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Assessment of the public acceptance of the nuclear power plant construction plan on the territory of foreign country

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Abstract

The article is devoted to the development of the mathematical tools for the assessment of public acceptance of the project. The authors consider the peculiarities of the megaproject implementation in the sphere of nuclear energy, namely the nuclear power plant construction on the territory of foreign country. The suggested approach can be used as the additional tool for the efficiency improvement of loyalty programs.
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Keywords: megaproject, loyalty program, decision-making process, automated decision support system intelligent information system, public acceptance, fuzzy logic tools, nuclear power plant construction.

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1. Introduction

In December 2007, according to the Decree of the President of the Russian Federation, there was established the State Atomic Energy Corporation ROSATOM (the abbreviated name is ROSATOM State Corporation). The powers of the abrogated Federal Atomic Energy Agency were transferred to the State Corporation [1]. The main objectives of the State Corporation are the creation of new conditions for the nuclear energy development and the strengthening of competitive advantages of our country in the world market of nuclear technologies.

In recent years, ROSATOM has been actively constructing new power-generating units both in the Russian Federation and abroad. ROSATOM State Corporation has signed agreements for the construction of 36 nuclear power-generating units abroad. In particular, the construction of Akkuyu Nuclear Power Plant (NPP) (Turkey), Belarusian NPP (Belarus), Kudankulam NPP (India), Rooppur NPP (Bangladesh), the second stage of Tianwan NPP (China), Hanhikivi-1 NPP (Finland) and Paks NPP (Hungary) is underway [2].

The NPP construction is a long-term project providing the great impact on the society, significantly developing the region infrastructure where it is implemented. Such peculiarities of the NPP construction prove that such project belongs to the category of megaprojects. A megaproject is a target program (large investment project) containing a set of interrelated projects, united by the common objective, committed resources and time for their implementation [3].

Pursuit of activities in the sphere of nuclear technologies is associated with various risks, among which information security risks [4]. Therefore, during job planning, it is necessary to pay great attention to the problem of public acceptance of the project. The public acceptance of nuclear energy industry is viewed as the result of managerial influence on the public opinion. The public opinion is the state of public consciousness providing the explicit or implicit attitude of the social community to the phenomena, events and facts of social life, reflecting the certain community-based position concerning the issues of the particular interest. Before the NPP planning and construction, it is necessary to assess the socio-political situation in the corresponding region, since the negative project perception by the society can cause negative effect on the project execution time, which ultimately adversely affects its economic efficiency in general [5].

The public acceptance of the NPP construction abroad can be characterized by the recognition of the economic and environmental advantages of the nuclear megaproject by the population of the foreign state, regardless of the possible risks. Such recognition is based on the knowledge of nuclear technologies and specialists' credibility implementing the megaproject [6].

The successful project implementation in any country means the provision of the public acceptance for the use of nuclear technologies. Thus, there is produced the strategy for working with public opinion as one of the key factors for successful implementation of nuclear projects. The public opinion can be determined with the help of the information and semantic field of the megaproject, i.e. its tonality [7]. Measures for increasing the public acceptance of nuclear technologies should be considered as one of the loyalty program directions aimed at the reduction of the information security risks. There are planned and implemented loyalty programs for the change of public opinion that are designed for the targeted impact on the society as a whole or restricted audience.

The first step of the market analysis is the segmentation for the determination of future option influencing the audience with the greater efficiency. One of the options for the nuclear energy market segmentation is the segmentation according to the behavioral principle, i.e. the market division into groups of consumers according to their knowledge level of the nuclear industry, consumer attitude to it and benefits for consumers (Fig.1).

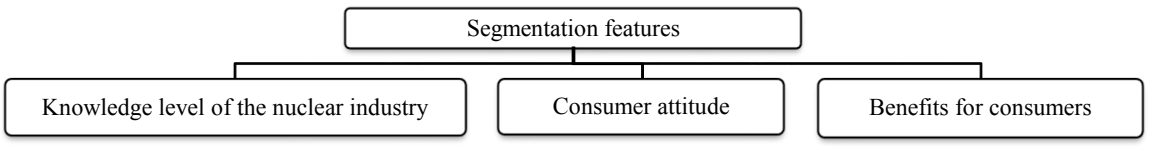

Fig. 1. Segmentation according to the behavioral principle

The NPP construction project is a megaproject affecting the interests of the great number of individuals and companies in general, both with the positive and negative positions concerning the project concept. In order to get the initial understanding of the situation in the country, predict the possible scenarios and develop the preventive actions, it is necessary to implement the assessment at the society level as a whole.

2. Assessment at the society level

2.1. Knowledge level of the nuclear industry

The first criterion according to which the segmentation can be implemented is the knowledge level of the nuclear industry.

In order to obtain the comprehensive assessment on this criterion, there can be used the indicators of knowledge indices. Such indicators include [8]:

- The Knowledge Economy Index;
- The Knowledge Index (KEI and KI Indexes, 2012; KAM, 2012)

They assess the country as a whole. The Knowledge Index is the average value of three sub-indices: the education index, the innovation index and the index of information technologies and communications [9].

In addition to the indicators of the Knowledge Index, the Knowledge Economy Index also includes the economic and institutional regime index.

The Knowledge Index reflects the country potential in the sphere of knowledge development, while the Knowledge Economy Index states whether the macroeconomic environment created in the country contributes to the effective use of knowledge for the economic development.

Three innovation indicators of the Knowledge Index and the Knowledge Economy Index can be presented in two versions – in absolute values or population-weighted indicators. As the volume of resources is the crucial factor for the innovative development, then the use of only population-weighted indicators can lead to the underestimation of the development potential of such countries as India and China.

2.2. Consumer attitude

Consumer attitude can be described with the help of the ISMI rating (Integrum Social Media Influence). The ISMI rating (Integrum Social Media Influence) is the recommendatory rating allowing assessing the object image (company, person) and the dynamics of its change on social networks [10].

According to the results of corresponding calculations, we get the score from 1 to 10. The resulting value can indicate the following:

- 1-2 – immediate attention to the image improvement,
- 3-4 – the image should be adjusted,
- 5-6 – the image does not require any adjustments,
- 7-8 – the object shows a good image on social networks,
- 9-10 – the object shows an excellent image on social networks.

This indicator uses the information specified on social networks, i.e. it takes into account:

- the average number of messages concerning the object over a long time period;
- the total number of messages concerning the object for the considered period;
- the messages from unreliable accounts (bots) for the considered period;
- the messages from top bloggers, large communities and opinion leaders for the considered period;
- the ratio of positive and negative messages for the considered period.

The final rating includes four values according to the ten-point scale and the following parameters (values do not equally affect the formation of the final rating; they are listed according to the priorities from the most influential rating to the least influential one):

- the presence / absence of messages from top bloggers, large communities and opinion leaders for the considered period (if top bloggers speak up, the rating becomes higher, if they do not speak up, it does not affect the rating as the absence of messages is a common case); the emotional coloring of messages from the top bloggers is also taken into account;
- the ratio of positive and negative messages for the considered period (the more positive messages you get, the higher score is).
- the increase / decrease in the number of messages for the considered period in comparison with the average indicator over a long time period (the more messages you get, the higher score is);
- the presence / absence of bots for the considered period (the fewer bots are, the higher score is).

The ISMI value for a particular object (from 1 to 10) is taken into account during the ranking and corresponds to the number of points (1:1) added to the points according to other parameters.

We can say that the image formation according to such index will describe the attitude of only certain society segment, as a rule, these are young people who are rather active on social networks.

In order to get more comprehensive public opinion assessment it is necessary to combine this research type with other forms, for example, sociological surveys, analysis of thematic forums and sites, depending on the peculiarities of the considered country and the dissemination of information technologies there.

2.3. Benefits for consumers

The third segmentation criterion is benefits for consumers. The benefit can be considered in terms of three key aspects:

- economic efficiency;
- social efficiency;
- environmental efficiency.

The economic efficiency can be estimated as the predictable increase in Gross Domestic Product (GDP) per capita, as the long-term growth trend of real GDP indicates the presence of economic growth in the country and the increase of real income of the population. In addition, the functioning NPP is the sustainable long-term energy source making it possible to increase the availability and to reduce the cost of electricity for the population and enterprises.

In terms of social benefits, there should be considered the benefits obtained by society as the result of successful project implementation. Such advantages can include the infrastructure and education development, the expansion of electrical network geography and the employment creation. In addition to the employment creation due to the increase of electricity availability, there is observed the employment creation due to the NPP launch and operation. Thus, according to the researches of the Nuclear Energy Agency (NEA) under the Organization for Economic Cooperation and Development (OECD) and the International Atomic Energy Agency (IAEA), each new gigawatt of the nuclear generating capacity (standard nuclear power unit capacity) provides about 200 thousand created jobs [11], including the employees involved in the construction and operation of the new power-generating unit, as well as the indirect involvement of labor resources throughout the chain of related enterprises involved in the construction of nuclear power plants.

The environmental efficiency can lie in obtention of cleaner electricity [12], in reduction of adverse impact on the environment in comparison with other methods of electricity generation.

3. Assessment on the basis of target group analysis

As soon as we obtain the holistic picture of the attitude assessment to the NPP construction at the society level, the next step is the more detailed study of the population attitude to the megaproject implementation.

The first stage of data processing is the primary contingent grouping (audience). The analysis and systematization of key people characteristics are required for the implementation of any project, as the success and speed of the project implementation can depend on these indicators. In this regard, the contingent can be divided into groups according to the differences in perception and attitude to the project.

The number of groups depends on the specific task and characteristics of the audience concerned. According to the preliminary analysis of the considered thematic area, the contingent can be divided into five key groups:

- Group 1. Positive-minded. People from this group not only support the project, but can also attract others due to their open, positive position. A part of the society waiting for valuable benefits in the result of the NPP construction (employment creation, demand for goods and services of local businesses, infrastructure renewal, cheaper electricity, etc.)
- Group 2. Neutral. Such people understand the project advantages, and are not its opponents. They do not actively express their position.
- Group 3. Under-informed. Such group denies all new technologies, as they do not possess any information and knowledge of the project benefits, potential and long-term prospects.
- Group 4. Negative-minded. They do not support the idea of the NPP construction. Do not take any actions. They deny the necessity for the project implementation, since there are examples of unsuccessful projects and resonant incidents and accidents associated with the similar projects.
- Group 5. Complete negation. Such people are project opponents. They express the active protest against its construction. They make the emphasis on the likely implementation of all possible adverse events related to the project concept.

During the next step, it is required to specify the criteria influencing the respondent distribution into the particular group. The present project can include the following three key criteria (segmentation features) with the corresponding characteristics:

- Knowledge level of the nuclear industry:
    - Uninformed.
    - Informed.
    - Interested.
    - Competent.
- Consumer attitude
    - Positive.
    - Negative.
    - Neutral.
- Benefits for consumers
    - Economic effect.
    - Social effect.
    - Environmental effect.

In order to identify to which group the respondent can belong; he undergoes the psychological testing, while the questions are formulated so that the person indirectly creates the picture of his characteristics with the help of his answers.

The influence of the values of these criteria on the distribution of the respondent into the certain group can be described by the set of rules of the fuzzy knowledge base. The rules are formulated by the group of experts working in the region with the analysis of the society attitude, and explain the logical conclusion concerning the belonging of the respondent to the certain group, depending on the assessment of the considered criteria. The rules use the logical

functions AND and OR. The logical function AND means the logical multiplication, while OR – addition [13]. The rule construction represents the implication, the message is specified on the left, while the conclusion – on the right. In Russian, it corresponds to the structure IF ... THEN.

In order to predict to which target group the respondents belong, there are created the following rules:

- IF consumer's attitude is positive AND is awaited (positive Economic effect OR positive Social effect OR positive Environmental effect), THEN the respondent belongs to Group 1. Positive-minded.
- IF consumer's attitude is neutral AND is awaited (positive OR close to zero Economic effect AND positive OR close to zero Social effect AND positive OR close to zero Environmental effect), THEN the respondent belongs to Group 2. Neutral.
- IF the knowledge level of the nuclear industry is uninformed AND consumer's attitude is neutral AND is awaited (negative Economic effect OR negative Social effect OR negative Environmental effect), THEN the respondent belongs to Group 3. Under-informed.
- IF the knowledge level of the nuclear industry is Informed OR interested AND consumer's attitude is negative AND is awaited (negative Economic effect OR negative Social effect OR negative Environmental effect), THEN the respondent belongs to Group 4. Negative-minded
- IF the knowledge level of the nuclear industry is (competent OR interested) AND consumer's attitude is negative AND is awaited (negative Economic effect AND negative Social effect AND negative Environmental effect), THEN the respondent belongs to Group 5. Complete negation.

After the determination of the rules based on the expert judgments, there are created the membership functions for the criteria depending on the degree of expert confidence that the output linguistic variable has the specific value. The example of such functions is shown in Figure 2.

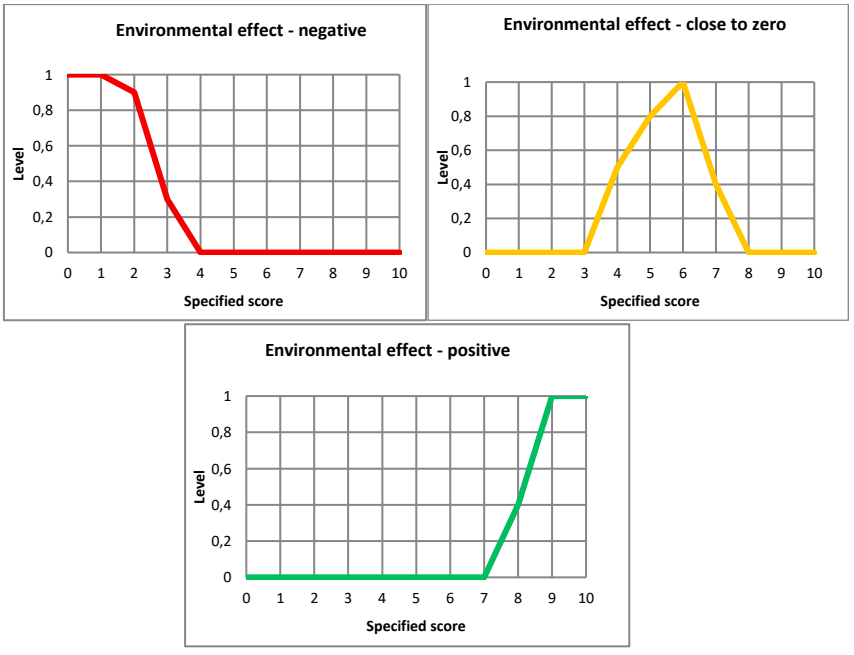

Fig. 2. Example of membership graphs to the criterion Environmental effect

Further, during the stage of fuzzification, there are made the graphs with the line designations reflecting the certain values. For each of the graphs there is calculated the coordinate along the y-axis for the interception point of the curve and the line corresponding to the estimated data. This ordinate shows the confidence degree of the expert that the

output linguistic variable has the specific value. Then these values will be used for the graphical display of the rules.

The next step is the fuzzy inference stage. According to the set of rules of the fuzzy knowledge base, there is calculated the truth-value of each rule based on the certain fuzzy operations corresponding to the conjunction or disjunction of term values on the left part of the rules [14]. In the majority of cases, it is either the maximum or the minimum value of the confidence degree of term values calculated during the stage of fuzzification. With the help of the fuzzy implication method, we get the fuzzy variable corresponding to the calculated value of the confidence degree on the left part of the rule and the fuzzy set on the right part of the rule.

The implication results can be observed after making the graphs. According to the analysis of obtained results, we determine the group, to which the respondent will be assigned. The schedule is selected according to the type group and the corresponding rules are applied.

The truncated summary graphs are united on X-Y axis according to all specified rules. Thus, we get the single combined graph. This stage is the next step of the fuzzy inference algorithm and follows the procedure of graphs making according to the corresponding rules. During this step, all fuzzy sets assigned to each term value of each output linguistic variable are united together, and there is formed the single fuzzy set – the value for each output linguistic variable.

The formation of the single fuzzy set occurs by plotting the upper envelope.

As soon as we get the summary graph, we can proceed to the last step – defuzzification. In order to do this, we should find the graph center of gravity:

$$a = \frac{\sum_{i=1}^{n} x_i \cdot \mu_A(x_i)}{\sum_{i=1}^{n} \mu_A(x_i)} \quad (1)$$

where x_i – value at the x-axis, a $\mu_A(x_i)$ – corresponding value at the y-axis.

For each respondent, we calculate a. Then, we can calculate the average $\bar{a} = \frac{\sum_{j=1}^{m} a_j}{m}$. The average $\bar{a}$ shows the loyalty level in the society during the certain timepoint. The following scale can be used for the score interpretation.

Table 1. Interpretation scale of the loyalty level score

Obtained score	Interpretation
From 0 to 2	Extremely negative environment for project implementation. Remote possibility of influence of any loyalty program on the existing public opinion.
From 3 to 4	Generally negative-minded environment for project implementation. It requires the large-scale loyalty program in order to actively inform the society on the positive prospects of project implementation and targeted information sharing.
From 5 to 6	Overall positive environment for project implementation. It requires the strengthen information sharing on the positive prospects of the project. It requires the targeted impact.
From 7 to 8	The society is positive-minded. It requires the targeted interaction with the certain groups of the population and the supporting loyalty program.
From 9 to 10	Active expectation of the benefits by the society after project implementation. It requires the loyalty program supporting the current situation and enhancing the positive attitude to the project implementation prospects.

Thus, after the analysis, we will get the integral assessment showing the society attitude as a whole, as well as the proportional composition of population groups on the basis of which we can make the directed recommendations for the loyalty program formation (Figure 3).

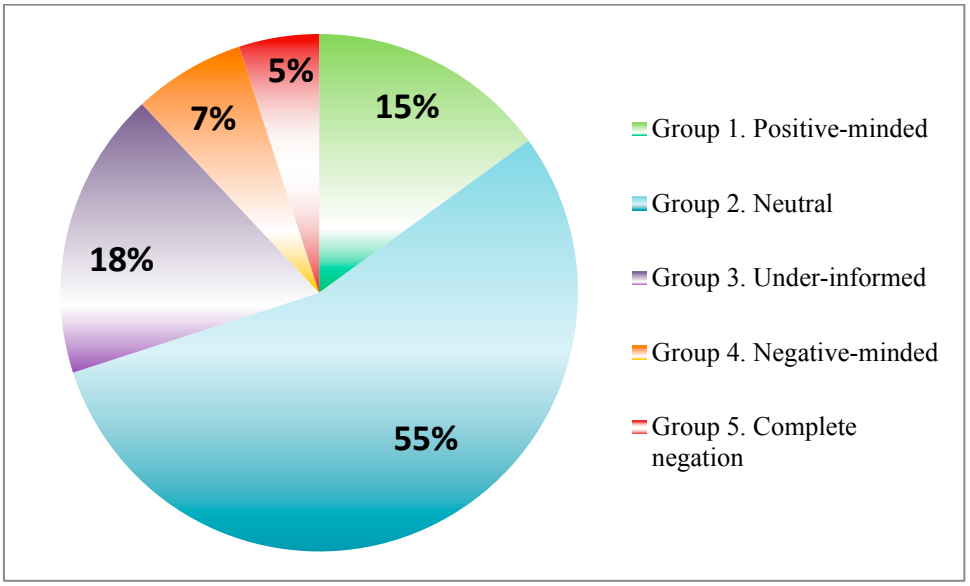

Fig. 3. Share distribution of the society by population groups

The interpretation of results can also be implemented from the standpoint of calculation of the Net Promoter Score (NPS), the metric determining the attitude of consumers to the company [15]. Such score is widely used by commercial companies for the assessment of growth prospects. The key formula of the NPS assessment is:

$$\text{NPS} = \%\ \text{supporters} - \%\ \text{opponents} \quad (2)$$

Thus, according to the information on the division into groups with the help of the provided method, we can get the assessment using the NPS. In order to apply the NPS, it is necessary to implement the ratio of groups of respondents suggested in the framework of the considered concept and the group used for the NPS assessment. The respondents of Groups 1 and 2 can be classified as "supporters", as they generally expect the positive effect from the project implementation, Group 3 as "neutrals", and Groups 4 and 5 as "opponents". Using the data shown in Figure 3, we can calculate the NPS:

$$\text{NPS} = \%\ \text{supporters} - \%\ \text{opponents} = (15\ \% + 55\%) - (5\% + 7\%) = 58\%$$

According to the loyalty program model, at each stage of the life cycle of the NPP construction megaproject abroad, the indicator $NPS \geq 50\%$ is the target value of the loyalty program [16].

This model is based on the integrated approach considering the development of loyalty program activities at various stages of the life cycle, as the system:

$L(Fi) = < M, B, R, Zl >$, where

$F = \{F1, F2, \ldots F7\}$ – stages of the megaproject life cycle,

$M = \{M1, M2, \ldots, Mn\}$ – set of loyalty program activities,

$B = \{B1, B2, \ldots, Bm\}$ – set of risks,

$R = \{R1, R2, \ldots, Rk\}$ – ratio of risks and loyalty program activities, both cognitive at the level of concepts and functional,

Zl– target system (including economic efficiency maximization).

In particular, the indicator $NPS \geq 50\%$ is one of the target values of the hierarchical system of objectives of the loyalty program. Within the framework of this model, there are three key objectives: Z1 – safety, Z2 – economic efficiency, Z3 – public acceptance. All three objectives are interdependent. The public acceptance largely depends on

the public awareness of the previously implemented similar projects, their consequences, real and potential risks, as well as the economic effect after the project implementation On the other hand, there should be noted the presence of the oppositely directed dependence. Thus, in case of low public acceptance, the project implementation period can be artificially delayed, and it directly affects the project economic efficiency. Thus, the specified objectives (Z1, Z2, Z3) should be considered as the inseparable system of interconnections and interdependencies, while the loyalty program activities, directly or indirectly, with different strengths will provide the corresponding impact on all specified objectives.

For the creation of more positive public attitude, there can be performed the key activities aimed at loyalty level increase. Such activities, to one degree or another, will affect the groups of people specified in the present paper, segmented according to the behavioral principle (Table 2). The loyalty program activities include the following procedures:

- development of new professions (DNP);
- development of new economy sectors (DNES);
- boosting employment of population (BEP);
- education development (ED);
- development of new technologies (DNT);
- achievement of the other quality of life in the region (AOQLR);
- seminars, the round table, etc. (SRT);
- forums of wide profile (F);
- information tours (IT);
- constant activity of information centers (IC).

Table 2. Correlation between the society segmentation indicators and the key activities of the loyalty program, if possible

		Segmentation indicator				
		Knowledge level of the nuclear industry	Consumer attitude	Benefits for consumers		
				Economic effect	Social effect	Environmental effect
Activities	DNP			direct		
	DNES			direct		
	BEP			direct		
	ED			direct	direct	
	DNT			direct		indirect
	AOQLR			direct	direct	
	SRT	direct	direct	indirect	indirect	indirect
	F	direct	direct	indirect	indirect	indirect
	IT	direct	direct	indirect	indirect	indirect
	IC	direct	direct	indirect	indirect	indirect

According to the table above, some of the activities can provide direct effect on one or another indicator, while the other part of activities provides indirect effect, due to the influence on another indicator.

At the same time it should be taken into account that the effect should be provided in the strictly specified direction, i.e. the shift in terms of the indicator “knowledge level of the nuclear industry” should occur from uninformed to competent, the shift of consumer attitude from negative to positive, the benefits for consumers regardless of the type (economic, social, environmental) of expected effect should lead to neutralization of the expected negative effect and / or the appearance of the expected positive effect.

The loyalty program effectiveness can be assessed only in dynamics, thus, it is necessary to periodically monitor the attitude of the indicative group of respondents as well as assess the degree and direction of changes of public opinion.

Thus, after some period of the loyalty program implementation, the indicator $\bar{a}$ can be recalculated and, according to the comparison of indicators for different periods, it becomes possible to assess the effectiveness of the implemented loyalty program.

Let us introduce the concept of the change rate of the fuzzy loyalty level assessment τ (%).

$$\tau = \frac{\overline{a_t} - \overline{a_{t-1}}}{\overline{a_t}} \tag{3}$$

The rate indicates the difference in public attitude before and after the launch of the loyalty program. It should be taken into account that the certain threshold values of the rate in any case depend on the initial society attitude. The less loyal it was initially, the higher its rate could be. At the same time, if society is already loyal on launch of the loyalty program, then it will be much more difficult to increase the loyalty level. Therefore, it is recommended to specify the set of threshold values, at which the program application is considered effective:

$$\begin{cases} \tau > l_1 & -for\ the\ society\ with\ initial\ loyalty\ level\ \ L_1^0 \\ \tau > l_2 & -for\ the\ society\ with\ initial\ loyalty\ level\ \ L_2^0 \\ & \dots \\ \tau > l_{10} & -for\ the\ society\ with\ initial\ loyalty\ level\ \ L_{10}^0 \end{cases} \quad (4)$$

In addition, for the comprehensive assessment of program effectiveness, it is necessary to take into account the loyalty program operating period, financial expenses and effect duration.

4. Summary

The suggested approach will make it possible to carry out the additional analysis at different stages of the megaproject implementation on the NPP construction, including at the stage of loyalty program preparation, as well as to assess the current effect of its implementation. The conclusions obtained due to the approach application will improve the efficiency of operational management.

The grouping of representative sample of respondents will make it possible to take the targeted measures concerning the society loyalty increase, taking into account the attitude of different typical population groups to the project. The accumulation of the sufficient amount of statistical data will make it possible to form recommendations concerning the loyalty program effectiveness, the project positioning and the choice of program activities.

The suggested approach can be used during project implementation in another scope of activity, but with the adaptation of rules and criteria according to the certain specifics.

Acknowledgements

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