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## **DIFFERENT VARIANTS OF GLIWICE PUBLIC TRANSPORT SERVICE – THE EFFECTIVENESS ANALYSIS**

### *Abstract*

*In the present times the high volume of traffic results in a particular emphasis on well-organized urban transport. According to the ideas concerning the sustainable development, city authorities are trying to eliminate congestion in the downtown area of large urban centers. The article attempts to analyze the economic efficiency of the bus and tram transport in Gliwice. This topic was chosen because of the decision of the city authorities abolish tram services. Consequently, tram lines have been replaced by the bus service.*

*The article presents the carriers who perform services for the Transportation Association of the Municipal Upper Silesian Industrial District in Katowice (Komunikacyjny Związek Komunalny Górnośląskiego Okręgu Przemysłowego w Katowicach, KZK GOP), and particularly – their fleet. It offers a comparison of operating the city bus and tram lines based on the economic efficiency, and taking into account the external costs of air pollution.*

### **INTRODUCTION**

In many aspects, urban transport is very different from other transport systems. It is greatly influenced by public authorities in organization and financing. This is mainly due to the conviction that a properly-functioning city needs to be friendly and cannot do without a well-managed and organized urban transport system.

Currently, urban transportation is experiencing a renaissance of the tram. In many Polish cities, as well as in the Western Europe, a modernization and expansion of the infrastructure is ongoing. Investments are made in a modern, comfortable and energy-efficient fleet. There are cases of cities building a completely new tram system. Arguments of proponents of this approach relate mainly to the sphere of ecology, as well as organizations and economic efficiency. For them the optimal solution seems to be to create a network of tram infrastructure, functioning apart from the regular, congested traffic, and is operated by a modern fleet. Unfortunately, reality can significantly hinder the implementation of such plans. In opposition to prevailing trends in ecology the city authorities of Gliwice decided to stop the financing of tram traffic in their municipality. In August 2009, Gliwice replaced tram lines by an expanded range of bus connections. The authors of the article have analyzed the economic efficiency of both solutions, proving in this respect the rationality of the decision.

The article is the result of the synthesis of BA thesis topics of the authors and is based on the collected materials and calculations which present the organization and financing of urban transport.

# 1. TRANSPORT CHARACTERISTICS OF GLIWICE

## 1.1. Road infrastructure

Gliwice is a city located in the Upper Silesian Metropolitan, which total area is 134 km<sup>2</sup>. On the 31st of December 2009 there were domiciled 189 502 people within the territory of the city [19]. Gliwice is one of the major urban centers in Silesia, characterized by a highly developed industry. The Gliwice Subzone of the Katowice Special Economic Zone is home to 58 companies, most of which specialize in the automotive industry, logistics, IT and electronics [4].

Gliwice is characterized by city expansion radially propagating from the center that is very well preserved in terms of architecture. As a consequence of such development, buildings in the city are scattered in all directions, so is the location of housing estates and industrial and commercial areas. The growth of the city in different directions was possible due to the displacement of cars, together with promoting the low-rise houses. Because functional and spatial changes in the city cannot be expected in the near future, the increasing passenger flows at the local level have to be expected.

In order to ensure the proper movement of people and cargo in the city, it is necessary to shape the road infrastructure, so that transit traffic will be eliminated from the downtown area. Proper formation of the streets transportation system will release the center from the motion not directly linked to its support [9, p. 57].

The Municipal Road Management in Gliwice administers 450 miles of roads [16], among which there are the important provincial roads (roads number: 408, 901), national ones (roads number: 44, 78, 88) and motorway routes (A1, A4).

The most important issue for the city is to build the road called the Drogowa Trasa Średnicowa, a process which, assuming a timely and efficient tender process, will begin in the first quarter of 2012. The investment should be finalized by the end of 2014 and is expected to cost about 750 million PLN [19].

**Tab. 1.** The list of sections of highways that pass through Gliwice

Highways	Sections of highways passing through Gliwice	The length of sections of motorways built [km]
A1	Gliwice Sośnica – Bełk (Rybnik); finished in 2009	15,5
A4	Kleszczów (Gliwice) – Sośnica (Gliwice) – Chorzów-Batory – Katowice-Mikołowska – Katowice-Murkowska; finished in 2005	43

Source: Own study based on the data of General Directorate for National Roads and Motorways, 2010.

Major road investment is expected to activate areas outside the city center. The creation of new jobs and dynamic growth can be expected to lead to changes in urban transport. A well-managed and efficient urban transport system is needed to provide an appropriate level of service.

## 1.2. System of urban transport in Gliwice

The urban transport should be perceived by the municipal authority as a fundamental competency. This system should be shaped in such a way so as to provide the primary benefits to the customer. The development of the modern cities is dependent on the effective competition with other cities in the network system [1, p. 12]. There is a close relationship between the development of the city and the transport system. The organization of this system is the primary task of the city, so it can effectively compete, or it has the opportunity to compete.

Public transport is an important element in the development of cities and their communities. It was included by the legislature against the commune's own tasks under the Act of 8 March 1990 on local municipalities [20]. Thus, an obligation to organize and control the operation of urban transport has been entrusted to the authorities of municipalities in accordance with Article 7 of this Act, as satisfying the collective needs of the joint. The municipalities,

according to the Act, may appoint managements of public transport and create special organizational units in the structure of municipal administration and delegate it to a private company that was selected in the tender procedure. If transport service covers an area of more municipalities, as it is the case in polycentric agglomerations, the legislature will provide the possibility to form an association of municipalities, together with the obligation for the new entity to carry out specific tasks designed in the communities.

An example of such a solution in the Katowice agglomeration is the Communications Municipal Association of the Upper Silesian Industrial Region (KZK GOP). The KZK GOP has been organizing public transport in the 25 municipalities, among them in Gliwice, since 1991.

The Statute of the KZK GOP stands in paragraph 7 of the Union of two bodies: the Assembly as a decision-making authority and control and the Board of the Association as an executive body. The Assembly provides a representation of the interests of all affiliated communities, through their representatives participating in it with the number of the population – one representative for every 100 thousand residents. The Board consists of nine members elected by the Assembly and executes the tasks specified by law[17].

Urban transport is based on the distribution function of the organizer and the carrier, which brings economic benefits of market pressure exerted on the transport companies. In order to keep market position, they tend to provide a service that meets the expectations of buyers. The buyer is the organizer of transport, which presence in the market competition provides verification of the level of carriers cost and the possibility to choose the best bid, submitted in the tender procedure[11, p. 212].

The measurable effect of the competition between operators is the reduced spending, manifested in lower cost of operational work unit. This suggests a higher efficiency of the model organization with delimited function of the operator and the carrier. The factors affecting the efficiency of transport management can be divided into: internal (organizational form, level of personnel education, and organizational culture) and external [10, p. 3].

This model of public transport organization, based on the separating the functions of the organizer and the carrier, has several advantages. The main ones are as follows:

- verification of unit prices by the market - orders can get various operators, both in terms of size of company, organizational and legal forms of business, ownership and country of origin of capital entity,
- the impact of public authorities on the size and parameters of transportation offer and exercise public control over the organization of urban transport and flows of financial resources,
- the possibility of privatization of public transport operators,
- ensuring the integration of services provided by various operators – the integrated boards offer services provided by the public transport operators; there is a solution for integration in the future: urban public transport systems and public transport with regional scope [2, p. 187-188].

The appropriate financing is the base of efficient organization of urban transport. The activities of the public transport sector can be financed from:

- revenues from sales of services,
- subsidies,
- operating incomes, non-core activities,
- financial incomes [7, p. 34-38].

The main sources of incomes for KZK GOP are: grants from municipalities, income from tickets sales and additional charges. Due to the specification of the area, a large number of municipal carriages is executed, which poses the problem of an equitable share of the associated entities in the joint financing. The rules for calculating the contribution of municipalities to KZK GOP changed several times over the years. The last formula change for calculating

the grants took place in 2006. The new system consists of counting revenues and costs of urban public transport lines, and the obtained result (usually a deficit) is accounted between all the municipalities concerned. This solution ensures that the subsidy is accounted pursuant to shortfalls associated with the operation of urban transport in the area. New methods differ significantly from the ones previously used, so it was decided to make changes in stages. Therefore the following formulas apply [5, p. 62-63].

$$D_g^L = \sum_{l=1}^{N_g} D_{lg}^L, D = \sum_{g=1}^K D_g^L$$

where is:

$D_g^L$  – the grant from the municipality, calculated as the line,

$N_g$  – the number of lines in the municipality  $g$ ,

$D_{lg}^L$  – the subsidy counted within the municipality  $g$  for line  $l$ ,

$D$  – the total subsidy from municipalities for the participants of the KZK GOP,

$K$  – the number of participants in the Association of municipalities.

$$Dg = AD_g^P + (1 - A)D_g^L$$

where:

$$D_g^P = D \frac{P_s}{P}$$

$D_g^P$  – municipality subsidy calculated according to the size of the operational work,

$P_s$  – size of the operational work in the community (in vehicle-kilometers travelled<sup>1</sup>),

$P$  – total operational work (in vkt),

$A = 1$  – in the year 2007,

$A = 0,75$  – in the year 2008,

$A = 0,5$  – in the year 2009,2010,

$A = 0,25$  – in the year 2011,

$A = 0$  – in the next years [21].

**Tab. 2.** The share of grants in the revenue of municipalities KZK GOP in 2006-2009

Year	The sum of the size of grants to KZK GOP (PLN)	Total revenues KZK GOP (PLN)	Size of share of grants in total revenue (%)
2006	139 408 931,07	382 415 879,67	36,45
2007	158 957 742,93	399 418 959,05	39,80
2008	194 409 060,00	438 034 991,22	44,38
2009	239 383 390,68	489 785 429,76	48,88

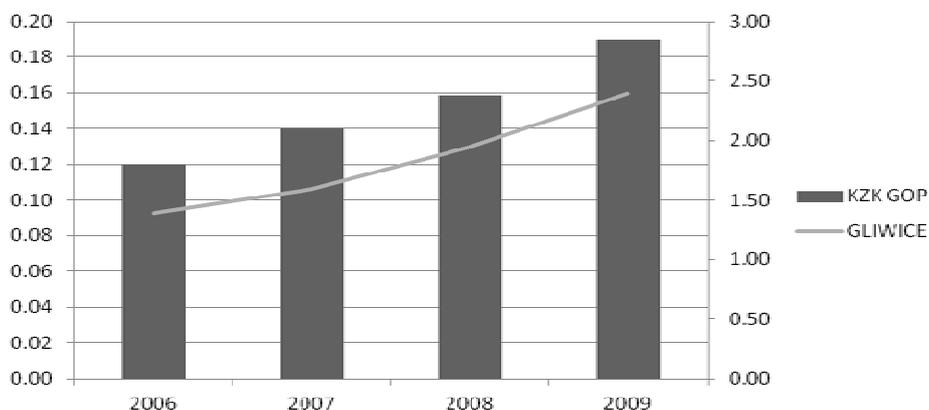
Source: Own study based on the data of KZK GOP.

The data presented in Table 2 shows a systematic increase in the amount of subsidies paid by the municipality for the organization of public transport. This is due to increased costs incurred by the carriers (e.g. fuel prices, wages of drivers) and raising the quality of service which is related to the introduction of a modern fleet. There is also the increase in total incomes of KZK GOP, which is synonymous with the decrease of revenues from tickets and additional charges in financing the transport sector. The increased share of the financial burden of municipalities can encourage them to seek savings by influencing the shape of the transport offer.

<sup>1</sup> Vehicle-kilometers is the number of vehicles multiplied by the average distance they travel. Road vehicles include cars, buses, and freight vehicles, but exclude two-wheelers.

Figure 1 presents a comparison between the size of Gliwice subsidy and the sum of total revenue from subsidy of the KZK GOP municipalities. The percentage of the city in co-financing of urban transport was:

- in 2006 – 8,60%,
- in 2007 – 8,81%,
- in 2008 – 8,15%,
- in 2009 – 7,92%<sup>2</sup>.



**Fig. 1.** The size of subsidy from Gliwice in comparison to the sum of the subsidy from all municipalities to KZK GOP (in mln PLN)

Source: Own study based on the data of KZK GOP.

The analyzed data allow to conclude that in 2008 and 2009 Gliwice subsidies began to decrease relatively. The influence on this situation could have been: transport limitations in the offer such as the reduction in the number of services on various lines and changing the type of fleet to support them, or the resignation of rail transport services for the benefit of the bus, which took place in the last year of the analyzed period and has an influence on the financial result.

## 2. CHARACTERISTICS OF CARRIERS PERFORMING THE LARGEST OPERATING WORK

### 2.1. Tramwaje Śląskie Inc.

There were two transport companies that played the major role in transport services of Gliwice – Tramwaje Śląskie Inc. and Przedsiębiorstwo Komunikacji Miejskiej Ltd., both of whom were selected in tender procedure. The transport companies belong to the group of carriers that perform the highest level of operating work on behalf of the KZK GOP as shown in Figure 2.

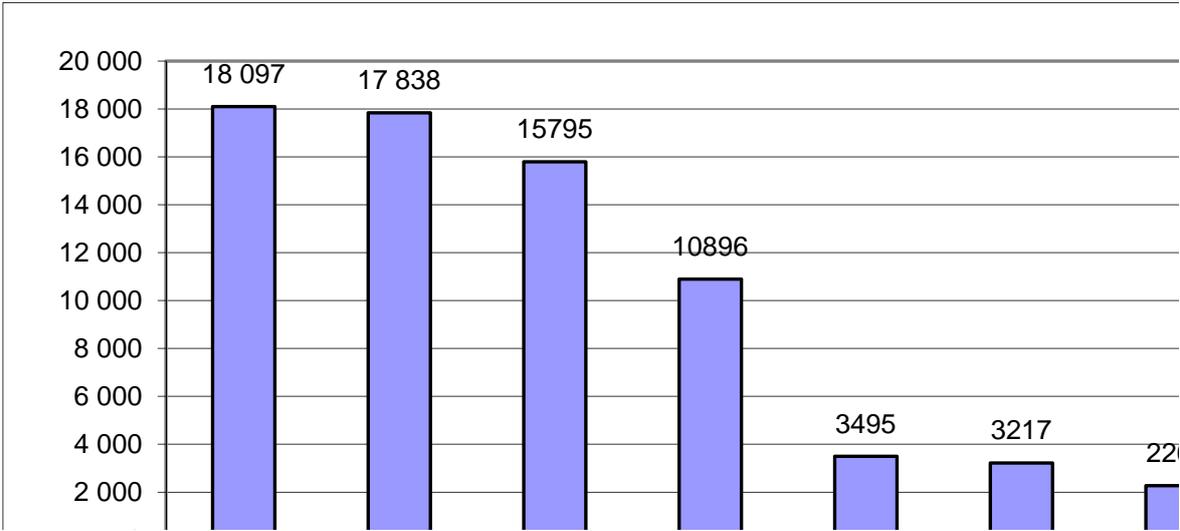
When making an analysis of economic efficiency, one must pay attention to the quality of services, which is connected with the age and the condition of the available stock. In addition, the analysis should include different variants of public transport service.

Tramwaje Śląskie Inc. is the only tram transportation enterprise, which perform services in Upper Silesia and the Zagłębie. In January 2009 the owners of the company are the municipalities. Shares are divided proportionally according to the work performed by the trams operating in the areas of individual municipalities.

Tramwaje Śląskie Inc. is in possession of outdated rolling stock with run-down construction. The age of the available transport equipment to perform the transport services caused the rail transport to becomes ineffective. As a result, a large number of failures is reported. Thus,

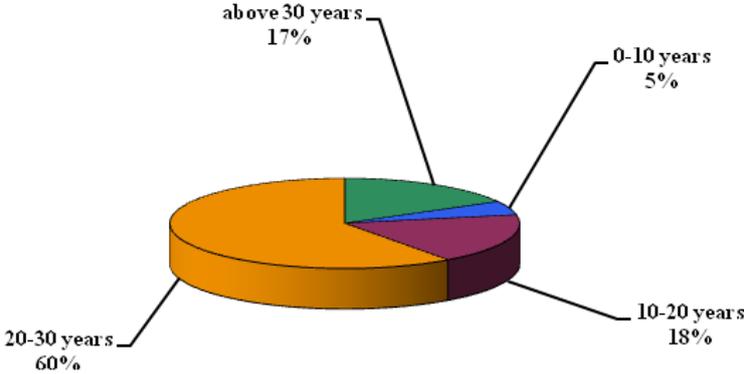
<sup>2</sup> Own study based on the data of KZK GOP.

its exploitation means an increased the level of noise, vibration and oscillation, which influence the passenger comfort. The age structure of stock is shown in Figures 3 and 4.



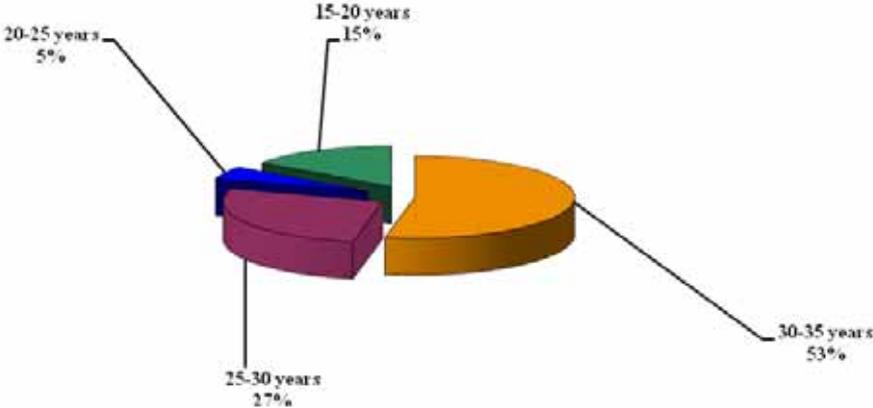
**Fig. 2.** The list of the largest carriers of KZK GOP, per operational work in thousands wozokm. (data for 2008)

Source: Own study based on the data of KZK GOP.



**Fig. 3.** Age structure of the rolling stock in the company Tramwaje Śląskie Inc.

Source: Own study based on the data of KZK GOP, Katowice 2009.



**Fig. 4.** Age structure of the rolling stock in the company Tramwaje Śląskie Inc.-depot Gliwice

Source: Own study based on the data of KZK GOP, Gliwice 2009.

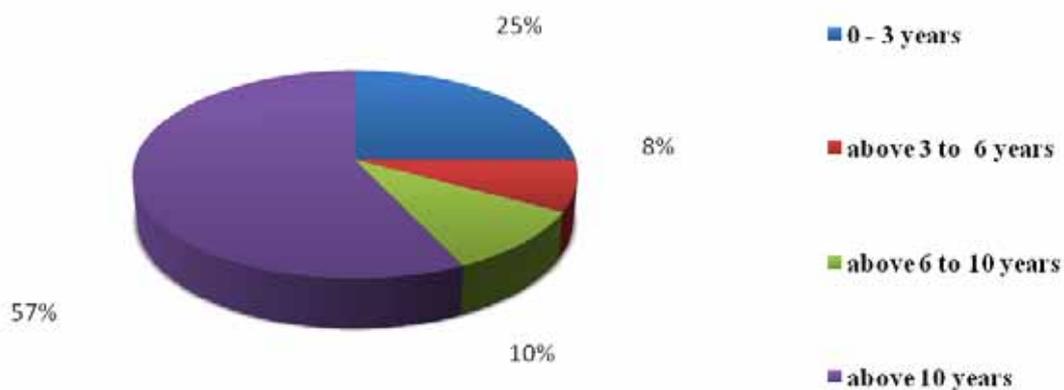
The age of the large number of the available vehicles intended to perform services by the Tramwaje Śląskie Inc. ranges from 20 to 30 years. Over 75 % of the company stock is of that age which in combination with a somewhat small number of units of new rolling stock, does not build a positive image of the carrier.

The division located in Gliwice is even worse. Here the age of the rolling stock available to service is considerably higher than generally operated by company vehicles. More than half the fleet was in the age group 30-35 years. In addition, it should be noted that the Gliwice division did not have units in its fleet younger than 15 years, and the average age was 29 years.

## 2.2. Przedsiębiorstwo Komunikacji Miejskiej Ltd. in Gliwice

Przedsiębiorstwo Komunikacji Miejskiej (PKM) was established in Gliwice on the 1st of October 1991, as a result of the split-up of the Wojewódzkie Przedsiębiorstwo Komunikacyjne into 17 completely independent operating bus companies and Przedsiębiorstwo Komunikacji Tramwajowej. Since the 28th of August 1997, the PKM has been operated as a limited liability company. The main shareholder is the city of Gliwice, with a 85 % of the shares. PKM Ltd., like the Tramwaje Śląskie Inc. is a carrier, performing on behalf of the KZK GOP [14].

Figure 5 presents the age structure of buses used by the PKM Gliwice company to provide transport services in the area of the municipalities.



**Fig. 5.** Age structure of the bus stock, used by the PKM Gliwice company

Source: Own study based on the data of the PKM Gliwice, July 2009.

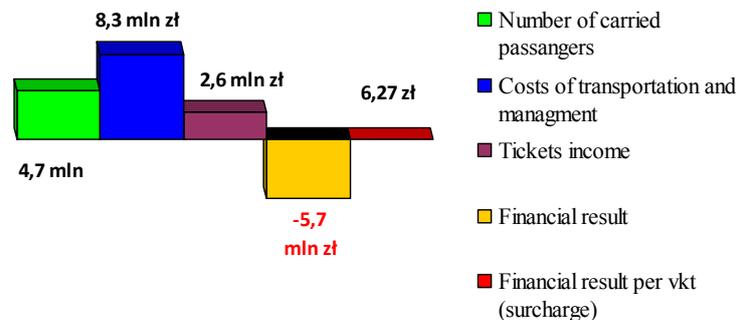
Due to the relatively large number of vehicles aged 3 years (25%), the age structure of the rolling stock appears positive. Still, more than half is among the group above 10 years. The situation will improve significantly year by year as a result of the development and implementation of operational instructions for scrapping old vehicles. In February 2009 the company withdrew 12 of the oldest Ikarus 280, produced between 1981 to 1982 and Jelcz from 1986 to 1987. In the following years other vehicles will be phased out as they have become useless for exploit from the standpoint of the carrier [14].

Bus manufacturers placed great emphasis on the long life of vehicles. Manufactured components are covered by a 10-year warranty. Engines and components are able to act effectively on runs in excess of 1 000 000 kilometers. In fact, annual mileage oscillates between 70 and 80 thousand kilometers, so the buses can be used for 12 and even 16 years. If the difference in operating cost between a new and a 10-year old vehicle is not large, the older buses which meet basic requirements of the road will not immediately have to be the subject of the elimination process. Currently, there are examples of effective use of 20 year old buses which precludes the elimination of the bus fleet, taking into account the age criterion. The process of decommissioning should be the subject to market mechanisms [8, p. 35].

### 3. ANALYSIS OF THE PRESENTED URBAN TRANSPORT SYSTEM

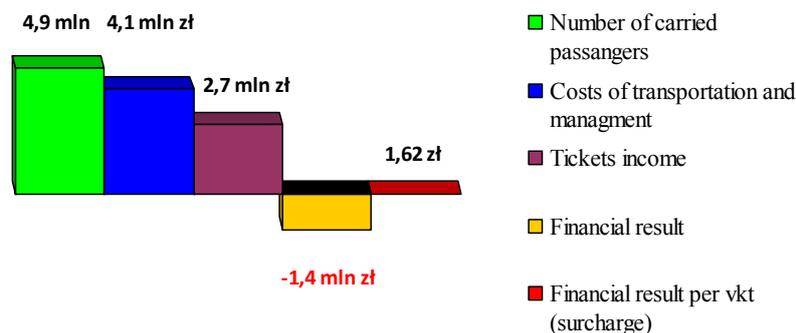
#### 3.1. Comparison of city transport service by the tram line T1 and the bus number 32

The basis of the analysis is to compare the number of passengers on the tram line T1 (Gliwice – Zabrze – Ruda Slaska) and the bus line No. 32 (Gliwice – Zabrze). In the analysis is taken account of the approximate fees for a vkt because of their valorization. In the case of the tram rate is about 4 PLN, while for the bus it is 8 PLN [13].



**Fig. 6.** Financial analysis of tram line T1

Source: Own study based on the ranking of lines of communication included in the financial plan KZK GOP for 2009 – prepared on the basis of results of measurements of fillings from years 2007-2008 (lines sorted in ascending order by earnings per 1 vkt).



**Fig. 7.** Financial analysis of bus line No. 32

Source: Own study based on the ranking of lines of communication included in the financial plan KZK GOP for 2009 – prepared on the basis of results of measurements of fillings from years 2007-2008 (lines sorted in ascending order by earnings per 1 vkt).

For a comparable number of passengers carried and consequently similar incomes from ticket sales the tram line shows significantly higher (102.5%) transportation and management costs. In this case the financial result is a loss of about 5.7 million PLN. The loss was four times higher than losses recorded by the bus line number 32 (1.4 million PLN).

Additionally, one should pay attention to the fact that the tram lines in Gliwice noted the greatest loss of all transport lines situated in the city. The city authorities had to pay extra per year 1 235 655.39 PLN in case of the tram line T1, while for the T4 line, this amount was even higher and amounted to 1 689 600.27 PLN [15].

#### 3.2. Statement of external costs associated with air pollution

External costs of transport are the social costs generated by transport equipment, which are not covered by the individual carrier. These include:

- accidents,

- noise,
- exhaust,
- climate change,
- changes in nature and landscape,
- additional costs in urban areas,
- additional costs, which are associated with energy and transport equipment production, construction and maintenance of transport infrastructure [12, p. 409-410].

In the study, because of the absence of the adequate researches, the authors focused on the external costs of air pollution. This simplification allows to base the analysis on objective and systematic indicators of the rates for using the environment, established by the Ministry of Environment.

The comparison of cost-effectiveness and environmental performance of substitute means of transport were used in the statement of costs incurred in the exhaust emissions of the Solaris Urbino 18 bus and the tram Citadis 116 Nd.

**Tab. 3.** External costs incurred in the exhaust emissions of bus-bus Solaris Urbino 18

Emissions of bus		Engine DAF 265 S2 (Euro 5) - emission per kWh	The rate for use of the environment (PLN/kg)	Cost per kWh (grams)
NOx	nitrogen oxides	1,57	0,43	0,07
CO2	carbon monoxide	0,022	0,11	0,00
HC	hydrocarbons	0,06	3,09	0,02
PT	airborne particulates	0,018	1,20	0,00
Sum				0,09
fuel consumption		45		l. / 100 km
Fuel consumption (gravity 1liter ON = max 860g)		387		grams / 1 vkt
The average specific fuel consumption in the motor bus		200		grams / kWh
Energy consumption per 1 km		1,9		kWh / vkt
The rate for use of the environment in grams		0,17		grams. / vkt
		0,04		grams / passenger

Source: Own study of KZK GOP on the basis of DAF 265 S2 engine and the Notice of the Minister of Environment of 20.09.2007 on the amount of fees for use of the environment in 2008.

**Tab. 4.** External costs incurred in the emission of pollutants by power plants for energy production in 2010 for the tram Citadis 116Nd

Emissions – power plants		Emission of power plant (grams/kWh) – 2010	The rate for use of the environment (PLN/kg)	Cost per kWh (grams)
NOx	nitrogen oxides	1,2	0,43	0,05
CO2	carbon monoxide	835	$0,23 \cdot 10^{-3}$	0,02
HC	hydrocarbons	2,3	0,43	0,10
Dusts – PM <sub>10</sub>		0,2	1,20	0,02
Sum				0,19
Tram – Citadis 116Nd – engine 4*140kW – expenditure energy 2,5 kWh / vkt				
The rate for use of the environment in gr		per vkt		0,48
		per passenger		0,07

Source: Own study of KZK GOP on the basis of emission data (A. Strupczewski, U. Radovic: Koszty zewnętrzne wytwarzania energii elektrycznej w Polsce) and Notice of Minister of Environment dated 20.09.2007 on the amount of fees for use of the environment in 2008.

From the figures shown in Tables 3 and 4 it is apparent that the environmental effects for one vkt is higher in the case of the modern tram Citadis 116 Nd. In addition, it should be noted that the amount of emissions generated by certain means of transport is lower for the Solaris Urbino 18 bus, which meets Euro 5 norms.

The tram infrastructure in Gliwice is not adapted to handle modern trams, so it is more appropriate to compare exhaust costs of the tram model 105N.

**Tab. 5.** External costs incurred in the emission of pollutants by power plants for energy production in 1990 for the tram 105N Series

Emissions – power plants		Emission of power plant (grams/kWh) – 2010	The rate for use of the environment (PLN/kg)	Cost per kWh (grams)
NOx	nitrogen oxides	2,6	0,43	0,11
CO2	carbon dioxide	1005	$0,23 \cdot 10^{-3}$	0,02
HC	hydrocarbons	10,5	0,43	0,45
Dust – PM <sub>10</sub>		3,5	1,20	0,42
Sum				1,01
Tram – series 105N - engine 4*41,5kW – expenditure energy 3,43 kWh / vkt				
The rate for use of the environment in gr		per vkt		3,45
		per passenger		0,50

Source: Own study of KZK GOP on the basis of emission data (A. Strupczewski, U. Radovic: Koszty zewnętrzne wytwarzania energii elektrycznej w Polsce) and Notice of Minister of Environment dated 20.09.2007 on the amount of fees for use of the environment in 2008.

The 105N type consumes much more energy, thereby it increases emissions of toxic substances produced by plants. Particularly large differences are visible in the secreted sulfur dioxide and PM10 dust type. The rate for the use of the environment attributable to both vkt and the passenger is seven times higher than the analyzed case of the modern Citadis 116 Nd.

Air pollutants emitted by transport, as well as coal-fired plants have a significant impact on human health, buildings and structures, crop yields and forest condition. The most harmful group are nitrogen oxides (NOx) and particulate matter composed of tiny particles, referred to the abbreviation of PM10 (particles with a diameter of less than 10 microns) [12, p. 418].

The transport policy pursued by the city is supposed to apply the objectives of the European Union in the field of sustainable development. The authorities must limit the negative impact of transport on the environment, in particular greenhouse gases and air pollutants [6, p. 23].

### 3.3. Analysis of the economic efficiency of bus and tram communications

Conducting proper financial analysis requires comparing the cash flows resulting from the difference between revenues and costs (expenses), which were incurred on the operation of the transport line. In the comparison various options were adopted, which include different lengths of routes, the number of passengers carried and the locations of stops. If different means of transport move at equally segregated routes with a similar number of passengers it will take into account the cost of a vkt [3, p. 1].

In the case of Gliwice, the tram was replaced by the bus on the same route, moving with the same frequency and a similar capacity. What is important in making the comparison, the location of stops did not differ significantly, so the analysis can take the same amount of passengers and the same level of income. It allows to focus on the expenditure analysis of these two different transport systems [3, p. 1].

An important fact is that the bus does not offer a direct connection from Gliwice to Zabrze, which could have an impact on the number of passengers carried. On the other hand, such change will provide better travel comfort and continuity of traffic on the transport line, because failure of one of vehicles does not completely stop traffic.

The financial analysis of the bus and the tram efficiency in Gliwice is based on the data presented in the tables. They appear as projected transport organizer assumptions appropriate for the decision to change the services offered.

**Tab. 6.** Characteristic of bus and tram carriages

Description	Bus communication	Tram communication
Unit cost per vkt	4,50 PLN	8,07 PLN
Number of buses wozokilomteres per day	1.846 vkt	1.846 vkt
Number of passengers carried per day	11.630 passangers	11.630 passangers

Source: Own study based on information materials of KZK GOP, Katowice, 2009.

**Tab. 7.** List of weekly – service work performed by the tram and bus communication

Structure communication	Gliwice	Zabrze	Ruda Śląska
-	14 531,10 [vkt]	15 516,60 [vkt]	2 711,45 [vkt]
Tram lines- structure after liquidation	1 277,85 [vkt]	1 3581,90 [vkt]	2 667,00 [vkt]
Bus line A4 Wójtowa Wieś - Zajezdnia Gliwice	11 507,05 [vkt]	-	

Source: Own study based on information materials of KZK GOP, Katowice, 2009.

**Tab. 8.** List of weekly -service work performed by the tram and bus communication

Structure communication	Gliwice	Zabrze	Ruda Śląska
Tram lines – structure before liquidation 1 Wójtowa Wieś - Chebzie 4 Wójtowa Wieś - Zabrze	117 300,13 [PLN]	126 121,25 [PLN]	22 857,52 [PLN]
Tram lines – structure after liquidation	10 772,28 [PLN]	114 495,42 [PLN]	22 482,81 [PLN]
Bus line A4 Wójtowa Wieś - Zajezdnia Gliwice	51 178,83 [PLN]	-	-

Source: Own study based on information materials of KZK GOP, Katowice, 2009.

The weekly transportation cost for the variant with tram service is 117 300.13 PLN, while bus transportation costs 62 554 PLN. This amount is the result of sum of transport costs generated by the buses and the trams, which move on short section of Gliwice. Operating the bus line – A4 Wójtowa Wieś to Zajezdnia Gliwice can reduce expenditures by 54 746 PLN per week. Usually, the calculations which are made for a longer period should discount the cash flows. Thus, assuming a one-year replacement of the trams by the buses may result in the reduction of the deficit of urban public transport of about 2 846 792 PLN. However, in the first year this amount will be lower due to expenses associated with these changes [3, p. 2].

In 2008, the Communications Association of Municipal GOP also considered another option, involving the introduction of various types of buses B (short) and C (articulated vehicles). The rate for vkt is 4.50 PLN for B types and 6.00 PLN for C. If the A4 line runs from Wójtowa Wieś to Zabrze Goethe, it will increase the total transportation costs and operational work about 11 849.10 vkt [13].

**Tab. 9.** List of weekly -service work performed by the tram and bus communication taking into account the different types of rolling stock

Structure communication	Gliwice	Zabrze
Bus line A4 Wójtowa Wieś – Zabrze Goethego (tabor B)	53 320,95 [PLN]	21 552,30 [PLN]
Bus line A4 Wójtowa Wieś – Zabrze Goethego (tabor B i C)	59 178,83 [PLN]	23 920,05 [PLN]
Bus line A4 Wójtowa Wieś – Zabrze Goethego (tabor C)	71 094,60 [PLN]	28 736,40 [PLN]

Source: Own study based on information materials of KZK GOP, Katowice, 2009.

Other variants which are shown in Table 9 are the more expensive solutions compared to the line A4, which will run from the Wójtowa Wieś to Zajezdnia Gliwice. The use of articulated buses is associated with much higher cost of transportation compared to the short bus used on the same route.

It would seem that a change to bus services will increase congestion and intensify the traffic on the road. In reality, the movement of 6 vehicles for one hour in the same direction does not lead to greater difficulty of movement. Travel time in both cases is comparable. According to the timetables, which are almost similar, a tram journey takes 27 minutes off-peak, compared to 25 minutes for the bus [3, p. 4].

## CONCLUSIONS

The proper management of the urban transport system is an important element in the development of the city and improves its competitiveness. Interference of the public authorities beyond specificity of the market is also caused by implementation of elements of social policy. Therefore, the municipality should provide an appropriate financing level of the transport system.

It can be seen from the analysis that Przedsiębiorstwo Komunikacji Miejskiej in Gliwice has a rolling stock sufficient for the higher quality level of transport services. This is due to a much more advantageous age structure and the technical advancement of vehicles owned.

The analysis conducted in chapter three leads us to the conclusion that replacing the trams with buses could enable a reduction of city subsidies on public transport to KZK GOP of about 2 846 792 PLN. In addition, the assessment of the impact of the means of the public transport on the environment indicates a higher harmfulness of the tram compared with the modern bus. An important element of the public transport management system is to control the spending of public funds. Rational use of these measures may result in strengthening the competitiveness of the public transport potential and improving the standard of service. Despite the implementation of the elements of social policy and public relations under certain political conditions, the city should place strong emphasis on the economic balance of the operation of urban transport system.

# ANALIZA EFEKTYWNOŚCI POSZCZEGÓLNYCH WARIANTÓW OBSŁUGI KOMUNIKACYJNEJ GLIWIC PRZEZ TRANSPORT ZBIOROWY

### *Streszczenie*

*W dobie dużego natężenia ruchu samochodowego szczególny nacisk kładziony jest na dobrze zorganizowaną komunikację miejską. Kierując się ideami zrównoważonego rozwoju próbuje się wyeliminować kongestię z centrum dużych ośrodków miejskich. W artykule podjęto próbę ekonomicznej analizy efektywności transportu tramwajowego i autobusowego na terenie Gliwic. Temat ten został wybrany ze względu na decyzję władz miasta, w wyniku której zrezygnowano z usług komunikacji tramwajowej, na rzecz transportu autobusowego.*

*W artykule przedstawiono przewoźników wykonujących usługi na zlecenie Komunikacyjnego Związku Komunalnego Górnośląskiego Okręgu Przemysłowego w Katowicach, a w szczególności wykorzystywany przez nich tabor. Dokonano porównania obsługujących miasto linii autobusowych i tramwajowych oraz analizy efektywności ekonomicznej z uwzględnieniem kosztów zewnętrznych związanych z zanieczyszczeniem powietrza.*

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