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INCREASING THE SOCIAL EFFECTIVENESS OF PUBLIC TRANSPORT IN THE CITY OF SOFIA

Abstract: *The ever-growing population and dynamic of urban traffic in the city of Sofia, as well as the utterly unsatisfactory condition of public transport have resulted in traffic jams on the capital's main streets and boulevards, exceeded limits of atmospheric and noise pollution, and multiple other negative social effects. The capital's residents prefer to use their personal cars and believe that public transport requires significant improvements – a notion that has been confirmed by a survey of citizens' opinions on the state and quality of urban passenger transport in the capital. All of this has led to a firm conviction in the necessity for adopting specific measures to improve the quality of urban passenger transport, along with determining the topicality of the current paper. The purpose of the article is to name specific measures for improving the social effectiveness of Sofia's public transport, based on an analysis of its dynamic and state.*

Key words: *Increasing the social effectiveness; Quality of public transport.*

1. Introduction

The issue of the social effectiveness of public transport and the quality of freights in the capital has become especially topical in recent years due to the fact that urban traffic is the main contributor to traffic jams and environmental pollution with about 40% of CO_2 emissions and 70% of other air pollutants. The lost travel time and the pollution of the atmosphere lead to many other negative consequences. The capital also registers a trend of reduced citizen demand for services offered by public transport, which has declined by 20% over the past ten years – in 2016, 45% of the citizens use public transport, 44% use their personal cars and 11% of the capital's population prefer to walk. The problems involving the growing urban traffic are the main challenge that all major European cities face (Tzvetkova, 2017a). The primary air pollutants are the subject of numerous international acts; one of the most difficult tasks for international politics in the field of environmental protection is combatting global warming and climate changes which result from the increasing volume of harmful emissions in the atmosphere (Minkov & Tzvetkova, 2017). For this reason the EU concentrates more and more efforts in introducing and adhering to norms for the manufacture of new transport vehicles and operating ones with the purpose of reducing the outlet of harmful emissions. All EU member states are obliged to reduce transport emissions of greenhouse gases with 60% by 2050, compared to their levels in 1990. These requirements are written down in the White Paper of Transport (European Commission, 2011). The EU's Green Paper of Urban Mobility (2007) defines the

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challenges which European cities face in their strive for ensuring stable mobility; they also involve the necessity for making movement in cities easier, reducing environmental and noise pollution and improving the organization, security and safety of public transport.

Public transport has a primarily social function. The social effects regarding its functioning are entirely dependent on the degree of quality of the offered transport services. The quality of the freight process, as well as the transport service of the population, has a big influence not just on the main indicators of the freight activity of public transport, but on the overall life in the city of Sofia. The city is the largest political, commercial, administrative, cultural and educational center in the country. Despite the multitude of problems regarding the organization and management of the city's transport system, as well as the lowered quality of the services offered by public transport, a large portion of the city's population still uses public transport as the primary means of traveling. This places the necessity for improving its social effectiveness on the agenda, by steadily improving the quality of the offered public transport services and their appeal to citizens, thus reducing the use of automobiles.

2. Social Effectiveness and Quality of Public Transport

The development of effective public transport is vital to the normal rhythm of life for all citizens, especially ones with limited mobility, people with disabilities, senior citizens and families with small children.

The improved quality of public transport in Sofia will lead to many positive social effects of its functioning. The higher the quality of freights and the culture of passenger service are, the bigger these effects will be. Quality public transport will redirect people from using their personal cars towards public transport services. The social effects from this will be multilateral: on one hand, satisfying the population's various needs – more free time, improved cultural-educational levels, better health, expanded nomenclature of consumed material goods and services, etc. On the other hand, by carrying out freights faster and by facilitating access to various tourist sites and establishments, public transport contributes to their rational use. Regular public transport, for instance, provides more opportunities for rural periodical or episodic rest for workers as well as more complete restoration of their working capacity and creative mindset. Increasing the time for rest and more complete rest for employees helps increase their productivity and it in turn has an active influence on the economic effectiveness of public proceedings (Tzvetkova, 2017b).

Sofia's public transport has a significant capacity for increasing free time, given that annually, a citizen spends an average of about 196.3 hours just on general use of transport for direct travel (minus waiting time), which is 12,1% of the quantity for free time. Improving transport services by increasing the number of public transport routes and the regularity and speed of vehicles will help reduce travel time and use it for other public service activities (Tzvetkova, 2016a).

The social effect of passenger freights is also exhibited in the positive emotions and the feeling of satisfaction from traveling. These positive emotions are stronger when the time spent inside a vehicle is accompanied by other activities such as listening to nice music, interesting conversations, watching movies, etc. The quality of freights and the level of transport service are among the factors that help improve the population's health by reducing transport fatigue which arises during travel; the mental and physical strain during travel is too dependent on the condition and comfort of vehicles. The development of public transport provides more opportunities for rural periodical or episodic rest for employees and for a more complete restoration of their working capacity and creative mindset.

Another thing that should be taken into account when reporting the social effects of the functioning of public transport is the harmful impact which results from the technical imperfections of transport vehicles, causing environmental pollution with exhaust gases, increased transport noise and traffic accidents.

In recent years the problems concerning the improvement of social effectiveness and the quality of passenger freights has become especially topical. It is defined by the fact that practically for many transport firms and enterprises passenger freights are an activity which leads to financial losses. Given their mass nature, this places the respective business subjects in a rather unfavorable economic position and limits the capacity for their development. On the other hand, the specificity of passenger freights and their explicit social purpose causes a wide public response when adequate actions for stabilizing and improving economic results are taken. All of this determines the necessity for extensive research on the whole quadrant of problems regarding the definition of guidelines for increasing the quality of passenger freights.

3. Measuring the Quality of Public Transport

The quality of public transport is a combination of useful properties which help satisfy citizens' needs during travel. It is measured on the basis of the European standard for public transport quality - EN:13816, which defines the following qualitative indicators: travel time; regularity and rhythm; safety and security; easy access to vehicles for disabled and disadvantaged people; comfort during travel; universal citizen awareness for public transport schedules; harmful influences on the environment (Tzvetkova, 2017c).

Given the social function of public transport, we can define the "travel time" indicator as a primary criterion for evaluating its activity regarding the quality of provided transport services. In principle, traveling from homes to workplaces in a city like Sofia should not take up more than 40 minutes for 80-90% of the people who travel. Travel time depends first and foremost on the state of the road infrastructure, the density of the city's transport network, the technical features of the rolling stock and the development of high-speed transport in the city.

The main factor for reducing travel time in the capital is increasing the speed of public transport and organizing high-speed transport.

High-speed transport in Sofia is represented by the subway. Its average speed is 38,84 km/h; by comparison, the average speed of buses and trams in the city are 19,4 and 12,7 km/h respectively. With its high freight capability of 50 000 passengers per hour, the undergroung transport provides effective, fast and safe movement of citizens and visitors by being an alternative to a significant part of ground transport. The capital's subway fits n with the European vision for developing intelligent, environmentally friendly and integrated transport.

Bus transport in the city carries out a high percentage of urban freights. Increasing the speed of buses by improving the state of the rolling stock and incorporating new and modern vehicles reduces travel time and ensures the fulfillment of the planned number of runs with a smaller number of the rolling stock. Its development in this direction depends on its operating features and the conditions for project engineering and city construction. Their improvement involves: increasing the density of the transport network; widening street lanes; creating conditions for the safe movement of all types of ground transport; constructing bicycle lanes; separating pedestrian flows from transport flows; construcing underpasses and overpasses for the purpose of crossing to different levels of intersections, etc.

The regularity of vehicle movement along public transport routes depends primarily on the observation of their travel schedule. This

is accomplished under the condition that all vehicles leave from the starting point and arrive at the ending point of the route precisely according to the set schedule, all the while ensuring even waiting intervals between vehicles. From the perspective of passenger interests, ensuring even waiting intervals for every single stop is especially important. Respectively, the normal interval for a vehicle's early arrival or delay is 2-3 minutes. This is also one of the main flaws in the organization of public transport, which causes the drastic worsening of the transport service of the city's population. The percentage of freight regularity should be 97-98% in order to achieve the necessary quality of servicing the city's population. This is essential, given the circumstance that irregularity in the movement of public transport vehicles involves a number of negative consequences. In order to opportunely avert possible violations of the regularity of vehicle movement, operation services in the system of public transport have to systematically study and uncover the reasons that cause these violations along every specific route. The system for controlling and managing traffic on a GPS basis is a true contribution to regulating the rhythm and regularity of public transport.

One of the most important indicators that determine the quality of passenger freights in cities is the easy and safe accessibility to vehicles. It is crucial to the movement of passengers via public transport and especially for people with limited mobility, people with disabilities, senior citizens, families with small children and small children themselves, all of whom need to have easy access to urban transport infrastructure. The time for passenger boarding and disembarkation is largely determined by the number, positioning and size of vehicle doors. Not all vehicles, however, have an optimal positioning of doors, which causes certain discomforts for passengers. Stairs with a comfortable height and a low floor for loading strollers or wheelchairs create the best conditions for safe boarding and disembarkation.

Vibrations which have an unfavorable effect on passengers are also among the factors that determine comfort in public transport vehicles. Limiting the vibrations and eliminating them is a problem which is solved through modernizing and updating the rolling stock. The departure and stopping of vehicles with high acceleration significantly worsens the travel quality, especially if there are standing passengers in the vehicles. Therefore, from the perspective of the requirement for raising the operating speed, high acceleration is not desirable, especially in regards to distances between less busy stops.

The reduction of the harmful influence of the capital's public transport on the environment is entirely dependent on the incorporation of environmentally friendly vehicles in the transport system, as well as the reduction of automobile traffic in the central parts of the city.

4. Analyzing the Public Transport in the City of Sofia

Public transport services for the capital's citizens are provided through all main types of transport – buses, trolleys, trams and subway.

The main indicator for the state of mobility in Sofia is the distribution of the number of travels done with various types of vehicles.

Figure 1 presents data from an expert survey carried out within the city with the purpose of determining the percentage of people who use public transport, personal vehicles, bicycles and people who prefer to walk.

As the figure demonstrates, the majority of Sofia's citizens – 49% - favor public transport, 38% prefer travelling with their personal vehicles, and only a small part of them prefer walking or cycling.

In order to gain a clear idea of the mobile situation in the capital and the development of

public transport, the structure and the number of freights with various types of transport in the past several years have to be compared.

In 2011 the capital's public transport has registered approximately 475 000 000 travels. Figure 2 presents graphically the percentages of the freights carried out with individual types of transport.

The figure clearly shows that in 2011 the majority of citizens use buses to move about the city. The rest of them use ground electric transport and only 11% of the citizens use the subway.

In 2017 the capital's public transport has registered approximately 500 000 000 travels, with a significant change in the structure of freights (Figure 3).

In 2017 buses have transported the largest number of passengers – 45% of the total amount of carried out freights. Subways have transported about 35%, trams – 13% and 7% of the passengers have been transported by trolleys.

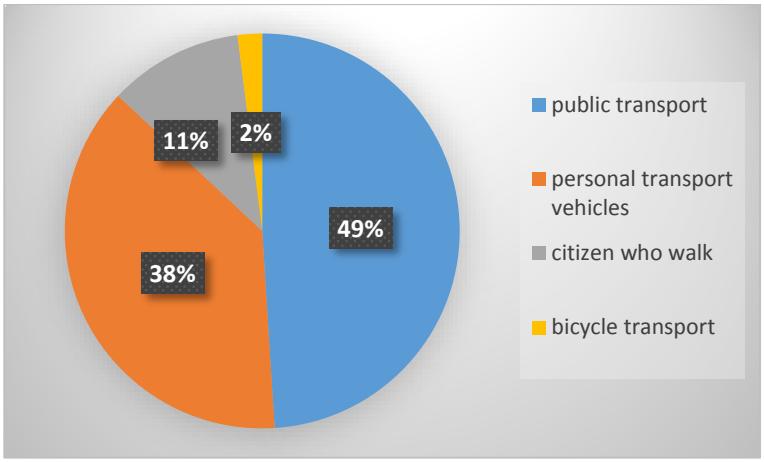

Figure: 1 Distribution of citizen travels in 2017

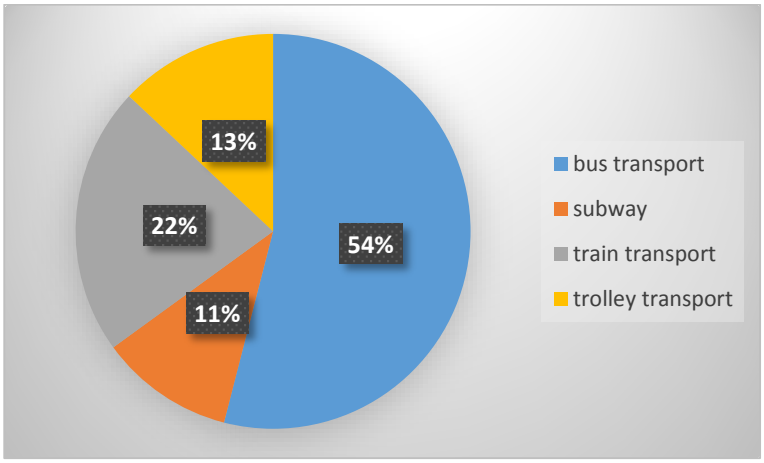

Figure 2. Freights carried out with various types of transport in 2011

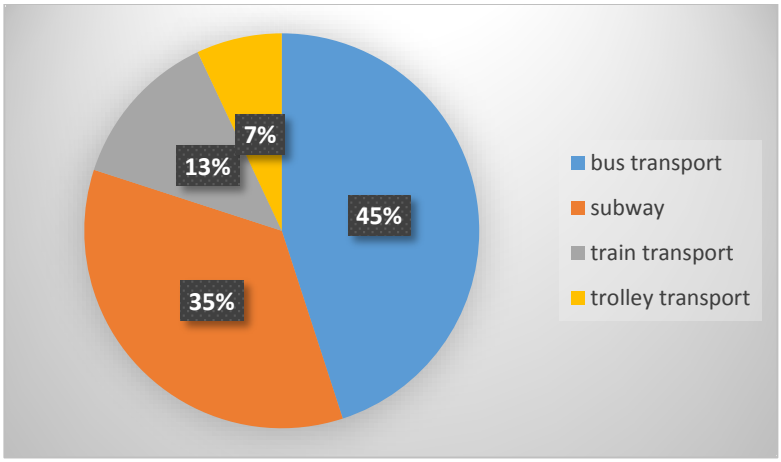

Figure 3. Freights carried out with various types of public transport in 2017

Figures 2 and 3 make it clear that over the course of five years the percentage of citizens who use bus, tram and trolley transport has decreased whereas the percentage of citizens who use the subway has grown. This is a very good trend for the capital, considering the environmental advantages and the high quality of the transport services that the subway offers.

4.1. Analyzing the Supply of Public Transport

Bus transport – buses are the primary and most preferred method of transportation by the capital's citizens. Annually the amount of passenger freights by bus in the capital reaches about 250 million. "Metropolitan Autotransport" JSC currently has 466 buses – 211 18-meter units and 255 12-meter units. The coefficient of using a bus park is 79% and the average age of a car part in 2017 is 11.5 years. The association supports a stand-by of 21% for guaranteeing quality maintenance of the rolling stock and providing service to lines in cases of repairs and damage, as well as for holding public enterprises. The capital's bus transport has 340 buses with low floors or 58% of the association's rolling stock, whereas this percentage is significantly lower for trams and trolleys.

Subway – the subway in the capital transports the largest number of passengers compared to the other types of electric transport. It is the most preferred one due to its high speed – 80 km/h, which is crucial to the conditions of the big city and surpasses all other types of public transport with its high freight capacity of 21 000-50 000 passengers per hour in either direction. The subway is effective only in the directions with the strongest passenger flows in the capital. This is the only type of transport in the capital that has demonstrated a significant growth in every aspect since its commission. About 500 000 people in the capital use the subway every day.

Tram transport – in recent years the percentage of citizens who use tram transport has dropped significantly – it is only 13% in 2016 due to the poor condition of the railways, the decommission of a large part of the vehicles and the overall declining quality of the transport service. Over the past 10 years the number of trams in the capital has decreased doubly – from 540 in 2006 to 270 nowadays; it should be taken into account that their average age is 23 years.

Trolley transport – urban trolley transport is secondary and an alternative to bus transport. Annually the number of travels by trolley drops with every passing year and by 2017 they are only 7% of the total amount of freights carried out by public transport. The available rolling stock of trolley transport has also dropped; in 2016 only 128 trolleys have traversed the streets of Sofia, with most of them being almost new. The average age of the rolling stock is eight years.

4.2. The Harmful Impact of the Environment

Public transport is the main reason for the pollution in the capital, with automobile transport being one of the primary sources of about 40% of CO_2 emissions and 70% of other harmful emissions in the air, as well as the noise pollution in the capital (Figure 4).

As the presented data shows, over 70% of the greenhouse gas emissions are caused by automobile transport, with the primary pollution sources from automobile transport being the type of fuel, the automobile's construction, the road surface, the manufacturing, maintenance and destruction of vehicles, the production of fuels, the construction of roads, machinery, service and auxiliary posts, various types of domestic waste, tanks and cisterns for storing fuel and lubricating materials, etc.

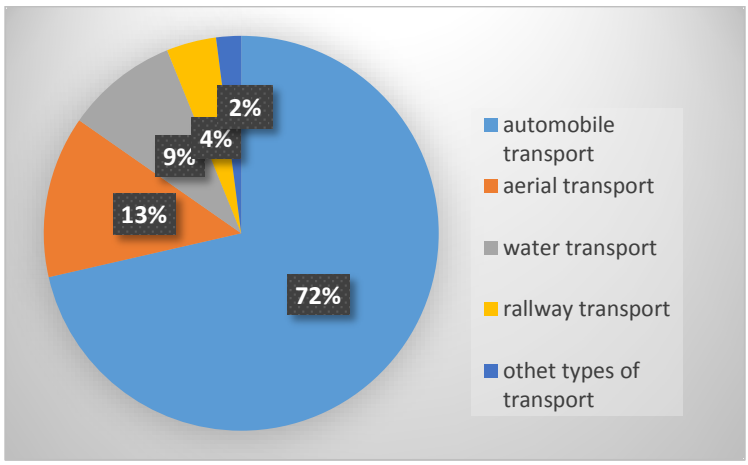

Figure 4. Arranging greenhouse gas emission in the transport sector into types – 2017

Presently, the most commonly used types of fuel in the capital are the so-called "conventional fuels", i.e. gasoline and diesel fuel. Aside from possessing different properties, they are also used in different types of engines and go through technologically varying fuel processes.

The table 1 shows that carbon oxide emissions from gasoline engines are approximately 10 times larger than the ones from diesel engines due to the circumstance that diesel engines burn the so-called "poor mixtures" which contain larger amounts of oxygen, whereas gasoline engines burn the so-called "rich mixtures" which contain more carbon. Gasoline engines also emit more hydrocarbons and lead, whereas diesel ones emit more nitric oxides, soot and sulphur compounds. On the whole, however, it is evident that diesel engines emit smaller amounts of harmful substances than gasoline engines – approximately 3 times and more for the indicated pollutants. It should also be noted that CO_2 emissions, which have not been presented in the table, do not differ significantly in regards to the two types of engines.

Table 1. Harmful substances in diesel and gasoline engines, measured in kg/ton of exhaust fue

Engine type	CO	CH	NO_x	SO_x	Soot	Lead	Total
Gasoline engine	267	33,20	26,60	1,34	1,34	0,27	329,75
Diesel engine	28,40	9,10	40,80	34	3,40	-	115,70

The data on transport emissions is based on the yearly stock-takings of primary air pollutants carried out by the National Statistics Institute and the Executive Agency for the Environment to the MEW (2019). The amount of emitted harmful substances is measured on the basis of the amount of used fuels. Polluting the environment with toxic gases from transport vehicles is a serious issue which concerns the capital's residents, the country's residents and the planet's entire population. In some cases the concentration of harmful aerosols, lead, carbon oxide and dioxide, sulphur dioxide, nitric dioxide and dust greatly exceeds limits.

Automobile traffic in the city of Sofia is the primary reason for the presence of 6-8% of aerosols in the air. They vary in magnitude, with smaller particles with a radius of under 20 micrometers being the most harmful to people. According to their size, particulate matter is divided into: PM_{10} – particles with a diameter of under 10 microns and $PM_{2.5}$ – particles with a diameter of under 2.5 microns. Particulate matter is either emitted directly into the atmosphere (primary PM) or formed in it (secondary PM). Primary particulate matter originates from natural sources or from anthropogenic sources. The natural sources include sea salt, naturally suspended dust, pollen, forest fire emissions and volcanic ash. Urban transport falls into the category of anthropogenic sources – i.e. exhaust gases from automobiles and dust from the exploitation of road infrastructure. Particulate matter enters the respiratory system, causing multiple health issues. It also has a harmful impact on the environment – it reduces visibility, affects the climate and can also damage buildings, depending on its composition. PM pollution continues to be a priority issue for the quality of the air in the capital. Several stations for measuring PM indicate a quadruple and even a quintuple excess of limits.

Aside from harmful emissions in the atmosphere, the dynamic of public transport also causes noise pollution whose acceptable limit for a normal lifestyle adopted by multiple countries, including Bulgaria, is 30-35 dB. From a total of 49 observed stations for measuring noise levels in the city of Sofia in 2015, 10 stations have registered noise under 58dB, 8 stations – between 58 dB and 62 dB, 13 stations – between 63 dB and 67 dB, 18 stations have registered a level of 68-72 dB in busier places during the day and 90-95 dB during rush hour. Noise in Bulgaria is a stress factor for the organism and its effect involves reduced productivity, over-exhaustion, lack of sleep and rest.

5. Inferences

In recent years the growing population of Sofia and number of automobiles in the city has become a serious problem, causing traffic jams along the city's main arteries and streets, a decline in the quality of public transport services and overburdening of parking lots. All of this has also led to other negative consequences such as exceeding the limits of harmful emissions and noise pollution of the environment in the capital and an overall decline in the quality of life in an urban environment. This has put the necessity for stable improvement of the quality of public transport and increasing its social effectiveness on the agenda and the necessity for designing a program for the future development of public transport and the adoption of specific measures for increasing the quality of passenger transport services in Sofia in accordance with customers' needs on the agenda. The capital's administration should focus its efforts on searching for new solutions, innovative and ambitious decisions in regards to the management and organization of urban traffic.

6. Recommendations

In order to improve the indicators characterizing the capital's public transport, conformable to its growth and citizens' transport needs, the adoption of the following organizational and technical measures can be recommended:

The main factor for increasing the speed of vehicles in the city is organizing high-speed transport. This necessity is defined by the potential saving of travel time. The probability for using high-speed types of transport depends on the transport network's density, as well as the distances. If the distribution of passengers by distance is known, and under a given density of the high-speed transport network, the number of high-speed transport trips can be determined.

Global practices show that the fast and efficient servicing of large passenger flows, as well as relieving traffic in major cities, requires the functioning and development of high-speed underground public transport which offers comfort during travel, high speed and freight capacity.

The subway, with its high capacity of over 50 000 passengers per hour, equipped with means for ensuring the safety and security of movement with a speed of 80 km/h, is the most distributed of this type of transport. The travel time from the city's periphery to the city's center with this transport type ranges from 10 to 18 minutes. Due to its high freight capacity of 50 000 passengers per hour, instead of a significant number of parallel ground transport lines with a freight capacity of up to 4000-5000 passengers per hour, the subway services these routes effectively. In Sofia, passenger flows along the Lyulin-Center-Mladost route reach 30 000 passengers during rush hour; forecasts expect them to grow to 38 000 passengers per hour. Along the "North-South" route they reach 24 000 passengers per hour, with a projected growth of up to 32 000 passengers. Another extremely busy route is "Tsar Boris III" Blvd-Center-"Botevgradsko Shose" Blvd, where the size of maximum passenger flows reaches 18 000 passengers per hour, with a projected growth of up to 25 000 passengers per hour. The three subway diameters of Sofia's subway lines are situated precisely along those busiest city routes by the General Scheme for the development of its lines. In order to cover the majority of the capital, deviations in the peripheral parts of these lines towards the residential complexes located in these parts are envisaged. "Metropoliten" SJSC's mission in recent and future years is to ensure the entire investment process for the development of the subway lines and their effective commission after the completion of the separate sections.

The main public benefits from the expansion of Sofia's subway include:

- saving travel time – over 150 000 hours daily;
- reducing traffic in the capital – 25%;
- reducing traffic accidents – 18%;
- reducing air pollution with harmful gases emitted by automobile engines – 80 000 tons annually;
- reducing noise levels in the city – 15-20%;
- decommissioning a significant number of vehicles from duplicate lines of ground MUT – 140 vehicle units;
- high speed – up to 80 km/h;
- increasing the subway's share in the urban transport system;
- improving the appeal of territories along the subway's road-bed.

The progress of the capital's subway has been very evident over the past several years. A short look at the numbers and facts speaks emphatically of that. The capital's subway perfectly corresponds with the European vision for the development of intelligent, environmentally friendly and integrated transport.

The future of Sofia's subway involves the construction of a third subway diameter which will be finished by the end of 2018. It will have 20 subway stations and it will link the capital's northeastern and southwestern neighborhoods, with completely automated trains moving along it. The final construction of the capital's subway will improve citizens' lives by providing them with safe, stable and environmentally friendly travel conditions.

The city of Sofia should start a gradual replacement of the obsolete and environmentally unfriendly rolling stock by

incorporating those innovative decisions whose ecological, technical and economic benefits are obvious. Electric buses are the vehicles of the future – they help solve part of the ecological problems in an urban environment and are comfortable and convenient to travel. They do not require an additionally expensive infrastructure and they can easily alter their routes. In addition to being environmentally friendly, electric buses take up four times less expenses for maintenance than traditional diesel buses (Tzvetkova, 2019). All European capitals have already taken specific steps for incorporating electric buses into their transport schemes or for differentiating zero-emission zones where only electric vehicles and electric buses travel. Many European cities have begun to impose bans on the purchase of diesel buses for the purposes of urban transport.

So far the European market has had little experience in the exploitation of such vehicles with completely new technology that has undoubtedly proven its advantages in Shanghai's transport sector, where it has been implemented for over 10 years. In 2016 Vienna and Brussels switched to solely purchasing electric cars. Amsterdam is also expected to start gradually replacing existing cars with electric ones by 2018. As of 2020, the policy of European cities like Oslo, Hamburg and Paris regarding the incorporation of electric cars will also be aimed towards purchasing electric cars. Authorities in London have made a decision to completely replace the entire rolling stock with electric buses and by 2020 only environmentally friendly electric buses will be operating on the city's streets. With the availability of this technology, no one anywhere would ever have an excuse for purchasing diesel cars.

The benefits of incorporating electric buses:

Ecological benefits: the most environmentally friendly decision for public transportation in an urban environment; no visual pollution (a contact network); non-alternative transport; lowest levels of noise pollution; no harmful effects on people's health, such as respiratory disorders and reduced CO_2 emissions (Table 2).

Table 2. Reducing CO_2 emissions in the operation of Chariot e-bus at a mileage of 50 000 km per year

Type of Bus	CO_2 (tons/bus)	Reduction of Chariot e-bus' CO_2 compared to other vehicles
Chariot e-bus with an ultracondenser	32,0	-
Electric bus with batteries	40,0	26%
Trolley	42,0	31%
EVRO VI diesel bus	74,6	57%
Methane bus (EVV standard)	62,6	48%

For the calculations, the CO2/MWh emission factor of Bulgaria for the production of electric energy in tons has been used. It should be noted that these emissions are lower compared to the emissions that would be given off from the direct burning of fuels by diesel and methane buses.

Technological: rapid and easy construction of a minimal infrastructure; unlimited daily run, with a charging time of 7-8 minutes at the last stop; it is not influenced by ambient temperature; remote monitoring; remote reading of the consumption of energy resources; high passenger capacity;

Economical: insignificant expenses for infrastructure (1-2 charging stations); lowest consumption of energy resources; low operational expenses; opportunities for removing the trolley contact network; lowest cost of ownership.

144 European cities use trolleys in their inter-urban systems – capitals like Athens, Bern,

Bratislava, Budapest, Moscow and Rome are among them. Forty-four of these cities are located in Central Europe; over the last ten years, 13 of them have actually integrated or restored trolleys as part of their public transport system after decades of suspension. Among them are cities like Rome, Bologna, Genova, Bari, Padua, Clermont-Ferrand, Castellon de la Plana, Košice, Landskrona. In nine other Central European cities like Leipzig, Leeds, Edinburgh, Helsinki, as well as five more Italian cities, debates are currently underway on the incorporation of trolley transport. Trolleys fit in successfully with the transport systems of 11 U.S. cities and 18 Canadian ones due to the fact that trolley transport saves more energy and is more environmentally friendly than other types of public transport.

Based on an assessment of the impact that the trolley system's external factors have on the public transport system, it is evident that even in countries with mineral-based energy production trolleys have an advantage over the best diesel buses in regards to the environment. Gas emissions from trolley systems are significantly lower, compared to the ones from diesel buses (Table 3).

Table 3. Comparing the harmful emissions of buses and diesel automobiles

	Bus (g./км)	Trolley (g./км)	Total amount of trolley emissions compared to diesel automobiles
Nitrogen dioxide	18,6	1,27	7%
Carbon monoxide	1,90	0,06	3%
Hydrocarbon	1,34	< 0,1	< 1%
Sulphur dioxide	1,44	0,62	43%
Particulate matter	0,56	0,012	2%
Carbon dioxide	1880	1380	73%

Advantages of trolleys over buses:

- Ecologically clean transport – no emissions of harmful substances, which is vital to preserving the environment in major cities;
- Low consumption of electric energy, compared to expensive fuels;
- Engines are capable of handling twice as much load, which allows rapid acceleration during departure;
- Speed regulation is smoother, which improves comfort during travel;
- Significantly higher speed, regardless of terrain conditions, which guarantees speed of movement for citizens.

Advantages of trolleys over trams:

- Trolleys do not need the expensive railway – capital investments per 1 km of road-bed are 60% of tram ones;
- Higher maneuverability;
- Trolleys are significantly less noisy than motor streetcars.

The significant advantages of trolleys like their less complex contact network, traction equipment, stable state electric substations further enhance their advantages

The necessity to modernize urban infrastructure so it corresponds with the city's needs is crucial to increasing the quality of public transport freights. Modern stops equipped with information panels need to be built. It is necessary for the city to be equipped with available parking lots near subway stations, next to which there need to be parking spaces for bicycles. Access to bus or tram transport has to be provided next to each subway station. The safety and security of stations, stops and vehicles has to be at the necessary level for both passengers and vehicle drivers, i.e. by introducing a security strategy through equipping stops and vehicles

with cameras and creating better safety conditions for stations and the surrounding territories. Regular security and safety training also have to be organized, as well as increasing vigilance. Traffic safety has primary significance for secure passenger trips with public transport. The main trends of increasing vehicle reliability and traffic safety are aimed at updating vehicles and increasing driver's qualification (Razmov & Varadinova, 2013).

If the management of the transport system in Sofia is improved and ITS is implemented in the public transport network, Sofia Municipality can increase the efficiency of the road assets. By improving the use of both road and public transport resources, the city will be able to manage the network so as to reduce public transport travel time while reducing congestion. In this way, the capital will have a better quality and more socially efficient urban passenger transport.

7. Conclusion

The social effectiveness of Sofia's public transport can be increased only by improving the quality of the services it provides. This will reduce travel time, ensure easy and timely access to work places and services for all city residents and guarantee safety and security during travel. The integration of new environmentally friendly vehicles into the city's transport system will minimize pollution, greenhouse effects and energy consumption and lead to an overall improvement of the quality of life in the city. The practical realization of all public urban transport system and the implementation of effective actions and measures for improving the quality. For this purpose, a plan for urban mobility needs to be developed – so far such a plan does not exist. It has to be based on the good development practices and the integrated approach in public transport management in European cities. This is the only way to fully satisfy citizens' travel needs and improve the quality of life in the city (Tzvetkova, 2016b).

This plan has to be a long-term concept, based on commercial, social and ecological aspects regarding the city's development and environmental protection. One of the plan's priority goals needs to be the stable improvement of the quality of public transport and the doubling of the percentage of citizens using public transport in the long run, as well as integrated, effective and stable improvement of the city's transport system, in accordance with the capital's growth and the transport needs of its residents and visitors (Velikova, 2019). In order to achieve this goal, the capital's high-speed transport needs to be fully developed. Global practices show that the fast and effective service of large passenger flows and traffic relief in major cities requires the functioning and development of high-speed ground public transport which offers comfort and convenience during travel, high speed and freight capacity. Sofia's subway has to become the primary mode of transport, defining the structure of relatively long-distance freights of large groups of people due to its undeniable techno-economic characteristics such as environmental friendliness, high speed, large passenger capacity and effectiveness (Tzvetkova, 2018).

Another supporting point of the plan for the future development of public transport has to be the incorporation of modern and environmentally friendly, electrically-powered vehicles into the city's transport network. Buses, motor streetcars and trolleys need to be gradually replaced and modernized. The technical condition of the vehicles and the comfort they offer are crucial to improving freight quality. Modern environmentally friendly vehicles guarantee the reduction of noise and dust pollution, as well as the tranquility of citizens whose residences are located next to elements of public transport infrastructure. In order to reduce the harmful impact on the environment, conventional taxi cars need to be gradually replaced with electric automobiles which use electrically-powered engines. They have the following advantages

over cars with internal combustion engines: higher efficiency, higher acceleration, quietness, low prices per kilometer, significantly simplified car service – fewer and more durable parts and, most importantly, they do not pollute the environment.

The urgent gradual reorganization of the tram and trolley networks as the most environmentally friendly types of ground transport is crucial to the effective management and organization of the capital's publictransport. The purpose of this restructuring has to be the adaptation and integration of these types of transport toward the existing and future project subway lines.

In order to expand the utilization ratio of public transport, it is necessary to make citizens' access to public transport as easy as possible by incorporating an integrated ticked-issuing system. The easy and convenient purchase of tickets will attract more customers to public transport. The innovative ticket sale system will be adapted to the needs of various groups of customers (Varadinova, 2017).

The improved quality of Sofia's public transport will guarantee the functioning of environmentally friendly transport which provides opportunities for attracting more people and fully satisfying their needs (Minkov, 2017) . This will make citizens less dependent on their automobiles and subsequently bring environmental benefits. Access to all urban zones and services will be improved; better environmental parameters such as air and noise quality will be achieved, thus improving the population's health status. The quality of life for people with limited mobility and people who live in regions that have not been connected to the city's public transport network in the past will be significantly improved. Sofia's overall image will be improved – it will have a new vision of an innovative and futuristic modern European city.

In that regard, Sofia Municipality, the Center for Urban Mobility, firms offering public transport and science experts should undertake joint efforts. This integrated approach will inevitably lead to positive results toward improving the quality and social effectiveness of Sofia's public transport.

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