

UDC 629.113

DOI 10.36910/10.36910/6775-2313-5352-2023-22-03

Zakharchuk V., Zakharchuk O., Shvabyuk V.

Lutsk National Technical University

PROSPECTS FOR THE USE OF ELECTRIC BUSES IN UKRAINE

The article considers the feasibility of using electric buses in Ukraine. As a result of the literature analysis, it was found that electric transport has a number of advantages over traditional cars. This type of transport in medium-sized cities can be represented by trolleybuses and electric buses. When using trolleybuses, significant capital investments are required for the construction of electrical lines and substations. The main advantages of electric buses are low operating costs, reduction of general background noise in the city, increased comfort for passengers due to low noise and vibrations in the cabin, and the absence of harmful emissions. Performed technical and operational analysis based on planning data for the main types of urban public transport. A method for assessing the economic efficiency of using electric vehicles has been developed. The economic feasibility of using electric buses in medium-sized cities where public transport is represented by buses and trolleybuses is considered. The research methods are theoretical. The savings in operating costs from replacing a bus with an electric bus of similar passenger capacity are UAH 1 million 600 thousand per year, and from replacing a trolleybus – UAH 1 million 250 thousand UAH per year. As of the beginning of 2022, the cost of running 1 km of an electric bus is UAH 7.2, a trolleybus is UAH 18.8, and a bus is UAH 22. The disadvantage of electric buses, which hinders their wider distribution, is the high cost of batteries, which can be up to 50% of the total cost, as well as lower passenger capacity compared to other modes of transport. A way out of the situation can be the installation of cheaper batteries of smaller capacity on electric buses and the use of recharging at the final stops.

Keywords: urban transport, public transport, electric bus, trolleybus, bus, operating costs, capital investments.

Problem statement. The relevance of using electric vehicles is related to various areas such as the environment, politics, economics, etc., and these areas are interconnected. From the perspective of environmental protection, the relevance of electric transportation is undeniable. Electric transportation is the cleanest form of transportation with the least amount of harmful emissions into the atmosphere and the lowest noise levels. These factors are particularly relevant in urban environments. In the political sphere, the relevance of electric vehicles lies in complying with international norms regarding the limits of harmful emissions. In the economic sphere, the relevance of electric transportation lies in the significant reduction in transportation costs and the savings on petroleum products.

In terms of technology, the electric motor is more reliable than the internal combustion engine and does not require costly maintenance. It also has higher efficiency and more optimal power and torque characteristics. The electric vehicle has better traction and speed properties, a simpler design, and only uses energy when needed for movement (the electric motor does not work during stops at traffic lights) [1-3].

Analysis of recent studies. The relevance of using electric vehicles is evidenced by the fact that practically all major car manufacturers are trying to release at least one electric model [4, 5].

The use of electric buses on urban routes is especially justified. China is the world leader in the use of electric buses, where 90% of all electric buses are concentrated. The first successful operation of electric buses was noted in 2008 during the Beijing Olympics. In 2018, it was planned to fully convert the 12-million-city of Shenzhen's wheeled ground transport system to electric buses. Electric buses are also gaining popularity in cities in India [6].

According to the International Association of Public Transport (UITP), in 2017, electric buses of various types were operated in more than 90 European cities in test and full modes [7].

Recently, electric buses have also started to be produced in Ukraine by the Lviv-based company "Electron". Their brand is the Electron E191. The electric bus is powered by two traction electric motors with a capacity of 125 kW each. The battery capacity is 115...230 kW*h. The range is 200 km. The price of the electric bus is quite high and is 350,000 euros. Perhaps this is the reason why it has not been put into serial production. Currently, this electric bus is being tested [8].

Objective and tasks of the study. The goal of the research is to assess the prospects of using electric buses in Ukraine.

The objectives of the study are to develop an approach to this assessment and to perform technical and operational analysis of urban passenger transport vehicles that typically provide transportation in medium-sized cities.

Main text. In March 2018, Skywell Ukraine presented the Chinese 12-meter city electric bus Skywell NJL 6129 BEV at the EcoDrive exhibition of environmentally friendly transport. Later, the Kyiv-based company "Trans-City" leased it and now it operates on route No. 599. Its exterior appearance is shown in Fig. 1, and its technical characteristics, as well as the characteristics of the identical bus and trolleybus of the "Bogdan" company produced by Lutsk ASC No. 1, are shown in Table 1.



Figure 1 – Electric bus Skywell NJL 6129 BEV

Table 1 – Technical characteristics of urban transport vehicles

| Indicator | Vehicle | | |
|---------------------------------|-----------------------|----------------------------|-------------------------|
| | Vehicle Bogdan A70132 | Trolleybus Bogdan T70117 | Electric bus NJL6129BEV |
| Length, m | 11,96 | 11,96 | 12,0 |
| Curb weight, t | 11,86 | 10,88 | Not available |
| Passenger capacity, persons | 106/30 | 105/34 | 81/33 |
| (total/seated) Engine power, kW | 194 | 140 | 200 |
| Maximum speed, km/h | 70 | 60 | 70 |
| Price, thousand USD | 155 | 184 | 320 |
| Driving range, km | unlimited | Limited by contact network | 300 km |

From table 1, it can be seen that the characteristics of the vehicles are similar, but the price of the electric bus is significantly higher due to the high cost of the battery. The passenger capacity of the electric bus is significantly lower, which is obviously due to the considerable weight of the battery.

The capacity of the lithium iron phosphate battery pack is 276 kWh. The electric bus is low-floor, equipped with pneumatic suspension and a liquid heating system, and has an automatic fire extinguishing system for high-pressure systems and batteries. There is a camera showing the rear door, as well as a rear view camera.



Figure 2 – Electric bus battery compartment

Table 2 – Comparative table of the results of modernization of existing trolleybus depots and bus fleets when replacing transport with electric buses

| Indicator | Trolleybus | Bus | Skywell electric bus |
|---|--------------|--------------|----------------------|
| Cost, UAH | 6 000 000 | 4 000 000 | 9 000 000 |
| Type of vehicle | | | |
| Profit per day, UAH | 7 560 | 7 560 | 7 560 |
| Expenses*: | trolleybus | urban | urban |
| Fuel (electricity) cost, UAH | 2,316 | 31 | 0,579 |
| Consumption per 100 km, L or kWh | 300 | 32 | 90 |
| Motor oil expenses, UAH/km | 0 | 0,08 | 0 |
| Driver's salary per day, UAH | 400 | 400 | 400 |
| Maintenance costs for the contact network, UAH/day | 170 | 0 | 0 |
| General production costs of the depot/fleet | 3 750 | 2 050 | 1 500 |
| Administrative expenses, UAH/day | 200 | 200 | 100 |
| Cost per km, UAH | 22,01 | 18,83 | 7,19 |
| Expenses per day, UAH | 6 604 | 5 650 | 2 156 |
| Profit per day, UAH | 956 | 1 910 | 5 404 |
| Savings when replacing with an electric bus, UAH per day | 4 448 | 3 494 | – |
| per month | 133 442,10 | 104 810,10 | – |
| Savings when replacing with an electric bus per year, UAH | 1 601 305,20 | 1 257 721,20 | – |
| * average indicators taken from available sources | | | |

The analysis was conducted based on prices at the beginning of 2022. A more accurate assessment of the efficiency of electric buses will be possible after calculations are made based on their operation in winter conditions - on slippery roads, at low temperatures, and with the heating of the passenger compartment turned on. Comparative characteristics of various types of urban transport are shown in Table 3.

Modern diesel buses are the most affordable means of public transport in terms of production, infrastructure, and operation. Thanks to their relatively low cost, they are the most popular means of urban public transport in the world.

However, their level of harmful emissions does not allow them to be considered as the transport of the future. Their low fuel efficiency (engine efficiency barely reaches 40%) is also a drawback. Trolleybuses have zero emissions of harmful substances, but they have a higher cost and require additional costs for the creation and maintenance of infrastructure. The main advantages of electric buses are low operating costs, reduced overall background noise in the city, increased passenger comfort due to low noise and vibration in the cabin, and the absence of harmful emissions. The disadvantage of electric buses is the high cost of battery packs, which can account for up to 50% of the total cost, as well as lower passenger capacity.

Table 3 – Comparative characteristics of various types of urban transport

| Indicator | Vehicle | | |
|---|---|----------------------------|----------------------------|
| | Bus (Euro VI) | Trolleybus | Electric bus |
| Operational characteristics | | | |
| Range, km | 600-900 | Limited contact network | Up to 200 km |
| Route Flexibility | High | Limited | High |
| Refueling/Recharging | Every 2 days, 5-10 minutes. | Unavailable | During nighttime |
| Energy Consumption, kW/km | 4,13 | 1,8 | 1,91 |
| Infrastructure | | | |
| Need for additional infrastructure | Unavailable | Yes | Yes |
| Availability of refueling/recharging stations | High | Limited contact network | Not high |
| Noise in idle/driving mode | 80/77 | 62/70 | Virtually absent |
| Harmful emissions into the atmosphere | Available | Unavailable | Unavailable |
| Economic evaluation | | | |
| Approximate cost, thousand euros | 220 | 300 | 320-600 |
| Total operating cost, euros/km | 2,1 | 3,1 | 0,5 |
| Main advantages and disadvantages | | | |
| Advantages | Efficiency, ease of operation | Environmental friendliness | Environmental friendliness |
| Disadvantages | Possible discontinuation of use due to depletion of fossil resources and stricter environmental regulations | High infrastructure cost | High cost Electric bus |

Conclusions. The cost savings from replacing a bus with an electric bus of similar passenger capacity amount to 1,600,000 UAH per year, while replacing a trolleybus with an electric bus results in savings of 1,250,000 UAH per year. The increasing interest in electric buses is evident. However, the replacement of trolleybuses with electric buses cannot be considered justified at this time. As for replacing buses with electric buses, a more detailed analysis of economic efficiency needs to be conducted, including determining the payback period for the acquisition costs. The final comparison of costs and benefits can only be made when a more detailed analysis is performed, taking into account the environmental impact of different types of vehicles.

References

1. Connolly, D. (2017). Economic viability of electric roads compared to oil and batteries for all forms of road transport. *Energy Strategy Rev*, 18, 235-249. DOI: 10.1016/j.esr.2017.09.005.

2. [Kubański, M. \(2020\).](#) Prospects for the Use of Electric Vehicles in Public Transport on the Example of the City of Czechowice-Dziedzice. [Transportation Research Procedia](#) 44(2), 110-114. DOI:[10.1016/j.trpro.2020.02.016](#).
3. Skalski, P. (2017). AUTOBUSY ELEKTRYCZNE W POLSCE. **Autobusy: technika, eksploatacja, systemy transportowe**, 12, 415-418. <https://bibliotekanauki.pl/articles/312442>.
4. Jelica, D., Taljegard, M., Thorson, L. & Johnsson, F. (2018). Hourly electricity demand from an electric road system – a Swedish case study. *Appl Energy*, 228, 141-148. DOI: [10.1016/j.apenergy.2018.06.047](#).
5. Vilppo, O. & Markkula, J. (2015). Feasibility of Electric Buses in Public Transport. *World Electric Vehicle Journal*, 7(3), 357-365. DOI: [10.3390/wevj7030357](#).
6. Ravneet, K. (2022). Electrification of public transport in India – A feasibility study of electrifying the bus system in Amritsar. University of Stavenger, 1-70. <https://uis.brage.unit.no/uis-xmlui/bitstream/handle/11250/3021890/no.uis%3ainspera%3a106584924%3a68714823.pdf?sequence=1&isAllowed=y>.
7. Sánchez, J., Del Rio, J. & Sánchez, A. (2022). Economic feasibility analysis for an electric public transportation system: Two cases of study in medium sized cities in Mexico. *PLoS One*, 17(8), 1-23. DOI: [10.1371/journal.pone.0272363](#).
8. Захарчук В.І., Захарчук О.В., Мельничук О.Ю. Доцільність використання вантажних електромобілів в Україні / Сучасні технології в машинобудуванні та транспорті. – 2020. – №1 – С. 95-101. <https://eforum.lntu.edu.ua/index.php/jurnal-mbf/issue/view/64/70>.

Захарчук В.І., Захарчук О.В., Швабюк В.В.

Луцький національний технічний університет

ПЕРСПЕКТИВИ ВИКОРИСТАННЯ ЕЛЕКТРОБУСІВ В УКРАЇНІ

У статті розглядається доцільність використання електробусів в Україні. У результаті аналізу літератури встановлено, що електротранспорт має низку переваг перед традиційними автомобілями. Цей вид транспорту в середніх містах може бути представлений тролейбусами та електробусами. При використанні тролейбусів потрібні значні капітальні вкладення для будівництва ліній електропередач і підстанцій. Основними перевагами електробусів є низькі витрати на експлуатацію, зниження загального шумового фону в місті, підвищення комфорту пасажирів за рахунок низького рівня шуму та вібрації в салоні, відсутність шкідливих викидів. Виконано техніко-експлуатаційний аналіз на основі проектних даних основних видів міського громадського транспорту. Розроблено методичку оцінки економічної ефективності використання електромобілів. Розглянуто економічну доцільність використання електробусів у середніх містах, де громадський транспорт представлений автобусами та тролейбусами. Методи дослідження теоретичні. Економія експлуатаційних витрат від заміни автобуса на електробус аналогічної пасажиромісткості становить 1 млн 600 тис. грн на рік, а від заміни тролейбуса – 1 млн 250 тис. грн на рік. Станом на початок 2022 року вартість пробігу 1 км електробуса становить 7,2 грн, тролейбуса – 18,8 грн, автобуса – 22 грн. Недоліком електробусів, який перешикоджає їх більш широкому розповсюдженню, є висока вартість акумуляторів, яка може становити до 50% від загальної вартості, а також менша пасажиромісткість порівняно з іншими видами транспорту. Виходом із ситуації може стати встановлення на електробусах дешевших акумуляторів меншої ємності та використання підзарядки на кінцевих зупинках.

Ключові слова: міський транспорт, громадський транспорт, електробус, тролейбус, автобус, експлуатаційні витрати, капітальні інвестиції.