SUSTAINABLE URBAN TRANSPORTATION DEVELOPMENT: PRIORITIZING PUBLIC TRANSPORT – BRT IN HO CHI MINH CITY

NGUYEN ANH DUNG

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE (INDUSTRIAL ECOLOGY AND ENVIRONMENT)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2008

Thesis
Entitled

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………………………………………………….
Mr. Nguyen Anh Dung
Candidate

…………………………..................................
Asst. Prof. William Ross, Ph.D.
Major-Advisor

………………………………………………….
Assoc. Prof. Chamlong Poboon, Ph.D.
Co-Advisor

………………………………………
Prof. Banchong Mahaisavariya, M.D.
Dean
Faculty of Graduate Studies

……………………………...................................
Lect. Kitikorn Charmondusit, Ph.D.
Chair
Master of Science Programme in Industrial Ecology and Environment
Faculty of Environment and Resource Studies

Thesis
Entitled

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was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science (Industrial Ecology and Environment)
on
June 16, 2008

……………………………………………….
Mr. Nguyen Anh Dung
Candidate

……………………………………………….
Asst. Prof. Sompote Kunnoot, Ph.D.
Chair

…………………………..............................
Asst. Prof. William Ross, Ph.D.
Member

……………………………………….
Asst. Prof. Thomas Hoy, Ph.D.
Member

………………………………………………
Assoc. Prof. Chamlong Poboon, Ph.D
Member

………………………………………
Prof. Banchong Mahaisavariya, M.D.
Dean
Faculty of Graduate Studies
Mahidol University

…………………………...............................
Asst. Prof. Sittipong Dilokwanich, Ph.D.
Dean
Faculty of Environment and Resource Studies
Mahidol University

ACKNOWLEDGEMENTS

There are many people who have contributed to the success of this thesis and my study in Thailand. Firstly, I would like to express my deep gratitude to Dr. William Ross, my major advisor, for inspiring me regarding the concept of urban transport and for his invaluable assistance and guidance. I would like to thank Dr. Chamlong Poboon, my co-advisor for his kind support, encouragement and suggestions. I also thank Dr. Sompote Kunnoot and Dr Thomas Hoy, members of the thesis defense committee, for their valuable comments and constructive suggestions for my thesis.

My special thanks to all professors, lecturers and staffs of international program at Faculty of Environment and Resource Studies for sharing their knowledge and support during my study in Mahidol University.

I would like to thank Thailand International Development Cooperation Agency (TICA) for the financial support provided for my study and living expenses in Salaya, Thailand.

I also thank my classmates for being cooperative and helpful to me and being part of my memorable stay in Thailand. My sincere thanks to my friends in previous and new cohorts for their exchange in ideas and comments for my thesis and course of study.

Last and very important, I am greatly indebted to my parents, siblings, relatives and friends at home for the patience, love, concern, support and inspirations for my overseas study and towards the attainment of my endeavors.

Nguyen Anh Dung

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NGUYEN ANH DUNG 4937450 ENIE/M

M.Sc. (INDUSTRIAL ECOLOGY AND ENVIRONMENT)

THESIS ADVISORS: WILLIAM ROSS, Ph.D., CHAMLONG POBOON, Ph.D.

ABSTRACT

This study addresses the question of sustainable urban transport. Ho Chi Minh City, Vietnam, is dominated by motorcycles, and its rapid economic development is bringing more cars and motorcycles onto its already congested streets every day. While Bus Rapid Transit (BRT) is gaining popularity as a low-cost and highly efficient mass transit system in many cities, it has not been able to gain enough support from the government in Vietnam to be implemented.

This study used a Stated Preference Survey to measure the attitude of motorcyclists, as the major stakeholders in Ho Chi Minh City's transport system, towards BRT. In addition, given the rising price of oil and the need to address global warming issues, a calculation was also performed comparing energy consumption of motorcycles and the proposed bus-based transit system.

The findings revealed that a high percentage of motorcyclists would switch to the proposed bus system. The study also found that the proposed BRT network could reduce transport-related CO2 emissions by more than 40,000 tonnes per year, and replace around one million motorcycle trips a day. The results of this study can provide an incentive for policy makers to implement BRT in Ho Chi Minh City as well as providing data for future BRT studies.

KEY WORDS: BUS RAPIT TRANSIT / BRT / HO CHI MINH / GREENHOUSE GAS / SUSTAINABLE URBAN DEVELOPMENT / SUSTAINABLE TRANSPORT

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CHAPTER 1
INTRODUCTION

1.1 Statement of issues

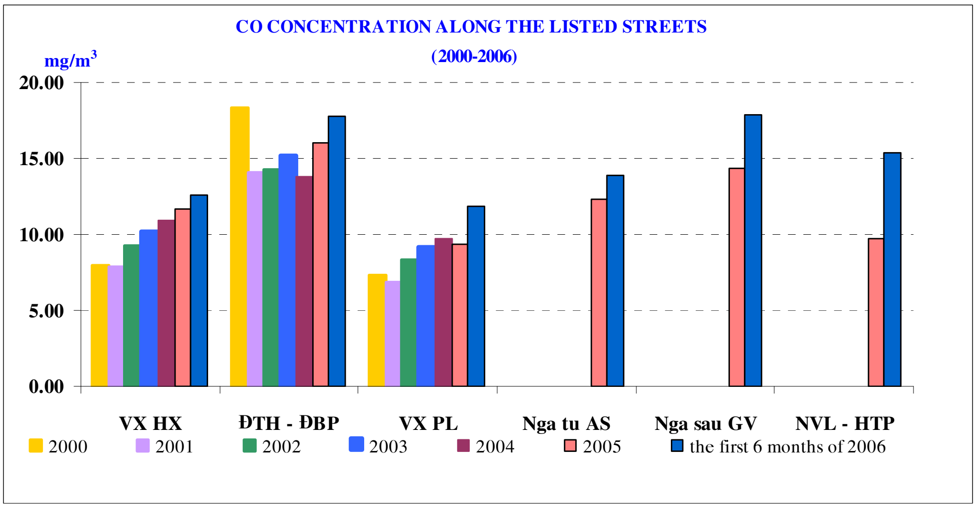
1.1.1 Ho Chi Minh City transport background

Ho Chi Minh City is the largest city and one of the most important economic hubs of Viet Nam. With a growth rate of 2.1 % per year, the city's population is forecast to increase from the current 7.7 million to 13.5 million by 2020 (ADB, 2006). In 2004, private vehicles represented an abnormally high proportion (90 %) of total trips (or equal to 19 million non-pedestrian trips per day), in which motorcycles account for 78.8 %, cars 4.8 %, and bicycles 5 % (Ngo, 2005). Although car ownership has been historically low when compared with similar economies in the region, with the annual GDP growth about 10.5 % (IER, 2006), there is real potential for household incomes to rise, enabling many more families to afford cars. On 1 May 2006 the Government again allowed used cars to be imported, and this is likely to lead to falls in car prices. It is expected that if current trends are not offset by a better public transport system, Ho Chi Minh City will face congestion, road safety, and air pollution difficulties similar to those in other large Asian cities such as Bangkok, Beijing, Manila, and Jakarta (Barter et al., 2003)

In Ho Chi Minh City, the average width of city streets is 6.5 meters, while streets wider than 12 meters only account for 19% (Thinh, 2002). From 1997 to 1999, during rush hours 22 streets had a volume of more than 15,000 passengers/direction/hour, 35 streets had more than 10,000 passengers/direction/hour and 82 streets had more than 5,000 passengers/direction/hour. The combination of lack of road space and extremely high number of passenger vehicles (primarily motorcycles) has inevitably led to congestion, air pollution and safety concerns (Thinh, 2002).

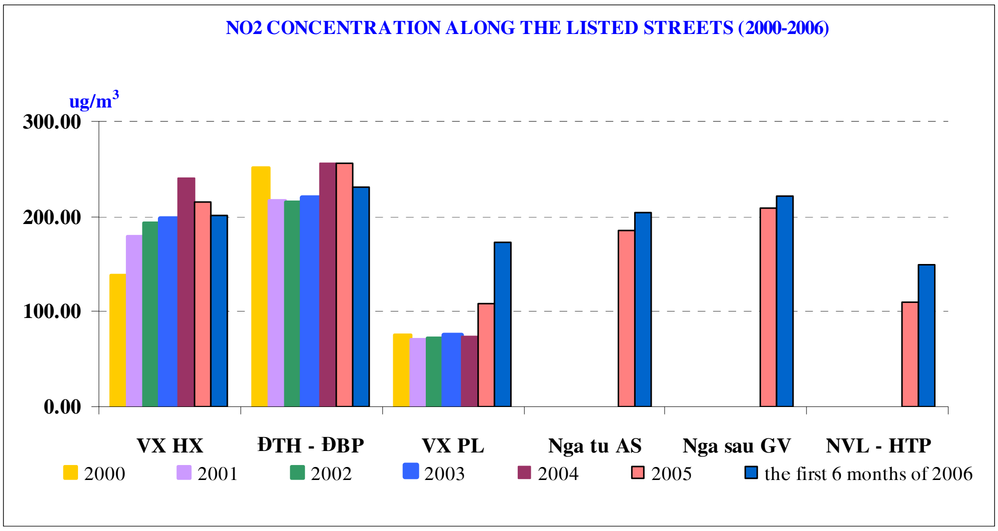
In 2005, Ho Chi Minh City's public transport only accounted for about 3.2 % of the mode split (Ngo, 2005). One factor leading to the extremely low public transport share is the large number of private motorcycles as the main means of daily travel. Other reasons include the low density of the current bus network, lack of public transport vehicles, problems in organization, infrastructure and insufficient incentive policies (Tin, 2001).

The damage to the urban environment caused by the huge number of motorcycles and inefficient public transport has affected public health and become a barrier to development. The concentration of CO, NO_x, lead, dirt and noise has been monitored at several points in the city. (Figure 1.1 and 1.2)



(Source: HEPA, 2006)

Figure 1.1 CO concentration along the listed streets from 2000 to 2006



(Source: HEPA, 2006)

Figure 1.2 NO_2 concentration along the listed streets from 2000 to 2006

1.1.2 Current policies and their weakness

In order to deal with transport-related issues, several conferences and studies have been conducted in the period of 2000-2004 (Phin, 2002; Ngo, 2005; Hong et al., 2005; Thinh, 2005). Generally, the suggestions resulting from these studies and discussions focused on:

- widening road space and roundabouts
- converting some two-way streets into one-way streets
- building flyovers (planned)
- increasing the number of buses and bus routes
- staggering the start and finish time for workers and students to spread the rush hours
- improving the traffic signal system
- educating people on transport law
- subsidizing public transport
- improving fuel quality
- building a metro system (commencing in September 2007)

Despite the fact that some of these policies have been implemented since 2002, the traffic situation is getting worse, especially during rush hours when there is more and more congestion and air pollution. It is clear that the People's Committee (the city government) shows no determination to restrict private motorized transport and is furthermore planning to provide the infrastructure to supply the road space for more motorcycles and automobiles in the future.

In addition, the metro has been seen as a solution for public transport. The first two planned metro lines totaling 20.5 km have a budget of 1 billion USD for constructing of the tunnels, depot, trains, stations, control center and planning, and aim to have 300,000 passengers/day by 2020 (DTPW, 2005). However, whether the metro is a feasible and sustainable option for Ho Chi Minh City is still in question not only because of the unacceptably high capital cost but also because of the operating cost. International experience shows that in cities like Bangkok, Manila, Pusan or Mexico City, a metro needs very high subsidies in order to continue its operations (Kain, 1991; World Bank, 1996). Moreover, there are cases such as Delhi and Kolkata where metro systems are operating at such low capacities that the term "mass transit" might be applied improperly (ITDP, 2007).

Meanwhile, there is another more economical option for public transport namely Bus Rapid Transit (BRT) which is gaining success more and more in developing cities. In terms of capacity, BRT can provide the same service or even better than some rail-based systems (Wright, 2005; Hensher, 2006). Bogota's TransMilenio BRT with a capacity of 45,000 passenger/hour/direction surpasses Bangkok's skytrain and Manila's MRT (22,000 and 26,000 passenger/hour/direction respectively) (ITDP, 2007). In terms of economics, there is also evidence that typically 1 billion USD buys 400 km of dedicated BRT in contrast to the 20.5 km of metro now being constructed in Ho Chi Minh City (Wright, 2005). From the users' perspective, a more comprehensive network will provide more opportunities for its use, thus solving both the problem of congestion and pollution.

Currently, there is growing interest in sustainability, sustainable development, and sustainable transport. In summary, sustainable development requires the balancing of its three pillars, the economy, society and environment regardless of time and location. An inefficient transport system can have significant sustainability impacts (Litman and Burwell, 2006):

- Economic: traffic congestion, mobility barriers, accident damages, facility cost, consumer cost, depletion of non-renewable resources.
- Social: inequity in accessibility for the poor, human health impacts, low community interaction, livability, aesthetics
- Environment: air and water pollution, habitat loss and depletion of non-renewable resources

The current transport system in Ho Chi Minh City seems to be generating all of the above- mentioned impacts. In this context, there is an emerging requirement for more comprehensive research into a sustainable transport system for Ho Chi Minh City.

1.2 The research and its contribution

An initial BRT sketch was technically designed in 2006; however the city government is showing a reluctance to give buses priority over motorcycles. This study investigates the attitudes of Ho Chi Minh City motorcyclists towards the current bus system and the implementation of a BRT system using a Stated Preference survey. The results gained from the survey will be used to calculate the potential for CO2 reduction if BRT is installed. The study can provide an incentive for policy makers to implement BRT in Ho Chi Minh City as well as providing data for future BRT studies.

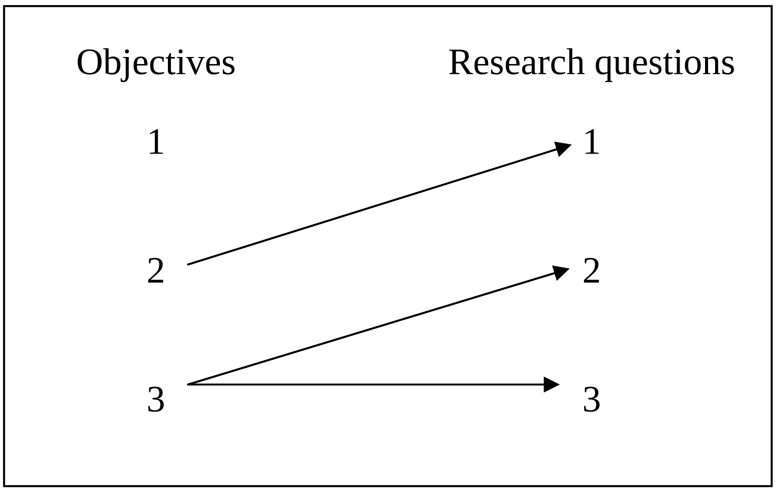
1.3 Objectives

1. To determine Ho Chi Minh City's motorcyclists' attitudes towards the introduction of a BRT network.
2. To examine the factors that would influence motorcyclists' decisions to shift to the BRT network.
3. To determine the potential for reducing energy consumption (in terms of CO2 reduction) if BRT is implemented in Ho Chi Minh City.

1.4 Research questions

1. What factors influence Ho Chi Minh City's motorcyclists' decision to use BRT?
2. How many motorcyclists will potentially switch to BRT?
3. What is the potential saving in energy consumption and greenhouse gas emission of BRT for Ho Chi Minh City transport sector?

The relationship between objective and research questions are shown in figure 1.3



Firgure 1.3 The relationship between objectives and research questions

1.5 Conceptual framework

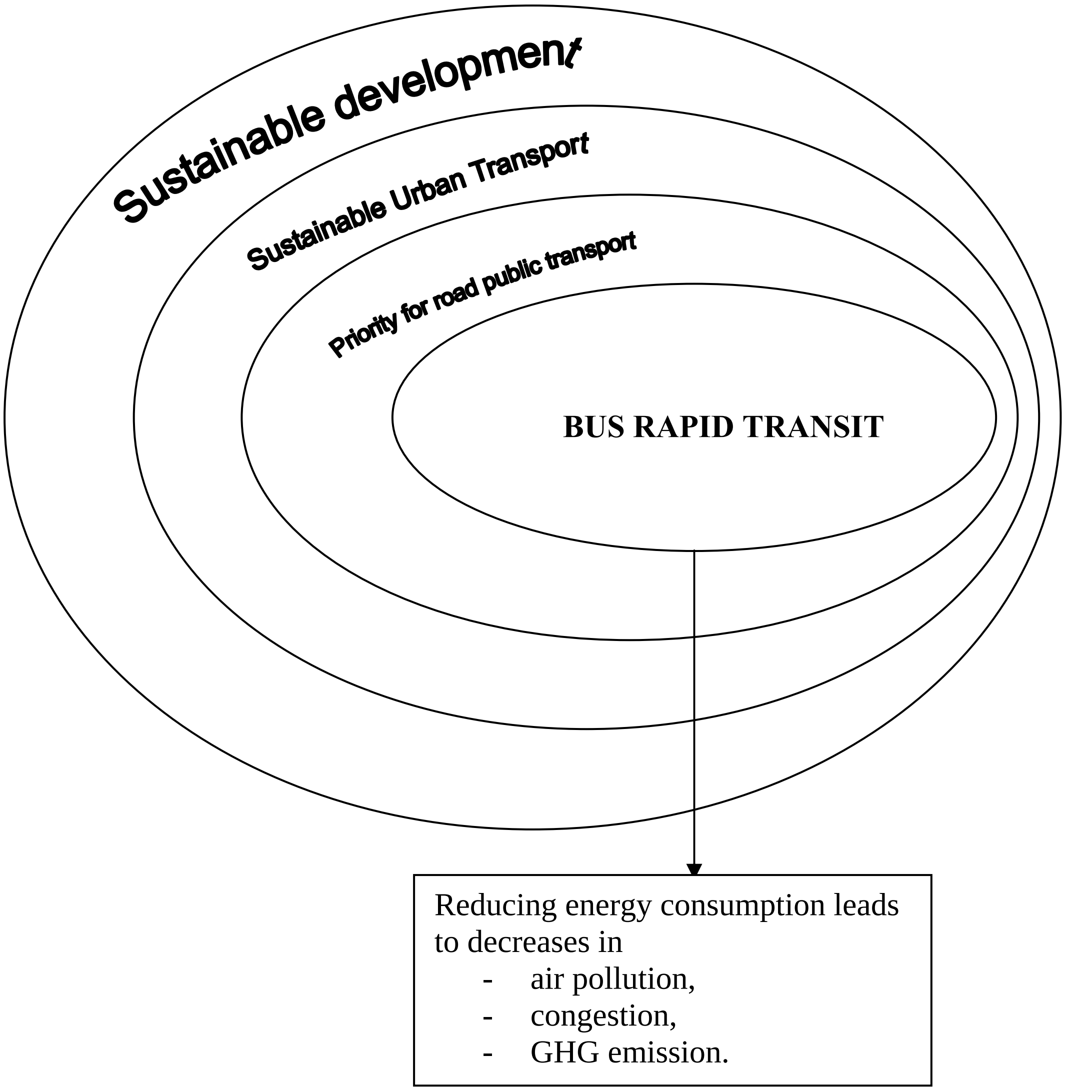


Figure 1.4 Conceptual framework

Concerning sustainable development, this study aims to find the potential for reducing energy consumption in Ho Chi Minh City's transport sector. There are several means to promote sustainable urban transport such as road pricing, pedestrianisation, and increasing transit use. In the case of Ho Chi Minh City where 78.8 % of the trips are made by private motorcycles, increasing the percentage of transit use by giving buses priority over motorcycles is a very effective way to discourage people from using their own vehicles. By using the Stated Preference survey including a brief BRT introduction, this study will investigate the response of motorcyclists to the proposed transport system. The results will give information that can be used to determine the potential for reducing energy consumption and accordingly reducing air emissions and congestion.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

The aim of this chapter is to review the trend in motorization as well as the traffic impacts on society, the environment and the economy. Also this chapter focuses on the concept of sustainability and sustainable urban transport. The policies for reducing the impact will follow the topics mentioned earlier. While private vehicles cause countless problems, public transport emerges as a sustainable solution as regards global impact, energy security and social equity.

2.2 The trend of private motorization and public transport use in developing cities

It is a widely accepted concept that effective problem-solving requires an appreciation of the context of a problem. (Koenigsberger, 1964; Gladwell, 2003). The final years of the twentieth century witnessed the “high-speed” urbanization of developing cities such as Bangkok, Kuala Lumpur, Jakarta, Manila and Ho Chi Minh. However the rapid economic growth brought with it a dramatic increase in the ownership and use of privately-owned cars and motorcycles. The economic reasons for this trend were explained (Townsend, 2003):

- Income growth raises the value of time. In other words, time represents money: travelers will shift from slower modes of transportation (walking, cycling and poor public transport) to faster modes (private motorized vehicles) to save time.

- Travelers choose privately-owned vehicles because of comfort, convenience, the frequency of service, reliability and accessibility compared to public transport. Webber (1981) noted that the primary benefit of automobiles is their capability to make door-to-door trips an option for low-density cities of the United States.

- The inferiority of public transport: Because of public transport's disadvantages thanks to official neglect, the bus has long been considered an option for the poor. Meanwhile, the level of automobile ownership has become the standard measurement of wealth between citizens in a city or among cities.

In general, the free market gradually allows people with higher incomes to purchase private motorized vehicles that in turn permit them to implement their strong desire to get out of crowded and polluted urban areas and to live in isolated, suburban houses with play-yards and lawns where public transport does not exist. Dargay and Gately (1999) noted that if the per capita income increases from 2,000 USD to 5,000 USD, vehicle purchases increase sharply.

Although the consequences have been sprawl and other environmental problems in western cities (Litman and Barter, 2000), many developing cities are following the trend. For example: in spite of Bangkok's high density, its motorization started in 1946 and so far it is the developing city in Asia that has the highest number of motorized vehicles (from 3 cars and 0.6 motorcycles per 1000 people after World War II (Poboon, 1997) to 249 cars and 205 motorcycles per 1000 people in 1995). In comparison, Kuala Lumpur had 209 cars and 175 motorcycles per 1000 people in 1995 although in the 1960s, its urban transport system depended mainly on walking and non-motorized vehicles (Townsend, 2003). With their recent economic growth, Jakarta and Manila also faced rapid motorization in the 1990s although the level of motorized vehicles is less than that of Bangkok and Kuala Lumpur (Barter et al., 2003). The International Energy Agency (IEA/SMP, 2004) predicted that by 2030 the number of vehicles in developing countries would surpass that in the OECD.

In contrast to the fast growth of private motorized vehicles, public transport use is often low in developing cities as the result of little official care and the increase in personal vehicles (Barter, 2000). People purchase personal vehicles in order to fulfill their travel demands that the poor public transport system cannot provide. However, the increase in the number of private vehicles will cause more congestion on the road which subsequently makes public transport even less attractive to passengers due to longer delays and lower quality of service. In Kuala Lumpur, Taipei and Bangkok, motorization has been able to reach quite high levels before mass transit systems were in place and public transport use was considered an inferior transport mode (Barter, 1999).

2.3 Impacts of private motorized vehicles oriented society

As mentioned above, the current trend of developing cities in building their transport systems is to follow low density Western cities' experience in some respect. As long as automobiles and highways are still the symbol of development and freedom, and public transport is neglected, private motorized vehicles (from motorcycles to automobiles when income allows) will be chosen by people in order to fulfill their demand for traveling in cities. Yet, despite the freedom and mobility seemingly provided by private motorized vehicles, serious impacts are undeniably following those cities with highly motorized levels such as bad air quality and noise, accidents and congestion.

Air quality and noise

Epidemiological studies have directly associated transport-related contaminants with asthma, bronchitis, heart attacks, and strokes (Dockery and Pope, 1994). WHO (2000) reported that in city centers 95% of CO and 70% of NO_x, 60% of lead and 50% of hydrocarbons are products of the process of burning fossil fuel in vehicles' motors. In addition, vehicles also discharge other aerial toxicants such as benzene and formaldehyde which can cause cancers even in small amounts

(McGranahan and Murray, 2003). Another group of emission products called volatile organic compounds (VOCs) can react with NO_x in the atmosphere to produce ground-level ozone (O_3) which is well known as photo-chemical "smog" causing severe damage to respiratory systems, vegetation and buildings.

Noise from vehicle operation, horns and car alarms can cause negative consequences for human health (WHO, 2005). In OECD countries, about 16 % of the population is exposed to noise levels from transport that might severely disturb sleep and communication (Barter, 2000). According to Evans and Maxwell (1997), sustained exposure to noise has been associated with reduced cognitive development and classroom performance of children.

Accidents

According to WHO (2003), accidents from road transport is one of the top causes of fatalities world-wide, with an estimated 1.2 million people killed and another 50 million injured in 2001. Worley (2006) found that every year, the number of people killed in road accidents is more than one million (of which developing countries account for 85 %). Not only do road accidents cause injuries and fatalities but they also affect the household income since crash victims are often the main breadwinners. A study in Bangladesh found that after a road fatality, 70 % of families experienced a decline in total income and food consumption (Rosenberg, 2005). Moreover, injured victims frequently experience depression and travel-related anxiety for years after a crash (Silcock, 2003). It is observed in developing cities that a high level of vehicle use is often related to a very high rate of transport deaths (Barter et al., 2003)

Congestion

Traffic congestion in cities inundated with private vehicles is getting worse, especially for developing cities with low levels of road space but high levels of motorization. By slowing down the speed of people and goods, traffic congestion reduces overall economic efficiency. In other words, people and goods, instead of working in the office or on the production line, have to spend significant "dead time" on the road. The loss of worker productivity and the inefficiencies from late or missed deliveries of goods and services can cause extensive losses to the whole society. In the US, traffic congestion costs the economy an estimated 63.1 billion USD annually, in terms of value of passenger time and wasted fuel (Wright, 2005). Similarly, the World Bank estimates that Bangkok's traffic congestion alone reduces the GDP of the whole of Thailand by 6% (Willoughby, 2000). Furthermore, congestion is also often seen as the main factor that worsens other traffic-derived impacts on the urban environment such as air and noise pollution.

2.4 Road provision: a common myth for tackling congestion in developing cities

Providing more roads was once considered an effective but costly way to resolve urban congestion. Some authors (Bodell, 1995; Midgley, 1994; Tanaboriboon, 1993) attributed the problem of traffic congestion to low levels of road infrastructure, and hence they encouraged road expansion as a main solution. The argument is naturally derived from an economic concept namely the shift in demand. This concept states that as demand for a given item increases, prices will rise, causing the extension of supply. When applied to transport, an increase in motorization means an increase in the demand for more street space, and unsurprisingly leads planners to expand road capacity. Some other authors (Cox and Pisarski, 2004; Hartgen and Fields, 2006) also linked roadway capacity expansion with reduction in fuel consumption, pollution emissions and accidents.

This trend is clearly shown in some dense Asian cities such as Bangkok and Kuala Lumpur where the authorities have followed the Urban Transport Planning (UTP) that was built in the middle of the last century and applied to cities in the US. The ultimate goal of UTP was to provide mobility, which has more recently been defined as road capacity (Dittmar, 1995). According to UTP, the standard urban road density (the ratio of road length per unit of urbanized land or road per area) should be 20 to 25 %. Bangkok, in attempts to mimic the transport infrastructure of Western cities, spent huge amounts of money every year (446 million USD) to build multi-layer elevated roadways in the 1990s (Poboon, 1997). From 1990 through 1998, Jakarta spent 88 % of its urban transport budget on road building (Cervero, 2002)

Yet, it is logically not the ratio *road per area* but another ratio called *road per capita* that affects traffic volume. While low population density might make the 15 to 20 % of *road per area* sufficient in term of *road per capita*, the same numbers cannot be applied for cities whose densities are ten- or twenty-fold. According to Barter (2000), in order to achieve "sufficient" road capacity per person in dense cities, road capacity per hectare has to be made unusually high. However, since road space is inherently scarce in these cities, building more roads would destroy the fabric of the city long before the demand for private travel could be satisfied (Zahavi, 1976).

Furthermore, providing more roads has long been shown not to help in reducing congestion but instead, to make the problem more severe by generating more traffic. The explanation for this is primarily based on another economic concept called the shift in supply. This concept holds that as supply of a particular item increases, prices will drop, leading to increased consumption. When applied to transport, building and expanding roads are the equivalent of supplying more street space for vehicles. These actions will act as a temptation for more vehicles to join the traffic (or more road space consumption), which is described by Tony Dutzik (2002) as two processes: diverted and induced traffic. Diverted traffic is the shifting of existing trips to a different time, route or destination. For example, when more roads are built, drivers will start thinking of traveling during peak hours using those new paths although before that, they would alter their time of travel to avoid traffic jams. Induced traffic is the creation of entirely new vehicle travel. For example, a commuter who previously traveled by public transport will think of driving his own vehicle to work because of the convenience of new road space. The increase in motorized vehicles finally ends up in more congestion and a never-ending spiral in demand for and supply of more road space (Newman, 1995).

Small (1992) concluded in his paper that 50-80 % of increased highway capacity is soon filled with generated traffic. Hansen, et al, (1993) pointed out that highway capacity expansion can induce additional vehicle travel on adjacent roads because such projects encourage automobile dependent land use patterns. He also mentioned the possibility that a new highway may leverage households and businesses to locate in suburban and exurban areas. Another analysis of traffic conditions in 70 metropolitan areas in the US revealed that cities which invested heavily in road capacity expansion were no better in reducing congestion than those that spent far less (STPP, 1999). Bangkok, an example of Asian cities, with a huge amount of money invested in building multi-layers road, has become famous for being one of the most congested cities in the world.

2.5 Urban transport under sustainable perspectives

2.5.1 The concept of sustainable development

In order to understand sustainable transport, the concept of sustainable development should first be explained. According to the Brundtland Commission (1987), sustainable development aims to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. Originally, interest in sustainability showed concern about long-term risks of over-consumed resource behaviors, reflecting the goals of ‘intergenerational equity’ (or being fair to future generations) and ecological integrity. Concerns about sustainability can therefore be considered a response to the trend in current decision making which mainly focuses on easy-to-measure goals and impacts (those that occur in the present) and ignores those that are more difficult to measure (those that might happen in the future). In order words, sustainable decisions can be described as planning that considers goals and impacts regardless of how difficult they are to measure (Litman and Burwell, 2006).

It has been emphasized that only being concerned about future equity and environmental impacts but disregarding those occurring in the current generation is not principled. In order to fulfill the equity aspect, UNDPCSD (1996) suggested another principle, namely the principle of intra-generational equity, that people within the present generation have the right to benefit equally from the exploitation of resources and that they have an equal right to a clean and healthy environment.

Cities around the world are facing a number of critical environmental, social and economic problems. One of the major factors in a city that contributes to such situations is its urban transport system. Firstly, it causes environmental problems such as air and noise pollution, water pollution and health impacts. Secondly, a bad transport system also slows down economic development through congestion, accident, facility costs and depletion of non renewable resources. Thirdly, social equity and community livability can also be hampered by, for example, a transport system that only gives priority to cars and the wealthy.

2.5.2 Conventional vs. sustainable planning

Poboon (1997) stressed that a sustainable transport system must go beyond conventional short term objectives of merely relieving traffic congestion and providing road supply to meet potentially insatiable demand. Conventional transport planners mostly consider vehicles and traffic conditions such as trying to increase average traffic speeds and parking convenience and to reduce crash rates per vehicle miles. Litman (2007) suggested that these attempts actually contradict sustainable transport because they favor motorized travel and reduce walking, cycling and public transit which finally increases resource and land consumption and pollution emissions.

Unlike conventional planning, sustainable planning requires its three economic, social and environmental aspects to be considered at the same time. In other words, a transport policy needs to be justified by whether it helps to make a more livable urban environment. For example, transport policies which rely on reducing fossil fuel consumption and CO2 emissions by promoting “clean” fuels or increasing vehicles efficiency seem to be environmentally friendly. Litman (2006) pointed out that in fact, these policies may fail to provide a sustainable solution because they may overlook some social and economic impacts such as unequal accessibility and automobile dependency.

2.5.3 Accessibility and non-motorized transport

Unequal accessibility can prevent people from securing their most essential needs and rights: the right to enough food, adequate shelter, good health, a basic education, etc. In many developing cities, the vast majority of the population are the poor who often have to face some kind of transport disadvantage. According to Barter (1999), it is because of the policies in these cities favoring private motorized vehicles, which tend to suppress non-motorized transport and reduce the variety of public transport available to the poor. As a result, poor people in developing cities make fewer trips with shorter distances but take more time than higher-income people do (UNDP, 1998).

In both developed and developing cities, walking is the basic mode of transport for everyone, especially for the elderly, disabled and children. However, in most Asian cities traveling on foot has usually not even considered to be a mode of transport so that pedestrians have to suffer very hostile and dangerous street conditions (Barter, 1999). Kodukula (2006) noted that government negligence in providing safe and pleasant facilities for walking in Bangkok has led people to drive rather than walk even for short distances. In Jakarta, although walking comprised nearly 60 % of all trips taken by the lower-income half of the population (JICA, 1987), more than 60 % of the roads in the city do not have sidewalks, and those that have are thickly blocked by telephone poles, construction materials, trash, and open sewers and drainage ditches (Hook, 2003). Since one will start and end his/her bus journey on foot, hostile walking condition also puts more difficulty on poor people who use public transport.

2.5.4 Oil crisis and private motorized vehicle dependency

The level of private motorized vehicles in a city is a strong indicator of resource consumption, especially energy, as well as transport externalities such as greenhouse gas production. Recently, the world has been affected by rapidly increasing oil prices. World oil production has been predicted to peak by 2010 and then to enter a phase of irreversible decline, leading to shortages and supply interruptions, rapidly rising prices and a greater concentration of oil power in the Middle East (Kenworthy, 2003), which overall will have profound impacts for a transport system that merely depends on conventional oil and cannot restructure within a short time (Campbell, 1991; Campbell and Laherrere, 1995; Fleay, 1995).

Policies favoring private motorized vehicle dependency such as favorable pricing and investment for parking, subsidies for fuel and providing infrastructure and land use practices which aim to make driving relatively fast, convenient and affordable enable businesses to practice more centralized distribution systems and to access a wider range of possible employees as well as customers. In order words, they allow and encourage people to live far from their work places, scattered outside the city, and encouraging urban sprawl (Litman, 2007).

Parking in the central business districts (CBD) of cities is an important indicator of private transport infrastructure. The availability of parking will increase the attractiveness of private motorized vehicles commuting to the central city (Kenworthy, 2003). For example, despite having a high density and relatively low level of infrastructure which are against private car use, Bangkok tried to provide comparable parking spaces per CBD jobs to US and Australian cities, which has contributed to Bangkok's burgeoning private car use (Poboon, 1997). As reviewed in previous sections, building more roads to release congestion also acts like a catalyst that favors more private vehicle use. The increase in private vehicles, in turn, requires more road and parking space that makes space provision never enough (Wright and Fulton, 2005). This is even worse in the case when motorcycle cities first start to increase infrastructure to reduce congestion, which encourages more people to purchase a car because of the increased available road space. Gradually, this supply strategy leads to urban sprawling which increases the total amount of vehicle travel required for access, increasing travel time and vehicle expenses.

2.5.5 CO_2 from transport and global warming

Despite the advent of more efficient fuel and propulsion technologies, such as hybrid-electric vehicles, petrol consumption has largely followed the increase in motorized vehicle usage. To date, the transportation sector consumes approximately 67 % of world petroleum use (Davis and Diegel, 2002). The process of burning gasoline emits CO_2 – a greenhouse gas that is the main cause of global warming. Even though new technologies and new emission standards can to some extent stabilize or reduce local air pollutants (such as CO, NO_x and particulates) these efforts can do little in controlling CO_2 emissions (Wright, 2004). By all accounts, though, transport is the fastest growing source of greenhouse gas emissions, with an annual growth rate of 2.1% worldwide and an annual growth rate of 3.5% for developing nations (OECD and IEA, 2001). If rapid motorization in developing countries keeps increasing, transport-related CO_2 emissions of these countries will soon overtake that of developed countries which already account for 16 % of the total worldwide CO_2 (OECD and EMCT, 1995).

2.5.6 Rationale for public transport

Historically, low and middle income cities have high density because people needed to remain compact in order to get accessibility through non-motorized modes and low-cost public transport (Barter, 2000). Just recently, higher incomes have allowed more people to buy private vehicles to increase their mobility although the city transport network characteristics are not sufficient to handle this vehicle “boom”. From previous sections, it is evident that low and middle-sized cities are duplicating the past errors as carried out in Western cities in coping with motorization by providing more road space (Dimitriou, 2006).

In terms of efficient transport and spatial demands, it is well known that public transport and non-motorized transport are more suitable to serve high urban densities of population, jobs and services than private transport (Pushkarev and Zupan, 1977). Moreover, there are many factors that favor public transport in high density cities suggested by Bruun and Schiller (1995) such as: first, there exists a large potential numbers of customers living near most of public transport services. Second, narrow roads will be used more efficiently by high-capacity public modes. Third, mixed land use, which is often associated with high density, encourages demand for public transport to be well spread throughout the day, as many trip purposes will be served within a small area. Similarly, mixed land uses and high density also support walking and cycling by allowing varying destinations to be reachable within a short distance (Barter, 2000).

It has been noticed that, however, high density and mixed land use do not always assure a successful public transport system. Other factors such as service quality and the competitiveness of public transport speeds compared with private transport are also important in attacting motorists from their own vehicles. Litman (2007) studied a situation on a highway lane and noted that a 5 % reduction in vehicle volume on a highway lane will help to increase travel speed by about 20 miles per hour and eliminate stop-and-go conditions. However he found that providing more road space to decrease vehicle density is not a sustainable solution since congestion tends to maintain equilibrium. It means people can change route, destination, and travel time to avoid delay, or take additional peak-period trips on roads that are not congested. In fact, unless people have better alternative travel options such as metro or fast bus, they will continue to use their private vehicles. He also emphasized the quality of alternative modes. If alternatives are inferior, motorists will be reluctant to shift mode and congestion will be severe. If alternatives are attractive (fast, comfortable and affordable), motorists will be more ready to shift. Laube (1995) and Mees (2000) suggested that an integrated network of high frequency services can provide citizens more freedom by making all parts of the urban area accessible to all and allowing public transport to serve random trip destinations and actually compete with the convenience of private vehicles

In reality, many cities around the world have started to give public transit priority by building or developing their rail-based system to provide a fast alternative to personal vehicles. For example, in Los Angeles, the first new urban railway system was opened in 1990 (Poboon, 1994). In Manila, the first elevated rail system has operated since 1984, with a plan for expansion. In Bangkok, the first mass transit – sky train was introduced in 1999 and followed by a subway system which was officially opened in 2004. Singapore and Hong Kong started earlier by building their extensive rail rapid transit systems in the 1980s and 1990s (Kenworthy et al., 1994).

2.5.7 Relationship between restraining private vehicle use and improving public transport

Urban traffic restraint and the enhancement of public transport are closely connected (Barter, 2000). International examples show that the success of Singapore and Hong Kong in making public transport popular is directly credited to policies that restrained private vehicle ownership, especially from the early stage of motorization (Ang, 1996; Wang and Yeh, 1993). In other cities such as Bangkok and Kuala Lumpur public transport was very slow to improve and remains much lower than private transport (Barter, 1999)

The reasons are, firstly, vehicle ownership has not been controlled and traffic limitation measures for congested central areas have been rejected in both Bangkok and Kuala Lumpur (Spencer 1989; Tanaboriboon 1992). Secondly and worse, these cities have implemented policies favoring private vehicles such as large road building and parking investments that encouraged driving and made the improvement of public transport more difficult in spite of the recent investment in mass rail transit systems. Experience shows that any successful metro system requires an efficient and reliable bus feeder. However, there was no bus priority in Kuala Lumpur which made bus an inferior transport mode and although a few bus lanes were introduced in Bangkok in the 1980s (Marler, 1982), its bus system still experienced congestion in mixed traffic due to lack of enforcement (Tanaboriboon, 1992).

2.5.8 BRT – giving priority for public transport over private vehicles

While segregated rail transit can provide high travel speeds as well as level of service, on-street public transport such as bus usually performs poorly and ridership seems to increasingly decline. The situation is quite clear in poor cities where installing an urban metro system might represent an insurmountable task; public transport relies wholeheartedly on an inefficient bus system where buses often get stuck in mixed traffic and offer an undesirable public travel experience (Barter, 1999). However, some developing cities in Asia, Europe and South America have begun to reverse the decline in the public transport share, primarily through investment in a bus system, which is commonly referred to as bus rapid transit (BRT). Unlike rail-based mass transit, BRT gives affordable public transport and greater visibility and independence from other modes of transport, enabling it to deliver levels of service that compete well even with the private car (Hensher, 2006).

Bogotá (Colombia) and Curitiba (Brazil) are possibly the most famous examples of cities with BRT. In both cities, high-quality bus systems have been successfully implemented, with a complementary package of supporting measures, including infrastructure for non-motorized transport and private vehicle-restriction measures (Wright and Fulton, 2005). The common idea for BRT is to essentially emulate the performance and amenity characteristics of a modern rail-based transit system but at a lower cost. To achieve this level of quality, BRT systems focus on a series of features that, in general, give buses priority over other on-street vehicles, enabling the bus service to perform as a high quality mass transit system. The following table consists of standard BRT features

Table 2.1. BRT features

Features
Exclusive right of way lanes.
Reformed business and institutional structures.
Rapid boarding and alighting (wide doors)
Free transfers between routes.
Pre-board fare collection and fare verification.
Enclosed stations that are safe and comfortable.
Clear route maps, signage and real-time information displays.
Modal integration at stations and terminals.
Clean vehicle technologies.
Excellence in marketing and customer service.

(Source: Wright, 2004)

With these attributes, BRT has unsurprisingly achieved many successes in both cities. The system helped Curitiba increase average annual ridership by 2.3% over two decades since its initial application in 1974 (Rabinovitch and Hoehn, 1995). At relatively high commercial speeds (15–32 km/h), Curitiba is now carrying peak volumes in excess of 14,000 passengers/hour/direction, increasing to over 20,000 passengers/hour/direction when extra passing lanes are provided at bus stops. (Hensher, 2006). In other words, the system can give 562,000 passenger trips per day with 232 bi-articulated buses (capacity of 270 passengers). Similarly in Bogotá, the BRT system with 1,013 articulated buses (capacity of 160 passengers) can provide 1,450,000 passenger trips per day (ITDP, 2007). Besides implementing a successful BRT, Bogotá has also gained fame for installing new cycling ways, making pedestrian upgrades and car-free events, controlling and turning parking areas into attractive public space. Likewise, Curitiba considerably improved its allocation of public space to pedestrians with large car-free areas in the city centre. The pedestrian zones also perform as feeder services to the BRT system by easing pedestrian movements towards stations (Wright and Fulton, 2005). Both cities have shown their efforts to restrain private vehicles use, promoting public and non-motorized transport and gained significant improvement in reducing local and global environmental impacts, congestion and more important changing themselves from being cities intensely resented and rejected by their inhabitants to being ones loved by their proud citizens.

2.5.9 The role of mode shift in reducing pollutant emission

The source components of transport emissions show potential opportunities for reduction. The following formula shows a framework for identifying and evaluating these different components

$$\text{Transport emissions per mode} = \text{Number of vehicles} \times \text{Distance traveled} \times \text{Emissions per vehicle distance traveled}$$

(Source: Wright and Fulton, 2005)

This formula consists of 3 elements. The first one, *number of vehicles,* is controlled by load factor and mode shares such as number of private vehicle, public transport, and non-motorized trips, etc. Any particular mode share is dictated by other factors like cost, travel time, security and convenience among transport mode. Providing more convenience for private vehicles such as infrastructure and parking will reduce cost and travel time and hence increase the number of trips (Litman, 2007). Similarly, improving public and non-motorized transport modes also helps to increase the number of people using these less polluting transport modes (in case of bus and rail) or even non-polluting modes (in case of walking and cycling). The second element, *distance traveled,* is affected by land use and network design. It is widely accepted that practicing transit-oriented development helps focus residential and commercial development around public transport nodes, thus reducing the distances traveled. The last one, *emissions per vehicle distance traveled*, is influenced by type of fuel and fuel efficiency (propulsion system and driver behavior). Much of the emphasis of national and international emissions reduction efforts has focused on 'type of fuel' and fuel efficiency (such as propulsion system) which may encourage more private vehicle use (Wright and Fulton, 2005). Wright also stressed that in case of CO_2 emissions, the carbon content of the particular fuel used such as CNG, hybrid-electric, fuel cells and bio-fuel has received a great deal of attention in emissions reduction efforts although it is challenging for these technology-based solutions to become competitive greenhouse gas emission reduction options. Meanwhile a significant increase in fuel efficiency can also be gained just through the provision of priority infrastructure such as busways that help buses to perform more smoothly without stop and go operation.

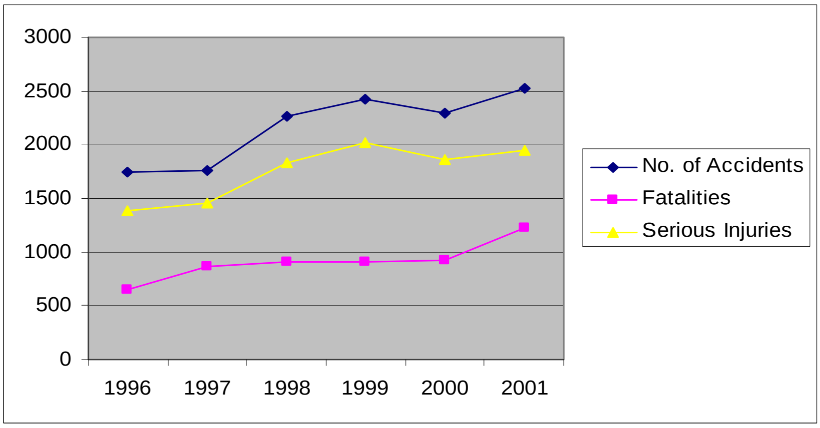
In reality, some cases where public improvement can gain significant emissions reduction have been conducted. 10% of the ridership on Bogota's BRT system derives from persons who previously drove a private vehicle to work. This contributed to a 40% drop in pollutants as recorded during the first 5 months of the BRT operation. The estimated greenhouse reductions for the first 30 years of operation range from 15 to 25 million metric tons of CO_2-equivalents (Gleave, 2003). After implementing BRT, Curitiba also used 30% less fuel per capita for transportation than other major Brazilian cities which obviously means less emissions. In Mexico City, the metro-bus BRT system reduces by up to 50% commuter exposures to CO, benzene and PM2.5 for 250,000 passengers (Zuk, 2006)

2.6 Transport characteristics and policies in Ho Chi Minh City.

2.6.1 Transport impacts

Available data suggests that transport is a serious contributor to Ho Chi Minh City's poor air quality, in particular with respect to carbon monoxide, nitrogen oxides and particulates. According to Ho Chi Minh City Environmental Protection Agency (HEPA, 2007), the Air Quality Index (AQI) along the city's road is 188 in value (Red group), which means everyone may begin to experience health effects. Another study conducted by Triet et al. (1999) showed that motorized traffic plays an important role in Ho Chi Minh City air pollution by producing very high level of Polycyclic Aromatic Hydrocarbons (PAHs) causing cancers. Moreover, even though the government banned the use of leaded gasoline in 2001 and hence lead concentration along the road decreased significantly from 2001 to 2005, the volume of lead in the air of Ho Chi Minh City has recently doubled, from 0.5µg/m3 to more than 1µg/m3 (which equals the WHO standard of 1µg/m3) (HEPA, 2007). Although data and research is scarce for noise pollution from transport, a recent survey made by Ho Chi Minh City Health Department revealed that the traffic noise in many areas, especially those along main traffic arteries, exceeds the maximum permissible level of 70 decibel by 100-200% (Saigon Times, 2006).

Ho Chi Minh City road safety has deteriorated over the past decade. Along with the increase in motorcycle numbers and use, the number of road accident continues to rise every year (see Figure 2.1). According to Ho Chi Minh City Traffic Police, motorists account for 92.88% of total number of traffic accidents in 2001 (Masujima, 2006). However, it was noticed that the number of accidents reported is still lower than the real number due to the limitations in collecting information and only severe cases are reported. Traffic congestion is also becoming a critical problem. It was estimated that 13,000 billion VND (about 0.81 billion USD) annually is the city's social and economic loss due to congestion (Thinh H., 2007).



(Source: Masujima, 2006)

Figure 2.1 Number of accidents from 1996 to 2001 in Ho Chi Minh City

Table 2.2 A breakdown of transport modes for causing accidents

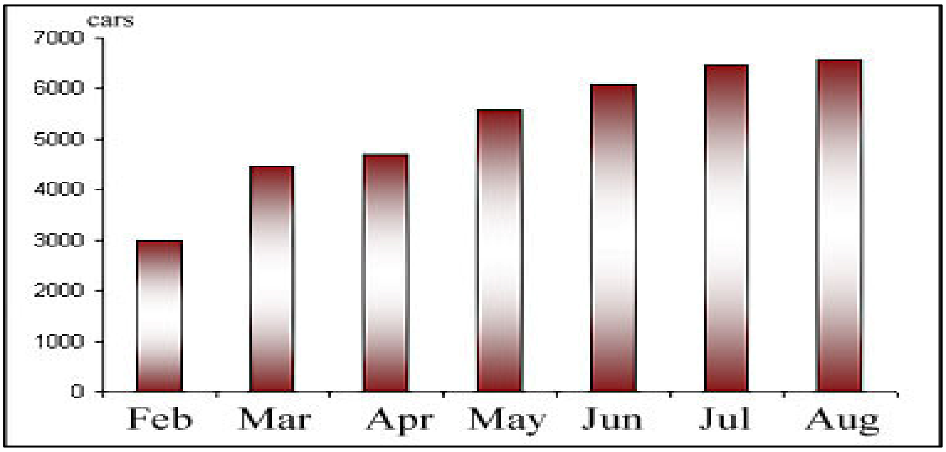
Cause	%
Motor vehicle drivers	92.88
- Speeding - Not giving way - Driving on wrong lane - Encroaching on opposite lane - Not keeping a safe distance - Careless turning - Entering prohibited roads, driving in wrong direction - Drunk driving - Driving without license - Self-caused accident - Others	
Unsafe vehicles	0.71
Non-motor vehicle drivers	3.36
Pedestrians	2.99
Roads	0.05
Others	0.02

(Source: Masujima, 2006)

2.6.2 Private transport mode - motorcycles

As in other developing cities, Ho Chi Minh City's motorization has started, although slowly, since 1950 because of the damage caused by Vietnam War and the trade embargo against Vietnam from the United States and most of Europe after reunification. Until the 1990s, bicycles were the most common travel mode in the city. However, after major policy changes in 1986, also known as "Doi Moi", the Vietnamese government has, step by step, implemented free-market policies and achieved rapid growth in the economy and this has greatly affected the urban transport system, especially in the two biggest cities Ho Chi Minh and Hanoi. In 2004, private vehicles represented an abnormally high proportion (90 %) of total trips (or equal to 19 million non-pedestrian trips per day), of which motorcycles account for 78.8 %, cars 4.8 %, and bicycles 5 % (Ngo, 2005). Although car ownership has been historically lower than other comparable economies in the region, continued growth of the economy showed significant potential for household incomes to rise, enabling many more families to afford to purchase motorcycles and cars (ADB, 2006). Figure 2.2 shows the continuous increase in automobile sales during the listed months, 2007 (of which, the two biggest cities Ho Chi Minh City and Hanoi account for the biggest part). Several factors that lead to the increase of motorcycles in the city are (JICA, 2004):

- Public transport (bus) was officially neglected after 1975 and only since 2000 has there been public awareness of its role
- General increases in wealth
- Motorcycles prices have become more affordable for many people
- The convenience of small private vehicles that can operate in narrow streets.
- They are cheaper than automobiles (capital and operating cost)



(Source: Nghiep, 2007)

Figure 2.2 Automobile sales from February to August, 2007 in Vietnam

Some researchers claimed that the current road density (the proportion of a city's land use designated for transport) of Ho Chi Minh City is insufficient to handle the number of private vehicles, compared to that of typical western cities which ranges from 20 to 25 %. These numbers are usually mentioned as an international benchmark or standard for the amount of space cities should set aside for transport purpose. For example, Hong et al. (2005) pointed out that the main reason for traffic problems in Ho Chi Minh is the combination of low road density, the lack of road capacity and no existing road hierarchy, which leads to below-standard road provision per capita". Phin (2002), the vice dean of Transport Development and Strategy Institute – Ministry of Transport, suggested to gradually increase the road density from 4 - 6 % (2001) to 8 - 10 % (2005), 12 – 15 % (2010) and 25 % (2020).

This idea is also reflected in Ho Chi Minh City's Transport Master Plan which was approved by the Vietnam government in early 2007. In the Master Plan, the authority called for an expansion of the current road space either by constructing flyovers or underpasses (to avoid compensation); providing more underground parking places in response to the mounting demand for private vehicles in the CBD area (besides the Nguyen Hue underground parking lot – the biggest one, there are seven other projects in progress, including Le Van Tam park, Hoa Lu stadium, Tao Dan stadium, and Bach Tung Diep park, Chi Lang park, Nguyen Du street, Lam Son square, most of which sit in the city centre) (Ngo, 2005)

2.6.3 Low public transport use

Despite the fact that today Ho Chi Minh City has been almost fully occupied by private vehicles, before 1975 the bus was widely used by people as motorized transport. However, after a long period with little official concern, the city's bus system has deteriorated and currently accounts for only 3 % of total trips (JICA, 2004) although recently the government has increased investment and subsidies for its public transport. As in other developing cities, the common reason is because of the congestion with private motorcycles that constrains the attractiveness and potential development of the regular bus service. There have been some solutions discussed and implemented to motivate more people to use the bus system such as: increasing the number of vehicles and bus routes, renewing and upgrading vehicles, and offering lower fares for students. However there is no vision for the current bus system to have a better future. The situation has further deteriorated with the bus being seen by the public as a cause of increasing congestion (Du, 2007).

In 2005, MVA Company under World Bank financing set up a project for developing a new bus system – the BRT for Ho Chi Minh City (World Bank, 2005). The project consisted of several phases as regards the current city bus system assessment: a BRT route system which is developed utilizing Travel Demand Assessment (vehicle count on street) from Houtrans report; busway and vehicle design; strategic, legal and business plan. The project also suggested a pilot busway planned to be started in 2008. The road designs are shown in Appendix C.

There exist several negative comments from the authority and researchers about the possibility of implementing BRT (DTPW, 2007):

- The road space left on the street after installing BRT's busways is not enough for other transport modes, which leads to more congestion.
- Suggestion for building BRT system in city's outer area to avoid high density problem in the CBD.
- The signal priority will make more traffic chaos, especially at rush hours.

These concerns, however, might have equated BRT with the current ineffective bus system by underestimating the possibility that citizens and motorcyclists will use BRT as their main transport mode. With its reliable and convenient features, BRT has gained popularity by continuously increasing the percentage of public transport share in many case-studies around the world (in addition to the previously mentioned cities Bogotá and Curitiba):

- The U.S Transportation Research Board (TRB, 2003) found some evidence suggesting that in many U.S cities improved bus service results in increased ridership with users making more trips and many of the new riders previously having been motorists. During the first 6 months of operation (in 2002) of the 16km state-of-the-art south east busway in Brisbane, Australia, the number of passengers grew by 40 % (about 375,000 private vehicle trips have been converted to public transport). In another example, up to 30 % of the riders were new riders, and up to 72 % were diverted from automobiles after BRT had been installed in Houston. Similarly, in Vancouver, motorists accounted for 20 % of the passengers while 5 % represented new trips, and 75 % were diverted from other bus lines.

- In Pittsburgh, the 8-km third busway, which opened in September 2000, secured average weekday patronage growth of 23 % over the first 17 months. Currently, the average number of daily passenger trips on the full busway system of 43.8 km is 48,000 and growing steadily (The Urban Transport Monitor, 2002)

- In Jakarta, the first BRT corridor of 12.9 km has experienced an increase in patrons from 20,000 per day to over 70,000 per day within two years of first operation. (Hossain, 2006)

- Several modeling studies suggest that, when combined with peak-period road pricing strategies, the significant transit travel-time reductions achieved by BRT in highly congested travel corridors may contribute to significant shifts in travel demand from private modes to BRT (DeCorla-Souza 2003; DeCorla-Souza 2004).

When more people leave their motorcycles at home and use public transport, the remaining street space will become less congested for those who really need to drive their motorcycles. For example, the BRT system in Taipei can effectively save travel time for both bus and non-bus trip makers, as travel speeds of buses as well as general traffic have increased significantly after the implementation of BRT (Chang and Sun, 2004). Therefore, the concerns that BRT dedicated busways and traffic signal priority will cause more congestion contradict the practical experience. The above argument also justifies building BRT in the CBD. The main purpose of building mass transit is to provide an alternative transport mode for majority of people. If the BRT system is built in outer areas where the roads are not densely used, there is no change for the transport situation in CBD as well as no spatial incentive for mode switching from private vehicles.

All in all, though BRT has been technically planned, it is unlikely to be implemented unless further research is conducted to confirm its feasibility and suitability for Ho Chi Minh City. Meanwhile, the government is beginning to construct a metro system as a main public transit system in the city. However, because of the daily traffic and environmental impacts due to the city's policies of non-restraining motorcycles, the high metro's capital investment, the long installation time and low quality of the current bus system, the rationale behind Ho Chi Minh City's planning for metro is questionable.

2.6.4. Ho Chi Minh City's population density, land use characteristics and the relation to renovation factor

In 2006, Ho Chi Minh City had a population of about 7.7 million people (ADB, 2006). The city consists of 19 inner districts and several suburban districts. However, because of the low density of the suburban districts and some inner districts which are not fully urbanized, the study focused on high density inner districts. Overall, the studied area was divided into two zones: The first zone has a relative small area ($44km^2$) and high density (408 persons/ hectare). The second zone with the density of 176 persons/ hectare spreads over the area of 98 km^2 (JICA, 2004). In general, the work/school trips that are considered long (around 8km) account for 36 % while the "short" work/school trips (around 3 km) account for 64 % of all work/school trips (JICA, 2004). Besides, jobs in the CBD area constitute less than 10% of the total jobs of the whole city which is different from Western cities where most of jobs are located in the CBD area (Ooi, 2006). To explain, it is a normal way for people to utilize their own houses for business, therefore generating a lot of jobs all over the city area. This indicates that the studied area has a really good environment for public transport because of its high density and mixed land use characteristic. While an observable advantage of mixed use of urban areas is to bring together housing, working, shopping, which will enable people to reduce trip distances, it also allows public transport to have sufficient demand in multi-direction over the day.

One of the indicators of a highly profitable public transport system is the renovation factor. It is defined as the average number of passengers that are on a vehicle divided by the total boardings along a given route. For example, if 50 is the average number of people on a vehicle at any given time going from point A to point B, but 200 people are boarding the bus between these points, then the renovation factor is 25 percent. In other words, the lower the renovation factor is, the higher the number of boardings and alightings or more effective capacity the bus has. The new Insurgentes corridor in Mexico City has recorded renovation factors of 20 percent, which means that 5 times more people getting on and off the vehicle as there are people on the vehicle at any given time (ITDP, 2007). If there was a good public transport in Ho Chi Minh City which is marked by high density and mixed land use, a low renovation factor would be achievable.

2.7 Conclusion

This chapter has presented briefly the trend of motorization and public transport in developing cities and the concept of sustainable urban transport. The literature has clearly shown that the current trend is to encourage private mobility to an extent that can be considered unsustainable concerning environmental impacts, social equity and economic development. Meanwhile, public transport has been shown to be the most sustainable transport mode for high density cities in term of reducing traffic congestion as well as other traffic-related problems. Also, public transport is now considered as a hope for reducing global warming. Although BRT is gaining popularity in cities around the world, including Ho Chi Minh City, there is no vision for installing bus-based mass transit since the city shows no efforts in restraining private vehicles and starts looking at metros as the main public transit mode. Meanwhile the transport impacts have caused huge damage to society and people's lives. Hence, the need for more study on the feasibility of installing the low cost sustainable bus-based transit – BRT – emerges as an urgent task.

CHAPTER 3
METHODOLOGY

3.1 Research method

Transport research usually employs case studies from other cities and countries as real life examples for investigating transport policies' impacts. In the literature review chapter, case studies from around the world showed the benefits of implementing sustainable transport options (non-motorized transport and mass transit) in terms of mitigating transport, economic, environment, urban and social impacts.

One of three main aims of this research is to calculate the potential for reducing energy consumption should Ho Chi Minh City implement a BRT network. The potential, however, depends on the degree or the extent that motorcyclists will shift to use BRT. Although BRT is gaining more and more popularity throughout the world, notably in Europe and South America, knowledge about it is relatively low in some cities. The Stated Preference (SP) method was developed first in marketing research in the 1970s and later the concept was used in the transportation field (Peter, 1997). A simple SP survey uses a willingness-to-accept framework and presents several scenarios with trade-offs in attributes and levels of service to a respondent and asks him/her to identify the preferred mode. The survey design, however, needs to be adjusted carefully to obtain a reliable output. Sivakumar et al. (2006) noted that even a slight difference in design can affect users' response considerably. ITDP (2005a) suggested that in order to generate reliable information, the SP survey should ask questions about specific mass transit proposal with complete fare prices, precise station location, and operating speed.

3.2 Population and sample size

Yamane (1967) suggested the sample size be calculated by the following formula:

$$n = \frac{N}{1 + Ne^2}$$

Where n is the sample size (persons)

N is the population size (7.7 million)

e is the level of precision (5% or 0.05)

Then:

$$n = \frac{7{,}700{,}000}{1 + 7{,}700{,}000x0.05^2}$$

= 399.97 = 400 persons

Because BRT, as a suggested mass transit system for Ho Chi Minh City, aims to serve all citizens, interviewees will be chosen by random selection, indifferent to gender, age or occupational differences. In 2004, private vehicles represented an abnormally high proportion (90 %) of total trips (or equal to 19 million non-pedestrian trips per day), in which motorcycles accounts for 78.8 %, cars 4.8 %, and bicycles 5 % (Ngo, 2005). Based on the current state of vehicle usage, motorcyclists which are the main motorized vehicle group will be focused on in the survey. Therefore, 400 motorcyclists will be randomly chosen to join the interview as follows:

A grid will be imposed on the area covered by the proposed BRT network. Each square will be indicated by a pair of coordinates (x,y) that range from 1 to 20 (Figure 3.1). Squares will be selected based on randomly generated numbers. The researcher will choose every fifth household on streets around the center of any selected square until 40 household in that square have been surveyed.

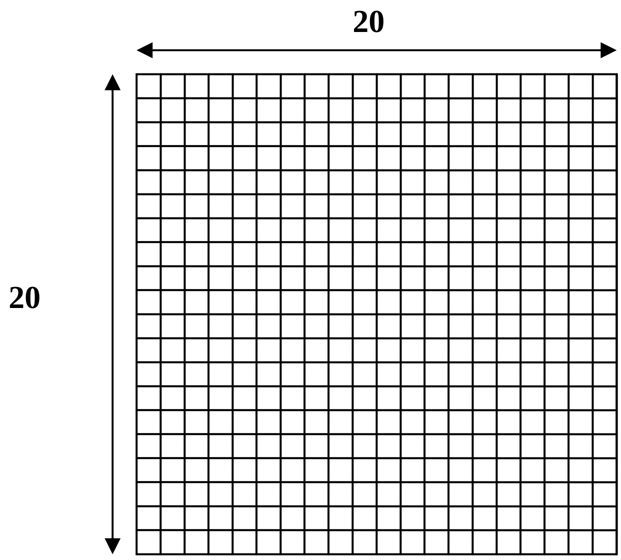


Figure 3.1 A map with coordinates for random selection.

3.3 Questionnaire and survey design

It is stressed that in order to generate reliable information, the stated preference survey should be designed very carefully. Moreover, the survey should ask questions about specific mass transit proposal with fare prices, precise stations' location, and operating speed (ITDP**,** 2005a).

Fare price

One factor influencing transit demand in the corridor is the fare price. From customers' economic sense, if there are two options for travel with the same levels of service, respondents will definitely choose the cheaper one. As noted by Litman (2007a), a frequently-used rule that each 3% fare increase reduces ridership by 1% which can be useful for rough analysis might be too simplistic and outdated for detailed planning.

Choosing an unreasonably low fare price for the hypothetical BRT scenario will produce a biased outcome that over-favors public transit to motorcycles. On the other hand, if fare price is set too high, it cannot attract motorcyclists to use BRT. The problem is how to set an optimal fare price that can cover operating cost and yield profit substantial enough to pay back installation costs within a certain time. An analysis in Jakarta recently shows that instead of utilizing flat fare system, a reasonably high minimum fare combined with a distance based fare would yield a best return profit and at the same time maximize the demand for the TransJakarta system (IDTP, 2005b).

According to Houtrans report for Ho Chi Minh City's transport system (JICA, 2004), on average one citizen makes 2.5 trips per day and 5.2 km /per motorcycle trip. From the IEA spreadsheet model (IEA/SMP, 2004), a motorcycle needs 2.2 liters of gasoline to run 100km with the fuel price at 13,000 VND/liter (US$1= 16,000 VND in September 2007). Then, a motorist will spend 2.5trips/day x 5.2km/trip x 30day/month x 2.2 liters/100km x 13,000VND/liter = 111,500 VND/month for transport fuel. Assume that every two trips (from home to work and back) requires a parking cost of 2,000 VND/motorcycle. Normally, a person makes 2.5 x 30 = 75 trips/month, and therefore spends 75 trips/2 x 2,000 VND parking fare = 75,000VND for parking. In reality, the money spent for parking might be higher than that since only 50% of daily trips are to work (or study) and back home. Moreover, motorcycles require an initial outlay, a yearly insurance and interval maintenance which also bears more cost to motorcyclists (for this study, an assumption of 40,000 VND/month represents the maintenance cost and extra parking fee). Therefore, an average amount of money set aside for transport purpose of motorcycle in Ho Chi Minh City is 111,500 VND + 75,000 VND + 40,000 VND = 226,500 VND/month. Using the load factor of a motorcycle in Ho Chi Minh City of 1.3 (JICA, 2004), a person using motorcycle spends 226,500/1.3 = 174,000 VND/month. Thus, to attract motorcyclists to using the BRT network, the fare price should fluctuate around this point.

Because public transit is far more efficient than the private motorcycle in terms of energy usage, the fuel cost per passenger kilometer of BRT should be less or at least equal to that of the motorcycle (2.2 liters/100km or 28,600 VND/100 km or 286 VND/km). From this figure and the above the monthly cost for transport purposes by motorcyclists (174,000 VND/month/person), the fare price for the BRT network in Ho Chi Minh City is suggested by the following formula:

Fare price for a trip= a 1,000 VND base fare + 250 VND per km

Because a normal trip of 5.2 km might require transferring between different routes, a time-based fare is combined with the above distance-based fare in order to provide passengers free base fare when transferring within the system. This means, the base fare will be only charged one time at the first vehicle of a multi-transferring trip. Within two hours, passengers can transfer as much as they need without being charged for the 1,000 VND base fare. In order to implement the above fare system, smart cards will be utilized which enable people to pay at the station before boarding (in trunk corridors) and pay on-board (in feeder routes).

Another BRT fare system using a time-based fare is also tested by asking for respondents' preference. This time-based fare system that consists of three types of ticket (daily, weekly and monthly - with discounts for longer periods) allows people to travel as much as they want within the time stated on the ticket. Based on motorcyclists' average monthly expense for transport calculated above which is 174,000 VND/month, the daily ticket would cost 6,000 VND. The weekly ticket costs 35,000 VND (discount 18%). The monthly ticket costs 130,000 VND (discount 29%)

Corridor selection

Corridors are selected based on the BRT route map introduced by MVA Company under World Bank financing (World Bank, 2005). Originally, the MVA's sketch route was drawn from the ten most crowded corridors suggested by Houtrans study's travel demand analyses. These analyses consist of the following surveys (JICA, 2004).

Table 3.1. Some of the transport and social surveys under Houtrans study.

Survey	Objectives	Coverage	Method
Cordon Line Survey	• Traffic volume on cordon line (vehicle/passenger) • Socio-economic profile and trip information of residents outside the study area	• 19 stations on the study area boundary • 20 stations at transport terminals (airport, port, railway station etc.)	• Direct interview with drivers/passengers at roadside • Traffic count (vehicle) • 24 and 12 hours
Screen Line Survey	• Traffic volume on screen line (vehicle/passenger)	• 43 stations on 2 east-west screen lines	• Traffic count (vehicle/passenger) • 24 and 12 hours
Traffic Count Survey	• Traffic volume at major road sections	• 16 stations	• Traffic count (vehicle) • 24 and 12 hours
Intersection Traffic Count Survey	• Traffic volume at congested intersections by turning direction	• 12 major intersections • 3 periods: am/pm peak and off-peak	• Traffic count (vehicle) • 3 hours by period

(Source: http://www.houtrans.org/pdf/survey-outline.pdf)

The proposed BRT network

Based on BRT routes, distance between two stations is 500m. The total length of 10 dedicated trunk corridors is about 120 kilometers with 252 stations. Buses used in trunk corridors are articulated buses with the capacity of 170 passengers (17-18 m length, 2.4 to 2.5 m width). Maximum speed in urban site is 50 km/h while commercial speed is 22km/h. Frequency in peak period is 3 minutes while that of off peak hours is 10 minutes. The dwell time at each station is 20 seconds.

The travel time for a bus on a 15-km corridor (30 stations) (with commercial speed of 22km/h and 20 seconds dwelling time at each station) is around 51 minutes. In peak hours when frequency is 3 minutes, the number of buses needed to run on that corridor is (51/3) x 2 = 34 buses. For the whole system with 120-km corridor (252 stations), the number of buses is estimated at around 285 buses.

(See map and survey layout in Appendix A, B and C)

3.4 Objective 1: motorcyclists' attitudes towards the introduction of a BRT network

Question 1 of the SP survey will be used to assess motorcyclists' understanding of the BRT system. Objective 1 will be addressed by questions 2 to 9 of the SP survey (Figure 3.2).

3.5 Objective 2: factors influencing modal shift to BRT

Question 10 of the SP survey will be used to address objective 2 and answer research question 1 (Figure 3.2).

3.6 Objective 3: CO2 reduction calculation

In order to meet objective 3 and answer research question 3, a series of calculations will be made using the following formula (Wright and Fulton, 2005)

$$\text{Transport emissions per mode} = \text{Number of vehicles} \times \text{Distance traveled} \times \text{Emissions per vehicle distance traveled}$$

Firstly, the number of motorcyclists willing to shift to BRT will be determined by the survey's results (questions 7 and 8) and their emissions calculated (Figure 3.2). Secondly, the emissions resulting from the BRT will be determined. The difference in the two will be the CO2 reduction attributable to the implementation of the BRT system.

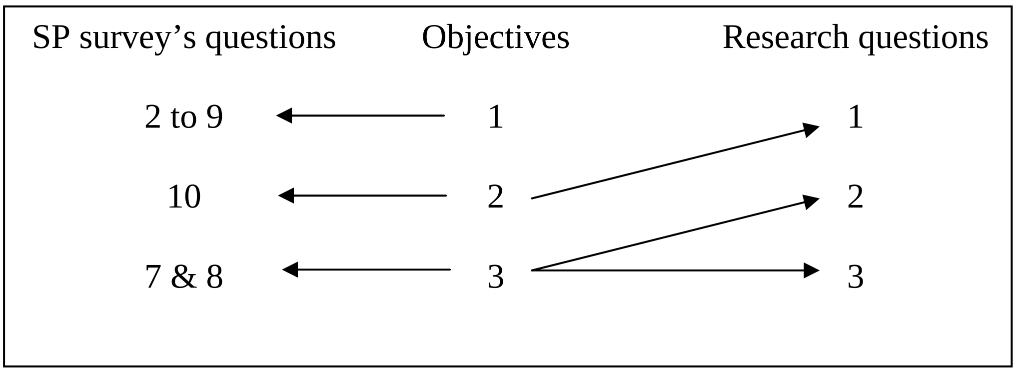


Figure 3.2 The relationship between objectives, research questions and SP survey questions

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Aggregation of the data

Overall, there were 398 responses from the 400 that were distributed. After removing responses that contained invalid or unbelievable data, the number of responses which were considered valid was 365. Since the sample size was thus not as high as expected, the confidence level of the results will be reduced and the confidence interval will be recalculated (section 4.4.5.4).

4.2 General information of respondents

4.2.1 Gender, age and occupation

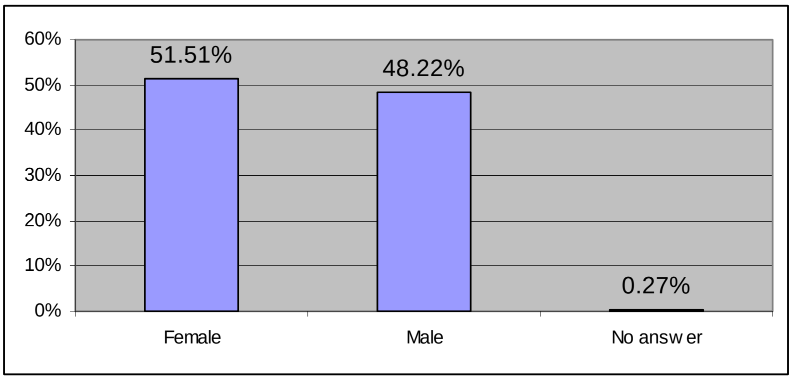


Figure 4.1 Gender of respondents

The percentages of participation between female and male are 51.51 % and 48.22 % respectively (Figure 4.1). Interviewers were asked purposely not to prefer only one gender (male or female) to fill in the questionnaires. One respondent did not provide this information which accounts for 0.27 %.

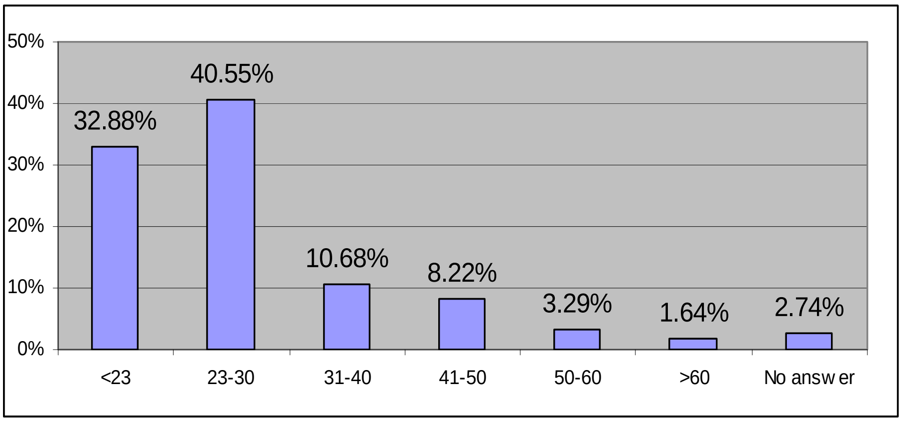


Figure 4.2 Age distributions of respondents

The respondents consist of people in different age ranges which can be classified into some categories (Figure 4.2). The majority of respondents who are younger than 23 or older than 60 years old can be considered students or non-working and to be financially dependent on their families. The youngest participant in the survey was a 15 year-old male and the oldest was an 80 year-old male. There were 2.74 % of respondents who did not answer the age question.

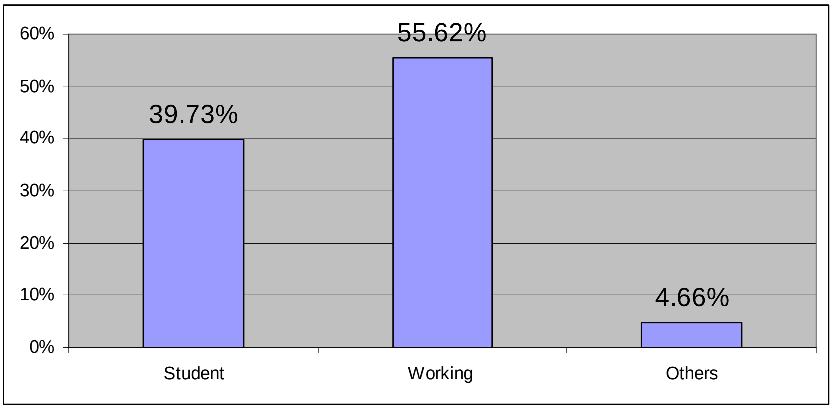


Figure 4.3 Occupation of respondents

Working people account for more than half of the respondents while students and others share approximately 45 % of the responses (Figure 4.3). The study was thus able to access to various social classes, age groups and both student and the employed.

4.2.2 Travel time and travel cost

Daily travel time varied from ten minutes to four hours per day, while travel cost varied from 80,000 VND to 1,000,000 VND (approximately 1USD ≈ 16,000 VND at this time). While we would expect these parameters be directly proportional to routine distance from home to work/school, they were found to be affected by several factors such as type of motorcycles, parking fee and traffic conditions in different areas. For example, old or 2-stroke motorcycles use more gasoline than new or 4-stroke ones. There are also higher service fees such as washing and parking for "high-end" automatic motorcycles. This can explain the non-linear relationship between travel time and travel cost (Figure 4.4).

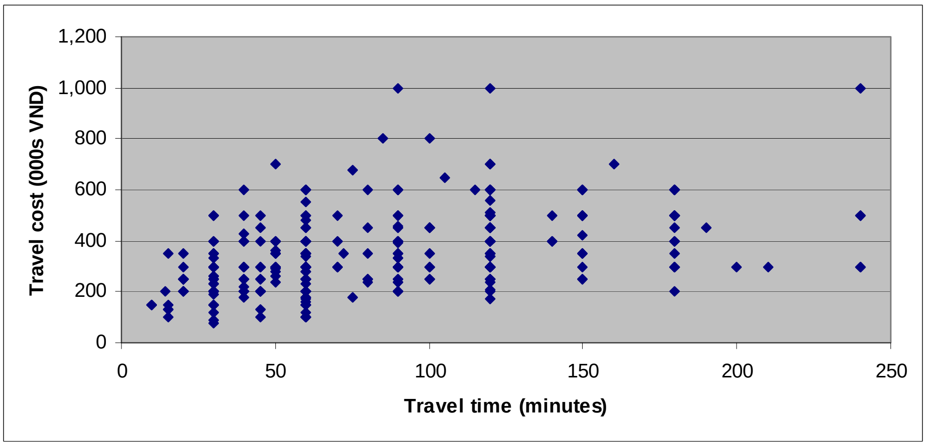


Figure 4.4 Travel time and travel cost of respondents

4.2.3 Level of satisfaction with current transport situation

It was found that only nine persons were pleased with the current transport situation, three persons did not answer the question and 353 persons were not satisfied with the current transport system. Respondents mentioned about traffic jams, worsening air quality, increasing road accidents and more respiratory diseases. However, the reasons causing their dissatisfaction with the current transport system were only what they read from newspapers such as insufficient road network, corruption of transport polices, lack of people's awareness of transport law and even too many buses. Apparently, the current inefficient bus system had, more or less, caused some prejudices towards the introduction of a new bus system (BRT). Thus, it was very important to distinguish the old bus system and the new BRT network.

4.3 The understanding of respondents about BRT

As stated in Chapter 3, in order to grasp the respondents' attitude toward a new transport system, a BRT introduction was presented prior to Stated Preference survey questions. The introduction described the BRT key elements as well as its comparison with normal bus system and motorcycles. Also, it mentioned some impacts of the transport system using motorcycles and the advantages of a new transport system to society. Following the introduction, respondents were asked questions to gauge their understanding of the BRT system.

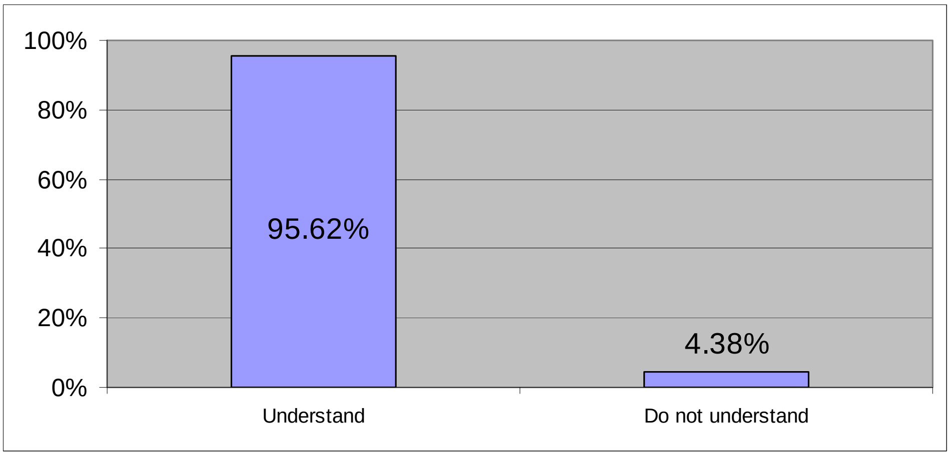


Figure 4.5 Repondents' understanding of BRT

More than 95 % of respondents answered all the questions concerning BRT features correctly (Figure 4.5). Less than 5 % did not get the whole idea of BRT and therefore those responses were sorted out from the calculation of the percentage of motorcyclists using BRT later in this chapter. From this point, the sample size was reduced to 349.

4.4 Objective 1: BRT preference analysis

This section addressed objective 1 (questions 2 to 9 in the survey) and research question 2 (questions 7 and 8 in the survey)

4.4.1 Mode preference concerning monthly travel cost (question 2 in the survey)

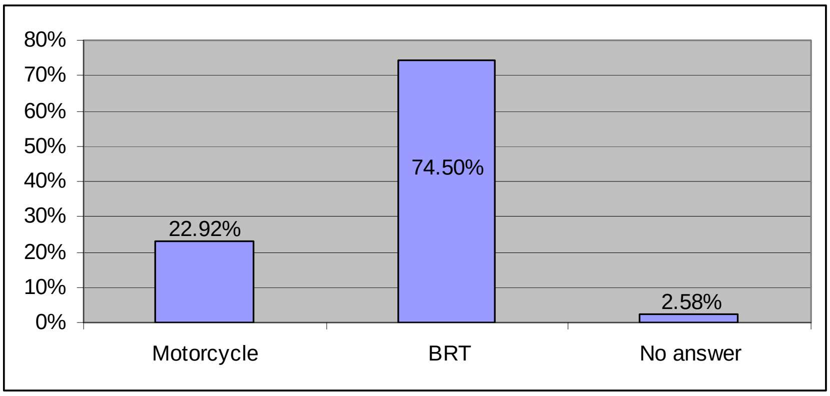


Figure 4.6 Mode preferences regarding monthly transport cost

Three quarters of respondents stated that they would save money by switching from motorcycles to BRT (Figure 4.6). While most respondents would like to reduce their travel costs, there are some tradeoffs in terms of convenience. Travelling by public transport requires walking some distance and a waiting time. If the walking distances and the waiting time are too long as in the case of Ho Chi Minh's current bus system, respondents will choose to pay more by using their motorcycles. The respondents stated that they were willing to accept public transport as long as the levels of service are of a high standard as supplied by BRT.

However, 92 % of the respondents preferring motorcycles (in 23 % of respondents choosing motorcycles) had monthly travel costs greater than 130,000 VND. Their reasons for continuing to use their motorcycles included:

- The nature of their jobs requires many trips per day.
- Feeling that it is not convenient to walk and wait at the bus station.

- Less convenient for those who live far from the main streets. Some questioned the distance for them to walk further than 500 m

4.4.2 Mode preference concerning travel time (question 3 in the survey)

This study asked respondents about their mode preferences given different travel times in peak hours. Firstly, respondents were asked to estimate their current travel time using motorcycles for a distance of 5km in the rush hour. The travel time using BRT that had been calculated in advance (from 24 to 30 minutes) was also provided for respondents to compare. There were 26 respondents who gave no answer for either the travel time or their mode preference or both, and therefore were excluded from the calculation for this question. On average, a motorcyclist spent approximately 35 minutes to travel 5 km in rush hours.

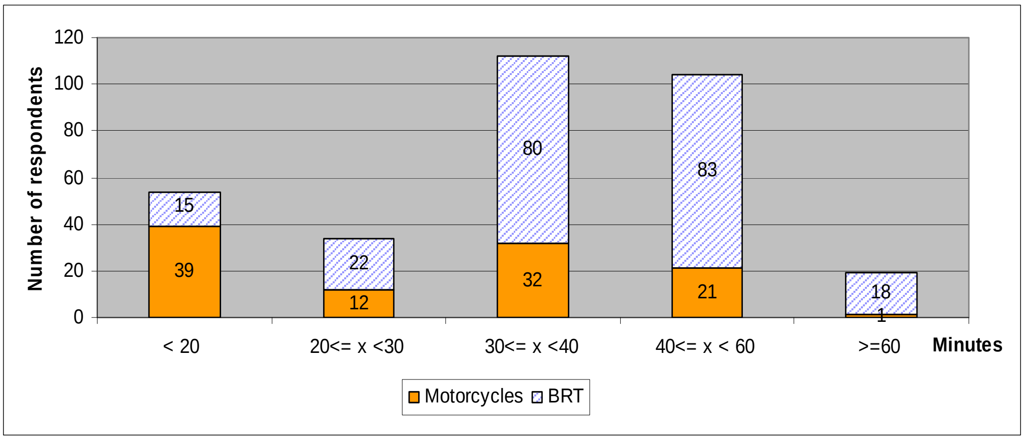


Figure 4.7 Travel time distribution and mode preference for 5 km in rush hours

From the results, when the travel time exceeded 20 minutes more respondents preferred using BRT to riding motorcycles (Figure 4.7). This showed that respondents did not select by favoring any particular mode but by trading-off among travel time, comfort levels, travel cost, walking distance and times of transfer. Some key reasons for respondents to choose BRT were:

- By staying on the bus they were exposed less to the outdoor air pollution and could enjoy air conditioned environment

- Bus travel is less stressful and safer than driving a motorcycle.
- Respondents agreed that 10 minutes walking everyday is good exercise.

4.4.3 Willing time to wait for bus and willing distance to walk to the station (question 4 and 5 in the survey)

Short waiting time and short walking time (and accordingly walking distance) also play an important role in persuading people to use public transport since it is usually valued higher than in-vehicle travel time. From the survey results, 68.8 % of respondents were willing to wait for the bus only up to five minutes, 26.36 % were willing to wait up to 10 minutes, and only 4.58 % were willing to wait up to 15 minutes (Figure 4.8). Respondents commented that one of the reasons for them not to use the current bus system was because they had to wait more than half an hour for a bus. While the current bus system cannot provide short and precise waiting times, BRT, on the other hand, will be able to satisfy most respondents regarding the waiting time at the station.

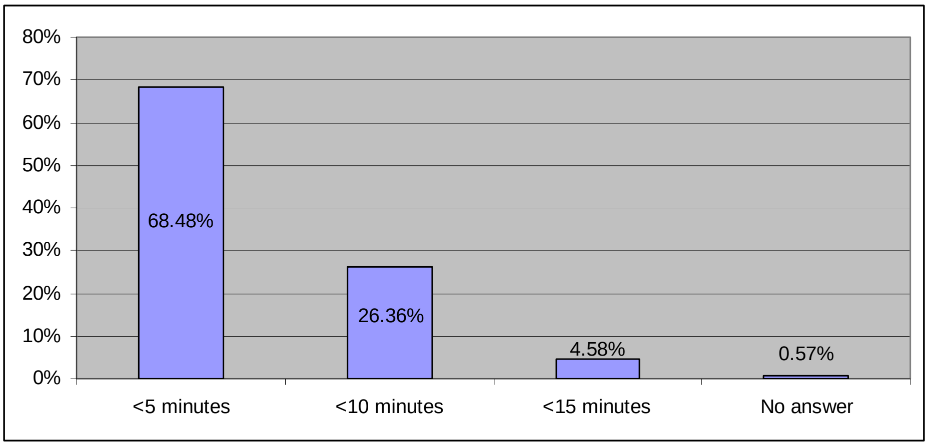


Figure 4.8 Acceptable waiting time

It is a bit different for the case of "willing distance" to walk to the station since some respondents perceived that this activity is a kind of exercise. Although 46.7 % of respondents preferred the shortest option (less than 100m), 50.43 % of respondents said it was fine to walk 500m to the station. Unsurprisingly, those who chose the last option (1000m) only accounted for 2.29 % (Figure 4.9). However, many respondents questioned the possibility of providing everyone in Ho Chi Minh City a distance of 500m to the nearest bus station. They said that the 500m distance was easily achievable for those people living along the main streets, but for those living in small and long side streets (or “hẻm” in Vietnamese), the distance to the bus stops might be much longer than they preferred to walk, which could discourage people from using public transport. Moreover, some respondents complained about the harsh walking environment in Ho Chi Minh City because sidewalks were blocked by parked motorcycles and misused for small businesses.

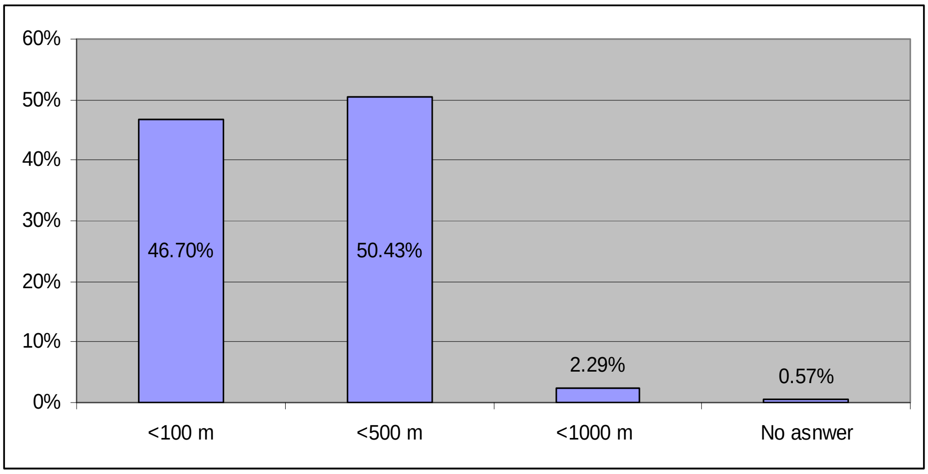


Figure 4.9 Acceptable distance to walk to the bus station

4.4.4 Private lane for bus (question 6 in the survey)

Although private lanes or busways are one of the most important features of BRT that might help to make dramatic improvements in system effectiveness and customer satisfaction (reducing waiting and travel time), it usually causes much protest from people who use private vehicles at the beginning of the project. It is because by making physical separation, the space left for other modes is narrowed down. In order to get support from people, it is important to make sure that they understand about the benefits of BRT to both motorcyclists and bus riders as well as to the whole society.

Overall, the study found that majority of the respondents, 75.93 %, had a positive outlook about private lanes, only 9.46 % of respondents protested the implementation of private lanes and 14.61 % said that they could not decide at that time (Figure 4.10). Some respondents said that they supported the private lanes not due to BRT itself but because they would like the current unruly bus system to be put into control.

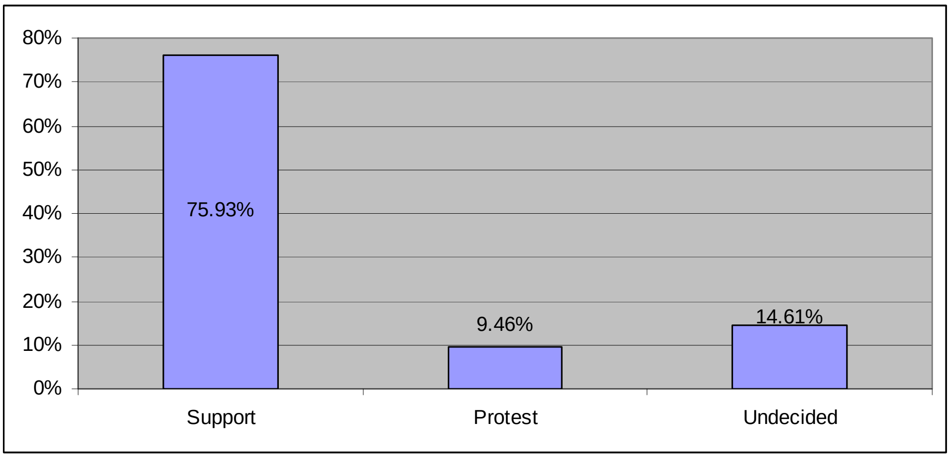


Figure 4.10 Opinion of respondents on private bus lanes

The respondents who were against the private bus lanes said that it was better to make separated running ways at either underground or overhead because at-grade busways might cause more traffic congestion. Some respondents preferred building metro or sky-train although they admitted that they were not sure how city government would be able to find the investment capital.

4.4.5 Likely use of BRT

This section addressed the research question 2 concerning the potential number of motorcyclists switching to BRT.

4.4.5.1 For work/school trips (commute trips) (question 7 in the survey)

Commute trips account for the main part of people's daily moving activity. This study asked respondents if they would use BRT for their daily main trips such as commute trips and trips to school and found that the majority of the respondents, 65.9 %, would likely use BRT for work/school trips, about 9.5 % replied that they would prefer their motorcycles and 24.6 % could not decide at that time and said that they might try and see how BRT really worked (Figure 4.11).

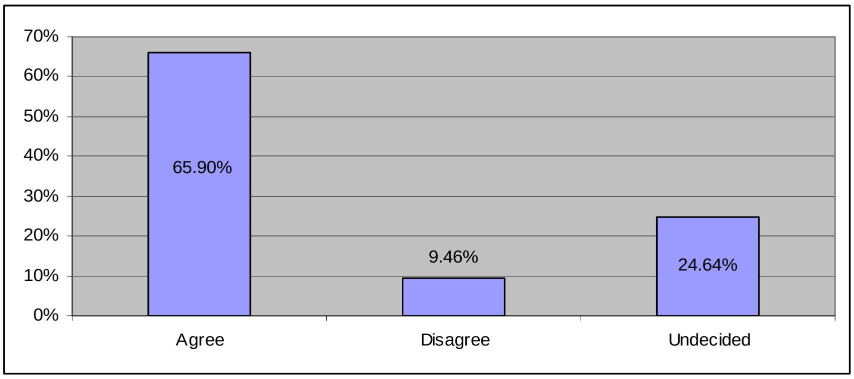


Figure 4.11 Likely use of BRT for work/school trips

4.4.5.2 For other trips (question 9 in the survey)

Unlike working/school trips, other trips represent other needs of people's daily mobility such as shopping and recreation trips. These types of trips are usually shorter and intuitively required less travel times than commute/school trips. To some respondents, it was a kind of "culture" that they preferred dating/going out trips using motorcycles since they felt more privacy than staying on a public bus. On the other hand, some respondents thought that these types of trips did not require "time pressure" like those of working/school trips and therefore chose the bus option. All in all, the results showed that 50.43 % of the respondents preferred using BRT for other trips (Figure 4.12). Those who could not decide at that time accounted for 30.09 % but it also meant that the possibility for them to try would be high in future. The respondents who chose keeping their motorcycles represented 17.48 % of total respondents.

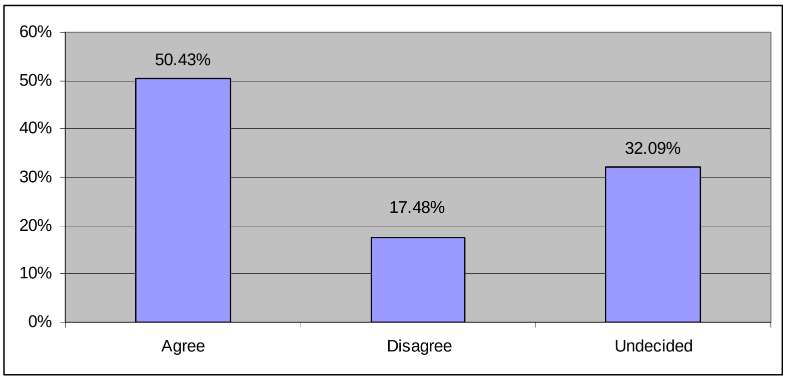


Figure 4.12 Likely use of BRT for other trips

4.4.5.3 For both work/school and other trips (questions 7 and 8 in the survey)

There were 137 respondents who would like to travel both work/school trips and other trips by BRT which accounted for 39.3% of total respondents (349).

4.4.5.4 Calculating and applying the confidence interval

Since the sample size (349) was not as high as expected (400), the confidence intervals were re-calculated to these mode shift percentage using the following formula:

$$CI = z_c \times \sqrt{\frac{p(1-p)}{n}}$$

where

CI = confidence interval, expressed as decimal

z_c = Z value in the standard normal probability distribution (e.g. 1.96 for 95% confidence level)

p = percentage picking a choice, expressed as decimal

n = sample size (349 “valid” questionnaires)

Applying the above mode-shifting percentages, the number of work/school trips that would shift from motorcycles to BRT accounted for 65.9 ± 4.97

% (or 60.93 % at least and 70.87 % at most). The results for other type of trips that would shift from motorcycle to BRT are summarily shown in table 4.1

Table 4.1 Percentage of trips switching to BRT after applying confidence interval

	p (%)	CI (%)	Min (%)	Max (%)
Work/school trips	65.90	4.97	60.93	70.87
Other trips	50.44	5.24	45.19	55.67
Both types of trips	39.30	5.12	34.18	44.42

4.4.6 Personal views of respondents about BRT (question 9 in the survey)

Unlike other cities where a mass transit network is common for everyone, Ho Chi Minh City people were not familiar with the idea of mass transit, especially an efficient bus system. Therefore, this study asked respondents’ personal views about this new transport system. Overall, BRT got more support from a majority of respondents over the transport system using motorcycles. Some even suggested broadcasting the idea of BRT to other mass media like newspapers or television to get other people’s attention. However, most of them expressed their concern about the fact that BRT’s required private lanes would cause a lot of difficulties in implementation because of Ho Chi Minh City’s narrow streets. Their concerns were also reflected in the negative comments from the authority and researchers about the possibility of implementing BRT (Section 2.6.3). After listening to the explanation that when more people use BRT, the traffic will be less crowded and it will cause no traffic chaos, respondents had a better view of the problem of private lanes.

Some said that transportation habits of the Vietnamese differed from others concerning the way houses were built in small long side-streets (or “hẻm”). Some people also perceived riding motorcycles at night as a way to enjoy the wind and relax which could not be achieved by bus (Figure 4.13).

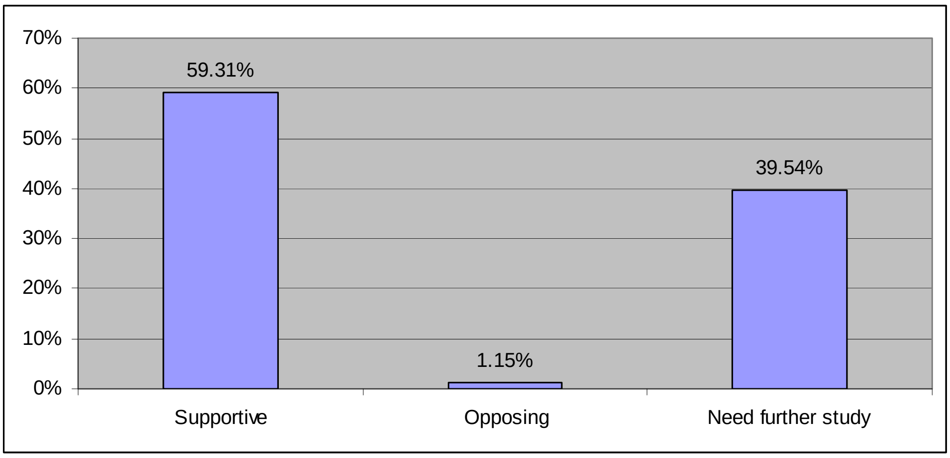


Figure 4.13 Personal views of respondents about BRT

4.5 Objective 2: the ranking of criteria affecting respondents' use of the proposed BRT network (question 10 in the survey)

The study asked respondents to rank several criteria that might affect their decision in using BRT to find out which features of the new transport system that Ho Chi Minh City people feel interested in the most.

Respondents' choices were summarized in percentage (table 4.2) for all criteria and the number of respondents for each criterion a rank. For example, as regards "comprehensive network" criterion, there were 8.6 % of respondents would think that it was the most important factor for them to use BRT while 15.8 % of the respondents would think that this factor is not important at all (by ranking it 11).

These criteria were sorted in ascending order by arithmetic mean (Table 4.3). The survey found that fare price was the most important criterion and signal priority at the intersections was the least important factor influencing people's mode choice if only the mean values were considered. However, the levels of importance for these criteria were not clearly classified concerning their standard deviation, the lower- and upper-limit values. During the survey, from respondents' point of views, in order to attract people to using public transit these criteria could not be separated. For example, people would not use the bus, regardless of how low fare prices were, if the buses did not operate punctually and were not relatively fast. Similarly, people emphasized the level of service of public transit. They would also expect the level of service to be as high as what was mentioned in the BRT scenario such as short waiting time, increased travel safety and the attractive appearance of the BRT system. As in the case of "unlimited transfers on the network", although this practice would reduce the transport cost and give more convenience for passengers, this feature alone which had been implemented in the current bus network could not offset other inconvenient attributes of the system.

Again, this underscores the importance of public transport's level of service towards travelers. The imperfection of one factor could discourage people from using public transport and result in the inefficiency of the whole system.

The study found that the criterion "reduced traffic congestion" was quite important (the third in rank) for Ho Chi Minh City people in choosing BRT. This showed people's acceptance and trust toward "the new public transport solution" for solving the current transport situation. This finding actually contrasted to their attitude towards the current bus system as mention in Section 4.2.3 and could be due to the "face-to-face" survey that provided them with more knowledge concerning this transport mode.

However, other important BRT features such as dedicated busways, comprehensive network and signal priority at intersections seemed to be quite unfamiliar to Ho Chi Minh City people and therefore got lower ranks. While some people showed their worry about the "signal priority at intersection" criterion would cause accidents since people would not be aware of it, especially children and the elderly, the dedicated busways which are required for fast and punctual bus services were not easy for people to rank due to its relatively new and indirect benefits.

Table 4.2 Percentage of responses ranked for each criterion.

No	Criteria	Rank										
		1	2	3	4	5	6	7	8	9	10	11
1	Comprehensive network	8.6 %	8.0 %	6.6 %	7.4 %	6.0 %	7.7 %	13.2 %	10.0 %	5.7 %	10.9 %	15.8 %
2	Dedicated busways	8.6 %	4.0 %	7.7 %	8.0 %	12.3 %	10.9 %	7.7 %	10.6 %	10.3 %	13.2 %	6.6 %
3	Quality of BRT system (appearance, comfort, and air conditions of buses and station)	10.3 %	9.7 %	6.6 %	7.2 %	9.7 %	9.7 %	9.7 %	11.5 %	12.3 %	6.3 %	6.9 %
4	Fare price	30.4 %	12.3 %	12.0 %	10.3 %	7.7 %	9.2 %	6.0 %	4.3 %	2.3 %	2.9 %	2.6 %
5	Waiting time for bus	6.6 %	14.6 %	8.3 %	12.0 %	9.2 %	7.7 %	10.0 %	10.0 %	10.6 %	7.2 %	3.7 %
6	Walking distance to station	1.1 %	3.2 %	8.6 %	6.6 %	8.3 %	7.7 %	13.8 %	8.3 %	12.6 %	13.2 %	16.6 %
7	Signal priority at inter--sections	2.0 %	2.0 %	4.0 %	6.6 %	8.0 %	11.5 %	8.3 %	9.2 %	10.9 %	14.6 %	22.9 %
8	Unlimited transfers on the network	3.4 %	7.7 %	8.3 %	12.6 %	12.9 %	10.9 %	10.0 %	12.3 %	6.3 %	7.2 %	8.3 %
9	Better road safety	12.9 %	12.3 %	15.5 %	9.2 %	9.7 %	9.2 %	6.0 %	6.0 %	8.0 %	6.9 %	4.0 %
10	Reduce traffic congestion	11.5 %	14.3 %	10.9 %	10.9 %	7.2 %	8.9 %	7.7 %	6.9 %	11.5 %	5.4 %	4.9 %
11	Reduced air pollution	5.2 %	11.5 %	11.5 %	10.3 %	8.6 %	6.6 %	8.3 %	11.2 %	9.5 %	12.0 %	5.4 %

Table 4.3 The results of ranking several BRT criteria in term of mean and confidence limit

Rank	Criteria	Mean $\overline{Y}$	Standard Deviation SD	Confidence limits: $\overline{Y} \pm t_{(\alpha/2,N-1)} \frac{SD}{\sqrt{N}}$ (With 95% confidence and degrees of freedom N-1 = 348) => t-test=1.96	
				Lower limit	**Upper limit**
1	Fare price	3.8	2.81	3.51	4.1
2	Better road safety	5.05	3.13	4.72	5.38
3	Reduced traffic congestion	5.26	3.1	4.93	5.58
4	Waiting time for bus	5.6	2.95	5.29	5.91
5	Quality of BRT system (appearance, comfort and air-conditioning buses and stations)	5.95	3.09	5.62	6.27
6	Reduced air pollution	5.99	3.06	5.67	6.31
7	Unlimited transfers on the network	6.13	2.81	5.83	6.42
8	Dedicated busways	6.35	3	6.03	6.66
9	Comprehensive	6.57	3.29	6.23	6.92
10	Walking distance to station	7.39	2.81	7.1	7.69
11	Signal priority at intersections	7.81	2.79	7.52	8.1

4.6 Objective 3: potential for reducing energy consumption

This section addresses objective 3 and research question 3 by determining the CO_2 emissions reduction due to the implementation of BRT in Ho Chi Minh City. In other words, this study will compare the CO_2 emissions of base-line scenario (nothing changed) and that of BRT scenario.

4.6.1 Baseline scenario

For the calculation, the study relied upon following assumptions:

- The population of Ho Chi Minh City at the time of this study was 7.7 million people (ADB, 2006)

- From Houstran report for HCMC's transport system (JICA, 2004): On average one citizen made 2.5 trips per day (non-pedestrian trips), 5.2 km per trip. Work/school trips constituted 27 % of all trips while other trips accounted for 73 % of all trips. Motorcycles accounted for 78.8 % of all non-pedestrian trips. The load factor of a motorcycle in Ho Chi Minh City is 1.3 person/motorcycle

- Average fuel consumption for the motorcycle fleet is given as 2.2 liters/100km where 1 liter of petrol produces 2.42 kg CO2 (IEA/SMP, 2004; Wright and Fulton, 2005)

From these assumptions,

The total motorcycles trips per day
= Population * number trips/person/day * motorcycles mode share
= 7.7 million * 2.5 trips/person/day * 78.8%

= 15,169,000 motorcycle trips per day

(Of these 15,169,000 trips, 27 % (or 4,095,630 work/school trips) occur in 4 peak hours of a day and 73% (or 11,073,370 other trips) happen in 14 off-peak hours of a day). **(T1)**

Then,

the total distance of all motorcycle trips for the city per day
= Total motorcycles trips * Average distance per trip (km/trip)
= 15,169,000 (trips) * 5.2 (km/trip)
= 78,878,800 passenger kilometers per day (by motorcycles)

Next, using the assumption that fuel consumption for a motorcycle is 2.2 liters/100km and a liter of gasoline/petro will produce 2.42 kg CO2,

the CO_2 emissions of a motorcycle per kilometer
= 2.2 * 2.42 /100
= 0.0528 (kg CO_2 per km)

Dividing the load factor of a motorcycle in Ho Chi Minh City of 1.3 (persons/motorcycle) (JICA, 2004),

the CO2 emissions per passenger kilometer (by motorcycle)
= 0.0528 / 1.3
= 0.0406 (kg CO_2 per passenger km) **(V1)**

Finally,

the total CO_2 emission for all motorcycle trips per day
= The total distance of all motorcycle trips (km) *
The CO2 emissions per passenger kilometer

= 78,878,800 (km) * 0.0406 (kg CO_2/km)

= 3,202,479 (kg CO_2 per day)

4.6.2 BRT scenario

For the calculation, the study relied upon the following assumptions:

- Average fuel consumption for a BRT bus is given as 0.64 liters/km (diesel) where a liter of diesel produces 2.87 kg CO2 (IEA/SMP, 2004; Wright and Fulton, 2005).

- About the proposed BRT network: As mentioned in Chapter 3, the total length of 10-dedicated trunk corridors was about 120 kilometers with 252 stations. The number of buses required to operate in peak hours and in off peak hours was calculated as follows: The travel time for a bus on a 15-km corridor (30 stations) (with commercial speed of 22km/h and 20 seconds dwelling time at each station) was around 51 minutes. In peak hours when frequency was 3 minutes, the number of buses needed to run on that corridor was (51/3) x 2 = 34 buses. For the whole system with 120-km corridor (252 stations), the number of buses was estimated at around 285 buses. Similarly, for off peak period (5-minute frequency), the number of buses was calculated at about 168 buses. The capacity of a trunk bus was 160 and the main fuel used was diesel. Also, it was noted that the proposed BRT system would operate from 5am to 11pm in which 6-8am and 4:30-6:30pm were considered peak hours. The bus occupancy in off peak period is 70 % and in peak period is 85 % (based on the experience in other BRT networks) (ITDP, 2007).

First, using the above assumption that fuel consumption for a BRT bus is 0.64 liters/km (diesel) and a liter of diesel will produce 2.87 kg CO2:

the CO_2 emissions of a BRT bus per kilometer
= 0.64 * 2.87
= 1.8368 kg CO_2 per km

Because the load factors of a BRT bus between peak and off-peak period are not the same, two different CO2 emissions per passenger kilometer (by BRT) for two periods were calculated:

<u>For peak period (bus occupancy is 85 % of 160 seats):</u>
The CO2 emissions per passenger kilometer (by BRT)
= 1.8368 / (0.85*160)
= 0.0135 kg CO_2 per passenger km **(V2)**

<u>For off-peak period (bus occupancy is 70 % of 160 seats):</u>
The CO2 emissions per passenger kilometer (by BRT)
= 1.8368 / (0.7*160)
= 0.0164 kg CO_2 per passenger km **(V3)**

4.6.3 CO_2 emissions reduction per passenger km from mode shift

Comparing (V1), (V2) and (V3), for every passenger kilometer shifted from motorcycle to BRT, the CO_2 emissions reduction per passenger kilometer were calculated

<u>For peak period:</u>
The CO_2 emissions reduction per passenger km
= 0.0406 (motorcycle) - 0.0135 (BRT bus)
= 0.0271 kg CO_2 per passenger km

<u>For off-peak period:</u>
The CO_2 emissions reduction per passenger km

= 0.0406 (motorcycle) - 0.0164 (BRT bus)

= 0.0242 kg CO_2 per passenger km

4.6.4 The capacity of the proposed BRT network

From the above calculation, it is obvious that the potential for CO_2 emissions reduction depends on the number of passenger trips shifted from motorcycle to BRT. From the survey's results, around 65.9 % of the respondents would likely use BRT for work/school trips and 50.43 % of the respondents preferred using BRT for other trips. However, the actual number of passenger trips shifted from motorcycle to the proposed BRT network depends firstly on the capacity of the system.

The proposed BRT network consisting of 10 trunk corridors spreads mainly over the highly dense zones (from 178 to 405 persons/ hectare) of Ho Chi Minh City featuring highly mixed land use. With the average distance of a corridor about 12 km, it is assumed that the renovation factor of a bus would be 0.33 (or three times more people getting on and off the bus as there are people on the vehicle at any given time – see Chapter 2). In other words, in one peak hour, a bus (with 160 seats and the occupancy of 85 %), could provide 160 * 85% * 3 = 408 passenger trips per bus. Multiplying the passenger trips per bus with the total number of buses operating in one peak hour (285 buses), the capacity of the proposed BRT network in one peak hour will be 285 * 408 = 116,280 passenger trips per peak hour. Assuming that 78.8% of the riders were previously motorcyclists; therefore the number of motorcycle trips shifted to BRT trips in one peak hour was 91,629 passenger trips. In four peak hours per day, the number of passenger trips shifted from motorcycles to BRT would be 91,629 (trips/hour) * 4 (hours) = 366,515 passenger trips /day. **(T2)**

Similarly, in one off-peak hour, a bus (with 160 seats and the occupancy of 70 %), could provide 160 * 70% * 3 = 336 passenger trips per bus. Multiplying the passenger trips per bus with the total number of buses operating in one peak hour (168 buses), we found the capacity of the proposed BRT network in one peak hour = 168 * 336 = 56,448 passenger trips per off-peak hour. With the assumption that 78.8% of the riders were previously motorcyclists, the number of motorcycle trips shifted to BRT trips in one off-peak hour was 44,481 passenger trips. In 14 off-peak hours per day, the number of passenger trips shifted from motorcycles to BRT would be 44,481 (trips/hour) * 14 (hours) = 622,734 passenger trips /day. **(T3)**

4.6.5 CO_2 emissions reduction for the proposed BRT network

The calculation was made using the CO_2 emissions reduction per passenger kilometer in peak and off peak period calculated in Section 4.6.3.

The CO_2 emissions reduction per day for peak period (4 hours)
= the CO_2 emissions reduction per passenger km in peak period (kg CO_2 / km) * passenger trips in peak (trips) * average distance of a trip (km/trip)
= 0.0271 (kg/km) * 366,515 (trips) * 5.2 (km/trip)
= 51,649 kg CO_2 per day

The CO_2 emissions reduction per day for off-peak period (14 hours)
= the CO_2 emissions reduction per passenger km in off-peak period (kg CO_2 / km) * passenger trips in off-peak (trips) * average distance of a trip (km/trip)
= 0.0242 (kg/km) * 622,734 (trips) * 5.2 (km/trip)
= 78,365 kg CO_2 per day

Given that a year has 250 weekdays and work/school trips occur only on weekdays,

the amount of CO_2 emission reduction in one year
= 51,649 * 250 days + 78,365 * 365 days
= 41,515,492 kg CO_2 per year
= 41,515 tonnes of CO_2 per year

4.6.6 The expanded BRT network for more percentage of mode shifting and options to increase the BRT's efficiency in reducing air pollution

When comparing (T1), (T2) and (T3), the capacity of the proposed BRT network in peak period accounts for nearly 9 % of the number of work/school trips in base-line scenario. For off-peak period, the proposed BRT network can only handle around 5.6 % of the other trips in current situation. In order to serve more people, the network should be expanded either by raising bus frequency or increasing the bus routes. In case around 65.9 % of the motorcyclists in baseline scenario would shift to BRT for work/school trips and around 50.43 % of the motorcyclists would shift to BRT for other trips as the survey's results, the CO_2 emissions reduction would be 10 times bigger (415,150 tonnes of CO_2 per year).

From the above calculation, BRT can provide significant CO2 reductions for Ho Chi Minh City. The main reason appears to be the high efficiency of the BRT bus and therefore the per passenger distance travelled (km) CO2 emissions for a BRT system are significantly lower than that of a transport system using motorcycles. It should be noted that the high efficiency of the bus not only helps to reduce CO2 emissions but also lowers the energy consumption per passenger distance travelled (km) and therefore moderates other air pollutant such as CO, PM, NO_x.

The positive impact of the proposed BRT would be larger if a cleaner fuel was used for the bus propulsion such as compressed natural gas (CNG), biodiesel or hydrogen. It should be noted that while CNG may well be justified in terms of reducing other types of pollutants (e.g. particulate matter and sulphur oxides), its potential in term of reducing greenhouse gas emission, especially when its whole life cycle from "well to wheel" is considered, has still caused controversy (Wright and Fulton, 2005). Besides, in order to calculate the GHG emission for the BRT system using CNG fuel, both data on CO_2 and CH_4 emissions are needed. Another cleaner fuel is hydrogen which would cause zero CO_2 emission but is currently still being tested. In the future, it might become a very good substitute for diesel to run the BRT network and thus reduce the emission very considerably.

4.7 Conclusion

This chapter has presented and discussed the results of the responses of people. In general, the study found that people feel dissatisfied with the current transport situation and their reasons were because of more severe air pollution and more traffic accidents which were noticed in Chapter 2. The depletion of fossil fuel leading to the increase in oil price, followed by the increase in travel cost, also played an important role in influencing them on switching to BRT. The finding of large CO_2 emissions reduction (or reducing energy consumption) which could be achieved if BRT was implemented in Ho Chi Minh City promised an agreement with other cities where BRT has already been built such as Bogota, Curitiba and Mexico City. Similarly, the fact that a majority of Ho Chi Minh City people showed their preference towards the new transport system was also in accordance with the increase in ridership of BRT in other cities. The following chapter will provide conclusions for the study and recommendations for future research.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

This final chapter gives the conclusions of the study and makes a number of recommendations for further research. Starting from the central idea of sustainable urban transport development, this study focused on prioritizing public transport for Ho Chi Minh City. Since BRT is growing in popularity throughout the world, the study examined the benefits of implementing BRT with regards to GHG reduction for the city's transport sector. Aside from the calculation of emission reduction based on the proposed BRT network and the number of motorcyclists switching to BRT obtained from the Stated Preference survey, this study also assessed motorcyclists' attitudes towards the implementation of the new transport system and find the factors that would effect their decision to switch modes.

The survey was conducted in Ho Chi Minh City where nearly 80 % of daily trips are made by motorcycle. The survey type was face to face interviews and the interviewees were 400 motorcyclists. Overall, a total of 365 responses were obtained and analyzed using descriptive statistics.

5.1 Objectives and research questions

The study, with its three objectives stated in Chapter 1: to determine Ho Chi Minh City's motorcyclist's attitudes towards the introduction of a BRT network; to examine the factors that would influence motorcyclists' decisions to shift to the BRT network; and to determine the potential for reducing energy consumption (in term of CO2 reduction) if BRT is implemented in Ho Chi Minh City would address the research questions.

The first objective is to determine Ho Chi Minh City citizens' attitude toward BRT and to see if they could fully understand the system. To fulfill this objective, an introduction of a BRT network was setup and presented to interviewees. Only those respondents who completed the understanding test about BRT's features without any wrong answer continued with the survey. From the findings described in Chapter 4, the majority of the respondents (59.3 %) felt supportive towards the project while only 1.2 % of the respondents opposed the idea of BRT.

The results showed that Ho Chi Minh citizens had a positive attitude towards BRT if they fully understand the system

The second objective of the study was "*to examine the factors that would influence motorcyclists' decisions to shift to the BRT network*". The results showed that: with regard to travel cost reduction, nearly 75 % of the respondents stated that they would like to switch to BRT because of its lower travel cost. Considering travel time, the study found that when the travel time exceeded 20 minutes respondents preferred sitting on a bus to riding their motorcycles. However, as clearly stated by respondents, they chose public transport because of many good features of the BRT system as a whole, not just due to one or two specific advantages such as lower cost and shorter travel time. This was also reflected in the last survey question which asked respondents to rank several of BRT's design criteria. Some criteria reflecting high levels of service and social factors such as better road safety, reduced traffic congestion, quality of BRT system (appearance, comfort and air-condition of buses and stations), reduced air pollution were ranked higher than unlimited transfers on the network (for lower travel cost) and dedicated busways (for faster travel time). In summary, the study found that

in order to encourage motorcyclists to switch to public transport, a thorough plan to improve simultaneously all levels of services of the system to a high and efficient standard is needed.

The last objective using the second and third research questions is to determine whether BRT would help to reduce energy consumption (measured in term of CO_2 reduction) from Ho Chi Minh City transport sector. From the results of the survey described in Chapter 4, with regards to work/school trips, the number of motorcyclists that would switch to BRT accounted for 65.9 ± 4.97 % (or 60.93 % at least and 70.87 % at most). Concerning other trips, the number of motorcyclists that would switch to BRT represented for 50.43 ± 5.24 % (or 45.19 % at least and 55.67 % at most). There were 137 respondents who would like to switch both their work/school and other trips to BRT which accounted for 39.3 % of total respondents. Using these figures, the study found that

the basic proposed BRT system has the potential to reduce energy consumption in term of CO_2 emissions by more than 40,000 tonnes of CO_2 per year. This is the equivalent of taking nearly 1 million motorcycle trips off the streets everyday.

In the case that the BRT network was expanded to accommodate all the motorcyclists who stated their preference for switching to BRT, the saving would be over 415,150 tonnes CO_2 /year or more than 8 million motorcycle trips per day.

5.2 Limitation of the research

Before answering the questionnaires, respondents were given an introduction of the BRT system with its high levels of service. This could introduce a bias to the results of number of respondents choosing the new mode as it may have acted like an advertisement for BRT. However, any bias is somewhat irrelevant since the number of respondents choosing BRT (65 % and 50 % for work/school trips and other trips respectively) far exceeded the capacity of the proposed BRT network to accommodate those stating that they would switch to BRT (around 9%).

Another limitation of the study is the number of valid responses (349 instead of 400). It would have been a precaution to gather a number of extra samples over the minimum requirement which would have avoided the problem of the “invalid” responses.

5.3 Conclusions

In addition, the study drew several conclusions regarding the implementation of the BRT in Ho Chi Minh City.

The study addressed and gave the answers for the concerns from the authorities and researchers about the possibility of implementing BRT in Ho Chi Minh City. The concern that the remaining road space on the street after installing BRT’s busways is not enough for other transport modes was addressed. Due to the high rate of people shifting to BRT, there will be fewer people using the remaining road space which, in fact, will make better transport conditions for both BRT’s users and those who are really need to use their private vehicles.

The cost of 400km BRT busways is 1 billion USD or 2.5 million USD per km busway. This cost includes the trunk lines, stations, terminals, pedestrian overpasses, bus depots and control center. Although it does not incorporate the cost of BRT buses, when compared to the cost of building a metro in Ho Chi Minh City (1 billion USD for 20.5 km metro), the cost of building the entire BRT network (2.5 million USD / km * 120 km = 300 million USD) has big economic advantages: The construction cost of a public transport system will decide the level of fare price. In the case of a metro when the high fare price has to be subsidized, the city’s budget needed for other pressing areas such as health, water, sanitation and education will be reduced. On the other hand, BRT’s low construction cost will allow a more comprehensive network and require no subsidy from the government. Therefore, besides the advantages in reducing air pollution from transport sector, BRT provide social benefits (low price, high quality public transit) and economic benefits (reducing energy consumption and travel time lost) to the city. Further more, the success of the new mass transit will encourage and increase pedestrianisation, which will finally help to reduce transport-related energy consumption and to make the city’s sidewalk more attractive to people.

5.4 Recommendations

5.4.1 Recommendation 1: Raising public awareness of BRT

The survey showed that before knowing about BRT, people in Ho Chi Minh City held a negative view of bus systems and they undervalued the potential for public transport to alleviate the city's transport problems. It is recommended that more knowledge and scientific expertise concerning sustainable development and long-term solution should be targeted to both citizens and transport professionals. Besides, as suggested by respondents, the information and examples of BRT should be published over mass media such as TV or newspapers providing detailed knowledge about BRT including technical (infrastructure and equipment), operational, social, economic, and financial aspects, and emphasizing its positive impacts and advantages to the city.

5.4.2 Recommendation 2: Implementation of BRT

Similarly, there is a need to increase the awareness of politicians and government officers of all levels of the benefits of BRT. This study has shown that BRT can address greenhouse gas issues and that it has a high acceptance amongst potential users, both factors related to good governance. Therefore, it is recommended that the government consider the benefits of BRT and begin implementation as soon as possible.

5.4.3 Recommendation 3: Future research

Due to the constrained time of a master's thesis, this study only explored the potential for BRT in reducing energy consumption in term of CO_2 emissions for Ho Chi Minh City's transport sector and explored the willingness of motorcyclists to accept the new transport system. However, it is suggested that future research could be carried out concerning:

- Other benefits of BRT for the city such as its potential to improve transport flow, alleviate traffic jams and accidents, reduce other types of air emissions and pollutants and increase pedestrianization.

- Cost/Benefit Analysis of BRT project in Ho Chi Minh City with regards to capital cost, operation cost and the total benefit in monetary value.

- A Clean Development Mechanism (CDM) project for the proposed BRT network including all greenhouse gas emissions from every phase: building, operating, changing in urban sectors, increasing in non-motorized vehicle uses.

- Studies have found economic development at the local level with the pedestrianization of local streets (Kodukula, 2006). Further research in Ho Chi Minh City could reveal the economic benefits to local businesses around planned BRT stops especially where improvement to the walking environment can be introduced.

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APPENDIX A

SURVEY OUTLINE

STATED PREFERENCE SURVEY OF MOTORCYCLISTS FOR STUDYING IN IMPROVING PUBLIC TRANSPORT FOR HO CHI MINH CITY

Date of interview: ______________

Before answering the interview, please fill in the following information
(for any information you don't want to provide, please leave it blank)

Gender: Female □ Male □
Age: _____
Job: Student □ Working □ Retired □

Average travel time (from door to door) for one-way trip to office/school
_____________ minutes

Monthly expense for (VND)
Fuel :_____________
Parking (home, office, others) :_____________
Maintenance and insurance :_____________

Are you satisfied with the current transport situation: Yes □ No □

After being introduced about BRT system, please answer the following questions:

1. BRT's attributes:

BRT has	**Yes**	**No**	
Exclusive right of way lanes?			
Rapid boarding and alighting (wide doors) with pre-boarding ticket?			
Free transfers between routes?			
Clear route maps, signage and real-time information displays?			
Large, high-capacity, high-frequency bus services?			

2. Compare operational costs between motorcycles and BRT, please choose the one you prefer

Assumed that an average travel distance is 5.2 km/ trip, everyone make 2.5 trips/ day. The total expense for transport monthly is 226,500 VND.

Option	Travel fee	Select
Motorcycle	174,000 VND/month (for 5.2 km/trip and 2.5 trips/day)	
BRT (distance based)	A base fare 1,000 VND + 250 VND/ km	
BRT (time-based with unlimited trips)	A daily ticket (6,000 VND) with validity for one day.	
	A weekly ticket (35,000 VND) validity for one week.	
	A monthly ticket (130,000 VND), validity for one month	

3. Comparing travel times from door to door between motorcycles and BRT *<u>in rush hours</u>*, please choose the one you prefer.

Option	Approximate travel time	Select option
Your travel time for a 5-km trip by motorcycle		
The travel time for a 5-km trip of BRT **(no transfer)**: 14 minutes + about 10 minutes walking.	24 minutes	
The travel time for a 5-km trip of BRT **(1 time transfer)**: 14 minute + about 10 minutes walking + 3 minutes transfer.	27 minutes	
The travel time for a 5-km trip of BRT **(2 time transfer)**: 14 minute + about 10 minutes walking + 2x3 minutes transfer.	30 minutes	

:

4. Time willing to wait for bus 5 minutes □ 10 minutes □ 15 minutes □

5. Distance/time willing to walk to bus stop
100m (or 3min) □
500m (or 8min) □
1000m (15min) □

6. Support for dedicated lane Support □ Oppose □ Undecided □

7. Likely to use BRT for work/school Yes □ No □ Undecided □

8. Likely to use BRT for other activities Yes □ No □ Undecided □

9. Personal view about BRT Supportive □ Opposing □ Need further study □

10. Rank these criteria (from 1 as most important to 11 as least important) that might affect your decision to use the proposed BRT network

Criteria	Rank (1-11)
Comprehensive network	
Dedicated busways	
Quality of BRT system (appearance, comfort and air-condition of buses and stations.	
Fare price	
Waiting time for bus	
Total travel time for journey	
Reduced traffic congestion	
Reduced air pollution	
Better road safety	
Priority at intersections	
Unlimited transfers on the network	

Other criteria that are important to you: ……………………………………….…………..…
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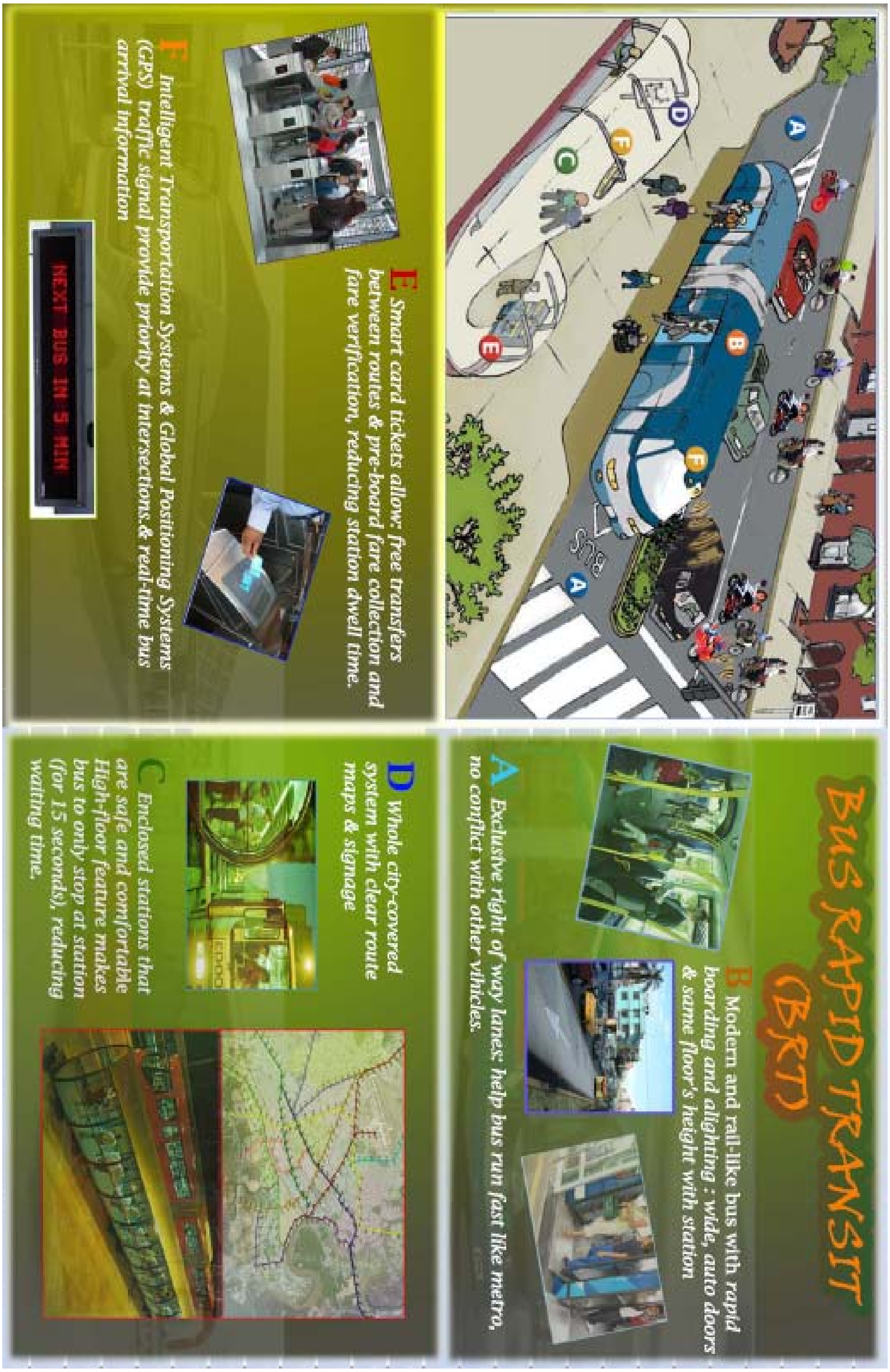
Thank you for participating in the survey!

APPENDIX B

BRT INTRODUCTION


BUS RAPID TRANSIT (BRT)
B Modern and rail-like bus with rapid boarding and alighting : wide, auto doors & same floor's height with station
A Exclusive right of way lanes: help bus run fast like metro, no conflict with other vhicles.
D Whole city-covered system with clear route maps & signage
C Enclosed stations that are safe and comfortable High-floor feature makes bus to only stop at station (for 15 seconds), reducing waiting time.
E Smart card tickets allow: free transfers between routes & pre-board fare collection and fare verification, reducing station dwell time.
F Intelligent Transportation Systems & Global Positioning Systems (GPS) traffic signal provide priority at intersections.& real-time bus arrival information
NEXT BUS IN 5 MIN
BUS

Run on segregated land + signal priority, high speed (30km/h), reduce travel time and waiting time, no effect on other vehicles

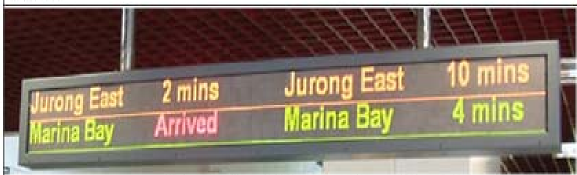
Run in mixed traffic , slow for getting congestion, have effect to other modes by stop and go condition

Rapid boarding and alighting, easy to get in the bus (due to wide door and same grade platflom)

Boarding and alighting is difficult because of steps and narrow doors

Easy go to anywhere in the network with fast speed, using smart card - easy transfer without paying money, pay per km travel

Routes are not conveniently connected, paying separate tickets for 1 trip if transfer.



Frequent service (5 minutes), Service time (5am-23pm) with real time passenger information on bus and at station

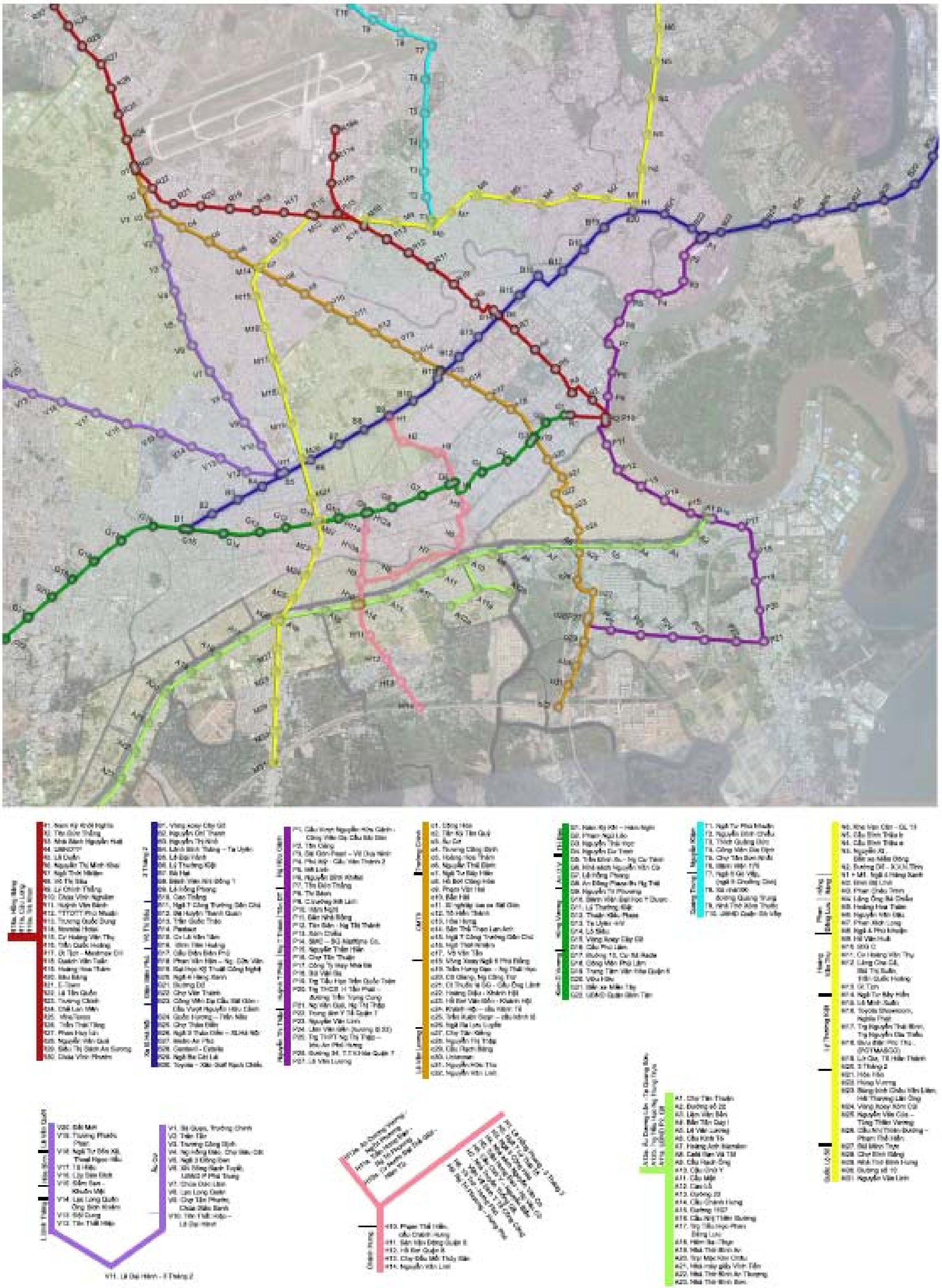
No information of when bus will come -> unreliable

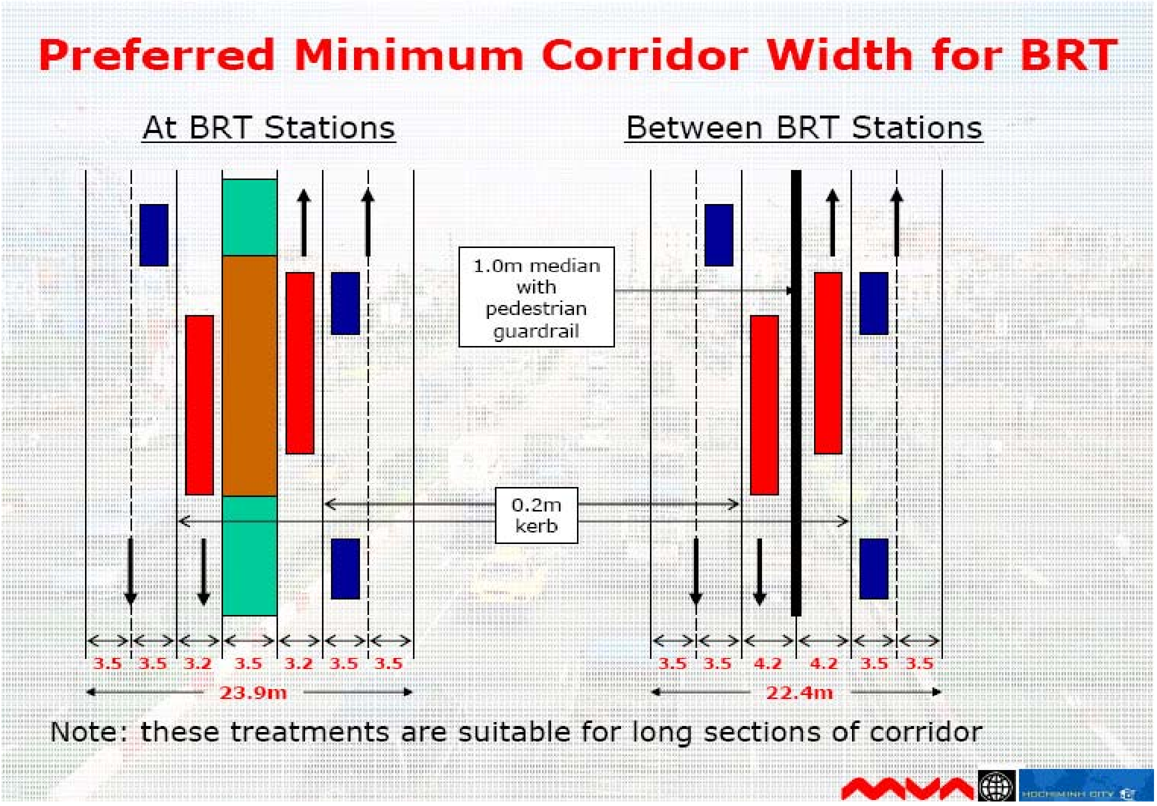
High capacity, more seats, reduce overlaped bus routes (number of normal bus on street)

Low capacity, less seat, overlaped routes more congestion

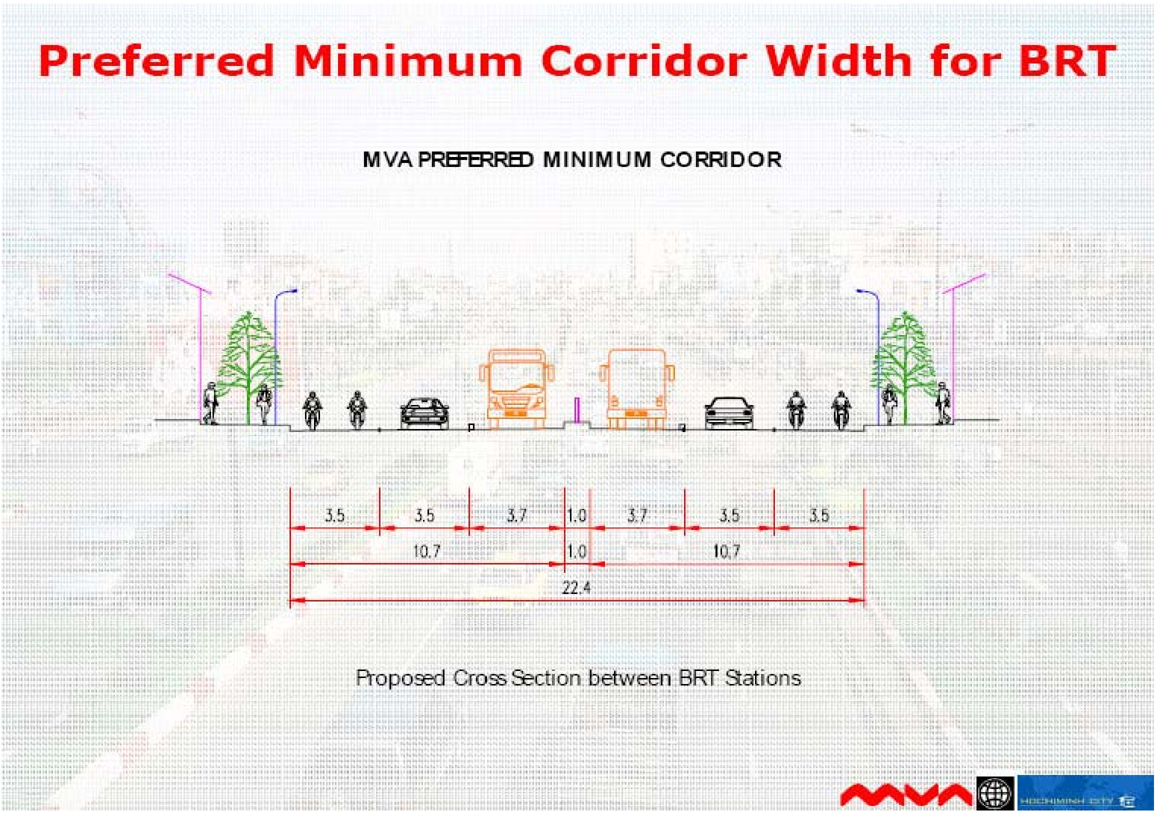
APPENDIX C

BRT ROUTE MAP AND STREET DESIGN

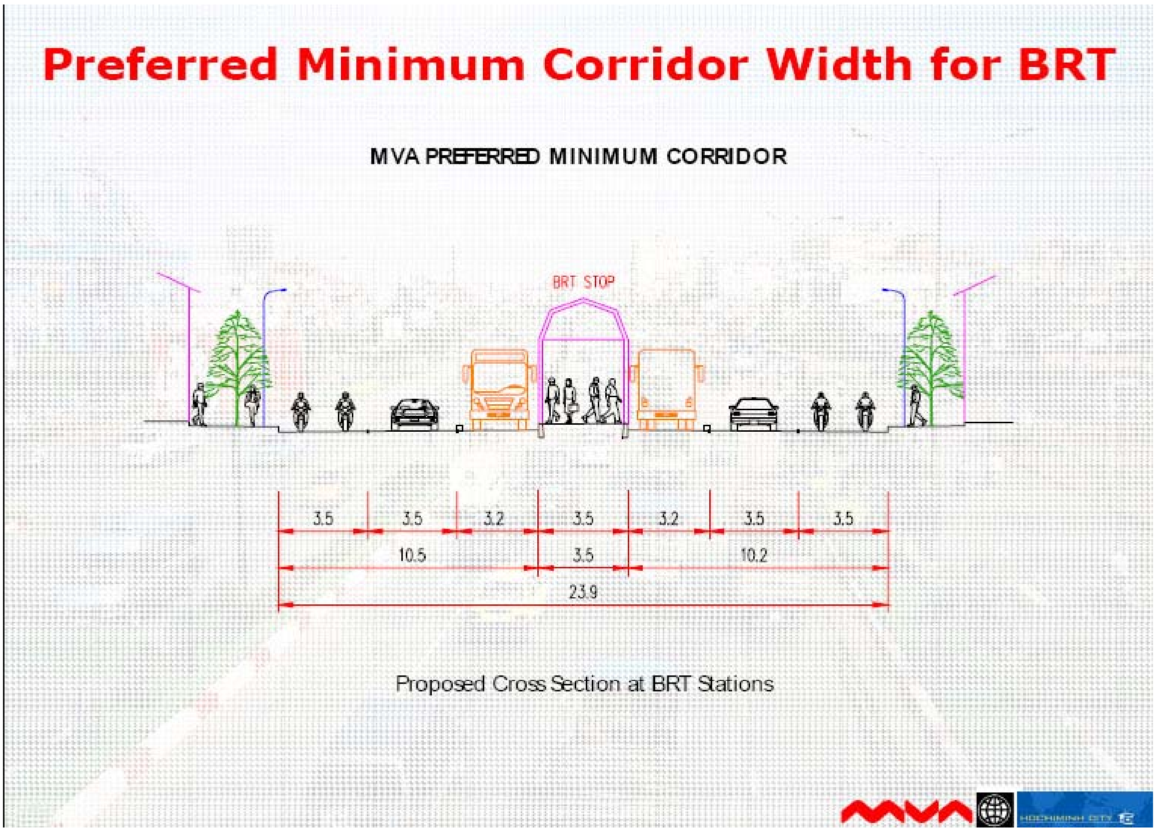




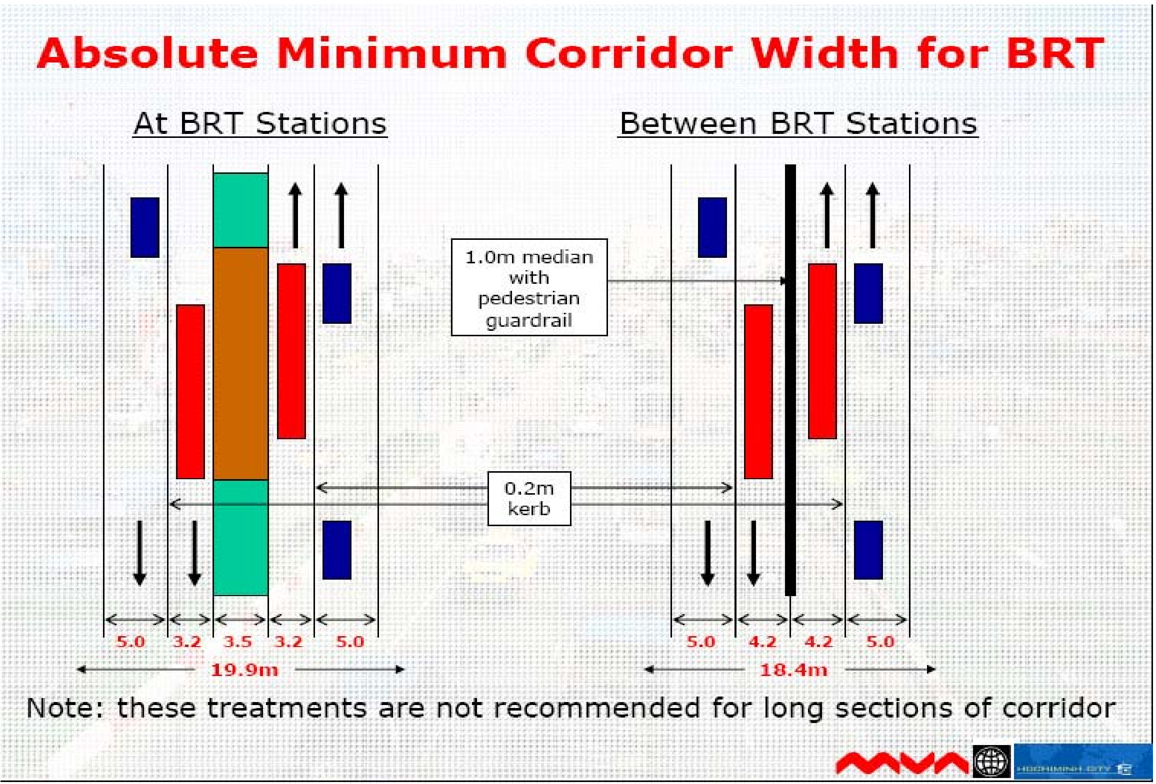
(Source: World Bank, 2005)



(Source: World Bank, 2005)



(Source: World Bank, 2005)



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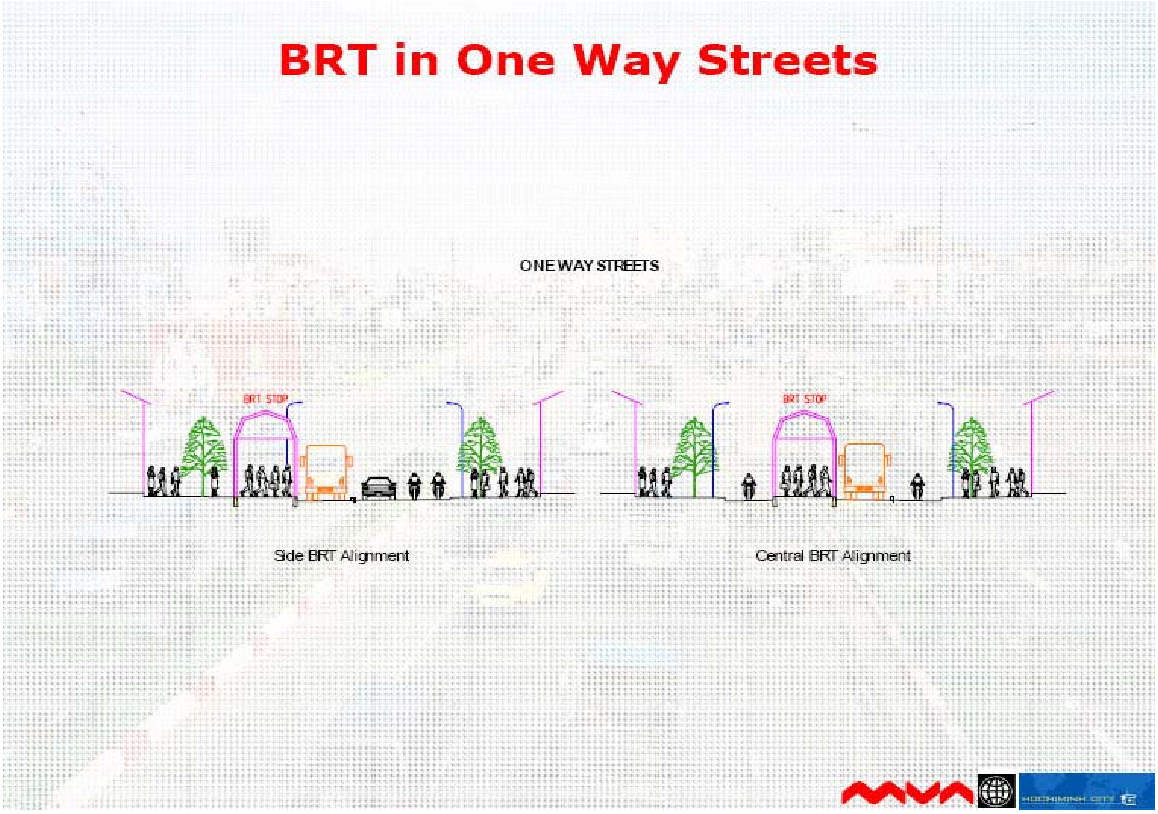

(Source: World Bank, 2005)

BIOGRAPHY

NAME	Mr. Nguyen Anh Dung
DATE OF BIRTH	19^{th} Nov 1982
PLACE OF BIRTH	Ho Chi Minh, Vietnam
INSTITUTIONS ATTENDED	University of Natural Science, 2000 - 2004 Bachelor of Science (Environmental Science)
	Mahidol University - Thailand, 2006 - 2008 Master of Science (Industrial Ecology and Environment)
FELLOWSHIP STUDY GRANT	Thai International Post-Graduate Fellowship Program for Academic Year 2006, Thailand International Cooperation Agency (TICA)
WORK EXPERIENCE	Researcher, Department of Ocean Mechanics and Environment, Institute of Applied Mechanics, Vietnam.
HOME ADDRESS	95 Pasteur District 1 Ho Chi Minh City, Vietnam
EMAIL ADDRESS	banmt@yahoo.com