DOI: https://doi.org/10.30932/1992-3252-2020-18-196-211

On the Issue of Regulatory Support for Passenger Electric Vehicles Operation

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ABSTRACT

The article provides the results of an intermediate stage of research on development of a project to create infrastructure for operation of highly environmentally friendly electric vehicles.

The transition to electric transport is one of the promising methods to solve the problem of emissions and achieve environmental goals. An electric bus is a relatively new type of rolling stock, requiring a balanced and objective justification for selection of certain possible options for technical, technological, economic and other aspects of organisation of its operation.

To achieve the goal of developing a project to create infrastructure for operation of environmentally friendly electric vehicles, an initial analysis of legal acts, technical characteristics of electric buses and the parking and on route infrastructure approaches to organizing transportation by electric buses with various charging concepts was performed. The analysis of the concepts of charging electric bus batteries allowed to divide them into 5 classes and group into 3 groups according to charging speed. An analysis of the required infrastructure for operation of electric buses showed that conceptually there are 2 types of charging stations.

The calculations and evaluation of various options for organizing operation of electric buses on a fixed route with various concepts of charging were performed. A necessary direction for further research is economic assessment of operation of electric buses with various charging concepts and the necessary transport infrastructure.

The methods used include analysis, evaluation of previously performed analytical studies, legal acts and a synthesis of domestic and foreign experience.

Keywords: electric bus, electric vehicles, charging stations, road transport, public urban passenger transport.

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Article received 20.12.2019, accepted 21.02.2020.

For the original Russian text of the article please see p. 196.

Background. The system of urban passenger transport is among the most important social sphere of the city of Moscow. The quality of life of population and productivity of various sectors of the economy depend on effectiveness of its functioning. Improving the system and improving quality of transport services for population requires implementation of comprehensive studies to assess, analyze and identify urgent problems of organization and safety, environmental safety, urban mass transit in the city of Moscow [1–5].

According to the state report «On the State and Environmental Protection of the Russian Federation in 2018» [6] the volume of emissions produced be transport vehicles in Russian Central Federal District is more than twice the volume of emissions from stationary sources (3849 and 1529 thousand tons, respectively).

The analysis of the dynamics of pollutant emissions from 2010 to 2018 shows a general trend towards a decrease of emissions from stationary and an increase from mobile sources [6].

The increase in the number of motor vehicles, particularly characteristic of central part of the city, and of the largest transport hubs, together with the increase in traffic congestion and the decrease in average speeds, lead to a deterioration of the environmental situation. In hot, calm weather, there are cases of formation of tropospheric ozone (smog). Exhaust gas emissions from motor vehicles pose a serious danger to people living in the vicinity of roads.

The transition to electric transport is one of the methods to solve the problem of emissions and achieve environmental goals [7–11].

Improving the legal and methodological regulations of the city of Moscow, including in the field of «greening» procurement for public needs, introducing environmental indicators in assessing the effectiveness of public programs in Moscow, creating standards for «environmentally friendly transport and transport infrastructure» are key principles aimed at qualitative transformation of the transport system. The article analyzes management of ground-based urban electric passenger public transport and related transport infrastructure.

Analysis of regulatory support for organization of transportation by electric buses

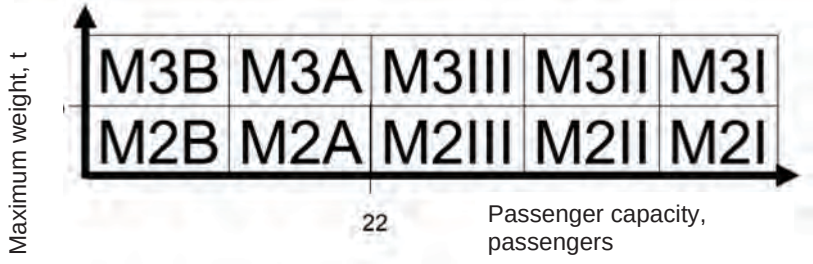
The main federal legal act regulating the activity of urban land electric transport is Federal Law No. 259-FZ [12]. That law has established the basic principles and provisions governing transportation of passengers by buses, trams, trolleybuses and passenger taxi. The analysis showed that Article 2 of this law, devoted to the basic concepts, does not contain information regarding vehicles, their types and classifications. The terminology regarding vehicles is given only when formulating and establishing the terms «Charterer» and «Charter provider».

There are references to «buses» throughout the text of this regulatory act, for example, in Article 3.2 on the procedure for licensing passenger transportation. Some articles use the term «vehicles», as well as «tram» and «trolleybus» in the part devoted to urban electric transport. Chapter 3 of this Law is devoted to regular transportation of passengers and baggage. The said chapter of the Law is of a general conceptual nature and, from the point of view of rolling stock, operates with the concept of «vehicles». The situation is similar when establishing principles and provisions for organization of customized transportation of passengers and baggage.

Thus, the analysis of the Charter of road and urban electric land transport [12] shows that at present it does not contain the concept of «electric bus» and mainly operates with the term «vehicle».

On the basis of the current Charter [12], the Resolution of the Government of the Russian Federation [13] approved the rules for transportation of passengers by road and urban land electric transport. In the section of general provisions of this act, concepts describing rolling stock are given. According to the specified document, classification of vehicles is given in the context of their categories. In the context of the subject we are considering, the currently known types of electric buses belong to M3 category. This category includes «vehicles» that are used to transport passengers, which, in addition to the driver's seat, have more than eight seats, and the maximum mass of which exceeds five tons. The document further on and regarding rolling stock operates the concept of «vehicle».

According to the Decision of the Commission of the Customs Union of the Eurasian Economic Community [14], it is possible to determine which category this or that vehicle belongs to. Based on this Decision, Moscow electric buses belong to category M3, class I,



Pic. 1. System of classification of electric buses.

because they are designed to carry passengers and have, in addition to the driver's, more than eight seats, and their technically permissible maximum weight exceeds five tons. Belonging to class I is explained by the fact that capacity of electric buses is over 22 passengers in addition to the driver, and also they have a dedicated area for standing passengers and provide a quick rotation of passengers.

In accordance with GOST [Russian State Standard] R52051-2003 [15] electric buses, which are in operation in Moscow, similarly to [14] belong to category M3.

It should be noted that classifications in accordance with GOST R41.36-2004, GOST R41.52-2005, GOST R41.107-99, GOST R52389-2005, Industry normal ON025 270-66 are currently not valid.

Based on the results of the analysis [14; 15] the following classification system is proposed (Pic. 1).

In the Russian Federation there is Federal Law [16] defining categories of vehicles. According to it, Moscow electric buses belong to D category, as they have more than eight seats, besides the driver's seat.

There are various classifications of vehicles (according to passenger capacity, overall length, environmental class, engine type, layout and arrangement of the compartment, etc.), however the analysis of these classifications and the corresponding categorization is beyond the task of the study.

When the first electric buses were launched in Moscow, about 400 Mosgortrans drivers were trained. For this, it was necessary to undergo special retraining and pass an exam for category D [17]. Thus, it can be noted that electric buses belong to category D, which according to the international classification corresponds to category M3.

According to the Tax Code of the Russian Federation [18] when calculating transport tax, rolling stock is classified by categories of «vehicles». According to Article 358 of the said Law, cars and buses are recognized as objects of taxation. According to the specified regulatory act, tax rates on vehicles are established by the laws of the constituent entities of the Russian Federation, depending on the power of their engine.

Since 2003, Moscow has a law on property tax [19]. In 2008, a separate law of the city of Moscow on transport tax was enacted [20]. The said Law determined tax rates for buses and cars with different engine power. In the city of Moscow, organizations that provide services for transportation of passengers by passenger public transport are exempted from paying transport tax for vehicles carrying passengers (except taxi). In accordance with Article 3 of the newly adopted law of the city of Moscow dated November 20, 2019 [21], the law of the city of Moscow on transport tax was amended [20]. Persons with vehicles equipped exclusively with electric motors are exempted from paying transport tax.

The measures of public support taken at the legislative level in the city of Moscow for development and use of electric vehicles are a logical continuation of implementation of the state program of the city of Moscow «Development of the transport system» [22]. According to the subprogram «Public transport. Land urban passenger transport», the task was set to introduce only electric buses on city public transport routes since 2021. For this purpose, starting from the indicated date, it is planned to purchase only electric buses for the city, as well as reconstruct existing bus fleets and other transport infrastructure facilities for operating electric buses and create an infrastructure for charging electric buses.

Table 1

Classification of rolling stock'

Normative legal act	Terminology
Federal Law dated 08.11.2007 No. 259-FZ [12]	Vehicles Buses, trolleybuses, trams
Resolution of the Government of the Russian Federation dated 14.02.2009 No. 112 [13]	Vehicle Category «M»
Decision of the Commission of the Customs Union dated 09.12.2011 No. 877 [14]	Vehicle Category «M3», Class I
Federal Law dated 10.12.1995 No. 196-FZ [16]	Vehicle Category «D»
Federal Law dated 19.07.200 No. 117-FZ [18]	Vehicle Cars, buses

Table 2

Infrastructure to support electric buses operation

Charging concept	Required infrastructure in the park	Required infrastructure on the route	Influence on energy system
Slow	It is required to build a charging station with a transformation substation in the park, to lay cables, to connect charging stations.	–	Requires power generation on the park territory.
Ultra-fast	It is required to build a slow charging station to charge electric buses with long idle time and to install an ultra-fast charging station in the park.	Traction substation, charging station. To ensure power supply of charging stations it is required to connect substations through cable networks.	Requires power generation at terminal points. Uneven load.
Dynamic	It is required to build a slow charging station to charge electric buses with long idle time. It is possible to operate trolleybus park infrastructure.	Contact network, supports, cables, special parts and reinforcement, traction substations.	Even load throughout the day. Can use the existing trolleybus network.

General information on the main normative legal acts classifying passenger motor vehicles is summarized in Table 1.

Analysis of classification of electric buses and infrastructure

As noted earlier, the electric bus is a bus using electric traction. The electric power necessary for electric bus movement can be generated both on board the vehicle (for example, a hybrid hydrogen bus), obtained from the battery, or supplied to the vehicle from the contact network.

One of classification parameters of electric buses is the method of charging them. Depending on the concept of charging batteries, electric buses can be divided into the following classes [23]:

1. With power supply in motion.
2. With recharging in motion.
3. With recharging on the route.
4. With recharging at the enterprise (park).
5. With power supply by fuel elements.

According to the charging speed, the electric bus charging system can be grouped into three groups:

1. Slow charging.
2. Ultra-fast charging.
3. Dynamic charging (power supply in motion) [24].

Depending on the system (concept) for charging electric buses, different infrastructure is required. The analysis of the required infrastructure for operation of electric buses on routes, depending on the charging concept, is presented in Table 2 [25].

Charging stations are divided into two types. Table 3 shows the characteristics of both types of charging stations [25].

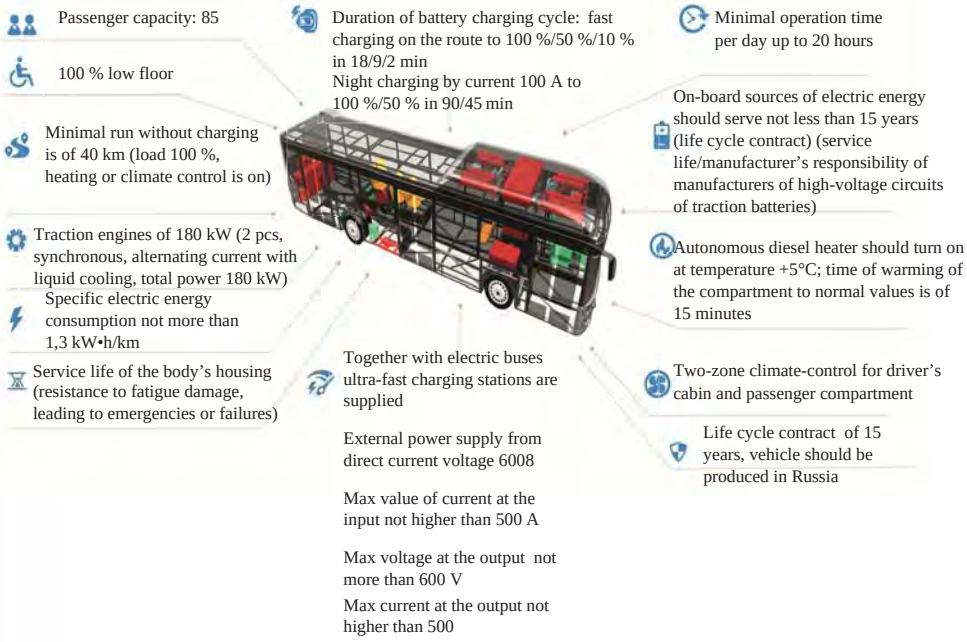
Technical requirements for electric buses

Currently, Moscow Government is implementing measures aimed at development and improvement of land urban passenger transport, reducing traffic

Table 3

Types of charging stations

Characteristic / Type	Pistol	Ultra-fast
Power	25–150 kW	150–600 kW
Charging time	Up to two hours	2–6 min
Purpose	Charging in the park	Ultra-fast charging at terminal stopping points, in the park and on the route



Pic. 2. Main technical requirements for electric buses.

congestion and improving the environmental situation in the city.

SUE Mosgortrans is the main testing ground in the Russian Federation and is actively testing different models of electric buses on Moscow routes.

At the end of 2017, SUE Mosgortrans with participation of the Transport Industry Development Assistance Association «Transport Association of Moscow Agglomeration» (TAMA Association) developed and published a draft technical specification (TS) for Moscow electric bus [26]. The development of TS draft was preceded by extensive discussions, a scientific and technical council was held with participation of experts, manufacturers of rolling stock and components. Based on this TS [26], a tender was announced for supply of 300 electric buses to Moscow under a life cycle contract.

The main technical requirements for electric buses according to TS by SUE Mosgortrans are presented in Pic. 2.

According to the classification given by us, these types of electric buses belong to electric buses with the concept of ultra-fast charging.

Together with electric buses, it is planned to supply charging stations capable of charging batteries as fast as possible. These electric charging stations will be located at terminal stations, transport-interchange hubs and directly in fleet parks. Charging stations are also purchased under a life cycle contract. A prerequisite of supply contract is localization of production of rolling stock in the territory of the Russian Federation.

Calculations of organization of route maintenance by electric buses

Initial information when organizing operation of rolling stock on a route and calculating its required amount in addition to data on passenger flow, route parameters, rolling stock capacity, etc. is charging time of an electric bus.

There are various methods for calculating the required amount of rolling stock on a route: according to a passenger flow, according to a given interval of movement, and according to performance of rolling stock.

	Round trip													
Route-10 km R.trip-40 m	From the park	1	2	3	4	5	6	7	8	9	10	11	12	To the park
 Electric bus with slow charging concept	Departure A Arrival B Arrival A	5:00 5:18	5:18 5:58 6:38	6:40 7:20 8:00	8:02 8:42 9:22 lunch	10:22 11:02 11:42	11:44 12:24 13:04	13:06 13:46 14:26 change	14:40 15:20 16:00	16:02 16:42 17:22	17:24 17:44 18:24 lunch	19:24 20:04 20:44	X	X	20:46 21:04
 Electric bus with ultra-fast charging concept.Li-ion batteries	Departure A Arrival B Arrival A	5:00 5:18	5:18 5:58 6:38 charge 20 min	6:58 7:38 8:18	8:20 9:00 9:40 lunch charge	10:40 11:20 12:00	12:02 12:42 13:22 change charge	13:42 14:22 15:02	15:04 15:44 16:24 lunch charge	17:24 18:04 18:44	18:46 19:26 20:06 charge	20:26 21:06 21:46	21:48 22:28 23:08 charge	X	23:28 23:46
 Electric bus with ultra-fast charging concept. Li-ion batteries	Departure A Arrivl B Arrival A	5:00 5:18	5:18 5:58 6:38 charge 10 min	6:48 7:28 8:08 charge	8:18 8:58 9:38 lunch charge	10:38 11:18 11:58 charge	12:08 12:48 13:28 change charge	13:43 14:23 15:03 charge	15:13 15:53 16:33 charge	16:43 17:23 18:03 lunch charge	19:03 19:43 20:23 charge	20:33 21:13 21:53 charge	22:03 22:43 23:23 charge	X	23:33 23:51
	Run, km	5	25	45	65	85	105	125	145	165	185	205	225	245	250
 Electric bus with ultra-fast charging concept. Li-ion batteries of smaller amount or super capacitors	Departure A Arrival B Departure B Arrival A	5:00 5:18 charge 6 min	5:24 6:04 charge 6:10 6:50 charge	6:56 7:36 charge 7:42 8:22 lunch charge	9:22 10:02 charge 10:08 10:48 charge	10:54 11:34 charge 11:40 12:20 charge	12:26 13:06 charge 13:12 13:52 change charge	14:07 14:47 charge 14:53 15:33 charge	15:38 16:18 charge 16:24 17:04 charge	17:10 17:50 charge 17:56 18:36 обед заряд	19:36 20:16 charge 20:22 21:02 charge	21:08 21:48 charge 21:54 22:34 charge	X	X	22:40 22:58
 Electric bus with dynamic charging concept	Departire A Arrival B Arrival A	5:00 5:18	5:18 5:58 6:38	6:40 7:20 8:00	8:02 8:42 9:22 lunch	10:22 11:02 11:42	11:44 12:24 13:04	13:06 13:46 14:26 change	14:40 15:20 16:00	16:02 16:42 17:22	17:24 17:44 18:24 lunch	19:24 20:04 20:44	20:46 21:26 22:06	22:08 22:48 23:28	23:30 23:48
 Bus	Departure A Arrival B Arrival A	5:00 5:18	5:18 5:58 6:38	6:40 7:20 8:00	8:02 8:42 9:22 lunch	10:22 11:02 11:42	11:44 12:24 13:04	13:06 13:46 14:26 change	14:40 15:20 16:00	16:02 16:42 17:22	17:24 17:44 18:24 lunch	19:24 20:04 20:44	20:46 21:26 22:06	22:08 22:48 23:28	23:30 23:48

Pic. 3. An example of organization of electric bus operation on the route.

Traffic on the route is organized in accordance with the schedule, which is compiled separately for weekdays and weekends, for autumn-summer and spring-winter periods.

An example of organization of electric bus movement on the route [25] with various charging concepts is given in Pic. 3.

The following data were taken as initial data: length of the route is 10 km; round trip time is of 40 minutes.

Pic. 2 shows that only a bus and an electric bus with dynamic charging ensure the planned compliance with the schedule.

The indicated types of rolling stock carry out 12 trips without additional time costs for recharging at the initial or final stopping points.

Given these parameters, operation of electric buses with the concepts of slow and ultra-fast charging does not ensure the fulfillment of the planned number of trips and, accordingly, the route schedule. In order to respect a given schedule, it will be necessary to release additional electric buses of rolling stock to the route. Electric buses with slow and ultra-fast charging concepts will be able to perform fewer trips due to loss of charging time.

The release of additional units of rolling stock on the route will require purchase of additional electric buses, which will lead to an increase in the costs of purchase and operation of rolling stock.

Due to the above, from the point of view of organizing movement of rolling stock along the route, operation of electric buses with the concept of dynamic charging is preferable.

However, in order to determine the optimal concept for charging electric buses, it is necessary to carry out an economic evaluation of the proposed solutions.

Conclusion. An electric bus is a relatively new type of rolling stock. So, a balanced and objective justification for selection of various possible technical, technological, economic and other aspects of solving the problem of organizing its work on the route is necessary.

The analysis of regulations and legal acts governing organization of passenger transportation by land electric urban transport, approaches to traffic management and infrastructure, as well as the choice of type of electric buses, allowed the following main conclusions to be drawn:

1. At present, various legal acts in force in the Russian Federation use different terms and definitions to classify rolling stock of road and land urban electric transport.

Current regulations regarding electric transport do not contain the category and term «electric bus».

Urban electric vehicles include only trams and trolleybuses.

2. Based on the requirements for admission of drivers to drive electric buses, they consider vehicles of category D, i.e. to buses. At the same time, drivers are required to undergo special additional training with participation of representatives of manufacturers of electric buses.

3. We consider it expedient to file with Moscow City Duma a proposal to initiate at the state level of the Russian Federation the implementation in classifications of vehicles of the term «electric bus» as a separate type of vehicle (amending the Charter of road transport and land urban electric transport).

4. The analysis of the concepts of charging electric bus batteries allowed to divide them into 5 classes and, on the contrary, to combine into 3 groups according to charging speed.

The analysis of the required infrastructure for operation of electric buses showed that conceptually there are 2 types of charging stations.

5. The calculations and evaluation of various options for organizing operation of electric buses on a fixed route with different charging concepts showed that dynamically charged buses are preferred from the point of view of the required number of vehicles.

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