The roadside infrastructure development: a geographical view

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Abstract. The roadside infrastructure has begun to form recently and is accompanied by different problems. These problems are common to many Russian regions, in particular Irkutsk Oblast. In this article, the authors share their experience in studying roadside infrastructure with the aim to improve the existing network and rational placement of new objects as well as prospects for developing roadside infrastructure in Russia as a whole. This publication is a continuation of our long-term research and the scientific novelty consists in the generalization of the results and comparison of various foreign models of road infrastructure development. In this study, we used the methods developed and tested in our previous works. This study is one of the first in Irkutsk Oblast, and the accumulated material can serve as a basis for creating a comprehensive scheme for the optimal placement of roadside infrastructure. We identified the main factors and problems of the roadside infrastructure development, made mathematical calculations, and compiled original thematic maps. As a result of the study, we came to the conclusion that the Irkutsk Oblast that has a rich natural, socioeconomic, and energetic potential can be a good testing ground for the successful application of the existing foreign roadside service development systems (European or North American).

1. Introduction
Contemporary economic conditions in Russia have been experiencing greater influence on relations between producer and consumer. Producer market has been gradually replaced by the consumer market. In that regard, the service sector is becoming increasingly important. Some services have a specific impact on cultural, business, and economic aspects of social development. Roadside infrastructure is one of them.

However, the roadside infrastructure in Russia has many various problems: lack of filling stations on the road, as well as lack of some diagnostics, repair and maintenance services, catering services, hotel, information services, trade, communication services, etc. Many services, including information, communication, medical services, leisure, and car rental are not sufficiently developed [1]. Moreover, most of the existing roadside infrastructure facilities do not meet modern requirements for safety and comfort [2]. These findings confirm the relevance of the investigated problem and the need for a competent evidence-based approach.

We have studied many different sources on this subject: literary, statistical, archival, and other materials [3-6]. This paper is one of the first studies in Irkutsk Oblast. The material is the basis for creating a comprehensive scheme for the optimal placement of roadside facilities, which can be a recommended basis for the development of roadside infrastructure in Russia. The paper contains our results of roadside infrastructure survey. Many of the calculations and conclusions have a particular
practical value for Irkutsk Oblast. The main ideas and results can be used by the federal and regional authorities to solve many problems of roadside infrastructure development.

The object of our study was not chosen by chance because on the example of Irkutsk Oblast, we can visualize the development of roadside infrastructure and its problems, characteristic of both Russia as a whole and many other regions. Irkutsk Oblast located in the south of Eastern Siberia with relatively favorable climatic conditions is an area of interest for tourist and recreational development as well as the development of roadside infrastructure. The annual increase in the flow of tourists and those wishing to come to Lake Baikal, especially foreign tourists, testifies to this. For the first time, the total volume of tourist flow to Irkutsk Oblast exceeded one million people in 2013, and in 2016, it was 1.5 million people. The share of foreign tourists was 21 and 34% in 2016 and 2017, respectively [7, p. 159].

2. Data and methods
Sources of information are data on the locations of fuel filling stations and roadside infrastructure facilities, their owners, and marketable products received from local governments and large network companies; data from the ministries of Irkutsk Oblast on the intensity of road transport, the number of registered vehicles by municipalities; search engines; city plans; large-scale satellite imagery; sites of network operators and independent sites that place information on sale points of petroleum products, the intensity of road traffic, the number of registered vehicles by municipalities, etc.

In this study, we used systemic and integrated approaches, cartographic research methods, methods of geographic information mapping and spatial analysis. Based on the results of our research, a GIS was created using the MapInfo software product, a convenient and powerful tool for working with spatial data and creating cartographic works.

The geoinformation system created as a result of the work contains geodata on all highways of Irkutsk Oblast, address plans of settlements, schemes of administrative structure and territorial planning of municipalities. It is possible to connect large-scale space and topographic surveys via the Web Map Service module. The basis of this GIS is the data structure, as well as software and hardware tools for operational mapping, which we previously developed and used for the territory of Irkutsk Oblast [1].

3. Analysis and results
Among all the services types, one of the most developed and attractive today is the supply of fuels and maintenance materials. Now the roadside infrastructure is accumulated around filling stations and complexes. They are the most organized and competitive. Other businesses as an automobile gas filling station, NGV filling station and multi-fuel filling station are not sufficiently developed.

There are approximately 530 enterprises that sell petroleum products of all types and 100 enterprises of additional roadside infrastructure in Irkutsk Oblast (diagnostic services, washing and catering services, repairs, etc.). There is a substantial lack of NGV filling stations here due to the absence of the main gas pipeline and distribution network. There is one NGV filling station in Irkutsk Oblast (in Bratsk). The developed network of filling stations and complexes is located along the federal highway, around large cities. This is due to the market and high demand in large settlements.

Irkutsk region is one of the leaders in the product of petroleum in Russia. There is Angarsk Petrochemical Company (ANKhK) here [1]. Wholesale and small-scale wholesale petroleum products market is represented by the vertically integrated petroleum-producing enterprises (Rosneft), big regional networking companies (OAO Irkutsknefteproduct, OOO Conterra+Kraisneft, and OOO Quant-Omni) and small and medium-sized enterprises that have their oil depots in Irkutsk Oblast. Retail network of petroleum product sales is unevenly distributed across the territory of Irkutsk Oblast, from the high density of filling stations and complexes in the south to isolated facilities in the north.

The development of roadside infrastructure depends on many factors and conditions: social, economic, legal, natural, and climatic (regulatory, population, employment, incomes of various population groups, price levels for goods and services, etc.). One of the determining factors is
economic factors, in particular fuel prices, profitability and payback of enterprises, the demand for roadside services, etc. According to some expert opinion, to return the investment, a filling station/complex must sell at least 4.5 thousand tons of petroleum products per year. By our estimations, the filling stations/complexes in Irkutsk Oblast sell an average of 3.5 thousand tons of petroleum products per year (figure 1).

![Figure 1. The average sold fuel volume at petrol stations in 2019, thou. tons per year.](image)

For the minimum profitability filling stations/complexes have to purchase and sell low-quality petroleum products, turning to illegal suppliers. This situation leads to the gradual replacement of small businesses from the retail market with large vertically integrated oil enterprises. The independent filling stations/complexes cannot compete and are forced to close down or move under
the control of large oil enterprises [1]. In the modern context, the only chance for the survival and development of the existing independent filling stations and complexes is to turn them into a multi-fuel station with a wide range of services, as in many developed countries. The total net income from the related services in many countries exceeds the net income from the sale of fuel [8].

If we consider the experience of the United States, then their roadside infrastructure is multifunctional and represented by various service enterprises and community facilities. Toll roads play an important role in the US road complex. The country implements the principle of concessions on toll roads, i.e. sections along roads are leased to private individuals rather than municipal authorities [9]. For this reason, in North America, roadside infrastructure is not represented by standalone facilities, as in most cases in Russian practice, but by large service areas located at the entrance of major highways.

In European countries, there is also a comprehensive approach to the development of roadside infrastructure. Along with standard filling stations and motels, original restaurant complexes with a developed entertainment component provide their roadside services [10, 11]. Roadside infrastructure in Western Europe, in particular, Belgium, Holland, and Germany, is developed at the highest level. There is always a snack bar at every filling station, and it is even possible to take a shower. In general, Western Europeans express themselves in detail. The entrances to the parking lots, signs along the roads, etc. are certainly well equipped.

The main problems of roadside infrastructure development are as follows:

- There is an uneven placement of roadside infrastructure facilities with complex services on federal and regional highways as well as lack of repair and maintenance services, diagnostics, catering services, hotel, communication services, information services, trade, etc.
- Low level of qualifications of roadside infrastructure workers and services, the high cost of fuel, neglecting traffic safety requirements cause erratic development of roadside infrastructure in general. Thus, all these features are characteristic of many Russian regions.
- There are no services for electric vehicles at the filling stations / complexes. Irkutsk Oblast has the cheapest electricity in Russia. Consequently, there is a greater prospect for this transport development.

4. Conclusion

As a result of the study, we made the following conclusions.

The existing problems have a negative effect on the development and management of roadside infrastructure. We have created schemes of placement of roadside infrastructure facilities using territorial planning schemes for Irkutsk Oblast. Each scheme contains information about roads under construction or planned, as well as brief recommendations on optimizing the number of existing facilities and locations for new facilities within the municipality. For reasons of space in the article, we were unable to provide these schemes.

The development of roadside infrastructure should be based primarily on scientifically proven research and considered not only as a field providing social solutions but also an important sector of the regional economy, guaranteeing employment growth, a significant influx of income and new tax payments to the federal and regional budgets.

We have created a geoinformation system of roadside infrastructure in Irkutsk Oblast, which acts primarily as a tool for spatial analysis and a means of displaying thematic maps, providing great opportunities for optimizing the existing network of roadside infrastructure and rational placement of its new facilities.

Irkutsk Oblast needs to modernize and improve roadside infrastructure network and create multifuel filling stations. This is the only chance for today to survive an independent filling station. At the same time, it is advisable to use existing approaches of developed countries as a guideline for the formation of roadside infrastructure objects. With rich natural, socioeconomic, and energetic potential, Irkutsk Oblast can become a good ground for successful application of any of the existing foreign roadside infrastructure development systems (either European or North American).
Location of facilities in towns and on highways must be carried out in strict accordance with legislation and urban planning documentation. Due to the weak legislative base, roadside infrastructure in Russia, as well as in Irkutsk Oblast, develops very slowly. We can judge the weak development of this industry even by the small number of laws that govern the roadside infrastructure of Russia.

The high wholesale fuel prices block the development of independent filling stations and complexes; only gas stations / gas stations of large oil companies develop. Additionally, the filling stations and complexes of large oil companies are not yet interested in developing the service component.

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