

## The Development of a New Approach to the Energy Management System Formation and the Estimation of Its Efficiency on the Basis of the Consumer Quality Theory

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**Abstract**—The energy management system, that is used in enterprises of different countries of the world, is directed to solve such tasks as to increase the energy efficiency of output and production processes, to economize energy resources in general economic activities of an enterprise. As it was stated in the process of studying of a wide range of international publications, the majority of these tasks relate to the level of operative tasks of an enterprise. However, the solution of strategic tasks in the energy management system is often limited by the development of perspective energy saving plans, which in their turn are partly or even not connected with the plans of strategic development of an enterprise. In the current research we offer the mechanism of formation of connection between the activity planning in energy management system and the strategic development of an enterprise. Such methods as Voice of Customer and House of Quality are offered to realize this mechanism. It should be noted that the given mechanism can be used most efficiently in the enterprises which seek the mutual increase of energy efficiency of the production and the energy efficiency of the final output. The mechanism that is suggested in the given research will promote the integration of aims and goals of the energy management system into the system of strategic management of an enterprise activity. The novelty of this approach lies, firstly, in the identification of a possibility to apply the instruments of the theory of productive quality (Voice of Customer and House of Quality) to solve a range of tasks that are not typical for these instruments, secondly, in the application of strategy-oriented approach to solve the tasks concerning the management of energy resources of an enterprise.

### I. INTRODUCTION

Studying the practices of domestic enterprises implementing the 50001 standard the author established the following tendency: at the expiration of a short period of time after the energy management system has been introduced, its efficiency decreases gradually [4]. As a rule, the dynamics of energy efficiency of an enterprise shows this tendency quite clearly. In the course of time in the process of energy efficiency indicators analysis, the less dynamics of their change is determined and accordingly the less clear economic effect gained from energy management system functioning is revealed. It takes place even in the case of full adequacy to the requirements of ISO 50001:2011 “Energy management system – requirements with the application guide” and the continuous improvement of management of enterprise activity efficiency, as suggested in the standard.

Thus, it can be noted that ISO 50001 standard is, undoubtedly, a rather convenient instrument for energy management system maintenance in the enterprise, but it is not an instrument for its development. According to the theory of life cycles, if we concentrate all our attention on the

stage of maintenance without taking any actions directed on the system development, it will lead to the end of life cycle in any case [11,15].

As we know, each life cycle can be divided into two stages: the stage of development and the stage of maintenance. Examining the life cycle of energy management system, it can be noted that on the stage of development we spend money on the system design and its implementation in the company. On the stage of maintenance one can see the natural process of the return of funds that have been invested before. Gradually the economic effect of the system implementation becomes less and in some time it can either finish or be rather insignificant. From the author’s point of view, the fixed tendency for the decrease of energy efficiency in the activity of an enterprise can be overcome.

For this purpose we suggest broadening the borders of the tasks solved in the energy management system from clearly operative to strategic ones with the further integration of the energy management system into the system of strategic management of an enterprise activity. It should be noted that one of the most important conditions of the increase in the efficiency of the companies activity and their competitive ability is the compiling of the consumer wants into the productive characteristics of a product. [1,2,5,8,9]. Investing in the increase of productive quality we can raise our competitive ability, if thereby we raise the utility of the goods for a consumer, or even worsen it if our investments have not lived up to the consumer’s expectations. It is the basis of the theory of productive quality which we would like to apply to solve the goals of the research, stated above. It should be noted that the attempts to adapt the theory of consumer quality in the countries of the West and the USA in the 80s did not develop broadly, as its strategy and instruments were not studied enough. Such instrument as QFD is still not well-known in the circle of modern western top-managers, and even less known by the Russians. Nevertheless, Xerox, Ford Motors, Mitsubishi, Toyota are among the companies that broadly use the QFD strategy in their activity. Hoshin Kanri strategy was worked out while the “management by aims” system was developed. AT&T, Xerox, Exxon Chemical, Florida Light & Power, Hewlett Packard can be mentioned here as the companies that apply Hoshin Kanri strategy successfully [16]. The examination of methodical approaches and the instruments of the theory of consumer quality made it possible to suggest that with their help the characteristics of energy efficiency, that are not obvious for the producer but are rather significant for the consumer, can be revealed. In this case the notion of energy efficiency of the activity will be understood broader. When it is estimated, the use of standard

indicators of energy efficiency, including power intensity of the production, specific consumption of separate kinds of energy resources against the volume of output, etc., will not be enough. It should be noted that when standard indicators are formed, as a rule, the specifics of the enterprise activity, the character of utilized energy resources, the size of the enterprise and other factors, that relate to the factors of the internal environment of an enterprise, are taken into consideration. In some degree, the indirect influence of the factors of the external environment like the energy resources suppliers can be reflected in these indicators. However, the influence of the consumers can be followed only through the dynamics of their demand and the indicators of the volume of output. Thus, in the author's opinion, the consumer quality theory application predetermines the necessity of the changes in the standard approach to the formation of the key indicators for the estimation of energy efficiency in the enterprise activity.

## II. RESEARCH METHODOLOGY

For the experiment we used such instruments of the theory of productive quality as the Voice of the Customer and the House of Quality diagram.

The Voice of the Customer technique is a hierarchical, full (necessary and sufficient) set of needs, explained by the consumer's language and measured at the scale of consumer's valuables.

We also used the main QFD diagram, known as House of Quality, the goal of which is the transformation of the consumer wants into the measurable technological characteristics of a product. It is a method of illustration, which resembles a house and is widely used in manufacturing industry. HoQ originally appeared in 1972 and is a significant part of Quality Function Deployment (QFD).

The necessity to apply the instruments of strategic planning and the energy efficiency strategy development is one of the most important conditions of the functioning of energy management system on the basis of the consumer quality theory. It will allow to go beyond the scope of the operational activity, which restricts us to the stage of the system maintenance.

## III. THE FORMATION OF CONDITIONS FOR REALIZATION OF THE NEW APPROACH TO THE ENERGY MANAGEMENT SYSTEM

According to the ISO 50001 standard, the energy management system functioning in the enterprise should be carried out in accordance with the PDCA cycle [7]. In this case, the existing problems are analysed on the stage of planning and the activities aimed at their solving are determined. On the stage of adoption the decisions, made at the previous stage, are realized. On the stage of control the level of the solutions of the problems, that have been determined before, is estimated. On the last stage the process

is corrected and improved in accordance with those activities that have given the necessary result. The first stage of the cycle is the most creative and at the same time the most difficult for its practical application. Firstly, the arrangement of the energy management system itself, the formulation of the system requirements, the aims and goals, which are worked out within the system, depends on it. Secondly, the system functioning inside the enterprise, the information flow movement, the responsibility assignment also depends on it. That is why the changes in the existing approach to the energy management system formation and the evaluation of the effectiveness of the system operation on the basis of the theory of consumer quality must be arranged on the first stage of the cycle. From the author's point of view, a range of attendant conditions are necessary for its successful realization. Firstly, the proper understanding of the exceptional importance of overcoming of stereotypes in the energy management system working only within its operation is quite necessary. It means that the instruments of strategic planning should be applied for the system functioning. Secondly, the methodical support that makes possible to realize the author's ideas covering the formation of the energy management system on the basis of the theory of consumer quality is necessary.

## IV. THE ENERGY EFFICIENCY STRATEGY FORMATION.

One of the key goals on the stage of planning of energy management system is the enterprise energy efficiency strategy formation. This document allows to order the activities concerning the management of enterprise energy costs in the future.

It is clear that the main aims and goals of the energy efficiency strategy must be coordinated with the development strategy of an enterprise as a whole [12]. It raises the significance of the energy efficiency strategy, the degree of its influence on the general development strategy of an enterprise and its performance control, as the evaluation of the fulfillment of separate indicators of the general strategy of an enterprise must be realized through the indicators of the energy efficiency strategy fulfillment. Not only the internal interests of the company but also the interests of its stakeholders [6] and particularly the interests of the consumers being very important from the position of the consumer quality theory should be taken into account in the energy efficiency strategy (Fig.1). However, it should be noted that when the strategy is formulated for the first time, a number of difficulties connected with the responsiveness to the interests of consumers can arise. It can be made after the implementation of the Voice of the Customer technique [13], allowing to establish the energy efficiency characteristics that are not clear for the producer on the further stages of the activities. Such instruments of strategic planning as strategic session and foresight can be applied in the process of the strategy stating [10,14].

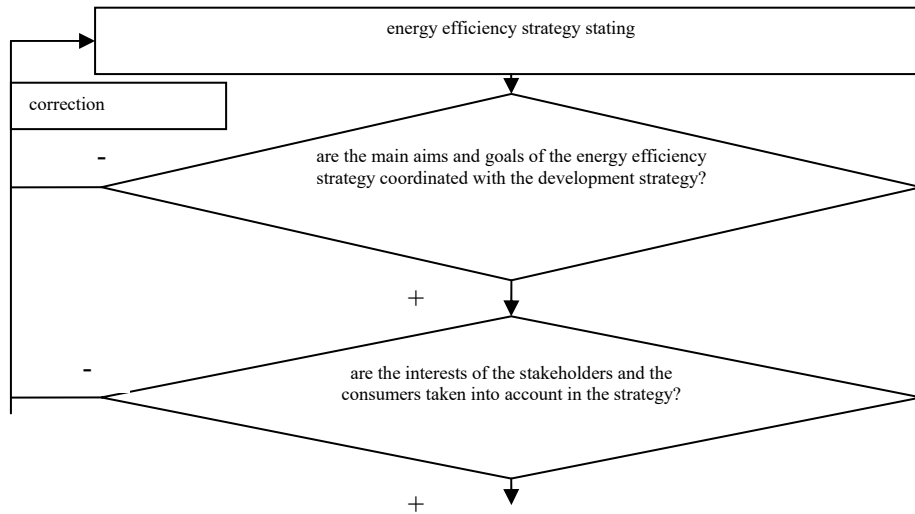


Figure 1. Verification of the interconnection of energy efficiency strategy goals and internal goals of an enterprise.

For the adjustment of energy efficiency strategy and the strategy of enterprise development as a whole, we suggest using the House of Quality diagram. Fig.2 presents an example of using this diagram to solve the goal of the inspection of the compliance of aims and goals of energy efficiency strategy with the aims and goals of the general strategy of the company development taking one of the chemical enterprises of Kazan JSC "KazanOrgSyntez" as an example.

The main aims (goals) of the company in the accordance with its development strategy have been enumerated in box 1. In box 2 for each aim (goal) of the development strategy of a company its contribution to the realization of the given strategy has been specified. The goals of the energy strategy of an enterprise have been enumerated in box 3. Box 4 is completed to eliminate the multicollinear dependence of the goals of energy strategy of an enterprise. Relational matrix composes the central part of House of Quality diagram in box 4, which determines the degree of influence of goals, enumerated in box 3, on the goals, enumerated in box 1. When the influence is weak, it is given the value 3; when it is medium, the value is 6 and when the influence is strong, it is valued as 9. The sum of the multiplication of the ratings, taken from box 2, by the degrees of influence, taken from box 5, are put in box 6. The completion of the House of Quality diagram resulted in stating that the realization of the goal of 3% decrease of energy consumption of the production promotes the achievement of the goals of enterprise development.

It should be pointed out that among the limitations for the utilization of House of Quality diagram on practice is the correct selection of aims and goals of the enterprise development strategy, put in quadrant 1. Thus, they should not too general (as, for example, the company profitability increase), so, not all the goals, presented in quadrant 3, should be suitable for their achievement. Also, it should be

taken into account that the quantity of goals of energy efficiency strategy should exceed or correspond to the quantity of goals of enterprise development strategy.

One of the key goals in the formation of energy efficiency strategy is the development of its key indicators, with the help of which one could further measure the degree of strategy realization. For this purpose, we offer to fulfill a sequence of activities, presented on fig.3 . Inner problems of an enterprise can be measured with the help of the method of the energy – economic analysis of the activity of an enterprise, suggested by the author [3].

By the results of this analysis the enterprise will get the opportunity to determine a range of problems existing in the sphere of energy efficiency and form the energy efficiency indicators. However, only the factors of the internal environment of an enterprise are taken into consideration in these indicators. Thus it can be stated that with the help of the developed algorithm of the energy–economic analysis only a part of energy efficiency indicators can be received.

Within the approach to the formation of key indicators for the energy efficiency evaluation for the activity of the company, suggested by the author, the influence of the consumers of the enterprise production should be taken into account. In this case it is most reasonable to apply The Voice of the Customer technique. The realization of this technique requires the fulfillment of the following sequence of activities:

- organization of the information about the existing consumer needs (by polls, context interviews, prototype testing, etc.);
- data processing;
- affine structuring of the material, within which the revealed needs are placed in a logical hierarchy, as approximate as possible to the one, existing in the consumer’s mind;
- scaling and prioritization of needs.

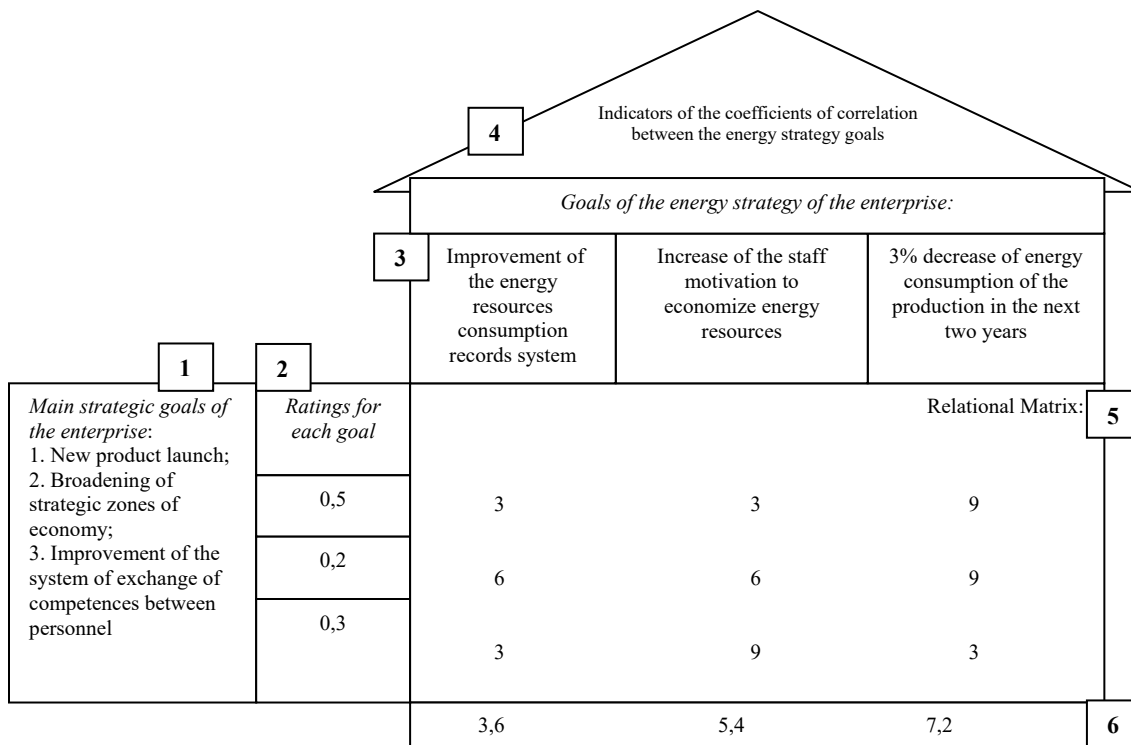


Figure 2. Application of the House of Quality diagram on the data of the enterprise "JSC "KazanOrgSyntez"

As a rule, the given technique is applied for the evaluation of the quality of new output or new modifications of existing goods. We suggest applying this technique for the evaluation of one of the constituent elements of the output quality – its energy efficiency.

It should be pointed out that the limitation of the Voice of the Customer technique is the types of the enterprise activity. Thus, it can be applied for enterprises, producing goods, the energy efficiency of which is important for a customer. This list can include enterprises, related to machinery-producing industry, the production of household appliances, instruments, electronics, toys, etc.

Thus, on the stage of energy management system planning the author suggests the application of two techniques: the technique of energy-economic analysis of the activity of an enterprise, allowing to determine the internal problems of the enterprise connected with its energy efficiency, and Voice of the Customer technique, allowing to establish the energy efficiency characteristics that are not clear for the producer.

The examination of the information that has been received due to the application of these techniques, its systematization and the determination of the most significant spheres, with the regard of which further decisions will be made, will be implemented by the use of the appropriate instruments.

The results of the energy-economic analysis of the activity of an enterprise can be processed further with the help of a range of instruments, including histogram making, Pareto-analysis, Ishikawa diagram making, etc. Under these conditions the choice of an instrument depends on the result that is needed. If a simple visualization of the frequency of a characteristics emergence along the axis of its values is needed, a histogram is made. If it is necessary to set the main problem, the elimination of which will make it possible to achieve the significant improvement in the results of the activity, Pareto – diagram is chosen. The expert structured scheme, visualizing the impact of the supposed reasons on the result under study, results from the use of Ishikawa diagram.

The results of the research conducted with the help of Voice of the Customer technique are further processed with the help of the main QFD diagram, known as House of Quality.

The House of Quality diagram can also help to check the validity of choice of energy efficiency indicators by defining their ability to reflect the degree of the achievement of aims and goals of the energy efficiency strategy. As a result of the analysis, firstly, the degree of the sufficiency of proposed energy efficiency indicators and, secondly, their ability to reflect the degree of achievement of aims and goals of energy efficiency strategy can be stated.

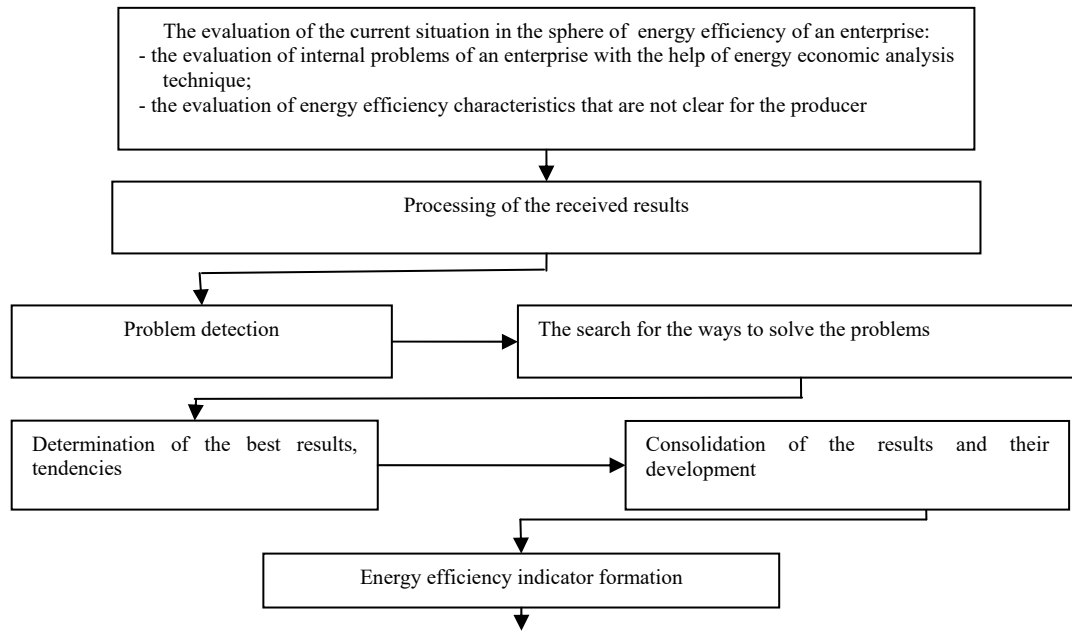


Figure 3. Formation of key indicators of energy efficiency strategy

The evaluation of the strategy fulfillment and its correction takes place on the third stage. It is the most important stage in the formation of the energy management system on the basis of the consumer quality theory, as on this very stage there is a possibility to formulate the energy efficiency strategy, allowing to take mutual requirements into consideration in full. The author suggests using QFD technique for the strategy correction. The process of the strategy correction is the following sequence of actions:

1. Inspection of the compliance of aims and goals of energy efficiency strategy with the aims and goals of the general strategy of the company development;
2. Inspection of the validity of choice of energy efficiency indicators by the determination of their ability to reflect the degree of the achievement of aims and goals of energy efficiency strategy.

Each of the actions, mentioned above, will be realized on the basis of making and analysing the House of Quality diagram. Therefore, although the existing House of Quality diagram has been used for more than 40 years, it still needs to be improved in a large data era.

## V. CONCLUSION

The instruments, examined in the given research, can be successfully used in the enterprise activity in the process of formation of its energy efficiency strategy and management of energy resources of an enterprise.

The novelty of the research lies in verification of the possibility of QFD instruments utilization to solve the goals, different from production development goals. It also involves

the application of strategy - oriented approach for management of energy resources of an enterprise.

The further development of the research will consist of practical approbation of QFD instruments in a number of largest enterprises of the Republic of Tatarstan, one of the leading regions of Russia.

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