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Application of Innovative Decision-Making Methods of Sustainable Development in Choosing Busineness Partners

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Abstract **— The article deals with methods of managing the process of choosing business partners in the conditions of sustainable development. It reviews and analyzes the existing systems of management of contractual activities of energy companies on the example of Rostov NPP. An analysis of contracts concluded in 2015-2017 was carried out. The author's algorithm for studying contractual activities of nuclear power plants was applied. A model for the formalized selection of a potential supplier was developed. It was modified to select a supplier for contracts of various degrees of complexity. The method of pair comparisons was applied; criteria scales were developed taking into account the specifics of contracts. The additive convolution model was used as a method for constructing the aggregated criterion.**

Keywords **—** ***partners, logistics systems, modeling of the selection process, innovative methods for selecting partners, sustainable development.***

I. INTRODUCTION

Improving the effectiveness of the national economy through the innovative development is the most important objective direction of sustainable development. Innovative sustainable development associated with adaptability, an adequate response to changes in the business environment is accompanied by the search for new effective resource management methods. Under the current conditions, relationships between the enterprise and partners are one of the main issues of effective management. Company managers observe harsh savings of all available resources as part of the implementation of the concept of sustainable development and minimize costs of their supply. Based on the opinions of V.E. Nikolaychuk, A.M. Gadzhinsky, A.G. Kalchenko, A.A. Yashin, supply cost reduction requires new, more reliable suppliers, cheaper and better raw materials. It is necessary to study the problem of their effective use as part of the sustainable development policy of the enterprise. The implementation of a rational procurement system should be based on the application of modern methods of selecting partners taking into account the main criteria of the customers.

The choice of a business partner is the main problem in managing the procurement of material resources. The selection of suppliers is very responsible and complicated, as the timing of deliveries, the prestige of enterprises and their effectiveness depend on them. This is due to the fact that in the modern market conditions, there are a lot of suppliers of the same material resources; the supplier must be a reliable partner. A large number of potential suppliers and their diversity increase the urgency of the problem of choosing partners who could improve the reliability of logistics processes. A large number of potential suppliers increases the urgency of the problem of choosing those that could ensure reliability of logistics processes with a maximum effect. The solution to this problem consists of several stages that are inextricably linked with each other: search for potential suppliers, analysis and evaluation of relationships with them.

This topic is particularly relevant for nuclear energy enterprises. First of all, this is due to safety requirements. In addition, contracts concluded on an industry basis are diverse: general construction works, supply and commissioning of power equipment, supply and operation of additional equipment (for example, fire and radiation protection systems, water treatment), and provision of various types of services. The situation is complicated by the presence of contracts for the supply of unique equipment.

All these factors determine the need to develop a unified model of supplier selection, which can be applied to all types of contracts.

II. METHOD

Currently, in various fields, including contract activities, expert methods are widely used. However, these methods have certain shortcomings which become critical for the nuclear industry.

In particular, reliability of the expert assessment depends on the number of experts involved in the implementation of the assessment system. Due to the extremely high degree of responsibility, their number should be significant. However, in practice, attracting a large number of experts causes certain difficulties and inconsistent estimates. In addition, expert assessments are characterized by a high degree of subjectivity.

The aim of this work is to improve the efficiency of procurement by developing a conceptual model for choosing partners of an energy company in the market environment. The proposed model should be aimed at solving the selection by unifying criteria for selecting potential suppliers and developing scales for their evaluation.

At the first stage, an analysis of the procurement procedure was carried out using the example of Rostov Nuclear Plant branch of JSC Concern Rosenergoatom (hereinafter referred to as RoAES).

Procurement planning is carried out in accordance with the requirements of the "Unified industry procedure for planning, preparing and conducting procurement procedures, generating reports for the needs of Rosatom State Corporation, approved by the order of Rosenergoatom Concern JSC of 12.01.2017 No. 9/27 – Guidelines for procurement planning and reporting on procurement activities MU – UZD.00.00.02.

In accordance with these documents, technical requirements should determine quality indicators, technical and operational characteristics, taking into account current standards, norms and technical regulations.

Regulatory documents define the following principles for the development of requirements and criteria for the evaluation of procurement:

requirements and evaluation criteria should be specific, clearly interpreted, measurable, consistent with actual needs of the customer;

it is not allowed to establish requirements and evaluation criteria that can be confirmed only declaratively and cannot be verified at the selection stage, and criteria that will not be evaluated at the evaluation stage;

evaluation criteria are taken into account when determining the degree of preference of applications when ranking them at the evaluation stage.

The method for selecting suppliers is based on the hierarchy analysis method (MAI) proposed by T. L. Saati. This method is based on pairwise comparisons of alternative options for various criteria using a nine-point scale and subsequent ranking of alternatives for all criteria and goals. The structure of the criteria, as well as the rating scale, is determined by the knowledge model of a particular subject area. MAI milestones are as follows:

Developing criteria for evaluating alternative options;

establishing the relative importance of criteria;

generating alternative options;

identifying expert preferences;

developing ranked sets of alternatives.

III. RESULTS

To develop criteria and assessment scales, all procurement contracts concluded at RoNPP were divided into 4 groups according to the degree of stringency of safety requirements and regulatory acts depending on the construction and maintenance object:

Contracts for NPP equipment and its maintenance (nuclear power equipment and its maintenance);

contracts for auxiliary equipment related to the technological support of nuclear power plants;

contracts for infrastructure facilities on the territory of nuclear power plants and specialized (including licensed) services;

contracts for other facilities outside the territory of the nuclear power plant, or services not related to the production of electricity and not requiring licensing.

An analysis of contracts by the degree of responsibility is presented in Table 1. The structure of contracts is shown in Figure 1.

The following criteria were used for all contract groups:

K1 - completeness of licensed software;

K2 – production experience for relevant types of products or services;

K3 - quality (presence / absence of complaints);

K4 - quality (level) of contract support;

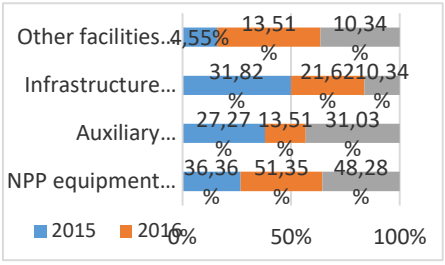

Fig. 1. The structure of contracts by the degree of responsibility

TABLE I. ANALYSIS OF CONTRACTS BY DEGREE OF RESPONSIBILITY

Category	2015		2016		2017	
	number	*%*	*number*	*%*	*number*	*%*
NPP equipment and its maintenance	8	36,36	19	51,35	14	48,28
auxiliary equipment and its maintenance	6	27,27	5	13,51	9	31,03
infrastructure facilities on the territory of NPP	7	31,82	8	21,62	3	10,34
Other facilities outside the territory of the NPP	1	4,55	5	13,51	3	10,34
Total	22	100,00	37	100,00	29	100,00

K4 - quality of contract support;

K5 - availability of services (for example, the presence of a potential supplier of transportation capabilities (delivery));

K6 – basic price;

K7 - price for additional services;

K8 - speed of contract execution.

The significance of the criteria was assessed using the paired comparison method for each category of contracts. Let us consider the procedure for determining the criteria weights on the example of contracts for the NPP equipment and its maintenance.

At the first step, a pairwise comparison of criteria by their significance was carried out on a nine-point scale and the corresponding n × n matrix (table) was built. The values were determined based on the following principles:

- equal importance - 1;

- moderate superiority - 3;

- significant superiority - 5;

- strong superiority - 7;

- very strong superiority - 9.

For example, if Ki is moderately superior to Ki, then 3 is put in the cell (i, j) of the table, and 1/3 (the reciprocal value) is put in the cell (j, i).

The normalized vector of priorities (NVP) is determined. A geometric mean is calculated for each row of the matrix, and the obtained values are normalized. The sum of the components of the NVP is equal to 1. Each component represents an assessment of the significance of the corresponding criterion. Calculation of NVP for the first group of contracts is presented in Table 2.

TABLE II. COMPARISON OF CRITERIA FOR CONTRACTS (GROUP 1) (NUCLEAR POWER EQUIPMENT AND ITS OPERATION)

Criteria	K1	K2	K3	K4	K5	K6	K7	K8	НВП
K1	1	3	1	3	9	7	9	7	0,309
K2	1/3	1	1	3	5	3	5	3	0,164
K3	1	1	1	5	7	7	9	7	0,278
K4	1/3	1/3	1/5	1	3	3	3	3	0,090
K5	1/9	1/5	1/7	1/3	1	1/3	2	2	0,037
K6	1/7	1/3	1/7	1/3	3	1	5	5	0,067
K7	1/9	1/5	1/9	1/3	1/2	1/5	1	1/2	0,024
K8	1/7	1/3	1/7	1/3	1/2	1/5	2	1	0,032
Sum	3,17	6,40	3,74	13,33	29,00	21,73	36,00	28,50	1

Comparison of criteria for contracts of group 1 (nuclear power equipment and its operation)

At the next stage, the consistency of estimates is checked. For this, three characteristics are calculated:

- eigenvalue of the matrix $\lambda_{\max} = \sum_{i=1}^{n}\left(НВП_{\text{i}} \times \sum_{j=1}^{n} a_{\text{ij}} \right)$;

- consistency index $CI = \frac{\lambda_{мах} - n}{n-1}$;

- consistency relation $CR = \frac{CI}{MSS}$,

where MSS is an indicator of random consistency, depending only on the size of the matrix, as indicated in Table 3.

TABLE III. THE VALUE OF THERANDOM CONSISTENCY INDICATO

Matrix size	1	2	3	4	5	6	7	8	9	10
MSS	0	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

Values of the MSS

Estimates are considered consistent if CR $\leq$ 10–15%, otherwise, they have to be reevaluated.

Let us calculate the consistency relation for the NVP contracts of group 1:

$$\lambda_{мах} = (0{,}309 \times 3{,}17) + (0{,}164 \times 6{,}4) + (0{,}278 \times 3{,}74) + (0{,}09 \times 13{,}33) + \\ + (0{,}037 \times 29) + (0{,}067 \times 21{,}73) + (0{,}024 \times 36) + (0{,}032 \times 28{,}5) = 8{,}54$$

$$CI = \frac{8{,}54 - 8}{8 - 1} = 0{,}077$$

$$CR = \frac{0{,}077}{1{,}41} = 0{,}0547 = 5{,}47\%$$

Similar calculations were performed for the remaining groups of contracts. In all cases, the matching ratio indicator does not exceed the threshold value (10-15%); therefore, the

obtained criteria weights can be used in further calculations. The results are presented in Table 4.

The obtained criterion weights are used to construct an aggregate ranking criterion for alternatives based on the additive convolution:

$$K(A_j) = \sum_{i=1}^{n} \alpha_i K_i(A_j)$$

,

where αi – weight of the i-th criterion, Ki(Aj) – estimate of the i-th supplier by the j-th criterion.

Estimates of alternatives can be obtained by paired comparisons; however, in order to unify the requirements for suppliers, it is advisable to develop objective assessment scales for each criterion. The authors suggest using the following scales (Tables 5-11).

TABLE IV. –SUMMARY TABLE OF CRITERIA WEIGHT

Criteria	Contract categories			
	1	*2*	*3*	*4*
K1 – Completeness of licensed support	0,309	0,102	0,043	0,019
K2 – Production experience	0,164	0,180	0,068	0,046
K3 – Quality	0,278	0,374	0,260	0,242
K4 – Quality of contract support	0,090	0,115	0,136	0,099
K5 – Availability of services	0,037	0,065	0,074	0,073
K6 – Price	0,067	0,080	0,243	0,284
K7 – Price of additional services	0,024	0,046	0,090	0,102
K8 – Contract execution speed	0,032	0,039	0,087	0,135

Summary table of criteria weighting

TABLE V. SCALE OF K1 CRITERION "COMPLETENESS OF LICENSE SOFTWARE"

Points	Contract categories			
	1	*2*	*3*	*4*
1	The absence of at least one document		Lack of a license for the required activity	X
2	X		X	X
3	X		Possibility of obtaining an additional license	X
4	X		The license for the required activity	X
5	All licenses available			X

Scale of criterion K1 “Completeness of licensing support”

TABLE VI. SCALE OF THE K2 CRITERION "PRODUCTION EXPERIENCE", IN YEARS

Points	Contract categories			
	1	*2*	*3*	*4*
1	No experience	Less than 5		
2	X	5–9		
3	10–19	10–14		
4	20–29	15–19		
5	Leading enterprise; more than 30 years	Leading enterprise; more than 20 years		

Scale of criterion K2 "Availability of production experience", years

The category “leading enterprise in the industry” should include an enterprise that occupies a leading position in its industry, has unique developments and / or can be considered as the only supplier

TABLE VII. SCALE OF THE K3 CRITERION "QUALITY"

Points	Contract categories			
	1	*2*	*3*	*4*
1	1, involving the risk of emergency		More than 2	X
2	1, involving the need for major repairs		2	More than 2
3	1	2	X	2
4	X	1	1	1
5	0	0	0	0

The scale of the criterion K3 "Quality"

TABLE VIII. SCALE OF THE K4 CRITERION "QUALITY OF CONTRACT SUPPORT"

Points	Contract categories			
	1	*2*	*3*	*4*
1	The contract involved support, but it was not offered by the potential Supplier			
2	The contract did not initially entail support, although it was possible (practiced in business)			
3	X			
4	Contract support was carried out in the amount stipulated by economic practice The contract did not entail support.			
5	Contract support is expected to exceed the amount of experience in business practices.			

The scale of criterion K4 “Quality of contract support”

TABLE IX. SCALE OF THE K5 CRITERION " AVAILABILITY OF SERVICES»

Points	Contract categories			
	1	*2*	*3*	*4*
1	Lack of services that cannot be provided by another counterparty			
2	Lack of services, the provision of which by another counterparty is not profitable for economic or technological reasons			
3	X			
4	Lack of services that may be provided by another counterparty			
5	Full range of services			

The scale of criterion K5 "Availability of services"

This criterion can be considered as a special case of criterion K4. However, the principle of evaluating the potential of suppliers is different and takes into account the possibility of obtaining the required service provided by a third-party, i.e. independent of the main transaction of the counterparty.

For criterion K6 “Basic price”, the proposed value of the contract is estimated by comparing it with the price level prevailing in the market. In the absence of such a level, the potential counterparty may be equated to the category "The inly supplier". The logic of the scale has a clear vector: Points are inversely proportional to the price offered by the supplier.

The criterion “Price for additional services” (K7) reflects the compliance of the cost of additional services with the level of prices prevailing in the market. The evaluation principle is the same as for criterion K6.

TABLE X. SCALE OF THE K6 CRITERION "BASIC PRICE" AND K7 "PRICE FOR ADDITIONAL SERVICES"

Points	Contract categories			
	1	*2*	*3*	*4*
1	The price exceeds the market one by more than 20%		The price exceeds the market one by more than 10%	
2	The price exceeds the market one by more than 10%		The price exceeds the market one by no more than 10%	
3	The price exceeds the market or planned one by more than 5%		The price does not exceed the market or planned one	
4	The price is higher than the market one, but the Supplier can be considered the only one		The contract price is below the market one, but not more than 10%	
5	The price does not exceed the market one		The price is below the market price by more than 10%	

The scale of criteria K6 “Basic price” and K7 “Price for additional services”

TABLE XI. SCALE OF THE K8 CRITERION " SPEED OF CONTRACT EXECUTION”

Points	Contract categories			
	1	*2*	*3*	*4*
1	Failure to fulfill the contract due to the inability to use the “catch-up” schedule			
2	Failure to fulfill the contract, if it is possible to implement a “catch-up” schedule			
3	Contracts are executed on time, with regular (contractual) approval of its transfer. Responsibility for minor violations.			
4	Contracts are executed on time, and their period corresponds to economic practice			
5	Contracts are executed ahead of schedule, and their period is shorter than that anticipated in business practice.			

The scale of the criterion K8 "Speed of execution of the contract"

Let us consider the situation of choosing a supplier with the following initial data.

The object / subject of the contract is modernization of the metal storage storage site. The facility located on the territory of Rostov NPP does not participate in its technological process. The contract can be attributed to the third category of contracts.

The approximate cost is 42,000 thousand rubles. The planned cost is 41 194 thousand rubles. There is no need to accompany the contract. There is no need for related services. The term of the contract is 5 months.

Since the work does not require the contractor to have a license, we can conditionally consider this indicator to be fulfilled (4 points). For all participants, contract support is not required, therefore the value of K4 is also 4.

Three potential suppliers are participating in the tender, offering appropriate conditions. It is proposed to consider their business proposals and evaluate terms of the contract according to the criteria.

Supplier 1. OJSC MosAvtoKran. It has been working in the market since 2003 (15 years) (K2 = 3). According to previously executed contracts, the company has one complaint (K3 = 4). Additional services are purchase and delivery of building materials (K5 = 5). The proposed cost of works is 40,725 thousand rubles, which is 469 thousand rubles or 1.13% less than the planned cost (K6 = 4). Additional services are purchase and delivery of building materials, the cost is 7.5% of the cost of materials, which is lower than the market price (K7 = 4). The execution period is 5.5 months (K8 = 2).

Supplier 2. LLC Rent-M. It has been working in the market since 2014 (4 years) (K2 = 1). According to the previous contracts, the company has two complaints (K3 = 2). Additional services are not provided, but since they are not obligatory and can be regularly performed by other contractors, K5 = 4. The proposed cost of works is 41,190 thousand rubles, which corresponds to the planned one (K6 = 3). Since additional services are not provided, K7 = 1. The term of execution is 5 months (K8 = 4).

Supplier 3. LLC OKAES. It has been working in the market since 2013 (5 years) (K2 = 2). The company has no complaints (K3 = 5). Additional services are purchase and delivery of building materials (K5 = 5). The proposed cost of works is 38679 thousand rubles, which is 2515 thousand rubles. or 6.11% less than planned (K6 = 4). Additional services are purchase and delivery of building materials, the cost is 12% of the cost of materials, which corresponds to the established practice (K7 = 3). The term of contract execution is 4 months (K8 = 5).

Before proceeding to the construction of aggregate estimates, we should note that suppliers 1 and 3 scored an equal number according to K6"Price", while the savings for nuclear power plants amount to 469 thousand rubles (when choosing supplier 1), and 2,515 thousand rubles (when choosing supplier 2). Therefore, we suggest ranking the value of this criterion for supplier 3 by adding half a point, i.e. K6 (3) = 4.5.

Let us consolidate the results in Table 12 and, using the additive model, let us evaluate potential suppliers

TABLE XII. – EXAMPLE OF APPLYING ADDITIVE CONVOLUTION IN THE SUPPLIER SELECTION MODEL

Criteria	NVP	Supplier 1		Supplier 2		Supplier 3	
		Points	*Points taking into account weight*	*Points*	*Points taking into account weight*	*Points*	*Points taking into account weight*
K1	0,043	4	0,172	4	0,172	4	0,172
K2	0,068	3	0,204	1	0,068	2	0,136
K3	0,260	4	1,039	2	0,520	5	1,299
K4	0,136	4	0,543	4	0,543	4	0,543
K5	0,074	5	0,370	4	0,296	5	0,370
K6	0,243	4	0,972	3	0,729	4,5	1,093
K7	0,090	4	0,360	1	0,090	3	0,270
K8	0,087	2	0,173	4	0,347	5	0,434
Sum of points	1		3,833		2,764		4,316

The example of applying additive convolution in a vendor selection model

Table 12 shows that supplier 3 (LLC OKAES) which scored the maximum number (4.316 points) is a winner.

IV. DISCUSSION AND CONCLUSION

The conceptual model makes it possible to improve the efficiency of procurement activities within the concept of sustainable development. The following conclusions can be drawn:

1. The proposed method for the study of contractual activities of nuclear power plants is universal and can be applied (with certain adjustments) to other enterprises focused on the implementation of the concept of sustainable development.

2. The proposed system of criteria for evaluating potential suppliers can be adjusted taking into account the specifics of the company.

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