is possible to assess the implementation of the specified potential by comparing the actually invested investments in energy saving at the enterprise and the value of its financial-investment potential for the implementation of energy-saving measures calculated according to the method described above.

Ultimately, assessing the financial and investment potential of companies for implementing energy-saving projects requires taking into account the influence of factors on the magnitude of this potential. One of these factors is the energy efficiency of production. From the above expressions, it is impossible to directly establish how the magnitude of the financial and investment potential of enterprises for implementing energy-saving measures correlates with the level of energy efficiency of companies. Therefore, a special algorithm was developed to address this issue, which is schematically depicted in Fig. 2.

Taking into account the above, the sequence of assessment of the investment potential of enterprises in relation to their implementation of energy-saving measures used in this study included the following main stages:

1. Collection and pre-processing of input information. At this stage, a sample of enterprises belonging to a certain type of economic activity was formed. Based on a review of information that is freely available and through a questionnaire survey of selected companies, an array of input information was formed, which included a number of blocks. The list of these blocks is given in Table 2. At the same stage, the main indicators of the activities of the studied enterprises in the field of energy saving were determined, in particular, the implementation of energy-saving measures by them in previous years and the level of their energy efficiency were assessed. In addition, the studied companies were divided into groups according to this level.

2. Assessment of the absolute value of the financial and investment potential of enterprises in relation to their implementation of energy-saving measures. At this stage, using formulae (1) to (9), for each of the studied enterprises, the financial, investment and financial-investment potential of the studied companies were estimated in monetary terms based on the data of the previous period. In addition, the values of these indicators were averaged within each group of firms, divided by the level of their energy efficiency.

3. Assessment of the relative value of the financial and investment potential of enterprises in relation to their imple-

mentation of energy-saving measures. At this stage, using formulae (10) to (12), for each of the studied enterprises, the financial, investment and financial-investment potential of the studied companies were estimated in relative terms based on the data of the previous period. Also, the values of these relative indicators were averaged within each group of firms, divided by the level of their energy efficiency.

4. Assessment of the actual level of implementation of the financial and investment potential of the companies under study. For this purpose, the actual amount of investment invested by the companies under study in energy-saving measures was divided by the absolute value of their financial and investment potential for the implementation of these measures. As in the previous stages, the results obtained at this stage were averaged by groups of enterprises divided by the level of their energy efficiency.

5. Assessment of the competence of the personnel of the companies under study in assessing their financial and investment potential for the implementation of energy-saving measures with subsequent averaging of the results obtained by groups of enterprises with different levels of energy efficiency. In this case, the specified assessment was carried out in points using a three-point scale.

6. Factor analysis. At this stage, using variance analysis, the relationships between the three main characteristics of the companies under study were studied. These characteristics were energy efficiency, the relative size of the financial and investment potential of enterprises in implementing energy-saving measures, and the competence of personnel in assessing this potential.

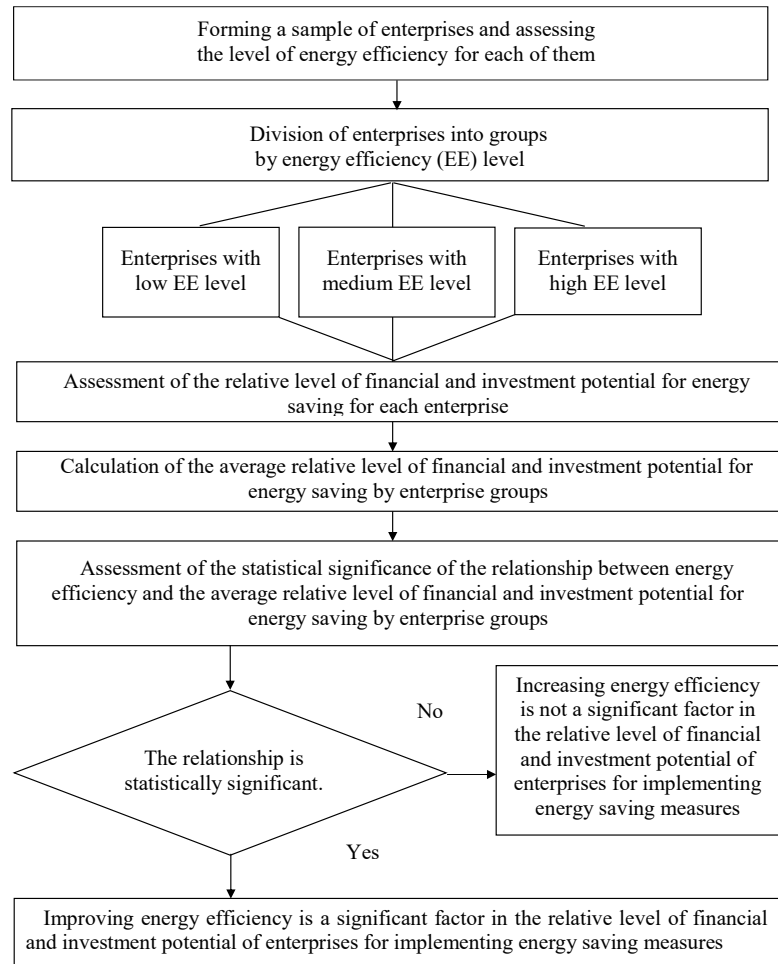


Fig. 2. Algorithm for assessing the impact of energy efficiency on the relative level of financial and investment potential of enterprises for implementing energy saving measures

Table 2

General characteristics of the array of input information for assessing the financial and investment potential of enterprises for the implementation of energy-saving measures

Names of information blocks	Brief composition of information blocks	Sources of information
Data on financial and economic results and expenses of enterprises	Data on gross and net profit, net income, operating and financial expenses, etc. Data on the value of total assets, equity, etc.	Data from publicly available databases (primarily, Opendatabot ( <a href="https://opendatabot.ua/c">https://opendatabot.ua/c</a> ))
Data on assets and liabilities of enterprises	Data on gross and net profit, net income, operating and financial expenses, etc. Data on the value of total assets, equity, etc.	Data from publicly available databases (primarily, Opendatabot ( <a href="https://opendatabot.ua/c">https://opendatabot.ua/c</a> ))
Data on investment activities of enterprises	Data on the volume of investments made by direction and by funding sources, actual and expected profit from such investments, etc. Data on the volume of energy consumption, costs for the purchase of energy resources, the number of implemented energy-saving measures, investments made in them, financial and economic results obtained from the implementation of energy-saving measures	Data from publicly available databases (primarily Opendatabot ( <a href="https://opendatabot.ua/c">https://opendatabot.ua/c</a> )); results of enterprise surveys
Data on activities of enterprises in the field of energy conservation	Data on the volume of investments made by direction and by funding sources, actual and expected profit from such investments, etc. Data on the volume of energy consumption, costs for the purchase of energy resources, the number of implemented energy-saving measures, investments made in them, financial and economic results obtained from the implementation of energy-saving measures	Results of enterprise surveys
Data on business owners' preferences for reinvesting their profits	Data on the share of the net cash flow of the enterprise in the period under review that the owners will agree to invest in the investment program of this period; the maximum possible rate of growth of the authorized capital acceptable to the owners during the period under review	Results of a survey of business owners
Other data	The level of interest rates, the terms for which loans are provided, etc.	Data from banking and other institutions

At the same time, this research suggests that with the growth of energy efficiency, the amount of financial and investment potential of enterprises for the implementation of energy-saving measures by them decreases, since a significant part of this potential has already been realized in energy-efficient companies. At the same time, with the growth of energy efficiency, there could be an increase in the level of realization of the above-mentioned potential. This, in turn, could be caused by a higher level of competence of the personnel in matters of assessment and implementation of this potential of those companies characterized by greater energy efficiency.

**5. 3. Testing the toolkit for assessing the financial and investment potential of enterprises in implementing energy-saving measures**

Our analysis of the energy-saving activities of the studied enterprises revealed that their average level of this activity during 2019–2024 was quite moderate. In particular, based on the results of the survey of companies, the share of those enterprises that implemented energy-saving investment projects during 2019–2024 was established in the total number of studied enterprises by type of economic activity. This share was: for enterprises that manufacture glass products – 37.14%; for enterprises that manufacture clay products – 47.06%, and for those that manufacture metal products – 41.67%. At the same time, the ratio of investments in energy-saving projects implemented during 2019–2024 to the average value of total assets of all companies studied was 0.044 (Table 3).

At the next stage of our research, the enterprises under study were divided by the level of energy efficiency of their activities (by natural gas consumption) in 2024. For this purpose, this level was initially estimated for each enterprise as the ratio of net income to natural gas consumption in the reporting year. Then, in order to provide opportunities for cross-industry comparison of the results obtained, the relative level of energy efficiency of their activities (by natural gas consumption) in 2024 was calculated for each studied company. This level was determined by the ratio of the actual energy efficiency of a particular enterprise to the energy efficiency of the enterprise in the relevant industry, which had the lowest level among all the studied companies belonging to this industry. Thanks to this, the distribution of the studied enterprises by the level of energy efficiency of their activities (by natural gas consumption) in 2024 was carried out. The results of such a distribution, given in Table 4, showed that almost half of the studied firms of each type of

economic activity considered are characterized by low energy efficiency (in terms of natural gas consumption).

Based on the models described in the previous section, the investment, financial and financial-investment potential of the studied enterprises in the field of energy saving for 2024 was estimated in absolute terms (Table 5). Then, using formulae (10) to (12), the results of such an assessment were represented in relative terms and averaged across groups of enterprises by their energy efficiency level. As follows from the data given in Table 6, with an increase in the level of energy efficiency, the average relative investment potential of the studied enterprises in relation to their implementation of energy-saving projects decreases. This is possible due to the fact that enterprises with higher energy efficiency have already managed to significantly realize this potential in previous years. At the same time, with regard to the financial and financial-investment potential in the field of energy saving, such a clear dependence on energy efficiency is not observed. Moreover, regarding financial potential, it is on average higher for enterprises with high energy efficiency than for companies with low energy efficiency. This is probably due to the fact that firms with high energy efficiency are characterized by a better financial condition, in particular higher profitability.

Table 3

Individual indicators of the implementation of energy-saving investment projects by the studied enterprises during 2019–2024

Indicator ID	The value of indicators for enterprises that manufacture			Indicator values for all enterprises
	Glass products	Clay products	Metal products	
1. Total number of companies, units	35	34	36	105
2. Number of enterprises that implemented energy-saving investment projects during 2019–2024	13	16	15	44
3. Share of enterprises that implemented energy-saving investment projects during 2019–2024, %	37.14	47.06	41.67	41.90
4. Ratio of investments in energy-saving projects implemented during 2019–2024 to the average value of total assets of companies, units	0.041	0.032	0.059	0.044

Table 4

Distribution of the studied enterprises by the level of energy efficiency of their activities (by natural gas consumption) in 2024

Enterprise groups by energy efficiency level (by natural gas consumption)	Relative energy efficiency values at which enterprises are classified into their respective groups	Distribution of enterprises by energy efficiency level (by natural gas consumption) depending on the products they produce					
		Glass products		Clay products		Metal products	
		Number	Share, %	Number	Share, %	Number	Share, %
Low energy efficiency	From 1.0 to 1.5	17	48.57	15	44.12	16	44.44
Medium energy efficiency	From 1.5 to 2.0	10	28.57	9	26.47	11	30.56
High energy efficiency	Above 2.0	8	22.86	10	29.41	9	25.00

Since in this empirical study the assessment of the financial and investment potential of enterprises regarding their implementation of energy-saving measures took place over the past year, that made it possible to assess the level of actual implementation of this potential. As follows from the data given in Table 7, at enterprises with low energy efficiency, the specified average level is quite low and varies according to the considered industries from 37.19% to 44.29%. It should also be noted that according to the data on the studied enter-

prises, the increase in energy efficiency is positively correlated with the increase in the level of implementation of the estimated potential. One of the reasons for this phenomenon may be that the personnel of enterprises with higher energy efficiency are characterized by a higher level of competence in the issues of assessment and implementation of the financial and investment potential for the implementation of energy-saving measures. To test this hypothesis, the level of the specified competence was initially assessed by surveying enterprises. This assessment was performed on a three-point scale (1 point – low competence, 2 points – medium, 3 points – high). As follows from the data given in Table 8, approximately half of the studied enterprises in all three industries are characterized by a low level of personnel in the assessment and implementation of financial and investment potential for implementing energy-saving measures.

The next stage of the study involved the use of analysis of variance. The results are given in Table 9.

As follows from the calculated values of the Fisher criterion, which are given in Table 9, all these values are greater than the critical one. Thus, according to the data on the studied enterprises, three statistically significant relationships were found between the studied indicators. First, with increasing energy efficiency, the relative level of investment potential of companies in the field of energy saving decreases. Second, with increasing energy efficiency, the realization of the financial and investment potential of the studied enterprises for implementing energy saving measures increases. Finally, thirdly, improving the competence of enterprise personnel in assessing and implementing the financial and investment potential for implementing energy saving measures has a positive impact on the energy efficiency of companies.

Table 5

Average values of the absolute value of financial and investment potential in the field of energy saving at the studied enterprises for 2024

Enterprise groups by energy efficiency level (by natural gas consumption)	Components of financial investment potential	Average values of financial and investment potential in the field of energy saving in the studied enterprises by types of products they produce, thousand US dollars		
		Glass products	Clay products	Metal products
Low energy efficiency	Investment	48.49	71.54	40.41
	Financial	29.84	51.1	31.43
	Total	29.84	51.1	31.43
Medium energy efficiency	Investment	25.92	41.25	20.72
	Financial	23.04	37.5	20.72
	Total	23.04	37.5	20.72
Low energy efficiency	Investment	20.95	25.74	13.08
	Financial	37.71	51.48	26.16
	Total	20.95	25.74	13.08

Table 6

Average values of the relative level of financial and investment potential in the field of energy saving at the studied enterprises for 2024

Enterprise groups by energy efficiency level (by natural gas consumption)	Components of financial investment potential	Average values of the relative level of financial and investment potential in the field of energy saving in the studied enterprises by the types of products they produce		
		Glass products	Clay products	Metal products
With low energy efficiency	Investment	0.13	0.14	0.09
	Financial	0.08	0.10	0.07
	Total	0.08	0.10	0.07
With an average level of energy efficiency	Investment	0.09	0.11	0.07
	Financial	0.08	0.10	0.07
	Total	0.08	0.10	0.07
With a high level of energy efficiency	Investment	0.05	0.06	0.04
	Financial	0.09	0.12	0.08
	Total	0.05	0.06	0.04

Table 7

Indicators of the implementation by the studied enterprises of their financial and investment potential in the field of energy saving in 2024

Enterprise groups by energy efficiency level (by natural gas consumption)	Names of indicators of the realization of financial and investment potential in the field of energy saving	The value of indicators for enterprises that manufacture		
		Glass products	Clay products	Metal products
1. Low energy efficiency	1. 1. Realization level, %	37.19	44.29	40.98
	1. 2. Unrealized part of potential, %	62.81	55.71	59.02
2. Medium energy efficiency	2. 1. Realization level, %	48.56	57.08	52.70
	2. 2. Unrealized part of potential, %	51.44	42.92	47.3
3. High energy efficiency	3. 1. Realization level, %	69.07	78.54	73.41
	3. 2. Unrealized part of potential, %	30.93	21.46	26.59

Table 8

Distribution of the studied enterprises by the level of personnel competence in assessing and implementing financial and investment potential for implementing energy-saving measures

Groups of enterprises by the level of personnel competence in assessing and implementing financial and investment potential for implementing energy-saving measures	Distribution of enterprises by the level of personnel competence and the quality of information support for assessing the financial and investment potential of enterprises in the field of energy saving, depending on the products they produce					
	Glass products		Clay products		Metal products	
	Number	Share, %	Number	Share, %	Number	Share, %
With low level	18	51.43	17	50.00	19	52.78
With medium level	9	25.71	10	29.41	8	22.22
With high level	8	22.86	7	20.59	9	25.00

Table 9

Results of the analysis of variance for the dependence between the level of energy efficiency (for natural gas) of the studied enterprises and individual indicators of these enterprises

Indicator ID	Enterprise groups by energy efficiency level (by natural gas consumption)	The value of the relative size of the financial and investment potential in the field of energy saving of enterprises depending on the products they produce		
		Glass products	Clay products	Metal products
Relative level of investment potential in the field of energy saving	With low level	0.13	0.14	0.09
	With medium level	0.09	0.11	0.07
	With high level	0.05	0.06	0.04
	Actual values of <i>F</i> -criterion	7.05	6.76	6.14
Level of use of financial and investment potential in the field of energy saving, %	With low level	37.19	44.29	40.98
	With medium level	48.56	57.08	52.70
	With high level	69.07	78.54	73.41
	Actual values of <i>F</i> -criterion	6.58	7.59	5.93
Level of staff competence in assessing and implementing financial and investment potential in the field of energy saving, points	With low level	1.26	1.32	1.29
	With medium level	1.64	1.79	1.72
	With high level	2.07	2.26	2.13
	Actual values of <i>F</i> -criterion	5.73	6.38	6.13

**6. Discussion of the designed toolset for assessing the financial and investment potential of enterprises in implementing energy-saving measures**

Our research has shown that the assessment of the financial and investment potential of enterprises in implementing energy-saving measures should be based on the application of the appropriate tool. This tool, in turn, should be based on the model of the formation of the potential of the financial component of the financial and investment potential of enterprises in implementing energy-saving measures, built in this work, shown in Fig. 1. At the same time, it was established that the specified potential is determined by the values of the investment and financial potential of companies in the field of energy saving. In turn, the value of the financial potential is the sum of its three varieties, namely the potential for obtaining, respectively, own, borrowed, and attracted funds for the purpose of implementing energy-saving investment measures. It was found that each of the listed types of potential is influenced by a number of main factors, and they were identified. This has made it possible to take these factors into account when designing a toolkit for assessing the financial and investment potential of an enterprise in implementing energy-saving measures.

When assessing the financial and investment potential of enterprises in implementing energy-saving measures, it is important to pre-select indicators that will characterize this potential. Based on indicators (1) to (12), it is possible to carry out a sufficiently complete assessment of the specified potential. Thus, the designed toolset contains a formalized model and sequence for assessing the general financial and investment potential of

companies in the field of energy saving. In addition, indicators are proposed for assessing the main components of the specified potential, namely, investment potential and the potential for obtaining, respectively, own, borrowed and attracted funds for the purpose of implementing energy-saving measures. In this case, an optimization approach to such an assessment is applied, and its results are proposed to be represented not only in absolute but also in relative terms. In addition, a methodological approach has been devised to assess the impact of energy efficiency on the size of the financial and investment potential of companies in the field of energy saving. This approach could also be used when identifying the impact of other factors on the specified potential.

The designed toolkit for assessing the financial and investment potential of enterprises for implementing energy-saving measures can be applied both at the level of an individual company and at the industry level. The practical value of this toolkit is due to a number of aspects. First, using the proposed indicators and the sequence of assessment, company owners and managers will receive a fairly complete idea of the level of the potential under consideration. Second, using the model built for forming the financial and investment potential of enterprises for implementing energy-saving measures, company owners and managers will be able to better understand the mechanism of such formation. Third, enterprises with high energy-intensive products, using the procedure devised in this study, will be able to devise scientifically sound measures to increase their energy efficiency.

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 3–9, showed, in particular, the existence of a number of statistically significant dependences. First, with increasing energy efficiency, the relative level of investment potential of companies in the field of energy saving decreases. Second, with increasing energy efficiency, the realization of the financial and investment potential of the studied enterprises for implementing energy saving measures increases. Finally, third, improving the competence of enterprise personnel in assessing and implementing the financial and investment potential for implementing energy saving measures has a positive impact on the energy efficiency of companies. It should be noted that the results reported in this study build on the methodological and applied principles of assessing energy saving potential, set out, in particular, in [11–14] as the indicated results take into account the financial capabilities of enterprises. These results also have a wider level of generalization than those reported in [22–24] because they consider the possibility of simultaneous financing of energy-saving projects using all major sources of financial resources.

In general, the designed toolkit sufficiently covers the issue of assessing the financial and investment potential of enterprises regarding their implementation of energy-saving measures. This is achieved due to the fact that the use of such a toolkit makes it possible to perform the specified assessment completely and with due accuracy. Therefore, the information obtained as a result of the use of the specified toolkit makes it possible to substantiate the ways for improving the financial condition of companies based on the implementation of energy-saving measures on them.

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

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

A certain drawback of this study is the approach used to establish the level of competence of enterprise personnel in the issues of assessing and implementing financial and investment potential for implementing energy-saving measures. This approach did not provide for detailed detailing of the main components of the specified competence, which may reduce the accuracy of assessing its current level. Therefore, it is appropriate to indicate such detailing among the areas of further development of this study. This would allow us to improve the accuracy and completeness of information on the competence of enterprise personnel in the issues of assessing and implementing financial and investment potential for implementing energy-saving measures. Then it might be possible to establish which of the components of the specified competence of the personnel of the studied enterprises require priority improvement.

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## 7. Conclusions

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1. The basic components and factors in the formation of the financial and investment potential of enterprises for their implementation of energy-saving measures have been highlighted. At the same time, it was found that the process of forming the financial and investment potential of enterprises in the field of

energy saving is a multi-level procedure of coordinating the strategic goals of modernization with the real resource capabilities of the business entity over a certain time interval. This occurs as a result of the interaction of two key vectors, namely, the investment request and the sources of financial coverage. The formation of the investment component begins with the identification and selection of energy-saving projects that are characterized by a sufficiently high level of economic efficiency. An important aspect at this stage is the cutting off of those projects whose profitability is lower than the cost of capital raised or alternative options for investing in other areas of the enterprise's activity.

2. Indicators have been constructed and a sequence of assessment of the financial and investment potential of enterprises in terms of their implementation of energy-saving measures and the components of this potential has been established. This makes it possible to assess the integrated capabilities of enterprises in terms of their implementation of the specified measures. At the same time, it was proposed to carry out such an assessment in several stages on the basis of applying the optimization model of the formation of the investment program of enterprises.

3. Our analysis of the energy-saving activities at the studied enterprises revealed that their average level of this activity during 2019–2024 was quite moderate. In particular, the share of enterprises that implemented energy-saving investment projects during 2019–2024 was for enterprises that manufacture glass products – 37.14%; for enterprises that manufacture clay products – 47.06%; and for those that manufacture metal products – 41.67%. At the same time, the ratio of investments in energy-saving projects implemented during 2019–2024 to the average value of total assets of all studied companies was 0.044. It was also found, in particular, that with an increase in the level of energy efficiency, the average relative investment potential of the studied enterprises in relation to their implementation of energy-saving projects decreases. At the same time, at enterprises with low energy efficiency, the indicated average level is quite low and varies according to the considered industrial sectors from 37.19% to 44.29%. It should also be noted that, according to the data on the studied enterprises, the increase in energy efficiency is positively correlated with the increase in the level of realization of the estimated potential.

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## Conflicts of interest

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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 and the results reported in this paper.

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## Funding

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The study was conducted without financial support.

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## Data availability

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All data are available in the main text of the manuscript.

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## Use of artificial intelligence

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

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**Authors' contributions**


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**Viktorii Prokhorova:** Conceptualization, Software, Validation, Funding acquisition; **Olexandr Yemelyanov:** Conceptualization, Methodology, Formal analysis, Funding acquisition; **Orest Koleshchuk:** Investigation, Data

Curation, Writing – review & editing, Funding acquisition; **Svitlana Shepelenko:** Investigation, Data Curation, Writing – review & editing, Funding acquisition; **Krystyna Slastianyukova:** Investigation, Supervision, Visualization, Funding acquisition; **Dmytro Havras:** Formal analysis, Data Curation, Project administration, Funding acquisition.

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