State and prospects of providing Russian rural areas with engineering life support systems

S V Levushkina 1, O M Lisova 1, I G Sviştirnova 1, O A Shutova 2

1Stavropol State Agrarian University, 12, Zootechnicheskiy lane, 355017, Stavropol, Russian Federation
2 Saint Petersburg state University of Architecture and Civil Engineering, 4, 2nd Krasnoarmeyskaya lane, 190005, Saint Petersburg, Russian Federation

E-mail: Kirachek@mail.ru

Abstract. The article establishes the relationship between the favorable living environment in rural areas and the level of housing equipment with engineering systems. The analysis of the condition of residential premises in rural areas in terms of the level of their provision with life support systems is carried out. The problems of low level and quality of rural housing improvement are identified. The reasons that prevent the formation of comfortable conditions for providing housing with life support systems, namely centralized engineering networks, are identified. Using statistical forecasting methods, an inertial variant of changing the target indicators of residential improvement in rural areas of Russia by types of life support systems, taking into account the existing level, is created.

Keywords: rural areas, development programs, engineering networks, housing improvement.

1. Introduction
One of the distinctive features of rural areas is that most of the rural areas are occupied by individual houses with outbuildings, dispersed over large areas. Therefore, the maintenance of housing and communal services in rural areas is more expensive than in the city as the unit costs for the technical operation of housing facilities due to objective reasons (scattering of objects, large length of communications per unit of produced municipal products, etc.) is much higher. For the same reasons, the specific capital investment for the development of engineering infrastructure in rural areas (per inhabitant or 1 m² of area) is higher than in urban areas. As a result, the level of provision of housing in rural areas with centralized life support systems is lower than in the city.

The housing stock is considered well-maintained if the total area of residential premises is provided simultaneously with water supply, drainage (sewerage), heating, hot water, gas (mains or liquefied) or electric stoves. The housing stock is considered provided with this or that type of improvement and in those cases when this or that type of improvement is inactive, for example, due to repairs. Indicators of the improvement of residential premises are not just equivalent, but, perhaps, superior to the size of the area in importance, a characteristic, since they determine not only the comfort, but also the safety of living, shaping a favorable living environment.

The availability of housing with life support systems in rural areas is determined by a number of factors, such as the economic opportunities of individual rural areas and the social priorities of agribusiness, the personal well-being of rural residents and budget constraints, individual preferences of the population and state strategies, the combination of private and public interests, etc.
2. Results

The level of provision of residential premises in rural areas with life-support systems has increased in recent years. During the period 2010-2019 there is a systematic increase in the share of the total area provided with certain types of home improvement due to an increase in federal and regional funding for the development of engineering communications in rural areas. Thus, the share of the total area of rural housing stock equipped with water supply in 2019 was 61%, water disposal (sewerage) – 50%, heating-69 %, gas (network, liquefied) - 73%, hot water-35% [1]. However, the territorial differentiation of housing improvement indicators by federal districts of the Russian Federation and their subjects in rural areas in 2019 has a significant difference.

At the same time, the share of the total area equipped with water supply, sewerage, heating, hot water, and gas in rural areas in 2019 averaged only 36.3%, which is almost 2 times lower than in Russia as a whole.

Despite the increase in the level of housing improvement in rural settlements, there is a decrease in the number of individual infrastructure objects put into operation in rural areas. During the period 2010-2019, the commissioning of water supply networks in rural areas decreased by 39.5%, gas networks – by 43.2%, and electricity transmission lines for agricultural electrification by 41.2% with a voltage of 0.4 kV and 58.6% with a voltage of 6-20 kV.

Mobile communication and wireless Internet are available almost everywhere, so the wired telephone network is losing its relevance, which determines a sharp drop in the number of PBX numbers. It should be noted that the introduction of paved roads of general use of local, regional or inter-municipal significance increased by 13.3% and non-public use in agriculture-by 61.3%. Such results in the field of road construction were achieved through the implementation of the State Program of the Russian Federation "Development of the transport system".

Against the background of a decrease in the level of commissioning of the centralized water supply system in rural areas, there is an increase in the single length of the street water supply network for the period 2010-2019 by 13.7%, while the production capacity of water supply systems increased by 19.5%. This trend is determined by the solution of the issues of water supply for individual housing at the expense of the resources of the population itself when connected to the main networks.

During the study period, the need in replacing the street water supply network increased by 17.1%, caused by the deterioration of pipes due to corrosion, which leads to water loss, a decrease in its quality and accidents. On average, more than 44% of water supply networks in the regions are subject to replacement. At the same time, there is a decrease in the number of water supply accidents by 67.6% due to local repairs, but not as a result of solving systemic problems of reconstruction of main water supply and sanitation networks in rural areas.

Water supply indicators for the federal districts of the Russian Federation are shown in Figure 1.
Figure 1. Indicators of the quantity and quality of water supply in the federal districts of the Russian Federation in 2019 [2]

The largest number of settlements that do not have water pipelines (separate water supply networks) is located in the North-Western (69.84%) and Far Eastern (63.83%) federal districts. The North Caucasus Federal District has a high level of provision of rural settlements with water supply, in which 86.63% of settlements are provided with water supply, which is due to the water resource potential of the district, which fully meets the needs of the population and sectors of the economy in water resources.

Despite the growth of the single length of the street water supply network, the problem of its replacement remains in the settlements of rural areas of the districts of Russia. The highest level of needs in the replacement of a single stretch of street water supply network is observed in the Central (from 49.04%), high number of settlements that do not have water (51.98%), and the low level of renewal of a single stretch of the street water supply network (1.8%) and South (47.74%), which indicated low level of updates of the water distribution network (3.83%) and a high level of water supply network need to be replaced (47.74%) in federal districts.

Special attention should be paid to the subjects of the Russian Federation that have a significant need for water supply due to the presence of settlements that do not have water supply (separate water supply networks) - more than 60% of the total number of settlements in the subject. The current situation in these regions requires the development and implementation of projects for the construction and commissioning of water supply systems and the search for sources of funding at the federal and regional levels.

An equally important issue in providing rural areas with life support systems is the availability of sewerage (water disposal). In 2010-2019, in rural areas, there was an increase in the single length of the street sewer network by 16.2%, while the level of utilization of the capacity of sewage treatment plants decreased from 23.7% to 18.0%, with a slight increase in the capacity of treatment plants by 5.8%. The replacement of the sewer network still remains the problem, the need for which has increased by 36.2%. According to the results of a comprehensive monitoring of the living conditions of the population by Rosstat for 2018, 66.5% of Russians living in rural areas do not have centralized sewerage. Including 48.1% of families in the villages who use cesspools, and 18.4% do not have a sewer at all [3].

The indicators of the quantity and quality of the sewer network for the federal districts of the Russian Federation in 2019 are shown in Figure 2.
Figure 2. Indicators of the quantity and quality of the sewer network in the federal districts of the Russian Federation in 2019 [2]

In the Russian Federation, 76.93% of rural localities do not have a sewer network. The North Caucasus (46.63%) and Ural (43.52%) federal districts have the highest rates of provision of rural settlements with sewer networks. In the Central Federal District, the Moscow (98.82%), Belgorod (49.62) and Tula (49.45%) regions have the highest level of provision with the sewer network of rural settlements. The remaining federal districts in their composition have more than 70% of settlements that do not have sewers.

However, the existing sewer networks also need to be replaced, the need for which is more than 34% in the federal districts. In 2019, the highest level of replacement of the sewer network is typical for the North Caucasus (102.12%, taking into account the coverage of the demand for 2018) and the Southern (77.86%) federal districts.

Heat supply in rural areas can be carried out: centrally—from a heating or heating-production boiler house, with heat supply for a group of buildings; decentralized—from built-in house boiler installations and apartment generators.

There is a slight increase in the number of heat supply sources by 11.5%, while the length of heat and steam networks is reduced by 9.7%. Positive trends towards reduction were observed in such indicators as the length of heat and steam networks in need of replacement by 9.9% and the number of accidents at heat supply sources, steam and heat networks – by 76.8%. However, the share of heat energy losses in the total amount of heat supplied to the grid increased from 11.2% in 2010 to 13.6% in 2019.

It should be noted that decentralized heat supply continues to prevail in rural areas. Decentralized heat supply in rural areas is carried out with the help of stove heating, gas water heating auto-mated devices AGV-80 and AGV-120 with a water heating system, steam boilers with a steam heating system, air heating systems and electric heating systems. In the old residential buildings of rural settlements, stove heating has become the most widespread. Along with these common and traditional energy sources, geothermal water and solar energy can be used.

One of the main problems in rural areas is gasification. Rural localities currently have a low level of gasification, which is reflected in Figure 3 in the context of federal districts.
In Russia as a whole, the number of non-gasified settlements in rural areas in relation to their total number in 2019 was 59.1%. Such districts as the Siberian (88.48%), North-Western (82.65%) and Far Eastern (79.77%) federal districts have a particularly low level of gasification (more than 80%).

Summarizing the analysis we should draw a general conclusion about the existing level of provision of rural settlements systems (figure 4), because it should be taken into account when making decisions on the improvement of residential premises in rural areas taking into account the specifics as the Federal district, and the subject of the Russian Federation and the settlement.

Among the federal districts with the highest level of basic life support, the North Caucasus, Ural, Volga and Central federal districts should be noted, due to the higher population density and density of rural settlements in comparison with other federal districts.

To create a well-maintained environment in rural localities, the illumination of streets, drive-ways, and embankments in rural areas plays an important role (Figure 5).
On average, in Russia, the level of illumination of non-centralized streets, driveways, and embankments accounts for 50%. Such federal districts as the Central, Southern, North Caucasus, Siberian and Far Eastern Federal Districts have a level of illumination below the average in Russia. This situation indicates an insufficient level of favorable living environment in rural areas in terms of the comfort of lighting the territories adjacent to residential objects, while, of course, the entire housing stock of the Russian Federation is provided with electricity.

In general, in rural areas in Russia, only 14.58% of municipal solid waste is exported to facilities used for waste treatment (Figure 6).

![Figure 6. Level of municipal solid waste recycling in 2019 [2]](image)

The leader in the level of solid municipal waste processing is the Far Eastern Federal District (43.92%) at the expense of the Republic of Buryatia (71.48%). The North Caucasus Federal District occupies the second position (19.99%), the leaders are the Republic of North Ossetia-Alania (86.12%) and the Stavropol Territory (25.30%). The third position is occupied by the Siberian Federal District (11.84%) - the Kemerovo Region (32.84%), the Krasnoyarsk Territory (29.25%) and the North-Western Federal District (11.83%) - the Murmansk Region (66.33%), the Republic of Karelia (20.80%), the Leningrad Region (18.82%).

3. Discussion

As part of the implementation of measures aimed at stimulating housing construction in rural areas, one of the primary tasks is accessibility to life support systems, both for individual construction entities and for compact housing development.

Of course, providing the rural housing stock with life support systems is a significant cost item for all levels of the Russian budget. At the same time, in our opinion, the burden of this task falls on the federal and regional budgets. The main task of rural settlements is to develop projects for the improvement of ready-made housing with life-support systems, taking into account the existing needs for each type and corresponding plans for future housing construction in rural areas, taking into account the need to improve housing conditions.

Housing facilities in rural localities in Russia have all types of life support, but from different sources of supply (networks, autonomous and natural sources), and this does not mean that they are equipped with life support systems. The necessary level of housing equipment with life support systems should strive for 100%, while maintaining comfortable conditions for providing housing with life support systems and, of course, they are centralized networks: gas supply, water supply, heat supply, sewerage.

However, it is not possible to achieve such a result due to a number of reasons:

- various socio-economic conditions of rural development, peculiarities of cultural and historical traditions, national customs and way of life;
- different population density and density of rural localities in the subjects of the Russian Federation;
- features of natural and climatic conditions in various zones of the Russian Federation;
- differentiation of federal, regional and local budget funds for the construction of engineering communications;
- low level of interest of construction organizations in the construction of engineering communications.
According to the Strategy for Sustainable Rural Development of the Russian Federation for the period up to 2030, the share of the total area of residential premises in rural localities provided with all types of landscaping should reach 45%; the share of rural households with access to the Internet from a home computer-85%; the share of rural localities connected by paved roads with a network of highways-80% [4].

It should be noted that the actual level of provision of the total area of residential premises in rural settlements provided with all types of landscaping, as of 2019, reached 36.3% in Russia as a whole. According to the Strategy for Sustainable Rural Development of the Russian Federation for the period up to 2030, this indicator was planned to be achieved only in 2023.

4. Conclusion.

Given the current level of improvement of housing in rural areas, we should define the adjusted level which is presented in table 1. To define the future required level of improvement of housing in rural areas statistical forecasting methods, proven trend linear function (figure 7) were used and thus the inertial type of key targets’ changes for the period up to 2025 was built.

Table 1. Target indicators of improvement of residential premises in rural settlements by types of life support systems, %

| Name of indicator | 2019 fact | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|-------------------|-----------|------|------|------|------|------|------|
| Share of the total area of residential premises in rural settlements provided with all types of landscaping | Targets according to the Strategy for Sustainable Rural Development of the Russian Federation for the period up to 2030 | 36,3 | 32,6 | 33,7 | 34,8 | 36 | 37,2 | 38,4 |
| Projected necessary indicators for the improvement of residential premises in rural settlements with all types of life support systems, taking into account the existing level | - | 37,1 | 38,5 | 39,9 | 41,3 | 42,7 | 44,1 |

![Figure 7. Inertial type of changing the level of improvement of residential premises in rural settlements with all types of life support systems](image)

The departmental target program «Modern Appearance of Rural Territories» has established target indicators for life support systems for integrated rural development in the period up to 2025 [5]. Also, using statistical forecasting methods, an inertial version of changing the targets for the period up to 2025 is constructed, and table 2 shows the target and necessary indicators for improving residential premises in rural settlements by type of life support system, taking into account the existing level.
Table 2. Target indicators by types of life support systems for integrated rural development, %

| Target indicator/Target indicator | 2019 fact | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|----------------------------------|----------|------|------|------|------|------|------|
| The level of gasification of residential buildings (apartments) with gas in rural areas | | | | | | | |
| Target indicators according to the Departmental target program «Modern appearance of rural territories» | 74 | 60,2 | 61,7 | 64,5 | 66,7 | 69,9 | 71,1 |
| Projected necessary indicators of improvement of residential premises in rural settlements by type of life support system, taking into account the existing level | - | 74 | 74 | 74,3 | 74,4 | 74,5 | 74,7 |
| Level of provision of the rural population with drinking water (water supply) | | | | | | | |
| Target indicators according to the Departmental target program «Modern appearance of rural territories» | 63 | 67,9 | 71,6 | 74,7 | 76,3 | 77,9 | 79,5 |
| Share of housing stock in rural areas provided with sewerage | | | | | | | |
| Target indicators according to the Departmental target program «Modern appearance of rural territories» | 52 | 49,7 | 51,8 | 54,1 | 56,8 | 59,5 | 62,2 |
| Projected necessary indicators of improvement of residential premises in rural settlements by type of life support system, taking into account the existing level | - | 52,8 | 54,4 | 55,9 | 57,5 | 59,5 | 62,2 |

To achieve the necessary level and equipment of housing with life support systems, taking into account the existing level of improvement, it is necessary to implement a number of complex measures [6]:

1. introduction and widespread use of autonomous systems of engineering provision for rural housing (autonomous power plants, autonomous gas supply, etc.);
2. ensuring the reliability of the power grid complex, reducing the cost of transmission and distribution of electricity through the introduction of advanced technologies for maintenance and repair of power grid equipment, switching to a higher voltage class of distribution networks, as well as non-traditional energy sources (solar panels, wind power plants, biogas plants, etc.);
3. use of heating sources taking into account the climatic conditions and the natural resource base regions, modernization of existing and construction of new facilities for the production and transmission of thermal energy, and energy-saving technologies in the production of heat and the widespread development of energy-efficient systems of autonomous heating;
4. reconstruction and development of centralized water supply systems, high-efficiency equipment and materials for water intake, transportation and treatment in order to improve the technical condition of water supply facilities, as well as reduce losses and improve the quality of water supplied to consumers;
5. accelerating the reconstruction of existing and construction of new wastewater transportation and treatment facilities; implementing high-efficiency technologies, energy-saving equipment and materials for wastewater transportation and treatment, including autonomous wastewater treatment plants,
as well as ensuring a high level of technical condition of wastewater disposal facilities and improving the quality of services provided to consumers;

6. providing rural settlements with a permanent year-round connection to the network of public roads on paved roads, as well as more active use of the existing network of railways and water transport.

References
[1] Housing in Russia 2019 Stat. sat./ Rosstat 78 p.
[2] Rural territories of the Russian Federation: stat. collection 2019 Rural territories (rosstat.gov.ru)
[3] Results of comprehensive monitoring of the living conditions of the population Federal statistical observations on socio-demographic problems (rosstat.gov.ru)
[4] About the approval of the «Strategy of sustainable development of rural territories of the Russian Federation for the period up to 2030»: Order of the Government of the Russian Federation of 02.02.2015 N 151-r (ed. of 13.01.2017)
[5] About the approval of the departmental target program «Modern appearance of rural territories»: Order of the Ministry of Agriculture of the Russian Federation of 20.04.2020 N 214
[6] State Program of the Russian Federation «Integrated development of rural Areas»: Resolution of the Government of the Russian Federation of 31.05.2019 N 696