

Metro as Urban Public Transport and Sustainable Urban Mobility in the Europe and Brazil

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Abstract

This article deals with the comparison of metro as a public transport in several cities in Europe and Brazil, all in a context of sustainable urban development. Contemporary society evaluates its performance especially by gross domestic product and the constant strive to grow economically. This growth is often redeemed by environmental degradation, particularly in developing countries. The effort of most advanced countries is the continuation of development of human society with full preservation of the environment. If we deal with the sustainable development in cities, especially concerning the traffic, the direction which was chosen by cities in Western Europe is different from in Brazil. The Western Europe prefers a reduction of traffic or a complete ban on entering the city for cars, but in Brazil is still popular individual automobile transport. One of the options, how to reduce the intensity of cars, is to have attractive and effective public transport..

Keywords: public transport, metro, sustainable urban development, reduce the intensity of cars

1. Introduction

The notion of sustainable development is a development of human society, which solves economical and social progress with full preservation of the environment (CEU, 2002). Among the main objectives of the sustainable development is the preservation of the environment for future generations, which will not be changed or will be changed very little. The sustainable development is built on social, economical, and environmental pillars. Public transport is a system of lines providing transport services in the city by public transport. In public transport, systems in cities there belong mainly buses and in big cities, there are the lines of trams, trains, and metro. The system of metro and train is one of the most convenient means of transport in the cities and that is mainly for its independence on the traffic situation (congestion).

Sustainable mobility in transport is understood by the Johannesburg Summit as a way of transport development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Johannesburg Declaration on Sustainable Development (Johannesburg Declaration for short) is one of two documents for sustainable development, adopted by the UN World Summit about Sustainable Development (also known as the Earth Summit (WSSD, 2002)).

In that document, it is possible to read that to achieve sustainable development of mobility in transport, it is necessary to have a plan which can be achieved based on the individual steps of this development.

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Achieving sustainable urban development is an issue that relates not only to the development of traffic networks, but also to limit car traffic in cities. Traffic reduction is related to the quality of public transport. It is necessary to reach a state, where passengers will prefer the public transport to traveling by their own cars. The aim of promoting public transport is to reduce individual transport, so that the individual transport will have only a supplementary function to local services and maintaining the economic activity of the city. To achieve these objectives, it is necessary to have a Sustainable urban mobility plan.

1.1. Sustainable urban mobility plan

A mobility plan is a way to reach a more energetically efficient and less pollutant transport system by implementing integrated measures (WHO, 2011). The aim is to promote the use of different modes of transport trying to avoid the increase of traffic in urban areas. Principal characteristics of the plans are:

- That they act on a local or metropolitan level;
- They guarantee the accessibility and necessities of municipal mobility;
- They cover all modes of transports, personal as well as freights;
- They are connected to strategic national and regional plans;
- They should reduce negative impacts from transports;
- They try to resolve increasing volumes of traffic and congestion;
- They intend to change the modal distribution in favor of the cleanest and most; efficient ones.

The area of matter in a mobility plan is larger than in an ordinary traffic plan. It affects all the mobility within all its aspects and one of the main aims is to make the citizens conscious about the necessity of a more rational use of the transport system (Mattson, 2006). The cooperation with the citizens is essential in order to make the plan work and obtain the effects wanted. Sustainability is the new important term adding an extra dimension to the plans. For all municipalities with a sustainable urban mobility plan implemented the following profits are likely to occur:

- Decrease of traffic jams and congestion followed by a diminution of noise, atmospheric contamination, contribution to the greenhouse effect and accidents;
- Lower energy consumption;
- Reduction of travel time;
- Improvement of the public transport services.

1.2. Urban public transport

Urban public transport is the system of the lines intended for providing of transport services by the city transport. Large cities often have an integrated transport system which applies to uniform tariffs and transport conditions, and traffic can be subsidized by the city. Integrated transport system is an advanced form of mass transportation in order to ensure quality passenger transport by different carriers, uniform transport and tariff conditions on a single transport document (ticket).

Coordinated timetables, a possibility of transfers at stations, current traffic information are important elements of the integrated transport system that should be considered. The level of these elements is different at different locations, it is necessary to strive for their improvement. Integrated transport system has played and will play an important role for a municipality/regions/countries in an effort to keep sustainable mobility services grow. Particularly those means of transport which damage the environment less than private transport (cars). These include bus, tram, but mainly metro.

1.2.1. Metro

For most of developed cities, the metro system forms one of the most important components of public transport. Like every means of transports, metro has advantages and disadvantages. Because of the fact that metro has its own transport network, its biggest advantage is the independence on the traffic situation on the roads. The own transport network also implies high reliability and cruising speed. Other advantage is the high transport capacity and almost zeros effects on the environment.

The biggest disadvantage is the high cost of construction. Due to that, the decisions about construction or expansion are always very complicated and often rejected by the authorities. Often these decisions are connected with the political and economic situation in a given city or state and it makes the decisions more complicated.

In Europe, for the construction of the metro, it is often chosen underground. That leads to high costs for construction, but also the possibility to build metro in places of existing and future buildings (e.g. historical city centers). Less costly option is the overhead lines of metro, which is a frequent variant in Brazil, but even that has its disadvantages. It needs an annexation of land (on the surface), the noise of traffic and the change of landscape.

2. Choice of the Cities and Methodology of Comparison

The choice of selected cities comes from the idea to show an importance of metro as public transport in the context of sustainable urban development in Brazil. European cities were selected for the comparison of the metro of Brazilian cities, because Europe is perceived as a place with high level of life standards (the UK - London, Germany - Berlin) and for historical ties (Portugal - Lisbon). The example of a small city, but with very good public transport, was selected Prague (the Czech Republic). In Brazil were selected Brasília as the capital city, São Paulo which is the biggest city and the capital of business and Salvador, the third populous city and the first capital city of Brazil (historically).

The comparison was done on the basis of individual statistical parameters. The comparison was done on the basis of individual statistical parameters, notably a number of inhabitants, land area of the city, number of lines, length of metro lines, number of metro stations, price of a basic ticket.

3. Basic information about the metro in selected cities

As a contribution to addressing the importance of metro as public transport in the context of sustainable urban development, there were selected seven cities for comparison of the metro system according to several parameters. In Europe, there were selected London, Berlin, Lisbon, Prague and in Brazil there were selected São Paulo, Brasília and Salvador.

The following paragraphs provide information about metro systems in the cities. Notably the information about inhabitants, land area of the city, a number of lines, a length of metro lines, a number of metro stations, a price of a basic ticket. All these information are rounded and are presented in the table. In addition, the cities are presented in an order by continent and the number of inhabitants.

The information about the inhabitants and the size of are taken from statistic of each selected cities or institutions. The information of public transport and each of parameters are taken from the website of the companies, which provide service of public transport. All of references are listed at the end of the article.



Picture 1: Chosen cities

3.1. London

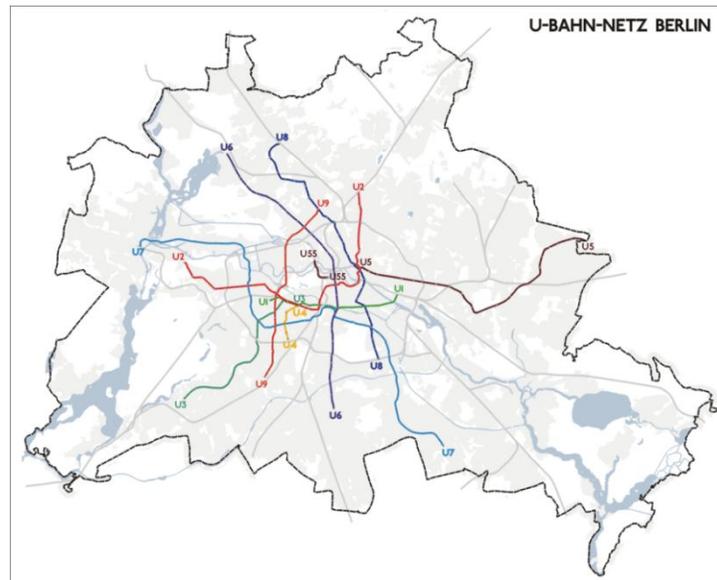
The metropolis of the United Kingdom is London. The capital city of the UK lies along the River Thames and takes the area 1580 km². London belongs to one of the most important and most visited cities in the world and are home to approximately 7,384 million inhabitants. London metro (London Underground or The Tube) is the oldest metro system in the world – 1. Part of it was opened in 1863 and it was with steam operation. Currently the metro has 11 lines, which have together the length 402 km and 270 stations. The metro transfers around 3,575 million passengers per day. The price of the basic ticket is 8GBP (approximately 9,4 EUR).



Picture 2: Metro system in London

3.2. Berlin

Germany's capital city is Berlin, which lies along the river Spree and he lives 3,419 million inhabitants. Its area spans approximately 892 km². The Metro system is in operation in Berlin from February 15, 1902 and has 9 basic lines and one additional line (label U). The bulk of the lines run along the surface. Underground lines are guided only partially and in the suburbs are above ground is conducted.



Picture 3: Metro system in Berlin

The total length of metro lines is 146 km with 173 stations. The Metro system cooperates with fast train lines and buses lines. Because of it the metro transports 1,417 million passengers per day. The price of the basic ticket is 3,30 EUR.

3.3. Lisbon

Lisbon is the largest and also the capital city of Portugal. The city has only about 550 million inhabitants, with the surrounding administrative units, which are essentially part of the city, the agglomeration has 2,666 million inhabitants, and the area is 958 km².



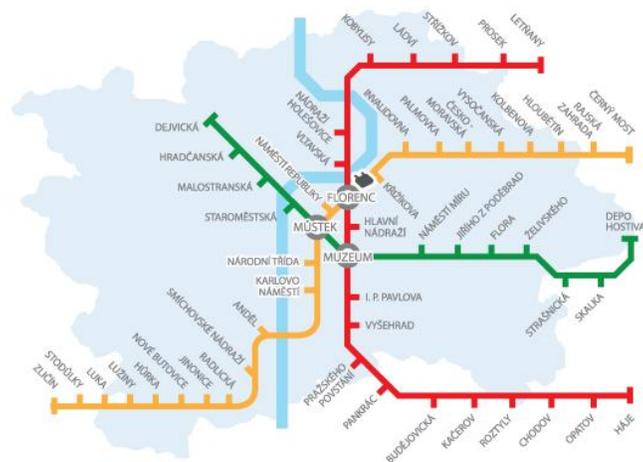
Picture 4: Metro system in London

Lisbon metro, which is in operation since 29 December 1959 has 4 lines. In 2012 the metro transports averaged 0.420 million passengers per day. Each line has its own color and character (blue gull, yellow flower, green and red boat compass). The total length of metro lines is 44 km with 55 stations. The price of the basic ticket is 1,4 EUR.

3.4. Prague

Prague is the capital city of the Czech Republic and extends along the Vltava River. The city has approximately 1,285 million inhabitants and the area of the city is 496 km².

Metro in Prague has opened on 9 May 1974 and currently, due to the large extension and cooperation with tram and bus lines, transports daily approximately 1,23 million passengers. This number is achieved also thanks to the system "P + R" (park and ride) when passengers from surrounding towns come to the final metro station and from here continue with the metro to the city center. The system of metro consists of 3 lines (red, green and yellow), and is an indispensable part of public transport in the city. The length of the metro lines is 65 km with 61 stations and almost whole network runs in underground. The price of the basic ticket is 32 CZK, average 1,18 EUR.



Picture 5: Metro system in Prague

3.5. São Paulo

São Paulo is a municipality located in the southeast region of Brazil. The metropolis is an alpha global city and is the most populous city in Brazil, the Americas, and the Southern Hemisphere. São Paulo has more than 11,967 million inhabitants and the area of the city is 1221 km².

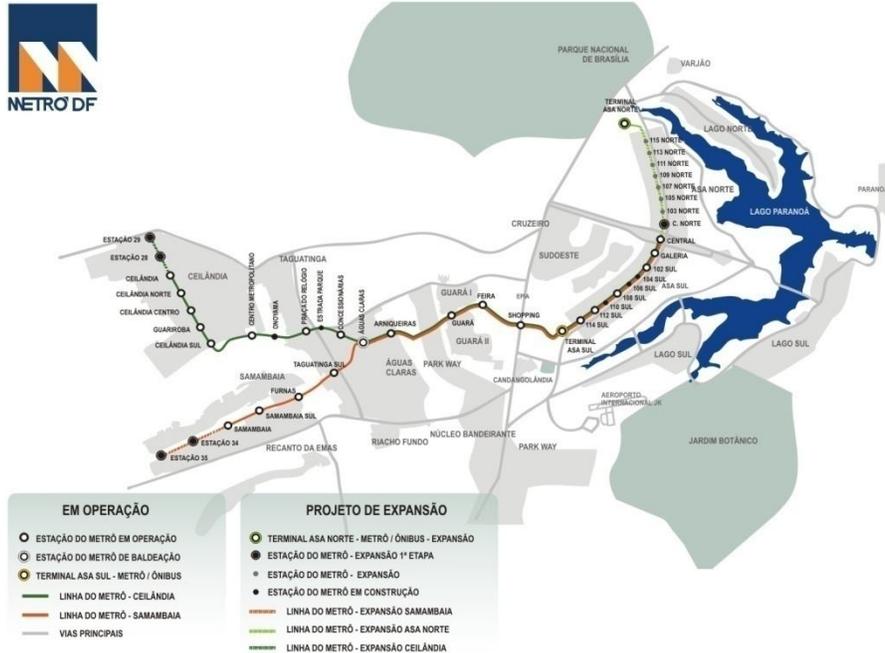
In 1972, the first test train trip occurred between Jabaquara and Saúde stations. In 1974, the segment between Jabaquara and Vila Mariana entered into commercial operation. The São Paulo Metrô is the main rapid transit system in the city. The five main lines in the metro system (Lines 1, 2, 3, 4, 5) operate on 75 km of route which have 67 stations. A sixth line (Line 15) is a monorail line that partially opened for service in 2014. The average weekday ridership is 3,090 million. The price of the ticket is 3,8 BRL, which is 1,02 EUR.



Picture 6: Metro system in São Paulo

3.6. Brasília

Brasília is the [federal capital](#) of [Brazil](#) and [seat of government](#) of the [Federal District](#). Brasília is a young city, because it was founded on April 21, 1960, to serve as the new national capital. Brasília and its metro (encompassing the whole of the Federal District) had a population of 2,914 million and the area of the city is 5802 km². The metro only covers part of the metropolitan area. Its main problem is the sheer distance between stations, making it a small component of the transit system of the Federal District.



Picture 7: Metro system in Brasília

Brasília's Metro has two lines, which has together 24 stations in the operation and runs for 42 km. The Metrô-DF transports approximately 0,170 million passengers per day. The price of the ticket is 4 BRL, which is 1,08 EUR.

3.7. Salvador

Salvador is the capital of state of Bahia. Salvador has 2,902 million inhabitants and it is the 3rd-largest city in the Brazil. Salvador spreads on the area 693 km². The current Salvador Metro system includes a fully open 12 km and 8 stations on the Line 1. The line 1 is between Lapa and Pirajá and which began partial public service on June 11, 2014. Line 2 will be connected the north parties of city with the city center and with the airport and Lauro de Freitas, which is the neighbouring town. The Line 2 currently under construction with projected opening dates at the end of 2017.

Ridership is not known, because the metro line is not long time in the operation and for long time was gratis. Although metro line is not now gratis, the ridership is not big, because metro is not well connected with the buses line. The price of the ticket is 3,3 BRL, which is 0,9 EUR.



Picture 8: Metro system in Salvador

In the next table is summary of basic information of metro system for each city:

Table 1: Parameters of Metro system

	London	Berlin	Lisbon	Prague	Sao Paulo	Brasílie	Salvador
Number of inhabitants (million)	7,384	3,419	2,666	1,285	11,967	2,914	2,902
Area (km ²)	1580	892	958	496	1523	5802	693
Density population (inhab./km ²)	4673	3833	2783	2591	7858	502	4188
Length of metro (km)	402	146	43	65	78	42	12
Density of lines (km lines/km ²)	0,254	0,164	0,045	0,131	0,051	0,007	0,017
Number of lines	11	10	4	3	6	2	1
Number of stations of metro	270	173	55	61	67	48	8
Daily ridership (million)	3,575	1,417	0,420	1,230	3,090	0,170	-
Price of the basic ticket (EUR)	9,40	3,30	1,40	1,18	1,02	1,08	0,90

4. The Evaluation

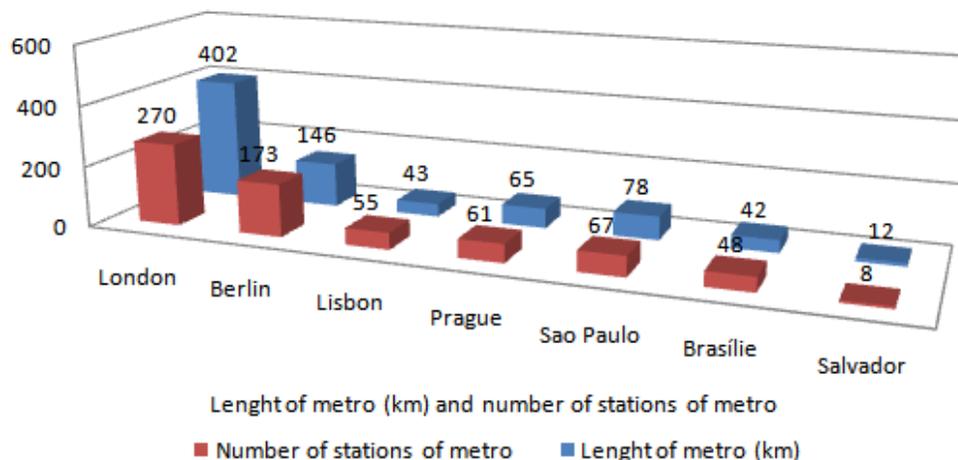
In the following paragraphs, there is a comparison of the characteristics of metro in selected cities. For each evaluation is described the possible justification as well as the possible advantages and disadvantages of selected characteristics.

4.1. Analysis and comparison

Before the analysis of individual characteristics, it is necessary to focus on some of the parameters that are written in table 1. The number of inhabitants was taken from the internet pages of municipality. In some cities, it refers to the population of the city metropolis, but in some for the agglomeration (Lisbon). The decisive factor was that the metro is operated only on the territory of the city or serves for metropolitan area. The area of the city corresponds to city or agglomeration. The problem is with size of area of Brasília. The single value of the area is for the whole Federal District. If we look on the map of Brasília, it is clear that more than half of the size of Federal District is not built-up (used for buildings and constructions). Because of that the values of density population and density of lines are misleading. The price of the ticket was chosen for the ticket with which it is possible to have a similar use in each city.

4.1.1. Length of metro lines and number of stations of metro

The length of metro lines depends often on the size of area and the economic situation. The construction of metro is very expensive and because of its development is slow. If we focus on the picture 9, from the picture is evidently clear that the biggest network of the metro lines has London. The reason is not only that the metro system in the London is the oldest in the world, but that the metro is one of reliable, fast, capacitive means of transport in the big developed cities. It is not necessary to count average length between stations, because this number is often irrelevant. The location of station corresponds to built-up area of the city.



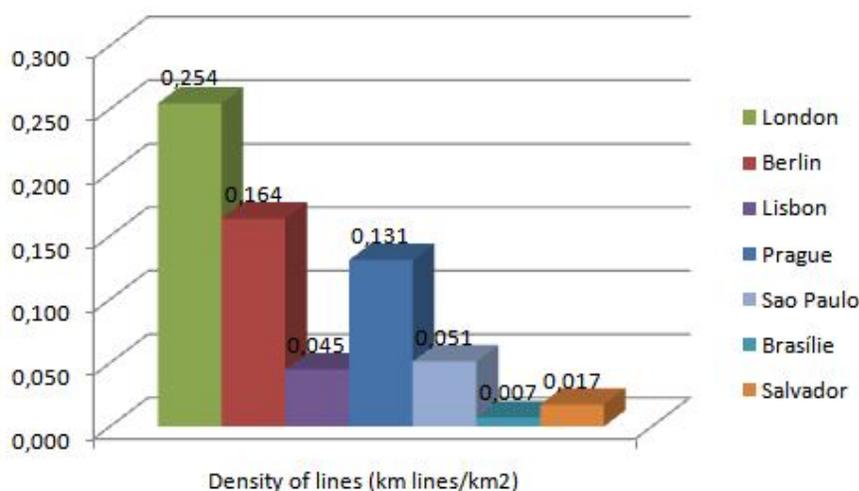
Picture 9: Length of metro lines and number of stations of metro

For example the average length between stations in London is 1,5 km and in São Paulo is 1,15 km, but in Lisbon is only 0,78 km.

4.1.2. Density of lines in the city

In the look at picture 10 is apparently, that the city with the highest density of lines is London. This result is obvious was expected, especially for the reason that London is one of the most developed and rich city in the world. The London's municipality knows, that a good traffic network and the public transport are very important for develop of the city.

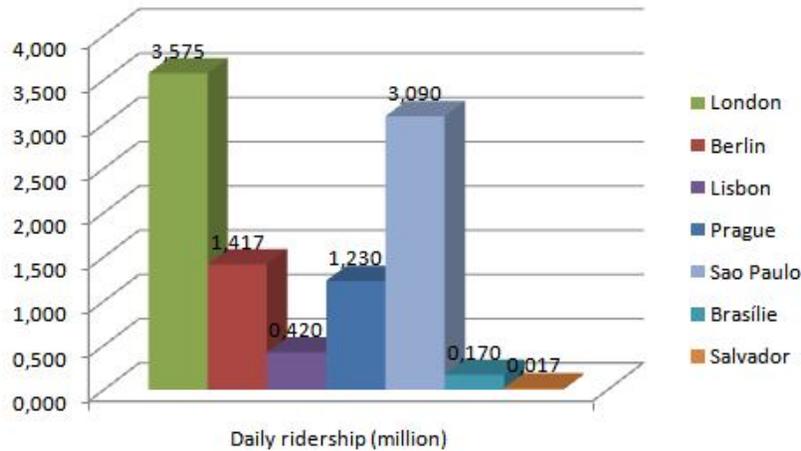
The values of the density at European's cities correspond to the size of the city and the number of inhabitants. The situation with density in Brazil is opposite. All of the selected cities in Brazil have bad result. The city as São Paulo does not have high network of the metro than Prague. São Paulo is also Earth's 12th largest city proper by population and has the largest economy (by GDP) in Latin America and Southern Hemisphere. The area of São Paulo is similar as the area of the London, but in São Paulo live more almost 12 million inhabitants, which is 1,6 more than in London.



Picture 10: density of lines in the city

4.1.3. Daily ridership

One of the main indicators of using the metro is the number of transported passengers – ridership. If we have the result for some years, it is possible to read from the value of ridership, whether the metro is sufficiently used, and whether it's using goes up.



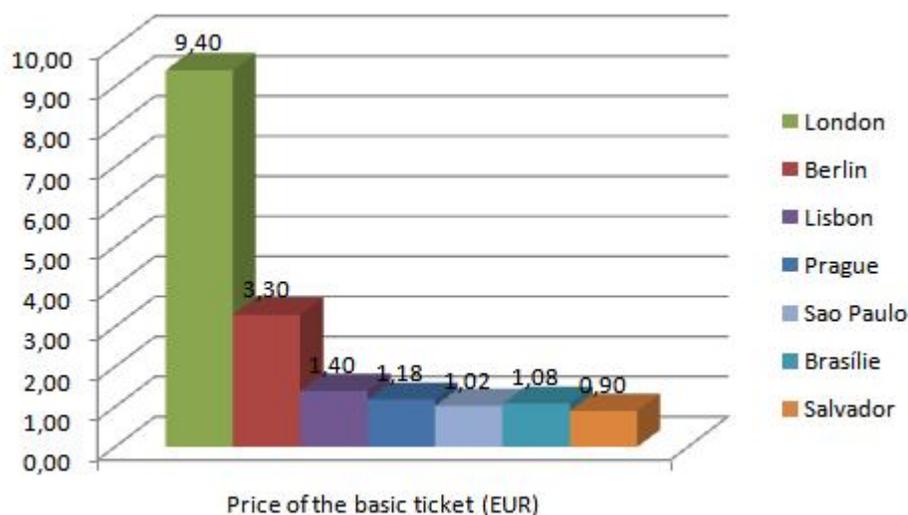
Picture 11: daily ridership

If we look at the picture 11, is good to focus on the result between metro in Prague and in Berlin. The area of city in Berlin is almost twice bigger than in Prague and the length of metro lines also, but the daily ridership is almost similar. The reason could be that the metro in Prague is more expanded than in Berlin or to the metro in Berlin competes with another means of public transport. Also it is very important to comment the result between London and São Paulo. The area of city in London is almost similar as in São Paulo and daily ridership also, but the number of inhabitants is different. In São Paulo is 2 more inhabitants than in London. Due to the density of lines of metro is clear, that the metro in São Paulo is not very expanded and because of it is little used. Also it is possible that in São Paulo one of the big problem in the traffic is the congestion, which identifies each visitor center.

The interesting comparison between London and São Paulo is with their number of inhabitants. If we think that one passenger is one inhabitant, so Berlin needs 2,06 days to transport all of its inhabitants, but São Paulo needs 3,87 days. Or the comparison about the time needs for the journey to work.

4.1.4. Price of the basic ticket

For using of metro is not important indicator only the size of the metro's network, but for some passengers could be the price of the ticket.



Picture 12: Price of the basic ticket

The highest price of the ticket is in London. It is possible to say, that the density of the metro lines and the number of the stations is justified the price of the ticket. Here it is very important to know, that the minimum wage per month in United Kingdom is 1209, 60 GBP (1419 EUR). The price of the ticket in London is average 1,5% of the minimum wage. In Berlin, where the minimum wage per month is 1428 EUR, it is 4,3 %. In Prague, the minimum wage per month is 366 EUR, the price of the ticket is 3,1 %, in Lisbon (the minimum wage per month is 618 EUR) is the price of the ticket 4,4%. In Brazil where is the minimum wage per month 238 EUR (880 BRL) is the price of the ticket in Brasilia 2,2 %, in Salvador 2,6 % and in São Paulo 2,3%.

The price of the ticket could be influenced not only by earnings of Transport Company from the sales of the tickets, but also from financial support of the municipality. For example, the financial support of municipality in Prague is around 60% of the budget and in London is around 23%. The financial supporting from the government or municipality means that the transport company could have lower price for ticket and thus get more users.

5. Final Considerations

The main idea of this paper is to show the importance of developing public transport network, especially the metro. Because it is constantly addressing the issue of sustainable urban development, so this issue also affects public transport in cities. Achieving sustainable urban development is an issue that relates to not only the development of transport networks, but also the limitations of individual automobile transport in cities.

The effort of cities should be to build a network of metro lines, which will not be depended on the traffic situation on the road, will be have sufficient capacity, and will serve in densely populated parts of the city or the place, where it is necessary to transport big groups of people and it will be safe and cheap. Reducing the number of cars in the city can be done by banning entry of cars into cities, or to pay for entry (London), or aggressive raise of prices for parking (Berlin, London). But this is possible only when the city has a good public transport.

It is necessary to attain a situation, where passengers will prefer for his journey the public transport before traveling by car. Investment costs for the construction and development of metro network are high, but despite that, these investments pay off and could be cooperation of the municipality or government with the private sector. The support of the municipality is needed also for companies, which operate public transport.

Increasing the number of public transport users means reducing the number of cars in the city and thus relieves the existing infrastructure, improve the space for inhabitants, and in addition improve the environment.

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