

INFRASTRUCTURE ISSUES OF THE PASSENGER ELECTRIC TRANSPORT FRAMEWORK OF KYIV

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Kyiv, Ukraine's capital, has a diverse electric transport network, but over the years, it has faced significant challenges. Financial constraints, outdated infrastructure, and the current combat situation have hindered development and maintenance. Consequently, the city's transport systems, including trams, trolleybuses, and the subway, are in urgent need of modernization and investment.

Passenger transport plays a crucial role in the functioning of any city, facilitating the movement of individuals across various points and contributing to economic vitality. Inadequate infrastructure can lead to significant disruptions, potentially paralyzing urban life and resulting in severe economic repercussions. Kyiv, the capital of Ukraine and its largest city, boasts a population of approximately 3 million inhabitants. Given its rich historical background and complex urban landscape, Kyiv offers a diverse range of passenger transport options, encompassing electrical transport of both high-capacity and low-capacity modes.

The subway system serves as the primary mode of transport, effectively managing large passenger flows. Complementing this are the tram and trolleybus systems, with the latter being the largest network of its kind in the world. While the tram system was once the most diverse transport mode, its role has evolved to support the subway. Additionally, various other unique transport modes contribute to the city's mobility landscape.

Despite this diversity, the overall condition of Kyiv's transport system is far from optimal. Challenges such as passenger comfort, punctuality, transportation speed, and most critically, safety, remain pressing issues. This article will delve into the infrastructure challenges facing Kyiv's passenger transport framework, highlighting the need for improvement and modernization to better serve the city's residents.

The most efficient mode of transport for moving passengers quickly and in large numbers is the railway. Most major cities operate railway transport in various forms, such as subways, regional trains, and tram systems (both regular and light rail). Kyiv utilizes all of these transport modes in different areas with varying levels of activity. However, the primary mode of

transport is the subway system, which consists of three lines with total of 52 stations that intersect in the city center.

The oldest red subway line was constructed in the USSR in 1960 with five initial stations. As passenger demand grew, the subway system gradually expanded, and in 1976, the green line was opened. The final blue line was completed in 1989, bringing the total number of stations to 31 by the end of the USSR's control. Many of the stations, particularly the older ones, were built very deep due to the presence of underground water tables, and the subway system was also designed to function as a bomb shelter. As a result, Kyiv's subway system holds the world record for the deepest station, Arsenalna, located 106 meters below ground.

With the collapse of the USSR in 1991 and Ukraine's subsequent independence, new financial and economic challenges emerged, slowing the development of all sectors, including transport. Nevertheless, the population in the capital continued to grow, and so did the demand for passenger transportation. The development of the right bank of the city further fueled this need, leading to a period of active subway system construction between 2003 and 2008.

Looking ahead, the Kyiv administration has a plan to open three additional lines to address the growing passenger demand from the right bank and provide citizens with more route options.

The subway system requires significant investments and operational costs due to the complexity of its operation. For example, most of the carriages in the Kyiv subway system are outdated, as they were all built in the last century. Although they still operate quickly and efficiently, passenger comfort falls below modern standards. There is no air conditioning, noise pollution is high, and the seats and interiors are very old.

However, the main issues today are related to a lack of funding, driven by various factors, the most significant being the imposition of martial law and the combat environment. This has led to reduced modernization and maintenance plans, impacting the safety of both personnel and passengers. Many older stations and tunnels, such as the "Pochaina" and "Tarasa Shevchenka" stations, are in urgent need of reconstruction. Additionally, in December 2023, an emergency situation occurred due to significant flooding in the rail grid between the "Demiivska" and "Lybidska" stations on the blue line, affecting 7 stations in total. As a result, transport traffic was suspended, leading to the loss of key transit links in the city center. The recovery process took around nine months in total, as a result, the blue line resumed the full-scale transportation process but with a speed limit on this section.

One of Kyiv's unique modes of transport comprises the Light Rail Transit system (LRT). LRT is a form of rapid transit that operates electric-powered single cars or short trains on fixed rails. "Light" refers to lighter passenger capacity, not the physical weight of the vehicles. Today's LRT originates from traditional streetcar systems but has been redesigned to run faster and carry more passengers over greater distances in metropolitan areas.

There are two independent LRT systems on different sides of Kyiv. On the right bank, the system encompasses a very significant route, transporting passengers from the Kyiv central railway station to the industrial part of the city, which now sees a high passenger turnover. Even though the entire line has been reconstructed and modernized, the vehicles transporting passengers are not suitable for a line with such high demand. The majority of these vehicles (47 units) are modern Polish-manufactured trams called "PESA," with a low floor and a capacity of 255 passengers.

On the other hand, the left-bank system is much less successful, with lower passenger turnover and poor-quality infrastructure. The share of outdated trams exceeds 80%, but the main problem is the crooked tracks, which require repair work. The relatively low passenger turnover can be explained by poor stop planning during the design and construction stages, as the line does not fully cover the main residential areas: "Trams remain only where they don't bother anyone," experts say [2]. The city train is not very popular among Kyiv residents because it runs infrequently and is highly unreliable. Instead of full-fledged lines, there are "fragments" that can only transport passengers within a single district.

The regular tram system in Kyiv comprises 230 km with a total of 22 routes. In the 1970s, a "tram renaissance" took place in Europe, where cities began restoring tram networks after decades of phasing them out. However, Kyiv is currently experiencing an era of "tram decline." The tram networks are heavily worn out, passengers have been riding in old "Tatra" trams for decades, and on some streets of the capital, trams move at a speed of only 10 km/h (compared to the usual 25 km/h) [3].

In the past, the Kyiv tram network was much more extensive, serving as the primary mode of transport for a large number of passengers throughout the city, rather than merely acting as a complementary system to the subway as it does today. The USSR's transport policy included the gradual development of tram networks in large cities. By the beginning of the 1990s, the Kyiv tram network had 35 routes and over 460 km of tracks.

However, the active dismantling of tram tracks in the early 2000s led to the "degradation" of trams in Kyiv. The network was reduced by more than half—from 462 to 202 km—and only 22 out of 35 routes remained.

Consequently, critical underfunding and the administration's unwillingness to further develop this mode of transport contributed to the decline of the system.

Due to insufficient funding and, as a result, inadequate maintenance, the tram network has significantly deteriorated. Simultaneously, there has been a shortage of rolling stock, leading to an inadequate number of new trams on the routes. The worn tracks mainly impact the speed of the trams, and the limited number of vehicles cannot accommodate a high volume of passengers. Consequently, this has led to a decrease in passenger traffic, causing people to avoid using the tram service.

The most successful and renovated mode of public transport is the trolleybus system, which is the largest network in the world, comprising a total of 496 km with 46 routes. Its history dates back to 1935 when the first trolleybus system in Kyiv was launched. Since then, the number of trolleybus lines has increased every decade. In the 1960s, there were already 20 lines connecting all the districts of the right bank of Kyiv. The trolleybus appeared on the left bank only in 1983, connecting Pochayna with Troyeshchyna, and by the end of the 1980s, there were over 30 routes in Kyiv [4].

The trolleybus is much more flexible than trams, as it does not require such extensive infrastructure. Additionally, with advances in technology and the release of new models, trolleybuses can now operate without connecting to wires for a certain period, allowing the network to extend to remote areas without specific infrastructure. However, considering the current conflict situation and regular power outages, both tram and trolleybus systems have become unreliable for citizens. Consequently, the number of vehicles was reduced from 445 units to 250 units—almost by half (Figure 1).

Even though new vehicles were purchased between 2011 and 2016, the operational lifespan of the majority is coming to an end. Financing remains the main issue, as with all other modes of transport; a lack of funding leads to reduced maintenance plans and poor vehicle conditions.

Kyiv's transport system features a unique and unusual form of electric transportation: the funicular. Given the city's diverse landscape with significant elevation changes, it can be challenging and uncomfortable to reach certain areas, particularly in the city center and the old town. To address this, the funicular was constructed to transport people from the upper part of the city down to the Dnipro River bank and the nearby "Poshtova Ploscha" subway station. The ticket price is uniform across Kyiv's public transport system, currently 8 UAH. However, the funicular closes several times a year for scheduled maintenance, making it less

reliable for regular commuters. Despite this, due to its long history and uniqueness, the funicular also serves as a tourist attraction today.

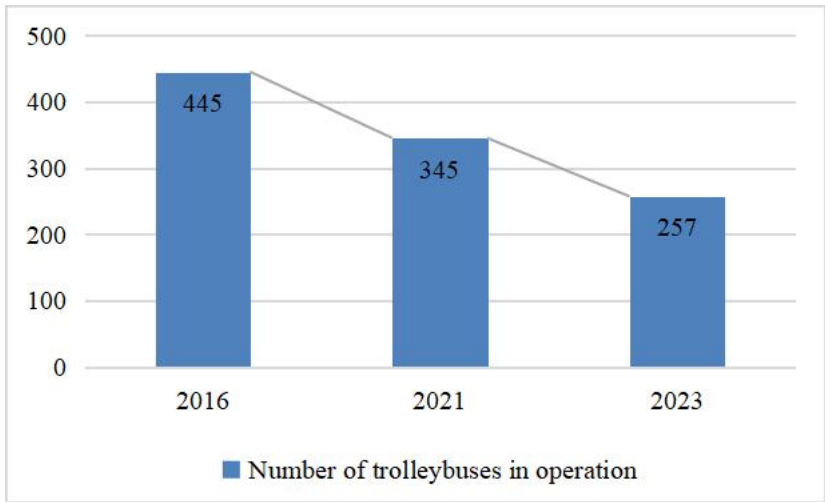


Fig. 1. The decrease of operative trolleybus units [4]

Additionally, the ongoing war is a major issue for infrastructure today. It has not only slowed down development but also made operations highly problematic. A significant portion of electric transport has suspended operations due to damage or complete destruction of the system. For example, tram and trolleybus systems in small towns in the Donetsk region, such as Konstantinovka, Kramatorsk, and Alchevsk, were destroyed between 2022 and 2024. Major cities like Kyiv, Kharkiv, Zaporizhzhia, and Odessa have suffered from power shortages and local infrastructure damage.

First of all, to address all the issues within Kyiv's public transport system, it is necessary not only to invest a significant amount of money but also to develop a strategic plan where all modes of transportation complement each other, leading to fast, reliable, and efficient service. It is important to take into account 21st-century sustainability trends, so it is advisable to focus on developing electric modes of transportation, including trams, trolleybuses, subway systems, and other similar options.

The Kyiv transport department has developed a comprehensive plan outlining the annual reconstruction and vehicle procurement tasks. The primary focus at this time is to procure and replace aging vehicles in the subway, trolleybus, and tram systems. The entire fleet of subway carriages will either be replaced (170 wagons) or modernized (220 wagons) by 2031.

Following this, the reconstruction of subway tunnels will take place, as the subway remains the main high-capacity mode of transport currently in relatively good operating condition, alongside the tram system. According to the local transport infrastructure development document for 2024-2025, the second priority should be directed towards the development of the most ecological, cost-effective, and reliable means of transport, which is considered to be trams. Therefore, the plan includes the replacement of a total of 35 tram units each year and 80 trolleybuses annually.

Conclusion

In conclusion, Kyiv's passenger electric transport system, while diverse and historically significant, faces critical infrastructure challenges that hinder its efficiency and reliability. The aging subway, declining tram network, and underfunded trolleybus system struggle with outdated vehicles and inadequate maintenance, exacerbated by the ongoing war and financial constraints. To improve this situation, a strategic plan is essential, focusing on integrating various transport modes, modernizing infrastructure, and prioritizing sustainability. By addressing these issues and following development plans, Kyiv can create a more efficient and resilient transport framework that meets the needs of its growing population and contributes to a sustainable urban future.

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