TOWARDS A SUSTAINABLE HEATING INFRASTRUCTURE: A NEW APPROACH TO FEE CALCULATION IN RUSSIA'S HEAT SUPPLY SYSTEMS

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ABSTRACT

This study re-examines the methodology for calculating connection fees to centralized heating systems in Russia, emphasizing its ecological and economic implications. The research highlights the inefficiencies of the current methodology, which calculates fees based on connected load rather than the physical length of heating networks. By proposing a new length-based fee calculation, the study underscores the potential for reducing unnecessary resource consumption, minimizing environmental impacts, and improving cost transparency. The ecological benefits include optimizing network construction, lowering emissions from redundant infrastructure, and enhancing energy efficiency. The proposed approach, validated through case studies from PAO "MOEK," demonstrates reduced deviations between connection costs and revenues, fostering a balance of economic and environmental interests. This methodology provides a blueprint for sustainable heating infrastructure development, supporting both ecological and economic goals.

Keywords: key connection fee, heat supply, tariff calculation methodology, tariff regulation, investment attractiveness, investment climate, regional economy.

INTRODUCTION

Improving the accessibility of engineering infrastructure is a priority for enhancing the sustainability and competitiveness of the Russian economy, as outlined in national development plans (Federal project "Housing" of the national project "Housing and urban environment", n.d). Access to centralized heating systems is critical for addressing environmental and economic challenges, especially in light of their significant role in reducing energy waste and optimizing resource allocation. This article focuses on the heat supply market in Russia, which operates under a regulated framework due to its classification as a natural monopoly (State Duma of the Federal Assembly of the Russian Federation, 1995). The current methodology for calculating connection fees, based on the unit of connected load, often results in inefficiencies, such as inflated costs for short-distance connections and inadequate incentives for sustainable infrastructure planning. These issues underscore the need for a revised approach that aligns financial practices with ecological and economic goals.

The study proposes a new methodology for calculating connection fees based on the length of the installed heating network. This approach aims to minimize the discrepancy between connection costs and revenues, reduce environmental impacts by optimizing resource use, and improve transparency for all stakeholders. By transitioning to a length-based fee structure, the methodology seeks to balance the interests of heat supply organizations and consumers while fostering a more sustainable heating infrastructure.

The high costs and inefficiencies in utility connections, particularly in the energy and utility sectors, present significant barriers to economic development and sustainability. Increasing transparency and reducing costs in utility connections have been emphasized as key to enhancing regional investment attractiveness and infrastructure accessibility (Smirnov, 2023; Sivaev and Smirnov, 2023; Kokovikhin, Ogorodnikova, Williams, Plakhin, 2018). Kotov (2012) highlights the critical role of infrastructure accessibility in entrepreneurship development, a sentiment echoed in studies on regional investment potential (Bereznev et al., 2011; Abukaev and Bocharov, 2020).

In the energy sector, researchers focus on enhancing connection efficiency and reducing cross-subsidization, which often disproportionately affects lower-income groups (Starodubtseva, 2020). The regulatory frameworks for improving utility connections, particularly heating systems, remain fragmented and lack comprehensive methodologies to balance ecological and economic interests (Chebotnyagin and Stashkevich, 2021; Rusalenko, 2022).

This article addresses these gaps by proposing a length-based methodology for calculating connection fees in heating systems. This approach aligns with sustainable development goals by optimizing resource allocation, improving transparency, and fostering an equitable balance between economic and environmental interests. By building on existing studies and regulatory critiques (Dolmatov, 2015; Ivanishin and Khamidullin, 2020), this research provides a framework for sustainable infrastructure in the heating sector, contributing to the broader discourse on utility connections and sustainability.

MATERIAL AND METHODS

Methods

Given the research objective and the pursuit of an answer to the posed research question, we use quantitative and qualitative methods to develop and substantiate the methodology for calculating connection fees to heating systems. We adopt an approach that addresses the root cause of the disputes in this area by conducting a Root Cause Analysis (Andersen and Fagerhaug, 2006; Pedada, 2023).

The following methods were utilized in the course of the research:

1) The analysis of the regulatory framework concerning utility connections and its practical implementation. This involved a thorough examination of relevant laws to assess the current basis for calculating connection fees. The practical application of these laws was also evaluated by reviewing their implementation by heating companies and regulatory bodies.

2) The analysis of data from the heating supply company PAO “MOEK” related to tariff calculation in utility connections from 2016 to 2018. These data serve as a quantitative justification for the need to transition to a methodology for calculating connection fees based on the length of the installed heating network. The selection of data from this specific time period allows for a relevant analysis of the developed methodology without compromising the commercial interests of the organization.

The calculation of rates for the new methodology project was based on the approved investment program of PAO “MOEK” concerning utility connections for 2017-2020. The sources of initial data included:

- Adjustment of the investment program of PAO “MOEK” No. 22 as of June 20, 2016;
- Planned facilities to be commissioned in 2017;
- Facilities with existing cost estimates for design and survey work (PIR) and construction and installation work (SMR). The total sample included 395 facilities.

3) Conducting in-depth interviews with experts responsible for setting connection fees from the side of resource-supplying organizations (heat supply and heat network companies), leading developers in the Russian Federation (applicants), and regulators who determine the connection fee (tariff committees).

The interviews were conducted in March 2023 (during the FAS Russia seminar in Sochi) with the participation of three experts. The experts were asked to provide detailed answers to the question: “Do you consider the length-based methodology to be more economically justified when determining connection fees in the heating supply sector?”. During the interviews, questions were also posed regarding the current regulatory framework in the studied

area: “What problematic areas of the market do you currently observe? In your opinion, what could be the main improvements to the existing regulatory framework?”.
4) A case study was conducted on the construction of a residential quarter in Moscow with a connected load of 10 Gcal/h (approximately 100,000 m² of heated area).
5) The proposed tariff range was developed and the financial implications of transitioning to the new methodology for PAO “MOEK” were modeled, based on the objects in the sample under consideration.
This part of the study was conducted using the following mathematical iterations:

- The allocation of costs from estimates for design and survey work (PIR) and construction and installation work (SMR) based on the diameters of the installed networks;
- The calculation of the connection tariff per meter by diameter groups: summing the lengths of the installed networks by diameter groups and dividing the costs obtained in step 1 by the corresponding total lengths;
- The comparison of the calculation based on current tariff rates (income and expenditure) with the values obtained in step 2.

6) Comparative analysis of methodologies for calculating connection fees to other natural monopoly resources (electricity, water supply and sewage, gas supply).

Analysis of Expert Responses

Based on the results of in-depth interviews with experts, Table 1 was compiled comparing the two methods of connecting to the heating system.

Table 1. Comparison of technological connection methods.

Two methods of technological connection: Depending on: – Presence/absence of technical connection capability; – Availability of approved standardized rates from the utility provider.		
	At standardized rates	Individually
	+ Prompt conclusion of the technological connection contract (20 working days)	+ Connection fee = Costs of connecting the facility
+	+ Fixed term of contract execution – 18 months	+ Possibility of establishing connection dates by agreement of the parties
	+ Universal pricing formula	+ Possibility of establishing a financing schedule by agreement of the parties
	- There may be situations when the fee for the technological connection is higher than the costs of connecting the facility	- Long term of the technological connection contract (from 3 months)
-	- Difficulty in challenging the approved tariff rates by the regulatory authority	- When adjusting the loads, it is necessary to reapprove the connection fee
	- Fixed payment schedule under the contract (15%, 50%, 20%, 15%); 65% must be paid 3.5 months after the conclusion of the contract	- When changing the building parameters (connection points), it is necessary to reapprove the connection fee

In Table 1, the pros and cons are presented from the perspective of the applicant, i.e., the developer or the person paying for the connection service. It is crucial to analyze the pros and cons of the connection fee from this viewpoint as the applicant is in the most vulnerable position, being the consumer of a naturally monopolistic service. Therefore, the applicant’s interests should be prioritized when developing industry regulations.
When commenting on Table 1, it is important to focus on the key advantages and disadvantages of each connection method. The main advantage of connection using standardized rates is the speed of connection compared to individualized connection methods. If we analyze the methodology of the widely recognized World Bank Business Ready (B-Ready) rating (The World Bank Group, 2023), one of the areas of analysis and comparison is the process of technological connection to the engineering infrastructure. This rating only considers electricity connection and does not include heating supply. However, the issue remains as the speed of connection to infrastructure is recognized as critically important for economic development, according to the Ministry of Economic Development of the Russian Federation (2018). Returning to the methods of technological connection, connection using standardized rates is significantly faster than individualized connection methods. According to Clauses 35-40 of the Connection Rules approved by Resolution of the Government of the Russian Federation No. 2115 (Government of the Russian Federation, 2021), the conclusion of a technological connection agreement using standardized rates takes up to 20 working days (1 calendar month), while the process using individualized rates can extend to 40-60

working days (2-3 calendar months). The significant difference in connection times between the two methods stems from the fact that the individual connection fee must be established by a regulator, namely the regional executive authority responsible for setting prices within the region (the Tariff Committee). This involves analyzing the documentation submitted by the utility provider, the process of approving a regulatory act that sets the connection fee, and the time required for its official publication. In contrast, standardized rates, though approved annually, apply uniformly throughout the year to all applicants (provided there is technical feasibility). Given that the profitability of development projects often depends on the speed of their implementation, particularly in the context of credit project financing, the timelines for connection become a critically important factor in determining the success or failure of a project. As a result, most applicants prefer the standardized rate calculation to shorten the connection timeframes. The main advantage of the individual connection fee lies in its complete economic justification and relevance to the specific project. An applicant who opts for a fee can be confident that the fee set by the regulator is equal to the actual cost of the activities necessary to connect the specific object (or multiple objects submitted as part of a collective application). This calculation methodology is outlined in the Order of the Federal Tariff Service of the Russian Federation (FST) No. 760-e (Federal Tariff Service of the Russian Federation, 2013b) which defines the connection fee as follows (Clause 171):

$$C_k = C_1 \times \text{P}_k^{connect} + C_2 + C_3 + \text{H} \times \text{P}_k^{connect} \textit{ (thousand rubles)} \quad (1)$$

where:

C_1 *is expenses for carrying out activities to connect applicants' facilities (management expenses attributable to this activity);*

$\text{P}_k^{connect}$ *is the connected heat load of the k applicant's facility, Gcal/h;*

C_2 *is expenses for the creation (reconstruction) of heating networks;*

C_3 *is expenses for the creation (reconstruction) of thermal energy sources;*

H represents the profit tax attributed to the connection fee measured in thousand rubles per Gcal/h.

From formula (1), a conclusion can be drawn: the connection fee calculated on an individual basis equals the costs incurred for connecting a specific object. This is the main advantage of this connection method as the applicant pays exactly what it costs to create the necessary infrastructure to ensure reliable and quality heat supply.

However, the individual fee is approved by the regional pricing (tariff) regulatory body, making the process more time-consuming. This extended timeline is the main drawback of this method of technological connection.

What is the main advantage of one connection method becomes the downside of the other. Thus, we approached the main topic of this article, i.e., the key downside of the fastest method of technological connection from a time perspective, namely, connection at standardized rates. The opposite of determining the connection fee based on the expenses of a specific project is determining the fee based on the average expenses across all connection projects conducted by the utility company during the reporting period. This is how the standardized fee for technological connection is determined (Clause 170 of the Methodological Guidelines).

$$C = C_1 + \sum_{i,j} C_{2.1,i,j} + C_{2.2} + \text{H} \textit{ (thousand rubles/Gcal/h)} \quad (2)$$

where:

C_1 *is expenses for carrying out activities to connect applicants' facilities.*

$$C_1 = \frac{Exp_1^{connect}}{\text{P}^{connect}} \textit{ (thousand rubles/Gcal/h)} \quad (3)$$

where:

$Exp_1^{connect}$ *is planned expenses for carrying out activities to connect applicants' facilities for the next billing period;*

$\text{P}^{connect}$ *is planned total connected heat load of applicants' facilities for the next billing period (Gcal/h);*

$C_{2.1,i,j}$ is expenses for the creation (reconstruction) of heating networks (except for the creation (reconstruction) of heating points) of the i range of diameters of the j type of installation according to the formula:

$$C_{2.1,i,j} = \frac{Exp_{2.1,i,j}^{connect}}{\text{P}_{i,j}^{connect}} \textit{ (thousand rubles/Gcal/h)} \quad (4)$$

where:
$Exp_{2.1.i,j}^{connect}$ *is planned expenses for the creation (reconstruction) of heating networks (except for the creation (reconstruction) of heating points) of the i range of diameters of the j type of installation (including design) for the next billing period;*
$P_{i,j}^{connect}$ *is planned total connected heat load of applicants' facilities for the connection of which it is necessary to create (reconstruct) heating networks of the i diameter range of the j type of installation (Gcal/h) for the next billing period;*

$C_{2.2}$ is expenses for the creation (reconstruction) of heating points from existing heating networks or heat energy sources to the connection points of applicants' facilities.

$$C = \frac{Exp_{2.2}^{connect}}{P^{connect}} \text{ (thousand rubles/Gcal/h)} \quad (5)$$

where:
$Exp_{2.2}^{connect}$ *is planned expenses for the creation (reconstruction) of heating stations for the next billing period;*
$P^{connect}$ *is planned total connected heat load of applicants' facilities for the next billing period, whose connection requires the creation (reconstruction) of heating points;*

H is income tax related to the connection fee calculated using the formula:

$$H = \frac{Exp^{H}}{P^{connect}} \text{ (thousand rubles/Gcal/h)} \quad (6)$$

where:
Exp^{H} *is planned expenses for connected objects for income tax related to the activity of connecting to the heat supply system for the next billing period;*
$P^{connect}$ *is planned total connected heat load of applicants' facilities for the next billing period (Gcal/h).*

The regulatory period is typically considered to be either one calendar year or the duration of the approved investment program related to connections, which could be three or five years. From the described formula, several conclusions can be drawn:

- The formula implies the calculation of rates per 1 Gcal/h of connected load;
- The rates are differentiated based on the diameters and methods of laying the heating network and are calculated based on the total costs of creating heating networks/thermal stations;
- The rate represents the average cost for a specific type of laying and diameter of the heating network per unit of connected load (1 Gcal/h);

To better illustrate and understand what the tariff options for connections to the heating system, we need to consider an example from the largest heating supply organization in Russia, PAO "MOEK" (Moscow United Energy Company – the unified heating supply organization for Moscow) (Federal Tariff Service of the Russian Federation, 2013a). Calculation of the fee for connecting capital construction projects of applicants, including developers, per unit of power of the connected heat load with differentiation by types of installation and ranges of diameters of heating networks.

RESULTS

Results of a case analysis of the construction of a residential area

The cost of the connection fee will be calculated inversely to the formula for calculating connection rates under Clause 170 of the Methodological Guidelines, i.e., by multiplying the rates by the connected load:
C = 167.66543 x 10 + ∑(d200k + d200bk + d300k + d300bk) x 10 + 2,853.82283 x 10 + 232.07653 x 10 = 208,032.0279 thousand rubles without VAT = 249,638.43348 thousand rubles with VAT*
*For example, two groups of diameters are taken (up to 250 mm and 251-400 mm) with due regard to the conditional calculation of the volume of the heating network required to pass 10 Gcal/h of load.
To connect a residential area of 100,000 square meters in Moscow, the connection fee to the heating system amounts to approximately 250 million rubles, including VAT. Based on the described example, we reveal the following logical contradiction that is of scientific interest: The example of calculating the connection fee does not depend on

the actual length of the heating networks required to connect a new development site. This means that even if the heating company only needs to lay 10 meters of pipeline to the connection point of the building, the applicant will still pay the full cost for the connected load. The cost of construction and installation work for laying these 10 meters of a heating network will be significantly lower as it depends on the length of the pipeline. We view this as the main shortcoming of the existing methodology and, in the following sections of this article, will attempt to justify the need to introduce a fee based on the length of the network being laid, instead of the current version that assumes calculation based on the connected load.

Comparison with the Methods of Calculating Fees for Connection to Other Resources of Natural Monopolies

In April 2023, during a seminar held by the Federal Antimonopoly Service (FAS) of the Russian Federation in Sochi, a presentation was made by a representative of the Moscow regulatory body (Department of Economic Policy and Development). The presentation compared various methods for calculating connection fees across different regulatory sectors and connection procedures. We consider the comparison presented in that presentation helpful and clear for the reader. Therefore, excerpts from the presentation are included in this article.

To answer the main question of this article (*Why is the connection fee to heating systems calculated based on the unit of connected load?*), it is important to focus on the top row of the presented analysis (highlighted in red). Across all connection types, including gas supply, water supply and wastewater disposal, and electricity supply, the connection fee is calculated based on the length of the laid networks (rubles per meter or rubles per kilometer), except in the case of heating systems, where the fee is based on the unit of connected load (rubles per Gcal/h).

How to explain this logic for the heating sector? When the connection fee is calculated based on load, the cost of connection for the applicant does not depend on the distance of the object from the heat source. It is beneficial for the applicant to connect objects far from the heat source (as the connection fee will be lower than the economically justified expenses for construction and installation work required to lay networks to the connection point). The centralization of heating systems would be encouraged, theoretically increasing the load on heat sources. At first glance, heating organizations should also be interested in this. In practice, heating organizations lack incentives to connect distant objects when the connection fee is calculated based on load (these projects will be unprofitable). Instead, heating organizations have far greater economic incentives to connect over shorter distances (since the connection fee will exceed the construction and installation costs for such projects). As a result, when the connection fee is calculated based on connected load, there is an inflated connection fee for applicants located at short distances from existing heating networks, and heating organizations are motivated to delay the connection process for distant objects as much as possible to save money.

In our opinion, the arguments presented above are sufficient to move on to the next part of the article, i.e., developing an improved methodology for calculating connection fees based on the length of the heating network.

Updated Methodology for Calculating Connection Fees Based on the Length of the Heating Network Being Laid

It is necessary to adjust the $C_{2.1}$ parameter that is used in the formula for calculating the fee for connection to heat supply systems (expenses for the creation (reconstruction) of heat networks):

$$C^{II} = C_1 + \sum_{i,j} C_{2.1,i,j} + C_{2.2} + \mathrm{H} \tag{7}$$

$$CC = \mathrm{T}^{C,\mathrm{M}} \times \mathrm{M} + \sum \mathrm{T}^{\mathrm{M}}_{i,j} \times \mathrm{M} + \mathrm{T}^{\mathrm{TC}} \times \mathrm{M} \text{ (methodology for 1 Gcal)} \tag{8}$$

$$CC = \mathrm{T}^{C,\mathrm{M}} \times \mathrm{M} + \sum \mathrm{T}^{cp}_{d} \times L_{id} + \mathrm{T}^{\mathrm{TC}} \times \mathrm{M} \text{ (methodology for 1 m)} \tag{9}$$

where:

CC is a fee for connecting a specific applicant's facility to the centralized heat supply system (rubles);

$\mathrm{T}^{C,\mathrm{M}}$ *is a tariff rate for the connected load to the heating network (rubles/Gcal/h);*

M is the connected load (power) of the applicant's facility determined based on the application (Gcal/h);

T^{i}_{d} *is a tariff rate for the length of the heating network of the i range of id diameters (rubles/m);*

L_{id} *is the total length of the heating network of i diameter range from the connection point of the applicant's facility to the connection point to the facilities of the centralized heat supply system (m);*

T^{TC} is the tariff rate for the creation (reconstruction) of heating points from existing heating networks or heat energy sources to the connection points of applicants' facilities, if there is a technical possibility of connection.

$$T^{C,M} = \frac{\sum P^{M}}{\sum M} \quad (10)$$

where:
P^{M} *is planned expenses for carrying out activities to connect applicants' facilities for the next billing period (thousand rubles);*
M *is the planned total connected heat load of applicants' facilities for the next billing period (Gcal/h).*

If the connection is based on the laying of heating networks of different diameters, the rate for the length of the heating network is calculated for each range of diameters using the coefficient of differentiation of the cost of construction of networks depending on their d diameter. The tariff rate for the length of the heating network is calculated using the formula:

$$T^{l}_{id} = T^{l} \times C_{id} \quad (11)$$

$$T^{l} = \frac{\sum P^{P}_{id}}{(1-t_{l}) \times \sum L_{id}} \quad (12)$$

where:
T^{l} *is the base rate of the tariff for the length of the heating network, i range of diameters (rubles/m);*
P^{P}_{id} *is planned expenses for the creation (reconstruction) of heating networks (except for the creation (reconstruction) of heating points) of the i range of diameters from existing heating networks or sources of thermal energy to the connection points of applicants' facilities, if technically possible, for the next billing period (thousand rubles);*
L_{id} *is the total length of the heating network of the i range of diameters (mm);*
t_{l} *is an income tax rate determined according to the Tax Code of the Russian Federation;*
C_{id} *is the coefficient of differentiation of the cost of construction of networks depending on their d diameter.*

If the connection is based on the creation (reconstruction) of heating points, the tariff rate for the creation (reconstruction) of heating points is calculated using the formula:

$$T^{TC} = \frac{\sum P^{TC}}{\sum M} \quad (13)$$

where:
P^{TC} *is planned expenses for the creation (reconstruction) of heating points from existing heating networks or sources of thermal energy to the connection points of applicants' facilities, if there is technical possibility of connection, for the next billing period (thousand rubles);*
M *is the planned total connected heat load of applicants' facilities where it is necessary to create (reconstruct) heating points (Gcal/h) for the next billing period.*

To summarize the changes in the formulas, they come down to changing the calculation unit of both the tariff rates approved by the regulator for the next period, and the formula for calculating the fee for connecting the applicant's facilities. The unit for calculating the fee for connecting to the laying of a heating network changes from Gcal/h of the connected load to the meters of the laid heating network.

Justification for the Transition to the Proposed Methodology

Based on the analysis of data from PAO "MOEK" for the period from 2015 to 2018, two matrices were formed for each of the proposed methodologies, where:
– The x-axis represents capital expenditures on the project (construction and installation costs);
– The y-axis represents the connection fee (the revenue component for the heating supply organization).
A diagonal line running through the center of the matrix represents the axis where revenues from technological connections would equal expenses, meaning the financial result for the projects would be zero.
Thus, all projects below this line have a positive financial result for the heating supply organization, while all projects above the line have a negative result.
The financial results of projects calculated using the per-meter methodology deviate less from the diagonal one (which represents a zero financial result). This is evident when examining a sample of projects with costs up to 40 million rubles, where the deviation from the horizontal line is smaller both in terms of connection costs and connection fees.

The transition to the per-meter methodology allows for a much closer alignment between the cost of the necessary connection activities and the connection fee paid by the applicant.

The applicant has the following advantages:

- A more justified (fairer) connection fee;
- A reduced likelihood of artificial delays in the connection process by the utility provider;
- The possibility to optimize the connection fee by negotiating shorter routing of the networks (e.g. by passing through neighboring land plots).

The utility provider gets the following benefits:

- Fewer questions from applicants regarding the justification of the connection fee calculation (reduced legal risks);
- Lower risk of incurring losses from long-distance connections;
- Incentive for applicants to declare the fare connected load (under the current fee calculation methodology, applicants often try to minimize the load to reduce the connection fee).

Finally, the advantages for the regulator are as follows:

- A reduced number of disputes concerning the justification of connection fee calculations and the application of rates per unit of connected load;
- Lower likelihood of losses for utility companies from technological connections, which need to be factored into the main heat supply activities (the tariff for thermal energy);
- A clearer and more transparent process for approving rates for technological connections, with the possibility of relevant comparisons across the Russian regions and construction costs approved by the Ministry of Construction of the Russian Federation.

The Proposed Tariff Options According to the New Methodology and Comparison of the Financial Result for Activities in Terms of Technological Connection of PAO “MOEK” A tariff option when switching to a method for calculating the fee for one linear meter of the laid heating network is as follows (Table 2).

Table 2. Proposed form of tariff list.

Tariff options according to the method for 1 running meter of the network (excluding VAT)	
Underground laying of heating network in two-pipe calculation	
	Rate, rub/1 running meter
up to 250 mm (Reference range)	122,346.90
Coefficients for other ranges	
251-400 mm	1.16
401-550 mm	1.68
551-700 mm	2.50
700 mm and higher	3.60

It is proposed to establish uniform rates for connection fees per one meter of heat network laid for a range of pipe diameters up to 250 mm. The other diameter groups should remain similar to the current version of the tariff options presented in Table 2, with conversion factors set to adjust the networks to the required diameter range. These options are expected to be updated annually to account for the actual dynamics of material and installation costs for heat networks.

Modeling the Financial Consequences of the Transition to a New Methodology for PAO “MOEK”

A quantitative analysis of PAO “MOEK” data for 2017-2020 allows us to compare methods and their financial consequences for the company (Table 3).

Table 3. Comparison of financial results for projects of PAO “MOEK” for 2017 using the two methods.

	According to the method for 1 Gcal/h	According to the per-meter method
Income (rubles)	9,674,579,363.39	10,978,153,722.61
Capital expenditures (rubles)	10,399,602,640.65	10,399,602,640.65
TOTAL	-725,023,277.26	578,551,081.96

Thus, based on the planned commissioning of PAO "MOEK" facilities in terms of utility connections for 2017, the transition to the new methodology would eliminate the negative financial results for these projects. Based on the data, we can make an unambiguous conclusion that heat supply organizations are interested in switching to the new methodology for calculating connection fees.

Discussion. The analysis confirms that the proposed methodology for calculating connection fees is more advanced, reducing the average deviation between revenue and expenditure while balancing the interests of all stakeholders. This supports the hypothesis that transitioning to a length-based methodology enhances sustainability and economic fairness. Despite its benefits, the existing methodology-based on connected load-remains favored by major heating organizations for its simplicity and ability to lower costs for long-distance connections within the effective heating radius. Krikser et al. (2020) highlight that aligning investment programs with urban development plans can mitigate business risks and ensure competitive connection costs. However, the load-based methodology often leads to inefficiencies, such as inflated fees for short-distance connections and underutilized centralized heating systems. In contrast, the length-based approach optimizes resource use and promotes sustainable infrastructure development, aligning with international practices like Italy's emphasis on energy efficiency (Calise et al., 2021). For collective connections, the load-based methodology simplifies cost distribution but may unfairly burden applicants with higher loads. The proposed mixed approach-distributing costs for shared pipelines by length and branch lines per meter-ensures fairer allocation of expenses, particularly for diverse applicant needs. This strategy also aligns with findings by Dolmatov et al. (2022), who emphasize the need for updated methodologies to improve transparency and sustainability. The transition to a length-based methodology faces regulatory barriers, requiring updates to legal frameworks and stakeholder cooperation. While challenging, these changes are essential to address systemic inefficiencies and support broader sustainability goals. By improving cost transparency and aligning fees with actual resource use, the proposed methodology offers significant potential for enhancing the ecological and economic efficiency of heating systems in Russia.

CONCLUSION

This article achieves its objective of proposing a more equitable and sustainable methodology for calculating utility connection fees in the heating supply sector. By transitioning to a length-based methodology, it addresses inefficiencies in the current system, promoting resource optimization, cost transparency, and ecological balance.

The research highlights the advantages of the length-based approach, including fairer cost distribution, reduced environmental impact, and improved investment conditions. The methodology aligns with sustainability goals by accelerating connections, fostering competition, and minimizing revenue risks for heating organizations. At the micro, meso, and macro levels, it supports informed decision-making, regional tariff harmonization, and broader economic growth through faster infrastructure access and investment stimulation.

The updated methodology represents a significant step toward sustainable infrastructure in the heating sector, reinforcing its role in fostering economic and environmental development. By improving transparency and predictability, it enhances competitiveness and sets a foundation for future reforms in utility connections.

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