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FINDING WAYS FOR IMPROVING THE EFFICIENCY OF PUBLIC URBAN TRANSPORT IN THE CITY OF KOŠICE

A case study in the frame of the international project "Cooperation for sustainable transport in the V4 region"

Partners

CDE centrum pro dopravu a energetiku

Žilinská univerzita – Vysoká škola dopravy a spojov Žilina – Universitas Solnensis

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SUSTAINABLE AND ENERGY EFFICIENT URBAN TRANSPORT IN SLOVAKIA

Finding ways for improving the efficiency of public urban transport in the city of Košice

A joint report in the frame of the international project "Cooperation for sustainable transport in the V4 region"

Supported by the International Visegrad Fund

April 2014

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1 Introduction

The project „SusTrans - Sustainable and energy efficient urban transport" was 3 years long international project, supported by Visegrad found, aimed at representing joint features and common interests of V4 countries for a sustainable transport infrastructure in the region. It target cooperation for transport and energy infrastructure. During the project lifetime the team of international experts studied joint features of V4 countries related to socio-economic impact and energy-consumption from transportation in the region. One of main outputs of the project is case study about sustainable and energy efficient transport in selected cities of Visegrad region countries.

This study for Slovak project partner – University of Žilina is presented on following pages. It concludes the knowledge gathered from literature, operational data, aimed at finding sustainable, energy-efficient and optimized form of transportation in conditions of providing urban transport in Slovakia.

As the most appropriate object for this study was selected by University of Žilina the public transport system of the city of Košice, because it is one of two Slovak cities[1] with the most diverse modes of urban transport - including buses (diesel and CNG), trolleybuses and tram. Moreover tram system in this city is the most traditional one with the largest history within the country (it was established more than 120 years ago).

The case study is presenting basic information about public transport system provided in the city of Košice, main characteristic of transport operator „Dopravný podnik mesta Košice" (DMPK), its economic indicators, information about transport infrastructure, vehicle fleet and the most important factors related to the cost of operation and energy efficiency of existing tractions. The trends in all these aspects are identified and commented in relevant chapters. Last part of the study contains conclusions based on presented information and findings of other projects related to energy efficiency, in terms of recommendation for future development of sustainable and energy efficient urban transport in the city of Košice.

[1] *The other city that is providing tram within its public transport system is Bratislava.*

2 Characteristics of current situation

2.1 The city of Košice

The city of Košice, with a population of 240.000, is the second largest city in Slovakia. Košice has a strong economic background, and the city creates employment opportunities for the population of the surrounding region as well as its own. Its advantageous location made Košice a key economic region and the centre of important trade routes that is supported also by its position as an important railway junction and international airport.

2.2 Basic parameters of public transport in the city of Košice

Transport Company of the town of Košice (DPMK) provides regular public transport in Košice. It provides its services not only to the residents of the city of Košice but also to passengers from suburban areas. The company operates three kinds of traction - trams, trolleybuses and buses. Majority of public transport system consists of tram and bus transport that are involved in the overall transport operations with more than 85.8 %. Other part consists from trolleybus transport (the share performance was about 9.1% in 2012) and irregular ordered transport. Overall, in 2012 were transported by DPMK 86 843 000 of passengers of which 82 032 000 passengers were transported by regular public transport.

Public transport system carried out the city transport service by 63 daily and 4 night bus, trolleybus and tram lines in 2012, whose total length was 904,8 km. Number of routes operated after falling down in 2006 was more less stabilized. The decrease was observed only for buses while number of operated tram and trolleybus lines remained unchanged. Despite of very slight decrease of operated lines the noticeable decrease of traffic performance and number of transported persons can be observed. The total length of the routes operated has decreased compared to 2008 by 40,5 km.

The above mentioned bus, tram and trolleybus lines were operated by 196 buses (of which 64 are CNG), 117 trams and 27 trolleybuses in 2012. During the night the transport service is provided by 3 bus lines and l trolley line. In addition, DMPK owns 5 buses which are used for public transport (2 for touring transportation, l historic bus, 1 bus for driving school and l bus with beds).

In 2012 there were operational 15 tram lines with a length of 178,10 km. Trolley service is currently operated only by two daily lines and one night line because the trolleybus network consists essentially only from one line that is 13,1 km long. Trolleybus lines No.71 and No. 72 in the opposite direction provide only transport between the eastern and western parts of the city through its centre but they are not linked to the railway station, which is a big disadvantage, especially because the tram and buses lines are linked to the railway station. Originally it was planned construction of a trolleybus network also in the north and the south direction but for financial reasons it has not had been constructed yet and it is a great shortage for its wider use. The current length of the three lines is 25,30 km and it does not changed over the last five years. Regarding the share of vehicle-kilometres carried out this increased from 5,74% in 2007 to 8,24% in 2012.

Showed a thickening of the frequency of connections in the rush hour in the saddle, but the number of passengers do not correspond. Capacity use is low due to the fact that in parallel with the trolleybus route operates buses and partially also trams.

The bus system is the most developed one and together with tram constitutes a fundamental framework of city public transport. The bus network covers the entire territory of the city of Košice and provides 32 daily lines, 3 night lines and 10 lines to the company U.S. Steel Košice. Main lines provide connections of western part of KVP through the railway station to the southern part of the city. Similarly the northern part of the city has direct connections with the centre and south part of the city (shopping centres) by several lines. All city neighbourhoods are also directly linked to the railway station and the city centre, without need of transfers, as an advantage compared to the trolleybuses. Bus transport is therefore the most important one of city public transport regarding the number of lines and the number of passengers transported. In the year 2007 there were operating 48 lines, but their number gradually decreased to 45 in 2012. Introducing 64 CNG buses the proportion of performance of diesel buses decreases from 61,63 % in 2007 to 43,24% in 2011. Overall performance of buses transport is about 61%.

Table 1 - Basic characteristics of public transport service in Košice (2000-2012)

Trams	2000	2002	2004	2006	2008	2010	2012
Number of lines	15	15	15	15	15	15	15
Length of public transport lines (km)	172.50	172.50	172.50	172.50	177.00	177.00	178.10
Transport speed in km/h	16.00	16.95	17.56	18.23	17.08	14.64	14.37
Traffic Operations – vehicle kilometres (in thousands)	4 371	4 188	4 188	4 060	4 010	3 832	3 821
The number of transported passengers (in thousands)	33 386	28 141	26 076	28 729	27 854	25 378	24 541
Place kilometres (in thousands)	526 435	501 413	493 526	484 575	484 247	473498	475 864
Passenger kilometres (in thousands)	112 679	101 727	90 003	93 394	86 242	79 814	79 821
Trolleybuses	**2000**	**2002**	**2004**	**2006**	**2008**	**2010**	**2012**
Number of lines	3	4	4	3	3	3	3
Length of public transport lines (km)	29.40	29.40	29.80	24.00	25.10	25.10	25.30
Transport speed in km/h	13.83	14.62	15.10	16.07	16.22	14.83	14.83

Traffic Operations – vehicle kilometres (in thousands)	1 031	999	978	916	936	1 213	1 246
The number of transported passengers (in thousands)	6 731	5 969	5 983	6 379	6 301	7 682	7 515
Place kilometres (in thousands)	116 310	113 590	111 473	107 676	109 189	142 911	146 011
Passenger kilometres (in thousands)	22 718	21 578	20 319	20 896	19 569	24 158	24 550
Buses	**2000**	**2002**	**2004**	**2006**	**2008**	**2010**	**2012**
Length of public transport lines (km)	44	47	45	51	45	46	45
Transport speed in km/h	649.00	757.70	722.00	809.80	743.20	739.70	701.40
Traffic Operations – vehicle kilometres (in thousands)	19.13	20.38	21.04	21.16	20.40	18.67	17.53
The number of transported passengers (in thousands)	9877	10 797	10 245	10 291	10 306	10 245	10 051
Place kilometres (in thousands)	52 855	51 166	4 9248	58 040	56 032	53 957	49 976
Passenger kilometres (in thousands)	935 157	1 013 358	968 959	979 089	975 355	975 355	971 819
Length of public transport lines (km)	178 386	184 957	165000	189 431	173 743	169 927	162 767

Source: Annual reports of DPMK

Chart 1 - Evolution of the number of passengers transported by buses (in thousands)

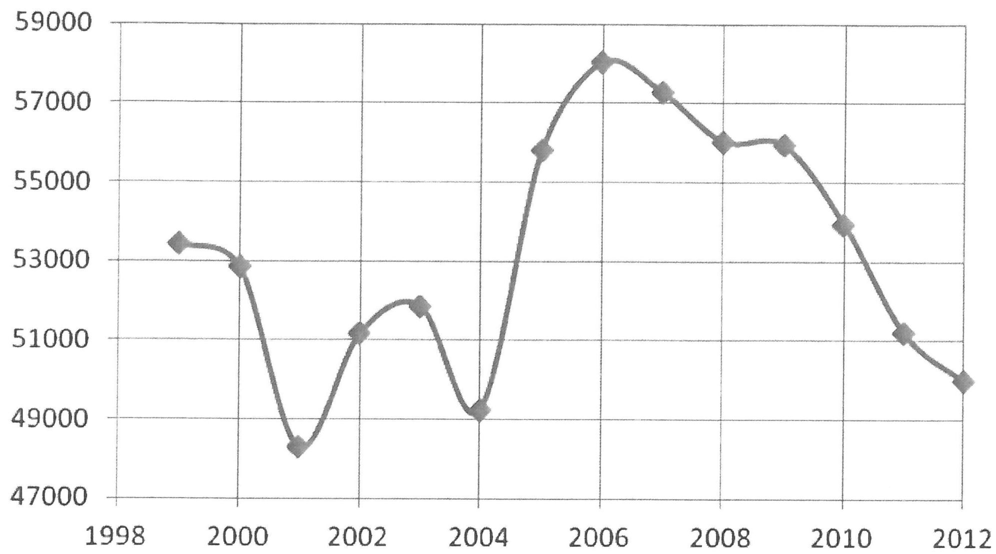


Chart 2 - Evolution of the number of passengers transported by trolleybuses (in thousands)

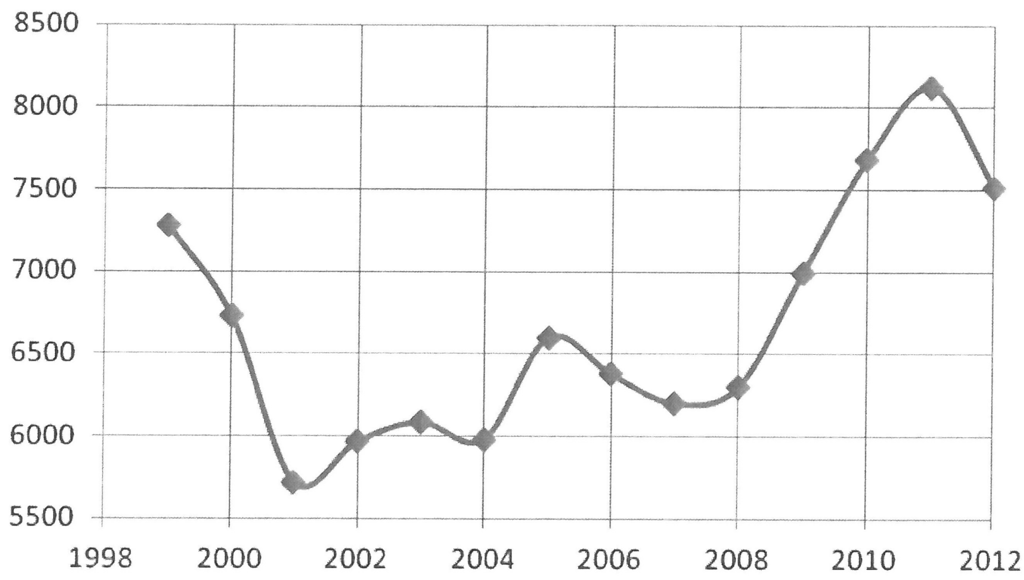


Chart 3 - Evolution of the number of passengers transported by trams (in thousands)

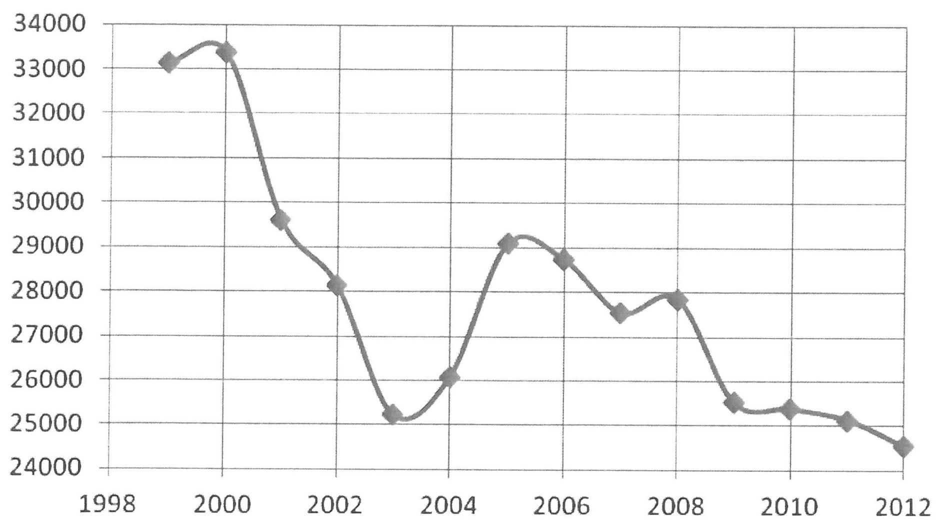
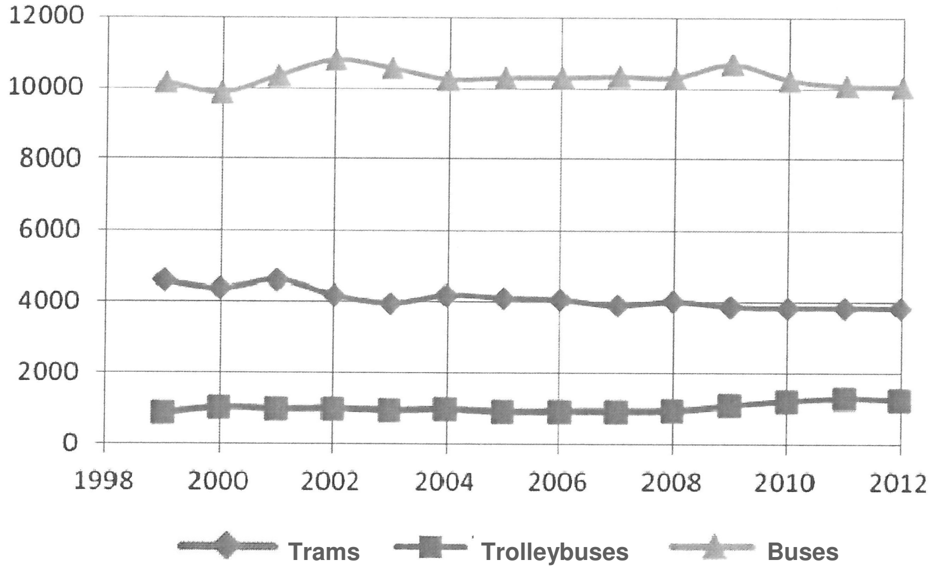
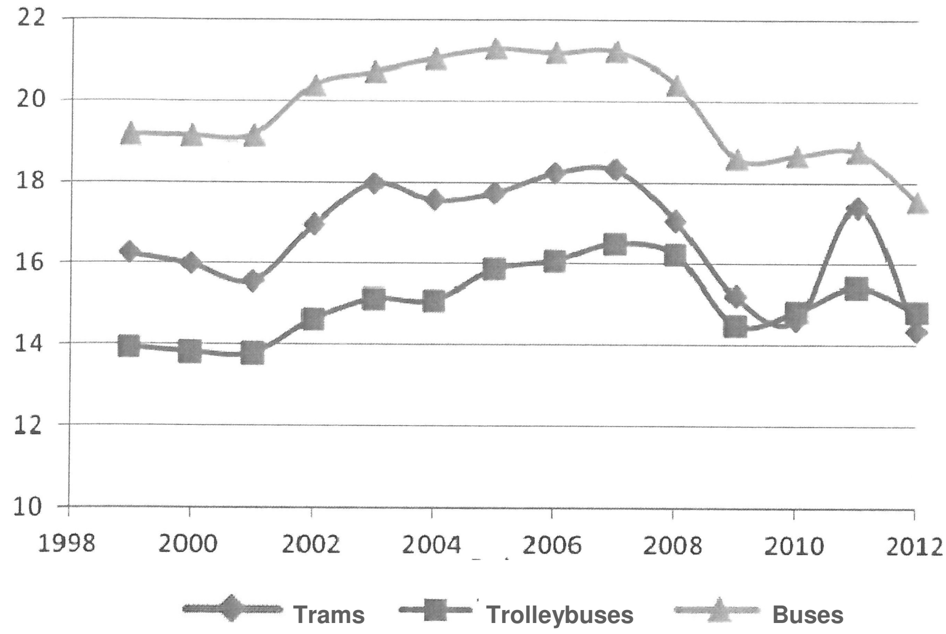


Chart 4 - Evolution of passengers transported in relation to vehicle-kilometres divided by tractions



For the past 14 years is evident decrease in numbers of passengers transported. This fact most significantly can be observed on the graphics related to the trams, where the number of passengers transported decreased by approximately 8 587 000 of persons during mentioned period (26 % decrease since 1998). Slight decrease was recorded in buses and trolleybuses where, despite the decline of total performance, the number of passengers increased comparing to the year 2000. Overall DPMK suffered in all regular services decrease of 10 940 000 passengers compared to the year 2000, which represents 11,80 % decrease for 12 years observed. At same time the traffic performance of all three tractions decreased from 15 279 to 15 118 vehicle kilometres, what represents „only“ 1 % decrease.

Chart 5 – Evolution of transportation speed by tractions (km/h)



All other relevant parameters (vehicle-kilometres, place-kilometres, passenger-kilometres) of the company are decreasing since the year 2000 (see more charts in the annexes) except for trolleybuses and fail to stop the decline. The transportation speed is continuously decreasing for all the tractions from 2007 and in 2012 the tram traction becomes even be the slowest one.

Economic indicators of the company are becoming significantly worse, reducing the number of passengers and raising the costs, covering the losses by increasing subsidies. This model is not sustainable. Revenues from transport activities reached the amount of 12,2 million. EUR in 2012, which is the same level as in 2000, when revenues reached the level of 12,1 million. EUR. Number of passengers transported by public transport (not counting passengers transported by irregular transport - touring) was 82032 000 in 2012, what is decrease of nearly 11 million. of persons transported compared to the year 2000 (92 972 000 persons transported). If we include also non-regular transport (touring) decrease of passengers is even more visible: 13,2 million passengers.

In addition to the loss of the passengers we can observe significant increase of operational costs, which is mainly caused by the inability to restructure the company (despite job cuts) and fleet renewal. Just obsolete infrastructure and vehicles are causing enormous costs of maintenance and repairs while reducing the quality of services provided. The total cost for the last 12 years has risen by almost 50 % and only with growing subsidies the company is able to hold operate public transport in the city of Košice.

Table 2 - Basic economic characteristics of public transport in Košice

Year	2000	2002	2004	2006	2008	2010	2012
Total number of employees	1 406	1 418	1 299	1 169	1 122	1 128	1 057
Revenues from performances and goods in EUR	12 563 301	14 102 503	13 035 252	12 572 496	14 720 374	13 329 490	12 731 384
Revenues from transport activity in EUR	12 125 871	13 707 429	12 255 095	11 671 944	13 687 612	12 620 114	12 184 469
Operational subsidy in EUR	6 843 059	7 886 211	8 962 026	13 160 094	13 942 442	16 212 140	16 700 000
Investment subsidy from the city of Košice and the state budget	5 028 580	6 140 875	5 973 644	1 251 278	111 000	0	0
Total costs in EUR	22 311 359	26 687 280	29 352 387	31 678 948	35 219 246	33 827 750	33 149 354
Vehicle-km (in thousands)	16 241	16 991	16 329	15 982	16 033	16 072	15 635
Passengers transported (in thousands) (including touring transport)	100 084	92 564	88 612	99 354	96 816	91 981	86 843
Revenues / 1 vehicle-km in EUR	0,75	0,81	0,75	0,73	0,85	0,79	0,78
Costs / 1 vehicle-km	1,37	1,57	1,80	1,98	2,20	2,10	2,12
Costs / 1 EUR of revenues	1,84	1,95	2,40	2,71	2,57	2,68	2,72

Source: Annual reports DPMK

Chart 6 – Evolution of revenues, subsidies and costs in EUR

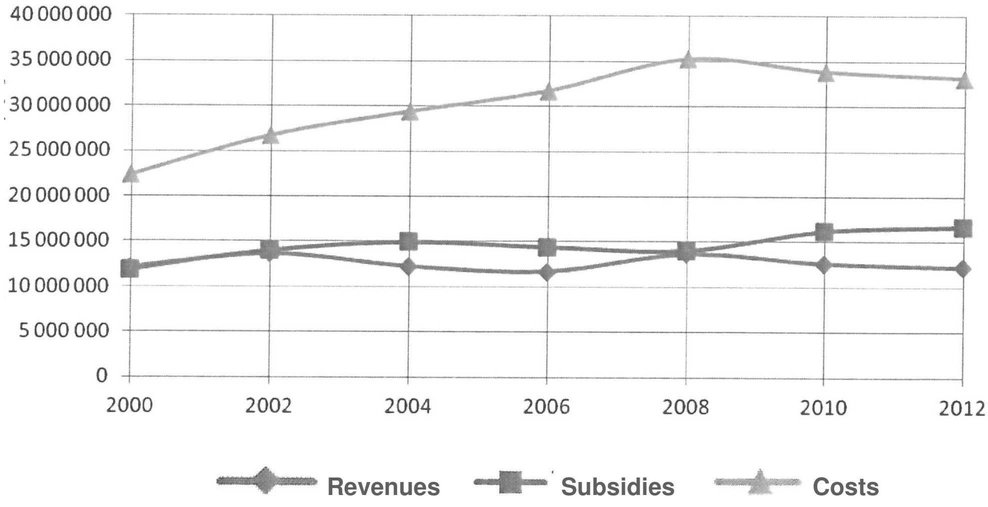


Chart 7 - Evolution of the number of passengers compared to the vehicle-km travelled

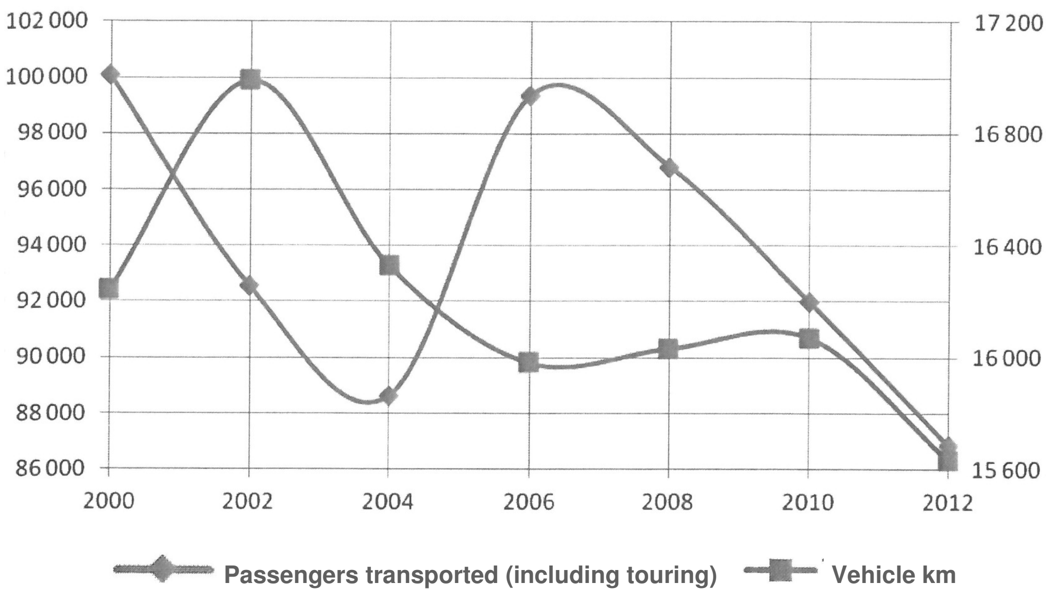
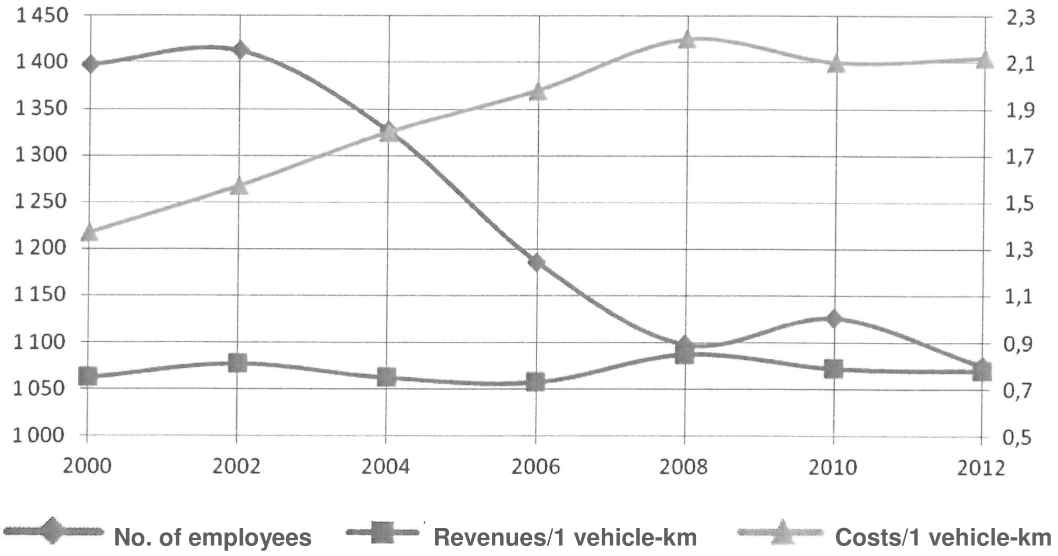


Chart 7 shows low flexibility of DPMK in response to the behaviour of the traveling public. Although in 2005 and 2006 the company was able to manage the restore of confidence and the number of passengers transported significantly increased, transport capacity was not increase and since 2007 there is a significant drop in the number of passengers, which so far failed to stop. In 2011 proved DPMK partially respond to changing situation and offer slightly corrected transport capacity.

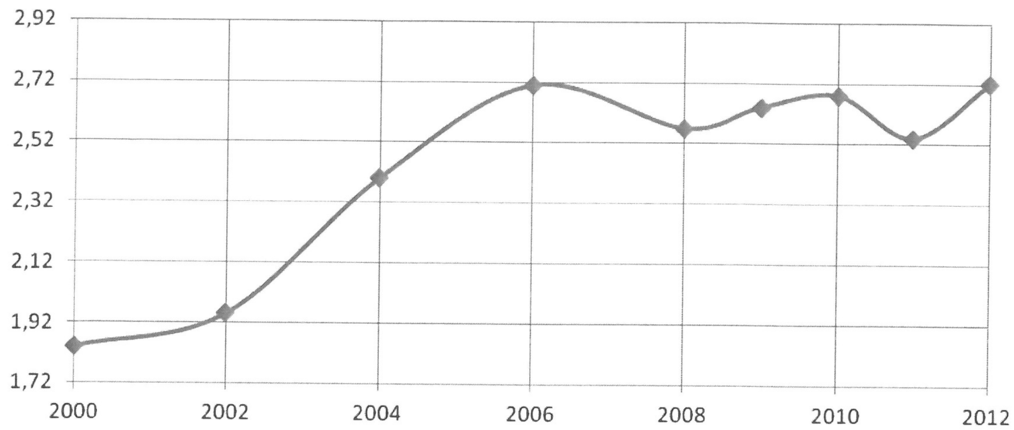
From Chart 8 it is evident that despite the attempt to partial restructuring of the company, mainly by reducing the number of employees, the costs of vehicle kilometre keep growing, even though it managed a dramatic increase in the last 4 years to slow down. The problem is clear inability to maintain the number of passengers, resp. increase their number and increase in costs of maintenance and repairs.

Chart 8 - Evolution of the number of employees, revenues and costs per 1 vehicle-km



Comparison of evolution of costs (presented at Chart 9) per 1 EUR of revenues clearly demonstrates current unprofitability of public transport operation in the city of Košice, where the cost is approaching 3 EUR per 1 EUR of revenues.

Chart 9 – Evolution of costs per 1 EURO of revenues from transport activities



2. 3 Fleet

2.3.1 Rail fleet

Trams

For date 31.12.2012 DPMK has available 117 trams (10 of them not ready for use) - 67 pieces T3 (average age 26,67 years), l piece T3 MOD (28,95 years), 29 units T6A5 (20, 27 years), 11 pieces KT8D5 (22,99 years), 8 pieces KT8D5.RN2 (22,55 years), l peace Vario LF-01 (28,89 years). The last mentioned piece was from the date of its purchase in 1992 KT8D5 subject of an extensive vehicles recovery for the last 21 years. Trams run on 15 routes, of which 8 are urban and 7 non-urban (lines to U.S. Steel company). In 2012 they represented about 30% of transport performance. Annual traffic is long-term stable despite a decline of the number of passengers transported and represents about 3 821 000 vehicle-kilometres. State of the fleet, however, is outdated, uncomfortable for passengers and operationally very costly.

Currently DPMK owns 98 ultra short trams 15 meters long and 19 pieces of short tram that are 30 meters long. These are the types T3, 6A5, KT8D5 and their modifications.

T3 model from CKD Tatra was first produced in 1960 and to actual date it were sold more than 14,000 units in 48 countries around the world. This is a world record, and so far it has failed to overcome any other manufacturer of trams. Tram T3 is made of all-steel welded construction with rounded shapes, large windows and three folding doors. In interior there are fiberglass seats mostly red coloured in the 1 +1 configuration. The tram is powered by a voltage traction with 600 V and a maximum current consumption of up to 500 Amperes. Drive procures four electric motors TE 022 with a total engine power of 160 kW, which are serially ordered in two bogies of two engines. Trams are fitted with manual Prague couplers, allowing connections to a maximum of three sets of trams, which are bonded auxiliary cables along which signals are guided to control the rear of the first electric cars. However, these cables cannot transfer traction voltage, so all the vehicles must have to be connected to all the pantographs.

T6A5 trams nicknamed for its boxy design "iron" were produced by Czechoslovakian company Tatra CKD between 1991 and 1998. 296 of tram vehicles are used only five cities in the Czech Republic and Slovakia. T6A5 tram coach body is mounted on two bogies and four axles, each of them is connected to a traction motor. Vehicle body is made of all-steel welded construction, it has three large windows and folding doors. At each door there is a open button on the outside and the inside part. Interior is lined with Formica, vicinity windows are metal, floor tram in the rubber and seats are leatherette, for newer vehicles with plastic textile cover. Inside of each vehicle are mounted markers for handle ticketing and information panel. Driving cab is separated from the passengers. Tram is controlled by electrical equipment TV3 thyristor. It has four synchronous traction motors TE 023 with a total output of 180

KW series included, which are connected to the chopper. T6A5 trams have pantographs for taking power from the catenary.

Tatra KT8D5 is bidirectional three section tram manufactured by CKD Tatra. The tram consists of three vehicles A, B, C, eight axles and four bogies each of which has two serial stored electric type TE 023 with a total output 360 kW and self braking mechanisms. It has 10 doors - 5 of them on each side. A and B are the end vehicles, C is the middle vehicle. On A and B vehicles are the control cabins, pantographs and roof fans. Vehicles are similar to T6A5 trams. KT8D5 is possible to combine with a tram KT8D5 with automatic couplers type ESW, but were in all the cities of trams KT8D5 dismantled considering its difficult operation and replaced in sets of a manual couplers type Prague. KT8D5 is equipped with a thyristor type TV3, which compared to the controlling resistive electric is a much more favourable due to lower operating costs. KT8D5 is equipped by two pantographs, rail braking mechanisms, electro-dynamic braking mechanisms and disc brakes. The interior is identical to the T6A5 trams.

Table 3 - Overview of the trams age – after extensive renovation, status on the date 31.12.2012

Recalculated vehicle age / Tram type	Total (pc)	Vehicles up to 15 years (pc)	Vehicles over 15 years (pc)	Vehicles up to 15 years (%)	Vehicles over 15 years (%)	Recalculated averaged vehicle age (years)
T3	67	3	64	4,48	95,52	25,74
T6A5	29	0	29	0,00	100,00	20,27
T3MOD	1	1	0	100,00	0,00	10,19
Vario LF-01	1	1	0	100,00	0,00	1,01
KT8D5	11	0	11	0,00	100,00	22,99
KT8D5.RN2	8	8	0	100,00	0,00	6,39
TOTAL	117	13	104	11,11	88,89	22,46

Source: DPMK, Statistics of Division for equipment maintenance, 2012

Table 4 - Overview of trams age – after introduction to service, status on the date 31.12.2012

Vehicle age / Tram type	Total (pc)	Vehicles up to 15 years (pc)	Vehicles over 15 years (pc)	Vehicles up to 15 years (%)	Vehicles over 15 years (%)	Real average age (years)
T3	67	0	67	0,00	100,00	26,67
T6A5	29	0	29	0,00	100,00	20,27
T3MOD	1	0	1	0,00	100,00	28,95
Vario LF-01	1	0	1	0,00	100,00	28,90
KT8D5	11	0	11	0,00	100,00	22,99
KT8D5.RN2	8	0	8	0,00	100,00	22,55
TOTAL	117	0	117	0,00	100,00	24,50

Source: DPMK, Statistics of Division for equipment maintenance, 2012

The maximum designed value of the load of l axle on the rolling stock is currently from 6.8 to 8.2 tonnes per axle. Maximum designed construction load of the lines for l axle is rated to 11 tons. Total capacity calculation is based on outdated standards - 8 passengers per m2.

Table 5 - Basic typological characteristics of operating trams

Tram type	Length of the body (in mm)	Number of seats	Total capacity	Number of doors	Number of traction motors	Quantity of pieces	Weight of non-occupied vehicle (in kg)	Weight of vehicle occupied on maximum (in kg)	Number of axles	Max load on 1 axle (in kg)
Vario LF	15 100	22	193	3	4	1	21 200	33 170	4	8 293
T3	14 000	34	118	3	4	67	16 000	27 400	4	6 850
T3MOD	14 000	21	111	3	4	1	17 500	31 500	4	7 875
T6A5	14 700	30	165	3	4	29	38 000	61 550	8	7 694
KT8D5	30 300	54	337	10	8	11	18 700	30 300	4	7 575
KT8D5.RN2	30 300	58	332	10	8	8	38 000	60 620	8	7 578

Source: DPMK, Statistics of Division for equipment maintenance, 2012

2.3.2. Road fleet

Buses

Bus transport forms the most important part of the fleet of DPMK and is operating since 1961. DPMK operates 196 buses in total, of which 64 pieces are using fuel CNG. Buses runs on 45 routes, of which 32 are urban lines and 10 lines goes to U.S. Steel company. During the night the transport service is provided by 3 bus lines. In addition, DPMK provides internal company transport in U.S. Steel company. DMPK also owns 5 buses which do not used for public transport (2 for touring transportation, l historic bus, 1 bus for driving school and l bus with beds). The firs most used are buses with length from 11 to 12 meters and capacity to 102 persons. The second most used category are articulated buses with length up to 18 meters and capacity up to 204 persons. Bus traction operated about 61 % of transport performance in 2012. It also provided the main transport services for densely populated neighbourhoods Ťahanovce and KVP, where are other tractions absenting.

Bus transportation has been sublimated to the most significant modernization of all the traction, with gasification about 64 buses. Despite stronger modernization of the buses a significant part of the fleet in poor condition actually. The vehicles are mechanically and technically worn-outed and also morally outdated. A major disadvantage of the buses is their technical and type diversity (18 types), resulting in high maintenance costs. There is because obsolete support infrastructure and appropriate parking capacity absenting.

Table 6 - Overview of length categories of buses

Length of vehicles	Number of pieces
8-10 m (midibuses)	1
11-12 m	110
14-15 m	35
17 -18 m	54

Source: DPMK, Statistics of Division for equipment maintenance, 2012

Table 7 - Basic typological characteristics of buses operated by DPMK, status on the date 31.12.2012

Bus type	Length of vehicle (in mm)	Number of seats	Number of places for standing	Total capacity	Operational weight (in kg)	Total weight (in kg)	Number of pieces	Kind of fuel
Solaris Urbino12	12 000	30	70	100	10 300	18 000	3	diesel
Urbi no SOLARIS 15	14 590	40	104	144	13 300	25 000	34	diesel
Solaris Urbino15 CNG	14 590	41	104	145	12 900	24 000	1	CNG
TEDOM C12 G	12 030	33	54	87	12 100	18 000	19	CNG
KAROSAB952.1714	11 320	32	68	100	10 200	17 800	11	diesel
KAROSA B 932. 1690, 1678	11 345	32	63	95	10 200	17 800	33	diesel
KAROSAB941.1962	17 615	43	118	161	14 400	26 000	11	diesel
KAROSAB741.1908	17 355	42	108	150	13 700	25 600	4	diesel
KAROSA C 744.24	17 355	60	70	130	13 800	24 000	2	diesel

KAROSA B 732.20, 732.40, 732.1652, 732.1654	11 055	31	63	94	9 500	16 000	22	diesel
KAROSA 732 B NGS	11 055	31	55	86	10 050	16 000	15	CNG
IKARUS 435.18E	17 850	40	164	204	15 100	26 300	6	diesel
IKARUS 415.30	11 440	26	76	102	10 600	17 600	5	diesel
IKARUS 208.87 and 08	16 500	33	112	145	13 500	22 500	2	diesel
MAN RHC 464 LIONS	13 800	57	0	57	16 200	24 900	1	diesel
Q ISUZU - BUS 31 TURQUOISE	7 670	28	0	28	6 430	9 317	1	diesel
NOVOPLANC-12	11 585	31	66	97	10 090	17 800	3	diesel
IRIBUS CITEL1S	17 800	39	116	155	17 780	28 000	29	CNG

Source: DPMK, Statistics of Division for equipment maintenance for 2012

Table 8 - Age of the buses in regular public transport, status on the date 31.12.2012

Type	Number of pieces	Real average age	Recalculated average age after renovation
Ikarus435.18	6	15,65	15,65
Karosa B 74 1.1 908	4	20,94	9,22
Karosa C 744.20	2	22,73	9,96
Karosa B 941. 1962	11	11,89	11,89
IRISBUSCITELIS18m CNG	29	2,84	2,84
Solaris Urbino 15	34	10,15	10,15
Solaris Urbino CNG	1	7,87	7,87
Solaris Urbino 18	3	6,93	6,93
Ikarus 415.30	6	15,52	15,52
Karosa B732	16	23,82	23,82
Karosa B 932	32	13,64	13,64
Karosa B 952 171 4	10	9,80	9,80
Novoplan C 12	3	13,01	13,01
Karosa B732.CNG	14	22,48	9,12
Karosa B 952 171 8	1	8,08	8,08
Solaris Urbino 12	3	8,67	8,67
TEDOMC12G	19	5,01	5,01
IVECO - FIRST	2	2,00	2,00
TOTAL	196	11,76	10,44

Source: DPMK, Statistics of Division for equipment maintenance, 2012

Trolleybuses

Trolleybuses were introduced in the public transport system of the city of Košice relatively recently (since 1993) and during the period that was positive for the development of this mode of transport was not fully develop. Currently trolleybuses operate about 9% of the total traffic of city public transport. The main weaknesses of the trolleybus transport is insufficient trolley network, obsolete fleet, high energy consumption and dependence on traction lines. All trolleybuses are on the border of life, their average age was 16,74 years at the end of 2012. Their average transportation speed was 14,83 km/h in 2012, so they were slightly faster than trams.

Table 9 - Basic typological characteristics of operating trolleybuses

Trolleybus type	Length of vehicle (in mm)	Number of seats	Standing passengers capacity	Total capacity	Curb weight (in kg)	Total weight (in kg)	Number of traction engine	Number of pieces
15 TR 10/7	17 360	44	106	150	16 400	26 600	2	15
15 TR 10/7 M	17 360	44	106	150	16 400	26 600	2	5
14 TR 14/7	11 300	29	53	82	10 350	16 000	1	7

Source: DPMK, Statistics of Division for equipment maintenance, 2012

Table 10 - Age of trolleybuses, status on the date 31.12.2012

Trolleybus type	Number of pieces	Real average age
15 TR 10/7	15	19.31
15TR10/7M	5	13.77
14 TR 14/7	7	13.35
TOTAL	27	16.74

Source: DPMK, Statistics of Division for equipment maintenance, 2012

2.3.3. Reliability versus failure of vehicle fleet

Failure frequency of the tractions was stabilized due to the fixed fleet in recent years. More significant variations are recorded in connection with the weather. Increased failure trams lives in days with snow (clogging electrical parts) and buses in early summer days with high temperatures (engine overheating). Centralized access to substitution of failures (operator dispatching department) is not replaced by time minimal downtime.

Table 11 - Vehicle-kilometres travelled per 1 failure in 2012

Tram type	Vehicle-kilometres travelled per 1 failure
T3	1 250
T6A5	1 427
KT8D5	1 680
Vario LF 01	2 169

Source: DPMK, Statistics of Division for equipment maintenance, 2012

In 2012 DPMK recorded in the maintenance system 2 399 failures. 976 failures occurred directly during the service (on concrete lines) and the rest was reported by drivers after termination of the service respectively or found by maintenance workers during the daily control.

From the total overview is obvious that most failures had a T3 oldest trams and the lowest number of failures had trams Vario LF 01 with electrical equipment using IGBTs.

The most frequent causes of faults in rail transport are failures in the interior (electrical faults - talkie, cab driver, fuses, other electrical disturbances, mechanical failures - cab, driver/passenger seat, other mechanical failures), door failures (electrical failure - door motor, settings, relays, other electrical faults, mechanical faults - wing doors, setting, other electrical failures), fault body (electrical fault - lights, battery, other electrical disturbances, mechanical failures - sander, mirror, other mechanical failure), an electrical fault contactor frames (skipping, other electrical disturbances), an electrical fault accelerator (15a, other electrical failures), failures of brake unit (electrical failure - coil, control valve, mechanical failures) and electric traction motor failures (skipping , carbons, other electrical failures).

The most frequent types of failures in trams T3 are a perturbation function of the accelerator, perturbation function of the contactors, run-contradictions engines - generator and control relay (electrical failures). On average, due to electrical failures are repaired about 2-3 trams per week. Length of repair depends on the extent of the damage. In T6A5 trams defect is the most common disorder regulator, inverter, static converters and chopper fan.

The most frequent types of failures in buses includes electric failures, failures in cooling/heating, failures in pressure installation, failures in communication system, blends leaks (fuel, oil, coolant), followed by failure of lubrication, maintenance, faults in documents, door failures, failures in recharging and air systems. From the most serious failures there are failures in transmissions, steering axles and brakes.

The most frequent types of failures in trolleybuses are faults identified as other electrical failure, other mechanical failures, failures of winch, air system, suspension and automatic driving.

Table 12 - Vehicle-kilometres travelled per 1 failure and number of failures in the bus, trolleybus and tram traction

Year / traction	Buses		Trolleybuses		Trams	
	Number of failures	Vehicle-km per 1 failure	Number of failures	Vehicle-km per 1 failure	Number of failures	Vehicle-km per1 failure
2010	24 723	447,09	2 238	541,9	3 797	1 010,2
2011	24 051	439,02	2 408	538,3	3 281	1 170,7

Source: DPMK, Statistics of Division for equipment maintenance, 2012

For the past 14 years we can observe significant decline in number of passengers transported. Most evident is this trend in trams, where the number of passengers decreased for about 8 587 000 passengers over the period (decrease of 26 % since 1998). Slighter decrease was recorded in number of passengers transported by buses and trolleybuses, where despite decrease the actual number of passengers transported is bigger than in 2000. Overall DPMK lost in all traction regular service from 2000 to actuality 10 940 000 passengers, which is 11,80 % decrease observed for 12 years. At same time traffic performance of all three tractions decreased from 15,279 to 15,118 vehicle-kilometres (l % decrease). The previous years were almost identical - using same number of vehicle-kilometres DPMK is transporting significantly less passengers.

Table 13 - Vehicle-kilometres travelled by tractions in the years 2011 and 2012

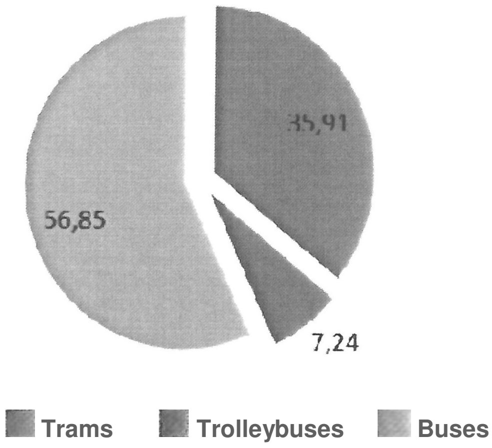
Item (pointer)	2011			2012		
	Trams	Buses	Trolleybuses	Trams	Buses	Trolleybuses
Vehicle kilometres (thousands)	3 841	10 590	1 296	3 821	10 051	1 246
Place kilometres (thousands)	471 415	962 430	151 887	475 864	971 819	146 011
Passengers transported (thousands)	25 131	51 201	8 121	24 541	49 976	7 515

Source: Annual reports of DPMK for the years 2011 and 2012

Resulting transport performances show that despite the stabilized transport supply the number of passengers is decreasing. Loss of passengers during the last three years can be attributed to poor transport conditions and quality of transport, inadequate time to harmonize the various types of public transport, low mobility of citizens for work, the impact of high unemployment (social situation), regional development disparities, etc. These and other reasons caused the outflow of passengers to individual passenger transport and public bus transport.

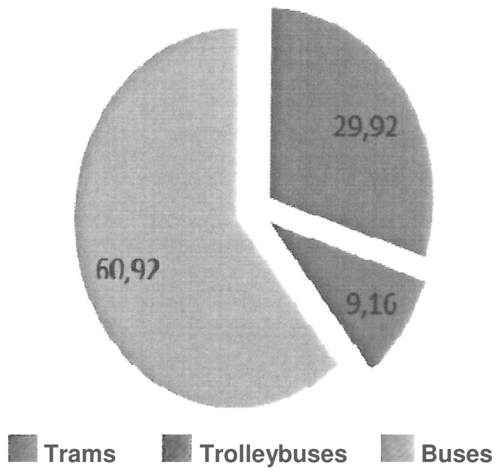
Decisive share of the number of passenger transported has the bus traction, which in the total transport volume in 2011 represented about 63 %, tram traction with 28 % and trolleybus traction with 9 %. This corresponds to a share of the place-kilometres driven. These proportions did not significantly change in 2012, although the proportion of bus services decreased to 61 %, in tram services increased to 30% and in trolleybus service remained at 9 %.

Chart 11 – Share of transport volume by tractions



Source: Annual reports of DPMK for the years 2000 and 2012

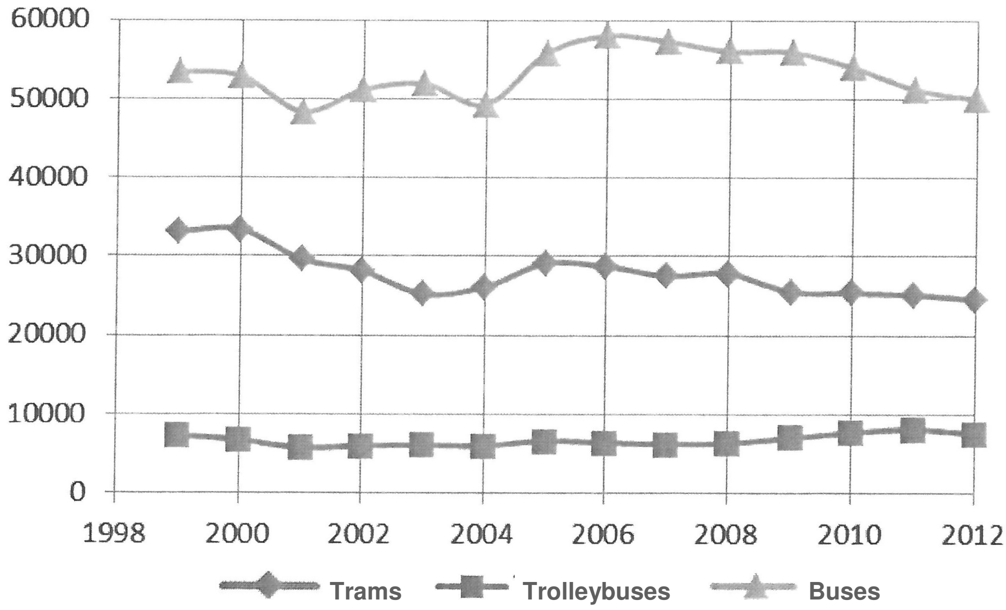
Chart 12 - The numbers of passengers transported by each traction



Source: Annual reports of DPMK for the years 2000 and 2012

Traffic and transportation performances of DPMK for the years 2011 and 2012 are shown in table 14.

Table 14 - Traffic and transportation performances for 2011 and 2012



2.4 Transportation volume

Public transport in the town of Košice is operated by subsystems of trams, trolley buses and city buses. In addition to these services passenger transport is operated also by rail system, system of suburban transport and long distance bus services. But the use of rail or suburban bus services for travels within the city is still minimal.

2.5 Lines operation - scheduling (concept, frequency, delay)

Service schedules are designed by the Department of Transport and Communications Technology of DPMK. The basic mode of transport is divided into three types, depending on the relevant day:

- day of school classes ,
- working day without school classes,
- free day.

This mode of transport is valid for the whole year, that means mode working day without school classes is valid during summer holidays and other school holidays. Free days are the weekends and public holidays.

There are four basic transportation service intervals:

IA - morning peak (6 a . m . - 8 a . m .)

IB - afternoon peak (1 p.m. - 5 p.m.)

II. - basic mode (5 a.m. – 11 p.m., except IA, IB and III)

III. - edge mode (8 p.m. – 11 p.m. and during free days also 5 a.m. - 8 a.m.)

Main characteristics of selected lines

Length of bus lines:

The longest lines: (No. 20 – 22,7 km) Košická Nová Ves - Šaca hospital; (No. 54 – 24,9 km) Madridská - Kláštor; (No. 56 – 21,2 km) Madridská - Šaca hospital; (No. RA 5 – 23,4 km) Ťahanovce - entrance area of U.S. Steel company.

Shortest lines: (No. 11 – 4,6 km) Luník IX - NO; (No. 3 – 2,9 km) Nad Jazerom - Krásna; (No. 14 – 5,0 km) Horný Bankov - Havlíčckova; (No. 23 – 3,4 km) Pri Hati - Railway Station; (No. 26 – 3,7 km) Šaca Hospital - entrance area of U.S. Steel company.

Lengths of tram lines:

The longest lines: (No. R2 – 17,6 km) Nad Jazerom - entrance area of U.S. Steel company; (No. R3 – 16,9 km) Havlíčkova - entrance area of U.S. Steel company; (No. 9 – 12,1 km) Nad Jazerom - Havlíčkova; (No. 7 – 9,9 km) Nad Jazerom - Botanical Garden.

Lengths of trolley lines:

The longest line: (No. 71 to 12.8 km) Lingov - Monastery;

Average length of lines:

Bus Lines: 13,15 km Tram lines: 7,83 km Trolleybus lines: 10,62 km

Total length of lines operated in 2012:

Bus Lines: 701,40 km Tram lines: 178,10 km Trolleybus lines: 25,30 km

Performances are within 24 hours distributed unequally at morning, saddle, afternoon, evening and night and are adapted to passenger demand for transport while maintaining basic service operability of the city area.

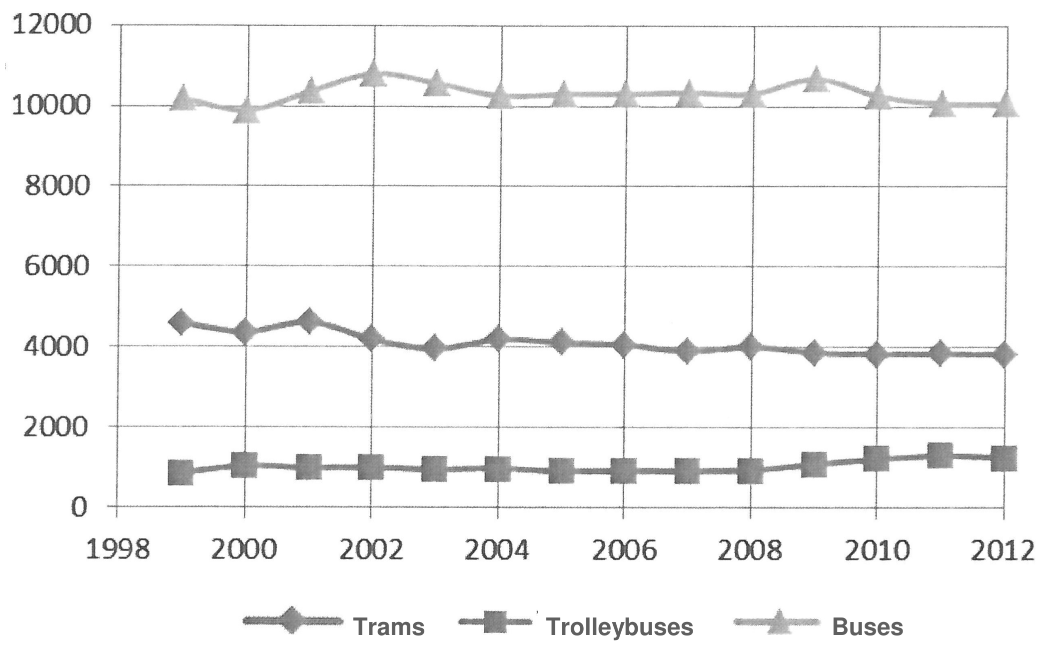
Traffic performance on free days

During the free days all trams operates at routes in a single interval of 20 min. from 5a.m. to 8 p.m., and 30 min. interval from 8 p.m. to 11 p.m., except electric R tram to U.S. Steel company, which is operating in 60 min. interval.

Traffic performance on weekdays and during school days

Day service interval during the morning rush hours from 6 a.m. to 8 a.m. and during the afternoon peak from 1 p.m. to 5 p.m. is from 10 to 12 minutes on the main lines. 15 minute interval on the main lines is at time from 5 a.m. to 6 a.m. and from 5 p.m. to 6 p.m. During the rest of schedule the interval ranges from 20 to 30 minutes. Within these intervals the most used are bus lines 10, 15, 16, 18, 19, 27, 34 (10 minutes), tram lines 6 and 9 (10 min) and trolleybus lines 71 and 72 (12 minutes). Interval of the night bus is 60 minutes and is provided by service of three bus lines Nl, N2, N3 and one trolleybus line N71, which route is identical to the daily line 71.

Chart 13 – Intervals overview during work days



2. 6 Routes and circulation

Historical development of building tram rail caused that the rail infrastructure is adapted for one-way traffic and the introduction of two-way traffic would cause further additional investment costs, which currently DPMK does not have at its disposal.

Actually the tram service is provided by one-way traffic tram T3 and T6 and bidirectional trams KT8D5. In the case of need unidirectional trams are assembled into kits. Weekend operation is ensured with the exception of line 9 only by rolling sets.

Ride facilities for cars and bikes

In the city of Košice currently significantly absent ride facilities P+R, K+R and B+R. DPMK or city currently do not own this kind of infrastructure. The city is currently trying to address this problem finding suitable investors. The municipality has a big problem with the increase of individual automobile transport so the building this type of infrastructure has become a top priority. The feasibility study of an integrated system of passenger rail transport in the region of Košice counts with introduction of the P+R including tents for bicycles and specifically on those works:

IKD Kosice, North Terminal - us. Peace Marathon - building no.2

- IKD Ko namely, us. Peace Marathon - the station square connected to the ZSR - building No.3
- IKD Ko namely North Terminal - Ťahanovce housing estate - construction No.4

IKD Kosice, Sturova / Kuzmányho - PP Peres - Airport Kosice - building No.6

Under the first phase of ITS (building No. 3) is proposed total of 30 new jobs, including 17 vertical standing at the bus station forecourt in 13 states for TAXI and K + R.

No strategic, conceptual development document or county level, city or DPMK not currently exist. Building routes going ad-hoc system and the system is not developed. Most tramway in terms of routes, more than 90% of the network, resulting in the middle of the road, which has a positive impact on traffic safety, does not result in collisions with cyclists. Within the public transport takes place only at the individual cruising routes, which is solved passages (many but without traffic lights), on which the tram priority.

Likewise, while there are at present in the city park and ride, which building is planned. Individual car transport is therefore apart from the main square to fully access to the city centre.

2.7 Frequency

As well as the capacity offered intervals tramways are no major changes. Coordinating shortcoming is the absence of network-wide interval, which is given the current level of performance is not possible at present to change. The bus and trolleybus from changes in the suburban lines in 2008 distinguished lines supporting and complementary. Supporting have intervals at tram other purpose. Transportation routes to the steel plan are well targeted and based on the times of rotation of shifts in U.S. Steel Kosice.

2. 8 Delays

Failure frequency and associated delays in Traction was given the finality fleet settled. More significant variations are recorded in connection with the weather. Increased failure trams lives in days with snow (clogging electrical parts) and buses in the early summer days with high temperatures (overheating engine). Centralized access to substitution of failures (operator dispatching department) is not replaced by time minimal downtime.

The less numerous causes of delay include the congestion (congestion) - the bus and tram transport. Problem with tram is that it is not essential to the intersections of giving preference, so for example some of the electrical junctions give way to traffic, which can sometimes take up to 5-7 minutes. Other causes may include delays driver to work or sudden incapacity of the driver, it takes some time to provide it at him compensation.

The table presented below contains data related to the total time of delay for each traction in 2011 and 2012.

One of the key safety indicators of public transport is the accident rate, which is the main assessment factor for evaluation of the quality of service provided to the traveling public and the level of each operator of public transport.

Table 15 - Delays of the tractions

		Number of failures	Total time of failures	No. of replaced failures	Time of delay
Year 2011	Buses	5 843	6 613:19:00	5 961:00:00	65:19:00
	Trams	1 543	1 626:12:00	1 394:20:00	24:25:00
	Trolleybuses	891	1 250:20:00	1 083:55:00	17:52:00
Year 2012	Buses	6 792	6 958:38:00	6 091:22:00	68:01:00
	Trams	1 715	1 842:70:00	1 528:31:00	01:28:00
	Trolleybuses	1 147	1 499:07:00	1 244:21: 00	04:34:00

Source: DPMK, Division of traffic management

2. 9 Unpredictable incidents

One of the key safety indicators of public transport is the accident rate, which is the main assessment factor for evaluation of the quality of service provided to the traveling public and the level of each operator of public transport.

In trolleybus transport happened in total 32 traffic accident events in the year 2012, what represents decrease of five cases compared to 2011. Number of traffic accident events caused by drivers of DPMK decreased from 13 to 11 (decrease of 15 %). In bus transport happened in total 227 traffic accident events in the year 2012, a decrease on 117 cases compared to 2011. Number of traffic accident events caused by drivers of DPMK decreased by more than 20 %. In tram transport happened in total 124 traffic accident events in the year 2012, which is increase of 11 events compared to 2011. Overall, the year 2012 presented a significant reduction in incidents from the past.

Table 16 - Incidents in the years from 2010 to 2012

Event /Year	2010				2011				2012			
Type of traction	Buses	Trams	Trolleybuses	In total	Buses	Trams	Trolleybuses	In total	Buses	Trams	Trolleybuses	In total
Unexpected incident - other	29	10	3	42	12	3	3	18	11	5	5	21
Traffic accident	24	12	0	36	21	17	5	43	7	6	2	15
Technical accident	1	14	3	18	2	12	2	16	4	13	2	19
Collision incident	365	83	25	473	309	81	27	417	205	100	23	328
Total	419	119	31	569	344	113	37	494	227	124	32	383
Number of injuries	24	11	2	37	22	8	4	34	15	5	5	25

Source: DPMK, Statistics of Division of traffic management for the years 2010-2012

Unexpected incident – other: is an event when there no police was called and it resolves conductor of the vehicle itself. This may be, for example nausea of some passenger and stop outside of predefined stops. The situation is considered as an incident because the vehicle is stationary.

2.10 Costs of providing transport

2.10.1 Total costs

In tram traction the largest share of the total cost represents item repairs and maintenance (21,64 % of the total costs). 20,15 % of the total costs represents the cost of operation and 18,17 % of traction energy. Cost of labour (direct salaries) represent 12,79 % of the total costs of tramway traction.

In bus traction the largest share of the total cost represent costs for fuel (24,08 % of the total costs). The second most important item in buses is the labour cost of with a proportion of 19,88 %. Operating mode contributes to the total cost with 16,95 %. For buses, taking into account certain renewal of the bus fleet in recent years, the cost of repairs and maintenance represents "only" 8,14 % of the total costs.

In trolleybus traction the largest share of the total cost represents the cost of operating (26,67 % of the total costs). Direct salaries represent 18,79 % of the total cost, repair and maintenance 17,40 % of the total costs and traction energy 15,91 % of the total costs.

Share of the costs within tractions has not changed significantly and has the same characteristics: with almost the same transport performance in terms of vehicle-kilometres all costs are increasing.

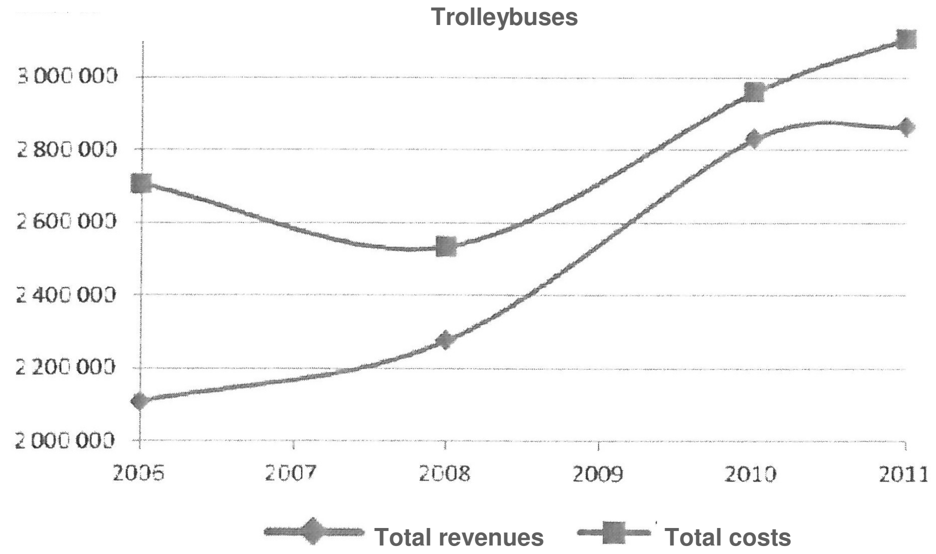
Table 17 – Costs per traction for the years 2011 and 2006 in EUR

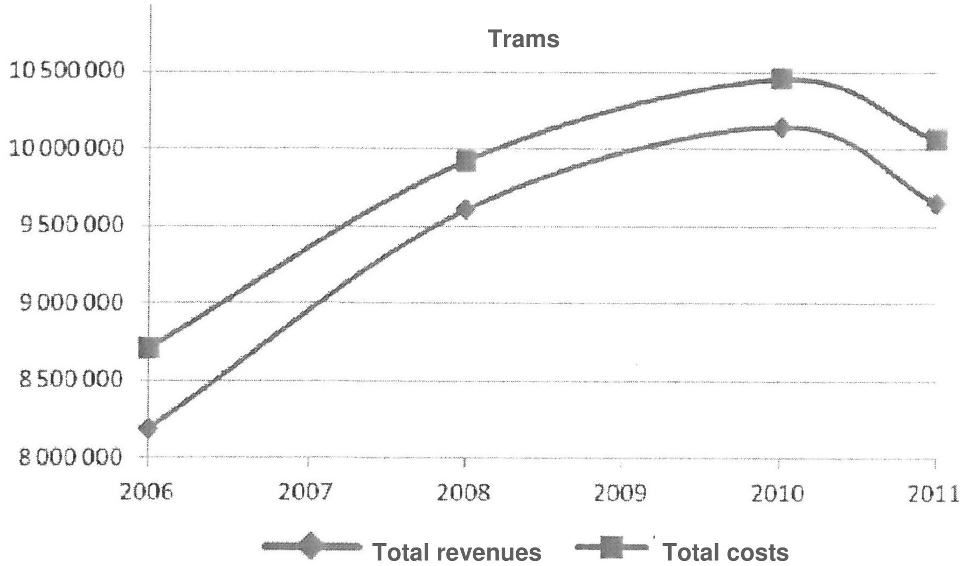
	2006				2011			
Item	Traction			Total per traction	Traction			Total per traction
indicator	Trams	Trolleybuses	Buses		Trams	Trolleybuses	Buses	
Vehicle-km (thousands)	4 060	916	11 006	15 982	3 841	1 296	10 590	15 727
Place-km (thousands)	484 575	107676	1 037515	1 629 766	471 415	151 887	1 006106	1 629 408
1. Fuel and traction energy	1 613 656	329 715	4 852 586	6 795 957	1 827 928	494 624	4 763 327	7 085 879
2. Direct material	480 117	127 863	1 186 882	1 794 862	589 606	132 314	1 425 762	2 147682
3. Direct salaries	955 753	307 907	3 043 749	4 307 409	1 286 918	584 053	3 934 777	5 805 748
4. Direct depreciation	687 877	518 754	3142 269	4 348 900	777 645	39 826	1 303 570	2 121 041
5. Renovation and maintenance	2 064 496	365 930	1 261 137	3 691 563	2 177 762	540 810	1 610 691	4 329 263
6. Other indirect costs	361 282	123 249	1 269 866	1 754 397	513 967	240 125	1 734 170	2 488 262
7. Direct costs in total	6 163 181	1 773 418	14 756 489	22 693 088	7 173 826	2 031 752	14 772 297	23 977 875
8. Operation	1 773 651	702715	2 980 681	5 457 047	2 026 925	829010	3 353 371	6 209 306
9. Performance costs	7 936 832	2 476 133	17 737 170	28 150 135	9 200 751	2 860 762	18 125 668	30 187 181
1 0. Management costs	774 680	231 030	1 755 062	2 760 772	860 354	247 296	1 662 237	2 769 887
TOTAL COSTS	8 711 512	27 071 63	19 492 232	30 910 907	10 061 105	3 108 058	19 787 905	32 957 068
Revenues from transportation	3 238 399	728 142	7 705 404	11 671 945	3 465 862	1 137 401	7 973 782	12 577 045
Subsidies	3 867 988	1 202 084	8 090 022	13 160 094	4 893 350	1 511 250	9 126 382	15 530 982
Other revenues	1 080163	179015	4 520 082	5 779 260	1 290 246	216548	2 426 731	3 933 525
TOTAL REVENUES	8 186 550	2 109 241	20 315 508	30611 299	9 649 458	2865199	19 526 895	32 041 552
Loss/profit	-524 962	-597 922	823 276	-299 608	-411 647	-242 859	-261 010	-91 5516
Total costs per vehicle-km in EUR	2,1457	2,9554	1,7711	1,9341	2,6194	2,3982	1,8685	2,0956
Vehicle-km (in thousands)	4 060	916	11 006	15 982	3 841	1 296	10 590	15 727

Source: DPMK, 2012

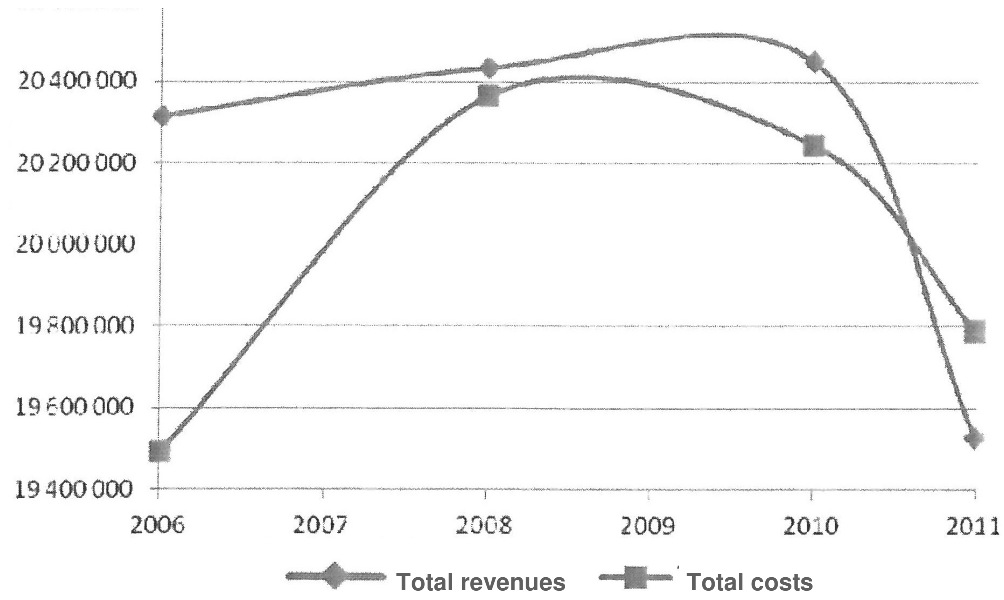
From economical point of view DPMK during the last five years generate a loss, despite rising subsidies from public budgets. The only traction, which was profitable in 2010 was the bus service. Even though it came in a loss in 2011. Tram and trolleybus transport continuously generate significant losses, although trolleybuses are doing gradually reduced loss. The common denominator of generating the loss is unconformity of passengers traveling by public transport that is caused by the obsolescence of the fleet and infrastructure. The second factor is the rising costs, mainly related to maintenance and repair.

Chart 14 - Evolution of income and expenses by tractions





Buses



In 2011 DPMK generates a loss of traction tram in amount of -411 647 EUR, of trolleybus traction in amount of -242 859 EUR and bus traction in amount of -261010 EUR. In terms of the cost of vehicle- kilometres is the most costly transport trams traction (in 2011 was the cost per 1 vehicle-km of 2,62 EUR. In trolleybus traction it was 2,40 EUR/l vehicle-km and in bus traction it was 1, 87 EUR/vehicle-km.

Obsolete rolling stock and rail lines makes trams compared to other tractions the most costly. At same time the cost of tram traction increase each year and in just the last five years increased by 50 euro cents per vehicle-kilometre. An important factor influencing this negative trend is the cost of maintenance and repairs.

2.10.2 Maintenance costs

Maintenance costs of the tram traction reached 4 794 000 EUR in 2011, which is 38 % of total maintenance costs. Maintenance costs of trolleybuses traction reached amount of 1 502 000 EUR, which is 12 % of total maintenance costs. Bus maintenance costs reached amount of 6 390 000 EUR, which represent 50 % of total maintenance costs. The total maintenance costs were 12 686 000 EUR. From the numbers presented it is clear that the highest maintenance cost has the bus traction, which does not represent highest proportion in the overall numbers of the persons transported by DPMK.

2.10.2.1 Maintenance costs in terms of the reliability of various types of vehicles

In terms of cost of operation and maintenance of the vehicles operated by DPMK the most costly type of traction constitutes trams and within this category the most costly is the vehicle KT8D5 where the cost of l km is 3,156 EUR. The second most costly vehicle is a tram T3 that costs 2,539 EUR/km. Comparative costs of l km has articulated tram and trolleybus T6. The least expensive types of vehicles are short bus in length to 12m (diesel) with cost 1,685 EUR/km and 18 meters bus powered by natural gas (CNG).

Table 18 - The cost of the selected vehicles (in EUR per 1 km) in the year 2011

	Buses					Trams			Trolleybuses	
	12 m	15 m	18 m	CNG 12	CNG 18	T3	T6	KT8D5	Solo	Articulated
Vehicle-km travelled	3 713 909	2 082 807	1 003 671	1 841 814	1 947 277	1 885 060	1 21 1338	744 734	192 449	1 103 834
Total costs per 1 km	1, 6852	1, 9803	2,2675	1,9215	1, 8435	2,5395	2,4132	3,1566	2,2994	2,4148

Source: DPMK, Department of Marketing and Economics, 2012

Within the repair and maintenance of the vehicles as the cheapest type of traction seems to be the bus service, which costs are around 8 000 - EUR/vehicle per year in the medium term. Trolleybuses and trams are in repair costs at the same level when the cost of repairing one tram in the years 2010/2011 represented about 19 000, - EUR and in case of trolleybuses were about 14 400, - EUR in the year 2010 and 20 000, - in the year 2011. It is more that obvious that the tram and trolleybus fleet of DPMK is significantly out of date, which increases the cost of maintenance, repair and operation itself. At the same time obsolete fleet due to high frequency of repairs and maintenance operation requires a high percentage of reserve vehicles in the tram and trolleybus traction.

Table 19 - Cost of repair of vehicles, tram tracks and the power system in thousands of EUR

	2011			2010		
	Trams	Trolleybuses	Buses	Trams	Trolleybuses	Buses
Repair of vehicles - labour costs	1 456	392	1 611	1 404	230	1 570
Repair of tracks - labour costs	375	0	0	490	0	0
Repair power subsystem - labour costs	347	149	0	371	159	0
Repairs together	2 178	541	1 611	2 265	389	1 570
Number of vehicles	117	27	202	117	27	204
Total cost of 1 vehicle per year	18,62	20,04	7,98	19,36	14,41	7,70

Source: DPMK, Department of Marketing and Economics, 2012

2.10.3 Fuel costs and costs of traction energy

In 2011, the bus transport on diesel fuel consumed in a total volume of l 526 599 litres of fuel (excluding from calculation inventories in tanks to the date 31.12.2011 – 37 040 litres). Specific consumption was 43,71 1/100 vehicle-km and 4,85 1/1000 place-km.

Table 20 - Diesel consumption in bus transport

Diesel consumption	in litres
Year 2009	3 798 420
Year 2010	3 540 564
Year 2011	2 916 830

Source: DPMK, 2012

Buses with CNG drive 704 451 more km in 2011, since middle of the year 2010 were introduced into service 19 new articulated CNG vehicles. Precisely because the proportion of articulated CNG vehicles is already higher than proportion of short vehicles, an average consumption kg/km increased.

Table 21 - CNG consumption in bus transport

	kg	EUR	average price	vehicle-km travelled	proportion kg/vehicle-km
Year 2009	1 113 458	810 894	€ 0.728	2 689 217	0,414
Year 2010	1 418 509	1 018 181	0,71 € 8	3 084 640	0,460
Year 2011	1 829 357	1 691 121	€ 0.924	3 789 091	0,483

Source: DPMK, 2012

In 2011, the traction ED and TD consumed 16 594 841 kWh of electrical power in total value of 2 320 409, - EUR.

Table 22 - Electricity consumption of trams and trolley buses

Year	kWh	EUR	average price	vehicle-km travelled	place-km travelled (in thousands)	share kWh/vehicle-km	share kWh/place-km (in thousands)
Tram traction							
2009	12 909 585	2 077 473	0.161	3 862 797	464 998	3,342	27 763
2010	13 468 373	1 809 039	0.134	3 832 120	473 498	3,515	28 444
2011	12 946 222	1 827 928	0.141	3 841 132	471 415	3,370	27 462
Trolleybus traction							
2009	3 110 279	478 842	0.154	1 081 814	127 525	2,875	24 390
2010	3 516 277	444 577	0.126	1 212 723	142 911	2,899	24 605
2011	3 648 619	492 481	0.135	1 296 283	151 886	2,815	24 022

Source: DPMK, 2012

3 Impact of public transport in the city of Košice on the environment

Impact of public transport on the environment is well known, also the advantages of public transport. Even using conventional buses in car equivalent quantity are compared to individual transport reached significant savings in total production of noise, gaseous and dust emissions and fuel consumption. The highest effect and importance of public transport in the cities consists in saving the space for movement (reduce traffic congestion on the roads) and for the parking of vehicles.

Other environmental benefits have subsystems of electrical traction vehicles - trams and trolleybuses, which do not produce gaseous emissions immediately. When using modern buses this effect is comparable, also in terms in the noise burden but as DPMK bus fleet is not the most modern one, this fact is not possible to apply.

The main advantage of trolleybuses are better acceleration capability and driving under load (uphill), so they are appropriate to use especially in hilly areas of the city.

Compared to diesel buses, trolleybuses do have a couple of disadvantages. A trolleybus is more manoeuvrable than a tram, but less so than a diesel bus. If the road is being repaired or rebuilt in a street where trolleybuses pass, chances are that the line has to be discontinued temporarily. A diesel bus can easily be re-routed. Similar to trams, trolleybuses also cannot overtake each other. The most important drawback of trolley systems is the need for overhead cables. They are generally regarded as ugly and meet protest. Especially at crossroads the cable network can be dense and hard to ignore. Similar to trams, the "tracks" of trolleybuses have points, but the whole mechanism of these hangs in the air.

The main disadvantage of trolleybuses - a dependence on fixed electric traction and need of its maintenance - can be partially addresses by DUO trolleybuses, which in marginal areas and extraordinary diversions may leave trolleybus route and go to an independent drive using a power generator (for liquid fuels) and in a suitable spot to come back and link to electric traction. This significantly increases the possibility of using these combined vehicles and increase trolleybuses "attraction" area of transport service.

Basic PROS and CONTRA of all the tractions used currently in DPMK are presented in the table 22.

Table 23 – PROS and CONTRAS of vehicle tractions operated by DPMK

traction	PROS	CONTRA
Trams	• Long vehicles require fewer drivers. • Vehicles can be connected together in trains for busy periods. • Non-polluting.	• Still quite expensive. • Unable to drive around obstacles. • Overhead lines regarded as an eyesore. • No posibility of overtaking
Trolley-buses	• Non-polluting and quiet. • Much smoother ride than diesel buses. • Can leave overhead lines to bypass obstacles.	• Even double articulated, they can only seat around 90 passengers. • More expensive than diesel buses. • Overhead lines regarded as an eyesore • No posibility of overtaking
Buses	• Cheapest option. • Also the most adaptable.	• Smelly, noxious exhaust is hazardous to human health. • Noisy. • Lurching ride. • Vibrations from the engine.

Big environmental benefits have also buses on gas (CNG) that are actually operated by Košice public transport company in quantity of 64 pieces. It is recommendable that vehicle fleet will be modernized this way because from the environmental perspective, the CNG option would reduce greenhouse gas and particulate emissions particularly in comparison with the diesel option. According to study published by ZME science in 2013 "the natural-gas option has a 65 percent to 100 percent chance of being lower cost than the diesel option, considering fuel price forecasts".

4 Conclusion

DPMK is currently in high economic lost so its main goal should be reduction of the total cost of maintaining and operating its fleet. One of the biggest parts of the total cost is fuel cost. DPMK has already implemented limited number of CNG buses, which have a higher fuel economy than a standard diesel buses, but considerably higher capital costs.

On one hand the higher upfront cost and subsequent maintenance cost of natural gas buses must be considered. Both natural gas and diesel prices have risen, but natural gas prices are increasing at a faster rate. But on another hand while capital (i.e. upfront) costs compared to diesel are higher in the case of natural gas, operational costs are less, due to the lower fuel cost of natural gas, in comparison with rising petrol and diesel prices. Taking health and environmental costs into consideration, when diesel motors operate on the most refined fuels and are fitted with advanced filters, they cost more than natural gas vehicles to operate.

From the environmental point of view there can be instances in which natural gas is worse than diesel for the environment. Natural gas production creates leaks of methane to the atmosphere. Methane has 25 times more impact on climate than CO_2, so even a small leak as a much larger impact than the same volume of CO_2 emissions at the tailpipe. When there is more than 1% leakage — no matter how efficient the vehicle is at the tail end — natural gas is more polluting than diesel says a recent World Resources Institute (WRI) report. At a 2 percent leakage rate the impact is the equivalent of CO_2 emissions from 120 million cars. The same WRI report states that the efficiency of using natural gas in an engine is lower for natural gas: “In the transport sector passenger cars fuelled by compressed natural gas are up to 10 percent less efficient than gasoline cars, and CNG buses are up to 20 percent less efficient than diesel-fuelled buses” (WRI report, p. 21). Also, independent studies conducted in London and Australia, have shown that the highest quality diesel, fitted with a special type of filter can achieve lower emissions rates than natural gas.

But there exist also other studies, including one by the International Association for Natural Gas Vehicles, which criticize the methodology used as both isolated and difficult to replicate. Moreover, we now have the technology capable of reducing methane leakage during the extraction process to less than 1 percent.

What holds promise for diesel vehicles is the application of state-of-the-art filters in combination with diesel containing less than 50 parts-per-million sulphur. For natural gas to achieve a net benefit to the environment, the production process must be further refined to capture escaping methane, at a great return on investment.

Because of the lower fuel price and pollution reduction, the CNG bus is considered to have good potential as an alternative vehicle used in DPMK vehicle fleet. From the environmental perspective, the more extensive implementation of CNG buses in the fleet would also produce less emission and provide benefit to the environment of the local society. So the CNG option is somewhat preferred from both a financial and environmental perspective.

Based on the findings presented in this study it is possible to conclude that public transport bus system running on natural gas (CNG buses) is more economically feasible and less harmful to the environment than the diesel model that is currently mainly employed in DPMK vehicle fleet. So the number of CNG buses should increase combined with trolley-buss and trams system with because the dependence on a single fuel for a public transport system is not desirable.

In long term the emissions reduction technologies should be a key factor for public transport vehicles. It is recommendable to consider and recognize the various benefits of different fuels in addressing local and global issues. It is more than a debate between fuel types, but rather an understanding of the key role that emissions reduction technologies and improved fuel economy do for reducing emissions from all fuels, especially at the macro-level, when governments take into consideration the emissions and costs from the production process.

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