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Reliability of heating networks as a factor of sustainable development of thermal power industry

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Abstract. The reliability of heating networks is the foremost principle for organizing relationships in the field of heat supply, as established by Federal Law. The overall reliability of heat supply across the Russian Federation is declining due to insufficient replacement of aging heating networks. This article explores the potential use of a program document, specifically a heat supply scheme, as a means to justify the allocation of budgetary funds for initiatives aimed at enhancing the reliability of heat supply or transitioning to a "price zone.".

1 Introduction

The climatic conditions in the Russian Federation, characterized by long periods of sub-zero outdoor temperatures across a vast area of the country, make the heat supply industry a key sector that ensures the normal functioning of the population.

Reliability of heat supply is one of the main principles governing the organization of relations in the field of heat supply, as established by Federal Law No. 190-FZ "On Heat Supply," dated July 27, 2010. The standard reliability of heat supply is essential for making sustainable development plans for the industry.

The heating network is a critical component of the heat supply system, determining its reliability. This is due to the presence of backup heat-generating and pumping equipment in thermal energy sources. In the event of a failure in one boiler or pump, it typically does not result in a disconnection of consumers. At worst, it may lead to a reduction in the parameters and quality of the supplied thermal energy.

In the event of accidents on heating networks, there is a possibility of a complete shutdown of heat supply to consumers. This can exacerbate the situation, particularly at low outside temperatures, due to the thawing of internal heating systems and sections of the heating networks.

2 Main part

Based on the report on the state of the heat power industry and centralized heat supply in the Russian Federation in 2020, prepared by the Ministry of Energy of the Russian Federation and the Federal State Budgetary Institution 'Russian Energy Agency' of the Ministry of Energy of Russia [1], it is evident that out of the total length of heating networks in the country, which is 167.4 thousand km, 51.51 thousand km (30.77%) require replacement, and 38.8 thousand km (23.18%) are in a dilapidated condition. Furthermore, over the past 5 years, the total length of heating networks in the Russian Federation has decreased by 4.15 thousand km, while the share of dilapidated heating networks has increased by 2.04 thousand km.

Insufficient replacement volumes serve as the main reason for the high wear and tear of heating network pipelines. In 2020, the relocation of heating networks in Russia as a whole amounted to only 3.371 thousand km, which represents merely 6.7% of the required replacement volume (Fig. 1).

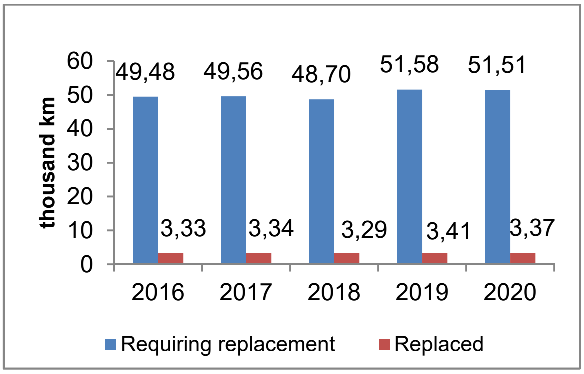

Fig.1 The ratio of the length of pipelines requiring replacement and those replaced in the Russian Federation in 2016-2020, thousand km.

An increase in the proportion of pipelines requiring replacement leads to a rise in the number of accidents in heating networks. From 2018 to 2020, the overall accident rate of heating networks in the Russian Federation increased by 22% [1].

The ongoing trend of escalating wear and tear in heating networks will inevitably result in a critical decline in the reliability of heat supply.

Simultaneously, the insufficient volume of replacement for heating networks can be attributed to both a shortage of funds allocated for reconstruction, modernization, and repairs accounted for in the thermal

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energy tariff, as well as unsatisfactory and poor-quality planning by heat supply organizations within their investment programs and repair plans.

It is worth noting that the Russian Government acknowledges the issue of diminishing reliability in utility infrastructure, including heating networks. Mechanisms have been developed to provide additional financing sources for replacing dilapidated networks. These programs are implemented with the support of the Territorial Development Fund:

- issuing subsidies to regions for the creation, reconstruction, and modernization of municipal infrastructure facilities (Resolution of the Government of the Russian Federation of December 26, 2015 No. 1451);
- preferential loans for the modernization of municipal infrastructure facilities (Resolution of the Government of the Russian Federation of February 2, 2022 No. 87);
- allocation of non-refundable budget funds for the reconstruction of linear facilities (Resolution of the Government of the Russian Federation dated December 8, 2022 No. 2253).

Programs implemented through DomRF Bank have also been developed:

- financing the construction (reconstruction) of infrastructure using bonds of SOPF Infrastructure Bonds LLC;
- provision of loans for the purpose of design, construction and (or) reconstruction of infrastructure facilities on the basis of a concession agreement or public-private partnership agreement, municipal-private partnership agreement.

Furthermore, it is important to highlight the solution proposed by the Government of the Russian Federation to address the problem as part of the transition to a new target model of the thermal energy market: the method of price zones or the 'Alternative Boiler House' (AK) method. This method of regulation was introduced by Decree of the Government of the Russian Federation No. 1562, issued on December 15, 2017, which determines the maximum price level for thermal energy (power) in heat supply price zones. It includes the indexation of the maximum price level for thermal energy (power) and the technical and economic operating parameters of boiler houses and heating networks used to calculate the maximum price level [2].

The concept of a new heat market model was initially announced in 2010 and has since undergone significant evolution, taking into account the minimization of all potential risks. This model involves transitioning from state regulation to establishing a maximum price level for thermal energy. Importantly, this maximum level is not determined based on the current costs of the heat energy supplier in the existing centralized heat supply system, but rather through a comparison (benchmarking) with the cost of the most effective alternative heat supply for the consumer, which is the price of an 'alternative boiler house.' The cost of centralized heat supply for the consumer should not exceed the cost of switching to their own sources of heat generation [3]. The methodology and procedure for calculating the maximum level for thermal energy have been approved [2] and are standardized nationwide.

Under the 'alternative boiler house' method, the price of thermal energy may differ from the actual established tariffs, both upwards and downwards. If the cost of the 'alternative boiler house' is lower, the tariffs will be frozen until they reach the price limit. If the cost is higher, a schedule will be developed to gradually bring it in line with the price of the 'alternative boiler house' over a period of 5-10 years.

Heat supply organizations are required to allocate additional funds from the sale of heat energy to measures that enhance the reliability, quality, and energy efficiency of heat supply if the price of the 'alternative boiler house' exceeds the tariffs for heat energy established prior to the transition to price zones.

When transitioning to the price zone method, a single heat supply organization (ETO) is designated for a populated area. This organization is responsible for all aspects of heat supply, including production, transportation, and sales of thermal energy. There may be multiple ETOs in one locality.

The ETO is granted expanded powers to manage the heat supply system, while control, including antimonopoly control, over its activities is strengthened. The ETO has increased responsibility to both consumers and authorities. It also has the opportunity to influence the optimization and development of the heat supply system. Prices for produced thermal energy and transmission services between the ETO and other companies in its area of operation are determined through mutual agreement, ensuring the direct economic interest of all heat supply participants in improving efficiency. The ETO enters into contracts with consumers, and fines, such as significant reductions in heat payments for consumers, are imposed on the ETO for heat supply shutdowns and violations of quality, such as low coolant temperatures [4].

Currently, 38 municipalities in Russia have transitioned to the new model for calculating tariffs, and the practical results demonstrate the effectiveness of the price zone method. Heat supply organizations that have adopted this new method are actively striving to expand its implementation to additional cities. The projected growth of investments under the new tariff calculation method exceeds the financing levels under the 'old' model. While the specifics of implementing the 'alternative boiler house' method may vary across regions, this does not hinder the overall goal of enhancing reliability and efficiency in heat supply.

However, the nationwide transition to the new model is not without its challenges. According to some experts, although the new method has proven to be a viable alternative to the current tariff regulation approach, it should not be considered the sole reference. They argue that adopting the AK method as the exclusive means of heat market regulation is misguided, as it may not be suitable for all municipalities. Moreover, scientists have identified negative consequences resulting from the transition to the new tariff regulation model. These include unjustified tariff increases, which could prompt consumers to abandon centralized heat supply systems, leading to a decrease in the heat load at combined heat and power (CHP) plants. The monopolistic structure of heat supply management does not encourage entrepreneurial initiative or foster competition for consumers. Additionally, higher payments for thermal energy may contribute to an increase in non-payment rates.

In response to these challenges, the Government of the Russian Federation has proposed an extensive infrastructure menu to attract investment aimed at improving the overall reliability of utility infrastructure, including heat supply.

However, it is important to acknowledge that the aforementioned solutions are either financed through budget funds or through an increase in thermal energy tariffs for consumers. Therefore, any decisions made by each heat supply enterprise must be accompanied by an analysis of the targeted use of existing tariff-based financing sources, ensuring that they are directed towards enhancing the reliability of heat supply. This analysis should consider the validity of investment programs and capital and current repair programs, as well as determine the minimum required financing to maintain the heat supply system in a standard condition.

A key task is to assess the reliability of heat supply, which involves evaluating not only current indicators but also future reliability under various scenarios for replacing heating networks. Reference [5] proposes a rapid assessment of the condition of heating networks without decommissioning them. Methods for calculating the reliability of heating networks, principles for generating failure statistics, and the influence of real initial data on the actual reliability indicator are discussed in [6]. Furthermore, [7] presents an assessment of the reliability of heating networks using cluster analysis.

In reference [8], the main features of decision-making regarding the selection of sections of heating networks for major repairs are examined, with a ranking based on various criteria.

Reference [9] provides proposals for monitoring the reliability of heating networks.

Despite the availability of numerous methods for assessing the reliability of heat supply systems, their practical implementation is not mandatory for heat supply organizations.

However, there is a document that must be developed and approved in accordance with current legislation - a heat supply scheme.

The heat supply scheme serves as the primary program document that outlines the long-term development of the heat supply system for settlements, urban districts, and federal cities. It is developed in compliance with the requirements established by [10, 11]. The heat supply scheme is subject to annual updates, and if the master plan is approved, a draft of a new heat supply scheme is formulated.

One of the crucial objectives in developing or updating a heat supply scheme is to ensure reliable heat supply in the most cost-effective manner while minimizing the negative impact on the environment. The heat supply scheme includes a dedicated chapter on assessing the reliability of heat supply to propose the reconstruction of heating networks that fail to meet standard reliability criteria. Reliability calculations are conducted using an electronic model of the heat supply system, ensuring adherence to the calculation requirements specified in [11].

The objectivity of calculating the reliability of the heat supply system relies on accurate and complete information regarding the historical damage records of heating networks and heat supply organizations for a retrospective period of at least 5 years, as well as information on the years of commissioning, reconstruction, and repairs of heating networks.

Accurate reliability calculations not only allow for an assessment of the current state of heating network reliability but also facilitate the development of long-term measures to bring the conditions of heating networks to standard values. Based on the reliability calculations, an objective evaluation of the necessary capital investments in heating networks can be made to ensure high-quality and reliable heat supply. In cases where there is insufficient funding accounted for in heat energy tariffs, the developer of the heat supply scheme should propose options for raising additional funds.

By the end of the long-term planning horizon specified in the heat supply scheme, the implementation of a set of measures should result in reliability indicators that meet standard values.

Unfortunately, in practice, the inclusion of a reliability chapter in the heat supply scheme is often a mere formality and fails to address the aforementioned issues.

The main reasons for the superficial development of the reliability chapter in heat supply schemes include:

- the problem of the lack of complete and reliable information for an objective calculation of the reliability of the heat supply system (for example, some organizations artificially underestimate the actual number of failures in heating networks, which, in turn, leads to erroneous attainment of standard performance indicators for the heat supply system). Additionally, there is a lack of information regarding the years of commissioning of heating networks;
- developers of the heat supply scheme take into account only measures proposed by heat supply organizations and secured by sources of financing, reliability calculations are artificially adjusted to standard values;
- to objectively perform a reliability calculation, significant labor costs are required for analyzing and entering a large array of data into an electronic model; when developing heat supply schemes for small settlements, taking into account the relatively small contract price for developing a heat supply scheme, the developer does not perform a reliability calculation.

The heat supply scheme is the most important tool for implementing state policy aimed at improving the reliability, quality, and energy efficiency of heat supply. Currently, in order to receive budget funding or transition to the 'price zone,' it is necessary to ensure the inclusion of planned activities in the heat supply scheme. However, only the latest update of the scheme is taken into account in this process. When comparing such schemes with previous updates, it becomes evident that the need for additional activities and sources of funding is only reflected in the latest update, while previous versions of the scheme lack this information. Updating heat supply schemes to meet the requirements of a specific project raises doubts about the objectivity of the results obtained.

To fully utilize heat supply schemes as a tool for long-term planning, high-quality reliability calculations, and the development of planned activities, it is proposed to legislate that, in order to justify the receipt of budget funding or the transition to the 'price zone,' the proposed activities must be aligned with at least three updated heat supply schemes.

This will ensure a more thorough development and updating of heat supply schemes and will make it possible to make maximum use of the results obtained in order to increase the reliability of heat supply.

3 Conclusions

1. The reliability of heat supply in the Russian Federation as a whole tends to decline as a result of insufficient replacement of heating networks. The breakdown rate of heating networks is increasing.
2. The Government of the Russian Federation has developed mechanisms for attracting additional investment in the industry.
3. Justification of the required volume of additional investments in the context of each heat supply organization is not objective enough.
4. The role of a tool for assessing the required volume of additional investments in the context of each heat supply organization can and should be performed by heat supply schemes when carrying out reliability calculations and proposing measures.
5. A significant part of heat supply schemes is made with formal, biased reliability calculations.
6. In order to improve the quality of development of heat supply schemes, the objectivity of the reliability calculations performed and the selection of measures, it is proposed to establish legislatively that in order to justify the receipt of budget funding or the transition to the “price zone”, it is necessary to coordinate the proposed measures with at least three updates of heat supply schemes.

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