UDC 338.465

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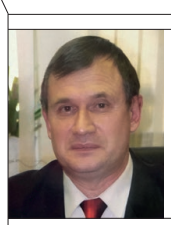
An organizational and economic mechanism for planning the development of systems that are part of the urban utility infrastructure

The systems that comprise the utility infrastructure are a structural element of the housing and utilities sector; they make an essential contribution to the quality of life in municipalities. The development of these systems is particularly relevant now, since the utilities sector is characterized by the high depreciation of fixed assets and the limited profitability of economic activities of organizations in this sector. A combination of the above-mentioned circumstances creates industry-wide problems that hinder the effective operation of public infrastructure systems. The analysis of statistical information has shown that approaches to the development of housing and utility services are insufficient for the renewal and modernization of public infrastructure systems, so there is a practical need to develop innovative approaches to their management. This article focuses on an integrated approach to the development planning of utility systems with regard for the strengths and weaknesses of traditional forecasting tools. Today, the main planning tool is a set of programmes on the integrated development of utility infrastructure systems; however, this tool has a number of disadvantages, including the lack of performance indicators applied to the implemented activities, the predominance of general goal formulations, an unclear relationship between specific projects and programme results, etc. In order to clarify the requirements for the selection of development projects on infrastructure systems, an economic and mathematical model has been designed that allows for the selection of measures based on objective criteria, that will ensure the generation of the most effective programme on the development of utility infrastructure systems in the cities. This economic and mathematical model can be used to develop an organizational and economic planning tool that allows to eliminate the drawbacks of traditional tools.

Keywords: *housing and utility services, utility infrastructure, development, planning*



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Housing and utility services and utility infrastructure systems are essential structural elements of the urban economy. In accordance with Decree No. 204, issued by the President of the Russian Federation on May 7, 2018 "On the national goals and strategic objectives for the development of the Russian Federation for the period up to 2024", one of Russia's strategic priorities is to create the conditions for the sustainable development of utility infrastructure systems[1]. However, despite the high importance of utility infrastructure systems, the industry has experienced a number of difficulties in the process of its operation and development, and respective solutions require supplementary methodological research efforts [1].

The problems of development of utility infrastructure systems in the Russian Federation are determined by the behaviour of a number of essential indicators that characterize the economic state of the utility infrastructure system[2].

One of these indicators represents the performance of the housing and utility organizations, including resource-supplying organizations (RSOs). The first indicator under consideration is the share of profitable and unprofitable housing and utility organizations (Fig. 1). The shares of profit and loss making organizations across the industry are calculated as the ratio of companies demonstrating positive/negative financial performance as of the end of the reporting period, to the total number of companies. The performance of this indicator allows to draw conclusions about the effectiveness of economic activities of the industry entities [2].

The shares of profitable and unprofitable enterprises across the industry showed that the number of unprofitable organizations decreased from 42 % in 2010 to 30 % in 2018, so the difference was 12 % over the period under review. However, by 2018 the level of unprofitable organizations increased by 2 % compared to 2016, when the indicator value was 28 %. Given the positive dynamics of the indicator over the period under review, it should be noted that one third of organizations across the industry were unprofitable in 2018, which translates into the need to increase the performance of housing and utility organizations.

The aggregate economic performance of such organizations is the difference between their income and expenses as of the end of the reporting period under review. The current performance of the indicator is presented in Fig. 2.

During the time period under review, the indicator values fluctuated, but the net performance of housing and utility organizations was always negative. Compared to 2010, in 2018 the net performance worsened and reached a loss of 3.3 billion rubles, which makes us understand that the housing and utility sector experiences problems.

Given the value of the indicator representing the number of unprofitable organizations, which reaches 30 % of their total number, the losses of 3.3 billion rubles make the housing and utility services

1 On national goals and strategic objectives of the development of the Russian Federation for the period up to 2024 : Decree of the President of the Russian Federation of May 7, 2018 No. 204. URL: https://www.garant.ru/products/ipo/prime/doc/71837200/

2 Housing management in Russia 2019: Federal State Statistics Service. URL: https://rosstat.gov.ru/folder/210/document/13234

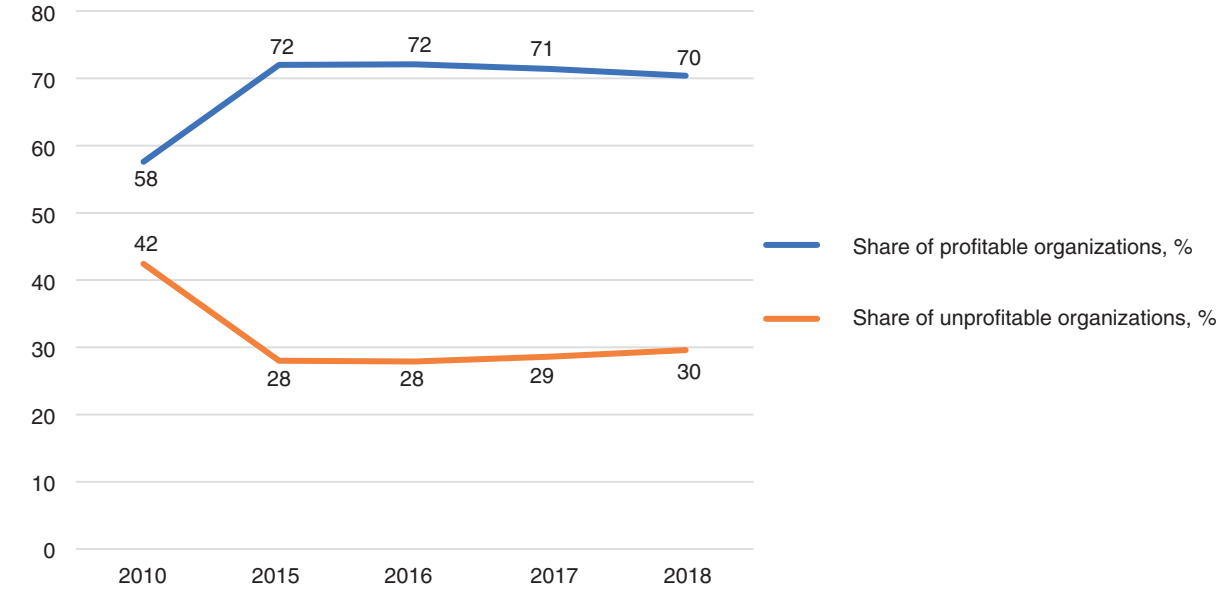

Fig. 1. Share of profitable and unprofitable housing and utility organizations, %

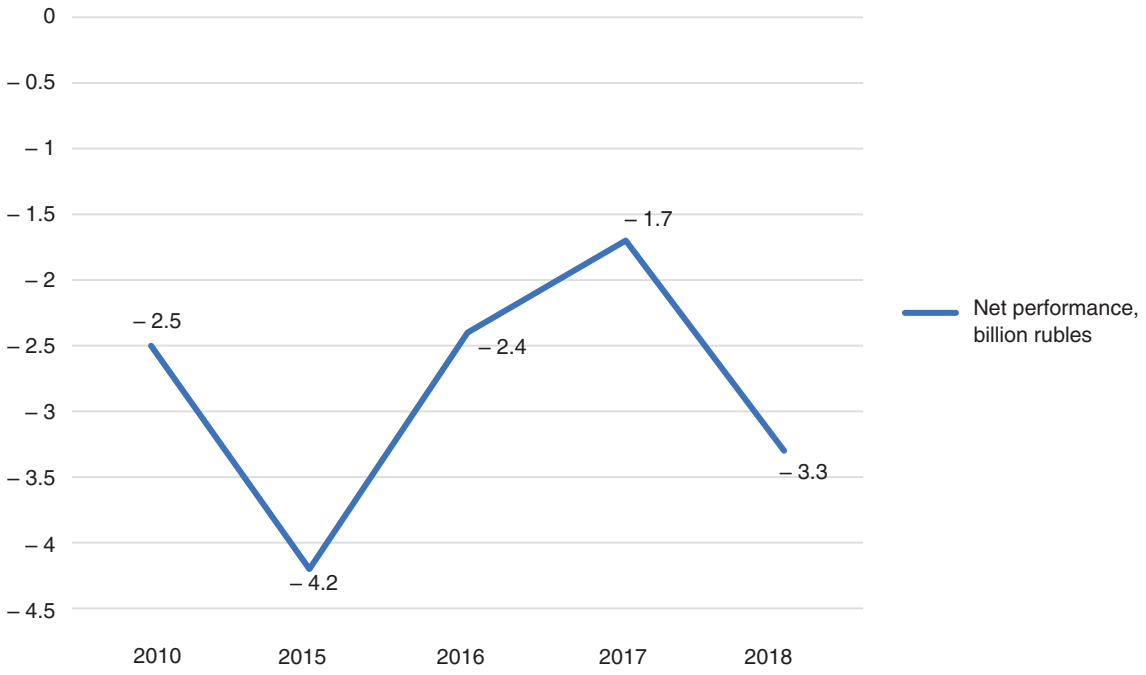

Fig. 2. Net performance of housing and utility organizations, billion rubles

sector a problematic branch featuring low performance of its subjects. The unprofitability of enterprises complicates the process of forming cash balances on the accounts of organizations, which, in turn, directly affects the development of the system. The lack of corporate profits creates difficulties in the process of reinvesting funds into fixed assets, so the updating and modernization of infrastructure facilities is untimely and insufficient.

Below is a graph of fixed capital investments broken down by the economic activities related to utility infrastructure systems (Fig. 3).

If we address the schedule of investments in the fixed assets of utility infrastructure systems, we will see that the amount of financing went up from 152 billion rubles in 2010 to 188 billion rubles in 2018, but the pace of depreciation of fixed assets was not responsive enough. Thus, if the current approaches to the development of these systems remain unchanged, additional fundraising into the industry does not significantly affect the pace of updating the utility infrastructure [3].

The pace of the aggregate depreciation of utility infrastructure systems, shown in Fig. 4, confirms the negative trend.

During the period under review, the average value of this indicator across all industries went down from 47 % in 2010 to 44 % in 2018 and reached 3 %. Hence, the approaches, used to develop the utility infrastructure, fail to ensure the sufficient renewal of utility infrastructure facilities. Dilapidated and worn-out fixed assets have a negative impact

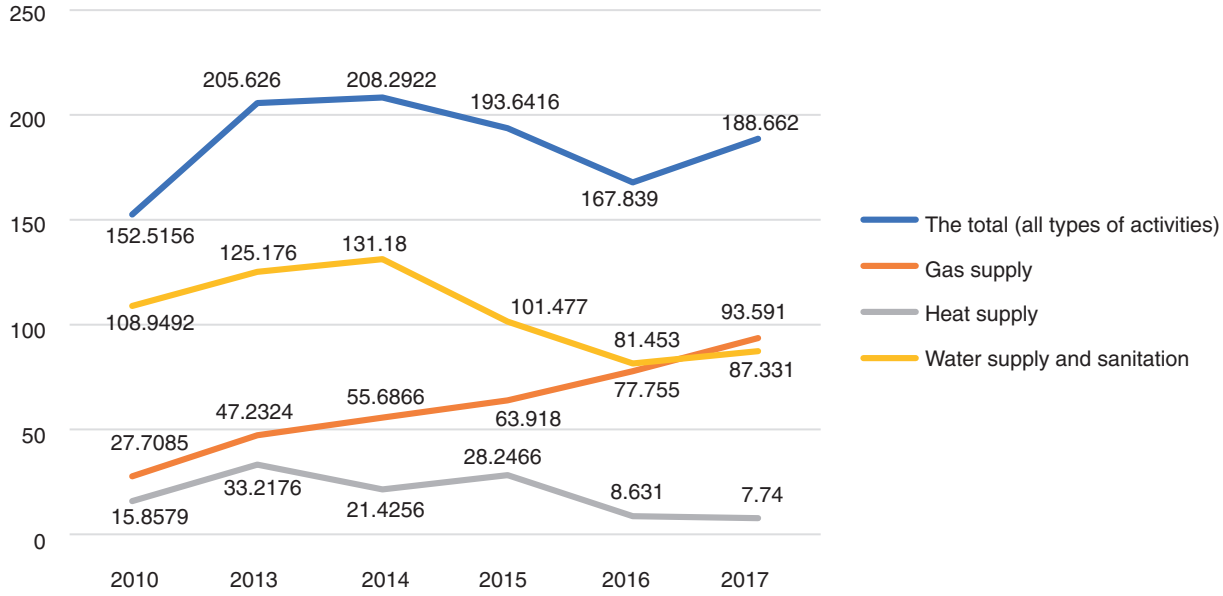

Fig. 3. Investments in fixed assets by types of activities, billion rubles

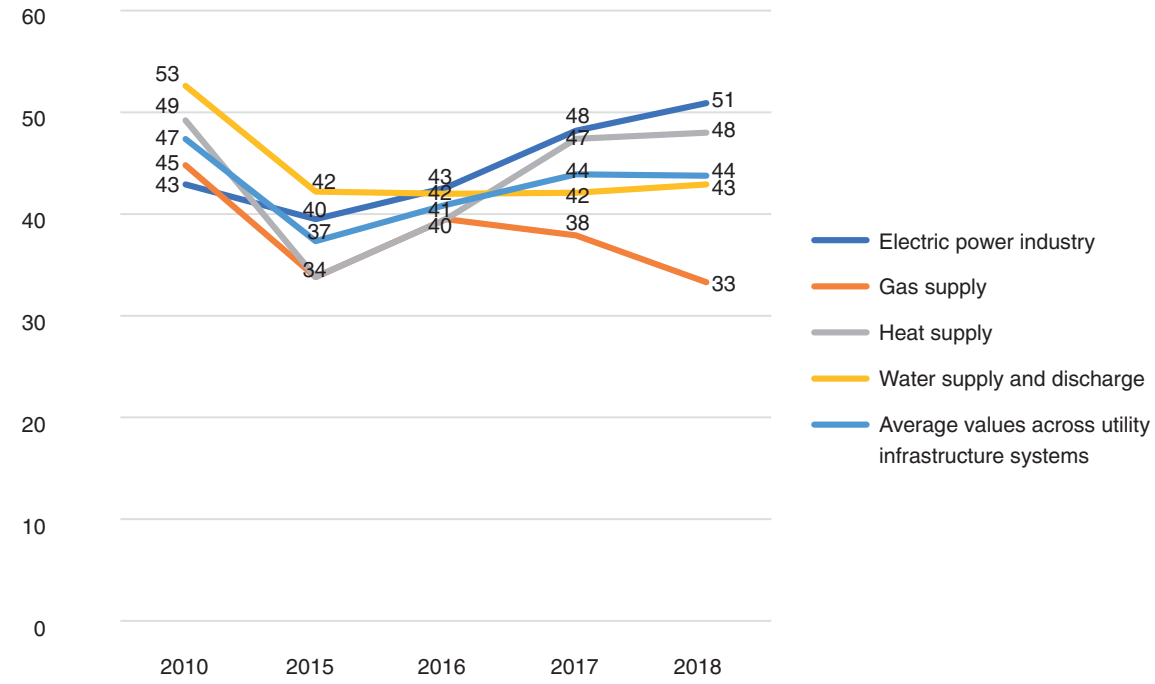

Fig. 4. Depreciation of fixed assets broken down by utility infrastructure systems, %

on the quality of services, the number of accidents, and the loss of resources during transportation. The combination of the above-mentioned difficulties causes additional losses for utility companies.

The importance of the development of utility infrastructure systems is emphasized by the priorities of the Housing and Utilities Development Strategy, which includes a transition to the most efficient technologies, as well as better living conditions for the population[3].

The statistical data, analyzed by the co-authors, demonstrate the insufficiency of the tools used to manage the development of utility infrastructure systems. At the moment, the goals and objectives, formulated within the framework of the state policy on the development of housing and utility services, are not implemented in full[4]. Thus, the combination of the above-mentioned factors necessitates an additional methodological research into this subject matter.

Many Russian scientists have studied the issues of effective development of utility infrastructure systems. The research undertakings, focused on topic of the article, feature a variety of methodological approaches to the development of the utility infrastructure, which is

3 Draft strategy for the development of housing and communal services in the Russian Federation for the period up to 2035. URL: https://www.gkhrazvitie.ru/media/174784/proekt-strategii-razvitiya-zhkh-do-2035-goda.pdf

4 On measures to provide citizens of the Russian Federation with affordable and comfortable housing and improve the quality of housing and communal services : Decree of the President of the Russian Federation No. 600 of May 7, 2012. URL: http://www.kremlin.ru/acts/bank/35264

characterized by the continuous interaction between the housing and utility sector and various social institutions. The following methods were analyzed in the research projects: methods of program-targeted planning aimed at the development of utility infrastructure systems [4], issues of the tariff regulation in the utility sector [5], energy-efficient technologies [6], the assessment of the efficiency of operation of utility infrastructure facilities, legal and regulatory framework of the utility sector [7], organizational and economic development mechanisms [8], etc. However, as evidenced in practice, despite the existence of versatile methodological approaches to the effective development of utility infrastructure systems, no solution to the current problems, experienced by the utility sector, has been developed.

Efficient modernization of the housing and utilities sector can be carried out by studying the processes that occur in the course of development of utility infrastructure systems and by means of designing an integrated economic and mathematical model that has key tasks, requirements, and restrictions that accompany the update of the utilities infrastructure.

The integrated development of utility infrastructure systems is characterized by a set of activities and projects implemented within the framework of the integrated city development programme. Economic and mathematical modeling tools can be employed to present the process of development of utility infrastructure systems. The main criteria that ensure the effective development of a utility infrastructure system as an organizational and economic system include:

- lower costs;
- optimization of the implementation time of development projects;
- higher profitability.

At the same time, the process of development of utility infrastructure systems suffers from limited labor and material resources and fixed production assets, which should also be taken into account in the process of designing an economic and mathematical model [9].

Hence, the development process can be described by the following economic and mathematical model:

$$\begin{cases} \sum_{n=1}^{N}\sum_{t=1}^{T}\frac{I}{I_{nt}}x_{nt} \\ \sum_{m=1}^{M}\sum_{n=1}^{N}\sum_{t=1}^{T}C_{nmt}x_{nmt} \end{cases} \rightarrow min, \quad (1)$$

$$\sum_{m=1}^{M}\sum_{n=1}^{N}\sum_{t=1}^{T}E_{nmt}\,x_{nmt} \rightarrow max, \quad (2)$$

$$C_{nmt} = Y_{nmt} + Z_{nmt} + W_{nmt}, \quad (3)$$

$$x_{nt} \le Q_{nt},\ x_{nt} \ge 0, \quad (4)$$

$$\begin{cases} \sum_{n=1}^{N} y_m\ x_{nt} \le Y_{mt} + \sum_{t=1}^{T}\Delta Y_{mt};\ m = 1,\ M;\ t = 1,T; \\ \sum_{n=1}^{N} z_m\ x_{nt} \le Z_{mt} + \sum_{t=1}^{T}\Delta Z_{mt};\ m = 1,\ M;\ t = 1,T; \\ \sum_{n=1}^{N} w_m\ x_{nt} \le W_{mt} + \sum_{t=1}^{T}\Delta W_{mt};\ \ m = 1,\ M;\ t = 1,T, \end{cases} \quad (5)$$

where I is the index of the year of the forecasted interval, $t = 1, T$; n is the index of the investment programme on the development of utility infrastructure systems in a particular locality, $n = 1, N$; t is the index of the year of the end of modernization of the n-th investment program, $t = 1, Y$; m is the index of local resources available for the implementation of development programmes; I_{nt} is the priority of the n-th investment programme on the development of utility infrastructure systems in the t-th year; Q_{nt} is the scope of work to be performed within the framework of the n-th investment programme on the development of utility infrastructure systems in the t-th year, million rub.; C_{nmt} is the cost of implementation of the m number of works for the n-th investment programme on the development of utility infrastructure systems in the t-th year, million rub.; E_{nmt} is the effectiveness of implementation of the m number of works for the n-th investment programme on the development of utility infrastructure systems in the t-th year, million rub.; y_{mt} is the unit cost of material resources needed to implement the m amount of works in the t-th year, in million rubles per one million rubles worth of construction works; z_{mt} is the unit labor cost for the implementation of the m amount of work in the t-th year, in million rubles per one million rubles worth of construction works; w_{mt} is the unit cost of fixed production assets needed for the implementation of the m amount of work in the t-th year, in million rubles per one million rubles worth of construction works; Y_{mt}, Z_{mt}, W_{mt} is the limit of material, labour and fixed assets available in the settlement for the implementation of the m amount of work in the t-th year, million rub.; x_{nt} is the amount of work required to implement the plan of local development of the utility infrastructure for the n-th investment programme on the utility infrastructure development in the t-th year, million rub.; ΔY_{mt}, ΔZ_{mt}, ΔW_{mt} — the increase in total resources in each year of the planning period, million rub.

The result of the economic and mathematical model is the amount of work x_{nt}, at which all the requirements for the development of utility infrastructure systems, described in the article, are met. The use of this approach in the course of designing integrated utility infrastructure development programs will ensure the effective application of available through limited resources [10].

Today, the main planning tool, applied to utility infrastructure systems, has a number of weaknesses, such as the lack of performance indicators describing the implemented measures, the predominance of general goal formulations, an unclear relationship between specific projects and programme results, etc.[5].

The proposed development planning mechanism, which meets the requirements of the economic and mathematical model, will allow to take account of the shortcomings of existing traditional tools and improve them. From the structural standpoint, the process of planning the development of utility infrastructure systems consists of the following components that reflect the functions of planning: the target block, the functional analysis block, the modernization block, and the resource planning block.

Within the target block, the primary analysis of indicators used for the development of utility infrastructure systems is carried out, and the mission and goal of the programme are set. The functional analysis block contains a more detailed study of the indicators for the development of urban utility infrastructure systems, identifying the most problematic elements and selecting activities based on the criteria determining their impact on programme results. When generating the modernization block, the most effective areas of development are identified, and options for the composition of activities, to be carried out within the framework of the programme, are drafted. The resource planning block is based on the requirements of the economic and mathematical model, including efficiency, cost, and programme implementation terms. The result of using this mechanism is the selection of the programme for the development of utility infrastructure systems that meets the criteria described in the research article. The graphic representation of the organizational and economic mechanism for the planning of the development of utility infrastructure systems is shown in Fig. 5.

5 On approval of methodological recommendations for the development of programs for the integrated development of systems of communal infrastructure of settlements, urban districts : Order of the State Construction Committee of October 1, 2013 No. 359/GS. URL: https://legalacts.ru/doc/prikaz-gosstroja-ot-01102013-n-359gs-ob/

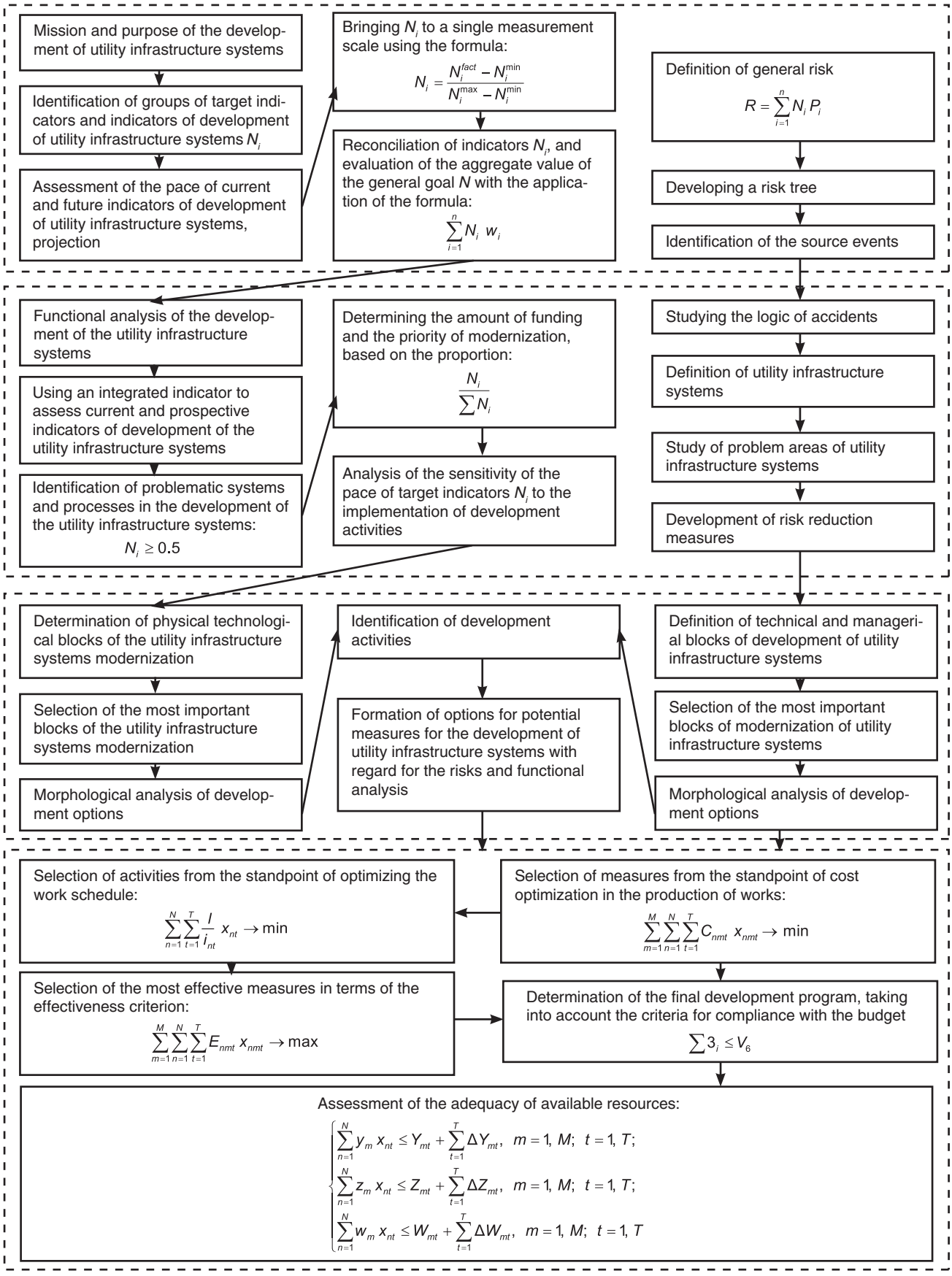

Fig. 5.Organizational and economic mechanism for planning the development of MIS

Thus, when organizing the development of utility infrastructure systems of the city using the planning mechanism developed in the framework of the article, the following results are achieved, which make it possible to supplement the existing shortcomings of traditional tools: the availability of indicators for evaluating the effectiveness of measures, the analysis of the impact of each event on the final result, the presence of a direct relationship between the implemented measures and the program targets.

It is proposed to use the developed mechanism within the framework of the executive authorities of the region or municipality responsible for the development of municipal infrastructure systems. Regular analysis, planning, and monitoring of the implementation of MIS development programs will ensure that municipal authorities are informed in a timely manner about the presence of problems in the city's municipal infrastructure, and will allow them to respond quickly and adequately to emerging challenges. The planned nature of activities for the development of MIS will provide a gradual solution to such problems of the industry as a high level of depreciation of fixed assets and low efficiency of the industry's enterprises.

CONCLUSIONS

Thus, the studied statistical information suggests that there are significant difficulties in the development and functioning of public infrastructure systems. At the same time, the dynamics of such indicators as the depreciation of MIS facilities, as well as the net result of housing and communal services organizations, allows us to conclude that the approaches used to the development of municipal infrastructure systems are ineffective. In order to provide additional methodological support for the development of municipal infrastructure systems, the article presents the main requirements for the effectiveness of MIS modernization. Based on the identified criteria that form the economic efficiency of MIS development, an economic and mathematical model describing the processes occurring within the framework of municipal infrastructure modernization is developed. The solution to the problem formed within the framework of the economic and mathematical model is the amount of work that meets the criteria of efficiency, optimal costs and implementation time, provided that the total resources allocated for the implementation of a set of measures for the modernization of MIS are limited. The formation of programs for the development of municipal infrastructure, taking into account the developed criteria, will make it possible to assess its effectiveness and optimality, which will have a beneficial effect on the quality of planning and selection of investment projects within the framework of MIS modernization.

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Организационно-экономический механизм планирования развития систем коммунальной инфраструктуры города

Системы коммунальной инфраструктуры (КИ) являются структурным элементом жилищно-коммунального хозяйства и играют большую роль в обеспечении качества жизни населения муниципальных образований. Вопросы развития систем КИ приобретают особую актуальность на современном этапе функционирования ЖКХ, для которого характерен высокий накопленный уровень износа основных фондов, а также ограниченная рентабельность хозяйственной деятельности организаций отрасли. Совокупность вышеупомянутых обстоятельств формирует проблематику отрасли, препятствующую эффективному функционированию систем коммунальной инфраструктуры. Анализ статистической информации показал, что используемые подходы к развитию ЖКХ не обеспечивают достаточные темпы обновления и модернизации систем коммунальной инфраструктуры, таким образом возникает практическая необходимость в разработке инновационных подходов к управлению КИ. Ключевым направлением исследования в рамках настоящей статьи является формирование комплексного подхода к планированию развития КИ, учитывающего сильные и слабые стороны традиционных инструментов прогнозирования. На сегодняшний день основным инструментом планирования в системах КИ являются программы комплексного развития систем коммунальной инфраструктуры, однако, данный механизм обладает рядом недостатков, таких как: отсутствие показателей эффективности реализуемых мероприятий, преобладание общих формулировок целей, неясная взаимосвязь между конкретными проектами и результатами программы и др. В целях конкретизации требований к отбору проектов развития КИ разработана экономико-математическая модель, позволяющая осуществлять отбор мероприятий по объективным критериям, что обеспечит формирование наиболее эффективной программы развития систем коммунальной инфраструктуры города. На основании экономико-математической модели сформирован организационно-экономический механизм планирования, в рамках которого были исправлены недостатки используемых традиционных инструментов.

Ключевые слова: *ЖКХ, коммунальная инфраструктура, развитие, планирование*

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For citation: Grabovyy P.G., Doan Duong Hai, Nelyubov A.V. An organizational and economic mechanism for planning the development of systems that are part of the urban utility infrastructure. *Real estate: economics, management*. 2021; 3:41-47.

Для цитирования: *Грабовый П.Г., Доан Зыонг Хай, Нелюбов А.В.* An organizational and economic mechanism for planning the development of systems that are part of the urban utility infrastructure // Недвижимость: экономика, управление. 2021. № 3. С. 41–47

Л.И. Павлова. Рим. Форум. Офорт