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## Accounting of the Enterprise's Financial Reserves at the Integration of Energy-Saving Principles and Transition to the Concept of Energy-Saving Production

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### ABSTRACT

The main task of modern production is to form the program of development and determination of the ways for technological improvement. The relevance of the work is in the fact that the technological concept for energy-saving development is almost always connected with the focus on it on the part of the company's management. In particular, with the availability of energy costs for the enterprise, the issue of energy saving is not formed as relevant. In conditions when all the enterprises are increasingly entering the global market and obtaining resources at prices of the world's manufacturers, there is a necessity of updating of the energy conservation system and the revitalization of the study's problematics. The novelty of the study is determined by the fact that it has investigated the means of accounting for the use of energy-saving measures in order to form a sustainable operation of the enterprise. The paper shows the aspects of the greening of an industrial enterprise in the implementation of the energy-saving program. The organizational, structural and technological features of accounting activities have been revealed in the economic reporting of the enterprise. The practical application of the study is possible provided that the company fully contributes to the goals of entering the international market and assesses their performance according to the international reporting standards.

**Keywords:** Energy Enterprise, Reporting, Accounting, International Market, Greening

**JEL Classifications:** K32, L3, L32

### 1. INTRODUCTION

The constant increase in the cost of the main energy resources of the industry, primarily electric energy, which became characteristic after entering the path to a market economy, encourages industrial enterprises, which are among the largest consumers of energy resources to introduce energy saving (Li et al., 2019). At the same time, the existing energy-saving potential of industrial enterprises cannot be realized only through organizational changes and low-cost measures on the basis of individual structural units of the enterprise, due to the peculiarities of economic activity since the

Soviet and post-Soviet times, as well as insufficient financing of projects for the modernization of energy equipment and inefficient management system, (Biel and Glock, 2017).

The economic and political crisis phenomena are typical for the state, and the externalities caused by them to a large extent limit the ability of enterprises to implement energy-saving expenditure projects (Li et al., 2019). Despite this, the management must select and prioritize such projects based on an evaluation of the expected effect of the current financial and economic state of an enterprise (Cannata and Taisch, 2010). Therefore, it is necessary to conduct

a feasibility study for the implementation of the energy-saving projects, considering both quantitative and qualitative indicators (Zelenyak and Kostyukov, 2018). At the same time, there is uncertainty in any enterprise (Nyilas, 1982). Traditionally, such uncertainty is perceived as a risk and a factor preventing informed decision-making. Additional uncertainty is caused by the instability of the external environment, which also increases the risks when deciding on the implementation of a specific energy-saving project (Schmidt et al., 2019). Since uncertainty cannot be fundamentally overcome, the natural desire of the enterprise management is to reduce it by using special decision-making methods (Bretzke and Barkawi, 2013).

## 2. LITERATURE REVIEW

To assess the investment attractiveness of energy-saving projects, a complex method based on the theory of fuzzy sets and fuzzy measures is particularly promising (Sahabi et al., 2013). It allows aggregating various information into a single indicator in conditions of low reliability of initial data (Cai et al., 2019). Given the fact that traditional methods of assessing economic efficiency under these conditions can only give an approximate idea of the effectiveness of the project, the application of the method based on the theory of fuzzy sets, which is less time-consuming and does not require forecasting cash flows, is even more popular (Giarini and Stahel, 1993).

Applying the method for estimation of economic efficiency of energy-saving projects based on the fuzzy principle allows using the perspective from the standpoint of mathematical formalization, and the theory of approximate sets (Semenyutina et al., 2018). It allows building the prediction algorithms based on the logical inference procedure on the basis of the final group estimates of the system state and objective or subjective estimates of its parameters (Alekseenko, 2008). Using the same developments in the further processing of the data obtained from experts, the terms can be provided with a specific mathematical meaning, which makes it possible to bring together qualitative and quantitative indicators (Upton et al., 2013). Thus, using the elements of the fuzzy sets theory, an effective mechanism for selecting and prioritizing the implementation of the most promising energy-saving projects, from an economic point of view, for a particular enterprise can be formed, even in conditions of uncertainty caused by a lack of information, which is implemented in several stages (Figure 1) (Solding et al., 2009).

The involvement of the specialists of an enterprise in the feasibility evaluation of the energy-saving projects makes it possible to move away from heuristic methods of planning expertise and to apply an adaptive expert system that is more effective (Dolgikh, 2018). Besides, the use of such terms as elements of the fuzzy set theory in the expert surveys gives the latter greater flexibility in evaluating numerical indicators depending on the characteristics of an industrial enterprise (Steinhilper et al., 2013).

## 3. METHODOLOGY

In the process of managing an industrial enterprise, there is a natural desire to find solutions that are objectively the best of all

possible (Schlund et al., 2013). Mathematical programming is now widely used as such an optimization tool. The advances in the application of mathematical programming to the solution of economic, economic and technical problems have determined the emergence of new methodological views, according to which, the solution of management problems is only possible in the conditions when all their aspects are displayed in a system of interconnected mathematical models (Pechmann et al., 2012).

A characteristic feature of modern economic objects of different levels is their rapid development (Costanza et al., 2017). The management of such objects always occurs in conditions of insufficient information about the future (Misra, 1996). In addition to the envisaged possible impacts, economic objects are largely influenced by random factors. Despite this, the development of economic objects is mainly random and scholastic.

To substantiate decisions under uncertainty, when probabilistic variants of events are not known for certain, it is advisable to apply special mathematical methods. These include game theory, which is a theory of mathematical models, the interests of the participants are different, and they reach their goal in different ways.

## 4. RESULTS AND DISCUSSION

The approbation of the above methodological approach to assessing the investment attractiveness of energy-saving projects was carried out based on the plant KeramoKirpich LLP, "Astana-as" ("Astana-As," LLP). For this purpose, from the plan of organizational and technical measures for economy of fuel and energy resources (FEC) 2019, from the business plan of the enterprise 2019 and the plan of investment development, the planned but not yet realized projects on energy saving were selected, namely:

- Purchase and installation of power factor control units in the shops;
- Replacement of high-voltage capacitor banks;
- Reconstruction of the lighting system of workshops with the use of energy-saving lamps;
- Improvement of the energy management system of the enterprise due to the coordination of equipment load schedules;
- Restoration coatings, electrical heat treatment furnaces;
- Replacement of the cable line with a length of 140 m with an increase in the cross-section of cable cores;
- The replacement of two reciprocating compressors rotary vane;
- Replacement of thermal insulation of the heat supply network pipeline;
- Insulation of piping heating network at thermal points;
- Hydro-pneumatic flushing of the heating network;
- Reconstruction of the hot water supply system;
- Replacing the lining on a soft insulating material and reconstruction of gas heating furnace;
- Transfer of the hot water preparation system of the transport section of the enterprise from natural gas to electric energy;
- The use of UFO electric radiation heaters on sites of CNC machines for replacement of gas heaters;
- Transfer of the hot water preparation system of the main production site to the coolant;

- Work on informing and increasing the motivation of employees to energy saving.

Among the staff of the enterprise, 15 specialists were selected as experts to assess the feasibility of energy-saving projects. The criteria for the selection of specialists was their involvement in the planning and implementation of relevant projects in previous periods, as well as experience of at least 10 years at the enterprises of mechanical engineering.

The experts were asked to fill in the forms of evaluation of investment attractiveness criteria for each of the energy-saving projects, which is being considered. In order to simplify the work of the experts, the following rank estimates of fuzzy variables were introduced: “extra high” – 5, “high” – 4, “average” – 3, “below the average” – 2, and “low” – 1.

The consistency of experts' opinions was checked by the method of determining the concordance coefficient. Checking the significance of the concordance coefficients of the lower level criteria groups by comparing the calculated and reference values of the  $\chi$ -criteria showed a sufficient level of consistency of the expert opinions for all the energy-saving projects.

Subsets by which experts are asked to characterize the criteria can be considered as names of fuzzy sets that are given in the universal set U and have a certain membership function. Thus, the universal set for some variable q, the set of values of which is the term set  $Q = \{Q_1, Q_2, Q_3, Q_4, Q_5\}$ , will be segment [0; 1]. Each term from the set Q is the name of a fuzzy subset on the segment [0; 1], which is one of the elements of the scale proposed to the experts to assess the criteria for the feasibility of the energy-saving projects.

A subset of a variable can be represented as a triangular fuzzy number with a defined membership fun

$$\mu(low) = \int_{-} 0^{0.25(1-4q)}dq; \tag{1}$$

$$\mu(below\ the\ average) = \int_{-} 0^{0.25(4q)}dq + \int_{-} 0.25^{0.5(-4q+2)}dq \tag{2}$$

$$\mu(average) = \int_{-} 0.25^{0.25(4q-1)}dq + \int_{-} 0.5^{0.75(-4q+3)}dq \tag{3}$$

$$\mu(high) = \int_{-} 0.5^{0.75(4q-2)}dq + \int_{-} 0.75^{1(-4q+4)}dq \tag{4}$$

$$\mu(extra\ high) = \int_{0.75}^1 (4q-3) dq \tag{5}$$

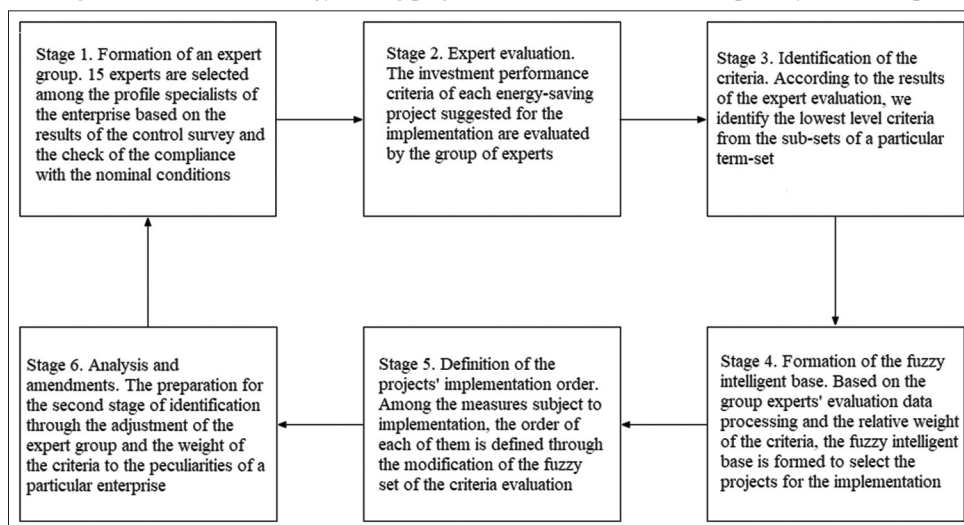
According to the results of expert evaluations for the lowest levels criteria of the energy-saving project Z1 (Table 1), the numerical values of fuzzy variables can be determined on the assumption that the belonging level of each subset of the linguistic variable is equal to 1.

Based on the data given in Table1, the numerical values of the variable q membership function for each expert advisor and its average values for the lowest level criterion for the energy-saving project Z1 were calculated (Table 2).

The determination of numerical values of a linguistic variable q, and the computation of their average values according to the results of expert group analyses allow establishing the belonging of each criterion of the lowest level to one of the subsets of the term-sets Q. Table 3 shows the results of the calculation for the average numeric values of variable Q, the criteria of the lower levels of all the projects on energy saving, as well as their belonging to certain subsets of the term-sets.

Similarly, the criteria for the lowest level of financial and economic condition of the enterprise can be assessed, which is the same for all the energy-saving projects. The average numeric values of the variable membership function for these criteria are as follows:  $q_{b1} = 0,73; q_{b2} = 0,68; q_{b3} = 0,95; q_{b4} = 0,83; q_{b5} = 0,92; q_{b6} = 0,55; q_{b7} = 0,88$ . Relative weight (rank)

**Figure 1:** Stages of evaluation of energy-saving projects and determination of the priority in their implementation



**Table 1: Expert evaluation of the criteria for the lowest level of energy-saving project Z1**

Criterion	Numerical number of expert														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>1. Compliance of material-technical and personnel base of the enterprise with the conditions of implementation of the energy-saving project</b>															
a <sub>11</sub>	5	4	5	5	5	4	5	4	4	5	5	5	5	5	4
a <sub>12</sub>	5	5	5	5	5	4	4	4	5	5	5	4	5	5	5
a <sub>13</sub>	3	2	4	3	3	3	2	3	3	4	4	3	3	3	3
a <sub>14</sub>	5	5	5	5	5	4	5	4	5	5	5	5	5	5	5
a <sub>15</sub>	1	2	2	2	1	1	2	2	1	2	2	2	2	2	2
a <sub>16</sub>	4	5	4	4	4	5	5	4	5	5	5	5	5	5	4
a <sub>17</sub>	4	4	5	5	4	4	4	5	4	5	5	5	5	4	5
a <sub>18</sub>	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
a <sub>19</sub>	4	4	5	5	5	4	5	4	5	5	5	5	5	5	4
<b>2. Financial costs of the enterprise for the implementation of the energy-saving project</b>															
a <sub>21</sub>	3	3	4	4	3	4	3	3	3	2	3	3	3	4	3
a <sub>22</sub>	4	3	4	4	4	4	3	4	3	4	4	4	4	4	3
a <sub>23</sub>	4	4	5	4	4	4	5	4	3	4	4	4	3	5	4
a <sub>24</sub>	4	5	5	5	4	4	4	5	5	5	4	4	4	4	4
a <sub>25</sub>	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5
<b>3. Administrative and legal obstacles</b>															
a <sub>31</sub>	5	4	5	5	5	4	5	5	5	5	5	5	5	5	5
a <sub>32</sub>	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
a <sub>33</sub>	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4
<b>4. Time expenditure</b>															
a <sub>41</sub>	4	4	3	3	3	4	3	4	4	4	3	4	4	4	4
a <sub>42</sub>	4	4	4	3	3	4	4	4	4	4	3	4	4	4	4
a <sub>43</sub>	5	5	4	4	4	5	5	5	5	5	4	5	5	5	4
a <sub>44</sub>	4	4	3	3	3	4	4	4	3	4	3	4	4	4	3
<b>5. Expected effect of energy-saving project implementation</b>															
a <sub>51</sub>	4	4	3	3	3	3	4	4	4	4	3	4	4	4	4
a <sub>52</sub>	5	5	5	4	4	4	4	5	5	5	4	4	4	5	4
a <sub>53</sub>	1	1	2	1	1	1	1	1	1	1	1	1	1	2	1
a <sub>54</sub>	1	1	2	1	1	1	1	1	2	1	1	1	1	2	1

criteria for the lower levels of the financial and economic condition of the enterprise in the calculation of the group criterion of the highest level as a lot will be determined by the criteria for the lower level will have a membership function of the variable:

$$q_B = \left\{ 0,73^{0,098}; 0,68^{0,067}; 0,95^{0,181}; 0,83^{0,247}; \right. \\ \left. \left\{ 0,92^{0,224}; 0,55^{0,212}; 0,88^{0,071} \right\} \right\}. \text{ The calculations}$$

get the numeric value of the membership function of a variable group of criterion ‘financial state of the enterprise’, equal to 0,88. This numerical value of the criterion variable b determines its affiliation, according to Figure 2, a subset of the ‘extra high’ term-set Q.

Since Astana-as LLP is not a full-fledged manager of financial resources but receives them according to the decisions of the management company, it is advisable to consider ‘a loan on preferential terms’ as a source of financing for the implementation of costly energy-saving projects. These include such energy-saving projects as:

- Purchase and installation of power factor control units;
- Replacement of high voltage capacitor banks;
- Reconstruction of the lighting system of workshops with the use of energy-saving lamps;
- Replacement of the cable line with a length of 140 m with an increase in the cross-section of cable cores;
- The replacement of two reciprocating compressors rotary vane;

- Replacement of thermal insulation pipeline of the heat network of the heat supply; the heat insulation of a pipeline network for heat;
- Reconstruction of the hot water supply system of the shop;
- Replacing the lining on a soft insulating material and reconstruction of the gas heating furnace in the shop;
- The use of electric beam heaters in the areas of placement of CNC machines shop to replace gas heaters;
- Transfer of the hot water preparation system of the main production site to the coolant;
- Work on informing and increasing the motivation of employees to energy saving.

Only low-cost measures can be implemented at the company’s own expense.

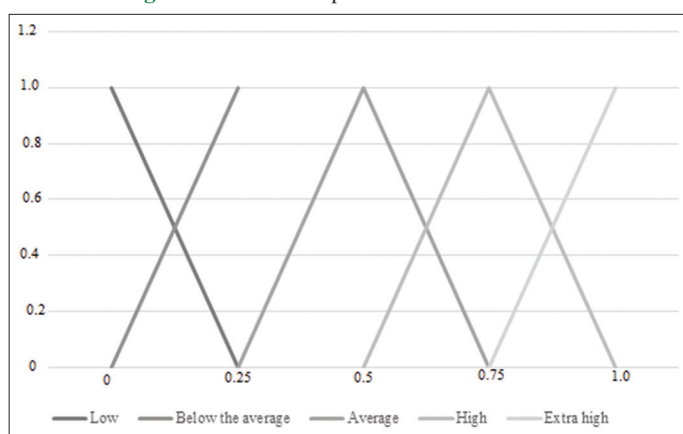
Using the found average numerical values of the membership function of the linguistic variable for the lower level criteria (Table 3) and considering their relative importance, the corresponding values of the higher-level group criteria for all the energy-saving projects can be determined. Calculating the values of linguistic variable of group criteria for the highest levels A1, A2, A3, A4, A5 allow defining preliminary acceptability of the projects on energy saving and considering financial and economic condition of the enterprise and the sources to receive the means for estimating their investment attractiveness in a complex (Table 4).



**Table 2: Numeric values of the variable q membership function for energy-saving project Z1**

Criterion	Numerical number of expert														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>1. Compliance of material-technical and personnel base of the enterprise with the conditions of implementation of the energy-saving project</b>															
a <sub>11</sub>	1	0.75	1	1	1	0.75	1	0.75	0.75	1	1	1	1	1	0.75
a <sub>12</sub>	1	1	1	1	1	0.75	0.75	0.75	1	1	1	0.75	1	1	1
a <sub>13</sub>	0.5	0.25	0.75	0.5	0.5	0.5	0.25	0.5	0.5	0.75	0.75	0.5	0.5	0.5	0.5
a <sub>14</sub>	1	1	1	1	1	0.75	1	0.75	1	1	1	1	1	1	1
a <sub>15</sub>	0	0.25	0.25	0.25	0	0	0.25	0.25	0	0.25	0.25	0.25	0.25	0.25	0.25
a <sub>16</sub>	0.75	1	0.75	0.75	0.75	1	1	0.75	1	1	1	1	1	1	0.75
a <sub>17</sub>	0.75	0.75	1	1	0.75	0.75	0.75	1	0.75	1	1	1	1	0.75	1
a <sub>18</sub>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
a <sub>19</sub>	0.75	0.75	1	1	1	0.75	1	0.75	1	1	1	1	1	1	0.75
<b>2. Financial costs of the enterprise for the implementation of the energy-saving project</b>															
a <sub>21</sub>	0.5	0.5	0.75	0.75	0.5	0.75	0.5	0.5	0.5	0.25	0.5	0.5	0.5	0.75	0.5
a <sub>22</sub>	0.75	0.5	0.75	0.75	0.75	0.75	0.5	0.75	0.5	0.75	0.75	0.75	0.75	0.75	0.5
a <sub>23</sub>	0.75	0.75	1	0.75	0.75	0.75	1	0.75	0.5	0.75	0.75	0.75	0.5	1	0.75
a <sub>24</sub>	0.75	1	1	1	0.75	0.75	0.75	1	1	1	0.75	0.75	0.75	0.75	0.75
a <sub>25</sub>	1	1	1	1	1	1	1	1	0.75	1	1	1	1	1	1
<b>3. Administrative and legal obstacles</b>															
a <sub>31</sub>	1	0.75	1	1	1	0.75	1	1	1	1	1	1	1	1	1
a <sub>32</sub>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
a <sub>33</sub>	0.75	1	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
<b>4. Time expenditure</b>															
a <sub>41</sub>	0.75	0.75	0.5	0.5	0.5	0.75	0.5	0.75	0.75	0.75	0.5	0.75	0.75	0.75	0.75
a <sub>42</sub>	0.75	0.75	0.75	0.5	0.5	0.75	0.75	0.75	0.75	0.75	0.5	0.75	0.75	0.75	0.75
a <sub>43</sub>	1	1	0.75	0.75	0.75	1	1	1	1	1	0.75	1	1	1	0.75
a <sub>44</sub>	0.75	0.75	0.5	0.5	0.5	0.75	0.75	0.75	0.5	0.75	0.5	0.75	0.75	0.75	0.5
<b>5. Expected effect of energy-saving project implementation</b>															
a <sub>51</sub>	0.5	0.75	0.75	0.5	0.5	0.5	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.5
a <sub>52</sub>	1	1	1	0.75	0.75	0.75	0.75	1	1	1	0.75	0.75	0.75	1	0.75
a <sub>53</sub>	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0.25	0
a <sub>54</sub>	0	0	0.25	0	0	0	0	0	0.25	0	0	0	0	0.25	0

**Figure 2: Membership function of the term-set**



Thus, according to the financial and economic condition of the enterprise, 12 energy-saving projects should be implemented in the first place. Nine of them require the involvement of financial resources of the company group, which means that their implementation requires the coordination with the management company. Since the allocation of funds necessary for the simultaneous implementation of energy-saving projects looks unlikely, in addition, in such a situation, there will be a shortage of available labor and material resources of the enterprise, it is advisable to determine their priority. To do this, it is convenient

to use the method of constructing membership functions based on paired comparisons.

The experts were offered to conduct paired comparisons of 9 energy-saving projects according to group criteria of the highest levels A1, A2, A3, A4, A5. A fuzzy solution to the task of prioritizing these projects will be at the intersection of the following group criteria:

$$\tilde{D} = \tilde{A}_1 \cap \tilde{A}_2 \cap \tilde{A}_3 \cap \tilde{A}_4 \cap \tilde{A}_5 \Rightarrow \tag{6}$$

$$\tilde{D} = \left\{ \begin{matrix} \frac{\min_{i=1,5}(\mu_{A_{i1}}(31))^{\alpha_i}}{31}, \frac{\min_{i=1,5}(\mu_{A_{i1}}(32))^{\alpha_i}}{32} \\ \frac{\min_{i=1,5}(\mu_{A_{i1}}(316))^{\alpha_i}}{316} \\ \dots \end{matrix} \right\} \tag{7}$$

where  $\alpha_i$  – relative weight of the i group criterion of the highest level.

According to the presented fuzzy set  $\tilde{D}$ , the most prioritized energy-saving project should be considered the one with the greatest degree of ownership.

After calculating the matrices of paired comparisons compiled by experts, we obtain the following fuzzy sets:

**Table 3: Belonging of the criteria for the lowest levels of the ‘Astana-AS’ LLP energy-saving projects to the subsets of term-sets Q**

Criterion	Energy-saving project														
	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	Z9	Z10	Z11	Z12	Z13	Z14	Z15
<b>1. Compliance of material-technical and personnel base of the enterprise with the conditions of implementation of the energy-saving project</b>															
a <sub>11</sub>	0.92	0.77	1	0.55	1	0.65	0.93	0.48	0.67	0.23	0.87	0.28	0.95	0.98	0.9
a <sub>12</sub>	0.93	0.92	0.97	0.87	1	0.75	0.97	0.53	0.73	0.43	0.92	0.17	0.97	0.93	0.95
a <sub>13</sub>	0.75	0.68	0.55	0.47	0.67	0.53	0.75	0.67	0.75	0.72	0.67	0.39	0.65	0.78	0.7
a <sub>14</sub>	0.97	0.55	0.93	0.67	1	0.58	0.47	0.78	0.83	0.67	0.75	0.52	0.9	0.92	0.95
a <sub>15</sub>	0.18	0.47	0.68	0.97	0.35	0.15	0.15	0.05	0.47	0.07	0.68	0.22	0.52	0.17	0.85
a <sub>16</sub>	0.9	0.88	0.97	0.73	1	0.43	0.92	0.73	0.92	0.57	0.95	0.76	0.98	0.97	0.97
a <sub>17</sub>	0.88	0.73	0.85	0.97	0.75	0.55	0.63	0.5	0.77	0.97	0.23	0.92	0.38	0.88	0.48
a <sub>18</sub>	1	1	1	1	1	0.27	1	1	1	0.88	1	1	0.92	1	0.75
a <sub>19</sub>	0.92	0.88	1	0.88	0.88	0.97	0.97	0.25	0.97	0.93	0.87	0.95	0.95	1	1
<b>2. Financial costs of the enterprise for the implementation of the energy-saving project</b>															
a <sub>21</sub>	0.55	0.34	0.63	0.97	0.93	0.47	0.35	0.68	0.88	0.92	0.65	0.75	0.7	0.68	0.77
a <sub>22</sub>	0.68	0.73	0.34	0.25	0.55	0.43	0.78	0.73	0.78	0.75	0.35	0.48	0.77	0.57	0.54
a <sub>23</sub>	0.73	0.84	0.53	0.97	0.73	0.75	0.83	1	0.93	0.5	0.67	0.45	0.93	0.95	0.9
a <sub>24</sub>	0.85	0.97	0.92	0.75	1	0.58	0.67	0.53	0.83	0.48	0.92	0.33	0.98	0.93	0.85
a <sub>25</sub>	0.98	0.82	0.55	1	1	0.92	0.92	0.33	0.73	0.45	0.97	0.52	1	0.98	0.93
<b>3. Administrative and legal obstacles</b>															
a <sub>31</sub>	0.97	0.88	1	0.93	1	0.03	0.97	1	1	1	0.87	1	0.37	1	0.58
a <sub>32</sub>	1	0.73	0.75	0.88	1	0.14	0.83	0.92	0.75	1	0.38	0.14	0.53	0.78	0.27
a <sub>33</sub>	0.77	0.68	0.47	1	0.93	0.233	0.92	1	1	1	0.93	0.9	0.73	1	0.38
<b>4. Time expenditure</b>															
a <sub>41</sub>	0.67	0.63	0.43	0.97	0.73	0.25	0.57	0.38	0.43	0.57	0.42	0.65	0.85	0.75	0.57
a <sub>42</sub>	0.7	0.78	0.55	0.47	0.77	0.53	0.92	0.49	0.45	0.62	0.23	0.38	0.7	0.83	0.64
a <sub>43</sub>	0.92	0.97	0.83	0.53	0.97	0.85	0.78	0.47	0.5	0.55	0.95	0.93	0.92	0.77	0.68
a <sub>44</sub>	0.65	0.48	0.57	0.95	0.93	0.34	0.58	0.67	0.68	0.73	0.48	0.78	0.57	0.74	0.75
<b>5. Expected effect of energy-saving project implementation</b>															
a <sub>51</sub>	0.67	0.75	0.92	1	1	0.35	0.55	0.88	0.92	0.37	0.62	0.55	0.88	0.9	0.73
a <sub>52</sub>	0.87	0.73	0.75	0.97	0.67	0.53	0.73	0.82	0.78	0.43	0.75	0.72	0.67	0.92	0.68
a <sub>53</sub>	0.03	0.23	0.67	0.05	0.25	0.58	0.33	0.17	0.07	0.23	0.77	0.08	0.08	0.03	0.43
a <sub>54</sub>	0.05	0.07	0.55	0.03	0.08	0.03	0.11	0.28	0.03	0.05	0.53	0.03	0.35	0.25	0.05

**Table 4: Investment attractiveness assessment of the ‘Astana-AS’ LLP energy-saving projects by the group criteria of higher levels**

Criterion	Energy-saving project															
	Z1	Z2	Z3	Z7	Z9	Z11	Z14	Z15	Z16	Z4	Z5	Z13	Z6	Z8	Z12	Z10
A <sub>1</sub>	0.79	0.76	0.87	0.74	0.77	0.79	0.81	0.87	0.68	0.78	0.83	0.81	0.53	0.51	0.51	0.55
A <sub>2</sub>	0.7	0.69	0.6	0.65	0.86	0.66	0.79	0.78	0.93	0.78	0.82	0.84	0.57	0.73	0.53	0.67
A <sub>3</sub>	0.72	0.69	0.58	0.71	0.53	0.5	0.77	0.67	0.54	0.75	0.85	0.73	0.47	0.52	0.68	0.63
A <sub>4</sub>	0.93	0.75	0.8	0.88	0.87	0.63	0.88	0.36	0.76	0.92	0.98	0.55	0.14	0.96	0.52	1
A <sub>5</sub>	0.54	0.55	0.75	0.54	0.56	0.71	0.62	0.58	0.58	0.65	0.58	0.52	0.48	0.61	0.46	0.34
E	0.72	0.68	0.73	0.68	0.75	0.69	0.76	0.69	0.74	0.77	0.79	0.7	0.46	0.62	0.52	0.62
B	0.88															
K	K2					K3					K2					K3
F	Implemented in the first place								Implemented as funds become available							

**Table 5: Assessment of investment attractiveness of the ‘Astana-AS’ LLP branches’ energy-saving projects according to the group criteria of the highest levels**

Criterion	Energy-saving project									
	Z17	Z18	Z19	Z21	Z22	Z23	Z23	Z25	Z20	
A <sub>1</sub>	0.85	0.88	0.93	0.81	0.68	0.84	0.71	0.74	0.63	
A <sub>2</sub>	0.79	0.67	0.87	0.75	0.79	0.73	0.62	0.57	0.58	
A <sub>3</sub>	0.97	0.8	0.62	0.67	0.81	0.87	0.68	0.88	0.51	
A <sub>4</sub>	0.86	0.75	0.67	0.52	0.82	0.75	0.51	0.73	0.76	
A <sub>5</sub>	0.53	0.37	0.82	0.64	0.78	0.67	0.86	0.84	0.68	
E	0.76	0.66	0.82	0.69	0.77	0.75	0.69	0.72	0.64	
B	0.81									
K	K3									
C	Implemented in the first place					Implemented as funds become available				

$$\begin{aligned} \tilde{A}_1^N &= \left\{ \frac{0,12}{31}, \frac{0,07}{32}, \frac{0,13}{33}, \frac{0,1}{37}, \frac{0,09}{39}, \frac{0,08}{311}, \frac{0,14}{314}, \frac{0,21}{315}, \frac{0,06}{316} \right\}, \\ \tilde{A}_2^N &= \left\{ \frac{0,08}{31}, \frac{0,06}{32}, \frac{0,05}{33}, \frac{0,08}{37}, \frac{0,15}{39}, \frac{0,06}{311}, \frac{0,12}{314}, \frac{0,14}{315}, \frac{0,26}{316} \right\}, \\ \tilde{A}_3^N &= \left\{ \frac{0,21}{31}, \frac{0,1}{32}, \frac{0,09}{33}, \frac{0,15}{37}, \frac{0,07}{39}, \frac{0,06}{311}, \frac{0,14}{314}, \frac{0,11}{315}, \frac{0,07}{316} \right\}, \\ \tilde{A}_4^N &= \left\{ \frac{0,18}{31}, \frac{0,08}{32}, \frac{0,12}{33}, \frac{0,14}{37}, \frac{0,13}{39}, \frac{0,08}{311}, \frac{0,14}{314}, \frac{0,03}{315}, \frac{0,1}{316} \right\}, \\ \tilde{A}_5^N &= \left\{ \frac{0,08}{31}, \frac{0,09}{32}, \frac{0,16}{33}, \frac{0,07}{37}, \frac{0,11}{39}, \frac{0,15}{311}, \frac{0,13}{314}, \frac{0,11}{315}, \frac{0,1}{316} \right\}, \end{aligned}$$

Applying the relative weights of higher-level group criteria, we obtain the following fuzzy sets:

$$\begin{aligned} \tilde{A}_1^N &= \left\{ \frac{0,65}{31}, \frac{0,58}{32}, \frac{0,66}{33}, \frac{0,63}{37}, \frac{0,61}{39}, \frac{0,6}{311}, \frac{0,67}{314}, \frac{0,73}{315}, \frac{0,57}{316} \right\} \\ \tilde{A}_1^N &= \left\{ \frac{0,46}{31}, \frac{0,42}{32}, \frac{0,39}{33}, \frac{0,46}{37}, \frac{0,55}{39}, \frac{0,42}{311}, \frac{0,52}{314}, \frac{0,54}{315}, \frac{0,66}{316} \right\} \\ \tilde{A}_1^N &= \left\{ \frac{0,93}{31}, \frac{0,9}{32}, \frac{0,9}{33}, \frac{0,92}{37}, \frac{0,89}{39}, \frac{0,88}{311}, \frac{0,93}{314}, \frac{0,91}{315}, \frac{0,89}{316} \right\} \\ \tilde{A}_1^N &= \left\{ \frac{0,74}{31}, \frac{0,65}{32}, \frac{0,69}{33}, \frac{0,71}{37}, \frac{0,7}{39}, \frac{0,65}{311}, \frac{0,71}{314}, \frac{0,55}{315}, \frac{0,67}{316} \right\} \\ \tilde{A}_1^N &= \left\{ \frac{0,52}{31}, \frac{0,54}{32}, \frac{0,62}{33}, \frac{0,5}{37}, \frac{0,56}{39}, \frac{0,61}{311}, \frac{0,59}{314}, \frac{0,56}{315}, \frac{0,55}{316} \right\} \end{aligned}$$

According to (3), as a result of the intersection of fuzzy sets  $\tilde{A}_1^U \div \tilde{A}_5^U$  we will obtain as follows:

$$\tilde{D}^N = \left\{ \frac{0,46}{31}, \frac{0,42}{32}, \frac{0,39}{33}, \frac{0,46}{37}, \frac{0,55}{39}, \frac{0,42}{311}, \frac{0,52}{314}, \frac{0,54}{315}, \frac{0,55}{316} \right\}$$

The resulting fuzzy set  $\tilde{D}$  determines the order of implementation of the 'Astana-AS' LLP energy-saving projects, which require the allocation of funds by the management company.

Similarly, we will assess the investment attractiveness and determine the order of implementation of the energy-saving projects planned in the branches of the 'Astana-AS' LLP, namely:

- Automation of the lighting system using motion and light sensors;
- Upgrading of electrical panels group workshops;
- Optimization of load on power step-down transformers;
- Modernization of heating furnaces using recovery schemes and automation of the combustion process;
- Reconstruction of the electrical distribution network of the administrative building;
- Installation of automated control units of heat consumption;
- Recovery domestic hot water circulation;
- Implementation of water recycling system;
- Insulation of the outer walls of the administrative building.

Based on the results of the processing of the expert group questionnaires, numerical values of the membership function for the criteria of the lowest levels of each of the energy-saving projects were determined. Considering the relative weights of the criteria of the lower levels, the numerical values of the membership function for the group criteria of the higher levels were calculated. The results of calculating the numerical values of the membership

function for the criteria of the highest levels and assessing the investment attractiveness of energy-saving projects in the branches of 'Astana-AS' LLP are given in Table 5.

According to the financial and economic condition of the enterprise and the use of own funds of the enterprise as a source of financing, the implementation of energy-saving projects looks reasonable. We determine the order of their implementation by calculating the matrices of paired comparisons according to the criteria of higher levels:

$$\begin{aligned} \tilde{A}_1^U &= \left\{ \frac{0,15}{317}, \frac{0,17}{318}, \frac{0,2}{319}, \frac{0,12}{321}, \frac{0,07}{322}, \frac{0,10}{323}, \frac{0,13}{324}, \frac{0,06}{325} \right\} \\ \tilde{A}_2^U &= \left\{ \frac{0,16}{317}, \frac{0,11}{318}, \frac{0,18}{319}, \frac{0,13}{321}, \frac{0,15}{322}, \frac{0,12}{323}, \frac{0,09}{324}, \frac{0,06}{325} \right\} \\ \tilde{A}_3^U &= \left\{ \frac{0,18}{317}, \frac{0,14}{318}, \frac{0,07}{319}, \frac{0,08}{321}, \frac{0,15}{322}, \frac{0,16}{323}, \frac{0,09}{324}, \frac{0,13}{325} \right\} \\ \tilde{A}_4^U &= \left\{ \frac{0,19}{317}, \frac{0,15}{318}, \frac{0,12}{319}, \frac{0,09}{321}, \frac{0,16}{322}, \frac{0,11}{323}, \frac{0,07}{324}, \frac{0,11}{325} \right\} \\ \tilde{A}_5^U &= \left\{ \frac{0,11}{317}, \frac{0,07}{318}, \frac{0,15}{319}, \frac{0,12}{321}, \frac{0,13}{322}, \frac{0,1}{323}, \frac{0,16}{324}, \frac{0,16}{325} \right\} \end{aligned}$$

Applying the relative weights of the higher level group criteria we obtain the following fuzzy sets:

$$\begin{aligned} \tilde{A}_1^U &= \left\{ \frac{0,68}{317}, \frac{0,7}{318}, \frac{0,72}{319}, \frac{0,65}{321}, \frac{0,58}{322}, \frac{0,63}{323}, \frac{0,66}{324}, \frac{0,57}{325} \right\} \\ \tilde{A}_2^U &= \left\{ \frac{0,57}{317}, \frac{0,5}{318}, \frac{0,59}{319}, \frac{0,53}{321}, \frac{0,55}{322}, \frac{0,52}{323}, \frac{0,47}{324}, \frac{0,42}{325} \right\} \\ \tilde{A}_3^U &= \left\{ \frac{0,91}{317}, \frac{0,9}{318}, \frac{0,86}{319}, \frac{0,87}{321}, \frac{0,9}{322}, \frac{0,9}{323}, \frac{0,87}{324}, \frac{0,89}{325} \right\} \\ \tilde{A}_4^U &= \left\{ \frac{0,68}{317}, \frac{0,65}{318}, \frac{0,62}{319}, \frac{0,58}{321}, \frac{0,66}{322}, \frac{0,6}{323}, \frac{0,54}{324}, \frac{0,6}{325} \right\} \\ \tilde{A}_5^U &= \left\{ \frac{0,57}{317}, \frac{0,5}{318}, \frac{0,61}{319}, \frac{0,58}{321}, \frac{0,59}{322}, \frac{0,55}{323}, \frac{0,62}{324}, \frac{0,62}{325} \right\} \end{aligned}$$

As a result of the intersection of fuzzy sets  $\tilde{A}_1^U \div \tilde{A}_5^U$  we will obtain as follows:

$$\tilde{D}^U = \left\{ \frac{0,57}{317}, \frac{0,5}{318}, \frac{0,59}{319}, \frac{0,53}{321}, \frac{0,55}{322}, \frac{0,52}{323}, \frac{0,47}{324}, \frac{0,42}{325} \right\}$$

The resulting fuzzy set determines the order of implementation of the energy-saving projects in the branches of 'Astana-AS' LLP in the following sequence: Z19, Z17, Z22, Z21, Z23, Z18, Z24, Z25.

Thus, the application of the proposed methodological approach to complex assessment of investment attractiveness of energy-saving projects based on the tools of fuzzy set theWory, allows making informed managerial decisions regarding pre-selection of such projects and prioritizing their implementation. This is facilitated with a wide range of both quantitative and qualitative criteria for the evaluation of energy-saving projects carried out by a group of highly qualified specialists of the enterprise as experts.



## 5. CONCLUSIONS

In the present paper, we have proposed to improve the methodical approach to formation of scenarios of energy-saving industrial enterprises and to choose the best one as optimum based on modeling of conflict situations in the form of positional games of several players. With the help of the proposed mathematical model, three possible scenarios of energy saving of the enterprise are formed. The use of economic and mathematical modeling based on the theory of games allows us to imagine the possible impact of other economic entities on the efficiency of energy-saving enterprises in the form of conflicts. Simulations in two noncooperative and one positional play allowed us to define scenarios for power saving, minimizing the risks of enterprises and the behavior of an "intelligent" player.

The mechanism of planning and implementation of effective energy-saving activities at an industrial enterprise has been improved by applying the elements of a systematic approach and analysis, as well as a program-target method. The algorithm for realization of the program on energy saving by the Shuhart-Deming cycle providing operational management of processes of energy saving, and also providing modification of it in case of need is offered.

It is proposed to improve the methodological approach to calculate the complex economic effect of the implementation of energy-saving measures to make an informed decision on the implementation of one of the alternative projects, which is mutually exclusive. Calculations on three implementation projects deep input in electrical networks of industrial enterprises has shown the feasibility of introducing alternative energy-saving project that saves 29% energy and has a payback period of 5.7 years.

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