

EVALUATION OF ECONOMIC RISKS FOR POWER-GENERATING COMPANIES

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ABSTRACT

The paper presents the results of a study on the economic risks affecting the competitiveness of power-generating companies. A methodical approach to the diagnosis of economic risks has been developed by the authors. The possibilities are estimated by using competitive advantages of various generating technologies on the basis of the method of decomposition of factors, which characterize economic risks. The process of development of power-generating companies involves the solution of complex problems related with the reliable power supply to consumers and the increase in efficiency of energy generation. The problem of increasing competitiveness requires the development of a special system for diagnosing the economic risks for power-generating companies. This implies forming a knowledge base necessary for the subsequent evaluation of the level of influence of economic risks on the competitiveness of energy sources. The approach proposed for diagnosing economic risks proposed is based on cluster and discriminant analyses. It allows determining the characteristics of energy-generating technologies that will give a high level of competitiveness. As a consequence, it becomes possible to study changes in the business environment and profitably take advantage of the potential advantages of the market. The evaluation of economic risks leads to assessing the level of their impact on the prospects of the presence of new energy-generating sources on the local energy market. It also permits analysis on the feasibility of exploiting their competitive advantages. The approach proposed is aimed at improving decision-making in conditions of uncertainty, minimizing economic risks and increasing the competitiveness.

Keywords: power industry, economic risks, efficiency, competition, strategy, reliability, mathematical economic models.

1 INTRODUCTION

In the power industry, when assessing economic risks in the power industry, it is important to study the properties, phenomena and processes that jointly reflect the susceptibility to economic risks resulting in the decrease of the competitive position of a power-generating company. During the seasonal decline of heat demand as well as due to reliability problems, power-generating sources involving cogeneration units begin losing their competitive advantage, which impacts the technical, economic and financial indicators and increases substantially the level of economic risks of the power-generating company substantially. This may result in the downturn in the regional power industry and the disruption of the fuel and power balance of the area [1]–[3].

To improve the reliability of the economic risk evaluation, of risks mostly contributing to untoward conditions, four conventional groups of object have been defined to characterize the status of a power-generating company and its capacity for the sustainable development on the competitive environment: 1) commercial efficiency; 2) energy efficiency; 3) power generation and transportation reliability; and 4) efficiency of use fixed assets use.

The first group of objects reflecting the commercial efficiency provides the level of demand and supply of power and heat energy including the maximal load. Electrical connections represent the level of deficit (or excess) of electric power within the area and the quantities to be supplied for covering the maximum load in adjacent regions. Besides, it



considers the indicators of the development dynamics of non-conventional renewable energy resources.

The second group includes the indicators of energy efficiency and fuel consumption distributed per type and per cogeneration unit within the area. Apart from that, the level of losses of power and heat energy in transit is.

The third group illustrating the reliability and redundancy includes the indicators showing the level of margin of capacity, as well as the coal and fuel oil stock and natural gas availability to power generation sources. In addition, it considers the network availability in terms of the capacity of transmission lines, district heating pipelines, and gas pipelines. The reliability is evaluated on the basis of a short fall of power and heat energy delivery to consumers because of cogeneration unit operation disruption, mainly due to accidents and emergency shutdowns.

The last fourth group of indicators demonstrates the costs level, the productivity, the yield on capital investments, and the deterioration of power generation sources. The critical component of this group is the amount of investments in new construction and refurbishment as well as non-productive assets and environmental protection.

With indicators aggregation of the four groups, databases are formed, which will become the basis for value arrays of indicators required for the evaluation of the economic risks of power-generating companies.

The source of the information are the official corporate and governmental reports; documents of power market regulators and investors' requirements on estimating the power industry outlook that estimating can be used to determine the weight of each indicator.

To ensure the necessary level of scientific validity, the system of indicators for assessing economic risks must be formed on the basis of the following general principles [4]–[6]:

- 1) comprehensiveness requiring the analysis of every aspect of the object of research – territorial, process, economic, financial, investment, etc.;
- 2) hierarchy of territorial production facilities considering interconnection and interdependence as well as external factors, from the perspective of the object of research being an element of the higher level economic environment;
- 3) alternatives consideration, which foresees revealing and substantiating the development options as well as determining the areas of social and economic development of area;
- 4) standard risk related with the identification and implementation of actions aimed at power industry development in a down economy.

2 METHODOLOGICAL SPECIFICS FOR EVALUATION OF ECONOMIC RISKS OF POWER-GENERATING COMPANY

The method developed for the evaluation of economic risks of a power-generating company allows for the integrated study of the following aspects: 1) the causes of emerging and intensifying economic risks; 2) the possibilities and ways of minimizing economic risks; and 3) the informational and methodical data base for further revealing the competitive possibilities of the power-generating company.

From the methodical viewpoint, when assessing economic risks, a power-generating company, it is important to consider a set of indicators that reflect the competitive advantages and the status of the power market and of the industry in general. This allows us to identify the causes of the intensification of economic risks and the cogeneration units of deterioration of competitive position. This is in order to focus resources on the weakest elements of the power-generating company in the future. Fig. 1 demonstrates the proposed schematic of risks evaluation of the power-generating company.

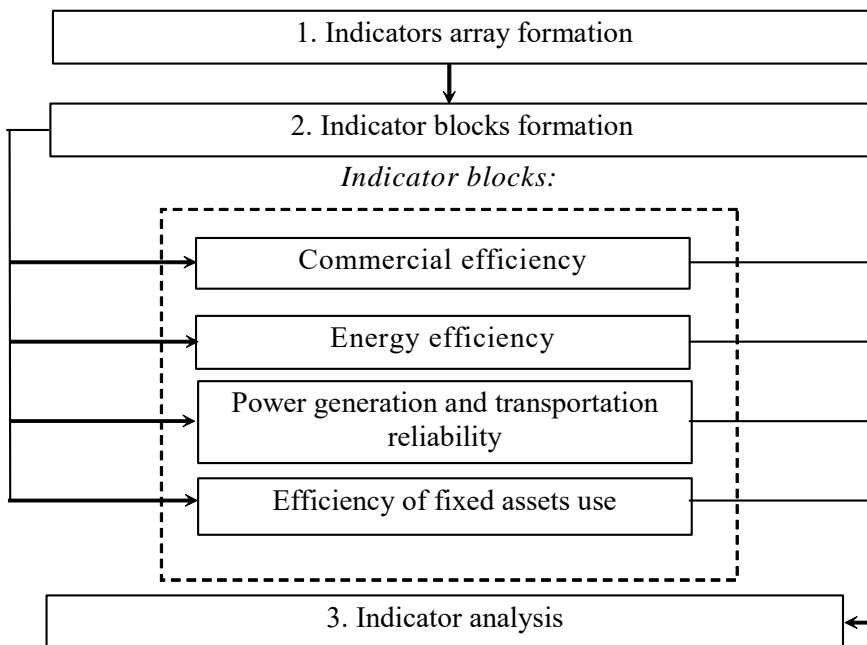


Figure 1: Schematic of power-generating company risks evaluation.

The methodical complexity of assessing economic risks, taking into account the specific features of the power-generating company positioning at the local power market, required the development of additional analytical tools that would make it possible to evaluate the impact intensity of economic risks impact on the competitive advantages of cogeneration units'. The main distinguishing feature of these tools is the process of indicator analysis process that is necessary for identifying the level of economic risks for each branch of the power-generating company. Furthermore, this information will be useful for the management of the company in searching for efficient solutions aimed at minimizing the economic risks and at increasing the competitive position [7]–[9].

The initial stage of the evaluation of the economic risks is the procedure of preparing indicators time series (it shall be performed by way of monitoring the power market business environment in the area). For this, the database constructed has to be connected with the indicator analysis algorithm. This allows processing in series the major information arrays per each monitored facility versus time and leads to improving the accuracy of results.

At the second stage, all the collected indicators shall be divided into the relevant groups considering the specific features of the entire indicator block. The procedure of forming the indicator blocks for further evaluation of the economic risks shall be based on the following principles:

- reflecting the power industry development laws;
- highlighting the most critical facilities to be monitored for having the criterial properties;

- aggregating the indicator on the basis of their common origin and the directional impact on the power industry development;
- assuring the availability of information support for indicators determining the values of each indicator being considered;
- facilitating the possibility of qualitative and quantitative classification of the levels of economic risks.

At the third stage, the indicator analysis per indicator block shall be carried out followed by that per the facility in general (for example, for each branch of the company), with the use of analytical tools based on cluster analysis and discriminative analysis.

In the course of the research it was found that, for the evaluation of economic risks of the power-generating company, it is of critical importance to identify threshold (maximum permissible) values of indicators. The failure to meet them (exceeding or failure to them) is critical and would result in the negative evolution [10]–[13].

3 METHODOLOGICAL ASPECTS OF INDICATOR ANALYSIS

The classification of economic risks for the power-generating company is obtained for each level of hazard and for each branch on the basis of the specific features of each indicator block. As to the general status as target of the object of research shall be made with the use is made of a dedicated indicator analysis method consisting of twelve stages, as shown in Fig. 2.

The essence of every stage of the method is as follows.

Stage 1. The indicator analysis method employs the term of “distance in multidimensional space”, that is why the source data shall be preliminarily normalized.

Normalization as per the X -coordinate is carried out with the following expression:

$$X_i^H = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}}, \quad (1)$$

where X_i^H – normalized value of i -th indicator as per X coordinate; X_i – actual value of i -th indicator as per X coordinate; X_{\min} – minimal value of X coordinate in the sample; X_{\max} – maximal value of X coordinate in the sample.

Stage 2. The formal multivariate statistical procedure – cluster analysis (Ward’s method) – shall be used for differentiating indicators per individual groups of economic risks [9].

The use of cluster analysis use makes it possible to classify the indicators as per the economic risks hazard groups – namely, normal (N), transient (T) and critical (K).

The rules are described below that characterize each of these conditions from the viewpoint of severity of threats for the development of the power-generating company.

The normal group is characteristic of non-existent or sufficiently weak external or internal economic risks that can be prevented by the management of the power-generating company management as well as by the market regulating processes [2], [8].

The transient group implies the substantial influence of economic risks on the development of the power-generating company and indicates its relative low competitive position. This condition requires the risk mitigating actions associated with high costs. Such actions are usually within the limits of the power-generating company’s own resources. However, insufficiently proactive actions taken to transfer the power-generating company into the normal group, or delays in taking these actions might result in economic risks aggravation.

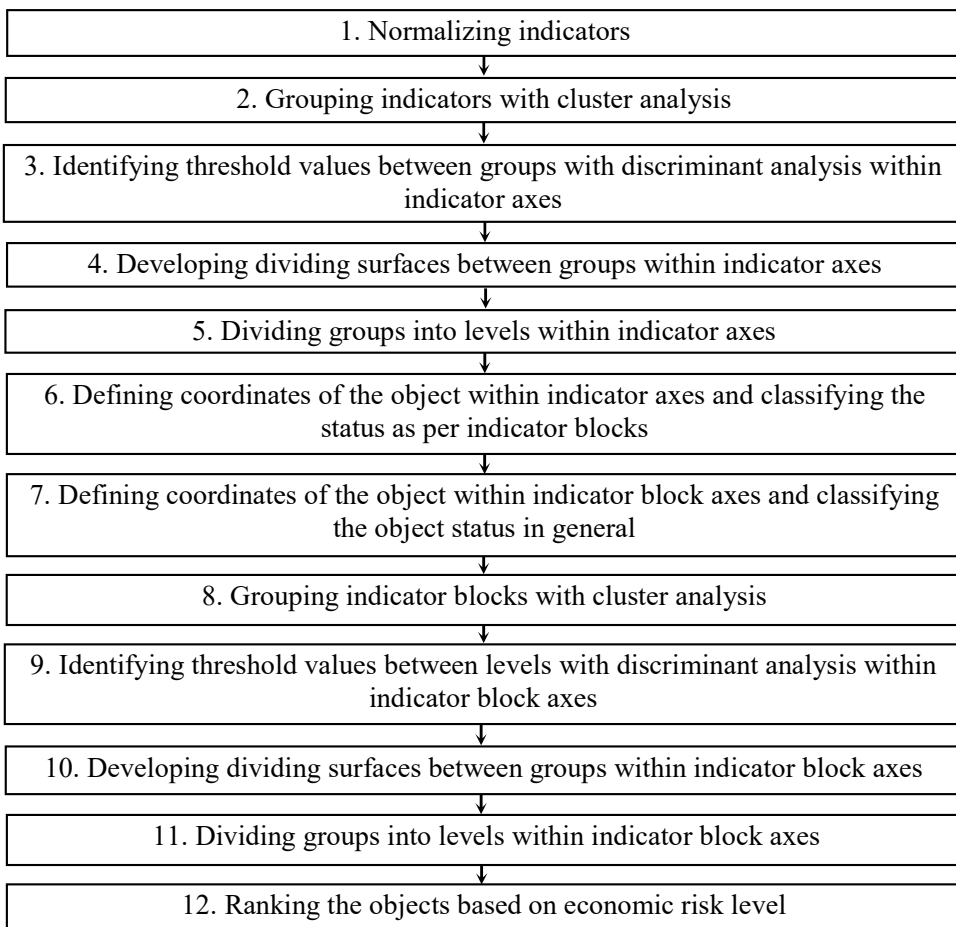


Figure 2: Schematic of indicator analysis method.

The critical group is characteristic of the substantially reduced resistance to economic risks and the marked decrease of the competitive position of the power-generating company. Under these conditions, it turns out to be rather difficult to manage the threats within a short period of time using the company resources. It becomes necessary to mobilize internal and external resources to overcome this situation. Getting into the critical group means the risk of losing the sustainability of the power-generating company's development, it also may result in its cogeneration units losing the competitive position at the power and heat energy markets.

Stage 3. Discriminant analysis is then used at this stage to identify the threshold values (coordinates) separating the main groups – the normal one and the transient one, as well as between the transient and the critical groups [11]–[13].

Stage 4. At this stage of the indicator analysis, the threshold values shall be identified between the competitive position groups for each indicator block.

Identifying the threshold values between the groups and their further subdivision into levels is carried out with the proprietary method of cutting hypersurfaces using the sphere

as the dividing surface, whose sphere is described with the following equation for the n -dimensional space with the center at the origin of the coordinates:

$$X_{j1}^2 + X_{j2}^2 + \dots + X_{jn}^2 = R^2, \quad (2)$$

where X_{j1}, X_{j2}, X_{jn} – coordinates in the n -dimensional space for j – the indicator block; R – radius of hypersphere.

It should be stressed that, based on the requirement of cutting hypersurfaces, it becomes necessary to scale the axes in such a way that the maximal radius of the hypersphere (r) determining the maximum threshold level is close to one.

In accordance with this, the coordinates of the cross points of dividing surfaces and right lines connecting the class centers must be normalized. This will allow us to further calculate the hypersphere radius length and to determine the threshold value with the help of it.

Stage 5. Experience has shown that the division into three groups insufficiently differentiates the qualitative status of the object and does not allow us to reliably establish the magnitude of reaction to the decrease of the economic risks level. This was found convenient with the different stages of aggravation of economic risks (ERL) within both the transient group and the critical group (Table 1).

Stage 6. At this stage, the object coordinates within the indicator axes shall be defined and the status shall be classified as per the indicator blocks.

To determine the status as per the block j it is necessary to identify the distance between the origin of coordinates and the object within the axes of indicators i according to the following expression:

$$X_{jim}^H = \sqrt{(X_{jim}^H)^2 + \dots + (X_{jim}^H)^2 + \dots + (X_{jim}^H)^2}, \quad (3)$$

where $m = A, B, C, D, E, F, G$, $i = \overline{(1, n)}$.

At that, the process of the economic risks classification becomes repetitive. At the first step, for the N–T threshold after the hypersphere is constructed, the points referring to the normal condition are identified and excluded. At the second step, the radius of the T–K hypersphere is constructed, and the objects get distributed into the transient group and the critical group.

Stage 7. At this stage, the object coordinates within the indicator block axes shall be defined.

Table 1: Classification of statuses as per the Economic Risk Levels.

Groups	Economic Risk Levels (ERL)	Designation
Normal (N)	Weak	A
Transient (T)	Low	B
	Medium	C
	Unstable	D
Critical (K)	High	E
	Ominous	F
	Grave	G

The method the coordinates definition and the objects classification is similar to the Stages 4 and 5, with the only difference that the axes of indicators (i) are replaced by the axes of blocks (j). The status in general is defined by the following formula at that:

$$X_{jm}^H = \sqrt{(X_{1m}^H)^2 + \dots + (X_{jm}^H)^2 + \dots + (X_{nm}^H)^2}, \quad (4)$$

where $m = A, B, C, D, E, F, G$, $j = \overline{(1, n)}$.

It should be clarified that the methodical approach to the Stages 8–11 is similar to that of the Stages 2–5, but the indicator block axes are used in them instead.

Stage 12. At the last stage, the objects shall be ranked per level of economic risk, and this ranking is then based on the situation evaluation into weak to normal.

4 RESULTS OF ASSESSING ECONOMIC RISKS OF POWER-GENERATING COMPANY

The practical application of the methodical approach proposed for indicator analysis has been with the example of the evaluation of economic risks of the production branches of the T Plus, PJSC power-generating company (www.tplusgroup.ru).

Choosing this company as the object for the indicator analysis is explained by the fact that the level of economic risks of the production branches, having the cogeneration power sources, determines to a large extent the development tendency of the power cogeneration systems at the power market of the Urals and the Volga region.

The analysis of the economic risks evaluation shown in Table 2 shows that the Perm and Sverdlovsk Production Branches are at the highest level, and Mordovian, Saratov and Komi Production Branches are at the lowest level.

The results obtained are the evidence of the necessity of accelerated development of certain production branches of the T Plus, PJSC in order to avert the amassing negative factors that may further result in: 1) the deficit of power and heat energy in the area; 2) the limited power supply to consumers; 3) the loss of the competitive position in the local power market; and 4) the overpricing of power and heat energy.

As the final analysis of the T Plus, PJSC development outlook demonstrated, there is a clear tendency towards the weakening of the competitive positions of most of its production branches due to the decrease of the commercial efficiency and of the power generation and transportation reliability.

It should be noted that the economic risks related to the decrease of district heating networks reliability are one of the problems preventing the improvement of competitive positions of power-generating companies at the heat energy market. This problem should be solved simultaneously with making the strategic decisions on the implementation of the cogeneration competitive advantages. Thus, the low reliability of district heating networks may affect substantially the cogeneration competitive advantages and it can stimulate consumers to establish their own heat energy sources, something which is evidently of no benefit for power-generating companies. The substantial increase in the price of heat energy along with its quality decrease becomes the powerful incentive for heat economy, thus changing the consumers' attitude to the district heating. At that, the intensifying competition of the distributed sources of heat energy changes substantially the power-generating company priorities substantially.

5 CONCLUSIONS

This research on the general problem of improving the competitive position in the power industry required a system for identifying economic risks and evaluating their impact on the



Table 2: Results of T Plus, PJSC economic risks evaluation.

Production branch name		Indicator block name				General status	Ranking
		Commercial efficiency	Energy efficiency	Power generation and transportation reliability	Efficiency of fixed assets use		
Vladimir	r	0.504	0.358	0.413	0.418	0.392	3
	ERL	E	C	B	D	C	
Nizhniy Novgorod	r	0.342	0.431	0.489	0.612	0.507	7
	ERL	B	D	B	E	D	
Kirov	r	0.372	0.504	0.618	0.315	0.426	5
	ERL	C	E	C	B	C	
Mordovian	r	0.625	0.714	0.817	0.817	0.774	12
	ERL	E	F	E	F	F	
Orenburg	r	0.481	0.326	0.576	0.431	0.417	4
	ERL	C	C	C	D	C	
Perm	r	0.206	0.293	0.387	0.509	0.368	2
	ERL	B	C	B	E	B	
Samara	r	0.578	0.419	0.545	0.513	0.496	6
	ERL	D	D	C	E	C	
Saratov	r	0.719	0.693	0.781	0.841	0.764	11
	ERL	E	F	D	G	F	
Sverdlovsk	r	0.112	0.117	0.315	0.423	0.294	1
	ERL	A	A	B	D	B	
Udmurt	r	0.613	0.495	0.407	0.364	0.586	9
	ERL	E	D	B	C	D	
Ulyanovsk	r	0.625	0.594	0.569	0.605	0.601	10
	ERL	E	E	C	E	D	
Komi	r	0.892	0.746	0.901	0.724	0.813	13
	ERL	G	F	F	G	G	
Mariy-El and Chuvashia	r	0.534	0.658	0.483	0.384	0.512	8
	ERL	D	E	B	C	D	

opportunities of positioning power-generating companies at the local power market. The analytical tools have been developed to help defining both the individual and the integral characteristics of economic risks based on the decomposition of the economic risk factors.

In future, it is planned to use the proposed system of economic risks evaluation for power-generating companies as the basis for developing the integrated system for information and analytical support of the competitive development. Such a system would allow analyzing the possibilities to implement competitive advantages of the cogeneration power sources. This system would also allow to follow the changes in the business environment on regular basis and to take the corrective actions that would make it possible for the management to timely mitigate the economic risks of the company and to use the potential advantages of the current situation at the market.

It should be stressed that the substantial mitigation of economic risks is possible with the help of comprehensive solutions in the area of strategic priorities: 1) improvement of the generating plants structure efficiency; 2) optimization of fuel consumption; and 3) construction of highly maneuverable CCGT and gas turbine cogeneration units. The proposed strategic priorities proposed here can be considered as the basis for improving the competitive position of the power-generating company at the local power market and profitability of power cogeneration business in general.

Further improvement of the methodology for evaluation of economic risks of the power-generating company will be associated with the development of a special module. This module will allow to research the sensitivity of indicators depending on the changes in the regional energy market competition.

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