Engineering infrastructure of the city: problems of development and tools for their solution

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Abstract. The questions of the organization of engineering support of residential and non-residential construction objects at the stages from planning to commissioning are studied. So far, these issues have been addressed for each site in a collegial decision-making mode: at Staff meetings, etc., separately, as they arise. This approach demonstrates inconsistency between the actions of construction and resource-supplying organizations both during design and at the construction site, and, as a result, delays in the construction and commissioning of facilities and the growth of social tension. The article presents new tools for increasing the level of interaction between the participants of engineering support processes based on the preliminary, advance interconnection of actions of all participants of the engineering support process and all involved objects. Such tools are especially relevant in large-scale renovation programs of large cities’ housing stock; the article shows the developments applied in the Moscow Housing Renovation Program framework.

Keywords: engineering support, capital construction facilities, integrated scheme, residential renovation

1 Introduction

The engineering infrastructure of a city is a key factor in the pace of its socio-economic development [1-6]. The issues of engineering provision are most acute in large cities due to high requirements to the timing of commissioning of new capacities for new construction, uninterrupted supply of resources to existing facilities, minimization of inconvenience to residents during excavations for laying networks, and other similar requirements.

1.1 General provisions on the engineering infrastructure of the city

Usually, the city’s engineering infrastructure is managed (on different rights, from ownership to lease) by resource-supplying organizations (hereinafter – RSO) and operated by them; in Moscow, these are, accordingly (the most prominent companies):
- power supply: PJSC Rosseti – Moscow Region and JSC OEK;
- heat supply: PJSC MOEK;
- gas supply: JSC “MOSGAZ”;
- water supply (cold) and domestic sewerage: JSC Mosvodokanal;

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surface drains: SUE “Mosvodostok”.

All infrastructure that provides the city with engineering resources is divided into three categories: urban area levels, engineering infrastructure levels, and infrastructure development documentation levels (see Figure 1).

Fig. 1. Categories of representation of the city’s engineering infrastructure.

The development of the city infrastructure (networks and headworks) is carried out following the technical policy of RSOs and their investment programs, sectoral resource supply schemes, as well as following the Addressed Investment Program of the City of Moscow and integrated schemes of engineering provision of the territory (hereinafter – CSEP). Infrastructure development at the neighborhood and individual building levels is determined by CSEP and connection (technological connection) agreements, respectively.

The process of connection (technological connection) of each capital construction facility (hereinafter – CCF) to the resource supply infrastructure is carried out following the algorithm prescribed in the relevant (by types of resources) Connection Rules, and the connection (technological connection) agreement concluded following this algorithm between the applicant (most often it is a construction organization constructing the CCF to be connected) and the RSO. The term of execution of such a contract varies depending on the type of resource, its volume, and the technical parameters of the network to be laid and is generally 18 months. Currently, the connection of the construction site to the networks takes the most time for the developer.

The most difficult challenges encountered in designing and implementing engineering infrastructure are concentrated in neighborhood-level areas. This situation is due to the fact that it is at the “last mile” where the interests (most often opposite) of RSOs, construction companies (investors), and the city converge. What are these problems?

1.2 Problems of creation and reconstruction of engineering infrastructure at the neighborhood level

As the practice of recent years shows, the main organizational and management tasks for the development of communal infrastructure facing the city, investors, and RSOs [1, 2, 8-12] can be formulated as follows:
- synchronization of CCF and engineering support implementation terms, both at the level of connection procedure (technological connection) and at the level of headworks and main networks implementation;
- minimizing re-excavation and resurfacing;
- ensuring that sufficient headworks capacity is available for the continued development of urban development;
- accessibility of connection (technological connection) of new capital construction facilities to engineering networks – availability of connection points, control of connection time and cost;
- uninterrupted supply of engineering capacities in the reconstruction of the neighborhood or construction of new facilities and existing buildings, including social facilities.

In addition to investor development in Moscow, housing stock renovation takes a large share in urban planning. And it is in renovation that the above tasks become especially acute [1, 8-11].

The integrated scheme of engineering provision of the territory was defined as the basis for solving the above tasks.

The following sections will include:
- methods used in the development of our tools,
- results obtained,
- discussion was held,
- in conclusion, we will summarize the work done and show the prospects for further research on this topic.

2   Materials and methods

Based on the above tasks, it was necessary to develop tools for interacting with all stakeholders of the CCF engineering process, allowing to solve these tasks promptly. A geographic information system was chosen as the platform on which the interaction was organized, and an integrated engineering scheme was selected as the document taken as the entity basis.

2.1 What is CSEP, its composition, history of development

2.1.1 First stage of development: Moscow 2001-2002

More than twenty years ago, the Moscow City Government Resolution No. 359 dated 17.04.2001 approved the “Temporary Regulations on the Uniform Procedure for Pre-Design and Design Preparation for the Construction of Engineering Communications, Structures and Road and Transportation Facilities in the City of Moscow”. This Regulation introduced the concept of a “comprehensive engineering scheme (all types of utilities)”; the brackets actually explained why it was “integrated”. And already in a year with a little, this Regulation was transferred to the status of permanent by the Resolution of the Government of Moscow from 30.07.2002 No. 586.

This decree established the development of an integrated scheme as mandatory in the pre-project preparation of buildings, and in the practice of construction, it was indeed widely used, especially in the first 10 years, but later, it was poorly demanded.
2.1.2 Second stage: Moscow 2018

The integrated scheme got a “second wind” with the emergence of a large-scale housing renovation program in Moscow. The scale of the unfolding project is the reason for the relevance of CSEP: it is the adequate basis for monitoring and harmonizing the timing of design and construction of infrastructure for all types of engineering support with the timing of construction of residential and non-residential construction, so necessary in such a large project [9, 13].

In this regard, the Moscow City Government issued Resolution No. 515-PP dated 05.06.2018, “On Establishing the Cases and Procedure for the Development and Approval of an Integrated Scheme of Engineering Support of the Territory, as well as the Procedure for Determining the Points of Connection (Technological Connection) of CCF to Engineering and Technical Support Networks, Electricity Networks for the Purposes of Implementation of the Housing Renovation Program in the City of Moscow”.

The name of the scheme itself has slightly changed – now it is an “integrated scheme of engineering provision of the territory” with a list of specific types of resource supply: electricity supply, heat supply, gas supply, water supply, and wastewater disposal (communication networks are not mentioned in the name of the CSEP, but they are also present) – but its essence and purpose remain the same: it is a document that brings together data from various sources of urban planning information and allows to present an overall picture of both the existing state of engineering infrastructure networks and their planned location in new construction.

CSEP is prepared considering the approved schemes and programs of prospective development of engineering infrastructure-approved investment programs of the right holders of engineering networks. The integrated scheme is also subject to coordination with the right holders of engineering and technical support networks located on the relevant territory and (or) to which it is planned to connect (technological connection) capital construction facilities.

The integrated scheme includes a passport, graphic materials, and an explanatory note. The passport specifies, among other things, the timing and stages of implementation of the integrated scheme (stages of commissioning of CCF and engineering networks).

The explanatory note to the scheme shall include the following information on the existing condition of the resource supply systems:
- technical corridors of the location of networks and directly related facilities;
- main technical characteristics of networks and directly related CCF (load in water supply, wastewater, and heat supply networks or capacity in power supply networks, the capacity of communication networks, material, and other characteristics);
- information on organizations operating networks and directly related facilities;
- information on sources of resource supply and availability of load reserves in water supply, wastewater, and heat supply networks or capacity in power supply networks, the capacity of communication networks;
- information contained in approved investment programs.

Graphical materials of the integrated scheme include a scheme of the existing location of networks and directly related CCFs, which shows the information specified in the explanatory note. Graphical materials of the main part of the complex scheme and materials on its substantiation are developed on the state topographic base at a scale of 1:2000.

As can be seen, the integrated scheme is a rather capacious document, and its perception in text and graphic form is quite difficult, especially in management activities analysis when making decisions related to multi-stage infrastructure expansion, as it happens in the renovation of the housing stock. In this regard, work has been carried out by NPC City Development to outline an integrated scheme on a GIS platform. In this form, the integrated scheme’s perception becomes sufficiently observable, visual, and informative.
The integrated scheme also contains information on the planned location of CCF connection points (technological connection) to resource supply networks, the maximum free capacity of existing and planned for placement of these networks, and their maximum load. This information (on connection points) is a basis for technical specifications issued by resource-supplying organizations for CCF construction. Therefore, having such a tool, the coordinator of the Renovation Program (Department of Construction of the Moscow City Government) can easily monitor the progress of execution of decisions on the connection (technological connection) of CCFs being built – from the Integrated Scheme to the Connection Agreement – at any stage of their creation: from design to commissioning. This eliminates, in particular, organizational and technological errors that cannot be detected during the development of project documentation, such as repeated re-laying.

The integrated scheme was initially intended only for the Renovation Program, but having shown its application effectiveness within three years, it was further extended to other “capital construction objects of regional significance” (revision of 23.04.2021).

2.1.3 Third stage of development: Urban Planning Code of the Russian Federation 2021

This is the stage of CSEP’s “outreach” to the federal level. The experience of application of integrated schemes in the Moscow Residential Renovation Program has shown its effectiveness, and it was decided to introduce it into the practice of engineering infrastructure construction throughout the country – the integrated scheme was included in the urban planning documentation by Federal Law No. 276-FZ dated 01.07.2023, and today it is presented in the Urban Planning Code of the Russian Federation in para. 13-16 of Article 52.1.

The experience of housing renovation in Moscow is also relevant for other large Russian cities [14], including the experience of using CSEP and similar schemes [15-21]; today, CSEP is already used, for example, in Angarsk, Belgorod, and other cities.

2.2 Relationship between the TPP and the Integrated Scheme

Why was the Integrated Scheme identified as the main tool for solving the tasks of creating and reconstructing engineering infrastructure at the neighborhood level? After all, a document like the Territory Planning Project (hereinafter – TPP) has an engineering section dedicated to developing engineering infrastructure in the studied territory.

The fact is that the engineering section of TPP is presented in a very general form, and the information available in it is insufficient for RSO services to form Technical Conditions under which resource supply networks are constructed. The integrated scheme was initially conceived as a tool for solving organizational and technical problems of infrastructure development at the neighborhood level.

The integrated scheme takes as input data the developed TPP provisions in terms of engineering, but it also “works” in the opposite direction: after a more detailed development (compared to TPP), it is possible to correct and develop the relevant TPP provisions.

In addition, the Integrated Scheme allows, unlike TPP, to conduct integrated (following its name, for all types of resources) monitoring of the processes of conclusion and execution of connection agreements (technological connection) to establish links (link) terms of design and construction of all engineering communications in the territory, thus solving one of the main problems of infrastructure construction.
3 Results

Two information tools were the result of the development work carried out:

3.1 Information module “CSEP. Renovation objects”

Work was carried out on the formation and presentation of monitoring processes, control over the implementation of CSEP, technological connection contracts, and implementation of headworks and trunk networks included in the TPP in the form of geographic information systems.

For example, the information module “CSEP. Renovation objects” (see Figure 2), if properly filled and properly exchanged between all participants of the process, can:
- visualize in real time a complete picture of the status and monitoring of the implementation of grid connection contracts for renovation houses for three years for each type of communication;
- identify problem objects that need to be addressed by the Program Coordinator to make management decisions. Conventionally, it is a tool for high-level executives to assess the whole picture.

![Image of start page of the information module “CSEP. Renovation objects”]

Fig. 2. Example of the start page of the information module “CSEP. Renovation objects”.

For more detailed elaboration and analysis, tools are provided at the block and house level, i.e., we can see on the network diagram and on the map the house to be commissioned, the house to be demolished, as well as all engineering communications, including removal from the development spot with all the features and timing, which, in turn, allows to identify problems and take corrective actions in time.

3.2 The information system “Territorial analytics system”

The “Territorial analytics system” information system is organized similarly (see Figure 3). By processing data on technological connection contracts, TPP activities, and directive schedules for the commissioning of facilities, the user represented by the Program Coordinator can see in real-time the general analytics on the objects of commissioning and engineering infrastructure, as well as complete information, including the status of each
object, whether it is an investor or renovation house, a social object, and most importantly, the status, need and timing of engineering provision of each object.

Fig. 3. Example of the start page of the “Territorial analytics system” information module.

4 Discussion

Information on the connection of capital construction facilities to resource supply networks is stored in various information resources belonging to different organizations. The presented information tool can solve the issues of interconnection and meeting the deadlines for the realization of objects if properly filled with relevant information by all process participants. At the same time, the considered information tools are constantly being developed and improved depending on users’ requirements. The current versions differ significantly from those developed in previous periods. The main differences are as follows: the possibility of analytics at different levels (city, quarter, building) has been added; data fields for each type of objects have been expanded; the cartographic component has been significantly improved both in terms of navigation and information display modes; in addition, algorithms for identifying problematic issues according to various criteria have been added.

5 Conclusion

The obtained results – the developed tools of two systems – correspond to the set development goal, which was proved by the practice of their application in the implementation of various objects in the city of Moscow, including the Moscow Residential Renovation Program.

Thus, along with the methods already proven over the years (headquarters, detours, planning, and the like), the City Development Center is currently actively working on the development of effective information tools that would allow coordinating as a whole and quickly making managerial decisions on individual operational issues of engineering support of facilities under construction in a large city.
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