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ELECTRIC VEHICLES AND THEIR IMPACT ON ENERGY INFRASTRUCTURE

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Keywords: energy, electric transport, electric vehicles, energy infrastructure, electric charging stations, economic efficiency.
Abstract. The article examines the impact of the increasing number of electric vehicles on the energy infrastructure. Attention is paid to analyzing the current state of the energy system and assessing the need for its modernization to meet the growing demand for electric vehicles. Recommendations on the adaptation of energy infrastructure for effective interaction with electric transport are presented.

ЭЛЕКТРОМОБИЛИ И ИХ ВЛИЯНИЕ НА ЭНЕРГЕТИЧЕСКУЮ ИНФРАСТРУКТУРУ

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Ключевые слова: энергетика, электротранспорт, электромобили, энергетическая инфраструктура, электрозарядные станции, экономическая эффективность.
Аннотация. В статье рассматривается влияние увеличивающегося числа электромобилей на энергетическую инфраструктуру. Уделяется внимание анализу текущего состояния энергосистемы и оценке потребности в её модернизации для удовлетворения растущего спроса на электромобили. Представлены рекомендации по адаптации энергетической инфраструктуры для эффективного взаимодействия с электротранспортом.

In recent decades, the world community has become increasingly aware of the need to switch to sustainable and environmentally friendly energy sources. The energy crisis and environmental issues such as global warming and air pollution are the main reasons for the development of electric vehicles. Electric vehicles are one of the most interesting and important areas that have emerged in recent years, which is seen as a key element in combating climate change, reducing greenhouse gas emissions and reducing urban air pollution. Considering these aspects, electric vehicles are not just an alternative to traditional vehicles, but also an important factor that can have a significant impact on energy infrastructure.

The history of electric vehicles and charging station infrastructure in Russia began relatively recently compared to some other countries. An electric vehicle is a vehicle powered by one or more electric motors that uses energy stored in rechargeable batteries. It represents an innovative alternative to traditional cars with internal combustion engines, providing transportation without exhaust emissions. Externally, electric vehicles may resemble conventional cars, but their design and principle of operation are significantly different. The electric vehicle is activated

using an electronic key or a start button, after which it is ready to move with almost no sound, which makes it much quieter compared to cars running on gasoline or diesel. Charging an electric vehicle can be done at home through a regular outlet or at special charging stations that offer higher charging speeds. The charging time can vary from 30 minutes to several hours depending on the charging power and battery capacity. The absence of a traditional fuel system, exhaust system and radiator means that electric vehicles have the opportunity for a more flexible design and weight distribution [1]. Batteries are usually located on the bottom of the car, which allows you to achieve a low center of gravity and improve handling (Fig. 1).

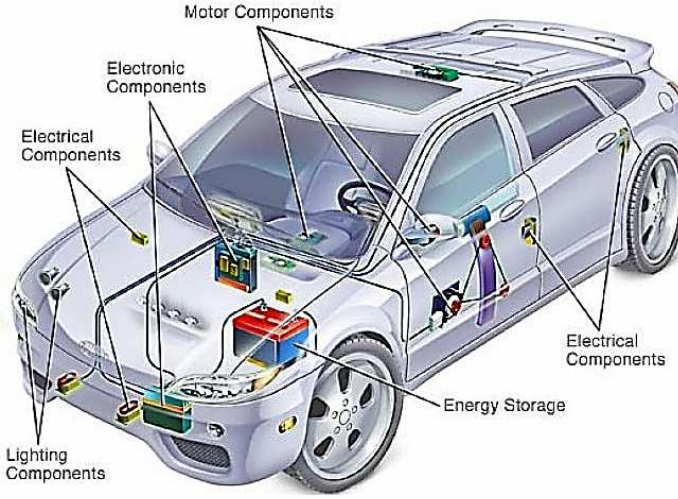

Fig. 1. The device of an electric car

The development of electric vehicles in Russia faced several problems and challenges that slowed down its pace of development. For example, climatic conditions, charging infrastructure, due to the scale of the Russian Federation, and the use of energy systems that can be quickly switched on to cover peak demand, for example, gas turbine or pumped storage power plants. Currently, they are already working on solving these problems, thus, electric filling stations has been installed in 65 regions of Russia (Fig. 2).

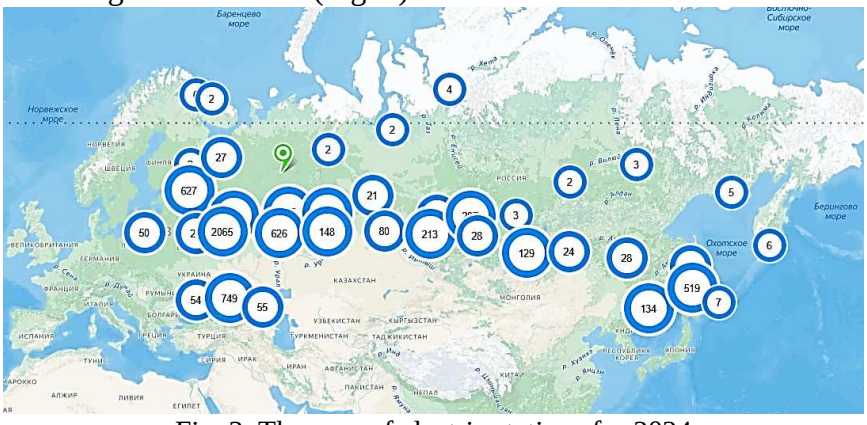

Fig. 2. The map of electric stations for 2024

To date, there are several projects in Russia aimed at developing electric vehicle infrastructure, including initiatives to install electric charging stations (ECS) along federal highways and in large cities [2].

In the context of the rapidly growing number of electric vehicles in the Russian Federation, given their geometric growth, it is worth expecting a significant increase in the load on the country's energy infrastructure (Fig. 3). This will necessitate the expansion and modernization of the existing network of power plants and substations, as well as the construction of new ones, taking into account the increased electricity consumption. One of the key points is to adapt to peak loads that can occur during simultaneous charging of a large number of electric vehicles, especially during peak hours. This may require the introduction of smart grids, which can distribute energy more efficiently, optimizing its consumption and reducing the load on the network. In addition, to mitigate the impact on the energy system, energy storage systems such as stationary batteries can be used, which can accumulate electricity during periods of low demand and supply it to the grid during peak periods. It also promotes more efficient use of energy from renewable sources, which, as is known, can be variable in nature.

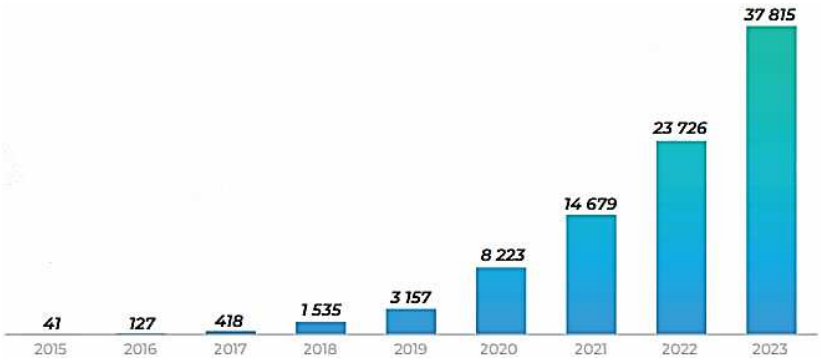

Fig. 3. The number of electric vehicles in Russia in 2015-2023

Load balancing in energy systems, especially in connection with the growing number of electric vehicles, is an important task that requires an integrated approach [3]. High-capacity batteries and other forms of energy storage can accumulate electricity during periods of low demand and supply it to the grid during peak hours. This makes it possible to smooth out fluctuations in consumption and stabilize the operation of the power system. Development and implementation of charging stations with the ability to regulate charging power depending on the current load on the network. Such stations can automatically reduce the charging speed during peak hours. Thus, a plan has already been developed for the installation of an electric power plant in the Russian Federation within the framework of the Concept for the development of production and use of electric vehicles in the Russian Federation, which will contribute to an increase in demand for electric vehicles (fig. 4).

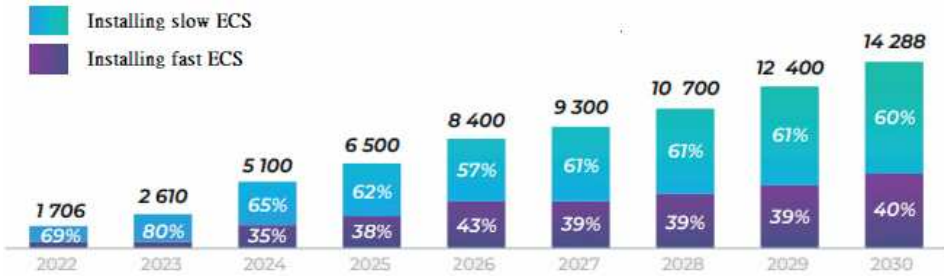

Fig. 4. Plans for the installation of in the Russian Federation until 2030

The electric charging stations market is growing at an accelerated pace. It is the problem of the availability of electric charging stations that remains the key factor that constrains the demand for electric vehicles [4].

Electricity tariffs for electric charging stations may vary depending on the region, time of day and type of tariff. As a rule, they are set by regional energy supply companies and regulated by local authorities, as well as federal authorities in the energy sector. The cost also depends on the choice of electric filling station. Slow and fast electric charging stations differ primarily in the charging speed of electric vehicle batteries (Fig. 5). The power of a slow gas station does not exceed 22 kW/h when fast ones have a power of 50 kW/h.

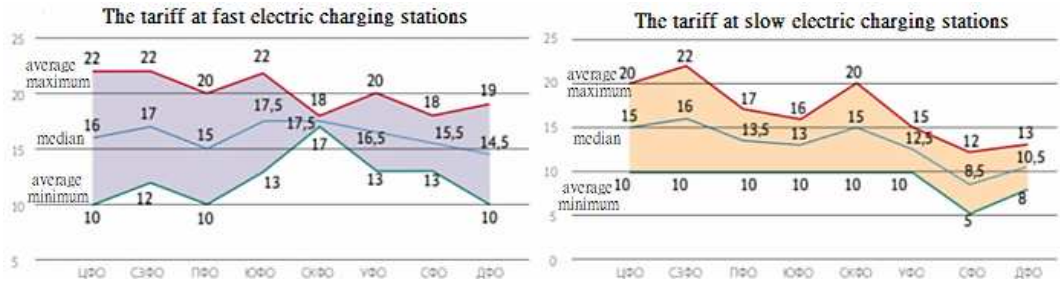

Fig. 5. Dynamics of tariffs of public electric charging stations in the Russian Federation, Rub/kWh

A typical electric charging stations includes charging racks or speakers, which are the main element. They are equipped with one or more connectors or cables that connect to an electric vehicle to transmit electricity. Transformers and converters necessary for the conversion and regulation of electricity coming from the grid. These devices are usually hidden from view and can be placed in a separate technical room or integrated into a charging station. Electricity, despite its potential danger, is still much safer than gasoline and other fuels familiar to the motorist. Basically, the charging process of an electric car is similar to charging a mobile phone, the main difference lies in the specifications of chargers and cables. In this regard, the maintenance of electric vehicles does not require the construction of large complexes. Therefore, the construction of entire complexes of buildings is not required – modern refueling of electric cars can, conditionally, be set up on the territory of a garage cooperative or on the basis of a hotel / roadside store / ordinary apartment building [5].

The study of the impact of electric vehicles on the energy infrastructure has revealed a number of key points related to their integration. According to the data, the growth dynamics of electric vehicles remains positive, which stimulates an increase in the number of electric filling stations around the world. This expansion of the electric charging stations infrastructure, in turn, requires significant investments and modernization of energy networks. Electricity production should not only increase to meet the growing demand, but also become more flexible and adapted to peak loads. The proliferation of electric vehicles and related charging infrastructure involves a review of electricity tariffs for the electric charging stations. Differentiated tariffs, which stimulate charging during periods of low demand, can be one of the solutions for smoothing peak loads and more efficient distribution of energy consumption. In conclusion, the observed growth in the number of electric vehicles and electric charging stations represents both an environmental and technological revolution in the transportation industry. It requires concerted efforts to upgrade energy infrastructure, introduce flexible electricity tariffs and develop renewable energy sources. These steps will ensure sustainable development and enable the full potential of electric vehicles to reduce the carbon footprint of transport.

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