Trends in the design and development of the infrastructure of electric filling stations

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Abstract. The article addresses trends in the design and development of infrastructure of charging stations. The article analyzes international experience of the development of electric transport (Germany, Great Britain, China). National concepts, principles of production development, as well as private business in this aspect are analyzed. A separate emphasis is placed on the fleet of electric vehicles, the most developed market segments (passenger cars, buses, commercial vehicles) are discussed. Problematic issues and stop factors in the development of electric transport are emphasized. Scientific novelty based on defining components of the development of charging infrastructure, practical recommendations for the development of infrastructure for electric transport and formulation of practical recommendations on creating a network of charging stations along federal highways, as well as roadside service facilities.

1 Introduction

Today, the global trend is the transition of transport to electric traction. This transformation requires a brief increase in the number of gas stations and the development of electrical infrastructure. In international studies, this topic is considered from various points of view. Scientists focus on both technical issues and issues of operation, modeling, network development, ecology, as well as management. In particular, the role of the development of charging stations and electric transport to reduce harmful emissions is emphasized [1, 4]. Note that this trend is developing equally in different countries of the world. For example, in the UK, an important component of development (along with the technical component) is the need to develop an appropriate government policy, approve standardized technical requirements for equipment. The German experience in the city of Stuttgart highlights another aspect – the issue of territorial planning of infrastructure placement. The choice of location is based on simulation modeling, consisting of several sections: model features (operation parameters of a particular vehicle), a demand determination module (predicts demand for charging infrastructure in a particular part of the city based on weather conditions and time of the day) [2]. This model allows you to form a comprehensive plan for the placement of charging infrastructure in the region.

Of course, such changes require transformation in industry and energy [3]. To date, the transition of industry from car manufacturing powered by internal combustion engines to

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the creation of electric vehicles is gradually taking shape. At the same time, do not forget the electric power sector. After all, the growing demand will require a brief increase in energy capacity. This demand can be met, among other things, by more efficient generation of energy from renewable energy sources (solar, water energy, solid communal recreation energy, etc.), which determines the level of environmental friendliness of electric transport [5]. Perhaps alternative energy sources will not become the main ones, but they will allow for a more flexible approach to energy supply.

2 Materials and methods

The purpose of the work is to analyze the factors determining the development of charging stations, research foreign experience and develop proposals for improving the design of highways (as well as roadside infrastructure (taking into account the growth of electrification). The following tasks were formed in the work:

- Highlight problematic issues in the development of electric transport and charging infrastructure
- Define promising areas for the formation of a network of charging power plants
- Outline problematic issues and trends in the development of electric transport in various countries of the world.

This study is based on the state statistics and the corporate consulting analytical reports. Descriptive, comparative, logical, economic and statistical methods were also used in the study. The authors also relied on the method of expert assessments, graphical analysis, which together made it possible to fulfill tasks set in the study.

3 Results

Today the issue of the development of charging infrastructure consists of several components relying on private sector, public policy, as well as manufacturing sector of the economy (Figure 1). At the same time, the demand for electric transport and infrastructure will increase. This development is carried out within the framework of the Industry 4.0 concept, where electrification and unmanned technologies are the main trends in the automotive industry [6-7]. Despite the great attention of the state, this project is still a pilot and requires the development of a detailed roadmap. The risk factors still remain: the possibility of running without recharging, insufficient infrastructure development, the primary source of electricity, as well as issues of production of subsequent disposal of lithium-ion batteries. In terms of charging infrastructure, there are serious achievements, which include wireless charging technology. The task of any research and development in this area is to accelerate the charging process. Currently, electric vehicles require a lot more time for "refueling" in comparison with cars using traditional fuel sources. In addition, these technologies are still expensive, limiting the possibility of more widespread use.

Thus, the process of forming the charging infrastructure should be based on two interconnected circuits: public and private.

The task of the public sector is not only to develop regulatory and legal regulation, but also to develop a network of charging stations along the federal highways and in large cities. This is due to the fact that state-owned enterprises are most often the operator of these highways. The second no less important issue is new road construction. The existing infrastructure does not take into account the changed realities. Nevertheless, for increasing demand, it is necessary to include in the road passport a criterion according to which the possibility of developing charging infrastructure is laid in the design process and appropriate communications are laid.
Other fundamental issues of the organization are the design, location and cost of charging. The integration of private business allows you to multiply the supply. The emergence of charging infrastructure in this case can develop through roadside service – adaptation of existing infrastructure (campsites, gas stations, rest and food points), equipping them with electric car chargers. In this case, it is necessary to pay attention to the field of auto tourism. Today's behavioral patterns of travelers largely share humanitarian values and are focused on the environmental agenda. In addition, the private sector allows you to form a proposal for industrial companies. The development of the component base will reduce the cost of these products.

Thanks to this, it will be possible both to organize this system at the national level (the state aspect) and to individualize the service of end consumers (the private sector). Branch science will also play an important role (Figure 2).
4 Discussion

Current data confirm the global trend for the development of electric transport and the corresponding infrastructure for it. According to various expert data, the market volume by 2030 will amount to 230 million vehicles (International Energy Association) or more than $1 billion in capitalization (MarketWatch, Fortune business Insights) [8-10]. At the same time, Europe, China and the USA will become the key market players (Figure 3).

![Fig. 3. Development of electric transport in various countries of the world.](image)

It is worth noting that the COVID-19 pandemic has become a risk factor that has somewhat slowed down the development of electric transport. The coronacrisis resulted to problems in logistics, which also affected the shortage of chips. A modern vehicle, especially an electric car, is an "intelligent" vehicle that combines digital services in addition to the traditional characteristics of the car.

Nevertheless, thanks to the efforts of government agencies, the production level has recovered, and the demand for electric vehicles continues to increase. As part of the government's measures, the following are highlighted: regulatory and legal regulation aimed at reducing CO₂ emissions, appropriate subsidies supporting the purchase of electric vehicles, as well as quotas - an obligation for automakers to produce a certain number of vehicles with electric power plants. In terms of measures to stimulate the spread of electric transport, there is a direct correlation between public investment and an increase in the fleet of electric vehicles. So during the COVID pandemic, industry support measures led to an increase in subsidies for the purchase of electric vehicles.

- **BEV** - Traditional electric car, battery-powered
- **PHEV** - Plug-in hybrid electric vehicle
- **HEV** - Hybrid electric vehicle
- **E-REV** - Electric vehicle with increased power reserve
- **FCEV** - Fuel cell electric vehicle

![Fig. 4. Modern classification of electric transport.](image)
The trend towards the development of electric transport suggests a different classification of road transport based on the technologies used. The most common is the BEV segment, which has more than 200 models. The length of a trip on a single charge for such cars is about 400 kilometers, which is significantly higher than the walking distance for plug-in hybrid cars (which often require charging). It should be noted that electric traction, in addition to passenger cars, is actively developing in other segments. So in the LCV (light commercial vehicle) segment, there are about 400 available models. The bus fleet stands apart, which requires an appropriate charging infrastructure. There are two main concepts in this matter: night charging and charging on the go. The latter option involves the creation of gas stations at the final stopping points. The number of electric buses exceeds 600 thousand units on an international scale.

5 Conclusion

Thus, the process of development of electric transport will only increase. Electric vehicles are increasingly finding their consumers in various countries of the world. At the same time, various segments of this technology are gradually developing, which create a high demand for charging infrastructure and require its rapid implementation. The formation of this industry is based on the participation of the public sector, science and business structures. At the same time, the difficulties of market formation are both organizational and technical in nature. Among the organizational tasks, the concept of the development of electric transport in a particular country stands out. Among the technical issues are projects for the development of road infrastructure (taking into account the design of infrastructure for electric transport), as well as the work of industry. It is worth noting that there is also competition in the production of lithium-ion batteries, only 30% of the volume is related to the automotive industry. The main part is exported by the consumer segment, industrial goods, etc. In this sense, in the medium term, it is advisable to vertically integrate the industry with the creation of separate battery production facilities focused separately on the needs of the automotive industry.

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