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Assessment of Electric Vehicle Readiness of St. Petersburg Transport Infrastructure

Ekaterina V. KAIZER

Anna S. LEBEDEVA

Ekaterina V. Kaizer [1], *Anna S. Lebedeva* [2]
[1, 2] *ITMO University, St. Petersburg, Russia.*
✉ [1] *semina_e_v@mail.ru.*

ABSTRACT

The article presents an assessment of electric vehicle readiness of the transport infrastructure of the city of St. Petersburg. The relevance of the topic is obvious since today there is an active growth in the electric vehicle market, and its further development is on the official agenda of the transport industry. It is noted that the active use of electric vehicles in Russia implies the corresponding development of infrastructure, especially in such large cities as St. Petersburg.

The authors have described core studies on the prerequisites and prospects for development of the electric vehicle market and relevant transport infrastructure. The analysis of various factors for popularisation of electric vehicles allowed to conclude that scientific literature does not contain fully developed methodology for assessing the rate of electric vehicle readiness of the transport infrastructure. The most significant factors influencing the scaling of electric vehicles have been identified and analysed allowing to identify criteria and indicators for assessing the electric vehicle readiness of infrastructure, to determine the weight of each criterion and to carry out an analysis of the current state of the urban infrastructure. Achieving of the objective of the research which is the assessment of electric vehicle readiness of the transport infrastructure of the city of St. Petersburg, was facilitated by authors' system approach, analysis, integrated and expert assessments.

The methodology for calculating the rate of readiness to use new transport solutions comprises assessment of four components. The analysis of scientific works helped to identify the factors influencing development and popularisation of electric vehicles. It was revealed that the most significant factor determining the pace of dissemination of electric vehicles is the availability of infrastructure. The conclusion is made about the better development in the city of such elements as operation of an electric charging stations (ECS) and an information system. The calculation of final assessment of the transport infrastructure of St. Petersburg is shown in the table. The study has allowed to obtain a general assessment of the electric vehicle readiness of the transport infrastructure, as well as to assess each element of electric vehicle system.

Keywords: *electric vehicles, readiness assessment, urban transport, electric charging station, urban transport, information systems, development factors.*

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INTRODUCTION

Currently, there is an active growth in the global and domestic market for electric vehicles.

In 2021, the demand for electric vehicles in Russia increased nine times, the annual volume of new electric cars amounted to 2254 units, the annual volume of the used electric vehicles amounted to 9070 units [1]. Further development of the electric vehicle market is on the official agenda of the transport industry. According to the plans of the Russian government, by 2030 every tenth produced car should be powered by an electric motor [2]. On August 23, 2021, the government approved the Concept for development of production and use of electric road vehicles in the Russian Federation for the period up to 2030, which set the task of developing a wide range of vehicles with improved energy efficiency indices, operating on a traction battery with localisation of production in Russia [3].

At the same time, the active use of electric vehicles in the Russian Federation implies the corresponding development of infrastructure, both extensive and intensive. The underdevelopment of certain elements of the infrastructure for electric vehicles hinders the growth of the market and the implementation of established strategic goals in this area. In this regard, issues related to infrastructure support for scaling of electric vehicles in the Russian Federation are relevant, especially for such large cities as St. Petersburg, where there is a significant impact of transport on environmental safety.

In Russian scientific literature, there are studies on the prerequisites and prospects for development of the electric vehicle market and transport infrastructure, as well as the on the analysis of various factors for popularisation of electric vehicles. The study by V. B. Moshkov, V. V. Ovchinnikov, D. V. Chernyakov and others, as well as the work of A. N. Afanasyev offered a list of factors influencing development of electric vehicles and considered prospects and forecasts for development of electric vehicles in Russia [1; 2]. Factors influencing the development of electric transport were also considered in the article by D. I. Demidov and V. V. Pugachev [3]. Some authors also studied issues of infrastructure, having analysed standards of location of electric charging stations (ECS), power sources for ECS, and recycling of used batteries. According to some authors, by 2030 most developed and developing countries will adopt uniform standards and infrastructure requirements for electric vehicles. The expert and analytical report prepared under the editorship of A. I. Borovkov and V. N. Knyaginina states that development of transport infrastructure for electric vehicles should outstrip development of the electric vehicle market [4]. However, some sources consider the charging infrastructure separately.

Thus, the existing studies on this issue mainly examine one or two factors hindering the scaling of electric transport in the Russian Federation. Particular attention is paid to electric charging stations while the infrastructure elements are not considered as the entire system. The scientific literature does not contain methodology for assessing the rate of electric vehicle readiness of transport infrastructure both in the regions and in the whole country.

METHODOLOGY

The *objective* of this study is to assess the electric vehicle readiness of the transport infrastructure of the city of St. Petersburg.

In accordance with the above objective, the following research *methodology* is proposed:

1. To identify and to analyse the most significant factors influencing the scaling of electric vehicles.

2. To determine the criteria and indicators for assessing the electric vehicle readiness of the transport infrastructure.

3. To determine the weight of each criterion for assessing the electric vehicle readiness of the transport infrastructure.

4. To conduct an analysis of the current state of the infrastructure of St. Petersburg and its electric vehicle readiness.

5. To assess the rate of readiness of transport infrastructure elements for scaling electric vehicles.

The research problems were solved with the methods of analysis, synthesis, integral and expert evaluation.

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[1] The Russian market for new electric vehicles tripled in 2021 (in Russian). [Electronic resource]: https://www.autostat.ru/news/50525./ Last accessed 22.05.2022.

[2] Development of electromobility: Stage II (in Russian). [Electronic resource]: https://events.kommersant.ru/events/elektromobilnost/. Last accessed 22.05.2022.

[3] Decree of the Government of the Russian Federation dated August 23, 2021 No. 2290-r «Concept for development of production and use of electric road vehicles in the Russian Federation for the period up to 2030». [Electronic resource]: http://static.government.ru/media/files/bW9wGZ2rDs3BkeZHf7ZsaxnlbJzQbJJt.pdf. Last accessed 22.05.2022.

RESULTS

Analysis of Factors Affecting the Scaling of Electric Vehicles

Modern research on dissemination and popularisation of electric transport applies various approaches to determine the most significant factors affecting the scaling of electric vehicles.

Thus, in a study by T. Yong and C. Park, devoted to a qualitative comparative analysis of factors affecting the introduction of electric vehicles, all factors are divided into three groups: technological factors (autonomy of electric vehicles, charging time, maximum speed, cost), political factors (all types of state support), environmental factors (fuel prices, consumer characteristics, level of infrastructure development) [5].

A similar approach is used in the KMPG study on the level of readiness of countries to use unmanned electric vehicles. In this study, the methodology for calculating the country readiness index regarding adoption of new transport solutions includes an assessment of four components: policy and legislation, technology and innovation, infrastructure, and consumer acceptance [4].

In the study of S. Stataros [*et al*], the main factor for popularisation of electric vehicles is associated with the economic benefit of consumers [6]. An equally important factor is the promotion of an eco-friendly lifestyle. This is confirmed by the results of VTsIOM survey, which show that 50 % of car owners are ready to switch to an electric car if possible. The respondents named main reasons for their choice that included the environmental friendliness and economy of the operation of electric vehicles, as well as the benefits of using an electric vehicle due to the high cost of gasoline [5].

There is also an approach that considers GDP per capita and the demographic structure of the population as the most important factors in the spread of electric transport along with the development of infrastructure and state support [7]. A similar opinion is shared by D. Yu. Katalevsky and T. R. Gareev, who note the cost of an electric car and the development of charging infrastructure as the primary factors for the formation of consumer preference for an electric car over a car with an internal combustion engine (ICE) [8].

The study of V. B. Moshkov, V. V. Ovchinnikov, D. V. Chernyakov and others include into the list of factors influencing the development of the electric car market the state support for development of electric vehicles and of electric vehicle business, the availability of own production of electric vehicles in the country, the development of the infrastructure of electric charging stations and special specific Russian conditions for the operation of electric vehicles [2].

Based on the analysis of scientific works, we can highlight the factors influencing the development and popularisation of electric vehicles:

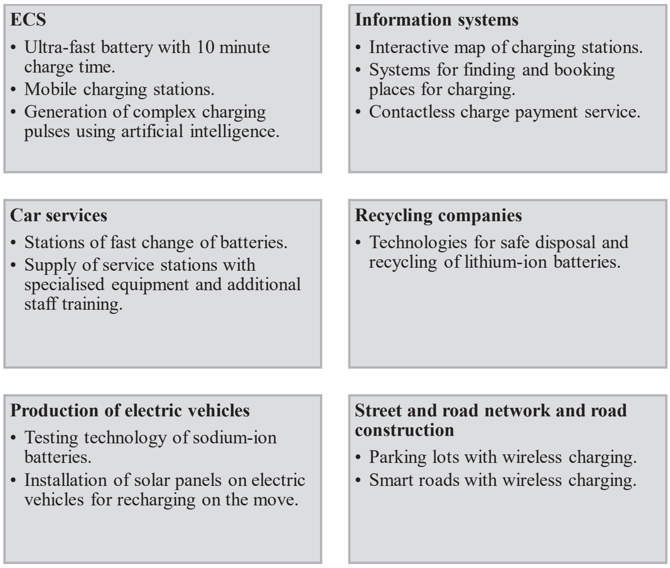
- State support for development of electric vehicles.
- Demand for electric vehicles from the commercial companies.
- Availability of own production of electric vehicles.
- Rate of development of the network of electric charging stations.
- Scientific and technical progress.
- Global trend towards environmental friendliness.
- Transition to the use of distributed electric power industry.
- Features of organisation of transport infrastructure in the region.

The state support, according to many authors, is one of the most important factors influencing the development of electric vehicles [2; 5; 7]. Government support measures include various ways to stimulate demand for electric vehicles, such as subsidies for the purchase of electric vehicles, exemption from value added tax, exemption from vehicle tax, organisation of free parking, permission to use dedicated lanes and free travel on toll roads. Also, state support measures should include support for domestic electric vehicle manufacturers and subsidies for the development of electric charging stations' (ECS) network.

Own electric vehicle manufacturing in the country is an important factor for development of electric vehicles, as well as the trend towards the use of distributed electric power, as electric transport not only consumes energy, but also

[4] The index of readiness of countries to use autonomous transport. [Electronic resource]: https://assets.kpmg/content/dam/kpmg/ru/pdf/2018/03/ru-ru-avri-index.pdf. Last accessed 25.05.2022.

[5] Battery on wheels: the future of electric vehicle batteries (in Russian). [Electronic resource]: https://trends.rbc.ru/trends/green/62671a189a7947c85bb26f0f. Last accessed 02.06.2022.



Pic. 1. Directions of innovative development of infrastructure elements for electric vehicles [compiled by the authors].

accumulates it for further distribution, which helps to smooth out the day and night highs and lows of the energy system.

The demand for electric transport in the commercial sector of economy is driven by both economic benefits and the global trend towards sustainability and reduction of carbon emissions. Over the life cycle, electric vehicles can reduce total CO_2 emissions by 66–69 %[6].

These factors play a significant role in the development and popularisation of electric transport, however, the most significant factor determining the rate of distribution of electric vehicles in the country is the availability of the necessary infrastructure [7]. According to KPMG research, at least a third of potential EV consumers base their purchase decisions on the availability of charging infrastructure[4].

However, the infrastructure for electric vehicles is not limited to ESC. The transport infrastructure is a result of the activity of all the organisations of the transport sector and that ensure the efficient implementation and maintenance of transportation [5]. The infrastructure for electric vehicles consists of the following elements:

- ECS.
- Car services.
- Information systems.
- Manufacturing of electric vehicles.
- Recycling companies.
- Street and road network and road construction.

At the same time, the large-scale introduction of electric vehicles is influenced not only by quantitative, but also by the qualitative development of all elements through the introduction of innovations. This is confirmed by the fact that the largest growth in EV sales in retrospect has been attributed to inventions that improve the design and performance of EV. For example, since the invention of a new type of the battery in 1986 and the advent of hybrid vehicles combining a conventional internal combustion engine and an electric motor, sales of electric vehicles have more than quintupled. Electric vehicles gained new popularity with the launch of Tesla electric vehicles in 2008, after which many automakers turned their attention to this market segment and started their own production of electric vehicles [7].

Actual directions of innovative development of the elements of the electric vehicle infrastructure are presented in Pic. 1.

Since most of the identified factors for large-scale introduction of electric vehicles are directly or indirectly related precisely to the availability of infrastructure, to achieve the strategic goals of increasing the share of electric vehicles in the

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[6] Electric cars proved to be more environmentally friendly than traditional ones, taking into account their life cycle (in Russian). [Electronic resource]: https://nplus1.ru/news/2021/08/04/comparison-of-life-cycle. Last accessed 22.05.2022.

[7] Global EV Data Explorer. [Electronic resource]: https://www.iea.org/articles/global-ev-data-explorer. Last accessed 29.05.2022.

Table 1

Criteria and indicators for assessing the electric vehicle readiness of transport infrastructure [compiled by the authors]

Infrastructure element	Assessment criterion	Assessment indicator	Target value	Criterion weight
ECS	Availability of ECS	Number of electric cars* per 1 ECS, units	10	0,4
		Number of ECS per 1 million population, units	200	
	Level of localisation of ECS production	Share of Russian-made ECS, %	70 %	0,4
	Structure of ECS network	Ratio of fast and slow ECS	2:3	0,2
Car services	Availability of car services	Number of electric cars per 1 car service, units	30	0,5
	Employees' training	Availability of training programs for maintenance of electric cars	Yes	0,5
Information systems	Information infrastructure	Availability of applications for finding and analysing charging stations	Yes	1
		ICT development index	>0,5	
Production	Organisation of production	Number of organisations-producers of electric cars, units	>1	0,6
		Number of organisations-producers of electric vehicles, units	>1	
		Number of samples ready for production, units	>3	
	Innovation	Level of inventive activity in the region	>3,5	0,4
Recycling	Recycling development rate	Number of organisations implementing recycling technologies, units	>1	1
		Share of batteries intended for recycling, %	90 %	
Street and road construction	Availability of street-and-road network	Availability of dedicated lanes for electric vehicles	Yes	0,3
	State support	Availability of free parking lots for electric vehicles	Yes	0,4
		Availability of preferential travel on toll intercity roads and sections of federal highways	Yes	
	Investments	The share of investments in the development of electric vehicles in the total volume of investments in transport infrastructure, %	5 %	0,3

* The term «electric vehicles» is used in the context of the article to translate Russian term «electric transport» that englobes electric cars, trucks, buses, trams, trolley-buses etc., the term «electric car» is applied when the authors directly use it. – *Transl. note.*

Russian Federation in the total volume of transport vehicles in use, it is necessary, first of all, to analyse the readiness of a region's transport infrastructure to service vehicles of this type.

Methodology for Assessing the Electric Vehicle Readiness of the Transport Infrastructure of a Region

In accordance with the factors influencing the development and popularisation of electric vehicles, we single out the criteria for assessing the electric vehicle readiness of the transport infrastructure: the availability of ECS, the rate of localisation of the production of ECS, the structure of the ECS network, the availability of electric car services, staff training, information infrastructure, organisation of production, innovation, the quality of development of recycling, accessibility of the road network, state support, investments. The weight of each criterion was determined based on the assessment of six experts: industry experts, as well as researchers and professors of ITMO University, involved in the development of electric vehicles in the Russian Federation.

Assessment indicators and their target values were determined for each criterion, based on the analysis of foreign expertise, the results of analytical studies and strategic documents (Table 1).

The target value of provision of electric cars with the required number of ECSs is one ECS per ten electric cars. A study on worldwide comparison of transport infrastructure performance for electric vehicles, the average for Asia is one ECS per eight electric vehicles, for Europe – one ECS per 20 electric vehicles, for Japan – one ECS per ten electric vehicles, and for the United States – one ECS per 29 electric vehicles[8]. The concept for development of production and use of electric road vehicles in the Russian Federation until 2030 provides for a target level equal to one ECS per ten electric vehicles[3]. D. Yu. Katalevsky and T. R. Gareev also consider one ECS per ten electric vehicles to be the optimal indicator [8]. The above study comparing global transport infrastructure performance for electric vehicles highlights the average number of ECSs per 1 million population for Asia is 3900, for Europe 2200, for Japan 150, for the United States 9809.

The target value of the level of localisation of ECS production is 70 % of ECSs made in Russia3. The corresponding level was established in Decree of the Government of the Russian Federation of December 3, 2020 No. 2014 «On the minimum mandatory share of purchases of Russian goods and its achievement by the customer» [9].

The target value for the ratio of fast and slow ECS is a ratio of 2:3. D. Yu. Katalevsky and T. R. Gareev in their study consider the ratio of 1:4 to be the optimal structure of the ECS network [8], however, in the Concept for development of production and use of electric vehicles, the target level of slow ECS is 60 %[3].

The target value of the number of electric cars per car service is 30 electric cars per a single car service. The number of hybrid cars and electric vehicles that applied for service in 2021 amounted to 3500 units [10]. At the same time, the total number of cars that applied for service in 2021 amounted to one million cars. The total number of electric cars at the end of 2021 was 10836 units [11].

The target value of the level of inventive activity in the region, considering also utility models, is 3,5 [6]. The target recycling rate is 90 %[12]. According to the directives of the European Commission, starting from 2015, for end-of life vehicles, w the re-use and recycling shall be increased to a minimum of 85 % by an average weight per vehicle, 5 % may be landfill, and battery recycling should be at least of 50 % of the weight of the battery [9] [12]. However, the average recycling efficiency of lithium-ion batteries reached 74,5 % in 2019 and 80,1 % in 2020 [13], so new rules are now being discussed with an increase in the percentage of recycling of various elements and the use of new technologies[5].

The target value of the share of investments in development of electric vehicles in the total volume of investments in transport infrastructure is 5 %. According to the Transport & Environment report published by the European Federation for Transport and the Environment, in 2020 the share of investment in infrastructure for electric vehicles in the EU attained 1 %. With the current rate of investment in infrastructure for electric vehicles and in road infrastructure, the expected share of investment will increase to 3 % in 2025 and to 5 % in 2030 [14].

To obtain a score for each criterion, the actual values of the indicators are correlated with the target values, after which an equal weighting

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[8] How to build an electric vehicle city: deploying charging infrastructure. [Electronic resource]: https://www.c40knowledgehub.org/s/article/How-to-build-an-electric-vehicle-city-deploying-charging-infrastructure?language=en_US. Last accessed 29.05.2022.

[9] Decree of the Government of the Russian Federation of December 3, 2020 No. 2014 (as amended on May 16, 2022) «On the minimum mandatory share of purchases of Russian goods and its achievement by the customer». [Electronic resource]. Access mode: http://www.consultant.ru/document/cons_doc_LAW_370114. Last accessed 22.05.2022.

[10] Electric vehicles: pros and cons (in Russian). [Electronic resource]: https://wciom.ru/analytical-reviews/analiticheskii--obzor/ehlektromobili-za-i-protiv. Last accessed 22.05.2022.

[11] Electromobilisation of the country. How will environmentally friendly transport be developed in Russia (in Russian). [Electronic resource]: https://tass.ru/transport/13593109?utm_source=yandex.ru&utm_medium=organic&utm_campaign=yandex.ru&utm_referrer=yandex.ru. Last accessed 02.06.2022.

[12] See also, Directive 2000/53/EC of the European Parliament and the Council of 18.09.2022 on end-of life vehicles. [Electronic resource]: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02000L0053-20200306&from=EN. – *Ed. note.*

[13] Recycling of lithium-ion batteries (in Russian). [Electronic resource]: https://rocla.ru/. Last accessed 29.05.2022.

[14] Transport & Environment. European Federation for Transport and Environment AISBL, 2020. [Electronic resource]: https://www.transportenvironment.org/wp-content/uploads/2021/07/01 %202020 % 20 Draft%20TE%20Infrastructure%20Report%20Final.pdf. Last accessed 02.06.2022.

approach is used. The assessment of each element of the infrastructure is calculated as a weighted average assessment, considering the importance of the assessment criteria:

$$R = \frac{\sum_{i=1}^{n} A_i \cdot w_i}{\sum_{i=1}^{n} w_i},$$

where R – weighted average estimate of the infrastructure element;

A_i – criterion score;

w_i – criterion weight;

n – number of criteria for an element assessment.

To obtain a final assessment of the electric vehicle readiness of the region's transport infrastructure, the scores of each element are summed up, so the final assessment is in the range from 0 to 6.

Assessment of the Electric Vehicle Readiness of the Transport Infrastructure of the City of St. Petersburg

To assess the electric vehicle readiness of the transport infrastructure of St. Petersburg, it is necessary, first, to analyse the current state of its elements in St. Petersburg and in the Russian Federation, and to determine the actual values of the established indicators.

In St. Petersburg, the total number of registered electric cars in 2021 attained 417 units, while 255 electric cars were registered in 2021 [15].

There are 83 charging stations in St. Petersburg and Leningrad Region (43 are slow ECSs, 40 are fast ECSs), of which 46 charging stations are operated by PJSC Rosseti Lenenergo (10 are slow ECSs, 36 are fast ECSs), 37 charging stations are installed and operated by other organisations (33 slow ECSs, 4 fast ECSs) [16]. As of March 12, 2022, more than ten ECS manufacturers have been certified in Russia, some of which are already operating (FORA ECS – DC, FORA ECS – AC, IECS-SKT, E-prom), but at the moment the rate of localisation in Moscow and St. Petersburg does not exceed 10 %[11].

There are 30 car services in St. Petersburg that provide repair and maintenance services for hybrid and electric cars. There are also eight services that carry out post-warranty repair of Tesla cars, 18 services serve Nissan Leaf, 18 services – BMW i3. Training programs for employees providing service maintenance of electric vehicles are taught in colleges and universities («Autoservice» vocational school, Academy of Transport Technologies), centres for professional training and advanced training (EuroAuto Academy) and are also implemented in the form of training courses in engineering centres (SMART engineering scientific and educational centre).

In Russia, domestic information systems can fully meet the demand of manufacturers and consumers of electric vehicles, since there are all the necessary software products on the market, including programs for managing ECS networks, tracking the level of charging of an electric car and searching for a free ECS. On the territory of St. Petersburg, more than 15 applications for finding and analysing charging stations are available for download, for example, Charge Map, PlugShare, NextCharge, Charge and Parking, PlugMe, IT Charge, Zevs. These applications allow not only to find the nearest ECS on the map, but also to pay for charging and reserve a parking lot. The index of development of information and communication technologies (ICT) in 2020 was 0,511, while the level of access to ICT is 0,671, and the level of ICT use is 0,803 [10].

In Russia, there is production of electric vehicles, but there has been no mass production of electric cars. This is due to the lack of domestic production of structural elements and electronics, as well as insufficient extraction of the necessary natural resources. The largest manufacturer of electric vehicles in St. Petersburg is PK Transport Systems LLC (production of [electric trams] 71-911 City-Star, 71-911E, 71-923 Bogatyr, 71-922 Varyag, 71-931 Vityaz, 71-931 M «Vityaz-M»). In the segment of electric cars, a number of projects were implemented to prepare models of electric cars, the most successful of which is creation of KAMA-1 in Peter the Great St. Petersburg Polytechnic University, performed within the framework of the Federal Target Program «Research and development in priority areas of development of the scientific and technological complex of Russia for 2014–2020» Research and complex of Russia for 2014–2020»[3]. This model is in the process of preparation for mass production, the release is scheduled for 2024–2025 [4]. The level of inventive activity in

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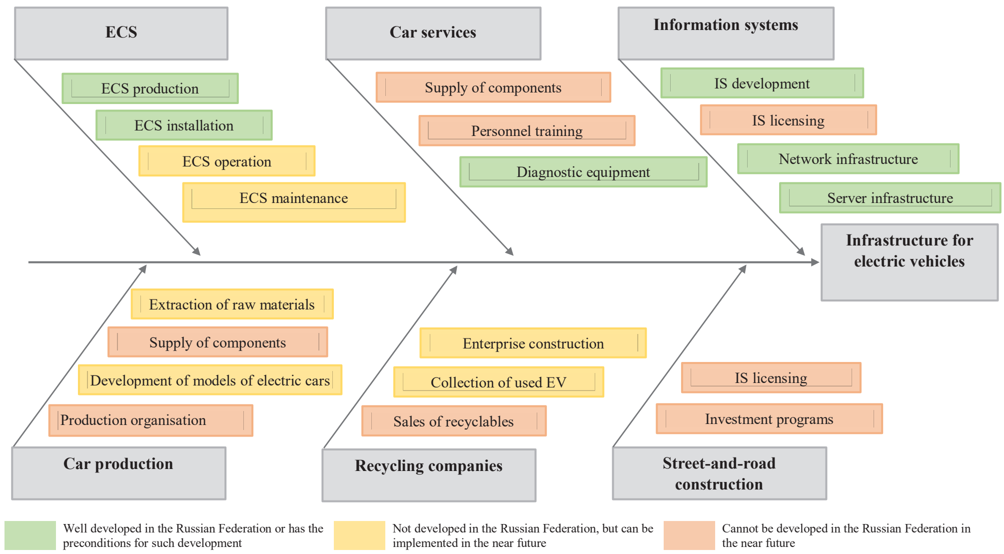
[15] The Russian market for new electric vehicles tripled in 2021 (in Russian). [Electronic resource]: https://www.autostat.ru/news/50525. Last accessed 22.05.2022.

[16] The number of charging stations for electric vehicles in St. Petersburg will increase by 2,5 times (in Russian). [Electronic resource]: https://spbdnevnik.ru/news/2022-02-03/chislo-zaryadnyh-stantsiy-dlya-elektromobiley-v-peterburge--uvelichitsya-v-25-raza. Last accessed 29.05.2022.



Pic. 2. Analysis of development of infrastructure elements intended for electric transport in the Russian Federation [compiled by the authors].

2021 was 3,23 and considering also utility models it accounted for 4,79. During the period 2011–2021, 50 solutions related to development of electric vehicles were patented in Russia, which include options for design of charging stations, as well as systems and methods for controlling charging stations and battery charge, as well as remote control and user identification [11].

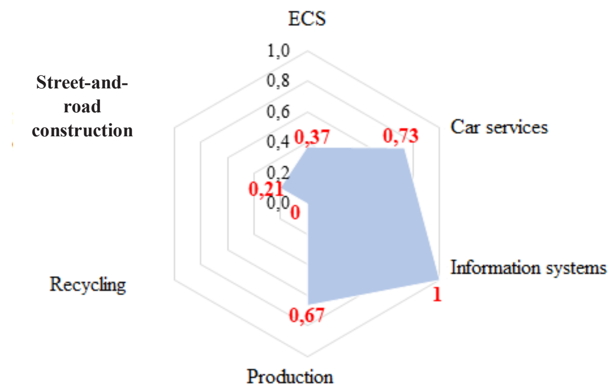
Electric cars use lithium-ion batteries, on average 95–96 % of each battery is a recyclable raw material that can be reused in production. About a hundred companies are involved in the recycling of lithium-ion batteries in the world [17]. But in Russia, recycling is currently underdeveloped, as there are no opportunities for commercially profitable legal disposal of lithium-ion batteries, as well as mechanisms for controlling the disposal of electric cars. At the same time, the recycling market is unattractive for investors due to insufficient demand for electric car's components obtained following the recycling. There have been no recycling organisations in St. Petersburg yet.

Street and road construction implies significant capital expenditures and licensing of foreign technologies, but at the same time there is not enough demand for specialisation of street construction on infrastructure elements for electric vehicles. In St. Petersburg, the owners of electric cars have the possibility of free parking in the toll parking area, it can be used when applying for a parking permit for an electric car. This opportunity has already been used by 349 people[12]. At the same time, there is no possibility of driving along a dedicated lane and of preferential travel on toll sections of intracity roads and regional sections of federal highways [2]. However, as part of demand support, a pilot project is planned in 2022 to eliminate fees paid by owners of electric cars on toll roads3. The expected volume of investments in implementation of regional programs for development of transport infrastructure for electric cars in 2020–2023 will be at least 70 million rubles[17].

Pic. 2 shows the current state of the structural elements of the transport infrastructure intended for electric transport. The already sufficiently developed elements are marked, as well as those that have the potential for development, along with the elements that meet significant constraints for development in Russia.

According to Pic. 2, ECS and information systems are the best developed among the elements of infrastructure in Russia, which is due to the availability of relevant technologies and developments in the Russian market. The least developed are street-and-road construction and recycling, as well as car services, due to the lack of sufficient demand for electric cars from buyers.

[17] China is doing Li-Ion recycling business, why not others? [Electronic resource]: https://neovolt.ru/blog/1045_pererabotka-li-ion-akkumulyatorov-v-kitae. Last accessed 22.05.2022.



Pic. 3. Assessment of the electric vehicle readiness of the elements of the transport infrastructure of St. Petersburg [compiled by the authors].

Photo:gov.spb.ru

However, an increase in the fleet of electric cars up to 1,4 million units by 2030[3] should include modernisation and adaptation of the transport infrastructure to the increased volume of electric cars. To do this, it is important to quantify the rate of electric vehicle readiness of the transport infrastructure for specific regions, in this case, for the city of St. Petersburg.

The calculation of the final assessment of the rate of readiness of the transport infrastructure of St. Petersburg, according to the proposed methodology, is presented in Table 2.

The final assessment of the rate of electric vehicle readiness of infrastructure elements is shown in Pic. 3.

According to the results of the analysis, a high level of readiness is observed for such elements as «Information systems», «Car services», «Production», a low level of readiness is characteristic of «ECS», «Street-and-road construction», «Recycling». The final assessment of the electric vehicle readiness rate of infrastructure was 2,98 or 49,67 % of the maximum assessment, which indicates the average level of electric vehicle readiness of infrastructure and the need to implement comprehensive measures to improve it.

CONCLUSIONS

The analysis resulted in a general assessment of the readiness of the transport infrastructure for large-scale adoption of electric vehicles, as well as in scores for each element of the infrastructure.

Successful large-scale development of dedicated transport infrastructure requires attracting more investment in areas that receive

Table 2

Calculation of the final assessment of the readiness of the transport infrastructure [compiled by the authors]

Infrastructure element	Assessment criterion	Assessment indicator	Target value	Fact	Integral assessment of the criterion	Criterion weight	Element assessment
ECS	Availability of ECS	Number of electric cars per 1 ECS, units	10	5	0,288	0,4	0,37
		Number of ECS per 1 million population, units	200	15			
	Level of localisation of ECS production	Share of Russian-made ECS, %	70 %	10 %	0,143	0,4	
	Structure of ECS network	Ratio of fast and low ECS	0,67	0,93	1	0,2	
Car services	Availability of car services	Number of electric cars per 1 car service, units	30	14	0,467	0,5	0,73
	Employees' training	Availability of training programs for maintenance of electric cars	1	1	1	0,5	
Information systems	Information infrastructure	Availability of applications for search and analysis of charging stations	1	1	1	1	1
		ICT development index	0,5	0,51			
Production	Organisation of production	Number of organisations-manufacturers of electric vehicles, units	1	3	0,444	0,6	0,67
		Number of organisations-manufacturers of electric cars, units	1	0			
		Number of samples ready for production, pcs.	3	1			
	Innovations	The level of inventive activity of the region	3,5	4,79	1	0,4	
Recycling	Level of recycling development	Number of organisations implementing recycling technologies, units	1	0	0	1	0
		Share of batteries intended for recycling, %	90 %	0 %			
Street-road construction	Availability of street-and-road network	Availability of dedicated lanes for electric vehicles	1	0	0	0,3	0,21
	State support	Availability of free parking for electric vehicles	1	1	0,5	0,4	
		Availability of preferential travel on toll intercity roads and sections of federal highways	1	0			
	Investments	Share of investments in the development of electric vehicles in the total volume of investments in transport infrastructure, %	5 %	0,09 %	0,018	0,3	
Total score							2,98

the lowest scores. The insufficient number of ECS today is the most important deterrent to the spread of electric cars, therefore, it is necessary to work on their increase using the following tools: partnership with business, gas station operators and regional energy operators to install private ECS, participation in the second phase of implementation of the government project, carried out within the framework of concepts for the development of production and use of electric vehicles in the Russian Federation until 2030, information and administrative support for Russian manufacturers of ECS, assistance in concluding tripartite contracts between regional authorities, business and Russian manufacturers of ECS.

Promoting an increase in the level of ECS localisation and an increase in the number of ECS should be accompanied by organisation of production of electric motors, batteries, as well as implementation of a project for safe disposal of batteries to achieve the target level of recycling. It is necessary to scale the existing experience of Russian companies with involvement of modern scientific developments.

For successful development of the street-and-road network, foreign practices can be used as an example of implementation of large-scale infrastructure projects (for example, the provision with ECS of all high-speed highways).

The developed methodology can be used to assess the level of electric vehicle readiness of the transport infrastructure both in the regions and regarding the entire country.

REFERENCES

1. Afanasiev, A. N., Sazonov, M. V. Prospects for development of electric transport [*Perspektivy razvitiya elektrotransporta*]. *Symbol of science: international scientific journal*, 2020, Iss. 12 (1), pp. 29–31. [Electronic resource]: https://www.elibrary.ru/item.asp?id=44389628. Last accessed 22.05.2022.

2. Moshkov, V. B., Ovchinnikov, V. V., Barannik, A. Yu., Chernyakov, D. V. [*et al.*]. Prerequisites and trends in electric vehicle development. *Civil Security Technologies,* 2021, Vol. 18, Iss. 2 (68), pp. 14–19. [Electronic resource]: https://elibrary.ru/item.asp?id=46170329. Last accessed 22.05.2022.

3. Demidov, D. I., Pugachev, V. V. Forecast of global development of electric transport and infrastructure of electric filling stations. *Bulletin of Orenburg State Agrarian University*, 2019, pp. 173–178. [Electronic resource]: https://elibrary.ru/item.asp?id=41288910. Last accessed 22.05.2022.

4. Sanatov, D. V., Abakumov, A. M., Aidemirov, A. Yu., Borovkov, A. I. [*et al.*]. Prospects for development of the market for electric transport and charging infrastructure in Russia: an expert-analytical report [*Perspektivy razvitiya rynka elektrotransporta i zaryadnoi infrastruktury v Rossii: ekspertno-analiticheskiy doklad*]. Ed. by A. I. Borovkov, V. N. Knyaginin. St. Petersburg, Polytech-Press publ., 2021, 44 p. [Electronic resource]: https://elibrary.ru/item.asp?id=46443315. Last accessed 22.05.2022.

5. Yong, Taeseok; Park, Chankook. A qualitative comparative analysis on factors affecting the deployment of electric vehicles. *Energy Procedia*, 2017, Vol. 128, pp. 497–503. DOI: https://doi.org/10.1016/j.egypro.2017.09.066.

6. Statharas, S., Moysoglou, Ya., Siskos, P., Zazias, G., Capros, P. Factors Influencing Electric Vehicle Penetration in the EU by 2030: A Model-Based Policy Assessment. *Energies*, 2019, Vol. 12, pp. 2739. DOI: 10.3390/en12142739.

7. Campisi, T., Ticali, D., Ignaccolo, M., Tesoriere, G., Inturri, G., Torrisi, V. Factors influencing the implementation and deployment of e-vehicles in small cities: a preliminary two-dimensional statistical study on user acceptance. *Transportation Research Procedia,* 2022, Vol. 62, pp. 333–340. DOI: https://doi.org/10.1016/j.trpro.2022.02.042.

8. Katalevsky, D. Yu., Gareev, T. R. Simulation modelling for predicting the development of automotive electric transport at the regional level [*Imitatsionnoe modelirovanie dlya prognozirovaniya razvitiya avtomobilnogo elektrotransporta na urovne regiona*]. *Baltiyskiy region*, 2020, Vol. 12, Iss. 2, pp. 118–139. DOI: 10.5922/2079-8555-2020-2-8.

9. Kormishkina, L. A., Kormishkin, E. D., Koroleva, L. P., Koloskov, D. A. Resource recycling in modern Russia: necessity, problems and development prospects [*Retsikling resursov v sovremennoi Rossii: neobkhodimost, problemy i perspektivy razvitiya*]. *Economic and social changes: facts, trends, forecast*, 2018, Vol. 11, Iss. 5, pp. 155–170. DOI: 10.15838/esc.2018.5.59.10.

10. Kasimova, T. M., Magomedova, S. R., Rabadanova, M. G. Assessment of the level of development of information and communication technologies and its impact on the regional economy [*Otsenka urovnya razvitiya informatsionno-kommunikatsionnykh tekhnologii i ego vliyaniya na regionalnuyu ekonomiku*]. *Fundamental Research*, 2021, Iss. 5, pp. 13–18. [Electronic resource]: https://fundamental-research.ru/ru/article/view?id=43032. Last accessed 01.06.2022.

11. Protsenko, N. V., Malozemov, B. V., Dmitrieva, Yu. V., Kuznetsov, S. A. The need to identify and patent promising solutions in the field of electric transport [*Neobkhodimost vyyaleniya I patentovaniya perspektivnykh reshenii v oblasti elektricheskogo transporta*]. *Reports of the Academy of Sciences of Higher Education of the Russian Federation*, 2021, Iss. 4 (53), pp. 36–48. DOI: 10.17212/1727-2769-2021-4-36-48. ●

Information about the authors:

Kaizer, Ekaterina V., *Master student at the Faculty of Technology Management and Innovations of ITMO University (National Research University), St. Petersburg, Russia, semina_e_v@mail.ru.*

Lebedeva, Anna S., *Ph.D. (Economics), Associate Professor at the Faculty of Technology Management and Innovations of ITMO University (National Research University), St. Petersburg, Russia, aslebedeva@itmo.ru.*

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