

## THE ISSUE OF TRANSPORT INFRASTRUCTURE ORGANIZATION FOR STORAGE OF ELECTRIC VEHICLES IN THE URBAN ENVIRONMENT OF THE LARGEST CITIES

**Abstract:** this article describes the issues of compatibility of electric vehicles with the existing transport infrastructure of the largest cities in Ukraine. We analyze the international experience (Europe, USA) of the successful implementation of electric vehicles in the existing «fabric» of a densely built-up urban infrastructure. This implementation includes: a network of charging stations, multistorey parking garages, and parking lots for short-term and long-term storage with charging stations, service stations, and electric vehicles in urban areas of the largest cities.

Results of the study can help to further develop the concept of a network of charging stations, the modernization of car service stations, parking spaces in the existing multistorey parking-garages, and the construction of new transportation facilities for the successful operation of their electric cars, as well as changes to the existing building regulations on this matter.

**Keywords:** the largest city, transport infrastructure; electric cars; charger; multistorey parking garages.

**Introduction.** The signing of the Association Agreement with the European Union requires Ukraine to adopt and implement European values in its territory. One of them is the development of environmentally friendly transport, including the electric or hybrid cars. The emergence of electric vehicles in Ukraine will contribute to the environmental protection, ensure energy independence, facilitate public access to the latest developments and technologies, and will allow the country to reduce expenses on petroleum products and reduce the cost of vehicle maintenance. Maintenance of the electric cars carried about 1 every year, and technical car service – every 2 - 4 years or every 50 - 60 thousand of km.

The advantages of electric vehicles are the absence of harmful emissions; low cost charging; a high level of environmental performance; simplicity and low cost of maintenance, great mileage between service; low explosion safety in an accident; designs and ease of management, high reliability and durability; quietness and smoothness; the possibility of charging from a household outlet. The fundamental difference of the electric cars is that they don't form the exhaust gas, while standing in traffic the engine doesn't consume energy. It's been determined that the use of the electric vehicles, compared with the price of fuel and electricity in Ukraine, is more cost-effective than, for example, in Russia or Europe [1, 2].

**The article's aim** is to determine whether the existing transport infrastructure is well-adapted for the implementation of its electric or hybrid cars, with the establishment of the necessary measures for the further successful operation of such vehicles in the largest cities of Ukraine, both in terms of infrastructure and at the level of state building codes.

Today the number of electric vehicles is about 0,02% of the total fleet in Ukraine. Their small number is due to the lack of a state strategy of the environmental initiatives, and necessary services. Increasing the share of electric cars in the road transport market in Ukraine will be noticeable especially in the largest cities, whose urban population is about 45% of the total population. It is cities such as Kyiv, Kharkiv, Dnipropetrovsk and Odessa.

In turn, the planning of the largest cities laid out in the early to mid-XX century for public transport was not designed for the growth of automobilization. In the developed modern city master plans of Ukrainian cities for the future, for example, Kyiv to 2025, the territory for the organization battery power plants for new, refurbished service stations is not isolated and parking space in facilities for the storage of electric vehicles is not reserved, etc.

The level of car ownership in 1970 was  $\approx 7$  cars in 1000, but today the figure is already  $\approx 300 - 350$  cars per 1,000 people and is growing. The growth of the car fleet in the implementation of electric vehicles in the unprepared infrastructure of cities can cause parking in unauthorized places (on the roadway of streets, lawns, sidewalks, residential yards, etc.), and this, in turn, will lead to congestion, reducing bandwidth major highways and generally resulting in traffic jams. Therefore, timely approach to the issue of the necessary transport infrastructure in Ukraine for the successful operation of the electric or hybrid vehicles should come first.

With the introduction of the electric vehicles to the largest cities it's important to pay attention to the development of transport infrastructure and state regulatory support on this issue in the country. Necessary measures regarding infrastructure should be: organization of a network of charging stations in the structure of cities and intercity traffic between cities and suburbs for convenient moving through the territory of Ukraine; providing additional parking spaces in buildings for storage through new construction or modernization with an emphasis on fire safety in them; creating a network of new and newly upgraded service stations, and more.

On the basis of these measures the world has created interesting and worthwhile models of transport infrastructure for the implementation of the electric vehicles. Specifically, they include the organization of: a network of the electric charging stations; open-plane parking lots with car parking spaces covered with the solar panels that function as charging stations; multistory parking garages, etc. [3, 4, 5].

At the level of building regulations should be implemented adjustments and changes to existing in the Ukraine building regulations «Open plane parking lots and multi-storey parking for vehicles» in parts: the provision of health permissible distances to charging stations in the structure of cities; rational organization of the parking spaces for the storage of electric vehicles and chargers with them, the issue of energy efficiency in placement of charging stations in the structure of cities.

For timely replenishment of the charging batteries of electric vehicles need to create a fast charging stations infrastructure. Considering the introduction of *the electric charging stations* to the planning structure of the largest cities in Ukraine revealed: dense building (planning has been prepared  $\approx$  50-60 years), overly small width carriageway streets not designed for the ever increasing level of car ownership; almost no reserve land for new construction.

The preceding may become an obstacle in the organization of a network of charging power stations and parking spaces in public parking lots plane covered with solar panels that function as charging stations at them. The disadvantage of plane parking is unduly large territory that they occupy and insufficient to ensure security deposit in them. And in the largest cities of Ukraine with few reserve areas for new construction this is an unjustified luxury. Therefore, the proposed decision can only be rational in its implementation in the industrial zone.

Currently, two methods of electric charge have become popular. The first and simpler of them is an ordinary home charging outlet 220V. Another way is the charging stations. The charging stations are classified according to: 1) purpose; 2) type of arrangement; 3) charging time; 4) number of vehicles that can simultaneously charge.

By purpose, charging stations are divided into: personal (home) use - is the simplest types of charging stations; commercial use – a station installed in shopping malls, corporate parking lots near the offices and other public places, they have a means of authentication, energy meters, and often made vandal style. By type of arrangement of the charging stations there are the following: floor; wall; mounted on the pole or mobile. At the time of charging, stations can be slow- and fast-charging. The time required to fully charge the electric vehicles can range from 30 - 40 minutes to 12 – 14 hours. Two to four vehiclest can be charged simultaneously at one station.

In Kyiv, with the agreement by the Kyiv City State Administration, it was proposed to create fast-charging stations infrastructure based on electric power supply networks of the «Kiev Metro». The project owner network of filling station «OKKO» and «Tesla Club Ukraine» located on the highway Kyiv – Odesa pump «OKKO» has already organized 34 charging terminals for the electric vehicles and continues to open new ones.

Today in Ukraine the vehicle service stations are not focused on the maintenance of the electric vehicles. If we add to this the constant improvement of batteries and

increase their life we get a car that requires minimal maintenance. Given the cost of maintenance, the electric car is cheaper than diesel car. The choice of sites for placement of service stations further defines its urban role, zoning, location of entry and exit, the circuit of the vehicles on the site [6].

In the largest cities, it's advisable to place: car service stations and centers on the periphery of the city, adjacent to the existing industrial zones near transportation hubs, which include bus stations etc.; average-capacity stations on the outskirts of residential areas; small service stations evenly within each residential area.

The organization of the multistorey parking is economically advantageous for using the territory for a maximum of the parking spaces for the storage of the electric vehicles. It is rational to build the multistorey parking garages open type when placed in their parking spaces for the electric vehicles. The architecture of these buildings corresponds to aspects of sustainable development, with the possible organization of solar panels to collect radiation on the roofs and the subsequent transfer of the electric charge to the charging stations located in their inner space. It is interesting to compare networks of car transport and electric vehicles (Table. 1.1).

*Table. 1.1 Similarities and differences between the vehicles on petrol or gas and the electric vehicles*

Process		Common	Excellent	
			Cars on fuel from oil, gas	The electric vehicles
Storage	Parking lots	Occupy large land area	Parking place (3,0 x 6,0 m)	Parking places covered with solar panels (3,5 x 6,5 m )
	The multistorey parking garages	Impose the same requirements for planning decisions	Standard requirement as to the organization of industrial buildings ventilation, evacuation and fire protection	Increased demands of ventilation, evacuation and fire protection

Vehicle (maintenance) service station	The choice of land to accommodate a gas station and electric filling stations should take place at the planning stage of a building site	—	
Fueling, electrical charging		Motorway filling station	Charging station

Both conventional cars and electric vehicles need a lot of parking space. However, electric vehicles' parking spaces need even more space, because the coating solar cells require a separate allocation of space for their attachment. The same requirements are common in organizing parking spaces for conventional and electric vehicles in multistory parking garages. Parking garages spaces with chargers place increased demands of the ventilation, evacuation and adequate fire protection.

Stations for both types of vehicles need land at the planning stage of building area. Territorial planning at the local level is provided by the respective local councils and their executive bodies and lies in the development and approval of master plans of settlements, planning schemes for territories and other planning documentation.

According to the Ukrainian building regulations «Parking lots and garages are for passenger cars», the motorway filling stations in towns should be placed on land that is separated from quarters of the residential and the public buildings, taking into account the overall needs of the locality, depending on the level of car ownership, traffic, consumer demand. In the largest cities, stations should be placed along the main streets of a city and regional significance and the streets and roads of industrial and municipal storage zones and their territories.

**Conclusion.** Based on the research in the article explored the basic problems of the electric vehicles operating in Ukraine and ways to implement them. Unfortunately, today the issues of the necessary infrastructure for compliance of Ukraine for the implementation of electric vehicles in Ukraine has not been resolved.

In general, we determined that:

- 1) operating cost is lower for electric cars than for fuel cars;
- 2) maintenance and repair of electric vehicles are almost identical to those of conventional cars, and the main difference is the electric drive;
- 3) the legal and regulatory framework for the implementation of electric vehicles is not developed, which inhibits the development of transport infrastructure funding for their operations;
- 4) storage, technical service and minor repairs of electric vehicles are no different from cars operating on fuel with petroleum products, require modernization and reconstruction of existing facilities for the storage and service stations; and

5) networking of the car service stations within and between are under formation, with a tendency to gradually expand.

However, one of the first ways to implement the task of introducing the electric vehicles to the infrastructure of Ukrainian cities, the example of Europe and the United States could be using them in a taxi from the airport, railway and bus stations, or to deliver cargo or mail for short distances.

In general, the implementation of the electric vehicles to transport infrastructure of the largest cities in Ukraine will boost their promotion and enhance loyalty and trust in an independent electric transport. And the infrastructure of the charging stations will be the foundation for the implementation of such projects as the city electric bus, significantly increasing standards for transit of the cities in Ukraine.

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### Анотація

У даній статті описані проблеми імплементації електричних автомобілів до існуючої транспортної інфраструктури найкрупніших міст України. Аналізується міжнародний досвід (Європа, США) успішного впровадження електромобілів до існуючої «тканини» щільно забудованої міської інфраструктури, що включає в себе: мережі зарядних станцій, багатоповерхові автостоянки, паркувальні місця для їх короткострокового і довгострокового зберігання та станції технічного обслуговування електричних транспортних засобів до структури найкрупніших міст.

Результати даного дослідження можуть сприяти подальшому розвитку концепції мережі зарядних станцій, модернізацій автосервісів, паркувальних місць в існуючих багатоповерхових автостоянках, а також зміни в існуючих будівельних нормах.

Ключові слова: найкрупніше місто, транспортна інфраструктура; електромобілі; зарядні пристрої; багатоповерхові автостоянки.

Аннотація

В данной статье описаны проблемы имплементации электрических автомобилей в существующую транспортную инфраструктуру крупнейших городов Украины. Анализируется международный опыт (Европа, США) успешного внедрения электромобилей в «ткань» плотно застроенной городской инфраструктуры, включающей в себя: сети зарядных станций, многоэтажные автостоянки, парковочные места для их краткосрочного и долгосрочного хранения и станции технического обслуживания электрических транспортных средств в структуре крупнейших городов.

Результаты данного исследования могут способствовать дальнейшему развитию концепции сети зарядных станций, модернизаций автосервисов, парковочных мест в существующих многоэтажных автостоянках, а также изменения в существующих строительных нормах.

Ключевые слова: крупнейший город, транспортная инфраструктура, электромобили, зарядные устройства, многоэтажные автостоянки.