ECONOMIC AND MATHEMATICAL MODELING OF THE QUALITY MANAGEMENT SYSTEM AT MUNICIPAL ENTERPRISES

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ABSTRACT

The article offers an optimization model for building a quality management system at municipal enterprises.

Keywords: Economical and Mathematical Modeling, Economic and Mathematical Model, Quality Management System, Municipal Economy, Optimization Model of Forming A Quality Management System.


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1. INTRODUCTION
Each local government body has its own management system regulated by legislative and regulatory documents, and guiding local legislative and executive bodies. Many of them adopt strategic plans for economic and social development and various programs for certain periods. They establish priority areas of the city's economic development, goals to be achieved, and tasks to be accomplished. The implementation of these plans requires financial resources, qualified personnel, and the will of senior management.

Production and services are inseparable in the field of utilities in the municipal economy, and are usually provided by one enterprise. This organizational, technological and economic uniqueness of the multidisciplinary integrity on satisfying the needs of the entire city agglomeration requires a regular review of all structural functions of the municipal economy on the scale of the city territory, municipal economy, general territorial process of the population subsistence, industry, and budget organizations.

The population today requires municipal enterprises to be managed on the basis of the systematic approach to the provision of utilities. Management based on the method of the process and systemic approaches, taking into account the trends of broad implementation of organizational and project solutions, allows to introduce transformations in the territorial development.

The introduction of a quality management system (QMS) based on international standards ensures the identification of approaches to building the QMS for municipal enterprises taking into account the specifics of legislation, economics and social traditions. Due to advances in science, practitioners can take into account rapid changes in the economic and political life, which set new demands to the activities of municipal enterprises.

METHODOLOGICAL ASPECTS OF BUILDING THE QMS AT MUNICIPAL ENTERPRISES
As the socioeconomic nature of the municipal economy develops and its role in the subsistence of the city and its population increases, views on the municipal economy are transformed as an object of research from the standpoint of the method of realizing the “quality” category.

The main elements ensuring the integrity of quality management at all stages of the life cycle will have specific features for the municipal economy. For example, the services of municipal enterprises do not need to use marketing technologies for selling products (services). However, they become relevant and necessary at the stage of billing the population for services of municipal enterprises, in order to increase their level.

Successful and efficient operation of municipal enterprises in the market conditions is impossible without increasing the efficiency and quality of their services, i.e. without the successful QMS operation. The tasks are achieved through:
– constant improvement of the QMS;
– building and using a package of information materials about the requirements of consumers, the study of the market demand;
– cooperation with suppliers of quality products; and
– creating friendly environment for high-performance work, identifying personal abilities and initiatives of each employee.

The main advantages of the QMS introduction are that it allows to enhance the level of management to achieve transparency and publicity in operation.
For the proper QMS operation, a municipal enterprise must develop, document, implement and maintain the QMS, and continuously improve its efficiency. To do so, the processes should be defined where the QMS will be implemented, the sequence and interrelation of these processes should be found, the criteria and methods required for the efficiency and implementation of these processes and their management should be defined, the availability of resources and information required to ensure the control over the introduction of these processes should be ensured, these processes should be monitored and analyzed, and measures required to achieve the target should be developed. At the same time, it is required to find the accurate cost of implementing and maintaining the QMS at a proper level [1].

The issue of the quality of housing services and utilities as an integrated system should be considered in a new way today. In this case, the concept of “a new way” should include the following features:

1. The quality of housing services and utilities as a system in general – this refers to the quality of the mission and functions’ realization (reliability, efficiency, fail-safety, affordability).
2. The quality of services provided, in a continuous mode (uninterruptedly), with the appropriate level of service in accordance with the needs and standards.
3. The product quality (water, heat, gas, electricity), in accordance with standards and progressive standards.
4. Quality over time – the need for constant growth (improvement) in quality indicators [2].

Scientists use various approaches to building the costs for the QMS development and implementation. V. I. Korobko proposes to differentiate the structure of quality costs into two groups: the costs of ensuring compliance (prevention of nonconformities, quality control) and losses from nonconformities (internal, external, lost profit) [3].

I. V. Volchkova proposed another but similar quality costs structure: the quality costs should be divided into the following groups: strategic costs of the quality development, current estimated costs of the service quality, and real losses from imperfect service quality [4].

According to the ISO standard, the costs include provision of preventive measures, elimination of inconsistencies and failures that occurred within or outside the organization, and identification of costs at the life cycle stages [5].

We share the opinion of K. N. Savin, who believes that the quality costs should be divided into the following groups: conducting preventive measures, assessing quality, eliminating failures caused by internal causes, and eliminating failures caused by external causes [6, 7].

In other words, the quality costs structure is relative. Minor differences in details are typical for various enterprises, but the expenditure items are permanent and should not duplicate; an element included in one item should not be repeated in another.

As such, the urgency of the study topic is related to the objective socioeconomic need to study and improve the forms and procedures for arranging the provision of services by municipal enterprises, ensuring quality and completeness of satisfying the needs of the population.

The goal of the study is the economic and mathematical modeling of cost estimate of the QMS, which will consist of the total costs of its introduction and implementation at all stages of development, production, and marketing of services of municipal enterprises.
THE MODEL OF ARRANGING THE QMS AT MUNICIPAL ENTERPRISES

The ultimate goal of the operation of any enterprise is to obtain the maximum possible revenue. The cost of introducing the QMS allows to minimize the total costs of the municipal enterprise.

The total cost of introducing and improving the QMS services at municipal enterprises is found using the following formula:

\[ C_{QMS} = C_{DI} + \sum_{i=1}^{n} C_{nom \ i} \]  

where \( C_{QMS} \) is total costs of the QMS introduction, rub.; \( C_{DI} \) is total costs of the QMS development and introduction, rub.; \( C_{nom \ i} \) is current costs in the \( i \)-th period related to the improvements and adjustments in the existing QMS, rub.;

- \( i \) is the period number; and
- \( n \) is the number of periods.

The development and implementation of the QMS \( C_{DI} \) provides for the following types of costs:

- planning and introduction of the QMS \( (l_1) \);
- creation of the QMS documentation, internal standards of the municipal enterprise according to the requirements of domestic and international regulatory documents \( (l_2) \);
- research of consumers' expectations regarding the quality of services \( (l_3) \);
- improvement of the production process and technical characteristics of services \( (l_4) \);
- assessment of the potential and existing suppliers \( (l_5) \);
- development of a program for training all the employees to use quality management methods \( (l_6) \);
- purchase and testing of the equipment \( (l_7) \);
- compilation of reports and analysis of data on the service quality \( (l_8) \);
- internal QMS monitoring \( (l_9) \);
- conducting an external audit for compliance with the standard requirements (national or international) and obtaining a certificate of compliance \( (l_{10}) \);
- identification, research and analysis of the requirements of stakeholders of the municipal enterprise \( (l_{11}) \); and
- other expenses of the enterprise associated with the QMS introduction \( (l_{12}) \).

Therefore, the cost of the QMS development and implementation can be represented with the following formula:

\[ C_{DI} = \sum_{i=1}^{12} C_{DI \ i} \]  

where \( C_{DI \ i} \) is the costs for the development and introduction of the QMS; and \( l \) is the type of costs for the development and introduction of the QMS.

The amount of current costs associated with the improvement and adjustment of the existing QMS of a municipal enterprise is found using the following formula:
The goal of optimization based on the economic and mathematical modeling is to define the optimal result from the QMS introduction. The economic effect is found as the sum of effects of all types of services provided by the municipal enterprise.

\[ E_{QMS} = \sum_{i=1}^{n} E_j \rightarrow \max \]  

where \( E_{QMS} \) is an economic effect from the QMS introduction; \( E_j \) is an economic effect of the \( j \)-th type of service; and \( n \) is the number of types of service.

In this case, optimization will be achieved if the economic effect reaches a maximum, which, in its turn, will contribute to the growth of the municipal enterprise efficiency, which directly depends on the QMS efficiency.

This is why the ratio of revenue from the sale of products, works and services to the costs of introducing the QMS at the municipal enterprise is used as the objective function and represents the QMS effect:

\[ E_{QMS} = \frac{\sum_{i=1}^{n} P_j}{\sum_{i=1}^{n} C_{QMS} + \sum_{i=1}^{n} C_{nom,i}} \]  

where \( E_{QMS} \) is the QMS effect; and \( P \) is the profit from the sale of the \( j \)-th type of service.

In this case, the attention must be paid to the fact that \( C_{DI} \) (the costs of the QMS development and introduction) will be taken into account when evaluating the performance of the municipal enterprise only in the first year after the QMS introduction.

As such, the model can be represented as a system of equations:

\[
\begin{align*}
E_{QMS} & = \sum_{i=1}^{n} E_j \rightarrow \max \\
E_{QMS} & = \frac{\sum_{i=1}^{n} P_j}{\sum_{i=1}^{n} C_{QMS} + \sum_{i=1}^{n} C_{nom,i}} \\
C_{QMS} & = C_{DI} + \sum_{i=1}^{n} C_{nom,i} \\
C_{DI} & = \sum_{i=1}^{12} C_{DI,i} \\
C_{nom,i} & = \sum_{i=1}^{n} C_{nom,i}
\end{align*}
\]  

It must be noted that the difference in the QMS introduction costs at municipal enterprises arises due to the fact that each enterprise is described by a different number of processes, headcount, and the number of consumers provided with services.
CONCLUSION

The municipal economy is a complex and socially important object of the subsistence of the city and its population, which simultaneously produces products (goods) and provides services in a continuous technological regime. Such a system has a whole group of various qualitative indicators and requires a new approach to their management system in the methodological terms.

The QMS efficiency depends on the amount of costs of its introduction and operation, as well as on the amount of profit that the municipal enterprise will gain from its implementation. It must be noted that when the QMS is implemented at municipal enterprises in the first years of its operation, its efficiency would be close to zero.

The main reasons for this situation are that the personnel do not realize the need of the QMS introduction, costs beared by the enterprise, as well as meager investments in equipment that will improve the quality of services provided by the municipal enterprise. Therefore, in the opinion of the authors, the problem can be solved through optimizing the costs associated with the QMS development and introduction at all stages of the service provision.

The economic and mathematical model can be used for planning the costs included in the QMS.

As such, the QMS introduction at municipal enterprises allows not only to improve the service quality, but also to significantly cut the company's costs (in particular, for correcting the inappropriate service), which, in its turn, will contribute to the growth of profits, reduction of total costs, and increase in the efficiency of the municipal enterprise.

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