Transforming Urban Mobility:

A Multidimensional Analysis of the Bus Rapid Transit System of Mexico City

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ABSTRACT

The Bus Rapid Transit is a system of transportation based on separated lanes for large buses that emerged in South America and now has spread to the rest of the world. This paper analyzes environmental, political and institutional aspects of the Bus Rapid Transit in Mexico City as well as a response to the challenge to achieve more sustainable transportation. The environmental benefits are several, the BRT has the capacity to carry more people than a conventional bus or minibus, reducing the emissions for each passenger transported by replacing the old polluting buses that carry less people. Another benefit is the behavioral change that the improved transport system can promote among people by switching from the use of the private vehicle to the use of the new system. A more direct benefit to commuters is the reduction of exposure to health-threatening pollutants in the old buses with doors opened allowing pollutants to enter against the significant decrease of that exposure with a cleaner bus with doors closed. The institutional arrangements are an important factor in the introduction of environmentally friendly measures in public transport, actors such as politicians, governmental bodies, non-governmental organizations, donors, multilateral agencies, private companies, as well as users and user groups all have a specific role to play in a project like this, and have been classified and discussed according to their importance and influence. The policies of the project and their outcomes have been summarized. Some possible additional solutions have been proposed. Finally, a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis has been developed for the BRT

Keywords: Bus Rapid Transit, Institutions, Emission Reduction, Pollution in Mexico, Sustainable Transport, Transport Policy

Cover Page Source: Center for Sustainable Transport, Mexico City www.ctsmexico .org

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Adrian Martinez Espitia

In memoriam of my brother

Juan Luis Martínez Espitia

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Acronyms

BRT	Bus Rapid Transit
CDM	Clean Development Mechanism
CeIBA	Interdisciplinary Center of Biodiversity and Environment
CISA	Insurgentes Corridor Civil Association
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CTS	Center for Sustainable Transport
CFC	Chlorofluorocarbons
FEx	Emission Factor
GDF	Government of the Federal District
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit

HC	Hidrocarbons
IPCC	Intergovernmental Panel on Climate Change
LGEEPA	Law of Ecological Balance and Protection to the Environment
NGO	Non Governmental Organization
NO_X	Nitrogen Oxides
O_3	Ozone
RTP	Passengers Transportation Network
PICCA	Program for the Control of Atmospheric Pollution
PM	Particulate Matter
Ppm	Parts Per Million
Pro-air	Program for improvement of the Air Quality in Mexico City Metropolitan Area
SEDUVI	Secretary of Urban Development and Housing
SETRAVI	Secretary of Road and Transport
SMA	Secretary of Environment of Mexico City
SO_2	Sulfur Dioxide
SWOT	Strengths, Weaknesses, Opportunities and Threats
TSP	Total Suspended Particles
TDM	Travel Demand Management
UNAM	Autonomous National University of Mexico
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compounds
VTBC	Voluntary Travel Behavior Change
WB	The World Bank

1 Motivation

During the recent summer of 2009, when I was in Mexico, after having studied a module in air pollution in Portugal, I saw Mexican cities with a completely different perception. I could feel in a new way that cloud of toxic pollutants coming from the exhausts of the buses while walking through the streets. I also realized that the transportation was another segregating factor in the cities; while rich people always drive their cars and would never take public transport, poor people have no option but to take the public transport even in the worst conditions. I believe that if a transport system can be effective, comfortable, safe and affordable it can be an important factor for promoting equality among citizens. The cities of the 21st century cannot continue with a regime of public policies that ignore the needs of the majority of the people. As an interesting anecdote, somebody even made fun of me because I took the bus (an old heavily polluting and uncomfortable minibus) to go downtown. That same person had an accident by crashing his car just a few weeks ago. In addition, in Mexico a pejorative term has recently emerged among common citizens: *pueblo bicicletero* or *cycling town,* which is used to denote contempt of cities that are in process of development.

The experience of the Copenhagen Climate meetings in December of 2009 led me to choose the area of public transport for my thesis topic. There I heard that Latin American cities are promoting change in mobility in the developing world, and I wanted to investigate. I have come to realize that the city is not the problem but the solution, because in the end that is where people live, interact and take decisions every day that affect the whole world. In a conference, the mayor of Puebla (Mexico's 4th largest city) pointed out that when the local authorities were building cycling paths, car drivers complained they did not have enough space to drive. Subsequently, I asked her if it was possible to build cycling paths where there is a demand for it. Her answer was surprising: "In Mexico, everybody drives a car. Rich people, but poor people as well. There hardly is any demand for cycling at all"

The urban transport in Mexico is still underdeveloped, buses stop wherever they like, at any time, are sometimes totally empty and sometimes overcrowded, and there is not any consideration for disadvantaged or disabled passengers. The need to improve transport is fundamental.

2   Introduction

In contemporary society, there is a growing concern regarding the impact of transportation on the environment. Increasingly, workplaces, schools, supermarkets and other public facilities can only be reached by car. This dependence on cars as a 'necessity' rather than a 'luxury' has become rooted in the minds of people over the course of the 20th century.

The effect of such a deep socially constructed dependence on the car has become a problem for governments in their efforts to adapt cities to the needs of the new automobile society. In the United States, iconic films like "Rebel Without a cause", novels like "On the Road", and even classic music albums like "Highway 61 Revisited" reveal how central individualism and the freedom of the automobile and the open road are to American culture. Nobel price-winning novelist William Faulkner even mentioned that "The American really loves nothing but his automobile: not his wife his child nor his country not even his bank-account first" (EMBARQ, 2010). This culture is, however, not restricted to the United States, across the world consumers want to have more and bigger cars. For example, China and India see respectively 1,000 and 650 new cars on their streets every day (ibid).

The revolution in terms of comfort of mass-produced automobiles is demanding more use of land and space, creating social disconnections, increasing physical inactivity and generating air and noise pollutants as well as accelerating the burning of fossil fuels from non-renewable resources. With these consequences, how are the cities dealing with the problem? What measures are being taken and how effective are they?

Transport systems are major emitters of greenhouse gases, responsible for 23% of the world energy-related GHG emissions in 2004, with about three quarters coming from road vehicles. Currently 95% of transport energy comes from petroleum (IPCC, 2007). However, most of the environmental impact measured in regard to sustainable transport is based on CO_2 emissions (Potter & Bailey, 2008), a pragmatic sustainability indicator which is suitable for countries that need to comply with CO_2 emissions, but Mexico City is still having problems of local air pollution, and transportation also needs to be sustainable in relation to other pollutants.

However, the concept of sustainability is a relatively new idea in developing countries, where the economic growth is still the main priority, in particular in Mexico, where its biggest city has become infamous for its pollution and congestion. Recent estimations have calculated that there is a new car for every baby born in Mexico City. (CTS, 2010). In 1992, Mexico City was declared the most polluted city of the world by the United Nations.

Estimations stated a number of 35,000 hospitalized persons and 1,000 deaths because of respiratory problems (O'Connor, 2010). The city acted immediately by replacing the soot-belching old cars, removing lead from gasoline, embracing natural gas, and relocating refineries and factories, introducing programs of compulsory non-driving days and for the purposes of this study, improving the urban transport and its infrastructure.

The role of urban transport systems is an important issue, because it is the only way to get access to distances that are beyond what can be possible to walk, and provides social and economic connections so that people can quickly take advantage of opportunities offered by increased mobility. These advantages need to be weighed against the environmental, social and economic costs that the transport systems pose. Political considerations are essential when taking a decision for a change in transport.

Sustainable transport is a derivation of sustainable development, see figure 1.1. Burwell & Litman (2006) conceptualize the term where a system must be planned in such a way that it favors economic efficiency, it is distributed equitably and causes little environmental harm.
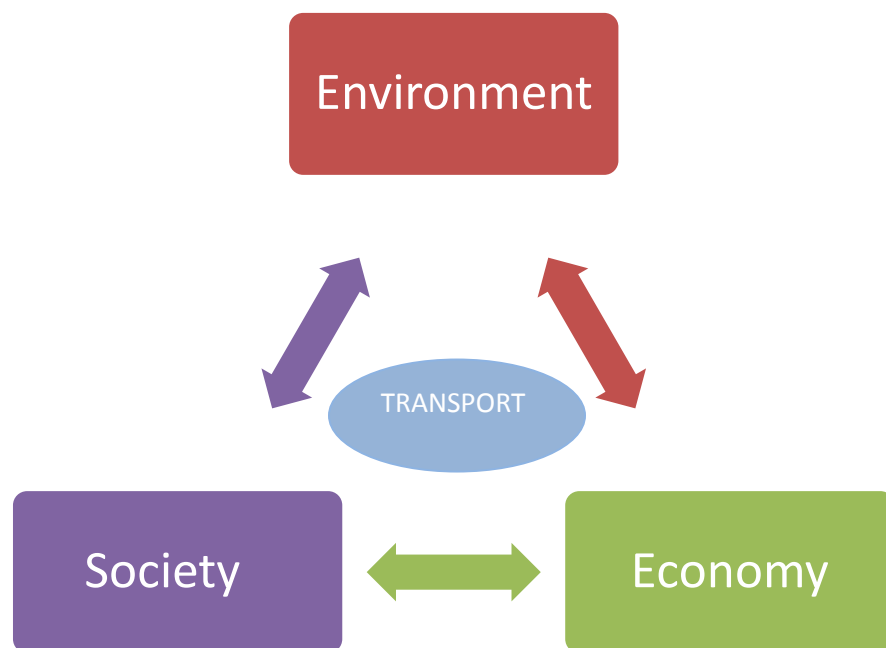
Figure 1.1 Sustainable Transport. A simple but fundamental Model

The Bus Rapid Transit (BRT) system consists of articulated or bi-articulated bases circulating across exclusive and segregated lanes of a street, with fixed stops and a prepayment system, similar to a subway system, but with the flexibility of a bus. The BRT

is an alternative of urban transport system that was first developed in the city of Curitiba, Brazil during the seventies. The city of Bogotá replicated Curitiba's model with some improvements in 2000.

The BRT has inspired a significant number of cities around the world. In Mexico, the city of Leon was the first one to implement the transport model in 2003. Mexico City implemented the model in 2005, its BRT was called Metrobus, it has an extension of 48.1 kilometers, with 81 stations. It has 2 corridors, the line 1 is running along Insurgentes avenue in south-north direction, the line 2 runs along Eje 4, in east-west direction. (Metrobus, 2010)

The environmental benefits of implementing a BRT are several. On the one hand, the system can replace old and polluting buses. On the other hand, it can encourage private vehicle users to change their patterns of mobility by using an improved way of transportation.

In this thesis, the environmental, socio-political and institutional arrangements as well as the main decisions of the BRT system are analyzed and assessed as an example of urban sustainable transportation in action.

3   Research Design

3.1   Structure of the Report

The aim of this paper is to elaborate a multidisciplinary analysis of the Bus Rapid Transit of Mexico City, the extent of the environmental benefits of the project and the political and institutional arrangement of the project

Chapter 1. Motivation. A brief explanation of why I decided to choose this topic.

Chapter 2. Introduction. Presents the overall topics of the report. Mobility, sustainable transport, mitigation actions to clean the air, stakeholders and policies.

Chapter 3. Research design: It is comprised of the problem formulation and research question, report structure and the methodology followed to answer research questions

Chapter 4. Theoretical Background: it gives an overview of Mexico City, Air pollution, Climate Change, the achievements in the cleaning of the air, and the Bus Rapid Transit

Chapter 5. The initiatives of sustainable transport: it presents the BRT in Mexico City, its planning, development and operation. It also contains a section about Metro and Non-motorized transport

Chapter 6. The environmental benefits of the BRT project presents the analysis of three different scientific studies in relation the contribution of the project to the reduction of pollution.

Chapter 7. Institutions and stakeholder analysis: it defines institutions, describes the institutions and other stakeholder involved in the project, it classifies and weight the importance of the different actors.

Chapter 8. Policy analysis: it identifies the main more successful policies applied for the creation of the BRT in Mexico City, their outcomes, their policy proposals and a SWOT analysis.

Chapter 9. Discussion and Conclusions. It presents the discussion of the project as a whole as well as it summarizes the main comments of the interviews

In-depth Interviews

References

3.2 Research Questions

The environmental degradation from road transport, has been becoming a major concern, mainly in the developing countries, as incomes are rising, motorized transport is tending to increase in the cities, which will worsen air quality, among other problems. Therefore, It is useful to look at the four geographical levels of environmental impact (see Table 3.1). These impacts involve both humans and ecosystems, in addition, social exclusion, lifestyle, economic effects and traffic congestion are other kind of important impacts of transport.

Table 3.1. Transport's environmental impacts and sources	
Level of impact	**Sources**
Local, e.g. Smell, air quality, health effects, accidents and noise	Particulates, volatile organic compounds, carbon monoxide, carbon monoxide, sulfur dioxide, ozone, vehicle noise
Regional, e.g. land use and waste disposal	Land take of infrastructure, stimulates urban sprawl; disposal of scrap tires, engine oil, chemicals, etc
Continental, e.g. acid rain	Vehicle exhaust emissions-nitrogen oxides, sulphur dioxide
Global, e.g. climate change, ozone depletion	Vehicle exhaust emissions-carbon dioxide, CFCs in air conditioning

Source: Potter and Bailey (2008)

The case study has been the problem of pollution in Mexico City that will be explained more in detail in the next chapter, my research has taken me to focus on transport, and how to make it more sustainable, with a deep emphasis in the Bus Rapid System and its implementation in Mexico City.

The research questions that have been formulated for this study are the following:

> *1 To what extent has the BRT in Mexico City reduced pollutants and improved air quality?*

> *2 Who were the main actors involved in the planning, implementation and operation of the BRT?*

> *3 What is the role of the BRT in making urban transportation more sustainable in Mexico City?*

3.3 Methodology

I proceed to classify 2 different levels, a first level of analysis is a technical assessment where a new transport system has contributed to reduce pollution, a second level of analysis is the socio-political level of the implications of the new transport system, subdivided in 2 sub-analysis, stakeholders and policies.

The research includes the selection of 3 quantitative and scientific analysis of the BRT that have estimated the difference in pollution under different objectives. I classify the study in 3 levels, i.e. global, regional and individual; comparing every study and classifying their approach and their finalities. The objective of this study is analytical in order to evaluate their objectives, order and logic, as well as the factual demonstration of how a new transport system has reduced pollution. In addition, the socio-political nature of the project implies an involvement of stakeholders, to review potential conflicts or risks that can affect an initiative, opportunities and relationships that can be built on during implementation, groups that can encourage participants at different stages of a project, and ways to reduce negative impacts on vulnerable and disadvantage groups.

3.3.1 Materials and Methods

The main tools used in this study are documentary analysis and in-depth interview to experts. The selection of Mexico City has been due to the possibility of more abundance of information and the relative familiarity with the city and its environmental problems.

The documentary analysis has been taken from a wide range of literature available mainly in the websites of the institutions involved, like the World Resources Institute, the World Bank, the Secretary of Environment of Federal District, the Center for Sustainable Transport, data from the National Institute of Geography and Statistics as well as large number of articles in conventional newspapers and journals of sustainable transport. Some keywords for finding material have been: Sustainable transport, Bus Rapid Transit, transport policy, air quality policy, pollution in Mexico City.

The in-depth interviews have been conducted through phone-calls or skype. The interviews have been semi-structured, with a line of questions done in a much more qualitative analysis, according to their role in the project and their experiences with the system.

The questions will be singularly developed through an analysis of the main aspects of the BRT:

> 1 To what extent has the BRT of Mexico City removed pollutants and improved air quality?

Objective: To identify the key considerations for the development of indicators and the key local mitigation actions of the BRT project that have improved the air quality

Material and Methods: three quantitative analysis have been selected and summarized. One of them was applied for Clean Development Mechanism, and the other 2 were performed for demonstrating the environmental and health benefits of the project.

2 Who were the main actors involved in the planning, implementation and operation of the BRT?

Objective: To identify the key stakeholders and institutions involved in the implementation process of the BRT project

Materials and Methods: the materials have been selected from the literature and from the interviews. An Institutional Analysis will be performed, through a stakeholder analysis that according to ADB's Methods for Stakeholder Engagement, involves three steps: Identifying major actors involved and who is their main representative, determining stakeholders' relative importance to and influence on project outcomes, and prioritizing and selecting stakeholders for consultative processes (ADB,2010). Their decision-making, performance and classification during the project will be analyzed and explained. An influence and importance matrix has been used to weigh the different actors.

3 What is the role of the BRT in Mexico City in making urban transportation more sustainable?

Objective: To identify successful policies in the project made by decision makers, to identify the outcomes of those policies and to propose policies that perhaps could improve the process

Materials and Methods: A policy analysis will be conducted based on the main decisions of implementation. A SWOT analysis of the political context of the moment will be conducted. A comparison with other transport policy will be performed. The interviews and the literature review has been the main source for this method

3.4   Limitation

The biggest limitation of this project, has been the lack of field work, and therefore, the collection of more empirical data, which would have helped more the researcher for understanding the process of urban mobility and the decisions in the studied area.

4   Theoretical Background

4.1   Mexico City

The foundation of Mexico City dates back to 1325. At the time, it was called Tenochtitlan. This city, which was founded by the Aztecs, was represented by the symbol of an eagle eating a snake while perched atop a cactus. Nowadays, the symbol is used in the Mexican flag. The choice for settling down in this location on the island of Texcoco was militarily and economically strategic for Aztecs leaders, due to its natural insulation. By 1519, when the Spanish arrived, Tenochtitlan was believed to be one of the biggest cities in the world. Some of the conquerors had travelled as far as Paris, Venice and Constantinople, but said Tenochtitlan was the largest city they had ever seen. As a result of warfare between the Spaniards and the native inhabitants of Tenochtitlan, the Aztec capital city was destroyed by the Spaniards in 1521. Subsequently, Mexico City was built on its ruins. It was rebuilt and redesigned according to the Spanish urban standards. (GDF, 2010).

The Federal District was created in 1824, encompassing the same area as today. Historically it has been the most densely populated area of the whole country. According to the first reported census which was published in 1921, the population of Mexico City had grown to almost one million inhabitants. By 1950, the population had even surpassed 3 million. In following decades, the city grew even larger due to large internal migration from the Mexico's rural areas. It could be said that during the decades following the 1950s, Mexico City had lost its charm, due to the large increase of inhabitants, the government had problems keeping up with the provision of public services. This problem was increased particularly as a result of the collapse of oil prices which made the government to cut public spending[1]. Despite these problems, the city kept growing in population. (GDF, 2010)Estimates of the current population size amount up to 22 million (see also the projection in Table 4.1).

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[1] The Mexican government uses its oil revenue to finance most of the public spending

Year	Population (thousands)	Surface (ha)	Density (persons/ha)
1950	2,953	22,960	129
1960	5,125	41,010	125
1970	8,816	68,260	129
1980	12,333	105,660	117
1990	15,047	121,320	124
1995	17,089	132,570	129
2000	18,210	145,000	125
2010	20,533	162,690	126
2020	22,253	174,830	127

Table 4.1 Population, surface and density of urban area in Mexico City Urban Area and surrounding, 1950-2020 (Source: Covarrubias, 2000; project for the design of a strategy for air quality management in the Mexican Valley, 2001-2010. MIT, 2000)

Over the years, Mexico City has extended outside the borders of the Federal District and now reaches into neighbor the state of Mexico, as there was no housing available within the city itself. This has led to the creation of huge shantytowns in the outskirts of the city (Ibid). The whole metropolitan area is comprised of 16 political delegations in the Federal District as well as 18 municipalities in the state of Mexico, as is also shown in Figure 4.1
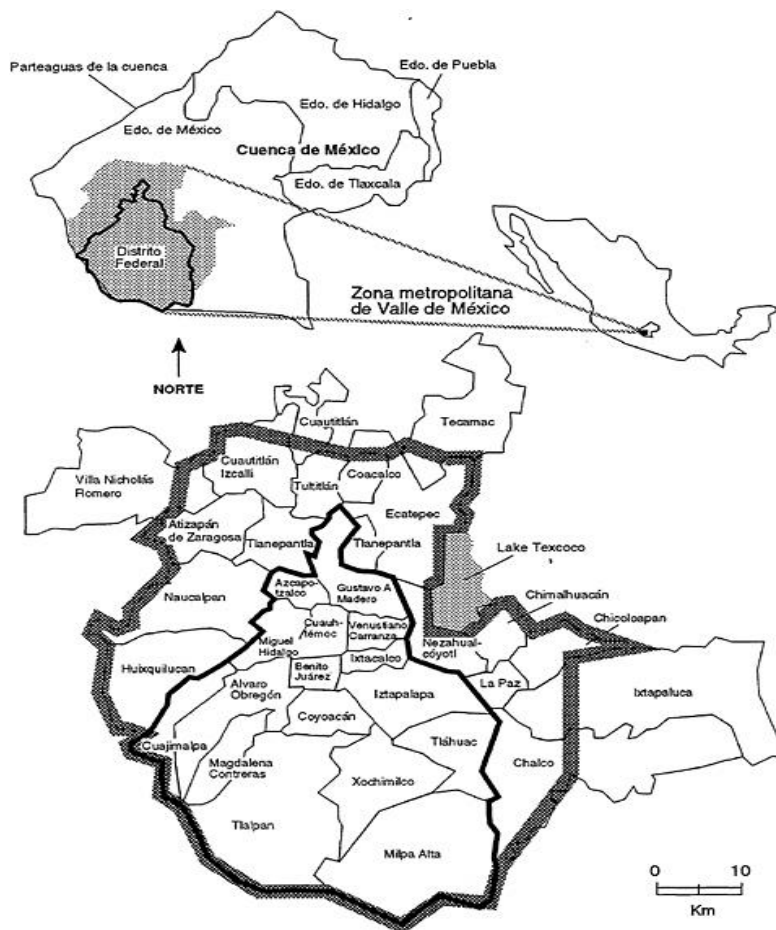
Figure 4.1. Map of Mexico source: www.inegi.org.mx/inegi/default.

4.2   Air pollution

In 1959, the famous Mexican novelist Carlos Fuentes wrote his first book about Mexico City with the title 'Where the air is clear'. This title is quite ironic when comparing it to the current perception of the city. Nowadays, Mexico City is one of the dirtiest cities in the world. While some cities are known for boulevards (Paris), churches (Rome) or skyscrapers (New York), Mexico City is known for its pollution. Most of the pollution in the urban areas results from fossil fuel combustion of cars and industrial processes, though natural sources as dust from the soil and volcanic activities also contribute to a relatively small percentage of pollution.

The main catalyst for the increase in congestion and air pollution is the economic growth. Economic growth leads to urbanization, as people move from the countryside to the city in order to find a job. It also influences motorization and mobility, as there is a strong correlation between income and car possession. The increased mobility can be reflected in changing habits of routine shopping and recreational and social trips. Additionally, dispersion of residential, commercial and industrial areas contributes to the increase in the number of trips taken by individuals, though the offer of infrastructure in the form of highways, train rails and transit services remains fixed (PROAIR, 2002-2010). This increase in congestion and air pollution has a negative effect on health.

The pollutants that are harmful will be explained elaborately below:

- *Sulfur Dioxide (SO_2)*

Sulfur dioxide is a gas that results from combustion of coal that contains sulfur and lignite. It is used in power stations and factories. Households can also contribute substantially to the emission of sulfur dioxide with inefficient stoves and diesel-engine vehicles. Gasoline contains between 0.03 and 0.05% of sulfur during combustion, of which almost all is converted into SO_2. High exposure of concentrations can result in breathing problems among asthmatic children and adults who are active outdoors. Short-term exposure has also been linked to wheezing, chest tightness and shortness of breath. (Clean Air Initiative, 2010)

- *Suspended Particulates TSP, $PM_{10,}$ and $PM_{2.5}$*

Suspended particulates are a mixture of solid particles and liquid droplets suspended in the air. They can vary across type of substance and size. It can be a naturally generated particle (e.g. from the soil), but also from other sources such as fossil fuels associated with power generation, home heating, cooking, motor vehicles and several industrial processes including waste incineration. The construction industry also represents an important source. Depending on the size of the particle, these suspended particulates can penetrate deep into the respiratory system. Large particles (diameter >5-10 μm) usually reach into the upper parts of the lungs while smaller particles (diameter <5 μm) penetrate much deeper into the

respiratory system. Therefore, when determining the negative health effects, it is necessary to look at the size of the particles, because a pollutant of a size less than 2.5 μm is significantly more dangerous to health than one of 10 μm. If the composition of PM contains a sulfate or acidic particle, the effect on health can be better predicted. It can cause pneumonia, bronchial pneumonia, asthma, middle and inner ear infections and blood vessel obstructions affecting the heart. Infants are mostly affected with a deteriorated immune system and lung tissue damage. As the particles can penetrate into respiratory system, PM_{10} can accumulate in the trachea-bronchial area, and $PM_{2.5}$ penetrates until the pulmonary alveoli (Center Mario Molina, 2005) (Elsom, 1996)

- *Carbon Monoxide (CO)*

Carbon monoxide is an odorless and colorless gas that is produced by an incomplete combustion of fossil fuels that mostly comes from motor vehicle engines. The formation is common when there is a lack of oxygen and, as a consequence, the fuel does not burn properly. Altitude and temperature also play a role, as cities at high altitude on cold days experience increased problems with carbon monoxide. Especially during rush hour, the CO concentration in the air rises, as a result of, for example, the number of engines idling for traffic lights. The effects on health are severe, for example, hemoglobin and carbon monoxide in the blood leads to the formation of carboxi-hemoglobin, which limits the flux of oxygen from the lungs to other organs and tissues. (Center Mario Molina, 2005)

- *Nitrogen Oxides (NO_X)*

Nitrogen oxides are produced, for example, when the temperature of the combustion is high. Its main source is motorized vehicles. Most of the combustion becomes nitric oxide (NO), while 5 percent becomes nitrogen dioxide (NO_2), which results mainly from chemical reactions with ozone (O_3). This reaction leads to smog, acid rain, global warming and health problems such as emphysema and bronchitis. (Center Mario Molina, 2005)

- *Ozone (O_3)*

O_3 is secondarily formed with the reaction of NO_2, volatile organic compounds (which will be explained below) and hydrocarbons in sunlight. These photochemical reactions create more oxidants and fine particulates that give photochemical smog a hazy appearance. During stable weather conditions, large quantities of the chemicals become trapped under a low-level temperature inversion, allowing time for ozone to be formed. It can cause acute respiratory infections cough, phlegm, atrophy of nasal mucosa, eye irritation, decreased ventilatory function and asthma attacks. Paradoxically, ozone protects us from solar radiation in the upper atmosphere. Exposure to this radiation, consisting of UVA, can lead to an increased risk for skin cancer. (Elsom, 1996)

- *Lead (Pb)*

The combustion of petrol with lead additives is the main source of lead in the urban atmosphere Lead pollution is mainly caused by old cars. For a long time, the adverse health effects of lead were unknown. Lead can cause birth defects among unborn babies, and when lead concentrations in a human or animal body are particularly high, they might die of lead poisoning (Elsom, 1996)

Air pollutants are characterized according to their origin. Pollutants emitted directly into the atmosphere are known as primary pollutants. Secondary pollutants are those produced as a result of chemical reactions in the atmosphere. The control of secondary pollutants is generally more complicated than the primary ones. This is due to the necessary identification of the precursor compounds and its sources as well as the comprehension of chemical specific reactions that form such secondary pollutants. The control becomes more complex when chemical reactions involve non-linear complex interactions among precursors. Under these conditions, there is no existing direct relationship between the reduction of precursor compounds and reduction of concentration of secondary pollutants. The period of exposure varies according to the standard of each pollutant. Carbon monoxide, ozone and nitrogen dioxide have more immediate impacts on health and need a shorter standard (WHO, 2005)

It is difficult to determinate to what extent air pollution can cause damage. As epidemiological studies have shown, smoking, occupation and diet are factors that influence health in a similar way as atmospheric pollutants do. In any case, a conservative estimate of the costs of the health effects of pollution is stated at US$1.5 billion per year worldwide (WHO, 2005). Additionally, it is estimated that about 300,000 to 700,000 premature deaths per year could be avoided in developing countries if concentrations could be brought to safe levels (Ibid). It is important point to note, however, that air pollution also includes indoor exposure. This turns to note that measures for outdoor indicators are not always the best suited for total exposure (Smith & Akbar, 1999).

The problem of Mexico City

As stated before, cities at high altitude have more severe problems with air pollution, since a higher altitude causes incomplete fuel combustion in engines and higher emissions of carbon monoxide and other compounds. In Mexico City this is a large problem, as the city is surrounded by mountains in a basin of 2,240 meters above sea level. The problem is increased further by other natural phenomena. Firstly, volcanic activity is common in the surroundings of Mexico City, contributing to a poisonous situation. Secondly, the metropolitan area suffers also from very stable air conditions in the urban spots. In winter, thermal inversions trap cold, stagnant air beneath the level of the mountains. Additionally, at day time, photochemical smog is produced by intense sunlight. The high altitude also increases the risk of health damage, due to the relatively low pressure and the ability to have more 'clean' air. According to the latest inventory in 2006, nearly 80 percent of $PM_{2.5}$ and NOx, 45 percent of VOCs and 30 percent of SO_2 emissions has come from mobile sources. (SMA-DF, 2010)

Though Mexico City's geographical location contributes to the pollution of the city, transport has been the primary source of air pollution of the city. Private transportation causes the highest source of contamination. Especially, emissions from gasoline of very low quality increase the problem. During the 1980s, an emission-testing program of 600,000 vehicles was conducted, of which 85 percent failed to meet the standards (Walsh,

1989). The next decade, PM_{10} exceeded the limit during 38 percent of the days of the year between 1996 and 1998, and 6 percent in the year 2000. The largest problems can be found in the north east of the city, especially at peak time (from 10:00 to 12:00 and from 19:00 to 21:00). Nitrogen dioxide pollution was at a relatively constant level during the 1990s, and the standard (0.21 ppm, one hour average) was exceeded 10 percent of the days of the year. Ozone pollution has had a decreasing tendency during the nineties, but it still exceeded the standard (0.11 ppm, 1 hour per year). Carbon monoxide improved substantially in 1995, when the number of violations of the standard was reduced to only 3 percent. Hydrocarbon concentrations were also relatively high (4.805 ppmC), mostly in the form of butane and propane. Higher SO_2 levels are present mainly at from 9:00 to 11:00, and from 21:00 to 1:00. This situation may be due to the use of inappropriate fuels by certain companies. (Center Mario Molina, 2005)

Nowadays, pollution levels in the city have improved, but the number of cars in the metropolitan region of Mexico City has been calculated to be more than 4 million. Also ozone and particle matter remain problematic issues. In 2009, 185 ozone-clean days were registered, which is four days less than in the previous year. Furthermore, 75 days of high levels of PM_{10} were counted (Rivera, 2010). From these numbers, it becomes apparent that, even though the situation might have improved slightly, the problem remains pressing. The Mario Molina Center for Strategic Energy condemns that air pollution in Mexico City has been the indirect cause of 4,000 premature deaths each year. In addition, a recent report conducted by National Autonomous University of Mexico (UNAM), has revealed that inhabitants of Mexico City have a decreased sense of smell, which means they need more concentrations of a certain smell to recognize it than the people from Tlaxcala, a city with similar geographical characteristics, but that is much less polluted (Guarnero & Hudson, 2009). The level of individual risk is determined by diverse factors: genetics, age, nutritional profile, cardiac and respiratory conditions, the use of medicines, daily activity and place of work. In general, the more risk-prone people are children younger than 5 years, people older than 65 years and people with cardiac and respiratory diseases, including asthmatics. The exposure to pollutants is classified in chronic and acute categories, according to the period of exposure and the concentration of pollutants. The

acute exposure involves elevated concentration of pollutants in a short time, causing systemic damage. Chronic exposure involves long term exposure to relatively low concentrations of pollutants, which gradually affects human health as a consequence of accumulation, interaction and recurrence. The most studied effects related to acute exposure are a decrease in the lung function, an increase of respiratory problems and mortality (Pro-air, 2002-2010). A global comparison of key pollutants can be seen in figure

Sector	Tons/ year (%)				
	PM_{10}	SO_2	CO	NOx	HC
Fixed Sources	3,093 (16)	12,442 (55)	9,213 (0.5)	26,988 (13)	23,980 (5)
Area Sources	1,678 (8)	5,354 (24)	25,960 (1.5)	9,866 (5)	247,599 (52)
Vegetation and soil	7,985 (40)	No existence	No existence	3,193 (2)	15,669 (3)
Mobile sources	7,133 (36)	4,670 (21)	1,733,633 (98)	165,838 (80)	187,773 (40)
Total	19,889 (100)	22,466 (100)	1,768,836 (100)	205,885 (100)	100

Table 4.2. Total emission of pollutants according to its source, 1998. Source: (PROAIR, 2002-2010)

Type of vehicle	2000	2006	2010
Private cars	3,083,383	4,065,964	4,975,995
Taxi	109,654	110,456	111,046
Minibus	34,586	27,720	25,069
Gasoline buses	164,065	195,902	220,490
Diesel buses	18,088	20,965	23,185
Gas buses	29,968	29,968	29,968
Motorcycles	72,704	72,704	72,704
Total	3,513,448	4,523,949	5,458.457

Table 4.3. Projection of vehicular fleet for México City 2000-2010. Source: PROAIR 2002-2010

	SO2	PM	Pb	CO	NO$_2$	O$_3$
Mexico City	Severe	Severe	Heavy	Severe	Heavy	Severe
Buenos Aires	Low	Heavy	Moderate	Severe	Severe	Severe
Beijing	Severe	Severe	Moderate	Low	Moderate	Heavy
Cairo	Low	Severe	Severe	Heavy	Low	Low
Seoul	Severe	Severe	Moderate	Moderate	Moderate	Moderate
Karachi	Moderate	Severe	Severe	Low	Low	Low
Jakarta	Moderate	Severe	Heavy	Heavy	Moderate	Heavy
L.A. & Sao Paulo	Moderate	Heavy	Moderate	Heavy	Heavy	Severe

● Severe   ● Heavy   ● Moderate   ● Low

Table 4.4. The Most Polluted cities in 1995. Source: (Mage D. et al.1996)

4.3 Climate change

There is an urgency to understand the difference between pollutants and greenhouse gases. Especially anthropogenic climate change, resulting from greenhouse gases as CO$_2$, N$_2$O, CH$_4$ and CFCs, has caused an increased global concern in the recent years. Scientists have presented several reports, showing the rise of temperatures in the air and ocean, the melting of ice on the poles, and the elevation of the average sea level. Therefore, the contribution of greenhouse gas emissions from motorized vehicles to the atmosphere has become a key area of mitigation in the clean development for cities. 23 percent of all CO$_2$ emission comes from transport. Out of these, 73 percent account for road transport worldwide (IEA, 2009).

Transport has become the largest and fastest-growing sector in terms of both energy consumption and greenhouse gas emissions in Mexico, accounting for about 18 percent of

total greenhouse gas emissions considering road, rail, air and water, whose road was only 90 percent of the sector's CO_2 emissions. Between 1996 and 2006, Mexico's vehicle fleet nearly tripled, increasing from 8 million to more than 21 million vehicles. Energy use by road transport in Mexico increased more than fourfold between 1973 and 2006. The importation of used vehicles from United States has been an important factor behind the growth of the vehicle fleet, which has also led to an increase in the average fleet age and concerns about low gas mileage and high emissions of air pollutants (World Bank, 2009). The emissions of greenhouse gases in Mexico City was calculated to be of 20,836 million tons of CO2 eq, of which 18,460 millions of tons were CO2, 347 millions of tons of CH4, and 743 millions of tons of N2O (SMA, 2008). The modal share is shown in figure 4.2.
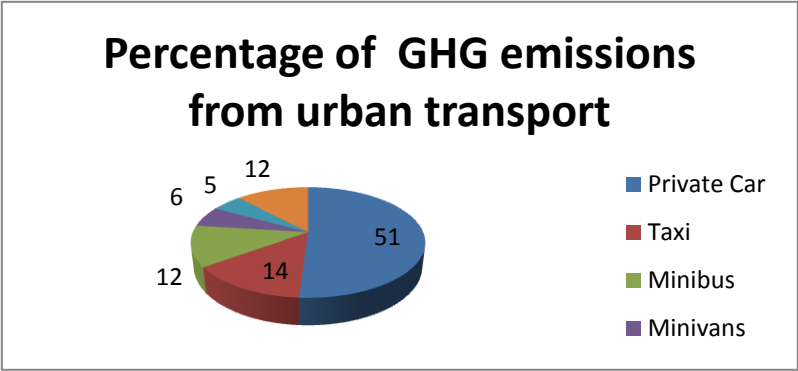
Figure 4.2: Source: SMA (2006), based on IPCC methodology

4.4 Achievements in the cleaning of the air

4.4.1 PICCA Program

After Mexico City was declared the most polluted city in the world in 1992, the public authorities were obliged to take actions of abatement. The reputation of the city was very low and the government of the city started taking measures with technological innovations and restrictions.

Authorities were obliged to launch a program which was called Integral Program for the control of Atmospheric Pollution (PICCA). A relevant achievement of this program has been the introduction of catalytic converters. The use of reactive and toxic compounds in

the gasoline became restricted. In 1993, a low-sulfur diesel was commercialized, and more restrictive vehicle norms were implemented, which in turn leaded to a fast implementation of cleaner vehicles. The fuel oil was substituted by natural gas in thermo-electric plants and main industries of Mexican Valley in 1992. Measures to control evaporative emissions in distribution station of gasoline were also introduced. One of the major resonance measures was the definitive close of an oil refinery in north of the city, which was one of the major sources of pollution. With these measures, PICCA achieved substantial improvements in the air quality, mainly in lead and sulfur dioxide contamination. Since 1992, PICCA ensured that the concentration of these pollutants became below the standard and that carbon monoxide does only overpass the standard in a reduced percentage of days. (PROAIR, 2002-2010)

In 1992, another program fighting pollution was introduced. Car use was banned during one working day every week, with the aim of diminishing the number of cars driving in the city. The last number on the license plate determines which day the car must stay parked. Though later on this initiative became a success, initially it had an adverse effect on pollution levels. This was because it persuaded high social classes to buy more cars (which sometimes were more pollutant) to be able to keep the ability to drive every day. By the mid 1990s, however, some changes were introduced to the program, including the implementation of a "Transfer Zero". This allowed new, less pollutant cars to be exempted from this program. In turn, it promoted the renovation of the vehicle fleet and the use of several non-pollutant filters (GDF, 2010). The way of operation of this program is based on a "Vehicle Verification", which can be described as a check-up of the car to verify whether the car is within acceptable levels of pollution.

4.4.2 Pro-Air Program

The fundamental purpose of the Pro-Air Program was to improve the air quality for the decade 2000-2010. Hence, this ten-year program can be seen as an improved continuation of PICCA by reducing emission concentrations in the main pollution sources and to prevent future contingencies that could provoke environmental damage and health

problems. The Pro-Air program incorporates concrete measures for the abatement of pollution. Its main goal is to establish the relationship among sources of pollutants and the impact upon air quality and health.

The main environmental Mexican law, the General Law of Ecological Balance and Protection to the Environment (LGEEPA) states that authorities must execute programs of pollutant reduction within the powers of federal jurisdiction and that they should coordinate their activities with other related "2010 EM10 David Jones.pdf" offices. The legal framework for air quality sustains the focus of coordination of three governmental levels committed to elaborate Pro-Air programs because of the necessity of synergy with common and congruent objectives. In the transport sector, the technological improvement and modernization has been done through retrofitting of systems of emissions control, installation of catalysts in gasoline vehicles, retrofitting of trap for diesel vehicles, substitution of motors and motor trains in diesel vehicles, conversion of natural gas compressed with certified systems, regularization of the use of liquefied petroleum gas, detention and retirement of pollutant cars, substitution of public service's fleet that do not meet environmental and safety standards. Some other economic measures have been deployed, such as taxes on petrol in order to cut car use. However, in the field of transport planning, the municipalities of the metropolitan area have an important function in order to create common policy initiative (Hardoy et al., 2001). The extent of pollution also depends significantly on the place and the time of year. Large cities with a high concentration of motor vehicles where local conditions allow the pollutants dispersion are more likely to suffer from this problem.

4.5   The Bus Rapid Transit in perspective

4.5.1   The history of BRT

The definition of the Bus Rapid Transit (BRT) is described as "a flexible, integrated, high performance transit system with a quality image and a strong identity" (Levinson 2008, p2). It is a sophisticated bus system with its own lanes in the city streets. It works with bus

stations instead of bus stops, a kind of design that allows passengers to pay before boarding the bus. The BRT allows faster boarding than stations with bus floors, so that passengers do not require to climb steps to enter the bus. Another advantage is the use of electronic signage to inform passengers when the next bus arrives (FTA, 2004)

BRT combines the speed, efficiency, safety, reliability and amenities of the railway system, but with the flexibility of road transport. A given BRT corridor application encompasses route segments of vehicle operation, where the spatial nature of transit demands change, and BRT adapts to dynamic conditions. The main concepts of BRT are dedicated bus-ways, limited stop with express services and exclusive bus lanes (FTA, 2004).

Table 4.5. Major Factors of BRT

Major Elements of BRT	System Performance	System Benefits
• Running Ways • Stations • Vehicles • Fare Collection • Intelligent Transportation Systems (ITS)	• Travel Time Savings • Reliability • Identity and Image • Safety & Security • Capacity	• Ridership • Transit-Supportive Land Developent • **Environmental Quality** • Capital Cost Effectiveness • Operating Efficiency
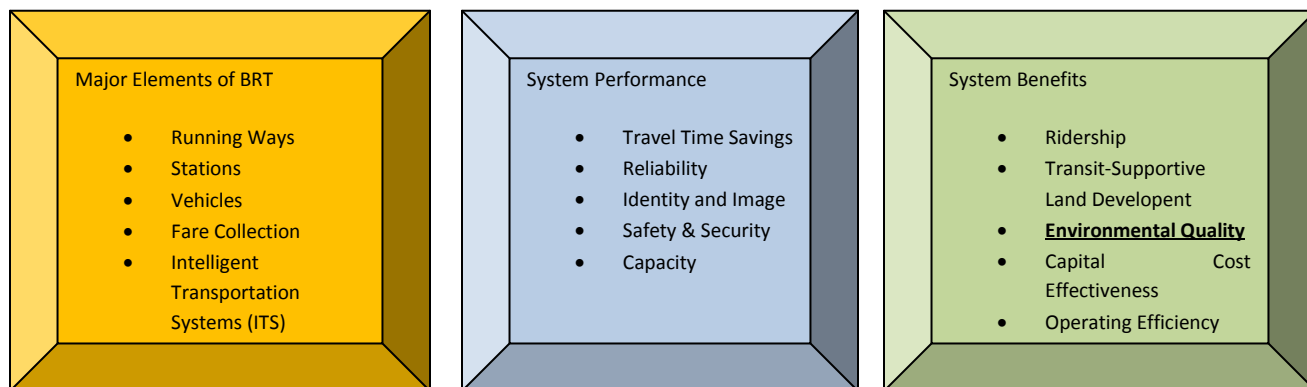
Source: Characteristics of BRT decision making. FTA, 2004.

There are two major advantages of the Bus Rapid Transit System when compared to rail transport. Firstly, building costs of the BRT system are 10 times lower than that of railroads. Secondly, it is faster to implement such a system and it leads to immediate positive results in terms of time and satisfaction of passengers.

When discussing transportation systems, the primary way to improve the environment is through reduction of vehicular emissions to improve air quality, even though there are also negative impacts in the form of noise and water pollution. Some of the mechanisms for reducing pollution are:

- Technology Effect: The use of larger and fewer vehicles; propulsion systems, fuels, and pollution control systems with less emissions (FTA,2010).

- Ridership effect: Atraction of riders to BRT through improved performance: travel time saving, reliability, safety and security.(FTA,2010).

- System effect: Reduction of conflicts between BRT vehicles and other traffic to reduce emissions from all vehicles. Attraction of rides to BRT that reduce overall system congestion. Segregated running was decrease emissions through more efficient speeds and fewer stops. (FTA,2010)

It leads to a cleaner air due to lower pollutant emissions as well as better efficiency. Additionally, emission control systems are changing dramatically. The vehicle manufacturing industry is also changing as a result of stricter environmental regulations. The EPA heavy-duty engine regulations of 2007 and 2010 require an 80 to 90 percent reduction in PM and NO_X for engine exhausts. They also require continual maintenance to ensure emissions will not exceed the limit as a result of deterioration. In 2007, the certification requirements are 0.01 and 0.02 grams per brake-horsepower-hr for PM and NOx, respectively (FTA, 2004). More environmental advantages offered by BRT are the efficiency in its fuel economy, noise-sound attenuation, and emission of greenhouse gases.There are, however, also disadvantages of the BRT system. Firstly, the system makes use of vehicles that are more polluting than electric trams. Secondly, there is less capacity and speed in relation to the subway. Thirdly, there is a possibility of traffic disruption and accidents with other vehicles. Finally, the high-weight travel in the wheels can cause deterioration of the roads and the slabs. (Bañobre & Romero 2008)

Not everyone is enthusiastic about the introduction of the BRT system. Sometimes, responses are positive, but at times, the system faces fierce opposition. Much heard criticism comes mostly from transport companies who do not want the status quo to change. As the number of BRT drivers is much more limited than under the common bus system, many people fear losing their jobs once BRT is introduced. Others are more positive towards the introduction of this new system: 'Normal' bus drivers usually

compete for more passengers and stop anywhere where they can get more passengers, resulting in a higher risk of accidents. These bus drivers also drive longer journeys. The BRT system, on the other hand, offers a better income to bus drivers. For example, a BRT driver can earn more money with an eight-hour journey than a normal bus driver with a sixteen-hour work day, as it was the case in Bogota, Colombia (Bañobre & Romero, 2008).

4.5.2   The case of Curitiba

The city of Curitiba located in the southern state of Paraná in Brazil was the point of departure of the BRT system. During the first half of the 1970s, the rapidly growing urban sprawl and congestion of Brazilian cities was ever-increasing. This provided an incentive for experts in urban planning to transform the transportation systems in these cities. The main priorities for Curitiba were focused on transport, land use and zoning of the city. In 1965 a regional transportation plan with strong developmental policies was established. The challenge would be to encourage more sustainable growth patterns and to support a strong public transit system. The plan was based in a city with four radial corridors that would put up the burden of growth and regional development. Curitiba opted for a Bus Rapid Transit system. Whereas, an underground Metro was priced at approximately $60 million to $70 million U.S. dollars per kilometer, the lines of the bus would be only $200,000 U.S. dollars per kilometer (Miller & Buckley 2000)

In 1979, planners created a line that connected urban neighborhoods without passing through the city center. Herewith, distant locations were connected. In 1988, bigger buses with a capacity of 170 passengers were introduced. Later on, in 1992, the operation of bi-articulated buses with a capacity for 270 passengers was launched with loading and unloading stations at the same level. Currently, Curitiba has several lines that interconnect, including schools, hospitals, city parks and tourist attractions. The number of people that uses the bus every day amounts up to 1,645,000 passengers. The process to introduce this system has, however, not been easy. The major of the city at the time, Jaime Lerner, issued little money for the introduction. Therefore, the initiators of the

system had to overcome these restraints with creative ideas. Furthermore, opposition groups made sure certain adjustments to the system were made (Rojas & Mello 2005)

Figure 4.3 The first Bus Rapid Transit System was in Curitiba, Brazil. Photo by Thomas Hobbes. Source: EMBARQ

The institutional arrangement comprehends a public-private partnership where ten private companies that operate the buses are paid by distance traveled rather than number of passengers which balances distribution of bus routes and avoids clogging of main roads. (Groodman & Laube 2006). Curitiba has been gradually expanding and upgrading its system as finances permit and demand is warranted. The government has been a strong actor that has instituted a strong control of land use, something that has encouraged development patterns along structural axes that reinforce and encourage use of the bus system. (Miller & Buckley 2000)

Montaner (1999) describes the city as an "ecological model that justifies development, growth and enrichment", by urbanizing the big avenues of the buses, where the operation

system has synchronized traffic-lights, and "tube" stops where the pre-paying ticket allows faster boarding by a platform that is deployed , working with the speed and efficacy of a subway. Curitiba's transport system has one of the highest public ridership in compare to other Brazilian cities (about 2.14 million daily passengers). The city registers the country's lowest rates of ambient pollution and per capita gas consumption. (McLeod, 2002). In addition, a network of 28 parks and wooded areas are placed around Curitiba. Builders get taxes discount if their constructions include green areas. Dangerous flooding is being avoided by diverting water into new lakes, which also protects the valley floors and riverbanks. Curitiba has a program of employment that takes into account social inclusion called "green exchange" that shares benefits to both the people and the environment. Low-income families can exchange their trash bags for bus tickets and food, which means less garbage dumped in sensitive areas. Retired city buses are normally reused as classrooms, offices, small markets. Downtown areas are totally pedestrian streets, including a 24-hour mall with cafes, shops and restaurants (Ibid).

The strategic vision of this particular Brazilian city was materialized by Jaime Lerner, a professional urban planner who led the transformation: "There is no endeavour more noble than the attempt to achieve a collective dream. When a city accepts as its mandate its quality of life; when it respects the people who live in it; when it respects the environment; when it prepares for future generations, the people share responsibility for that mandate, and this shared cause is the only way to achieve that collective dream" (McLeod, 2002)

Thanks to the initiative taken by Curitiba to transform urban transportation with the use of the BRT system, the city has gained much international recognition. For example, the chairman of Habitat II, the United Nations Division on Human Settlements, has termed it as one of "the most innovative cities". Furthermore, it is the only city in a developing country that appears on the list of the most recent studies of urbanism and transport, which explains the possibility that developing cities can be successful in achieving sustainability (Rojas & Mello, 2005).

4.5.3 The case of Bogota

The second city in the world that implemented the BRT system was Bogota, Colombia. During the last three decades previous to the year 2000, the collective system of urban transport was organized by private companies, they allowed bus owners to operate in their routes exchanging a lump sum for affiliation and a monthly fee. The bus drivers were sometimes hired by small external investors, but most of the times the owners of the bus were the drivers themselves. This issue particularly meant that the operation was totally assigned to the bus driver. The drivers were competing through the streets of the city to get as much passengers as possible, which was detonating a dangerous way of driving often materialized in accidents (Valderrama 2010, p. 133). This issue was denoted as "The war for the penny" (Ardila-Gómez, 2004) which was identified as one of the main problems of the transport system. In 1998, 22,000 old buses were owned by more than 25,000 persons engaged in some of the 68 companies. (Valderrama 2010, p. 134). The system was oversupplied with normally semi-empty, slow and pollutant buses, service of low quality, and widespread inefficiency. 70 percent of air pollution in the central corridors were coming from traffic jams. (Echeverry et. al 2005)

In December of 2000, Bogota's major Enrique Peñalosa applied the BRT model to his city in a project, which by now is widely known as "Transmilenio". Seven corridors and 42 kilometers of primary road were established across the city (EMBARQ, 2010). The main technical difference to Curitiba's model is that the buses run in the middle of the road in dedicated lanes with only one station that serves both directions. The bus contains four sets of doors on the left side that match to automatic sliding doors at the stations allowing passengers to enter and to abandon the bus. The system also contains lines of conventional buses that feed passengers at the end stations which concentrate more demand, as usual as in subways. Private transport companies operate the buses, but they are coordinated by the public agency Transmilenio S.A. (www.transmilenio.gov.co).

The support of the national government for the new transportation system in Bogotá was a key issue in the willingness to partly finance the associated infrastructure investments,

and they became a critical argument to convince transporters that they were in right time for a reform.

Figure 4.4. Transmilenio stop in Bogota. Photo taken from www.cmi.com.co

The Transmilenio project has been very successful, with new routes continuously being added to the existing lines. It is estimated that 20 percent of current passengers of Transmilenio used to be car drivers before its introduction. This has resulted in a reduction of emissions by individual modes of transport as well as less traffic congestion in general. The significance of Transmilenio is that it gained international recognition, and showed a positive example of how an energy efficient transportation system can successfully be implemented in a developing country. Transmilenio started operating in the year 2000 under a public-private partnership. The public sector was responsible for the

infrastructure, while the private sector controlled the bus fleet, including ticket sale and operation of the system.

In 2005, Transmilenio became the first Clean Development Mechanism project in the transport system, and received emission reduction certificates in 2006. By that time, it had reduced the emission by 95,567 tons of CO_2equivalent. After 2006, the emission has continued to decrease. Currently, phase II, III and IV are generating carbon credits (Grutter Consulting, 2008) The BRT system has had an overall positive effect on the city. By offering an attractive and modern transit system while reducing the economic costs of congestion, Bogota is benefiting from an improved competitive position on the macroeconomic level (Ibid). Another environmental benefit of Transmilenio was in particulate matter and ozone, Mendez analyzes the impact of pollution programs near Transmilenio corridors. She denotes the implementation of three policies (restrictions in the use of private car, compulsory inspections and Transmilenio project) and then estimates time series regressions to forecast the progression of pollution levels with these policies. Her results reveal that TransMilenio is quite significant in compare to the other policies in terms of solving pollution. While compulsory inspections reduced 13.6 percent and restrictions in the use of private car reduced 21 percent of ozone levels. The first phase of Transmilenio produced a 28.8 percent decline only in ozone levels. (Echeverry et al. 2005)

The success of Transmilenio can also be measured by the popularity rating of the former, mayor Peñalosa. When he left his office, he received a record approval rating. His strategy was considered positive in the sense that he created a "city environment where the majority of people will be as happy as possible". Some other important achievements were the creation of more public spaces, by reconstructing public parks, implementing car-free streets in the city center and the creation of cycling lane (Targa & Rodríguez 2004)

5 The initiatives of sustainable transport for Mexico City

5.1 The planning of Metrobus

In 2001, Mario Molina, chemistry nobel award in 1995, recommended to Mexico City's Government to improve the public transport as a requirement to attend the problem of air quality, the suggestion was attached as one of the priorities for attending the problem in the Program for Improvement of Air Quality in Mexico City Pro-AIR 2002-2010. In addition, the BRT was part of the Integral Road and Transport Program of Mexico City, published in 2002. (SMA-DF, 2010).

In May of 2002, the government of Mexico City and EMBARQ-The World Resources Institute Center for Sustainable Transport signed jointly an agreement of cooperation for the construction of a corridor system BRT for a five-year project (2002-2006). As a result of this cooperation there was created the Center of Sustainable Transport (CTS) of Mexico City as one of the programs of the NGO Interdisciplinary Center of Biodiversity and Environment (CeIBA), with funds from The Global Environmental Fund, Shell Foundation, and the construction would be co-financed by the World Bank and Mexico City's government (Interview 1). The proposed model would be based in the city of Bogotá rather than Curitiba, CTS first director Jose Luis Samaniego mentioned that Curitiba's model considers roads wide enough for two segregated confined lanes that was more paradigmatic for urban planners, and Mexico would have to adapt their roads, something that would be very expensive. In September of 2003, the first route was designed in Insurgentes Avenue, and the construction started one year later. (Sosa, 2004)

The BRT of Mexico City in its conception had two main components, one was the mobility of citizens by guaranteeing faster and more safe trips and reducing travel time by improving connectivity to other transport shares. The other one was the environmental dimension, and the impacts upon the construction of the stations, specifically the project would support aspects of the Pro-Air Program previously mentioned. The government was needing to promote a modal shift of passengers under more efficient use of infrastructure and to move passengers in an integrated mode with the metro at higher speeds, lower costs per passenger and lower emissions per passenger kilometer. It would also be an important challenge for improving the institutional coordination and for holding a sustainable business environment with organizational measures and incentives that would promote the transport corridors. Another important issue would be an action plan to promote the use of non-motorized transport such as bicycles and walking to the bus

stations (Vergara, 2002). The challenge was how to sell the project in an efficient way, and what would be necessary for its implementation (Interview 1, 2010)

The project would be mainly promoted by the Secretary of Environment of Mexico City and its leader Claudia Sheinbaum, and would be performed under several important indicators: a) the harmonization of sector planning in the environment, transport and urban development related to air quality measures; b) the adoption of a Climate Change plan in transport, c) the organization of a plan for possible barriers; d) and the increase in the use of high capacity vehicles as well as the promotion of public awareness of the high advantages of use of the new corridors. (Vergara 2002).

The new BRT buses would be Euro III and Euro IV[2] Diesel buses. The emissions of BRT buses would be significantly lower compared to conventional buses[3] operating during that time in Mexico, which one third were Euro I or elder and around 50% less than Euro III (Grütter Consulting, 2010). The project selected advanced diesel buses from other alternatives such as, CNG and hybrid[4].

The project would function as an enabling environment and integration of urban planning, air quality management and sustainable transport strategies into the development, evaluation and monitoring of a Metropolitan Climate Change Action Plan. (Vergara, 2002).

5.2   The implementation of Metrobús

In March of 2005 the Major of Mexico City, Andres Manuel López Obrador created *Metrobús* as a new decentralized public organism from the Ministry of Transport of

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[2] Ultra low in sulfur contain.

[3] Conventional diesel buses: produce significant amounts of pollutant emissions – especially particulate matter (PM) and nitrogen oxides (NOx)- that cause deterioration of air quality with resulting adverse impacts on public health.

[4] Advanced Diesel Bus: equipped with a good technology on emission control, such as filters and catalysts, becoming cleaner than conventional diesel buses. A low-sulfur diesel fuel is required by this bus, which is more expensive. A widespread distribution of low-sulfur diesel is expected to be one of the future challenges.

CNG Bus: it means (Compressed Natural Gas), which is mostly methane CH_4, it burns cleaner with spark-ignition engines than with diesel fuel. A recent test in Australia has reported that the CO_2 equivalent reduction compared to diesel is 17%-25%. Another advantage is the low sound technology, and its extraction from the nature. It is employed in a lot of cities around the world. One of the main barriers is the lack of fuelling infrastructure.

Hybrid Bus: It uses two different energy conversion systems. Normally, an internal combustion engine with a battery and electric motor that lowers the demand placed on the first power source. It reduces emission mostly in its fuel efficiency. It has received also some critics, a recent study by the University of Connecticut measured the particulate emissions from two hybrid transit buses and two conventional diesel buses, the results showed no decrease in both of them and the necessity of using diesel particulate filters. (Clean Air Initiative of the World Bank, 2010, URL)

Mexico City, with the objective of planning, management and control of the System of Corridors of Public Transport of Passengers of Mexico City. (Gaceta Oficial del Distrito Federal, 2005)

In June of 2005, the first bus started operating under the name of Metrobus. The line 1 or red line comprehends 45 stations along 28.1 kms, it has two main corridors moving south-north direction: *Metrobús Insurgentes* and *Metrobús Insurgentes Sur*. Insurgentes Avenue is the largest avenue in Mexico City, it serves some of the city's most important locations, such as the World Trade Center complex, universities and numerous residential buildings and commercial centers. The line 2 or purple line was inaugurated in December of 2008, it comprehends 36 stations along 20 kilometers in east-west direction, the name of the corridor is *Metrobús Eje 4 Sur,* and it is connected to the line 1 in one of the stations. *Metrobús* assigns and distributes to 7 different concessions or transport companies that own the buses. In March 2010, it was started the construction of a new line 3, with the support of the government, with a corridor called *Eje Troncal Metropolitano* (Metrobus, 2010)

The stations were installed every 400 meters with the objective of minimizing the cost. In difference to Curitiba's circulation[5], the BRT circulates over the central confined lanes, with the station located over the central ridge of the avenue, therefore, the access and exit to the unit are situated in the left side of the bus (Negrete, 2006)

The project was thought since its conception to be validated as Clean Development Mechanism for reductions in emissions from bus operations. Metrobus earned US$145,885 from the Spanish Carbon Fund in the system's first year of operation. (Shell Foundation, 2010). However, carbon revenues were not particularly significant In relation to the whole cost of the project (Interview 1, 2010)

One of the main improvements was the use of exclusive lanes in the avenue, which makes to recover the public space. The stations were well implemented with provision of security to users, something that harmonized and integrated its design with the cityscape. The areas where the terminals are located that were dangerous in the past are now more safe. (CTS, 2010)

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[5] Curitiba's buses circulate in the right confined lane of the streets with one station in each side of the street instead of one in the center.

A chronology of the implementation process is explained in the next table:

Date	Issue	Explanation
June 19th. 2005	Inauguration of metrobus	20 kilometers 60 articulated buses 352 substituted buses Handicap access
June 2007	1st. Payment for Emission Reduction	The project was validated as Clean Development Mechanism under Kyoto Protocol
March 13th. 2008	Inauguration of Insurgentes Sur (continuation of line 1)	10 kilometers 19 articulated buses 137 substituted buses 350 thousand passengers/ day
October, 2008	Introduction of bi-articulated buses	12 bi-articulated buses
December 17th. 2008	Inauguration of Eje 4 Sur (line 2)	20 kms 75 articulated buses 350 substituted microbuses 123 thousand passengers / day

Table 5.1 Important dates and events of Metrobus project. Source (CTS, 2009)
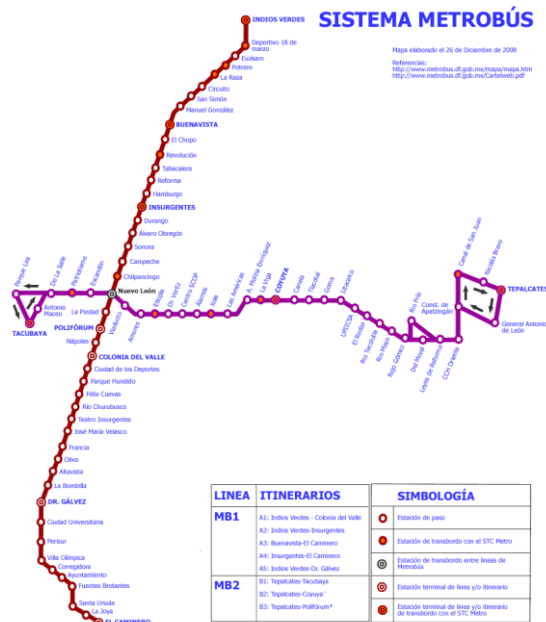
Figure 5.1. Routes of Mexico City's Metrobus Lines. Source: (Metrobus, 2010)

Most of the commuters that were relying on public transport, used previously microbuses and combis (smaller minival-sized vehicles), and also up to 19 percent were using private vehicles (Interview 2, 2010)

In most of the cases, concessioners rented their vehicles to a driver for a certain fee, something that was making the driver to have an irregular income with an informal job. In addition, no planning for mobility requirements across time was a seen as a huge problem of transport concessions, causing an oversupply of service in the routes and a competition for fares with vehicles under poor conditions of maintenance. Metrobus has been a system regulated through an entity that operates with organized concessioners in companies, a prepaid method and with formal employment schemes. (CTS, 2010)

The maximum capacity of the vehicles is of 160 passengers, running at high frequencies, about 46 per peak hour along the northern half of the route. Currently, Metrobus is carrying roughly 500,000 passengers per day. Prior to Metrobus, the trip time was roughly 1.5 hours at an average speed of 14 km/ hour. With Metrobus, the speed has increased to 21 km/hour and the trip time has become only about 1 hour. (CTS, 2010)

The structure has been based on several regulations and decrees and organizational structures generated by a strong institutional understanding among roads and transport, Metro (subway), Network of public transport, Ministry of Finance, Ministry of Environment and the Head of the government. Three years were necessary for all concessioners of the route to be integrated to the system, distributing profits of the business. The prepaid system is based on a card that runs on open source software, generating independence and autonomy. (Sheinbaum, 2009)

In September of 2009, the John F. Kennedy School of Government at Harvard University awarded Mexico City's Metrobus, with the Roy Family Award for Environmental Partnership, for improving the quality of life and mobility options in the Mexican capital. Mexico City's Major Marcelo Ebrard mentioned about plans to expand Metrobús to 10 lines carrying 1.5 million passengers. (CTS, 2010)

Figute 5.2.Bi-articulated bus from Mexico City. Photo taken by Magolis Briones

5.3   Other initiatives for sustainable mobility

5.3.1   Non-motorized Transport

Walking and cycling are the most effective modes of transportation in terms of sustainability, they can provide a large list of benefits to society. Some of these benefits can be explained by the improvement of fitness and health, the economic saving for consumers, the reduction of traffic congestion, the decrease in the number of accidents and the risk it implies, as well as the reduction of energy consumption and pollution (Litman, 2010: 2)

Litman (2010) argues that the ultimate goal of most transport is accessibility[6]. But mobility is only one of the main factors in accessibility; also significant are land use, network connectivity (the quality of roads and paths), as well as the affordability, quality and incorporation of those options of accessibility, i.e. walking, cycling, public transit, taxi, delivery services, electronic communication, etc. By one hand, when there are improvements in relation to the use of automobiles, the benefits of accessibility for non-car users are diminished. For example, the expansion of roadways or the construction of second floors contribute little to improve accessibility, which makes the urban sprawl to create physical barriers to non-motorized travelers. On the other hand, the creation of

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[6] Accessibility is the individuals ability to reach desired goods, services and activities.

compact, mixed, walking and cycling neighborhoods can improve accessibility without increasing mobility.

In the case of Mexico City, most of the people do not possess a car and many public areas in downtown or parks (although quite limited) have been designed specifically for walking, however in relation to cycle lanes, there is little done. The cycler normally has two options, or going through the streets and avenues risking his or her life, or invading the side-walks, which represents a hostile environment for both bicycles and walkers.

In 2004, the government realized about the potential of building cycling paths. The first cycling path was built over the old train lanes from *Tacubaya* to *Polanco* in the west part of the city, together with a second one in *Paseo de la Reforma* (one of the most representative avenues) to *Zocalo* (historic downtown); and a third cycling path communicating the 3 sections of Bosque de Chapultepec (one of the biggest green areas in Mexico City) also in the west part of the city. Some months later, a fourth cycling path was built in the southern part, with a much more rural environment in the middle of crops and forests. Two years later a fifth cycling path was inaugurated, communicating the first one in the west with the fourth one in the rural south and extending to the neighbor state of Morelos. (GDF, 2009)

In addition, the government of Mexico City led by the secretary of Environment has recently started (February of 2010) a program called "Ecobici", that considers 85 stations and 1 114 bicycles. The user can pick up a bicycle in one station and put it back in another station. The routes have been implemented along some central neighborhoods of middle class. The objective was the people to use bicycles for short distances, to park the bicycle in the station for a certain activity and then to use it again to move back to the starting point. There is a program of expansion of the routes that will depend in the success of the first stage. The concept was brought from some European cities that started implementing the program since 1998 and developed by the company Clear Channel, in charge of developing and adapting the concept to Mexico City in expectation of 9,000 thousand daily trips. (Alcócer, 2010)

In addition, Paramo mentioned me that there is also a program every Sunday for cycling in the Reforma Avenue (one of the most representative avenues of the city) where the last time, up to 15,000 responded positively to the program. Among some disadvantages that the specialist from the Center of Atmospheric Science of Mexico University mentioned "walking during some hours in Mexico City Streets can be as the same as smoking 12 cigarettes. And if we go beyond, to walk in the most polluted avenues would mean to smoke 2 packs of cigarettes".

5.3.2   The subway or Metro lines of Mexico City

A metro system is a rapid transit train system. It is defined as "an urban, electric passenger transportation system with high capacity and high frequency of service, which is totally independent from other traffic, road or pedestrians" (Merrian-Webster)

From 1967 to 1972, the construction of the first subway line in Latin America took place in Mexico City. This first stage was characterized by strong participation of different specialist and a French technical assessment. During the last 40 years, the project has been in expansion, The last line to be constructed was the line B, which also connects to the state of Mexico in the west, it was inaugurated in 2000. By this time the system counted with 201.8 kilometers. Today it counts with 9 lines in Mexico City and 2 lines that connect to the State of Mexico. Additionally, some projects in infrastructure of bus stops were being placed in order to connect subway lines with other transport forms. (RTP, 2010)

Currently a line 12 is under construction, which is around 31.5 percent in advance (May 2010). The Metro line connects the lines in the south of the city, it has been mentioned that this line will be one of the biggest of the world. There have been many criticism, due to the Natural Areas that would cross the line, however, Mexico City's major Ebrard, mentioned that they are doing elevated viaducts avoiding environmental impacts with studies and calculations made by experts. (Romero, 2010) . The project is also under planning of Clean Development Mechanism.

The subway of Mexico City transported in 2009 1,414,907,798 passengers with a daily average of 4,352,019 passengers. The tariff is the one of the lowest in the world 0.24 USD. It connects to Metrobus in 15 stations, as well as with Light Train, Tram, and Bus stops. (RTP, 2010)

6   The environmental Benefits of Metrobus from different perspectives

6.1   Evaluation of the Benefits of personal exposition of passengers by introducing changes in public transportation. Individual level

The study of the National Institute of Ecology and the Center for Sustainable Transport measures in another approach the reduction of pollution. The perspective was by total personal exposure to air pollution, i.e. combined concentration of pollutants and the time spent in each environment during a given period of time. In this case, during the transport the population is exposed to a level of atmospheric pollutants inside the bus that can be superior to the ones registered to the monitor stations.

The transport strongly determines the personal exposition, for both elevated concentrations of atmospheric pollutants, and long time of transfer. Several studies have found that between 50 and 89 % of daily personal exposition to particles occur during transport. (Adams et al. 2001; Fitz et al., 2003) on (Wörnschimmel et al. 2005:4)

Their main hypothesis to test was to see if the new transport system would result in a reduction of exposure to atmospheric pollutants. The research team assumed that with better bus technologies, fixed stops, doors of the buses closed (avoiding entry of pollutants), and segregation from the rest of the traffic, the concentration would be less than without exposure (Wörnschimmel et al 2005:5)

The sampled atmospheric pollutants were suspended particles ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO) and benzene (C6H6), their samplings were during morning peak time in Insurgentes Avenue. The experiment was designed for comparing the exposition to the pollutants during 2 stages: before and after the implementation of Metrobus. The sampling pre-intervention in microbuses and buses was from June to August 2004, and the sampling post-intervention of Metrobus was from August to October 2005. (Wörnschimel et al 2005:4)

Their experimental methods employed were with monitor equipments installed inside the buses (Langan monitors, SKC pumps, SUMMA canísters). The hoses of the pumps were collocated in order to have a closer sample to the exposure of the passengers, the Langan monitors were in the back of the seats, and the canisters in the floor. The Langan monitors were used for measuring Carbon monoxide concentrations. The particulates were

measured through gravimetric analysis[7], with the use of the SKC pumps. The benzene was measured through air sampling entering to the canister vacuum with a control valve. (Wornschimmel et al, 2005:9). The table explains in a regular basis their findings.

	Microbus	Bus	Metrobus
Number of trips	36	37	68
Concentrations (median)			
Carbon Monoxide (ppm)	15.8	11.4	7.5
Particulates $PM_{2.5}(\mu g/m^3)$	152.4	128.8	98.7
Particulates $PM_{10}(\mu g/m^3)$	196.3	202.3	183.1
Benzene (ppbv)	10.2	8.9	4.2
Average travel time (minutes)	70.2	73.2	58.2

Table 6.1 Median of pollutant concentration for every bus. Source (Wörnschimmel et al,2010:22)

The hypothesis of the study was confirmed, except for PM_{10}. The higher level of the exhaust in Metrobus than most of the Microbuses, and the less "self-pollution" (generated by the vehicle itself) that penetrates inside the vehicle caused by a defective combustion system or a bad design of the vehicle, were identified as other factors. The reduction of PM_{10} concentrations was not significant, probably due to the fact that around 40% of PM_{10}, is formed by coarse fraction which comes from mechanical processes and not from car combustion. The study also found that the travel time is less, which also decreases the exposure of passengers to those pollutants.

	CO	$PM_{2.5}$	PM_{10}	Benzene	Travel Time
Metrobus vs. Microbus	-53%	-35%	-7%	-59%	-17%
Metrobus vs. Bus	-34%	-23%	-9%	-53%	-20%

Table 6.2 Percentage of Reduction in the concentration medians of CO, $PM_{2.5}$, PM_{10}, Benzene and Travel time compared against Metrobus. Source (Wörnschimmel,2010:23)

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[7] Gravimetric Analysis is a method of quantitative chemical analysis in which the constituent sought is converted into a substance (of known composition) that can be separated from the sample and weighed. The steps commonly followed in gravimetric analysis are (1) preparation of a solution containing a known weight of the sample, (2) separation of the desired constituent, (3) weighing the isolated constituent, and (4) computation of the amount of the particular constituent in the sample from the observed weight of the isolated substance.

6.2 The Benefits and Costs of a Bus Rapid Transit System in Mexico City. Second approach. Regional

In May of 2008, the National Institute of Ecology of Mexico City published a study called "The Benefits and Costs of a Bus Rapid Transit System in Mexico City". The study was basically a quantification of the environmental, economic and social benefits of Metrobus, by quantifying reduction in local emissions and impacts on health, reduction in greenhouse gas emissions, and reduction in travel time along Insurgentes during peak time. Their estimations were from 2005 to 2015, the table 4.4 shows in detail the final reductions on a yearly basis:

Reduction of 144 tons of hydrocarbons
Reduction of 690 tons of nitrogen oxides
Reduction of 2.8 tons of fine particulate matter
Reduction of 1.3 tons of sulfur dioxide
12 new cases of chronic bronchitis, 3 deaths avoided and saving of 3 million dollars in health benefits
Reduction of 280,000 tons of carbon dioxide-equivalent
2 million hours in travel time with a value of $1.3 million U.S. dollars

Table 6.3 Benefits from Metrobús for each year . Source: Stevens et al,2008

The scope of my explanation of this study will be just the change in emissions of greenhouse gases and local pollutants, my main aim by analyzing this case study is to learn and have an insight of the main factors that affect pollution.

They used a travel demand method that quantifies changes in emissions and travel times, evaluating a system of 33 corridors extending throughout the metropolitan area. They calculated the difference between the situation with the BRT and the situation without the BRT or baseline scenario that was calculated from vehicle activities and average speeds prior to the project corridor in 2004. Their projections were calculated from 2005 to 2015. And they measured mainly three variables: total vehicle kilometers traveled per year, total fuel used per year, and average vehicle speed. (Stevens et al. 2008:5)

Schipper et al, (2009) argue that information on the vehicle fleet composition (models, types, fuel economies) could have been a huge task, because it would require to gather data in particular routes for a long time. The age and types of cars on Insurgentes was estimated from photographs of the traffic at different times of the day, and fuel was determined with this methodology, rather than with the citywide average fleet.

6.2.1   Baseline scenario
The baseline scenario is the one which would have occurred in the absence of the project.

- *Buses and Microbuses.* For the establishment of the baseline scenario of buses and microbuses the data used (Table 6.4) was based on the number of buses and microbuses replaced by articulated buses, average number of kilometers per day per vehicle type (km/day), average traveling speed (km/hour) and average fuel economy[8] (km/l) or (km/m3) for natural gas. (Stevens et al. 2008:10)

Fuel type	Buses	Microbuses		
	Diesel	Gasoline	Liquid Petroleum Gas (LPG)	Compressed Natural Gas (CNG)
Number of Vehicles	277	29	54	7
Activity (km/day)	140	130	130	130
Average Speed (km/hr)	17.4	17.4	17.4	17.4
Fuel Economy (km/l)	1.53	1.95	1.141	2.2 km/m^3

Table 6.4. Number, activity level, speed and fuel efficiency of vehicles that were replaced with the Metrobus corridor. Source: Stevens et al. 2008:10

They measured the number of buses and microbuses and the activity before the inauguration of the BRT. The average speed was estimated by taking the mean speed in a peak hour during school vacations in a yearly basis. The fuel efficiency was measured using the values reported by the Intergovernmental Panel on Climate Change (IPCC). There was an agreement between the local government and the operators about removing the same quantity of buses –although not the same ones- from any route of operation. (Stevens et al. 2008:10)

- *Mode change.* The baseline scenario of the mode change means basically the quantification of passengers who used to drive a private vehicle or take a taxi and have switched to the use of the BRT. The research team conducted a survey in order to evaluate the performance of the system, where 1,622 commuters at all the stations answered the survey. They found that 4.6% of BRT users were previously using a private car, and 1.8% were using a taxi. They calculated the reduction of gasoline private car kilometers traveled by using these data. Their results had a margin error of 2.9%. Metrobús reported that average weekday demand was 230,000 trips, with a decrease in demand of 40% for Saturdays and 60% for Sundays. They observed the average speed prior to the implementation to be 22 km/hr. The employees mentioned that the average trip length was about 7 km, which would be assumed to be the same for private cars. They assumed the

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[8] Fuel economy is the relationship between distance traveled by an automobile and the amount of fuel consumed

fuel economy to be 7 km/l taken from the CDM analysis. The vehicle kilometers estimated a reduction of 32 million of kilometers per year. (Stevens et al. 2008: 12). They also did not consider a possible switch from Metrobus to private car, because the system had in general a positive approval process.

6.2.2 BRT Scenario

The BRT scenario was taken from the new 89 articulated buses. They projected a travel average of 243 km/day, after taking into account reserve vehicles, weekends and holidays. The fuel economy was assumed to be 1.1 km/l. The projected velocity was 21 km/hr. The difference in vehicle kilometers traveled (km), change in fuel use (L) and average speed (km/hr) was quantified. They used a model from the inventory to calculate emission factors for $PM_{2.5}$, nitrogen oxides (NO_X), and total hydrocarbons (THC). They considered projected changes in fuel quality and vehicle emission standards, mainly a reduction in fuel sulfur levels and technologies in the vehicles. Emissions of sulfur dioxide were calculated using mass-balance[9]. Mean fuel sulfur content was considered depending on the fuel (i.e. gasoline, diesel or gas). Finally, they used emission factors from IPCC, for calculation of greenhouse gases. Fuel densities sold in Mexico City were also considered. The fleet's age distribution was projected using Mexico City's 1998 emissions inventory. Finally they calculated the change in emissions in table 6.5. (Stevens et al. 2008:12)

Vehicle Type	Change in VKT (km)	Change in Fuel Use (L)	Average Speed (km/hr)
Metrobús	6,800,000	6,200,000	21
Diesel Bus	-14,000,000	-9,300,000	17.4
Microbus (Gasoline)	-1,400,000	-710,000	17.4
Microbus (LPG)	-2,600,000	-150,000 m^3	17.4
Private Vehicle	-23,000,000	-3,300,000	22

Table 6.5 Annual difference in vehicle kilometers traveled and fuel use, 2005-2015, metrobus scenario less baseline scenario. Source: Stevens et al. 2008:13

Equation for calculating change in emissions for pollutants PM, NOx and THC

$$E_k = \Sigma \ \Delta KRV_i \ x \ FE_{ik} \ x \ N_i$$

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[9]Mass balance is an application of conservation of mass to the analysis of physical systems. By accounting for material entering and leaving a system. The exact conservation law used in the analysis of the system depends on the context of the problem but all revolve around mass conservation, i.e. that matter cannot disappear or be created spontaneously.

Where:

E_k = Total vehicle emissions of contaminant k (g/year)

ΔKRV_i = Change in average vehicle kilometers traveled for vehicle type i, (km/year)

FE_{ik} = Emission factor for vehycle type i, of contaminant k (g/km)

N_i = Number of vehicles (or number of trips) of type i

6.3 The Project Design Document of Metrobús as Clean Development Mechanism. Global Level

The Metrobus was validated as Clean Development Mechanism under the Kyoto Protocol, the Project Design Document was prepared by the Swiss Consultancy office specialized in Carbon finance Grütter Consulting, who made a much more comprehensive study than the previous ones explained. I would like to give an overview of their key considerations for reducing greenhouse gases. The calculation in the document estimated a yearly average of 70,303 tCO_2 that would be avoided from 2011 to 2017, the PDD was a renovation of the first 5-year period (2005-2010) (Grutter Consulting 2010:6)

The project considered also the Baseline and Metrobus Scenarios, but they also made a leakage calculation (i.e. changes of congestion and speed resulting potentially in a rebound and a speed effect plus potential change of load factors of remaining buses and taxis in the city. The emission reduction considers three key factors: improved efficiency (cleaner buses than the old ones); mode switching (attractiveness that induces users of private cars, motorcycles and taxis to the use of articulated buses); and load increase or change in occupancy (with a centrally managed organization dispatching buses, thus, differing from a large number or private companies competing for the same passengers resulting in an oversupply of buses and low rates of occupation).

The baseline emissions were calculated per passenger surveyed by: Identifying all relevant categories of vehicle (including non-motorized transport); determining the emissions per passenger kilometer[10]; determining the average occupation rate (based on visual occupation studies); and determining the emission factors per kilometer (fuel types for each vehicle category). (Grütter Consulting, 2010: 9). The baseline scenario is comparable to the situation prior to the project. "The baseline scenario however incorporates technological advancements in terms of emissions per distance driven of various modes of transport as well as eventual fuel changes of baseline modes of transport during the project activity"(Ibid:4). The project emissions were based on the fuel consumed by the

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[10] Passenger- kilometer is the average passenger trip distance multiplied by the number of passengers

BRT buses (direct project emissions) plus emissions caused by passengers from their trip origin to the entry station of the BRT and from the BRT to their final destination (indirect project emissions). (Grütter Consulting, 2010:12)

Year	Annual Estimation of Emission
2011	72,171
2012	71,852
2013	71,231
2014	70,526
2015	69,654
2016	68,779
2017	67,904
Total estimated reductions 1st crediting period (tonnes of CO2eq)	492,118
Total number of crediting years (1st crediting period)	7
Annual average over the crediting period of estimated reductions (tCO_{2eq})	70,303

Table 6.6. Estimation of reductions for Metrobus. Source.Grütter Consulting 2010

They considered only CO_2 and CH_4 as greenhouse gases. CO_2 as a major contributor, and CH_4 was included only for gaseous fuels. Both CH_4 and N_2O emissions are less than 2% of total GHG emissions from diesel and gasoline vehicles, and therefore, excluded from total emissions. (Grütter Consulting, 2010:4)

6.4   Discussion over the 3 studies of pollution reduction:

The three methods and results are completely different in results and objectives, however the three of them show in detail analysis of how the new transport system has reduced pollution significantly.

The study of personal exposure to pollutants inside the buses, gives the more exact and reliable data, and clearly shows the concentration of pollutants in the air during that specific time at that specific place, the study is a perfect tool for policy makers, which serves to evaluate the environmental benefits of the BRT, however, the study could be interpreted in different ways, for example, if a public transport user sees the same study, he could assume that being both outdoors and inside the public transport is dangerous, therefore, he will switch to drive a private car.

The study of benefits and cost of Metrobus comprehends different pollutants that have been avoided. The study is basically something that the pioneer in this kind of studies, Dr. Lee Schipper from Berkeley University has called "Measuring the Invisible", that also

serves as a tool for policy makers to know about the environmental, economic and health benefits of a Mass Rapid Transit Projects to a more regional level, however the study values are considered under a lot of assumptions, sometimes not very reliable. For example, the amount of CO_2 equivalent calculated is much more significant from the CDM study (280,000 tons of CO_2 eq. vs. 70,303 tons of CO_2). The study also ignores all of the cars that could have entered circulating in the street, something that the CDM study considers.

The CDM study is a much more comprehensive study, which has not been done for showing reduction of pollution threatening health but for reduction of greenhouse gases. The regulations and high exigencies of the UNFCCC require the document that operates on a global basis to give a much more scientific and economic detail. Because the project is finally a market mechanism, where every ton of CO_2 equivalent, calculated and validated from the study would be paid up to 9 €, and therefore, the real reduction does not take place, because the rights to pollute have been acquired by the Spanish Government, and according to my interviewed 1, the carbon revenues were not even significant compared to the total cost of the project.

Study	Objectives	Measured variables
Personal exposure Analysis	Estimation of environmental benefits in-site (Individual level)	Concentrations of CO, $PM_{2.5}$, PM_{10}, and Benzene.
The Benefits and Costs of a Bus Rapid Transit	Estimation of economic and environmental benefits (Regional level)	Avoided emissions over a yearly basis of THC, NOx, PM_{10}, SO_2.
Clean Development Mechanism	Acquisition of Carbon credits (Global level)	Avoided emissions over a yearly basis of CO_2 equivalent

Table 6.7. Comparison of 3 forms for reducing pollution in the BRT of Mexico City.

7 Institutional Analysis

This chapter focuses on the description and analysis of the different actors involved in the field of public transport of Mexico City, and more in detail goes to the stakeholder approach. This chapter will respond to who are the responsible of implementation, improvement and operation of the BRT for Mexico City

For a project of sustainable development to be effectively implemented, it is particularly important to identify politic, legal and social levels that may lead to a particular change. Apart from a change in values and social attitudes regarding the environment, it is necessary to consult current institutions, which can be contradictory, depending on the different focuses over the social change in a certain time, e.g. reflexive modernization (Beck, et al. 1996) or postmodernism (Inglehart, 2000), where there is necessity of modification in the normative and regulative schemes (Lezama & Dominguez, 2006:165)

The most important social agents for a change to occur are governments and institutions, because they are the ones who take the decisions. However, sometimes reality shows that inefficiency and passivity of the ones who are legally in charge of protecting the environment, can be linked to other interests, amplifying the range of social agents that are part of the decision-making process, sometimes prioritizing over limited actors (Lezama & Dominguez, 2006:168). The consequences of the environmental problems sometimes are totally external to their origin, e.g. Anthropogenic Climate Change. Beck (1994) mentions in his "Risk Society" about the necessity to modify the actual comprehension of institutions because the normative elements with universal validity conserve that character of belonging, generality or justice.

7.1 Defining and identifying Institutions

"Institutions are social structures that have attained a high degree of resilience. They are composed of cultural-cognitive, normative, and regulative elements that, together with associated activities and resources, provide stability and meaning to social life. They are transmitted by various types of carriers, including symbolic systems, relational systems, routines and artifacts operate at multiple levels, from the world system to localized interpersonal relationships. By definition, they reflect stability, but are subject to change processes, both incremental and discontinuous" (Scott, 2010:65). Another definition of North (1990:3) "institutions can be defined as humanly devised constrains that shape human interaction and can be both formal and informal".

The main reason of its existence is the provision of basic level of justice and equity in societies. They define political rules, well-defined property rights and an emphasis on

impersonal links are usually considered important factors explaining the economic success of a country. (Piet, 2002). However, how important are they for achieving sustainability, particularly in transport.

Over the past few years, the operation of governments has drastically changed in relation to transport decisions. The outcomes of public transport are more influenced and determined by different actors like planning infrastructure, imposing taxes, and granting subsidies to public transport. This has led to a decrease in the power of governments and a change in the styles of governance. It has become standard in many countries for actors who will be affected by the policies to participate in the policy preparation process. Thus, the range of stakeholders involved has widened. Public-private partnerships have become more common, and regulation has been partly replaced by contract type agreements between the government and sectorial organizations (Piet, 2002).

This has not the exception in the BRT project of Mexico City, the involvement of all kind of institutions was particularly important for its execution, herewith, the different actors of the project can be classified:

Organizations	
User's organizations	Passengers
Local NGOS	Center for sustainable transport (Centro de Transporte Sustentable) CeIBA
National and International NGO's	EMBARQ – World Resources Institute (WRI),
Executive organizations eg. Public sector research and extension organizations	Center Mario Molina, Department of Air Quality of the Secretary of Environment
Private sector	Bus Operators and Concessionaries (CISA; RECSA; CTTSA; COPSA; CE4-17M)*
Financial institutions	World Bank, The Spanish Carbon Fund, Global Environment Facility
Parastatals	PEMEX
Political bodies	Mexico City's Government District) SETRAVI (Secretary of Transit and Roads), RTP Network of Transport Passengers of Federal District; SMA (Secretary of Environment; Secretary of Finances. SEDUVI (Secretary of Urban Development and Housing
Donors	Shell Foundation, Hewlett Foundation
International Research Organizations	World Resources Institute

Table 7.1. Relevant Institutions for Metrobus

7.2   The stakeholder approach

The stakeholder identification, analysis and facilitation techniques facilitate a good way to have an overview of the organizational environment. The stakeholder approach helps to identify institutions with the interest in the project's activities and outcomes. One useful method is the continuum of stakeholders shown in Table 5.2

Continuum level	Stakeholders	
Macro level		
↓	Global and international	World Bank, World Resources Institute
		Hewlett Foundation
	National	Indirect participation of national interventions, but not considerable
Micro level	Regional	Major of the City, Secretary of Environment, Secretary of Roads and Transit, Network of Passengers Transportation , Secretary of Urban Development and Housing, Secretary of Finances
	Local Off-site	Center for Sustainable Transport
	Local On-site	Passengers, Bus Operators and concessionaries, cars circulating along the avenue, Metrobus

Table 7.2 Relevant Stakeholders of the BRT project in Mexico City. Stakeholders model Source from Grimble et al. 1995

This conceptual frame of analysis makes possible to identify a range of institutional forms or individual elements and understand how they work and interrelate in the processes studied. It takes into account the specific historical trajectories that have influenced the development of each community. It helps to sort out and gain insight into which forms of institution that have been an obstacle to or which have been advancing, the economic restructuring of the communities (ADB, 2008). Based in the order from Macro level to Micro level, I identify main actors and their function in relation to the project:

7.2.1   Global and International

- *WRI (World Resources Institute) and EMBARQ*: an environmental research organization which mission is "to move human society to live in ways that protect Earth's environment and its capacity to provide for the needs and aspirations of current and future generations". WRI provides- and helps other institutions to

provide – objective information and practical proposals for policy and institutional change that will foster environmentally sound, and socially equitable development. (WRI, 2010)

EMBARQ is a sub-division of WRI dedicated to Sustainable transport- their mission is to propose sustainable solutions to the problems of urban mobility in developing countries. Their main work is by cooperation with authorities at local and global levels by reducing the time, risk and costs required for a solution in the implementation and design of a transport project. (EMBARQ, 2010)

The network of EMBARQ was created in 2002, and it has extended to five centers for Sustainable Transport, located in order of creation in Mexico, Brazil, Indian, Turkey and the Andean Region, that in cooperation with transport authorities, environmental scientists and city planners work together to reduce pollution, improve public health, and promote more urban public spaces. The foundation of CTS-Mexico was a project to create local capacity to develop a Bus Rapid Transit corridor on a high-profile avenue running through Mexico City streets. (EMBARQ, 2010)

- *World Bank and the Spanish Carbon Fund*: The World Bank is a multilateral organization which provides financial and technical assistance to developing countries. The organization provides low-interest loans, interest-free credits and grants to developing countries that foster development in sectors of education, health, public administration, infrastructure, financial and private sector development, agriculture and environmental and natural resource management. (WB, 2010)

  The Spanish Carbon Fund was created in 2004 in an agreement between the Ministries of Environment and Economy of Spain and the World Bank, with a total of $ 278 million dollars. This fund would acquire a minimum of 34 million tons of Carbon Dioxide Equivalent that operates under the Clean Development Mechanism, Joint Implementation and Emissions Trade of Kyoto Protocol. Their main objective is the acquisition of Greenhouse Gas emission Reduction Certifies that would help to achieve the binding targets of reduction for the government of Spain by financing projects overseas.

  The World Bank prepared a fund of 12.2 million dollars for improving public transport in Mexico City, trying to improve by using less vehicles for moving the same quantity of people in a more energy efficient way, the project relied on people to stop using car and to start using improved public transport, the advantages that the project offered were mostly in the environment, in the urban form, and in the reactivation of the economy (Ardila-Gomez, 2009).

The Spanish carbon Fund has bought the carbon credits of the project bus corridors in Mexico City, for a 7-years period, with the option to renovate it for a maximum of 21 years. The verification and certification has been on a three-year basis. The total emission reduction is of 354,607 tons of CO_2 eq for a price of $307,000 for year (WB, 2010)

- *Shell Foundation*: This is a UK registered charity that was established in June 2000 by Royal Dutch/Shell with the proposal of new solutions to old problems, in parallel with its efforts at internal transformation, it would launch a new global, social investment effort that would concentrate on working with external partners to advance sustainable development worldwide.

  EMBARQ was co-founded by the Shell Foundation in 2002 as the World Resources Institute's Centre for Sustainable Transport (Shell Foundation, 2010)

- *Hewlett Foundation*: Officially known as *"The William and Flora Hewlett Foundation"*, is a foundation which makes grants to solve social and environmental problems around the world. Its representative Magolis Briones mentioned that their priority of grants is on the most polluted and most populated cities of Mexico, Chile and Brazil. They supported a transport plan with Mexico City's major, Center for Sustainable Transport and Center Mario Molina, a document with 6 mobility strategies that comprehends lines in Mexico City and the neighbor State of Mexico.

  Their role has been particularly important, participating at different stages of the project, the different grantees of the Foundation can be seen in the table 7.3

Grantee	Function in the BRT project
Institute for Transportation and Development Policy (ITDP)	For general support of the ITDP sustainable transportation initiatives in Mexico City
Colegio de México	For Centro de Estudios Demográficos y de Desarrollo Urbano for evaluation of the impact of BRT corridors and to serve as Project advisor to Mexico City's government
Interdisciplinary Center of Biodiversity and Environment (CeIBA)	For design and implementation of an integrated bus rapid transit corridor in their amount of donation and contributions

Centro for Sustainable Transport (CTS)	For evaluating the benefits in personal exposure due to changes in the transit system in Mexico City

Table 7.3. Grantees of Hewlett Foundation. Source: Hewlett Foundation

7.2.2 Regional

- *Head of the Local Government.* The intervention of Mexico City's Major Andres Manuel López Obrador (2000-2005), was fundamental for the implementation of the BRT project. His support obeyed to pressures from his Minister of Environment Claudia Sheinbaum. He inaugurated Metrobus in 2005. It was, however, not his most expensive investment in infrastructure. The largest was the second floor of Periferico Boulevard. Something that has been severely criticized by environmental and urbanist experts, "if a government builds a megaproject road that promotes car use, and later develops a massive transit project for sustainable mobility in the city, it means that the government is totally inconsistent" (Lerner, 2005). In 2006, Marcelo Ebrard was elected as new head of the government under the same political party as the previous mayor. His policies of expansion of Metrobus were clear, and more ambitious than those of López Obrador. In December of 2008, he inaugurated the line 2. On the 23rd of June of 2009, Ebrard announced the construction of line 3. He commented that "the system is a cornerstone of a strategy that seeks to change the mobility behavior of the city that has prioritized the use of private vehicles for more than 4 decades". (Pantoja, 2009). However, Ebrard has had also some limitations, for example, in order to improve the circulation of the rapid buses, a second lane may be necessary which would lead to make several expropriations, something that Major Peñalosa did in Bogota, but for Ebrard it would mean to lose political reputation. (Interview 2, 2010)

- *Secretary of Environment of the Federal District (SMA).* The secretary of Environment of Federal District is a local institution from Mexico City's government which main objective is "to achieve the preservation and sustainable use of resources to constitute a proposal and a collective action". They execute environmental policies in order to use the instruments and actions that foster responsibility, knowledge and capacity among citizens, and to front collectively the solution of environmental problems. (SMA-DF, 2010)
  Mario Molina recommended to improve transport as one of the priorities to reduce air pollution. The Secretary of Environment agreed with this thought and the advice was added to the measures for solving the problem in the Program for Improvement of Air Quality in Mexico City Pro-air 2002-2010. In addition, the BRT was part of the Integral Road and Transport Program of Mexico City, published in

2002. Claudia Sheinbaum mentions that metrobus is a mode that simulates the working of modern trains, but instead relies on buses, making it more economical. The physical infrastructure is the most visible part, but the institutional arrangement is probably the most difficult part. Its implementation has included the aspects of: modification of an organizational platform to improve service, operation and business conditions; general fit of infrastructure of vitality to achieve a major flux of vehicles by time unit; technological modernization of the fleet to achieve a best energy efficiency, and therefore, reducing greenhouse gases and local pollutants. (Sheinbaum, 2009)

- *Secretary of Transit and Road (SETRAVI)*
  Its function is the management and the control of urban automobile transport and the planning and operation of urban roads. They execute coordination between Mexico City and Mexico State to address integration of transport services in Mexico City Metropolitan Area. The Secretary is also in charge of phasing-out the old and obsolete buses, and gradually privatize emission testing requirements. Other functions of them are the inspections of vehicle, the evaluation of the tariff systems and the definition of measures to improve the management and business environment. (SETRAVI, 2010)
  The secretary of Transit and Roads has been the main negotiator with the old routes and concessionaries, and their gradual integration to the BRT project (Interview 3, 2010)

- *Secretary of Urban Development and Housing (SEDUVI)*
  The dependency is in charge of the creation and management of policies for human settlings, urbanism and housing under a legal framework. (SEDUVI, 2010)
  The intervention of SEDUVI in the project has been related to the land use that the infrastructure of the BRT requires for its operation. An interesting SWOT analysis published in 2008 by the Council of Sustainable Urban Development has severely criticized the BRT as a polluting, unsafe and uncomfortable system that besides is provoking problems of traffic congestion and has lack of access facilities for handicapped and elderly people. (SEDUVI, 2010)

- *Network of Transportation of Passengers of the Federal District (RTP)*
  The RTP is a decentralized public agency of the Public Management of Mexico City, created in 2000, with legal representation of its own assets, located as a subdivision of the Secretary of Transport and Road (SETRAVI). The creation of the RTP was based on the challenge of providing public transport to the surroundings

of the city and connecting with the other transport systems. They have 2,600 workers, 860 buses operating along 75 routes, 7 operative modules and 3 specialized workshops.

It has settled their service under three different functions: to provide with an economically affordable service for everyone; to connect surrounding areas with the System of Collective Transport, (Subway), and with routes of Electric Transport Service, which obeys to a program of Urban Reordering of Urban Transport by part of City's government; and to accelerate social pressures that could be disrupting with the public service. (RTP, 2010)

They created Metrobus as a new Institution in 2005. They possess 25% of the fleet of articulated buses. (Metrobus, 2010)

7.2.3   Local Off-site

- *The Center for Sustainable Transport (CTS)*

The Center for Sustainable Transport of México (CTS) is a Mexican non-profit, non-governmental organization which has emerged as a local division of WRI- EMBARQ, it offers solutions in the following aspects: reduction of local pollutants, reduction of greenhouse gases, performance for the economic effectiveness of urban transportation systems.

CTS-Mexico's work compiles seven strategic areas: 1)inclusion of transportation as a fundamental pillar of urban planning; b) creation of a comfortable, safe, accessible and high-capacity public transportation system; c)promotion of more rational private car use; d) recuperation of public space and promotion of non-motorized transport, e) regulation of freight transport; f) more clean fuels and clean vehicle technologies in the transport, g)implementation of BRT corridors in cities of more than 750,000 throughout Mexico. (CTS,2010).

CTS has collaborated with other Mexican cities as Leon, and Guadalajara, and is now analyzing a deeper cooperation with Cancun, Tuxtla, Chihuahua, Toluca and Monterrey.(Ibid)

CTS has been the main actor involved in the process of the BRT implementation, with the active participation in the functions of diffusion of achievements, information management, training, research, and technical support. CTS was described as a promoting and visionary NGO that is seeking change in the cities (Interviews 1, 2010)

7.2.4   Local on-site

- *Metrobus*

Metrobus is a decentralized public Organism created in 2005, with the objective of operating the fleet vehicles along the confined corridors. This system surged as part of the integral program of Road and Transport 2000-2006. The organism was created in order to manage and control the flow of buses and passengers, as also the payment system. (Metrobus, 2010, URL). The participation of the director of Metrobus has been strategic, due to the partnerships with private transport companies and concessionaries.

Their different compounds are showed in the next figure:

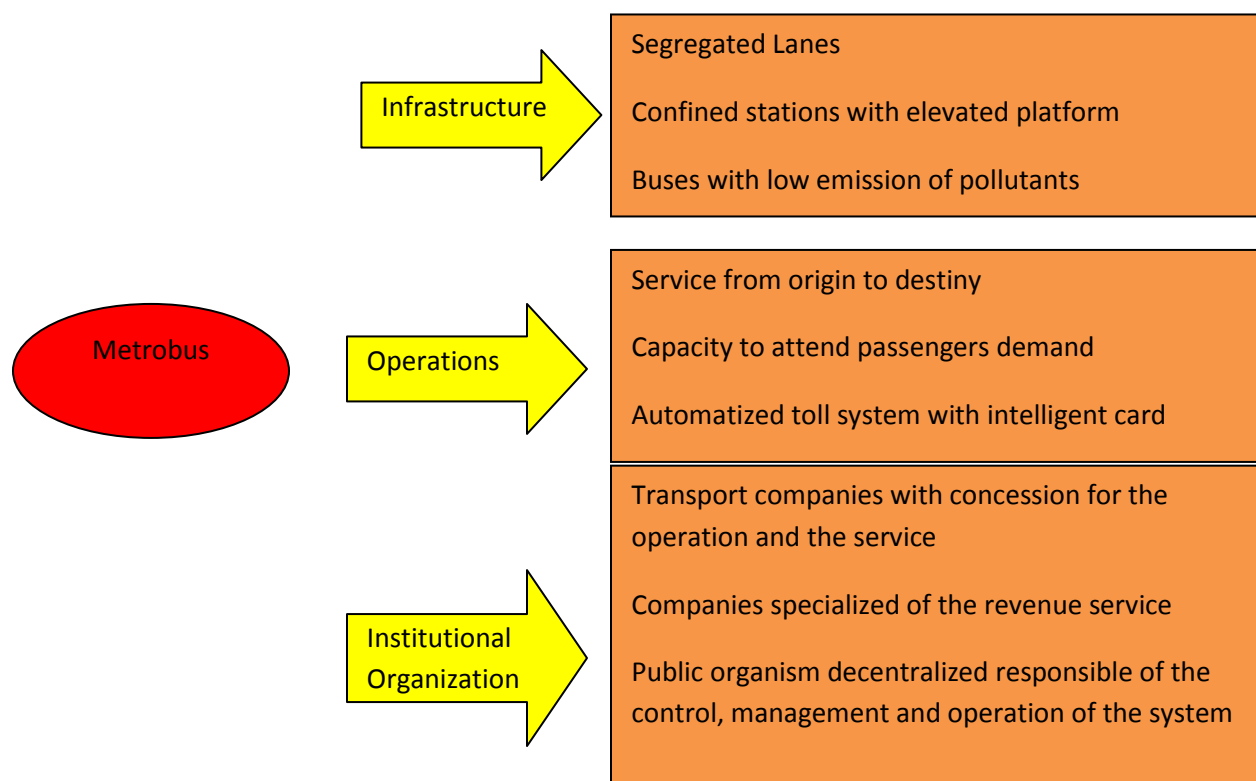Figure 7.1. Different compounds of Metrobús. Source: (Metrobus, 2010)

- *Transport Concessionaries*
  The transport concessionaries of the project are some of the routes that were previously circulating in the Avenues of the BRT and that have, subsequently, been integrated to the operation of the BRTs. These concessionaries were the main opposition to the project. A large negotiation process took place.

Their role has been one of the most controversial. The transport previously running through the city was profitable and satisfying the demand of passengers. The change would be of environmental priority rather than transport (Interview 1 2010).

One of the concessionaries, Corredor Insurgentes S.A. (CISA) participated in the share of operation of the routes together with Metrobus. However, CISA by becoming a formal company under the management of a public organism as Metrobus, would lead the rest of the concessionaries without any power of decision and their route would be expropriated as a public service. They took several legal actions associated basically to the inversions that some of the concessionaries had over the last years and the removal of their interests. (Consuegra, 2005).

Internal politics in Route 2 during the construction of the line 2 in 2008, the Bus drivers of the route 11 that was circulating across the avenue blocked 2 streets and confronted grenadiers of the Secretary of Public Security of the Federal District (SSP-DF).

- Passengers

The new BRT lines is carrying about 500,000 passengers per day (May, 2010) and have been the direct benefited of the project. Another important date was that up to 19% of Metrobus passengers were previously using a car. (Interview 1,2010)

The agency specialized in social research Investigaciones Sociales Aplicadas published a survey (june and September, 2009) about passengers satisfaction and gender equity. The main findings are as follow:

- Around 60 percent of passengers use the system to go working, 20 percent to go to school, the remaining passengers use the system for visits, shopping, recreation and others.
- Passenger satisfaction amounts up to 8.1 on a scale from 1 to 10.
- 79 percent considered the system better than microbus, 56 percent finds better than bus, 53 percent better than the subway, 54 percent better than electric transport, and 41 percent better than taxi.
- 46 percent thinks the buses are overcrowded and 45 percent said they are sometimes crowded.
- 65 percent considered the buses rather fast and 25 percent considered the buses as very fast
- 25 percent of the users does has a car.

- o Of the ones who have a car, 60 left their car parked, while the rest used the system because their car was broken down or used by somebody else (ISA, 2009)

However, some negative comments of the passengers registered in the complaints forum were:

"I use the BRT by necessity, because I work near to one of the stations, but now my belly grows and grows because of my pregnancy, and I am afraid of so many squeezings, nobody gives me way to sit or to pass. I would prefer to use car or taxi if I could have the money, but I don't have it, I just ask for more help and respect for somebody with my conditions" Luna, February 21st. (Metrobus, 2010)

"It is imposible to Access metrobus when it is overcrowded," Eduardo, February 5th. (Metrobus, 2010)

"I am in favor of the use of public transport, when they were promoting a fast, comfortable and efficient service, however, after one year of using the service, I am seriously considering to use my car again during the week. The machines are not working, the buses are overcrowded. I don't really perceive a scheduling time. I just would like to emphasize my claim to the authorities, not even to find a place to sit, but at least to be comfortable." Gerardo, January 25th. (Metrobus, 2010)

"Change the buses to natural gas, hybrid or fuel cells, demand synchronization of the traffic lights, decrease the cost of the bus and make longer buses" Gabriel, January 12th. (Metrobus, 2010)

- • Private car users

The line has particularly caused some discontent among car drivers that circulate across Insurgentes avenue, their main reason has been due to the narrowing of the Avenues that has caused more traffic congestion.

Another particular problem has been the accidents due to the invasion of the confined lanes for the BRT. According to a recent report, an average of 20 drivers per day are fined because of the invasion of the confined lanes, something that is strictly forbidden in the Regulation of Metropolitan Transit (RTM). Only from February 11th to March 9th, there were applied 531 infractions, of which 65% were private cars, 20% other public transport vehicles as taxis and microbuses, and 15% motorcycles. In addition, there have occurred 31 accidents, of which curiously one was caused by 2 police officers who invaded the lane with their patrol. (Notimex, 2009)

An interesting comment in one of the newspaper article states:

> "The Major Ebrard has not realized that crossing Insurgentes is now an 'odyssey'. Because of Metrobus many parallel streets and avenues to Insurgentes have become more congested"

7.3   Influence and Importance of stakeholders

The stakeholders involved in the implementation and operation of the BRT project had varying degrees in the decision making processes such as in the implementation of policies and plans. The influence and importance of the various stakeholders involved in the project was assessed using "the influence and importance matrix" shown in the next figure:
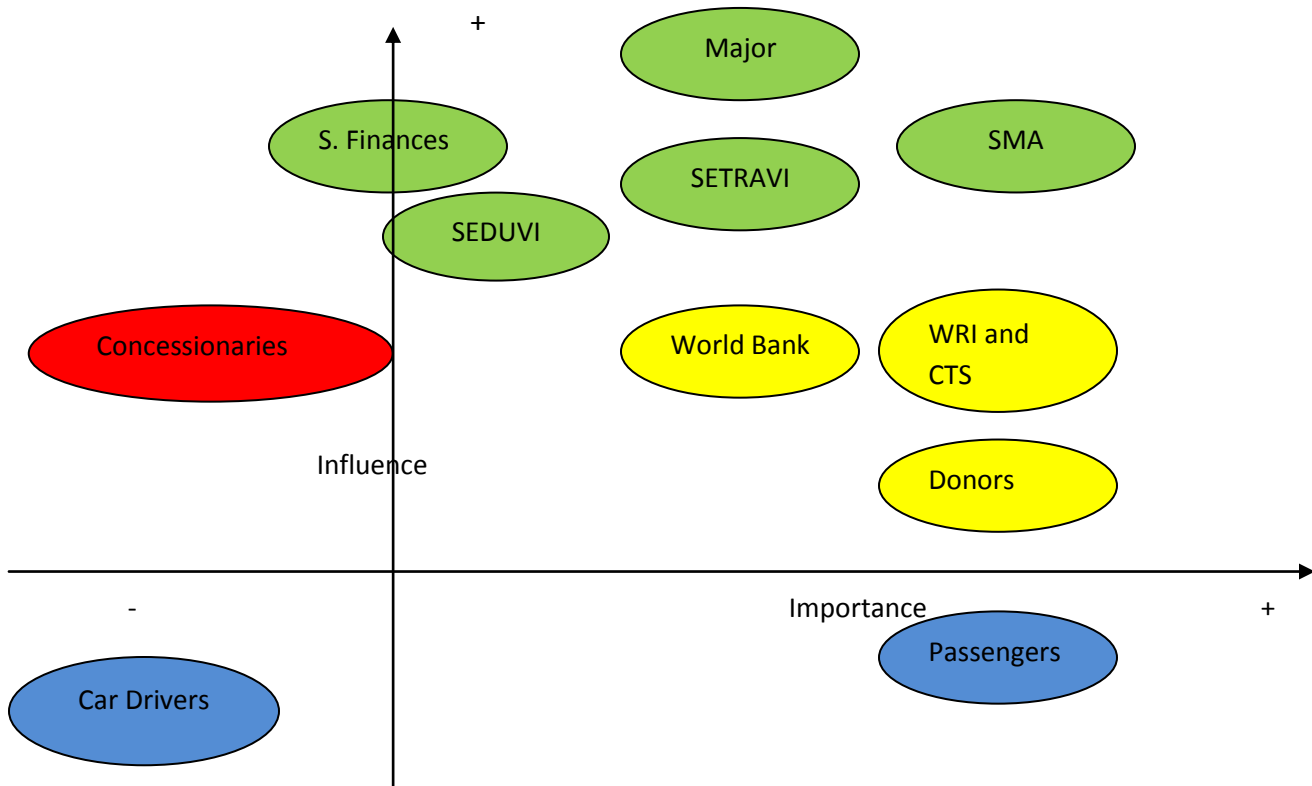
Figure 7.2 The influence and Importance for the implementation of the BRT.

The high influence is attributed to a legal mandate, formal authority, possession of economic resources and specialized knowledge, and organizational structure with complementary organs. The high importance is due to the strong linkage with other stakeholders, the control of strategic resources, strong negotiating position and their objectives coupled with benefits of the project.

- The mayor has the highest influence because he has formal authority on the project, his middle importance is due to Metrobus was just his second biggest project of infrastructure in the government

- The Secretary of Environment is the stakeholder with more influence (less than the major) and more importance, it is the most benefited and the leader of the project, and could negotiate successfully with the rest of the stakeholders.

- The Secretary of Transport and Road has high influence and high importance, but less importance than the Secretary of Environment, they are the political body that suffered more institutional arrangements during the project.

- The Secretary of Finances has high influence and neutral importance, they channel economic resources but they were neither affected nor benefited from the BRT project.

- The Secretary of Urban Development and Housing has high influence and very few importance, they were not considerably affected by the project. Their high influence is due to their role for the acquisition of the land that would be used by the project, their few importance is due to the critics in the SWOT analysis of sustainable development for the city.

- The World Resources Institute and the Center for Sustainable transport have less influence than the political bodies but very high importance, due to the possession of specialized knowledge for the operation and implementation of the project, without their assistance, the government agencies would have been particularly limited, and the project would have probably failed.

- The World Bank has some influence but less than the rest of the local government dependencies, their influence is due to their economic power and concentration of economic resources. The importance is also less than the NGOs, the World Bank assigns funds normally for development projects that offer stability and good image, and Metrobus was attractive for them, but they could had instead financed a similar project in another region of the world.

- The Donors as Hewlett Foundation and Shell Foundation have high importance on the project, but only some influence. They provided grants to the World Resources Institute and Center for Sustainable Transport to realize a better assessment on the problem of mobility in Mexico City. They possess some influence because of their grants, but their intervention is quite limited in compare to the political bodies and multilateral organisms. Their high importance is due to the formality of their grants and their mission to solve environmental problems in the most polluted and most populated cities.

- The concessionaries of transport have some influence, and no importance in the project. They were the most affected by the project, their influence was due to their organization as syndicate. Their negative importance was due to the total change in operation, they have low social, economic and political status. Policies, programs, projects and activities should address also their concerns.

- The passengers of the BRT have high importance in the project, because their requirements of mobility were satisfied and their traveling times were reduced. They don't have any organized institution or organization, therefore, their influence is negative.

- The car users of the avenue have no importance and no influence. They were particularly affected by the project by segregating a lane of the avenue, which increased the congestion. They don't have any organization and their concerns were not listened.

8   Policy analysis

This chapter analyzes the main policies applied to the project of Metrobus, as well as the outcomes of these policies, policy proposals and finally a SWOT analysis is made to the project as a whole. Policy analysis is a normative discipline "A policy is a course of action or inaction taken by governmental entities with regard to a particular issue or set of issues " (Wolfe & Elder, 2007)

8.1   Defining Transport Policy

The situation of mass passenger transport today normally turns to ask about how sustainable transportation can be achieved. In order to advocate the principles of sustainable transportation and apply them in real cases, some specific policy strategies need to be achieved. Furthermore, the implementation of suitable policies in each case, needs a detection of very concrete policy goals to which instruments could be targeted would be helpful. (Route & Andersson, 1999).

Skinner & Fergusson (1999) suggests that a sharp definition of the initial policy goal might contribute to achieve a number of sustainability objectives and could prevent future controversial results. In other words, policy goals are those to provide the link between the sustainability objectives and the specific instruments

Transport policy strategies can be classified according to their orientation. Voukas (2001) summarizes the transport policy strategies in four major categories:

Demand Oriented Policies

Restricting traffic for private cars and road pricing
Parking restrictions and parking pricing
Speed limits
High occupancy lanes and car sharing

Supply oriented Policies

Improve public transport system in terms of quality capacity efficiency and comfort
Attractive fares
Dense bus stops
Bus & ride facilities
Bus priority, bus lanes
New transport modes (subway, light trains)

Policies regarding Land Use and Urban Planning

Decentralization

Controlling housing patterns

Improve network infrastructure

Policies regarding Energy Efficiency & Innovative Technology

New engine & fuel technologies
Tax differentiation on fuels and vehicles
Promotion of non-polluting transport modes
Reduce need for travel through telecommunications and IT systems
Provide better public and private services (e-commerce)
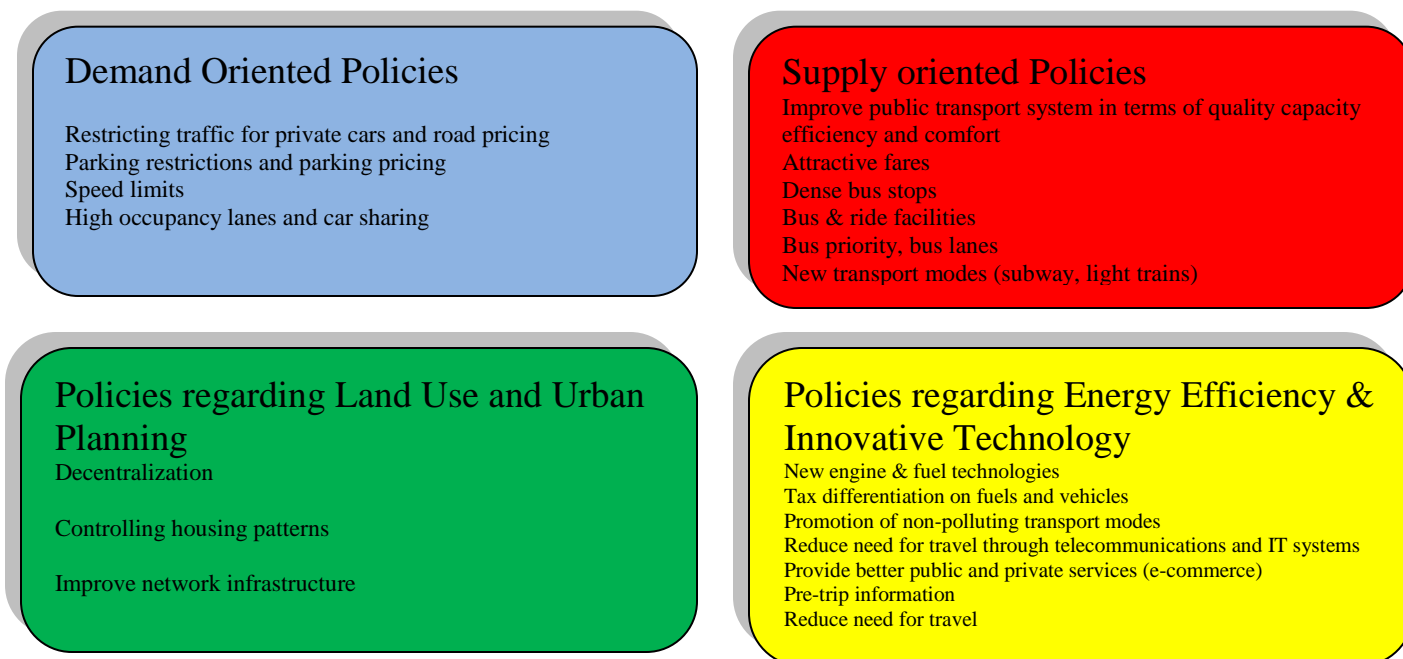Pre-trip information
Reduce need for travel

Table 8.1. Policies for sustainable transport. Source: (Voukas, 2001)

The major interest of this policy analysis is related to the supply oriented policies, therefore, the rest of the policies will be ignored.

Environmental and transport policies require financial resources in order to increase its efficiency. New mechanisms should be generated in order to obtain resources and facilitate the performance of the best environmental management. The problem was to apply an environmental policy or initiative that would overpass the environmental terrain to an area that is related to environmental degradation, to overcome stringent barriers regarding institutional arrangements as well as in sector policies.

8.2   Policies during planning

During the planning of the BRT project, there was addressed the main policies to apply:

Issue	Policy	Impact
Regional character of public transport corridors, and coordination between the city and State authorities	Intention letter, confirming the metropolitan nature of the proposed corridors	Improved coordination actions by administration of the state and the City
Business environment hindering the development of an efficient public transport system	Creation of an enabling regulatory framework that is conducive to efficient public transport operations	Development of an environmentally and financially sustainable transport system
Lack of institutional framework to manage public transport services along the corridors	Development of an institutional framework that fosters efficient public transport operation along the corridors	Efficient public transport services along the corridors, raising their attractiveness to the traveling public
Fare structure does not meet efficiency criteria and discourages intermodal transfers.	An integrated fare strategy for metro and bus services along the corridors	Modal shift toward large public transport vehicles generating relatively low levels of pollution
The current structure of bus operations is inefficient and results in unsafe, polluting and unattractive public transport services	The introduction of modern bidding criteria for bus operation in the corridors, individual operators would be invited to join consortiums	Professionally operated bus services, generating economies of scale. The efficiency gains achieved may obviate the need for fare increases. This will strengthen the case for replication in the MCMA.
Suitability of initial public transport corridors	Identifying best replicable corridors to demonstrate effectiveness of concept	Ensures replicability of pilot corridors
Environmental and social impacts of public transport corridors	Action plans to address any potential environmental and social issues associated with the corridors.	Ensures environmental and social sustainability of the corridors to be built under the loan

Table 8.2. Policy Matrix of the Global Environmental Fund Project. Source: **(Vergara, 2002)**

The table 8.2 shows a particular set of policies planned during the implementation, herewith I proceed to explain and evaluate how did these policies worked in the planning:

8.2.1 How good is the relationship with the State of Mexico taking into account the physical nature of the project?

The intention was stated since the beginning, it is necessary to have a strong political commitment in the state of Mexico for a transport project. The corridor ends in the limits of Mexico City, there are plans of expansion for the period 2012-2018 in a mobility plan that comprehends 8 lines for the state of Mexico. The governor of the state of Mexico has not been as interested in this kind of projects (interview 2, 2012), in compare to the Mayor of Mexico City, they are from different political parties, even though the relationship between the two governments is relatively good. One of the strengths of this relationship is the creation of the Environmental Metropolitan Commission coordinated by institutions from both governments in order to solve the problems of pollution in the geographical nature of the region. This commission was created since 1992 by the government of Mexico City, the government of the state of Mexico, the national government and a consultative board formed by specialist from academic and private sectors. (Roccatti, 2006).

8.2.2 A good business environment

The business structure of bus services in the Mexico City Metropolitan Area (MCMA) was under highly inefficient operations, resulting in a costly, unsafe and environmentally unsustainable public transport system. Some key issues were a) lack of an organizational model that would facilitate efficient public transport operation in the metropolitan area, b) dispersed operations that hinder the effective control of bus services and contribute to traffic congestion, c) inefficient use of vehicles, d) deficiencies in bus inspection and maintenance, e) lack of professional management among bus operators, f) lack of coordination between transport operations in the state of Mexico and the City, g) a fare system which penalizes transfers and thus discourages intermodal movements, and h) systematic decline in the number of metro passengers since 1989 despite a 35% network extension during that period. These barriers were significant and required substantial efforts at the policy and regulatory levels. (Vergara, 2002)

The business environment in general worked relatively weak, the previous system of conventional buses was profitable and the technical capacity was also quite limited. In addition, the decisions made by the government were considered with lack of financial maturity. The imposition of a low fare was difficult to achieve, and non conservative

estimations were applied to some design elements: for example, the commercial speed, the bus costs and interest rates, and the fare collection system costs. Those contingencies made the system to have an operational deficit in the first year of operation. (Interview 1, 2010)

8.2.3   Creation of an institutional framework that manages the corridors

The decree of the creation of Metrobús as a decentralized public organism was announced by the Major Lopez Obrador in March 9th 2004. The bylaw of Metrobus as organization was created in August 18th 2008, which basically established responsibilities of the board council, directors and comptrollers. The manual of a Committee for the management of promotional areas, rules of operation, administrative manual of Metrobus was published in 2008. Figure 5.1 shows the regulatory and legal framework that applies to Metrobus.

Figure 8.1: Legal framework that applies to Metrobus. (Gobierno del Distrito Federal, 2007)

The use of public and private operators and public oversight was very challenging, bringing opportunities and risks. The participation of a large public company with operational "know-how" has been helpful, as it has helped the newly created CISA with training and a point of comparison. It has also provided operational experience to Metrobús, with key staff coming from RTP. (Interview 3, 2010).

The private operator CISA is a mixed entity. It worked as cooperative, where the shareholders distribute revenues from the system on a monthly basis. They are in the process of organizing themselves to distribute revenues and becoming operators of other corridors. (Interview 3,2010)

8.2.4   An integrated fare strategy for metro and bus services along the corridor

The bank in charge of fare collection was not experienced in mass transit operations and had to adapt and learn under actual operation. (Interview 1, 2010). The price of the fare was only $3.5 Mexican pesos (1.4 DKK) per trip in the beginning, something highly criticized by the project evaluators of the World Bank. The previous tariff was at the same price than the buses circulating in the avenue, the government decided to applied this tariff for political reasons, because the administration was almost finishing and the Major was competing for the presidential elections (Inauguration of the system in March of 2005 and elections for new government in July of 2006). Today, the fare system has increased considerably, even though is relatively cheap in compare to other regions of the world, $ 5 Mexican pesos (2 DKK).

However, there is no intermodal transfer yet with the same ticket in Mexico, as it is already established in cities in Europe where a passenger can use the same ticket to change from subway to bus. The main barrier of this practice, may be the high subsidies of the subway in Mexico City, the price is only $2 Mexican pesos, i.e. less than 1 DKK and one of the cheapest in the word. The collection in Metrobus is done through a single electronic card that can be recharged after it has been used. The subway system is based on a single ticket that is acquired with a person in a dispatcher window.

8.2.5   The introduction of modern bidding criteria for bus operation in the corridors, individual operators would be invited to join consortiums

Of the total amount of drivers that were operating buses and microbuses of the Route, 210 could not satisfy the requirements established by the company CISA for the hiring, therefore, they could not be incorporated as Metrobus drivers. Their working alternatives were in function of their capacity to work in other routes, from among the 28 thousand concessions that provide transport service in Mexico City that claim the collaboration of approximately 50 thousand bus drivers, however, they may be called in order to receive voluntarily free training to apply for a job in Metrobus, with Federal District Government Funds. (Gobierno del Distrito Federal, 2007)

8.2.6 Identifying best replicable corridors to demonstrate effectiveness of concept

The government of Mexico City hired the German development cooperation agency GTZ[11] to identify 33 possible corridors in Mexico City. The selection of the corridor in Insurgentes was chosen as the most suitable after evaluating various alternatives and rejecting the initially selected corridor Tláhuac-Taxqueña. Insurgentes is an emblematic, very visible, mixed activity road, crossing in vertical direction the entire city, including the Central Business District. The implementation along this corridor was identified as easier in relation to other corridors in terms of technical and political possibilities. It exhibited characteristics with non grade intersections over 7 km in the north and grade intersections there after. The cross section is around 30 m in the narrowest segment (Interview 1)

8.3 Outcomes of these policies

8.3.1 Lesson-drawings from South America

The Lesson-drawing term describes "the process by which knowledge about policies, administrative arrangements, institutions and ideas in one political system (past or present) is used in the development of policies, administrative arrangements, institutions and ideas in another political system (Dolowitz & Marsh, 1996). "Policy transfer" is another term commonly used.

Matsumoto (2010) compares the lesson-drawing from South America to three Asian cities. He finds that "Lesson-drawing describes the overall transfer process of policies and institutional arrangements (Rose, 1993), while some argue that it is a narrower concept than "policy transfer" in that it focuses on voluntary lesson-drawing while the latter encompasses diffusion and coercion (Dolowitz & Marsh, 1996). "

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[11]The Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) is a federally owned organization that works worldwide in the field of international cooperation for sustainable development. They support the German Government in achieving its development objectives. They provide viable, forward-looking solutions for political, economic, ecological and social development in a globalised world, working under difficult conditions, promoting complex reforms and changing processes. Their corporate objective is to improve people's lives on a sustainable basis. GTZ involvement in Mexico focuses on sustainable energy (renewable energies and energy efficiency) and urban-industrial environmental management (solid waste and contaminated site management). (GTZ, 2010)

Matsumoto also mentions Rose definition as a lesson in the policy process as "a program for action based on a program undertaken in another city, state or country, or the organization itself in its own past". Evans (2004) draws 4 different levels of lesson-drawing: international, national, regional or local.

The role as 'agents of diffusion' of international organizations has been particularly important for development projects. (Evans, 2004). They are the promoters of the exchange of information and ideas between nations with comparable levels of financial resources. Agencies as the World Bank and the United Nations promote development programs in less developed countries, they encourage the "best practice" and finance implementation of projects. In this specific regard, the role of the World Bank was fundamental for the funding of infrastructure in the BRT system of Bogota. (Matsumoto, 2010)

However, the most important actors are the governmental bodies. The applying of policies and endorsement to legitimize a program of development is essential, while other stakeholders can contribute with knowledge and capacity for such program. (Rose, 1993). The most important ingredient for an implementation of BRT to happen is the 'political will' (Wright, 2005). In both cases Curitiba and Bogotá, the majors in turn played prominent roles in the conclusion of the project, and today both of them are worldwide famous.

There might have been some changes in the values of decision makers (Matsumoto, 2010). Rose (1993) describes these values as the more important influences on the process of lesson-drawing from beginning to end. One possible explanation is the change of the image of BRT as a replicable option for public transport. It has been argued that the success of Bogota's Transmilenio system drew lessons from Curitiba, and this fact changed the perception around the world (Wright, 2005).

It is worth to mention that Mexico City's Major Marcelo Ebrard elected in July 2006, just right after his takeover of the government, took all his government heads to Curitiba and Bogota to show them how the cities were reformed and changed. And most of the assistants in the project were from Colombia, Transmilenio's director, Transmilenio's operational director, and from Brazil, Sao Paulo and Curitiba's transport director since the beginning to the end. (Interview 3, 2010).

8.3.2   The acquisition of Carbon Credits

The Clean Development Mechanism as one of the tools of Kyoto Protocol is a fundamental revenue for projects that reduce greenhouse gas emissions. The revenues were not that significant in the project, as compared to the whole cost (interview 1, 2010). However it has been an important income to the project, Marcelo Ebrard announced the reduction of 160,000 tons of CO_2 equivalent and its sale to the Spanish Carbon Fund.

Since its planning, the project was thought to generate carbon credits. However, the process was rejected 2 times, and it started generated carbon revenues until 2007, when the expansion of line started operating. The applicability conditions for a BRT to be validated as CDM are: a) a clear plan to reduce existing public transport capacities through scrapping, permit restrictions, economic instruments or other means by replacing with BRT system; b) Local regulations do not constrain the establishment or the expansion of the BRT system, c) any fuels including gaseous fuels or biofuel blends, as well as electricity, can be used in the baseline or project case ((Grütter Consulting, 2010)

However, Mexico City's Metrobus was the second CDM project in transport in the world, after Bogotá. Most of the CDM projects in Mexico are based in landfill and waste management. The trend seems to change, Mexican cities like Guadalajara, Leon, Querétaro, Toluca, and even Mexico City's Subway are exploring possibilities to get a successful income through the acquisition of Carbon credits.

8.3.3   Modal Shift in transport

"Modern society is a society on the move, where mobility is responsible for the alteration of peoples's experience in the modern world". (Lash & Urry, 1994). Modernity is heavily dependent on transport to link individuals, corporations and communities to global of networks and flows. "Transport is an integrated part of the economic, technological and political system of the postmodern capitalist society, and as such, it embodies relations of power and suppression linked to the social and to the nature". (Thomsen et al. 2005).

Beck mentions that reflexivity is the way in that a society examines itself, they change their action processes, i.e. with a technological change the people change by adapting to the technological-information revolution. A replacing of values in society takes place. When individuals make a decision they choose something instead of something else, in that choice the individual is much more aware of the risks of his or her decision. (Beck, 1994). In relation to this, it is interesting to see the evolution of how a certain portion of individuals have responded to a new development in society –Metrobus- over their previous way of mobility, Mexico City's mayor Marcelo Ebrard mentioned in his last

governance report: "A successful transport initiative can modify mobility patterns considerably to many people. For example, In Metrobus, the 15% of the line 1 users has a private car. The journey from *Indios Verdes Station* to *El Caminero Station* uses to last an average time of 2 hours 30 minutes. Now, with Metrobus, that time has been reduced in one hour and 20 minutes. It is a very competitive public transport in relation to other transport forms. (Ebrard, 2009)"

A declaration of one of the users states:

"I live in the sprawling outskirts of Mexico City, I study English downtown, and I have a design workshop in Coyoacan, a quaint neighborhood in the southern part of the city. To get around the city, I used to drive my car, often getting snared in traffic on Avenida Insurgentes for up to an hour and a half. Although I could have taken the microbuses—the informal mass transit providers that once plied Insurgentes—I chose not to; they were uncomfortable and I didn't feel safe. Now I take Metrobús when traveling on Insurgentes, and the whole trip takes just a half hour."(Leticia,2010)

The rationale of her selection is mainly based on her convenience to satisfy her mobility. She has now the access to a more efficient transport system.

8.4   Policy Proposals

8.4.1   Improving the fuel-technology of the bus

Technology innovation is an important issue that is causing revolution in climate change policy. Manufacture and government agencies interested in promoting clean fuel vehicles need to know how demand is affected by attributes that distinguish these vehicles from conventional gasoline or diesel buses. The most effective policies are appropriate, well-designed and effectively implemented standards. Because the change doesn't require a change in lifestyle and users adapt to the purchase, operation and use. Vehicle and fuel standards are usually the prerogative of governments. The problem is the supply of the fuel. For example, trade-offs, between two pollutants or between pollution reduction and fuel efficiency could be an important factor. Most of the gains in pollution are gained by setting up new standards. Fuel improvements and advanced vehicle technologies should be taken in the same direction. (Gwillian et al. 2010)

Before the implementation, the Secretary of Environment participated in the testing of the several bus technologies. Bus-manufacturing companies presented a model which was tested, by modeling the emissions that the bus would have, "technology-push". Three types of technologies were used: buses with conventional diesel, ultra-low sulfur diesel and hybrids. The selection for the first phase of Metrobus was with conventional diesel.

The decision was based on the difficulties to supply a cleaner fuel during that time.(Interview 4). The NGO Mexican Center for Environmental Law CEMDA, is in charge of following the environmental litigation with PEMEX (Parastatal Mexican Oil Company) in order to develop a new and cleaner fuel. Just in the end of 2009, the implementation of ultra-low sulfur diesel could be achieved in all of the metropolitan area even despite some difficulties. For example, the containers of the trailers that supply fuel were not completely clean, contaminating the new improved and clean fuel with the old and dirty fuel. (Interview 2,2010). However, there is no information about how could have other bus technologies worked.

8.4.2 Promoting public transport and discouraging the use of private vehicles

Across the world there are many strategies that governments are using in order to promote the use of public transport and discourage use of cars.

For example, some options proposed by Baffer (2006) are:

➢ Subsidies on mass transit fees for employees
➢ Education to citizens to dismantle negative stigmas of public transportation through media
➢ Reward car-sharing
➢ Reduction of number of vehicles allowed in urban areas (Baffer, 2006)

In Australia, the government is undertaking a program under the name of Voluntary Travel Behavior Change (VTBC) as an important initiative in the search for more sustainable transport. They use a Travel Demand Management (TDM) by convincing people to reduce their usage of the private car by changing modes of transport. For example in Perth, Western Australia, the adopted three strategies were: 1) A travel survey to assess current behavior and motivation to change, 2) Individualized marketing for survey participants, 3) and an evaluation survey to measure the extent of behavior change. Their results suggested a 10% reduction in car driver trips and a 14% reduction on vehicle kilometers traveled. (Taylor, 2007)

In Danish Universities, researchers are looking at the concept of mobility with a strong focus on sociology and some of its theories of science. For example, Naess (2006) demonstrates how the social factors like income, values and social structures, the geographical distribution and design of buildings, the mutual location of functions within the building stock and the transportation systems (road capacity, service of the public transport and parking conditions) can affect the transportation behavior. Freudendal-Pedersen (2005) takes a socio-constructivist approach by looking at the car drivers,

analyzing something denominated as "structural stories" (actions of individuals based on their own beliefs) e.g. a woman who drives her car because it supports her lifestyle even despite good conditions of other modes of transport. She concludes that the individual mobility patterns are based in several conscious and unconscious choices and that reflexive mobility (concept related to the choice of mobility based on the reflection that is not always necessary to drive a car) can play an important role in order to discourage the use private vehicle

The government of Mexico City, has been an active promoter of the transport system, they are trying to educate media in this issue. (Interview 2). However, the difference with developed countries is the segregation factor caused among other things by the huge gap of the different socio-economic strata. The challenge is still a big issue about exploring possibilities to move Mexican society in a more environmentally friendly direction. The 15% in modal change that the new line reached of Metrobus was important, but it still needs to improve.

8.5 SWOT analysis

SWOT analysis stands for strengths, weaknesses, opportunities and threats. It is a quick a simple tool to understand the overall big picture. The objective is to analyze strengths, by minimizing threats, and taking advantage of opportunities. The SWOT analysis can be used for decision-making enabling proactive thinking, starting point of strategic planning, it may be very subjective- therefore it needs to be seen as guide but not a prescription. Strengths and weaknesses look internally. Help identify what a project can do. Threats and opportunities are external. Help see beyond the project walls. This SWOT had been prepared mainly from the interviews and some documents provided by the interviewed:

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Environment	Reduction of local pollution and greenhouse gases by substituting old pollutant buses Reduction of noise	Deforestation of trees across the avenues Generation of debris, and some pollution during construction	Improvement of the quality of the diesel for the bus Improvement of the bus technology (hybrids, or fuel cells)	Increase of the use of private car
Culture & Society	Passengers satisfaction in general Time saved Less respiratory diseases Reserved space for women	Lack of suitable access to old and handicap people Neighbors protesting against the system Passengers complain about the bus overcrowded Accidents and violations	Education to media, car users and passengers Promotion of the public transport	Risk of being robbed Damage of stations by banditry

		by invading the lane		
Infrastructure	Segregated lanes of the bus Good fare system	Lack of passing lane Use of asphalt of bad quality Use of bollards of bad quality	Expansion of the system Use of bigger buses Use of hydraulic concrete in the roads	Deterioration of the roads and stations
Operation	High performance: commercial speed of 19 km/ hour, 50000 passengers / day Effective full electronic fare collection	Lack of capacity to satisfy demand (the buses are overcrowded) Low quality of service in compare to Metro	Improvement of the access and exit with automatic doors	Fails in the management of the bus
Economy & Finance	Project infrastructure costs were relatively low Generation of Carbon Revenues	The price of the ticket is considered too low Lack of financial maturity in the government (Financial planning was too tight and assumptions were on the non-conservative side)	Improvement of Managements Fees for Fare Collection	The price of the ticket could decrease even more
Politics	Leadership of the Secretary of Environment Will of the Head of the Government	Priority of the government is focused in second floors which gives much more reputation Lack of decision to construct a passing lane (appropriation or acquisition of residences would have been necessary	The relatively good relationship with the governor of the neighbor State of Mexico	Institutional misunderstanding Change of governments who do not rely in this kind of systems Widespread of Corruption

Table 9.1 SWOT of Metrobus: Suggested by Andrew Jamison

9 Discussion and Conclusion

When the government of Mexico City proposed to separate one lane on Insurgentes Avenue which would help to operate a system of articulated buses, there were many people who did not think that such a project would be politically feasible. The most pessimistic forecast that the lost of space for parking and the reduction in the traffic flow on the avenue would result in protests from the neighbors and commercial districts, and that car users would singularly invade the bus lane. The most pragmatic ones observed that the main difficulty would be to phase out the microbuses that were providing service on the route, forecasting blockades and demonstrations. Some people were critical that a system based on buses would never be able to encourage citizens to use it, meanwhile others were doubting that the operation of the government could be financially sustainable without multimillion peso environmental subsidies. All these voices were right, to some extent. However, after five years in service, Metrobus receives more applause than complaints. Some old concessionaires are satisfied, because they were incorporated as shareholders of the operating company. Besides, Insurgentes looks much cleaner and more ordered without the hundreds of microbuses that were circulating before, competing for the passage and stopping on every corner.

One interesting perspective of the BRT is the strong sustainability discourse in which it is based; if this project could have taken place 15 years ago, it would have only been a development project of transport. Today it is an "environmentally friendly measure", which makes it possible to have a much stronger political and financial support. Rail-based systems have the capacity to carry more people, which would be more effective in terms of sustainability, but the high cost of such systems represents a big barrier.

Metrobus contributes to air quality. This is not merely rhetoric, but as we have shown in this thesis, the use of Metrobus reduces the personal exposure to carbon monoxide, benzene and particulate matter 2.5 to passengers in comparison to the old buses (Wörnschimmen et al,2005). The BRT reduces 144 tons of total hydrocarbons, 690 tons of nitrogen oxides, 2.8 tons of fine particulate matter and 1.3 tons of sulfur dioxide each year (Stevens et al,2007). In addition, the BRT will reduce a yearly average of 70,303 tons of carbon dioxide equivalent that will be sold as carbon credits (Grütter, 2008).

The selection of the main stakeholders and the mapping done in this project could be quite useful for a consultative process in the development project of a BRT. A strong suggestion could be to involve all stakeholders at the very early stages of the project, to invite them to be part of a joint solution and of the benefits the system can provide.

The major achievement is the revolution in the public transport that now is having repercussions in other Mexican cities, where the BRT has been replicated with more facilities. The number of consultants and governmental bodies that are aware of how to promote this kind of project has grown significantly and the transport companies are taking the idea more seriously. Governments are now aware of the political importance of such projects and financing sources are widening. In addition to the National Fund for Infrastructure of the Federal Government, the World Bank is giving credits to finance other corridors in Mexican cities. The BRT is under evolution from non-existent utopia to feasible policies. The paradigm is changing, the low cost metropolitan transport system is achievable, by adopting measures to intensify development of the existent corridors. This system shows the ability to more quickly and more effectively serve an entire metropolitan population. The next technological challenge is to incorporate hybrid buses as cleaner solution.

The BRT is a perfect example of South-North technology transfer that fosters development and promotes equity in the city. The BRT was the first Clean Development Mechanism to be validated by its potential to reduce emissions. The fundamental principle of sustainable transport for Mexico City seems yet to lie in a future horizon. The public acceptability is an important issue for the implementation of policies regarding transport. No matter whether or not a policy is able to guarantee successful results, there is no chance of successful implementation in practice if public acceptability is not supported. A major factor that influences the public acceptability is the level of awareness of the environmental impact of each individual.

There is an urgent need to increase education at all levels regarding pollution and transportation. To support educational programs in universities and to improve communication and exchange of information with policymakers from European Cities and other successful regions in the world could be important. The role of specialized NGOs is fundamental. The city deserves a cleaner environment and healthier people, politics need to be aware of the benefits that an improved transport system represents. A promotion of behavioral changes to make people move in a more environmentally friendly direction will be linked with all aspects of life in the community and it will probably lead to greater change and certainly greater sustainability
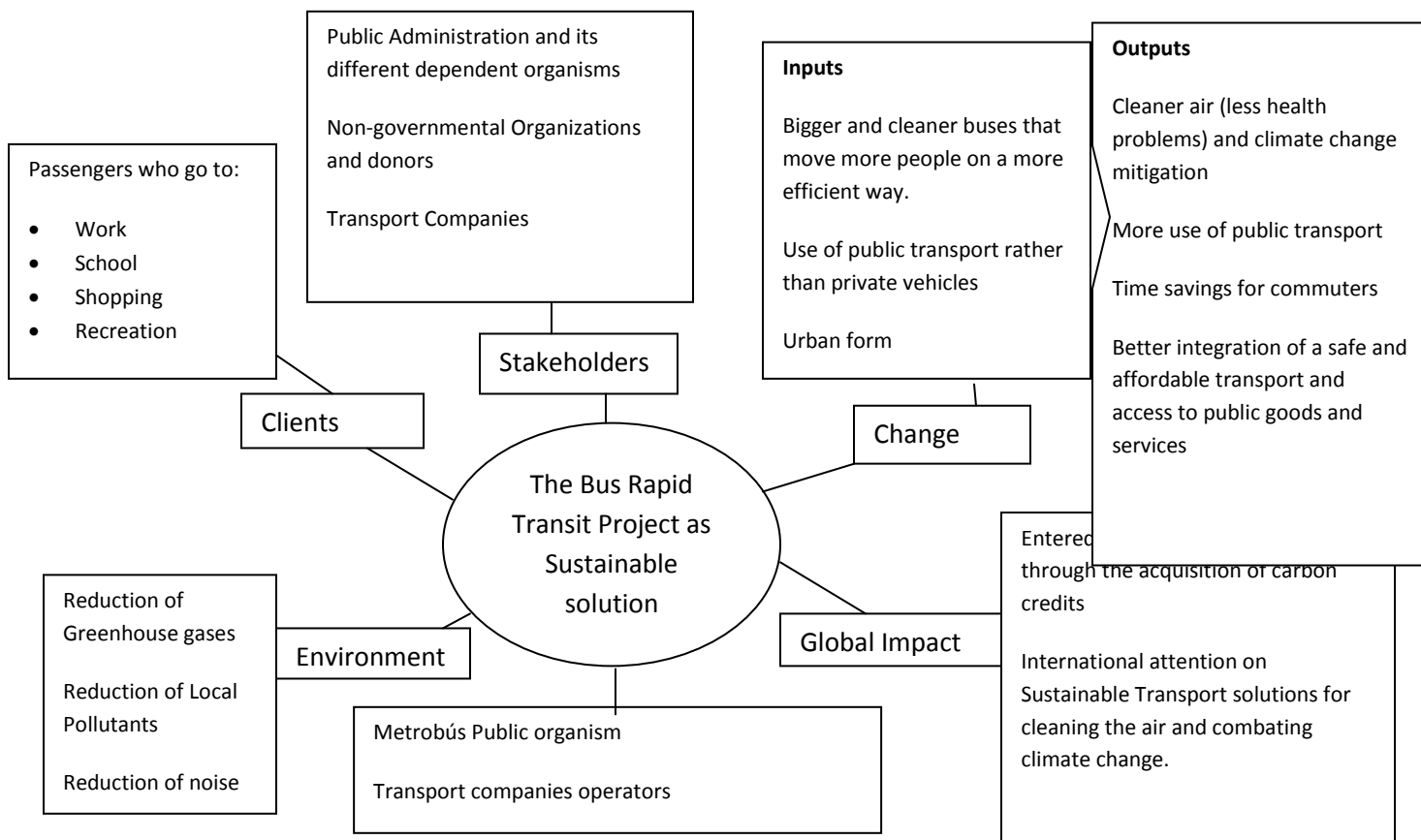
Public Administration and its different dependent organisms

Non-governmental Organizations and donors

Transport Companies

Passengers who go to:

- Work
- School
- Shopping
- Recreation

Inputs

Bigger and cleaner buses that move more people on a more efficient way.

Use of public transport rather than private vehicles

Urban form

Outputs

Cleaner air (less health problems) and climate change mitigation

More use of public transport

Time savings for commuters

Better integration of a safe and affordable transport and access to public goods and services

Stakeholders

Clients

The Bus Rapid Transit Project as Sustainable solution

Change

Entered through the acquisition of carbon credits

International attention on Sustainable Transport solutions for cleaning the air and combating climate change.

Reduction of Greenhouse gases

Reduction of Local Pollutants

Reduction of noise

Environment

Global Impact

Metrobús Public organism

Transport companies operators

Figure 9.1 A summary of the Bus Rapid Transit

10 In depth Interviews with Experts

Interviewed	Comments
Interview 1 Project Evaluator (World Resources Institute) April 30th	I was evaluator of ex-post of the function of CTS as the main stakeholders of the project Metrobús in Insurgentes. I did 42 personal interviews for EMBARQ and CTS to evaluate their capability. With the World Bank, I worked with urban transport and climate change for Mexico City, including the supervision of the projects GEF, the Carbon Finance with the Spanish Carbon Fund and the identification of the loan that would be made for the BRT system in the nation. The planning lasted more than one year, the project would have corridors of high occupancy. Metrobus was an environmental project rather than transport project Bogotá imported most of the knowledge and technical capacity, but Mexico created that local capacity The government was in need of showing important results in infrastructure with benefits to popular classes. The leadership of Claudia Sheinbaum (Ministry of Environment of Mexico City) The technical capacity and poor experience of the project implementers was a weak factor. There was low mobility without initiatives to solve the problem among different actors. The operation of the public transport is a public good and not a property of the operator The market assigned and weighed a risk with the feasibility of the project. The carbon finance is up to 200 thousand dollars each year, which was particularly insignificant compared to the whole cost of the project". The project offered good image and stability to the Spanish Carbon Fund The real change was the transformation of the operation model that promotes more technological change
Interview 2 Magolis Briones (Hewlett Foundation) May 10th	Associate Program Officer at the Environment Program of the William and Hewlett Foundation in Mexico. We support most polluted and most populated cities Ebrard took Government heads to Curitiba and Bogota. The light rail trains and subways are very costly, therefore, we cannot support those, we mostly rely on BRT. We have supported a plan with Mexico City's Major, CTS and Mario Molina, "Plan de transporte", a document with 6 mobility strategies: 10 lines for Mexico City and 8 for the neighbor State of Mexico We are trying to educate media, to inform public opinion about the process The car culture (many car users have expressed their malaise) and the overcrowding of buses. However, 19 percent of commuters have stopped using their car Low cost tolls for the transport are considered as too "populists" measures among some politicians Appropriation of terrains requires a political reason, Bogota and Mexico City are were very different with these decisions Ebrard's discourse is not consistant, he says he supports sustainable mobility and now he is constructing a second floor
Interview 3 Giorgos Voukas (Center for Sustainable Transport) May 19th	My areas of expertise are in transport systems and integration, urban toll, demand and accessibility management. We provide technical assessment to projects of sustainable mobility of Mexican cities, we are trying to change the man-bus systems (bus operated without any fleet control) to more appropriate companies of transport. We also work in areas of urban development and non-motorized transport, as for example, cycling paths. Another of our areas is climate change and air pollution, which works basically with the emissions technology, basic lines and public policies to rationalize the use of private car We are sponsored by foundations and embassies. We brought experts from Curitiba and Bogota for the project in Mexico City We evaluate also the modernization of transport systems by changing the structure of transport. The political will is very strong, but the economic resources are quite limited. The complexity was very big in all levels, the main problem was a new system, they didn't have experience, the collaboration was quite good, the system was considering all the limitations with a transition period of tolerance. The system is very successful and therefore, most of the times overcrowded, but we cannot attend the demand without a passing lane The economic crisis in 2008 stopped plans of expansion

	The Secretary of Roads and Transport have the most complicated part, because they are the ones who need to negotiate with transport concessionaries
	We are elaborating a communication strategy to support all social groups and neighbors about how to be with them during the process anticipating to the problem.
	The best of BRT in the world have assessed Mexican construction.
Interview 4 Victor Hugo Paramo (Secretary of Environment) June 4th	I was director of Air quality Management in the national Institute of Ecology. I am now the General Director of Air Quality Management
	We execute environmental policies for Mexico City and Metropolitan region. We elaborate local norms, which are different to federal norms.
	We have programs under our responsibility as vehicle verification, air quality monitoring network and program of compulsory school transport
	We elaborate local norms
	We elaborated the test for different buses with several technologies and several fuels.
	Claudia Sheinbaum was the leader of the project
	The diesel provided in Mexico City contains ultra-low sulfur
	The meteorological conditions of the city during the last days are the main factor of the recent environmental pre-contingencies. The systems of high stability means little air, and the heat and sun radiation are the fabulous ingredients that form ozone. The
	We simulate the behavior of ozone with a photochemical model by providing different scenarios of a specific policy measure, in this case, the introduction of Metrobus
	The government has called to make a Sunday family ride, 15 thousand has responded positively, and 15 thousand is a lot, that is the size of a town. I know that with improved conditions, the people will start using the bicycle.
	Major Ebrard took advantage of the initiatives of the last major Lopez Obrador in order to make them faster and more efficient.
	The previous leader of Environment Claudia Sheinbaum led Metrobus and the actual leader Martha Delgado is leading the cycling paths. Those are projects of transport and urban planning but not of environment.

11 Bibliography

ADB. (2008). *Social Analysis for Transport Projects.* Asian Development Bank: Technical Note.

Alcócer, J. (2010, February 15). *Estrena el GDF el programa Ecobici; desde mañana, por 300 pesos anuales, los capitalinos podrán disponer de bicicletas para sus traslados*. Retrieved June 8, 2010, from La Cronica news: http://www.cronica.com.mx/nota.php?id_nota=487987

Ardila-Gómez, A. (2004). *Transit Planning in Curitiba and Bogotá: Roles in Interaction, Risk and Change.* Boston: Massachusetts Institute of Technology.

Ardila-Gomez, O. (2009). Banco Mundial Apoya proyecto para Mejorar la Calidad del Aire y del Transporte. (C. e. http://www.youtube.com/watch?v=skKG4iAvx38, Interviewer)

Baffer. (2006, May 8). Promoting Public Transportation for Sustainable Development. *Princeton University* , p. 9.

Bañobre, E., & Romero, A. (2008). *Los BRT en Corredores Segregados como Sistema Óptimo de Transporte Urbano.* Retrieved from http://www.catedraetm.es/pdfs/brt.pdf

Beck. (1994). *The Risk Society: Towards a New Modernity. Originally published as Risikogesellschaft: Auf dem weg in Eine Andere Moderne.* New Delhi: SAGE publications.

Beck, U., Giddens, A., & Lash, S. (1996). *Reflexive Modernization: Politics, Tradition and Aesthetics in the Modern Social Order.* Stanford University Press.

Center Mario Molina. (2005). *La Calidad del Aire en la Megaciudad de Mexico.* Mexico City.

Clean Air Initiative. (2010). *Clean Air Initiative of the world Bank*. Retrieved May 3, 2010, from http://www.cleanairnet.org/cai/1403/channel.html

Consuegra, R. (2005). Conflictos en Corredor Insurgentes. In *http://renatoconsuegra.blogspot.com/2005/05/conflictos-en-corredor-insurgentes_02.html.* Mexico City: Revista Vértigo.

CTS, C. d. (2010). http://www.ctsmexico.org/, Accessed April 4th.

Dolowitz, D., & Marsh, D. (1996). Who learns what from whom: a review of the policy transfer. Political Studies XLIV.

Ebrard, M. (2009, September 1). *Gobierno del Distrito Federal.* Retrieved May 23, 2010, from http://www.informe.df.gob.mx/images/pdf/3er_informe/3er_informe_de_gobierno_2009.pdf

Echeverry, J. C., Ibáñez, A. M., Moya, A., Cárdenas, M., Gómez-Lobo, A., & Hillón, L. C. (2005). *The Economics of TransMilenio, a Mass Transit System for Bogotá.* Bogota: The Brookings Institution.

Elsom, D. (1996). *Smog Alert: Managing Urban Air Quality.* London: Earthscan Publications Ltd.

EMBARQ. (2010, May 30). *The World Resources Institute for Sustainable Transport*. Retrieved from http://www.embarq.org/en/problem/car-culture

Evans, M. (2004). Understanding policy transfer. In *In Policy Transfer and Global Perspective.* Aldershot: Ashgate.

Freudendal-Pedersen. (2005). Structural Stories, Mobility and (Un)freedom. In N. a. Thomsen, *Social Perspectives on mobility* (pp. 30-44). Ashgate Publishing Limited.

FTA. (2004). *Federal Transit Administration. Characteristics of Bus Rapid Transit for Decision Making.* Washington: United States Department of Transportation.

Gaceta Oficial del Distrito Federal. (2005). *Jefatura de Gobierno del Distrito Federal*. Retrieved from http://revista-por-que.blogspot.com/2009/04/metrobus-en-ciudad-de-mexico-vialidad-o.html

GDF. (2010). *Gobierno del Distrito Federal*. Retrieved April 18, 2010, from http://www.df.gob.mx/wb/gdf/historia_de_la_ciudad_de_mexico, accesed april 18th.

GDF. (2009). *Ofertas en el Distrito federal*. Retrieved June 15, 2010, from http://www.ofertasdf.info/ciclismo-en-mexico-df.php

Gobierno del Distrito Federal. (2007). *Proyecto Introducción de Medidas Ambientalmente Amigables en Transporte.* Mexico City.

Grimble, R., Chan, M.-K., Aglioby, J., & Quan, J. (1995). *Trees and Trade-offs: A Stakeholder Approach to Natural Resource Management, "International Institute for Environment and Development".* Gatekeeper Series No.52.

Groodman, J., & Laube, M. (2006). Curitiba's bus system is Model for Rapid Transit. *Race, Poverty and the environment* .

Grub, M. (2009). Technology Innovation and Climate Change Policy:. *Keio Journal of Economics* , 9.

Grütter Consulting. (2010). *BRT Metrobus Insurgentes and Eje 4, Mexico.* Mexico: UNFCC.

Grutter Consulting. (2008). *UNFCC.* Retrieved from Bogotá, Colombia Transmilenio Phase II-IV. Project Design Document (CDM PDD): http://www.cdm.unfcc.int

GTZ. (2010). Retrieved from The Deutsche Gesellschaft für Technische Zusammenarbeit: http://www.gtz.de/en/689.htm

Guarnero, M. A., & Hudson, R. (2009). La contaminación del aire deteriora la función olfativa cotidiana en residentes de la ciudad. *Medigraphic* , 81-86.

Gwillian, K., Kojima, M., & Johnson, T. (2010). *Reducing Air Pollution from Urbann Transport.* Washington: The World Bank.

Hardon, J., Mitlin, D., & Satterthwaite, D. (2001). *Environmental Problems in an Urbanizing World: Finding Solutions in Africa, Asia and Latin America.* The City Environment: Earthscan Publications Ltd.

Inglehart, R. (2000). Globalization and Postmodern Values. *The Washington Quarterly, Volume 23, Number 1* , 215-228.

IPCC. (2007). *Intergovernmental Panel on Climate Change. Mitigation of Climate Change.* Bangkok: Working Group III Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Summary for Policyymakers and Technical Summary.

ISA, I. S. (2009). Opinion Survey about Passenger Satisfaction and Gender Equity. Mexico City: http://www.metrobus.df.gob.mx/encuestaequidad.pdf, Accessed april 4th.

Lash, S., & Urry, J. (1994). Reflexive Modernization. Cambridge: Polity Press.

Lerner, J. (2005). *Metrobus Mayor que Segundo Piso*. Retrieved from http://www2.eluniversal.com.mx/pls/impreso/noticia.html?id_nota=68951&tabla=ciudad

Levinson. (2008). *Bus Rapid Transit-Implementation Guidelines.* TCRP.

Lezama, J. S. (2006). Medio Ambiente y sociedad. 3-4.

Litman, T. (2010). Quantifying the Benefits of Nonmotorized Transportation. *Victoria Transport Policy Institute* .

Mage, D. (1996). Urban Air Pollution in Megacities of the World. *Atmospheric Environment Vol. 30, No. 5. Elsevier Science, UK* , pp. 681-686.

Matsumoto, N. (2010). Analysis of policy processes to introduce Bus Rapid Transit systems in Asian cities from the perspective of lesson-drawing: cases of Jakarta, Seoul and Beijing. *Institute for Global Environmental Strategies* .

McLeod, K. (2002). Curitiba-Orienting Urban Planning to Sustainability. *The International Council for Local Environmental Initiatives ICLEI* , 4-5.

Metrobus. (2010). Foro de Discusión. http://www.metrobus.df.gob.mx/foro.html?tema_id=2.

Metrobus. (2010). *Metrobus-Corredor Insurgentees. Distrito Federal, Mexico*. Retrieved from http://www.metrobus.df.gob.mx/

Miller, M., & Buckley, S. (2000). Institutional Aspects of Bus Rapid Transit. *California PATH working paper* , 13.

Montaner, J. (1999). El modelo Curitiba. *Ecología Politica No.17* , p. 128.

Naess, P. (2006). Accessibility, Activity Participation and Location of Activities: Exploring the Links between Residential Location and Travel Behaviour . *Urban Studies, Vol. 43, No. 3. Routledge.* , 627-652.

Negrete, M. E. (2006). *El Metrobús de la ciudad de México*. Retrieved from http://www.esmas.com/portada/625857.html

North, D. (1990). *Institutions, Institutional Change and Economic Performance.* Cambridge: Cambridge University Press.

Notimex. (2009, March 14). Multan a 20 conductores por invadir carril de metrobús al día. *Noticieros Televisa* , pp. http://www2.esmas.com/noticierostelevisa/mexico/048707/copy-multan-20-conductores-invadir-carril-del-metrobus-al-dia, Accessed April 28th.

O'Connor, A. (2010). "Making a progress against pollution, but the battle is far from over. *Nexos* .

Pantoja. (2009, August 12). Ebrard anuncia licitación para linea 3 de metrobús. *El Universal* .

Piet, R. (2002). Institutional dimensions of sustainable transport. In W. Black, & P. Nijkamp, *Sustainable Transport and Social Change.* Indiana University Press.

PROAIR. (2002-2010). *Programa para mejorar la Calidad del Aire de la Zona Metropolitana del Valle de México. Comisión Ambiental Metropolitana. Secretaría de Ecología del Gobierno del Estado de México, Secretaría de Medio Ambiente del Distrito Federal, Secr.* The government of Mexico City.

Rivera, J. (2010). *Menos Contaminación en el valle de México. En 2009 se registró el año más limpio de la historia*. Retrieved from http://www.misionpolitica.com.mx/index.php?option=com_content&view=article&id=782:menos-contaminacion-en-el-valle-de-mexico&catid=45:urbana&Itemid=60

Roccatti, M. (2006). *La Comisión Ambiental Metropolitana: un Nuevo Esquema de Coordinación.* Ciudad de Mexico.

Rojas, F., & Mello, C. (2005). *El Transporte Público Colectivo en Curitiba y Bogotá.* Retrieved from http://www.josepmariamontaner.cat/arti/lavanguardia/curitiba%2012%20de%20julio%202006.pdf

Romero, G. (2010, March 6). *La Jornada*. Retrieved June 5, 2010, from http://www.jornada.unam.mx/2010/03/06/index.php?section=capital&article=027n1cap

Rose, R. (1993). Lesson-drawing in Public Policy. In *A Guide to Learning across Time and Space.* Chatham, New Jersey: Chatham House Publishers, Inc.

Route, M., & Andersson, S. (1999). *Environmental Goals for Sustainable Transport in Europe. A report from the Swedish Euro-EST project. .* Stockholm: Swedish Environmental Protection Agency.

RTP. (2010). *Red de Transporte de Pasajeros del Distrito Federal*. Retrieved June 6, 2010, from http://www.metro.df.gob.mx/organismo/construccion6.html

Scott, R. (2010). *Institutions and Organizations.* London: SAGE Publications.

SEDUVI. (2010). *Secretary of Urban Development and Housing.* http://www.seduvi.df.gob.mx/seduvi/, Accessed May 2nd.

SETRAVI. (2010). *Secretaria de Transportes y Vialidad.* Mexico: http://www.setravi.df.gob.mx/wb/stv/3er_informe_setravi, accessed April 8th.

Sheinbaum, C. (2009). Metrobus: A winning Formula. *Centro de Transporte Sustentable de México A.C.*

Shell Foundation. (2010). *Embarq.* http://www.shellfoundation.org/pages/core_lines.php?p=corelines_content&page=embarq, Accessed April 28th.

Skinner, I., & Fergusson, M. (1999). *Instruments for Sustainable Transport in Europe. Potential Contributions and Possible Effects.* Stockholm: Swedish Environmental Protection Agency.

SMA-DF. (2010). *Secretaria de Medio Ambiente del Distrito Federal.* Retrieved from http://www.cvcccm-atmosfera.unam.mx/cvcccm/proyectos/Transporte_Sheinbaum.pdf

Smith, K., & Akbar, S. (1999). *Health-damaging air pollution: a matter of scale, in Gordon McGranahan and Frank Murrans, Health and Air Pollution in Rapidly Developing Countries.* Stockhom: Stockholm Environment Institute.

Sosa, I. (2004, December 5). Arrancan Las Obras del primer metrobus. Distrito Federal, Mexico. *Periódico Reforma* .

Stevens, G., Zuk, M., Rojas, L., & Iniestra, R. (2008). The Benefits and Costs of a Bus Rapid Transit System in Mexico City.

Targa, F., & Rodríguez, D. A. (2004). *Analysis of Bogota's Bus Rapid Transit System and its Impact on Land Development.* Retrieved from http://terpconnect.umd.edu/~ftarga/downloads/Papers/Targa-Rodriguez-2004.pdf

Taylor, M. (2007). Voluntary Travel Behaviour Change Programs in Australia: The Carror rather Than the Stick in Travel Demand Management. *International Journal of Sustainable Transportation* , 178-192.

Thomsen, T. U., Drewes, L., & Gudmundsson, H. (2005). *Social Perspectives on Mobility.* Roskilde University: Transport and Society.

Valderrama, A. (2010). How do we co-produce urban transport systems and the city? In I. Farias, & T. Bender, *Urban Assemblages: How Actor-Network Theory Changes Urban Studies* (pp. 125-137). New York: Routledge.

Vergara, W. (2002). *Introduction of Climate Friendly Measures in Transport. Project Appraisal Document on a Proposed Grant from the Global Environmental Facility.* Washington: The World Bank.

Voukas, Y. (2001). Personal Transportation in Athens. *Lund University* .

Walsh, M. (1989). Emission testing program in Mexico City. *Handbook of Air Pollution* .

WB. (2010). *The World Bank*. Retrieved from http://www.worldbank.org/

WHO. (2005). *World Health Organization. Air Quality Guidelines.* Retrieved April 8, 2010, from http://www.euro.who.int/document/e90038.pdf

Wolfe, R., & Elder, D. (2007). Retrieved from Queens University: http://post.queensu.ca/~wolfer/802MPA/MPA802.htm

Wolfe, R., & Elder, D. (2010). *Department of Policy Studies*. Retrieved June 4, 2010, from Queens University: http://post.queensu.ca/~wolfer/802MPA/MPA802.htm

Wörnschimmel, H., Cardenas, B., Rojas, L., Antonio, C., Zuk, M., Cerom, J., et al. (2005). *Evaluación de la Exposición Personal a Contaminantes Atmosféricos en Pasajeros de Vehículos de Transporte Público.* Mexico City: Centro de Transporte Sustentable.

WRI. (2010). *World Resources Institute*. Retrieved from http://www.wri.org

Wright, L. (2005). Bus Rapid Transit, Sustainable transport. In *A sourcebook for policy-makers in developing.* Eschborn: Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH.