On the issue of developing urban infrastructure for electric vehicles

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Abstract. The work is devoted to the development of infrastructure for recharging electric vehicles. The relevance of the use of electric vehicles and the need to provide means of recharging their batteries are considered. The article provides an economic justification for the use of electric vehicles in an urban environment. A concept has been proposed for using electric charging stations at night in the parking lots of apartment buildings. Recommendations and justification for the use of Mode 1 charging stations are given.

1 Introduction

Transport powered by electric energy is gaining popularity in Russia. Today, the share of electric buses is about 1% of the total bus fleet. According to the RBC newsletter [1], in 2021 the number of electric buses in Russia has doubled and, as a result, the demand for the production of infrastructure for this type of transport has increased. However, most electric vehicles are privately owned in the form of electric vehicles and electric bikes.

Electric cars are the most suitable urban vehicles because... negative impact on the environment is minimal. There are government programs to support the use of electric vehicles through subsidies, tax breaks, etc. [2, 3].

In turn, car manufacturers are constantly investing in the development of electric vehicles and their modification, which leads to an increase in the availability of this type of transport. Electric vehicles have a high engine efficiency, which is 75–78%, while thermal engines have only 25–30% [4].

2 Prospects for the use of electric vehicles and the development of the market for electric charging stations

One of the most important factors in the limited spread of electric vehicles in Russia is the low battery life of the car itself [5, 6]. The time from a fully charged battery to its discharge is only a few hours of continuous operation.

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The maintenance and operating costs of electric vehicles are significantly lower than those of a thermal engine vehicle.

If we use the average price of gasoline at the beginning of 2023 at 50 rubles per liter, then every 100 kilometers of travel costs the owner of a car with a thermal engine approximately 600–1300 rubles, depending on the class of the car and the engine displacement. When operating an electric vehicle, the average consumption is about 20-25 kWh. For every 100 kilometers. The cost of electrical energy for owners of electric vehicles is 10–11 rubles/kW. Thus, 200–270 rubles will be spent on 100 kilometers of travel.

Most motorists and transport companies are hesitant to use electric vehicles due to the lack of a developed infrastructure of battery charging stations [7]. The problem of charging batteries worsens in winter, when electrical energy consumption increases sharply.

Experience in operating electric vehicles in regions with unfavorable weather conditions has made it possible to develop a number of recommendations that owners of “green” cars should adhere to in winter [8, 9].

In winter, the mileage without recharging the battery is reduced. This circumstance should be taken into account when planning trips. Lithium-ion batteries lose 25-30% of their capacity at low subzero temperatures, and the range when using heating elements and heated seats will decrease by 40-45%.

According to Autostat, as of July 1, 2023, 18.7 thousand electric vehicles were registered in Russia; according to the Ministry of Energy, there are more than 1,600 automobile electric charging stations in the country [10].

In order to provide car owners with the ability to recharge their batteries, it is necessary to expand the network of electric filling stations.

To assess the efficiency of building electric filling stations, an analysis of the costs of its creation was carried out. Today, the cost of equipment for an electric filling station designed to refuel 50 electric vehicles will be approximately 3 million rubles, and from 2024 to 2025 it will be approximately 1.7 million rubles. As an assumption, it is assumed that in one day an electric car travels on average about 45 km; one kilometer requires approximately 0.3 kWh of electricity [10]. The selling price of 1 kWh at an electric filling station is set at 10 rubles, the cost of electricity sold is 4.2 rubles/kWh, the salary of a specialist servicing an electric filling station is approximately 40 thousand rubles per month. Thus, the profitability of operating electric gas stations is obvious [12, 13].

The concept for the development of electric transport in Russia until 2030 defines the priority tasks for creating a network of electric filling stations. These include: developing the production base, increasing technological competencies, introducing fundamentally new products to the market and creating modern engineering and transport infrastructure (Figure 1). In Russia, by 2025 it is planned to produce at least 25 thousand electric vehicles.

![New fast charging stations in Russia](image)

**Fig. 1.** Analysis of the increase in the number of charging stations in Russia.
3 Results and discussion

An alternative solution for recharging the batteries of electric vehicles, in addition to electric charging stations, is recharging in the local area, by extending the charging cable from the car to the outlet, which leads to significant difficulties when used in communal houses.

As one of the options for solving this problem, research was carried out and a proposal was made to introduce local charging stations in the parking lots of courtyards of apartment buildings.

During the study, calculations were made of the required power of an electric filling station; an average car with a battery capacity of 30 kWh was considered, provided that the charging time would be 6 hours.

Using expression (1), you can determine the required power of the charging station.

\[ P = \frac{Q}{T} \]

where \( T \) is the charging time (hours), \( Q \) is the battery capacity (kW*\( \text{h} \)), \( P \) is the required power of the filling station (kW).

Dividing 30 kWh by 6 hours, we get the required charging station power of 5 kW.

By assessing the traffic usage in an apartment building, the relationship presented in Figure 2 was obtained.

\[ P, \text{kw} \]

500

0 8 16 24 t, hour

Fig. 2. Traffic consumption of electrical energy in an apartment building.

Analyzing the data obtained, we can conclude that charging the batteries of electric vehicles must be done in the following time intervals: from 0.30 to 7.45 and from 14.30 to 19.00. At this time, the minimum values of electrical energy consumption traffic are observed.

Taking into account the results obtained, we can conclude that in the proposed version of the charging infrastructure, it is possible to use stations with a low battery charging rate, and, consequently, low power consumption (Table 1).
Table 1. Classification of electric gas stations.

<table>
<thead>
<tr>
<th>Charging mode</th>
<th>Charging type and connector type</th>
<th>Characteristics: voltage, current, power</th>
<th>Time until fully charged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode 1</td>
<td>Regular, Type 1 J1772</td>
<td>voltage 230 V, current 16 A, power 5 kW</td>
<td>6-14 h</td>
</tr>
<tr>
<td>Mode 2</td>
<td>Regular, Type 1 J1772</td>
<td>voltage 230 V, current 32 A, power 7.4 kW</td>
<td>5-11 h</td>
</tr>
<tr>
<td>Mode 3</td>
<td>Fast, Type 1 J1772, Type 2 (Mennekes)</td>
<td>voltage 400 V, current 63 A, power 43 kW</td>
<td>4-8 h</td>
</tr>
<tr>
<td>Mode 4</td>
<td>Fast, ChadeMo, CCS Combo (Type 1/Type 2)</td>
<td>voltage 550 V, current 125 A, power 50 kW</td>
<td>15-25 min</td>
</tr>
</tbody>
</table>

In order to ensure the implementation of the charging site project in the local area, it was proposed to create a parking lot equipped with special charging installations for owners of electric vehicles. Considering that parking of cars in the local area continues for a long time, the best option for maintaining the stability of electricity in houses and yards would be a first generation charging installation (Mode 1) [11].

Technical characteristics of the charging installation type Mode 1 (Figure 3):
- Alternating current – up to 16 A;
- Voltage – 220-240 V;
- Power – 2-5 kW*h.

Using this installation will allow you to charge the battery of an electric vehicle in up to 6 – 12 hours.

Fig. 3. Example of using the first generation Mode 1 charging station.

4 Conclusion

The developed concept of using first-generation charging stations in the courtyards of multi-storey buildings will provide a comfortable and safe charging mode for electric vehicles at night. The use of Mode 1 settings will allow you to evenly and safely distribute the load on the electrical networks of urban infrastructure and prevent possible network overloads. Mode 1 charging stations are equipped with protection systems against possible overloads and electrical power control systems.
Taking into account the technical characteristics of these charging stations, during their operation it is possible to use a system for automatically regulating the electric flow depending on the occurrence of peak load in the electrical network. The regulation system will make it possible to rationally redistribute the electric flow between residents of houses and charging stations.

References

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