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# Possible problems of transport electrification in Tashkent

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**Abstract.** The purpose of this article is to assess the process of electrification of transport in Tashkent and forecast some of the possible consequences of this process until 2027. It has been established that with the growth of transport electrification, it is possible to achieve hazardous concentrations of particulate matter in the atmospheric air of the city. A significant relative increase in ferrous and non-ferrous metal waste (by 1.3...3.6 times), as well as scrap tires (by 1.5 times) is also predicted.

## 1 Introduction

The problem of electrification of vehicles has become a priority in recent years in many countries around the world.

The World Climate Summit (COP26, COP26) on October 31, 2021 set a common goal - to stop selling combustion engines no later than 2040, by the end of 2022, 33 countries have agreed to this initiative.

Worldwide sales of electric cars have increased rapidly, accounting for 9% of the total market. In Spain, a complete refusal of cars running on petrol and diesel fuel is planned by 2050, in Denmark, Germany, Ireland and the Netherlands - the ban on the sale of such cars from 2030, in Norway - from 2025 [1].

At the beginning of April 2022, China's largest electric car manufacturer BYD stopped producing cars with internal combustion engines from February 2022 and now produces only electric and hybrid cars [2].

Uzbekistan has also pledged to bring the share of electric cars to 20% of all vehicles by 2030. It is expected that ministries, departments and organizations with authorized state share of more than 50% will have to transfer at least 10% of company cars to electric cars by 2025 and 100% by 2030 [3].

It is planned to increase the degree of electrification of transport not only through imports, but also through the opening of own production. In this direction attempts are made since 2017-2018 [4]:

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- By the end of 2019, it was planned to set up production of electric cars in Asaka. The Korean company Rooper teikom Co. Ltd.
- in 2019 it was announced to organize the production of electric cars in Khanabad, Andijan region. The enterprise was scheduled to be commissioned in July 2021.
- In 2021, plans were discussed to establish an enterprise in Bukhara region to produce electric cars with a capacity of 30 thousand units/year jointly with the South Korean company Songuo Mobility Innovation Co. Ltd.
- in 2017, it was planned to start production of electric vehicles at Shafof Omadli Sanoat (Fergana) from 2021. In reality, the enterprise will start production in 2023 in the amount of 10 thousand units per year, of which 40% will be exported.

Of all these projects, only the launch of the plant in Fergana is currently underway.

Despite the fact that the degree of transport electrification is one of the indicators of the environmental sustainability of transport, we cannot certainly speak about the full environmental safety of electric cars. Electric vehicles on average have a greater mass than vehicles with internal combustion engines (ICE-vehicles), so they pollute the air more actively with products of tire wear and road dust [1, 5]. Also, electric cars become sources of accumulation of waste of various materials, require significant energy consumption.

In addition, it is required to create an appropriate infrastructure for maintenance of electric cars

The leadership of Uzbekistan believes that the country has enough resources to ensure the production of electric cars with its own raw materials. For example, local production of components for electric cars, as well as charging stations, will be established on the basis of the created copper clusters. It is also stated that Uzbekistan has the raw materials necessary for the production of lithium-iron-phosphate batteries for electric cars [6]. To date, such production has not yet been created and it is still difficult to assess what impact they will have on the environment.

The purpose of this study was to give an approximate estimate of the possibilities of electrification of motor vehicles in Tashkent and the expected environmental impact of this process over the next 5 years.

# 2 Objects and methods of research

## 2.1 Research area

Tashkent city was chosen as the research area, since the highest level of motorization and the most active electrification of automobile transport is observed in this city.

There were 525,028 registered private cars in Tashkent in 2022. The motorization level in Tashkent is 179 cars per 1000 inhabitants, while the average indicator in Uzbekistan is 90 cars per 1000 inhabitants [7].

## 2.2 The level of electrification of passenger vehicles in Tashkent

The import of electric vehicles into the republic began only in 2018 and over the past 4 years there has been a sharp increase in imports. About 65% of electric vehicles are imported from China, 28% from Turkey, and the rest from South Korea, the USA and Lithuania [4]. The dynamics of imports of electric vehicles is shown in fig. 1.

The corresponding infrastructure for servicing electric vehicles is very poorly developed: there are no specialized repair and maintenance bases, and the number of charging stations is very small. The government plans to bring the total number of charging stations to 2,500 by the end of 2024. To date, the total number of charging stations for electric vehicles in Uzbekistan is 70, of which 43 are in Tashkent [8] (their location in the city is shown in Fig. 2). This explains the fact that 90% of electric vehicles in Uzbekistan are concentrated in Tashkent.

### 2.3 Research Methods

To assess the dynamics of electrification of vehicles in Tashkent, the analysis of statistical data on the dynamics of imports and growth rate of the vehicle fleet was carried out.

In order to forecast the level of electrification of transport for the next 5 years (for 2027), data processing in the software package Origin 6.1 was used.

To estimate emissions into atmospheric air, calculation methods developed at the Research Institute of Atmosphere (Russia) and described in [9, 10] were used. The norms of mileage emissions are accepted according to [9, 11]. Oil consumption rates for different types of cars were taken according to [12], and the mass of tread dust generated per year by one car (for a car 1.35 kg per year, for a truck 17.1 kg per year, for a bus 53.2 kg per year) according to [12].

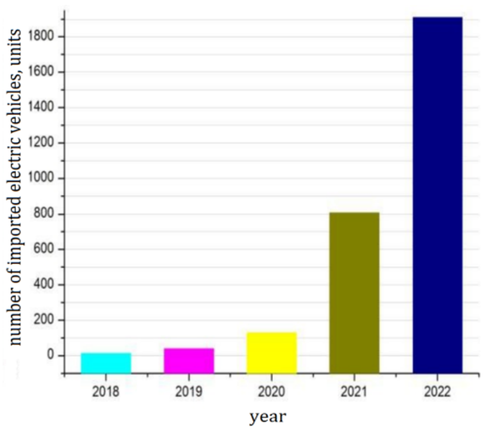


**Fig. 1.** Dynamics of electric vehicles imports to Uzbekistan


**Fig. 2.** Location map of electric charging stations in Tashkent

Estimation of the amount of waste produced was made with the help of calculation methods outlined in [10, 13], based on mileage rates before replacement of vehicle components.
The terms of replacement of some parts of the electric car are taken according to [14, 15]:

-brake fluid - every 2 years (or after mileage of 40-60 thousand km);

-transmission oil - every 2 years;

-antifreeze - every 5 years.

-tires - after mileage of 48-64 thousand km.

The calculation also takes into account the fact that tires of electric cars wear out 20% faster than those of cars with internal combustion engines.

When estimating the amount of waste formation and disposal of electric vehicles from operation, experimental data on Tashkent were used, obtained in [10, 13]. According to these data, the annual decommissioning of electric cars in Tashkent is about 3-4% of their total number (14,544...19,392 cars per year). Taking into account the fact that electric cars are just beginning to be used in Uzbekistan, such percentage of their retirement in the coming years is not expected. Therefore, to estimate the volume of waste generation of retired electric cars, a retirement rate of 0.5% per year has been conventionally assumed.

It is also known from social surveys [10] that some of the cars taken off registration are resold to other owners, and some are stored/left in the city. As a result, only about 1% of the cars taken out of registration are sent for recycling.

Due to the lack of data on the brands, capacities, battery types and other characteristics of imported and planned electric vehicles, the forecast period is only 5 years (until 2027).

# 3 Results and their discussion

## 3.1 Assessment of degree of public transport electrification

Public transport in Tashkent is as actively developing as private transport. Significantly larger volumes of passenger traffic than that of private passenger transport allow efficient use of space and provide an opportunity for a huge number of people to move in different directions for any distance.

Fig. 3 shows the diagram of changes in the ratio of electric and traditional public transport in Tashkent. The diagram is built taking into account not only the number, but also the nominal passenger capacity of each mode of transport [16]. The total nominal passenger capacity of all modes of transport is taken as 1.0 (100 %), and then the shares of electrified and ICE-vehicles in passenger traffic are determined.

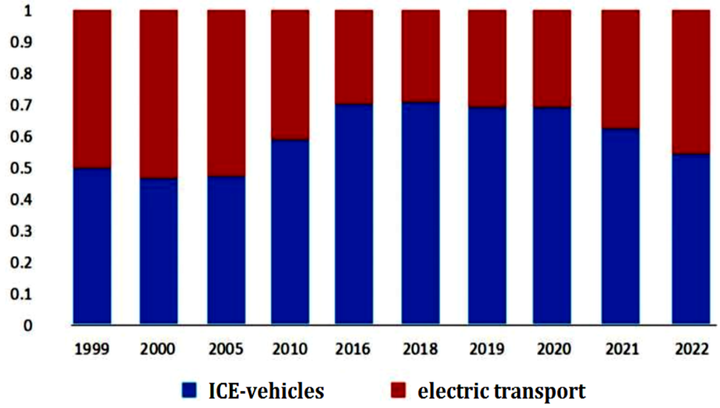


**Fig. 3.** Dynamics of change in the ratio of electrified transport and ICE-transport in Tashkent

It can be seen that the share of public electric transport in Tashkent is currently 54%. It should be borne in mind that 92% of the electrified public transport in Tashkent is accounted for by the subway.

## 3.2 Forecast of growth of electric cars in Tashkent

Analysis of electric vehicle import data for 2018-2022 (Figure 1), performed in Origin 6.1 software, shows an exponential growth in the number of imported electric vehicles according to the equation

$$N = 11.836e^{(t/0.98117)}$$

where *t = (current year - 2017)*. Since the import of electric vehicles to Uzbekistan began only in 2018, 2017 was chosen as the zero year.

Based on the obtained expression, a graph of the growth of electric vehicle imports was plotted (Fig. 4).

It can be seen that if the current growth rate is maintained, it can be assumed that by 2027 (in 5 years) the total number of electric cars will reach 110.8 thousand units due to imports. In addition, the planned own production of electric cars may increase the number of electric cars to 140.8 thousand units by 2027.

Currently, the bulk of electric cars are concentrated in Tashkent. If we assume that within the next 5 years there will not be a sharp change in the situation, then about 90 % (126,720 units) of the projected total number of electric cars will be concentrated in Tashkent

The total number of passenger cars by this year may reach 682,687 units (with a growth coefficient of 1.05 [10]). Thus, if the current growth rate is maintained, the degree of electrification of vehicles in Tashkent will reach 18.5% by 2027. This suggests that for Tashkent the planned program of motor transport electrification (20% by 2030) will be fulfilled. At the same time, it is obvious that for the rest of Uzbekistan achieving this level by 2030 is impossible.

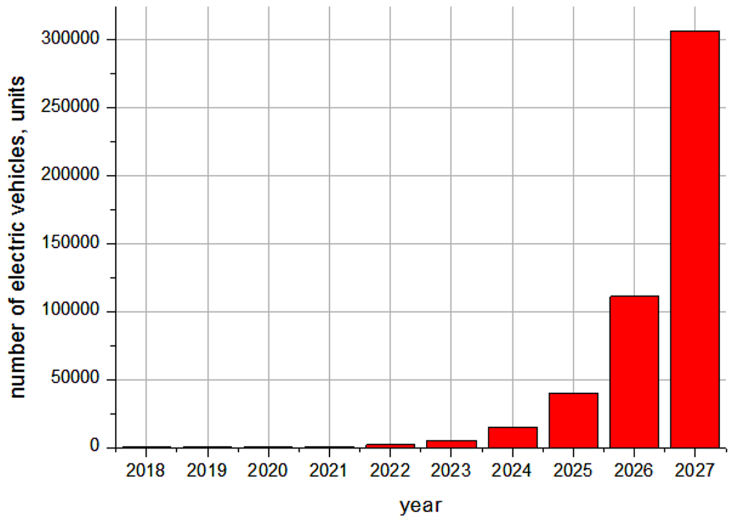


**Fig. 4.** Diagram of exponential growth of electric vehicle imports to Uzbekistan (forecast)

### 3.3 Energy indicators

It can be assumed that with the increase in the number of electric cars, gas consumption will decrease (currently about 50% of all cars in Uzbekistan consume gas fuel). However, production of additional electricity also requires gas consumption.

Currently, according to Uzbekenergo JSC (http://uzbekenergo.uz/ru/press center), 85.7% of electricity in Uzbekistan is produced by thermal power plants, 13.3% - by hydropower, the rest - by solar and wind power plants. However, firstly, more than 80% of TPPs operate on natural gas, the share of coal-fired plants is only 5%; secondly, it is planned to increase the share of electricity production using renewable and alternative sources (by 2025 planned to increase by 20%). Electricity supply of Tashkent is completely based on natural gas combustion.

It is known that electric cars on average consume energy of 0.19 kWh/km. Gas fuel consumption by vehicles with internal combustion engines is on average 0.11 ... 0.12 $m^3$/km.

To produce 1 kWh of electricity at TPP in Uzbekistan, 0.171 $m^3$ of natural gas is spent [18] - the volume, providing 1.5 ... 1.55 km of run of a car with methane-engine engine. Taking into consideration the losses at TPP (5...10%) and losses during charging of electric vehicle batteries (15...20%), useful energy makes 0.7...0.8 kWh. This energy can provide 3.7...4.2 km of mileage of an electric car, i.e. electric cars are 2.5 times more economical compared to the direct use of natural gas in an internal combustion engine.

This result differs from the results of other researchers who claim that electric vehicles have lower energy efficiency than internal combustion engine vehicles. The difference in the results can be explained by the difference in the way and purity of obtaining electricity in each particular region [1], and losses in power plants and power grids. However, even in the case of real energy savings by electric vehicle, it should be remembered that the production of electricity by thermal method is accompanied by significant emissions of $CO_2$ and other gases, and these emissions exceed the amount of emissions of cars with internal combustion engine.

Despite the seemingly high economic efficiency of electric cars in the conditions of Uzbekistan, it should be noted that in 2022 there was a deficit of electricity production, which for the city of Tashkent was 80 million kWh, and for 2023 a deficit of 240 kWh is projected. This trend calls into question the feasibility of electrification of transport.

## 3.4 The impact of electric vehicles on urban air pollution

Our objective was to estimate the change in emissions only within the city, so we did not consider TPP emissions. The results of calculating the emissions of car fleet in Tashkent by 2027, taking into account the projected increase in the share of electric cars are presented in Fig. 5.

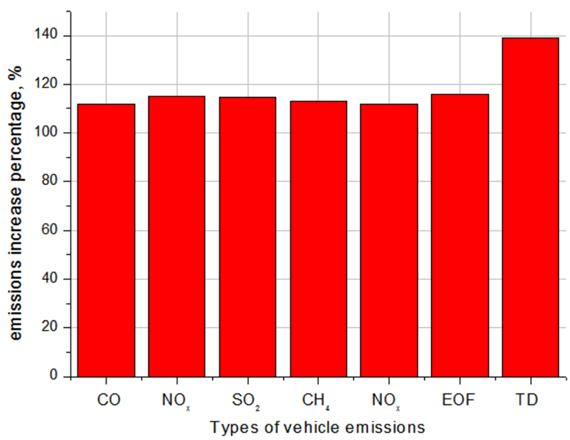


**Fig. 5.** Diagram of the growth of various emissions of motor vehicles by 2027: EOF - engine oil fumes; TD - tire dust

From Fig. 5 we can see that the expected increase in almost all components of emissions by 2027 compared to the present time lies in the range of 110-120%, which is proportional to the increase in the number of cars with internal combustion engines, except for tire dust emissions. This is explained by the greater mass and increased wear rate of tires of electric cars compared to the tires of internal combustion engine cars.

In Tashkent city air is often characterized by increased dustiness, e.g. in January 2023 air quality was characterized as Unhealthy, with PM 2.5 being the main pollutant (Fig. 6). Under such conditions, the expected additional emissions of particulate matter can lead to their life-threatening concentrations.

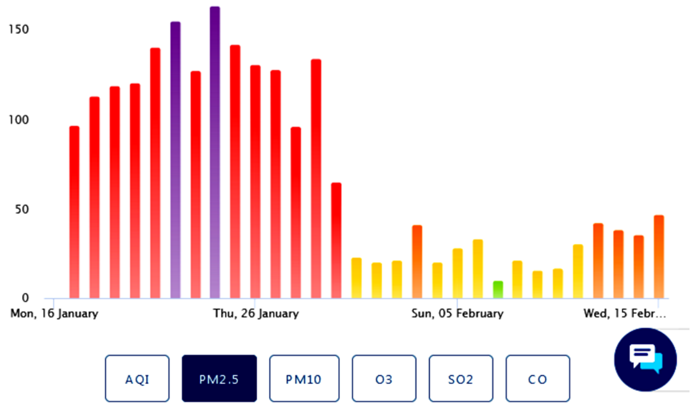


**Fig. 6.** Air quality graph for Tashkent, January-February 2023

### 3.5 Waste of operating materials

The estimation of the projected amount of waste vehicles was made for the operation phase (replacement of used parts and operating fluids) and the utilization phase (preparation of retired vehicles for recycling) based on the data on waste vehicles in Tashkent city for 2020.

The calculation results are presented in Table 1. It should be noted that the amounts of waste lead and electrolyte are calculated only for traditional cars with internal combustion engines, as there is no possibility to reliably establish the types of traction batteries for electric cars.

**Table 1.** Motor vehicle waste ton per year

| | Vehicle components | | | | |
|---|---|---|---|---|---|
| | FM | Copper | Al | Pb | Electrolyte |
| **Waste generated during the vehicles operation phase** | | | | | |
| total | 8343.8 | 905.1 | 503.7 | 2722.5 | 1087.9 |
| I | 1.3 | 3.6 | 1.7 | 1.1 | 1.1 |
| SE, % | 13.3 | 69.6 | 33.4 | - | - |
| **Waste generated during the vehicles recycling phase** | | | | | |
| total | 5757.63 | 132.85 | 642.73 | 89.94 | 39.90 |
| I | 1.47 | 2.18 | 1.70 | 1.30 | 1.33 |
| SE, % | 7.21 | 41.55 | 20.86 | - | - |

**Continuation of table № 1.**

| Vehicle components | | | | |
|---|---|---|---|---|
| | Tires | Glass | Oil | Anti-freeze |
| **Waste generated during the vehicles operation phase** | | | | |
| total | 8249.0 | No data | 3637.0 | 1176.0 |
| I | 1.5 | - | 1.2 | 1.3 |
| SE, % | 28.5 | - | 9.4 | 13.3 |
| **Waste generated during the vehicles recycling phase** | | | | |
| total | 265.59 | 300.14 | 75.48 | 45.92 |
| I | 1.53 | 1.5 | 1.26 | 1.31 |
| SE, % | 11.37 | 10.30 | 4.84 | 9.45 |

*Note: FM - ferrous metals; I - increase in the amount of waste compared to 2020, times; SE - the share of electric vehicles in the total amount of waste generated*

For the conditions of Tashkent city, earlier, the coefficients of motor transport waste recycling were established [10]: for metals 0.53, for tires 0.2. Thus, the growth in the number of waste tires will cause additional problems associated with their insufficient recycling. For comparison, in the United States the recycling rate of aluminum waste is 90 % and that of ferrous metals and copper waste is 95 %; non-recyclable waste is buried in landfills or incinerated [1].

Since it has not been possible to quantify battery waste, we can only assume that they will be sources of a variety of waste, the disposal of which presents some difficulties.

## 4 Conclusions

Due to the fact that in Uzbekistan, the electrification of road transport is currently only beginning to develop, it is not yet possible to accurately assess all the prospects and possible problems of this process.

It is obvious that the current growth rate will allow fulfilling the national plans for electrification of 20 % of all motor vehicles by 2030 only for Tashkent city.

There are serious gaps in the organization of the necessary infrastructure to serve electric vehicles. Therefore, it is necessary first of all to expand the network of charging stations and service points.

Atmospheric air pollution with exhaust gases and products of combustion of petroleum products in the territory of Tashkent will gradually decrease as the electrification of vehicles, however, a significant increase (by 1.39 times by 2027) of atmospheric air pollution with solid particles is predicted. Taking into account the fact that already now the concentration of suspended particles in the air of Tashkent. Tashkent often reaches the level of "unhealthy", additional pollution can create a constant threat to the health of residents. At the same time, our forecast did not take into account the low level of evenness of the road surface, typical for the roads of Uzbekistan, so it should be expected that the actual amount of tire and road surface wear products could be even higher. Therefore, more research is needed to reduce this type of pollution from electric vehicles as the greatest threat.

In terms of solid and liquid waste accumulation, it is obvious that the biggest problem will be waste tires, the mass of which will increase significantly due to electric vehicles. The problem can be explained by the very low recycling rates of automobile waste in Uzbekistan.

It can be expected that with the advent of electric cars, the situation with the recycling of motor vehicle waste will get even worse, as new components, such as batteries of a different type, will appear, requiring a revision of recycling technologies.

The objectives of further research should be:

1) estimate the water and carbon footprint of electric vehicles for the conditions of Uzbekistan;

2) analyze the change of material footprint, taking into account the launch of their own productions (electric cars, batteries for them, electric charging stations, maintenance points, etc.).

This kind of research will enable competent planning of further electrification of motor transport and timely development of measures to prevent harmful effects on the environment.

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