ENERGY EFFICIENCY OF PUBLIC TRANSPORT FOR SUSTAINABLE URBAN MOBILITY

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ABSTRACT

The article discusses the main problems associated with energy efficiency in creating a sustainable mobility system in cities. Urban public transport occupies a special place in meeting the needs of the population to move around the city. Solutions are considered that can help save energy resources, improve the ecological state and speed up the delivery of city residents. The possible effects of the use of alternative types of public transport and vehicles with an alternative source of energy, the integration of the mode of operation of various types of transport, the coordination of traffic schedules are analyzed.

Keywords: public transport, urban mobility, passenger, energy efficiency

INTRODUCTION

Creating a healthy living environment for residents of big cities is of great importance. One way to achieve a healthy city is to reduce vehicle emissions. Good alternatives to vehicles with internal combustion engines are the vehicles with electric and hybrid engines.

At present, there are good potentials for the production of electricity from various natural sources. Particularly attractive are the methods of generating electricity from solar sources. Depending on the geographical location of cities, they have very different potentials in this direction. Taking into account the fact that the eastern cities, including the city of Baku, are a sunny city, there are good prospects for improving the energy efficiency of the functioning of urban systems, including urban public transport.

Energy consumption per capita differ significantly for different countries. For example, the US, Canada, Australia and Saudi Arabia are the countries with the highest per capita energy use. In addition, the level of energy use in public transport in the United States is significantly high in comparison with other states [1].

Public transport plays a significant role in providing mobility within cities. Most of the movement of the population in cities comes to public transport. Therefore, special attention should be paid to the energy efficiency of public transport.

DATA AND METHODOLOGY

At the first stage, the main directions for improving the energy efficiency of public transport were identified. The main reasons that reduce the efficiency of public transport are investigated.

The main statistical indicators of the bus fleet of the Republic of Azerbaijan were used. The development trend of the fleet of buses with an alternative engine is analyzed.

In order to ensure sustainable urban mobility, it is proposed to consider all possible comprehensive measures to improve urban passenger traffic. Since in Baku only one type of surface public transport operates, the transport network of this type of transport is considered. The effectiveness of the use of various alternative modes of transport, interchange hubs is considered.

STUDYING TO IMPROVE THE ENERGY EFFICIENCY OF PUBLIC TRANSPORT

Improving the public transport system is one way to optimize energy efficiency in cities. The use and proper choice of alternative modes of public transport is of great importance in this direction. Well-organized infrastructure and quality service in public transport are attractive and reliable. The expansion of the public transport network also increases the attractiveness of this system. The choice of a particular type of public transport depends on many factors, including population size, density of the transport network, geographical structure, costs of creation and duration of the system.

When considering the issue of energy efficiency of transportation, it is worth considering the energy intensity of the mode of transport. For urban public transport, it is necessary to take into account the use of energy per kilometer traveled by a passenger. The occupancy of a passenger vehicle affects the energy consumption for vehicles. Since with an increase in the consumption of liquid fuel (petrol or diesel), the level of CO2 emissions increases. Therefore, fuel consumption for each vehicle for a specific distance is of great importance. This can be called vehicle efficiency. The impact of public transport on the environment can be assessed in various ways. Mobility management and public transport planning can influence the choice of city residents for safer modes of transportation [2]. The study shows that the behavior of drivers also affects the energy efficiency in public transport [3]. To analyze the energy efficiency of public transport, each influencing indicator and property should be studied.

For urban public transport, it is important to choose an efficient vehicle in all respects. This also applies to energy efficiency. The most efficient types of urban public transport are the subway, urban electric trains, light rail transport, and high-speed bus transportation. It should be noted that it would be effective if it connects the network of regional and suburban passenger transport with urban transport. The effective integration of these systems will reduce the time spent by passengers and increase the mobility of the city's population.

High-speed bus transportation has a special place in ensuring mobility in cities. This type of combined transport creates a good alternative to urban rail transport. A distinctive feature of this type of urban transport is that it requires relatively less cost and time for construction. Bus corridors along city streets significantly speed up the delivery and quality of passenger service.

In cities, to increase the speed of bus transportation, specialized traffic lanes can be used, and passenger service at stops can be improved. As already noted, the integration of different types of urban public transport is of particular importance. Reducing the transition time from one mode to another is of particular importance to passengers. This is also a condition for improving urban mobility.

For the effective interaction of types of urban transport, the work of interchange hubs is also important. Well-equipped and organized interchange hubs increase the quality of service and the attractiveness of public transport. Improper placement or lack of interchange hubs reduces the efficiency of public transport. In the absence of such points, route vehicles in many cases cover a longer distance. And if the interchange hub is placed incorrectly, in addition to lengthening the path, conflicts with other road users increase.

Only one passenger interchange hub is fully operational in Baku city. It is located near Koroglu metro station. The creation of this point has greatly improved passenger interchange between suburban and city buses. But the disadvantage of this item is the long distance from the metro station (Figure 1).

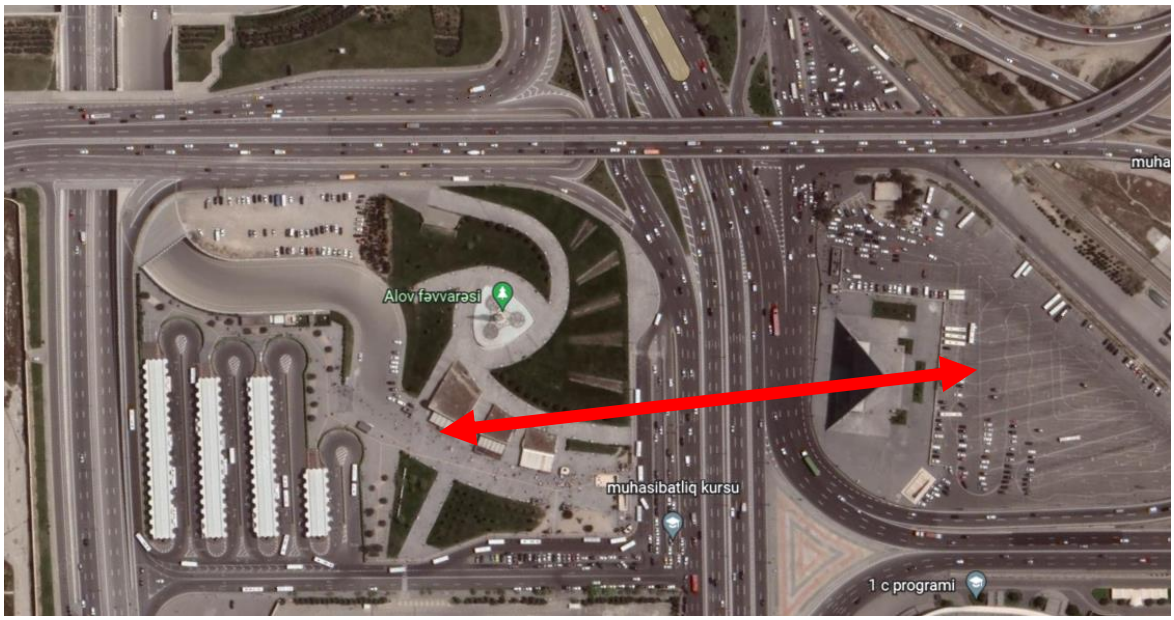

Figure 1. Placement of an interchange hub near the Koroglu metro station

An intelligent transport management system operates in the city of Baku, which provides for the organization and management of traffic in the city. But the system itself does not take into account energy efficiency issues very effectively.

The coordination of public transport vehicles also affects the energy efficiency of public transport. Research shows that even between routes of the same mode of transport sometimes there is no coordination. At some bus stops in Baku city, a large number of buses accumulate and sometimes there are queues of buses of different routes before stopping. In the city of Baku, there are bus stops that serve 20 bus routes. Figure 2. shows satellite images of stops near the Nizami bazaar and in Moscow Avenue. It should be noted that there are several such stops with a large number of arriving buses on Gara Garaev Street.

Figure 2. Lines of buses in front of stops near the Nizami Bazaar and in Moskva Avenue

As can be seen from the figure, the queue of buses before stops leads not only to delays of the buses themselves, but also of vehicles in the general stream. Sometimes this situation continues throughout the working day. The result is an increase in emissions from vehicles and a decrease in energy efficiency. This

state can be avoided by coordinating the work of routes according to the time of arrival at this particular stop. This way you can reduce fuel costs and loss of time for both vehicles and passengers.

Rational planning of inter-zonal trips makes it possible to reduce travel distances, which allows the population to save time and resources. The shortest delivery routes between city zones makes it possible to reduce the time and material costs of travel. In the city of Baku, due to the relief conditions, there are no good transport links between some areas of the city. For example, in the city, there are no direct links between Bilajari and micro districts (Figure 3), Garachukhur and the 8th km, Badamdar and the 20th area.

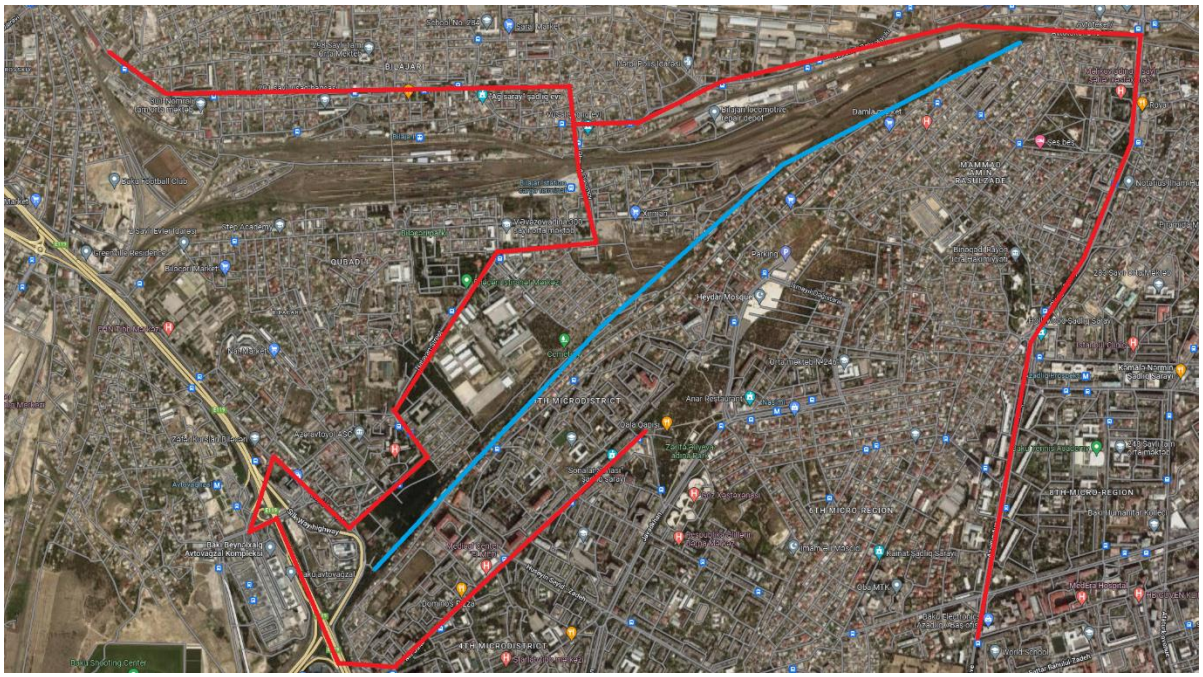

Figure 3. Location of highways connecting Bilajari with microdistricts

There are no roads for a link that crosses the line highlighted in blue in the figure. Connections between Balajari and micro districts are possible only along the roads highlighted in red. It should be noted that there is a relative difference between the heights of these territories. But these differences are not so great that they cannot be overcome.

There are mainly radial, diametrical, tangential and ring routes in the city. Efficient distribution of routes across the city is also important for energy efficiency.

The bus is the most affordable and cheapest type of public transport. In addition, this type of transport is easily and dynamically changing in design. Therefore, hybrid technologies and electric motors for city buses have found wide application. Given the advantages of hybrid traction, it is advisable to use them on regular routes. In addition to saving fuel consumption, the use of such rods makes it possible to recuperate braking energy. Due to the high number of stops on public transport routes, brake energy recovery can significantly reduce fuel consumption. The use of buses with a hybrid engine on urban routes significantly reduces fuel consumption and thus the amount of emissions to the environment [4,5,6].

According to the statistical indicators of the State Statistics Committee of Azerbaijan, out of 30,815 buses for 2021, 12,505 operate with gasoline, 18,109 with diesel, and only 201 with gas fuel [7]. Table 1 shows the number of buses by fuel used from 2016 to 2021.

Table 1.

The number of buses by the form of used fuel

form of used fuel	Year					
	2016	2017	2018	2019	2020	2021
petrol	8 426	8 354	8 226	12 628	12 590	12 505
diesel	22 532	22 434	22 478	18 005	17 989	18 109
gas	-	-	-	150	178	201

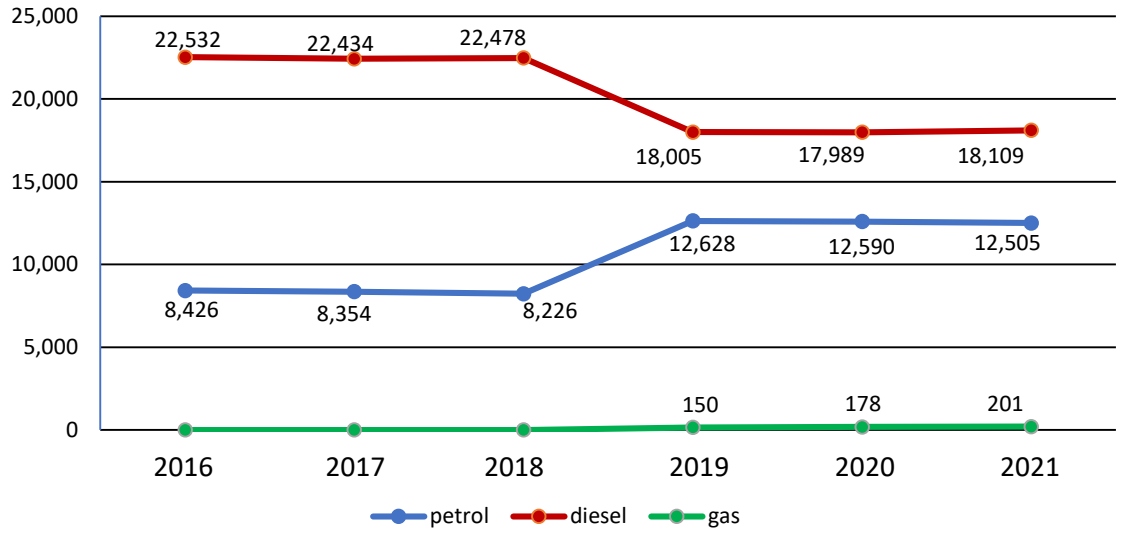

Figure 3. Dynamics of changes in the number of buses by type of used fuel

From Table 1 and Figure 3, it can be seen that over the past 3 years, buses operating with liquid gas have appeared in Baku. The number of gasoline-powered buses has decreased and the number of diesel-powered buses has increased. Until the end of 2021, buses with an electric motor have not yet appeared on the lines. But it is planned to use and gradually increase the number of electric buses on the routes.

In recent years, the use of light rail transport has become widespread. As shown by a study conducted on the territory of the city of Baku, the majority of the population consider it expedient to create an alternative type of public transport, including the LRT network or a high-speed bus [8].

RESULTS AND DISCUSSION

General surveys of the surface public transport network show that urban mobility and energy efficiency are independently monitored. It is effective to use of buses with electric and hybrid engines. But in the Republic in 2021 there was not a single bus with an electric engine.

With improved energy efficiency in public transport, the following benefits can be achieved:

- air purification (improving the quality of life);

- reducing health care costs;

- improvement of traffic safety;

- reduction of noise level;

- saving resources due to reduced use of liquid fuels;

- reducing the density on the roads;

- reduction of time losses.

To improve energy efficiency of public transport, the following activities should be carried out:

- creation and improvement the work of interchange hubs;

- creation of high-quality public transport infrastructure;

- expansion of the public transport network with the use of alternative modes of transport;

- use and increase of buses with electric motor;

- coordination the work of vehicles of different public transport routes;

- improvement of inter-zonal urban transport links

CONCLUSIONS

The study shows that the work on the creation of various urban systems was carried out independently of each other. This also applies to work to improve the mobility and energy efficiency of cities. In recent years, the issue of increasing the number of electric vehicles in cities has become very relevant. Especially for public transport, the use of vehicles with an electric motor can create conditions for environmental protection and energy savings. But at the same time, it should be noted that in many countries and large cities, there is no integrated system to fully ensure energy efficiency. Transport, including public transport, is one of the main consumers of energy in cities. Based on observations of the development of the transport complex, it will be more and more difficult to create a perfect system every day. Therefore, it is advisable to integrate the work of various parts of the city infrastructure, increase the public transport network through alternative modes, use buses with an electric motor, and improve transport links between city zones.

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