Appendix 1

Supporting Study

March 2009

This chapter should be cited as
Working Group for Sustainable Automobile Society in East Asia (2009), 'Supporting Study', in Patunru, A. A., K. Minato, M. Hori and K. Hirota (eds.), *Sustainable Automobile Society in East Asia*. ERIA Research Project Report 2008-7, pp.13-45. Jakarta: ERIA.

Appendix 1: Supporting Study

1. Introduction

Concerned with the increasing levels of air pollution caused by motor vehicles in Asia's major cities, Working Group for "Sustainable Automobile Society" in East Asia initiated a project Approach to Clean Air in Asia in December 2008. The project collected and disseminated information on policies to reduce automobile emissions in Asia.
Through meetings, the project provided a venue for the sharing of experiences among various countries in Asia and the introduction of best practices on reducing vehicle emissions.

Practical and Efficient Proposal of Measures & Policies for Air Quality Improvement
→ First of all "Evaluating the Real World"

The Policy Guidelines for Reducing Vehicle Emissions in Asia consists of these objectives:

- ■ Reducing Vehicle Emissions in Asia
- ■ Vehicle Emissions regulations and Inspection and Maintenance
- ■ Cleaner Fuels
- ■ Health effect
- ■ Transport Planning and Traffic Management for Better Air Quality
- ■ Implementation / enforcement issues.

For Evaluation of sustainable automobile society, the following approach has been adopted:

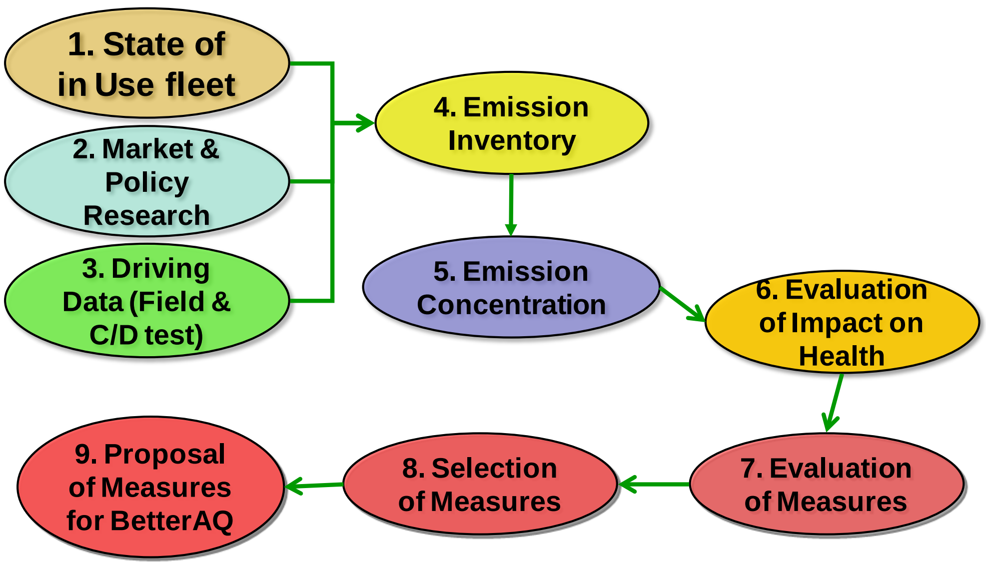


Figure A 1.1: The approach of the study

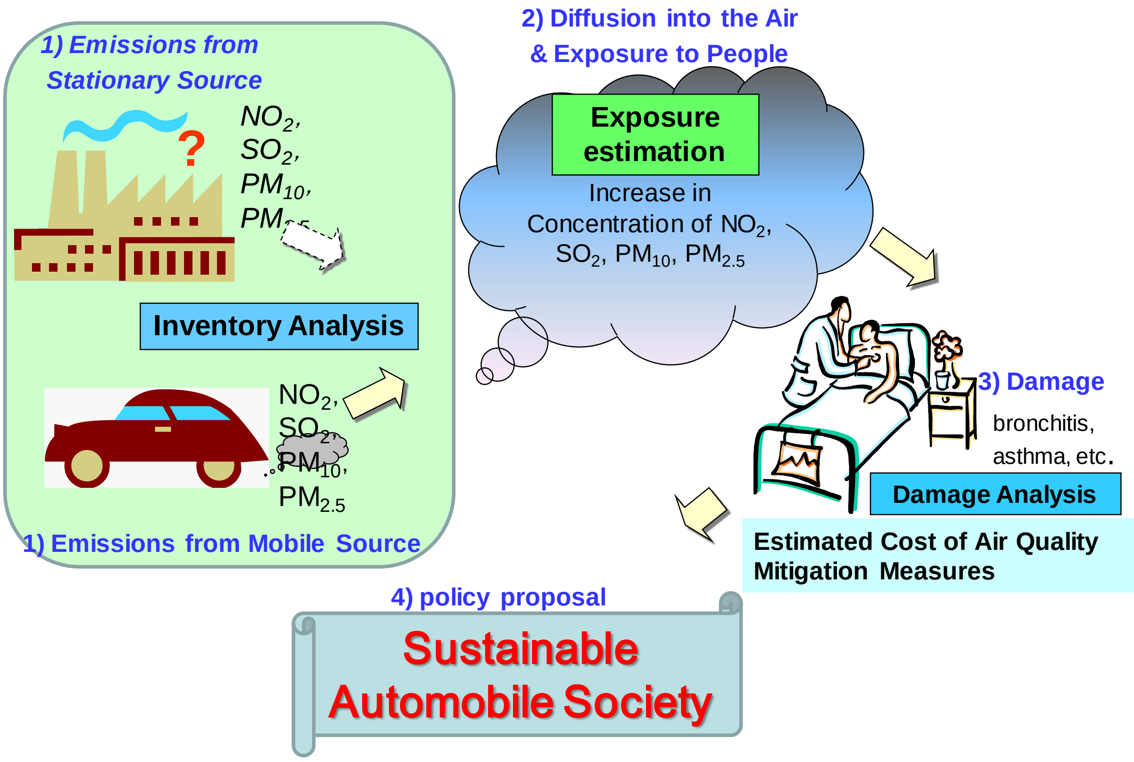


Figure A 1.2: Scheme of the study

The growth in mobility in Asia helps Asian countries in their economic development. At the same time the increased air pollution that is associated with the growth in mobility also has a negative impact on development. In many cases, air quality in Asian cities does not meet the standards set by World Health Organization (WHO). Pollution levels above the WHO standards mean that the health of people breathing the air is adversely affected. Appendix 2-1, Table A 2.1 shows the average air quality in mega cities in Asia from 1990 to 2005, in relation to the WHO air quality standards.

Research carried out by WHO, clearly established the relationship between exposure to air pollution and health problems such as cardiovascular disease, asthma and other respiratory diseases. Far less research work has been carried out in Asia on the impact of air pollution on human health. This is a reflection of the general weak capacity in Asian countries to undertake research on the health impact of air pollution. Also, comprehensive baseline data on air quality and health problems are often not available or not very reliable when available.

As response to this need, the Health Effects Institute (HEI) have coordinated the multi-city time-series studies on the health effects of air pollution in Asia (PAPA studies) that are comparable to the robust and consistent results in the United States and Europe (Katsouyanni et al. 2001; Samet et al. 2000). These PAPA studies in Hong Kong, Shanghai, and Wuhan, China, and Bangkok, Thailand, were published in the Environmental Health Perspectives 2008.

Air pollution in Asian cities is caused by different sources such as mobile sources like buses, trucks, cars or motorcycles; stationary sources or industries; or from area sources like garbage burning, dust etc.

In the majority of Asian cities, mobile sources are the most significant contributor to air pollution. This is especially true for PM, CO and NOx, the pollutants that most often do not meet the ambient air quality standards and have established adverse health and environmental impacts (see Appendix 2-1, Table 2.1). Mobile sources are expected to continue to be a major source of air pollution in the future. There is still a very large unsatisfied demand among households and individuals who would like to buy a motorcycle or a car once they can afford it. Most cities in Asia do not have adequate plans to improve public transportation to a level that will convince vehicle owners to use public transport more frequently instead of using a car or motorcycle. The study location (site) for this year is Thailand, Bangkok

2. Air Pollution in Asian Countries

2.1 Summary of Air Pollution in Asian Countries

Global environmental issues are being addressed as important matter these days, and tackling them is considered to be an immediate and necessary need. However, as mentioned before environmental challenges such as global warming are not the only current environmental issues affecting the daily lives of people. Air pollution, a serious social issue also exists as one of the severe environmental problems on a rather local scale, and this has been aggravated yet further in the recent years.

Most human activities nowadays are performed in urban areas, and urbanization is a worldwide trend. Increasing activities in cities and the advances of urbanization have caused harmful effects on various local and city environments and even brought about severe health problems in residents. The nature and manner of the advances of these city activities differ among economies, and the resulting environmental issues vary as well, usually worst in the less developed economies.

With the national industrialization policies, Asian countries have experienced striking economic spurt and development, and their economies have grown with unprecedented speed. The improvement of living and income standards, among others, has encouraged the use of automobiles, and accelerated rapid motorization. Such prevailing use of automobiles has brought a boom to local auto industries and a convenient and wealthy lifestyle to the people. On the other hand, poor public transportation systems have increased the personalized transport in the form of private use of cars, which has revealed such negative aspects as the deterioration of the urban environment. Emissions from automobiles are damaging public health in addition to affecting the environment. Asian countries have a responsibility to improve urban environments in order to sustain and develop a motorized society, to regenerate environment friendly cities and to cultivate an environmentally-sustainable motorized society.

In the midst of the information and technology revolution progressing globally, a transformation towards new developments and new challenges is required for Asian countries. It is certain that the auto industries in Asian countries will make huge leaps along with economic growth in the 21st Century. If the motorization enters into its full scale progress and things are left as they are, aggravated energy problems and deteriorated urban environments will bear heavily in Asia. The main factors that automobiles cause the environment are air pollution, noise problems, and waste materials. Especially, Air pollution has become a serious issue in many Asian cities. It is important to implement environmentally-friendly transportation systems at earliest.

Under the progress of motorization, Asian countries share similar challenges related to automobiles. The main issues are as follows:

(1) Worsening air pollution and increasing health damage
(2) Deterioration of living environment due to traffic noise and road vibrations
(3) Increasing deaths and injuries from traffic accidents
(4) Traffic congestion from increasing traffic demands, leading to loss of man-hours.

We propose technical and non-technical measures for tackling the present problem according to APEC questionnaire (2004). To build up better automobile society in Asia, we should address these issues.

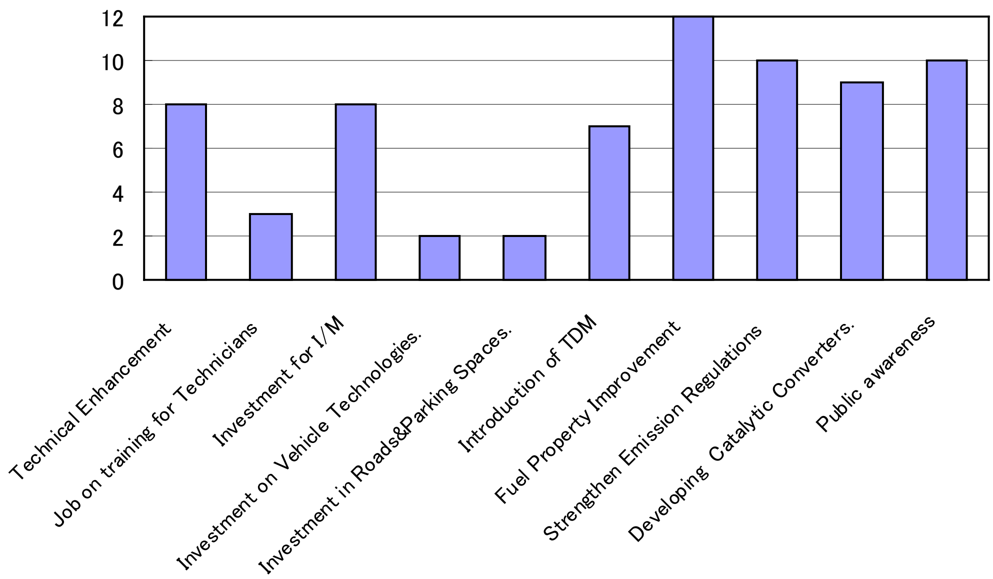


Figure A 1.3: Results of APEC questionnaire survey

Proposed technical measures:

(1) Reduction of emission from automobiles by upgrading car inspection and maintenance systems
(2) Reduction of emission from automobiles by improving the quality of fuel
(3) Strengthening the restriction on emissions from automobiles (introducing more stringent emission norms)
(4) Popularizing clean energy and clean-energy vehicles
(5) Promotion of harmonization of technical regulations

Non-technical measures:

(1) Promotion of environmental education and campaigns for better awareness
(2) Upgrading air pollution monitoring systems.

Many Asian countries adopt and use European or American automobile emission standards. However, they will need adequate policies and measurements corresponding to their own individual conditions of vehicle use. To deal with urban environments, it is essential to implement effective means such as accurate understanding of actual traffic conditions and other problems in each country and even in each city. Merely implementing the EU or American standards may not give the best environmental returns on efforts and investments towards automobile emission control. The policies and measures stated above may show excellent cost effectiveness for Asian countries, in improving urban air environment. They need to grasp the current conditions, to predict future changes accompanied by the economic growth accurately, and to examine measurements, which would work most effectively if conducted with simultaneous coalition and cooperation in the area.

2.2 Emission Control Measures to be Implemented

(i) Reduction of emissions from automobiles by upgrading car inspection and maintenance (I&M) systems

Introduction of a car I&M system to lower emission is a well proven measure for preventing air pollution with excellent cost effectiveness. It is a well-known fact that the success of emission control in Japan owes a lot to its car I&M system as well as after-exhaust treatment (catalytic) technology. Without appropriate maintenance and check-ups, the performance and safety of automobiles will inevitably deteriorate, which will increase the environmental pollution. In Asia, the ratio of used cars is high, and the longer a car is used the more emission it emits. While trading in used cars for new ones may be a cost effective solution, a car inspection and maintenance system can reduce emissions by 30 to 40%. Governments should establish at least the minimum number of items for car inspection and maintenance to ensure the safety of cars in use and prevent pollution.

(ii) Strengthening the restriction on emissions from automobiles

In Asia, motorization has caused air pollution in vast areas and has damaged living conditions. It is expected that the further increase of population and cars should make the level of air pollution much worse than at present. To lower the level of air pollution and to prevent damage to people’s health, it is necessary to enforce a strict restriction of vehicle emissions gas by introducing more stringent emission norms.

(iii) Reduction of emission from automobiles by improving quality of car fuel

A recent characteristic of air pollution in Asian cities is the very high levels of NOx and PM. In Europe and US, focus has already been placed on reduction of these emissions and several control measures are already in place. It is important to reduce the sulfur content of diesel fuel to improve vehicle emissions by facilitating adoption of advanced catalyst technologies. Improving the quality of car fuel, especially with respect to lead in gasoline and sulfur in diesel, is an effective means to prevent air pollution. Experts recognize that airborne lead is a serious danger to human and ecosystem health, so that eliminating lead in gasoline is critical step. As a result, the complete removal of lead from gasoline became technically feasible and relatively simple. In most cases, it can be also carried out at relatively low cost, making it a cost-effective measure to mitigate the public health damage caused by lead. It may be mentioned further that elimination of lead is also essential for the use of catalyst technologies for emission control.

(iv) Popularizing clean energy and clean-energy vehicles

Popularizing clean-energy vehicles is one of the important measures to reduce urban air pollution caused by automobiles. To enhance popularization of clean-energy vehicles, it is important to encourage the development of such cars by automobile manufacturers as well as to promote public incentives to purchase them. For this purpose, government support is essential in the areas of preferential tax systems and upgrading related infrastructure. Asian countries are abundant in such clean energy fuels such as natural gas and solar energy. With infrastructure improvement and upgraded technology, promoting effective use of such clean energy can substantially improve air pollution.

2.3 Promotion of harmonization of technical regulations

It is required to take measures against increasing traffic accidents and environment pollution in accordance with the motorization. At the same time, globalization of auto industry and ancillary industry are in the world market as international commodities. However, each country or area has defined its own “safety and pollution control regulations” for cars and the parts. It has been time and cost consuming to adjust technology level to each country regulation. In order to economize resources and bring benefits to consumers in the long run, global harmonization on technical regulations for car safety and pollution control should be recommended.

2.4 Promotion of environmental education and campaigns

Ignorance and lack of awareness to environmental issues should also be another cause of deteriorating urban environment. Particularly Asian countries can be marked by lack of environmental education. It is therefore important to seek comprehensive promotion of environmental education and awareness, including active participation in environmental conservation, supply of basic educational materials and information, and support for public awareness and related projects.

2.5 Monitoring system for air pollution

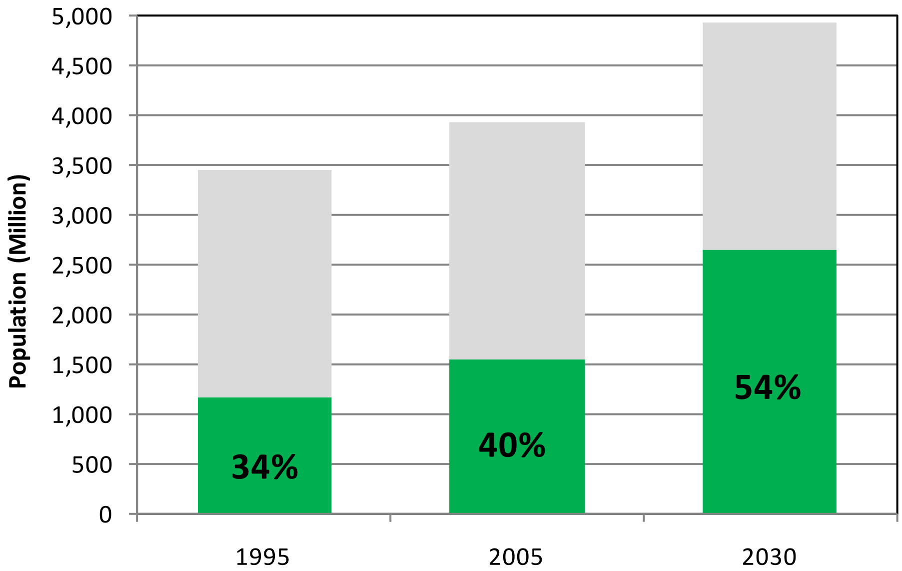
There is no organized information collection system to reliably assess the adverse effects of air pollution to human health. This is generally because of lack of adequate monitoring networks and data processing capacities to monitor air quality and composition of pollutants or epidemiologic data to extract information on sources of pollution. Measures against automobile emission emissions must contribute to reduction of air pollutant concentration, but without appropriate data, it is impossible to select the most effective measure. Epidemiologic research and basic observations of the atmosphere are necessary.

3. Background of research

Cities have been the engine of economic growth since the beginning of 20th century. With the structural change from agricultural based economies to industrial and service-based ones, cities have increasingly been attracting capital, resources, and other inputs. In addition, cities' greater employment opportunities and much better infrastructure compared to rural areas have driven substantial gains in population. This trend of urbanization – migration from rural area to urban area or transformation of a rural area into an urban one– is particularly noticeable in the Asia region. From 1995 to 2005, urban population in Asia grew at an annual rate of 2.3 percent – outpacing the world average urbanization rate over the same period. According to UN projections, Asia's urban population is expected to continue growing steadily at 1.5 percent per year between 2005 and 2030, expanding the share of total population from 40 percent in 2005 to 54 percent in 2030.

This continued growth in urbanization poses challenges to some Asian countries. Urban area challenges include the need to create basic urban infrastructure and services – such as a clean water supply, stable and affordable electricity/gas supply, affordable housing, and efficient mass transit infrastructure. Despite such immediate needs, cities oftentimes cannot provide these basic services due to a shortage in financial capacity and proper governance.

Lack of sufficient urban mass transit infrastructure combined with the growth in income of urban population has driven motorization trends in developing economies of Asia. This has in fact culminated in substantial growth in oil consumption. Likewise, some developed economy cities also face challenges revolving around passenger transport energy use in urban areas. Such challenges have something to do with difficulties in the changing lifestyle of urban dwellers. They already depend heavily on passenger vehicles for their mobility. With increasing affluence, those living in sprawling urban areas travel longer distances by heavier vehicles, which leads to a steady increase in oil consumption. Increases in oil demand – driven largely by urban area motorization and heavy dependence on passenger vehicles in sprawling urban areas –have not been met by increase in domestic oil production, thereby rendering greater oil supply security concerns.



Source: United Nations (2005). World Population Projections. New York, USA

Figure A 1.4: Asia population, 1995,2005 and 2030

3.1 Objectives and Scope

With due consideration to both the rising concern for oil supply security and rapid or maintained growth in urban transport energy demand, this report aims to provide policy-makers with various options that may contribute to reduce both *growth in* and *level of* urban transport energy demand and reduce air pollution. The report also attempts to analyze both contributing and offsetting factors to the urban transport energy demand in both *developing* and *developed* economies of Asia.

By analyzing factors affecting transport energy use around the region, the report assesses the current situation surrounding urban transport energy use, and it provides implications for policy-makers to plan energy efficient urban transport systems in the future.

Analysis in this report focuses on the motor vehicle transport sector in urban areas. By transport mode, the report investigates energy use of passenger vehicles, bus and truck. The report excludes analysis of the freight transport sector as well as intercity passenger transport as these transport activities generally extend beyond functional boundaries of urban areas.

3.2 Structure of report

How can we reduce air pollution from motor vehicles and passenger vehicle dependence in urban life? What options do we have to reduce emissions and improve energy efficiency in urban transport? To answer these questions, the report deals with the following key issues:

Firstly, the nexus between urbanization and passenger transport energy consumption is explored. This will be followed by an overview of historical trends in urban transport energy use of several cities in Asia.

Secondly, factors affecting urban motor vehicle transport energy consumption in Asia are analyzed through the development of novel indicators.

Thirdly, the measures to control growth in Asian urban transport energy use (=reduce air pollution) are analyzed in order to capture general trends across the region and to provide lessons learned from the cases with either successful outcomes or unintended consequences. The unique feature of this study to possibly highlight these observations from the similar developing Asian countries, rather than those developed and often referred to.

Finally, a case study of Bangkok is presented to address city-specific passenger transport issues and their implications for energy and environmental security.

3.3 General Information about Bangkok and Thailand

Thailand is located in the southeastern region of the Asian mainland. The total land area of the country is approximately 513 thousand square kilometers (320million). Located in the monsoon region, the climate is dominated by three distinct seasons: hot, wet, and cool. Average annual precipitation is 1,630 mm, although rainfall exceeding 2,000 mm is common in the Southern peninsula of the country.

The country is divided into five regions: North, Northeast, Central, East and South. The North is generally mountainous, with altitudes rising over 200 meters above mean sea level. A large part of the Northeast is on a high plateau and dry. The land in the central region is flat and relatively fertile. The East is dominated by fertile land suitable for tree crops and a long coastal line. The Southern Peninsula constitutes most of the 2,500 km coastline of the country. The topographical nature, soil characteristics and climate conditions influence agricultural specialization and socio-economic development in each region. Profile of Thailand is divided into 6 regions as presented in Table A 1.1.

Table A 1.1: Profile of Thailand

Region	Area (sq,km)
Northern	93,690.85
Northeastern	168,854.35
Central	91,795.14
Eastern	34,380.50
Western	53,679.02
Southern	70,715.20
Total	513,115.06

4. Bangkok

Passengers in the capital city of Bangkok mainly depend on the road transport for commuting and other purposes due to the urban sprawl along with the main road transport and the slow progress in developing a comprehensive mass transit system. Such passenger vehicle dependence coupled with limited road infrastructure development has led in recent years to severe traffic congestion problems in the urban core. Policy coordination is necessary for Bangkok to improve transport systems and to efficiently handle growing transport demands.

Table A 1.2: Basic data of Bangkok City

Total Population	Land Area	Population Density	GRP	PCI	Passenger Vehicles
5.48 million	1,568 km2	3,495 p/km2	151 billion	27,560	1.5 million

4.1 Introduction

Bangkok, Thailand is known as the "Venice of the East" due to the many waterways running throughout the city. With a total land area of 1,568 square km, and consisting of 50 districts and 154 sub-districts, the city's 2005 population was 5.5 million. The more broadly-defined Bangkok Metropolitan Region (BMR), which includes the Bangkok Metropolitan Area (BMA) as well as five surrounding provinces, registered a 2005 population of 9.8 million; that is, approximately 16 percent of Thailand's total population lives in the region. Moreover, Bangkok is dense; ranked 68th out of Thailand's 76 provinces in terms of land size, Bangkok easily has the largest population in Thailand.

Bangkok is commonly described as a "primate" city for Thailand; that is, it is the overwhelming centre of culture, population, and economic development for the whole economy. Between 1998 and 2005, the city's gross regional product (GRP) grew at an annual rate of 8.8 percent – faster than that of Thailand's 6.0 percent. In 2004, income in Bangkok was approximately 3.4 times higher than that of the economy as a whole, reaching USD 25,376 (2000 PPP).

The city's history of urbanization dates back to the early 1960s when the Thai government released its 1st National Economic Development Plan. As the Plan delineated, the economy's government aimed at achieving development through transforming the Thai economic structure from one of agriculture to one of manufacturing. To meet the target, Bangkok played the central role, attracting capital investment for the manufacturing industry. This, as a result, has increased employment opportunities and encouraged migration from other rural areas within Thailand.

Contemporaneous to the Thai Development Plan, Bangkok formulated its first land use plan in 1960. Despite the relative early formation of land use plan, however, little action followed to turn the plan into reality. It was only in 1992 – more than three decades after the plan's formation- that the city government issued its first statutory land use plan. Because of the lack of effective mechanisms to control urban development, Greater Bangkok has sprawled out towards the east, north south, and more recently towards west as well. This urban sprawl took place primarily along the main roads.

Because of this urban sprawl along main transportation arteries and the slow progress in developing a comprehensive mass transit system, passengers in Bangkok mainly depend on the road transport for commuting and other purposes. Such passenger vehicle dependence coupled with limited road infrastructure development has led in recent years to severe traffic congestion problems in the urban core.

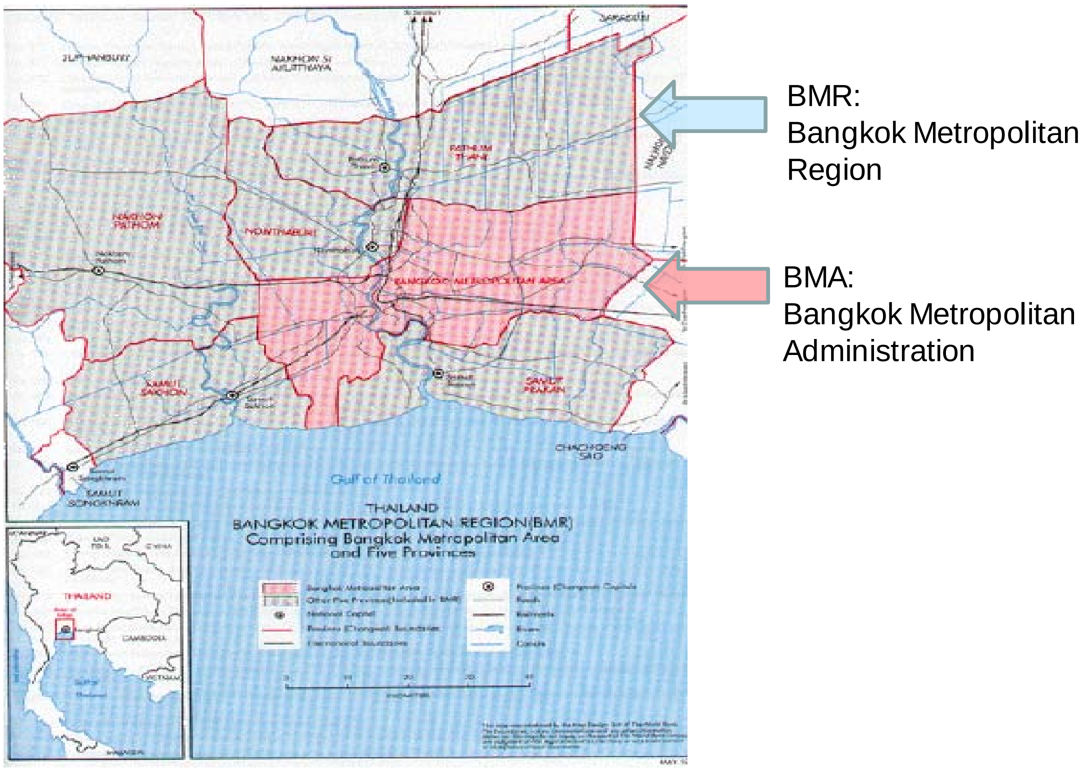


Figure A 1.5: Map of study area (Bangkok, Thailand)

4.2 Population in Bangkok

The Bangkok Metropolitan Region (BAR) includes the City of Bangkok and five neighboring provinces. In 2003, the BMR's population was estimated as 10.4 million and was estimated to be growing at just under 2% pa as shown in Table A 1.3. Per capita Gross Regional Product (GRP) in the BMR is 150% greater than that for the whole country. With the rapid growth in the economy real household incomes are increasing, which is driving increased motorization and travel demand.

Bangkok has grown rapidly from a small compact city located on the eastern bank of the Chao Praya River to a large sprawling urban area covering over 2,000 sq km. Growth was originally to the north and the east. Since the early 1970s there has been an extensive program of bridge and road building that has accelerated urban development to the west. Development is following the major road corridors and the neighboring provinces (within the BMR) are rapidly suburbanizing.

Table A 1.3: Projected population growth in Bangkok and BMR

Area	*Population (persons)* *2003*	*2017*	*Growth Rate (% per annum)*
Bangkok (BMA	6,502,000	8,066,000	1.6
Nearby Provinces			
Samut Prakan	1,025,000	1,347,000	2.0
Nonta Buri	906,000	1,346,000	2.9
Nakhon Pathom	800.000	1,007,000	1.7
Phatum Thani	702,000	1,211,000	4.0
Samut Sakhon	446,000	592,000	2.0
BMR Total	**10,381,000**	**13,569,000**	**1.9**
Thailand	**63,665,000**	**70,016,000**	**0.7**

Source: Northern Train Expansion Project by PCI, OTP and National Statistics Office, Thailand (2004)

4.3 Number of Vehicle Registration in Bangkok

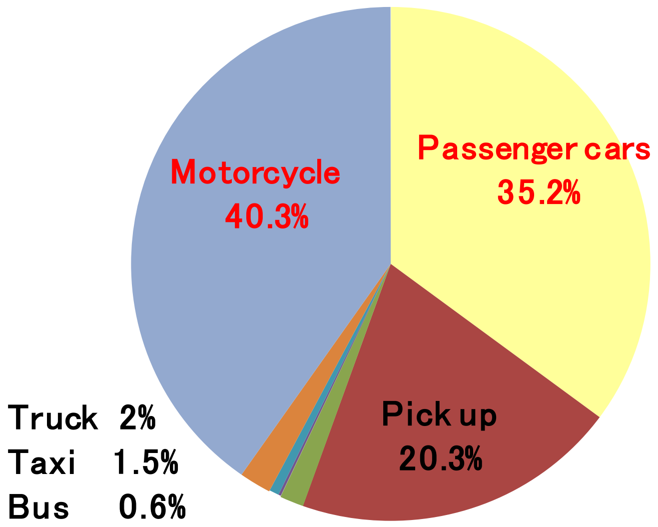
The dynamics of car ownership are affected by economic, technological and social factors. We can use the word "dynamics" to describe this aspect of motorization since ownership patterns can be expected to change because of change in income, urban structure, vehicle technology as well as social norms. Thus, it is important to understand the past and present car ownership patterns in order for planners to make reasonable predictions about future vehicle usage.

Motor vehicle registration in Bangkok Metropolis as a whole is given in Table A 1.4. All the regions show positive growth in total number of vehicles registered. However, these were significantly decreased during 1998 and 1999 during economic crisis in Asian countries thereby proving their direct co-relation. The average increase in the number of registered vehicles in Bangkok Metropolis from 1900 to 2007 is 6.2%. For comparison, the increase in the number of registered vehicles through country for the same period is 8.8%. Private cars, vans and Pick up and Motorcycles were increasing at relatively higher growth of about 8% each year, while Buses were increasing only by 3%. Looking at Figure A 1.6, motorcycles were the most popular among all vehicles register in 2007.

Table A 1.4: Total number of registered vehicles in Bangkok

	1990	1995	2000	2005	2006	2007
Passenger cars	598,223	940,573	1,240,985	1,691,544	1,867,902	1,974,751
Pick Up	569,536	724,176	1,033,003	1,040,100	1,135,034	1,137,961
Taxi	22,551	58,335	72,851	82,476	87,585	83,850
Tuk Tuk	7,406	7,406	7,403	7,314	7,688	9,019
Bus	20,923	24,364	26,128	30,939	32,659	33,716
Truck	67,987	91,427	120,163	116,144	107,671	110,571
Motorcycle	728,979	1,373,990	1,966,126	1,918,074	2,229,889	2,262,144
Total	2,015,605	3,220,271	4,466,659	4,886,591	5,468,428	5,612,012

Source: Department of Land Transport



Source: ESMAP, Developing Integrated Emissions Strategies for Existing Land-transport (DIESEL), 2008.

Figure A 1.6: Percentage shares of registered vehicles of Bangkok in 2007

The number of vehicles in BMR accounts for about 36% of the total number of vehicles in Thailand in 2007 (excluding Motorcycles). This indicates that BMR families/households are more likely to own more cars as compared to residents from other parts of the country, notwithstanding residence in urban or rural areas. The higher vehicle possession observed for Bangkok Metropolis is due partly to the higher standard of living and quality of residents in the capital city. But, the Bangkok ratio of the cars is dropping year by year, so in 1990 share of vehicle registered in Bangkok was 77%. This means that motorization is advancing in Thailand.

Table A 1.5: Share of vehicle registered in Bangkok

	1990	1995	2000	2005	2006	2007
Passenger cars	77.0	68.0	58.8	58.3	56.4	55.5
Pick Up	41.5	29.5	27.4	25.8	24.8	23.9
Taxi	79.9	91.9	94.2	95.7	96.3	94.8
Tuk Tuk	37.8	16.0	15.7	29.8	33.0	38.1
Bus	29.2	27.8	25.9	28.7	28.6	27.9
Truck	20.6	18.3	18.4	16.2	15.0	14.8
Total	49.5	40.7	37.0	37.7	36.7	36.0
Motortricycle	15.2	14.7	14.2	13.2	14.2	14.2

Source: Department of Land Transport

This section analyzes the motor vehicle use situation in detail. Bangkok's in-use national motor vehicle fleet was about 3.9M in 2006 as shown in Table A 1.6. Bangkok accounts for about 23% of the nation's registered motor vehicles including 51% of the private car fleet, but only 14% of motorcycles and 14% and 19% of buses and trucks respectively. Pick-ups, almost all diesel engine powered, are widely used as a personal vehicles particularly in urban areas.

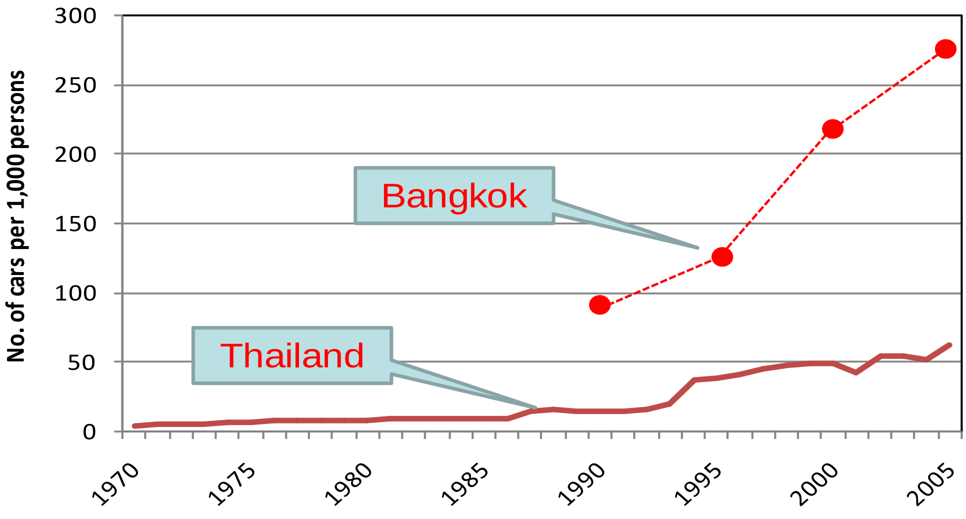
Table A 1.6: Number of in-use vehicles in Bangkok (1994 & 2006)

Type	1994	2006	Annual growth rate	Modal Shares in BMA (2006)
Car	716,591	1,974,751	6.24%	37.57%
Microbus & Passenger Van	241,120	197,075	-5.8%	2.99%
Van & Pick up	245,942	940,886	10.65%	21.02%
Urban taxi	22,256	83,850	9.43%	1.66%
Motor tricycle taxi	3,645	9,019	5.93%	0.18%
(Tuk Tuk)	851,853	2,262,144	3.56%	32.87%
Motorcycle	73,145	110,571	1.35%	2.18%
Truck	17,457	33,716	0.50%	0.47%
Bus	13,220	42.048	10.12%	1.07%
Other				
Total	**2,185,229**	**5,570,791**	**5.04%**	**100%**

Source: Department of Land Transport

During 1994 to 2006, Bangkok's vehicle fleet grew at a rate of 5.04% per annum- that is, its motor vehicle fleet grew by 80% over this 12 year period. A high proportion of this growth was due to motorcycles. Private car registrations increased at a rate of 6.2% per annum in the same period. Despite rising vehicle ownership in Bangkok, it was estimated in 2005 that 25% of all households did not own or have access to a vehicle (i.e. car or motorcycle), a reduction of almost a half from the estimated 44.5% of households that did not own a car in 1995

As the average income of the general public increases, people are able to afford to motor vehicles. With the development of road networks and infrastructure, vehicles (small trucks and buses) diffuse among people as a public means of transport. Trucks for business use, which have the characteristics of financial assets and are affordable, also come into wider use. Private passenger cars, once only accessible by high-income people, are more affordable to middle-income people. A brief profile for Bangkok is provided with information on population, income (purchasing power parity (PPP), 2000 USD), and passenger vehicle stocks per 1,000 population (Fig. 4.3). Economic activity is expressed in terms of gross regional product (GRP) and personal income. A transport category contains data on car ownership expressed as the number of passenger vehicles per 1,000 populations, the share of mass transit, and the number of buses and taxis. Subsequent sections assess how these variables are related to each other from different perspectives. Bangkok represents substantially higher income relative to the national average and the income gap between Bangkok and the rest of the country is exceptionally big. The income of Bangkok is about 10 times of the Thai income. This income difference gives big influence for car ownership in Bangkok.

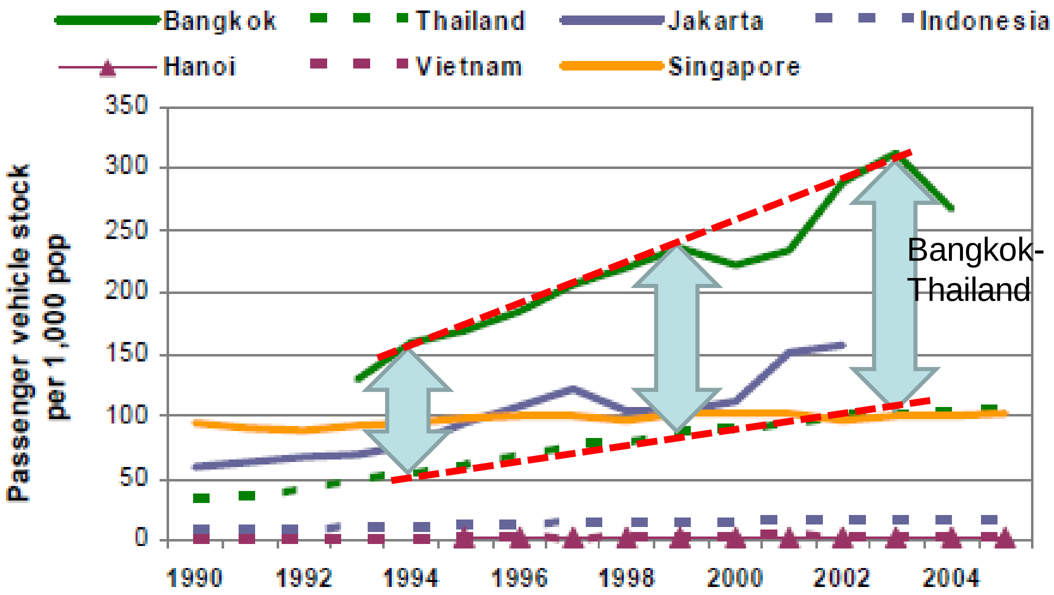


Source: APEC report 2007

Figure A 1.7: Motorization in Bangkok & Thailand

Figure A 1.8, and A 1.9 show how passenger vehicle stocks increased across the four regions over the last 15 years. As a general tendency, passenger vehicle stocks are higher in cities than in whole country except for two cases: Tokyo-Japan and Seoul-S-Korea, where the economies have higher passenger vehicle stocks on average in the whole country. Income disparity between the city and he country level is quite substantial in Asia, specifically for Bangkok-Thailand, Beijing- and Shanghai-China, and Tokyo-Japan. The most significant gap between a city and national average observed between Bangkok and Thailand. As already mentioned, Bangkok's income is ten times higher than that of the national average level. Similarly, Beijing's income is three times higher compared to the whole the country. In the case of Tokyo and Japan, Tokyo's income is twice that of the economy average.

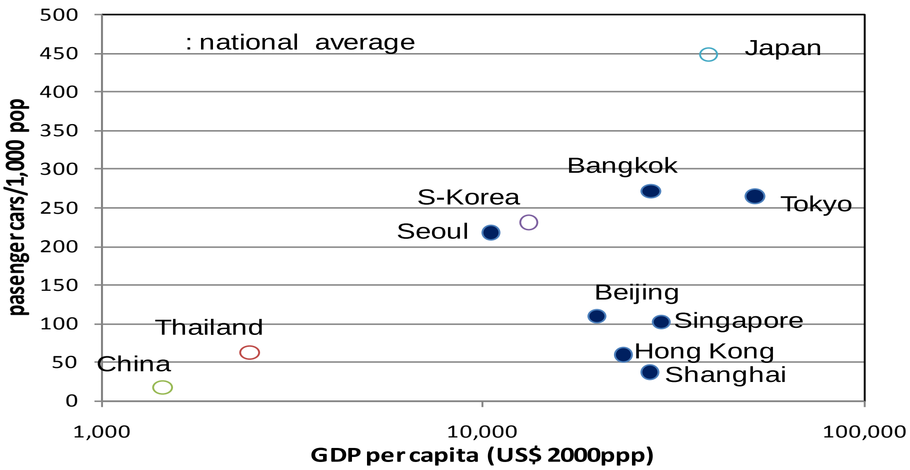
In Asia, a wide gap between the national and the city levels is also seen between Bangkok-Thailand, and Jakarta-Indonesia. Passenger vehicle stocks in Jakarta have been increasing while those in Indonesia have remained low. In Hanoi–Vietnam, however, passenger vehicle stocks have remained low at both levels.



Source: APEC report 2007

Figure A 1.8: Historical trends in passenger vehicle stocks in Asia, 1990-2005

An Asian characteristic is that the motorization of the metropolitan area is very high in comparison with the standard of the country. The development of the motorization is higher in Bangkok, Beijing and Shanghai than the standard of the country. On the other hand, the standard of Tokyo and Seoul are lower than country. This difference depends on the standard of the urban traffic. Subway and railroad develop in Tokyo, Seoul, and inhabitants don't prefer to own car. There are also other factors responsible including costly parking fee. However, many Asian cities has similar situation like Bangkok.



Source: APEC report 2007

Figure A 1.9: Economic activity and motorization

Study on new vehicle registration in Bangkok discloses the effect of the crisis on the sales of vehicle, which at the end affects the whole automotive industry. The sales dropped to more than 50% of the 1996 figure, which was realized in the 1998 and 1999. However there has not been much noticeable drop on the total number of vehicle registered either in Bangkok or nationwide due to large amount of existing vehicle fleet. Table A 1.7 shows the information on the vehicle registration in Bangkok.

Table A 1.7: New vehicle registration in Bangkok

Type of Vehicle	1991	1992	1993	1994	1995	1996	1997	1998	1999
Passenger cars	58,960	83,800	118,318	126,637	117,406	122,432	106,619	35,820	50,663
Pick Up	70,924	66,375	86,713	94,776	112,306	122,050	80,925	32,034	47,542
Taxi	64	5,307	22,839	7,674	5,362	5,656	4,142	2,776	1,563
Tuk Tuk	-	-	-	-	-	-	-	-	-
Bus	2,341	3,039	1,338	1,626	2,173	1,573	1,393	1,629	435
Truck	9,046	8,739	8,832	10,682	13,082	13,760	9,058	3,262	3,311
Motorcycle	151,820	166,361	219,673	254,677	257,797	195,204	137,881	75,666	91,577
Total	141,335	167,260	238,040	241,395	250,329	265,471	202,137	75,521	103,514

Type of Vehicle	2000	2001	2002	2003	2004	2005	2006	2007
Passenger cars	69,185	92,064	118,564	146,945	176,933	188,936	179,206	175,122
Pick Up	63,789	57,782	74,533	93,272	106,988	121,608	113,186	106,746
Taxi	3,418	4,899	7,509	7,010	7,677	11,893	12,046	10,717
Tuk Tuk	-	-	-	-	-	-	307	1,332
Bus	346	622	836	3,348	2,135	1,216	2,972	3,244
Truck	6,488	5,492	7,422	8,073	10,799	9,197	8,725	8,379
Motorcycle	112,859	138,100	213,971	255,468	352,194	399,913	420,029	365,264
Total	143,226	160,859	208,864	258,648	304,532	332,850	316,442	305,540

Source: APEC report 2007

4.4 Road network

The road network is characterized by the presence of very wide primary roads and small local side streets roads (known as "soi") that run off them. There are few medium-width distributor roads effectively connecting the primary roads. The primary roads, which are extremely congested, thus carry local, medium and long distance traffic. The first urban expressway, a toll road, the First Stage Expressway (FES) opened in 1981. Since that time an extensive series of major road and expressway projects have been completed. Within the BMR as of the year 2000, PCI (2005) reports there were a total of 4,700km of public roads categorized as follows: (1) minor roads 4,057 km; (2) major roads 290 km; and (3) expressways 406 km.

Bangkok is suburbanizing and development is following the main road corridors. However, secondary and local road network are inadequate giving rise to the well known problems of "superblocks" in which large tracts of land between the major highway corridors are under-developed because of low accessibility.

Length of road network of Bangkok highly concentrated inside the inner ring road shown in Table A 1.8. The following highways start a business in the Bangkok metropolitan area:

- The First Stage Expressway System (27.1km)
- The First Stage Expressway System (38.4km)
- Ram Intra-At Nrong Expressway (18.7km)
- Bang Na-Chon Buri Expressway (55.0km)
- Bang Pa-In-Pakkred Expressway (32.0km)

Total length of Road network: 4,076km (2004)
Total length of Express road network: 207km (2004)

As a method to solve traffic congestion in the city, the grade separation of the main crossing is pushed forward rapidly in the center.

Table A 1.8: Length of road network in BMA

Location	Expressway(km)	Major Road(km)	Soi(km)
Inside Inner Ring Road	103	328	831
Outside Inner Ring Road	104	982	2,009
Total BMA	207	1,310	2,840

Source: Transport Data and Model Center (TDMC,2004)

4.5 Trends in travel

In 2005, it was estimated there were about 19.4 million linked person trips and 16.7 million linked mechanized 19 trips per day with about 25 million unlinked mechanized trips (World Bank 2007). Patronage on public transport in general is in steady decline despite increases in ridership on the two rails MRTs. GTZ (2003) reported that bus patronage declined by around 5% pa through the late 1990s and early 2000s.

The rail network serving Bangkok is presently not extensive. It is primarily comprised of an at-grade railway with double track on most alignments. The railway system serves freight, inter-city (and regional) and urban passenger traffic. Water transport services are operated in the Chao Phraya River and two major canals.

In summary, daily travel demand in Bangkok has the following features:

* 19.4 million linked person trips per day estimated in 2005 (World Bank 2007)
* 46% of all person trips including walk trips are made by private modes (car, pick-up, motorcycle) with 3% by rail MRT, 37% by bus, and 14% by walking and non motorized transport modes (NMT);
* 25% of all households had no private vehicle in 2005 down from 45% in 1995;
* In November 2005, patronage on the Bangkok Transit System and Blue Line subway was, respectively, 430,000 passengers/average weekday and 180,000 passengers/-average weekday;
* BTS patronage has grown steadily from around 140,000 passengers per day in April 2001, a growth rate of just under 20%.
* Bus patronage is steadily declining by around 5%.

Figure A 1.10: Public transport network in Bangkok

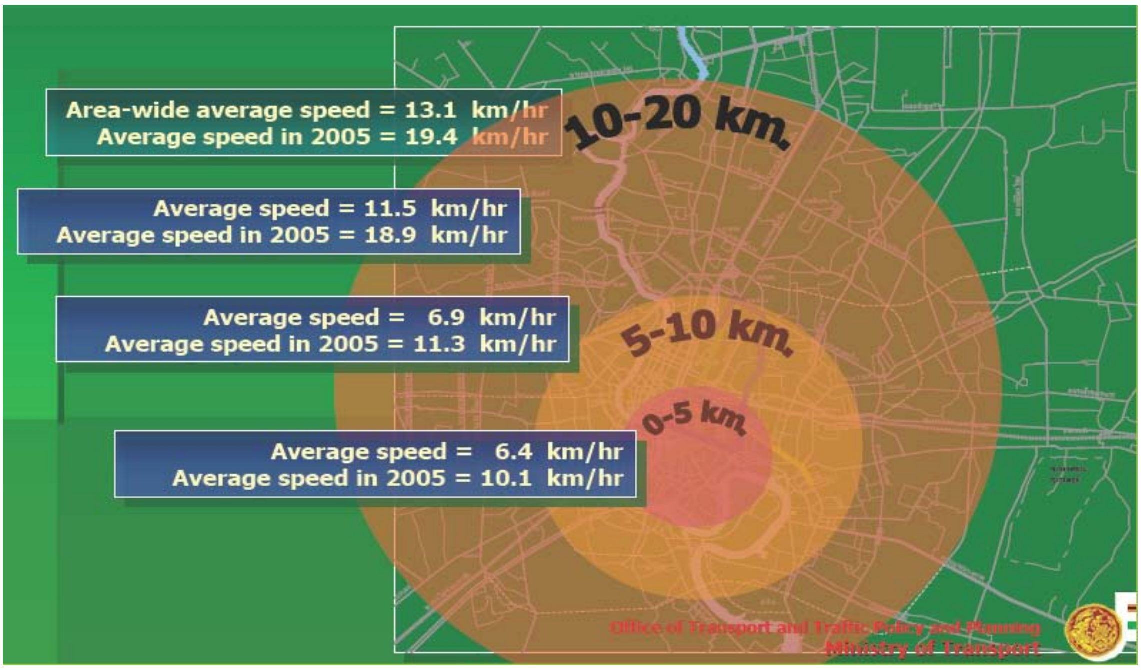
4.6 Trends in Vehicle Speed

In July 2003, average speed on major roads in BMR was 15.5 kilometers per hour (kph) during the morning rush hour in the peak direction of traffic flow, which is inbound to the central business district and 22.6 kph in the evening rush hour in the peak direction of traffic flow which is outbound (from Thai government report: Developing Integrated Emissions Strategies for Existing Land-transport (DIESEL) 2008). Speeds in the non-peak direction were likely to be higher. Speeds in the off-peak period were not reported but were likely to be higher again.

These speeds are typical of other major cities although comparisons are difficult. There is very limited historical data on traffic speeds in Bangkok for the early 1990s that can be validly compared to the 2003 data, (in the period 1990 to 1995 (and even through to 1997) due to major construction of road and rail systems along or intersecting major roads in Bangkok).

Traffic congestion appears to be rising due to increased economic activity and the growth in the vehicle fleet.

If an effective policy isn't introduced, traffic congestion turns worse and an area less than 10kph spreads. Fig A 1.11 Shows Forecast Bangkok Traffic Condition in 2010.



Source: ERIA meeting report, 2008

Figure A 1.11: Forecast on Bangkok traffic condition in 2010

4.7 Average Distance Travel

Estimates of stated and actual travel (according to odometer readings) varied for vehicle types, which are more likely to be used in a more intensive manner than other vehicle types. Follow up call back surveys including requests to check and verify previous odometer readings were made with a sample of vehicles and adjustment factors derived, which were applied to the whole data set as described in Project Evaluation Co., Ltd. (PECO: 2004). PECO concluded that the odometer reading was the most reliable measure of annual distance operated given familiar problems with estimation and recall by respondents common in this type of survey.

The estimates of the annual distance are important to assess energy / environmental problem solution. Authors visited the car dealers of Bangkok and collected information on annual distance travelled by the customers. The personally collected data and result of PECO are collected. The adjusted and best estimates of vehicle annual travel distance per vehicle by each vehicle type as collected from the odometer reading are given in Table A 1.9 below.

Table A 1.9 Vehicle annual travel distance

Vehicle type	Average(km)	Derived from Odometer
Passenger car	30,050	25,800
Pickup	35,650	26,750
Private Van	51,850	37,450
Van, Rot Tu	94,650	41,350
Song Taew	51,540	25,150
Taxi	240,000	
Route Bus	80,000	
Truck(large)	80,000	

Source: ESMAP, Developing Integrated Emissions Strategies for Existing Land-transport (DIESEL), 2008.

Other responses indicated that:

- 84% of vehicles were not under warranty – meaning maintenance was likely based on need and not in a preventative fashion;
- Just over half of the vehicles were maintained (routine maintenance) by the owners/ drivers.

4.8 Energy Consumption of Motor Vehicles

This section describes historical trends in gasoline and diesel consumptions in Bangkok. To better understand the unique characteristics of Bangkok's gasoline/diesel consumption, comparison was made with Seoul, Korea. Seoul was chosen due to similar income level with Bangkok.

Table A 1.10: Motor vehicle fuel consumption in Bangkok

	Absolute Level (Unit: ktoe)				
	1986	1990	1995	2000	2003
Gasoline	868	1,399	2,271	2,475	2,842
Diesel	1,732	3,131	4,313	4,054	6,247

	Absolute Growth Rate (%)				
	1986-1990	1990-1995	1995-2000	2000-2003	1986-2003
Gasoline	12.7	10.2	1.7	4.7	7.2
Diesel	16.0	6.6	-1.2	15.5	7.8

Source: APEC report 2007

Bangkok's gasoline consumption grew robustly at an annual rate of 7.2 percent from 1986 to 2003. Though the growth rate of gasoline consumption slowed down in the late 1990s during the 1997 financial crisis, economic recovery after 2000 has nevertheless led to increased gasoline consumption, with record consumption levels of 2,842 ktoe in 2003. Compared to Seoul, Bangkok represents the higher per capita gasoline consumption as well as the higher number of passenger vehicle stocks per 1,000 populations. In addition, the annual growth rate of gasoline consumption per capita in Bangkok accounts for the faster rate than in Seoul.

Diesel consumption grew at a robust rate of 7.8 percent per year between 1986 and 2003. Because of the economic slow-down caused by the 1997 financial crisis, in the period 1995-2000, diesel consumption declined at an annual rate of 1.2 percent. Nevertheless, it bounced back to 15.5 percent growth between 2000 and 2003. Truck stocks per capita in Bangkok are smaller than in Seoul. However, Bangkok's diesel consumption per capita is larger than Seoul's figure. In addition, diesel consumption per capita in Bangkok grew at 4.3 percent per year between 1990 and 2002, while that of Seoul decreased at 2.3 percent. These results suggest that diesel is consumed more intensively in Bangkok than Seoul. Somewhat surprisingly, Bangkok's road transport sector actually consumes more diesel than gasoline. This higher level of diesel consumption is partially attributed to the Thai policy of promoting that economy's automotive industry. This policy puts priority on local production of pick-up trucks and offers favorable conditions to consumers for the purchase of such pick-up trucks. For instance, the excise tax imposed on a standard pick-up truck is merely 3 percent whereas the same tax on passenger automobiles is between 30 and 50 percent.

Table A 1.11: Gasoline and diesel consumption

	Gasoline Consumption Per Capita(toe/capita)			
	1990	1995	2000	2002
City				
Bangkok	0.25	0.41	0.44	0.47
Seoul	0.10	0.18	0.17	0.16

	Passenger Vehicle Stocks per 1,000 Population		
	1995	2000	2002
City			
Bangkok	180	232	293
Seoul	154	178	205

	Diesel Consumption Per Capita(toe/capita)			
	1990	1995	2000	2002
City				
Bangkok	0.57	0.77	0.71	0.94
Seoul	0.08	0.15	0.11	0.06

	Truck Stocks per 1,000 Population		
	1995	2000	2002
City			
Bangkok	16	21	22
Seoul	30	35	39

Source: APEC report 2007

The consumption of different fuels in Bangkok and in Thailand in 2005 is shown in Table A 1.12, which shows that 52% of all fuel consumed in Thailand is diesel and that the BMR represented 44% of all diesel fuel use in Thailand. For fuels of all kinds the BMR represents 47% of all Thailand fuel use.

Table A 1.12: Fuel consumption in Bangkok and Thailand in 2005

Fuel type	BMR (million liter)	Thailand (million liter)	BMR shares (%)
LPG	2,201	4,364	50.4%
Gasoline	3,079	6,573	46.8%
Gasohol	449	674	66.6%
Diesel	8,565	19,510	44.0%
Fuel oil	3,168	6,227	50.9%
Total	17,523	37,436	46.8%

Source: Department of Alternative Energy and Efficiency

4.9 Emission regulations and Fuel quality in Thailand

The European Union (EU) adopted catalyst-forcing standards for new gasoline-fuelled cars in the early 1990s (so-called Euro 1 standards) and have gradually tightened them in several steps: Euro 2 in 1996, Euro 3 in 2000 and Euro 4 in 2005. Similar requirements were adopted for diesel cars and light and heavy commercial vehicles.

In conjunction with the tightening of vehicle standards, fuel quality improvements were also mandated. In some cases, the fuel modifications are necessary to allow the introduction of vehicle technologies that are required to meet the new vehicle emissions standards. For example, the adoption of Euro 1 standards for gasoline vehicles requires the use of unleaded gasoline. The adoption of Euro 2 for diesel vehicles will require the use of diesel with sulfur levels lower than 500 parts per million (ppm). Further reductions in sulfur levels in both gasoline and diesel fuel are linked with Euro 3, 4 and, for diesel trucks, Euro 5 standards (see Table A 1.13). While setting new vehicle standards, policymakers must appreciate the close linkage between vehicle standards and the resulting technologies and fuels requirements, and must assure that the appropriate fuel quality will be available when the vehicle standards are introduced.

Table A 1.13 EU emission standards

	Gasoline		Diesel
Standard	Lead	Sulfur(ppm)	Sulfur(ppm)
Euro1	0	NA	NA
Euro2	0	500	500
Euro3	0	150	350
Euro4	0	50	50

Table A 1.14: Thai emission standards

	95	96	97	98	99	00	01	02	03
EU	Euro1	Euro2					Euro3		
Thailand(Gasoline)	Euro1						Euro2		
	500ppm								
(Diesel)			Euro1		Euro2				
	2500ppm		500ppm						

	04	05	06	07	08	09	10	11	12
EU		Euro4			Euro5				
Thailand(Gasoline)	Euro3								Euro4
	500ppm			350ppm					
(Diesel)		Euro3							Euro4
	350ppm								50ppm

4.10 Inspection and Maintenance in Bangkok

Vehicles that are properly tuned and adjusted tend to be cleaner than out of tune vehicles. Modern vehicles equipped with advanced pollution control systems are even more dependent on properly functioning components to keep pollution levels low. Minor malfunctions in the air/fuel or spark management systems can increase emissions significantly. Major malfunctions can cause emissions to skyrocket. A relatively small number of vehicles with serious malfunctions frequently cause the majority of vehicle related pollution problems (gross polluters). Unfortunately, it is rarely obvious which vehicles fall into this category as the emissions themselves may be unnoticeable and emission control malfunctions do not necessarily affect vehicle drivability. Effective vehicle inspection programs based on periodic short tests can identify these problem cars and, by requiring a re-test after necessary maintenance, assure their repair. The combination of inspection and remedial maintenance is commonly known as I/M. Targeted I/M programs can contribute substantially to reduce pollution caused by such vehicles. In introducing I/M programs, however, certain overriding principles have emerged:

Table A 1.15: Thai inspection system

	Periodical Inspection	
Land Transport Act; bus, truck, trailer, etc.	Trucks weight < 3.5 tons	Every 3 years
	Other trucks	Twice a year
	Buses, pass.seats < 20 seats	Every 3 years
	Other buses	Twice a year
Motor Vehicle Act; passenger vehicle, pick-up truck, motorcycle, etc.	Private pass. veh.> 7 yrs	Yearly
	Motorcycles > 5 yrs	Yearly
	Taxi	Every 4 months
	Public service veh. > 7 yrs	Yearly

5. Air Quality and Emissions in Bangkok

5.1 Rationale and Significance of the Study

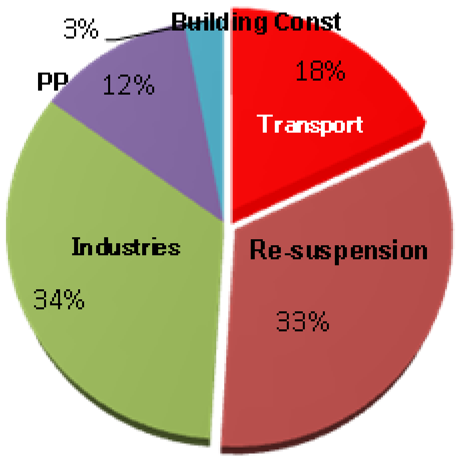
Rapid economic growth in the past twenty years, but little or no urban planning in the large city like Bangkok resulted in serious traffic congestion and related air pollution. The new vehicles registered in Bangkok each year was recorded above ten percent during that era. This tremendous increase of vehicles have retarded the traffic flow and hence, the air quality in Bangkok. The pollutant concentrations in many areas along the street curves in the inner part of the city have been reported to exceed the ambient air quality standards. This unfavorable situation asserted a great concern over Bangkok residents. Various cooperative efforts are being made by the government industries, the public and non-governmental organizations to improve the quality of the air in Bangkok. A number of measures have been proposed to reduce air pollution problems caused by the transport sector. They are aimed not only at exhaust gas emission controls but also at the improvement of fuel and vehicle specifications, implementation of in-use vehicle inspection and maintenance program, public transport improvement and management.

After Thailand's economic crisis occurred in 1997, the country was facing a negative value of GDP. In 1998, the transport fuel consumption in Bangkok was down by 67 percent from the previous year and by 83 percent from 1990. This has asserted a significant effect on Bangkok air quality and it is interesting to investigate any change caused by this economic down turn. Bangkok is a mega city, rich in culture, and an ideal model of unplanned city to conduct a study. This chapter is therefore, intended to provide a trend in environmental pollution in Bangkok related to the country's economic crisis, the fuel mix consumption pattern in transport and in other sectors, and the emission load caused by different fuel consumption in various sectors.

Atmospheric particles originate from a variety of sources and possess a range of physical and chemical properties. Collectively, particulate pollution load is often referred to as total suspended particulates (TSP). Fine particulates less than 10 and 2.5 microns in size are referred to as PM10 and PM2.5, respectively. These have the most significant impact on human health because they can penetrate deep into the lungs. PM emissions are a key health concern with estimated economic damage costs much higher than for other pollutants.

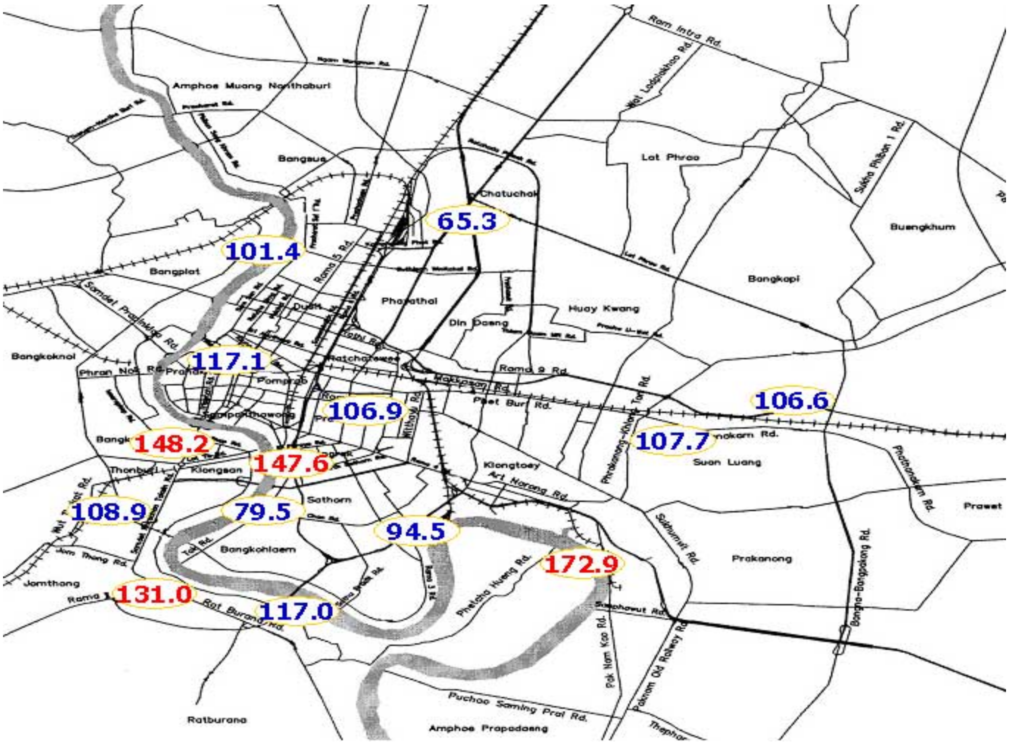
A recent 2007 study of PM source apportionment for five sites in the Bangkok Metropolitan Region (BMR) summarized shows that PM2.5 is the major component of PM10 comprising about 60% of PM10 mass in dry season and over 50% in the wet season. The major contributors to PM2.5 are traffic emission (diesel vehicles), biomass burning and secondary inorganic particles such as sulfates, nitrates, and ammonium. Previous estimates confirm that mobile sources directly or indirectly contribute to more than half of all PM emissions. For example, in 1998, PM directly emitted by mobile sources, that is, from transport was estimated to be 18% of the total but a further 33% was estimated to be due to re-suspension of dust and soot from all sources.

Transport is also a major contributor to re-suspension as shown in Figure A 1.13. The figure represents a PM2.5 concentration map for 2003 showing that the PM2.5 standard was frequently exceeded in Central Bangkok despite improvements in PM control measures.



Source: Thailand Environment Monitor 2002

Figure A 1.12: PM emissions inventory (1998) for Bangkok

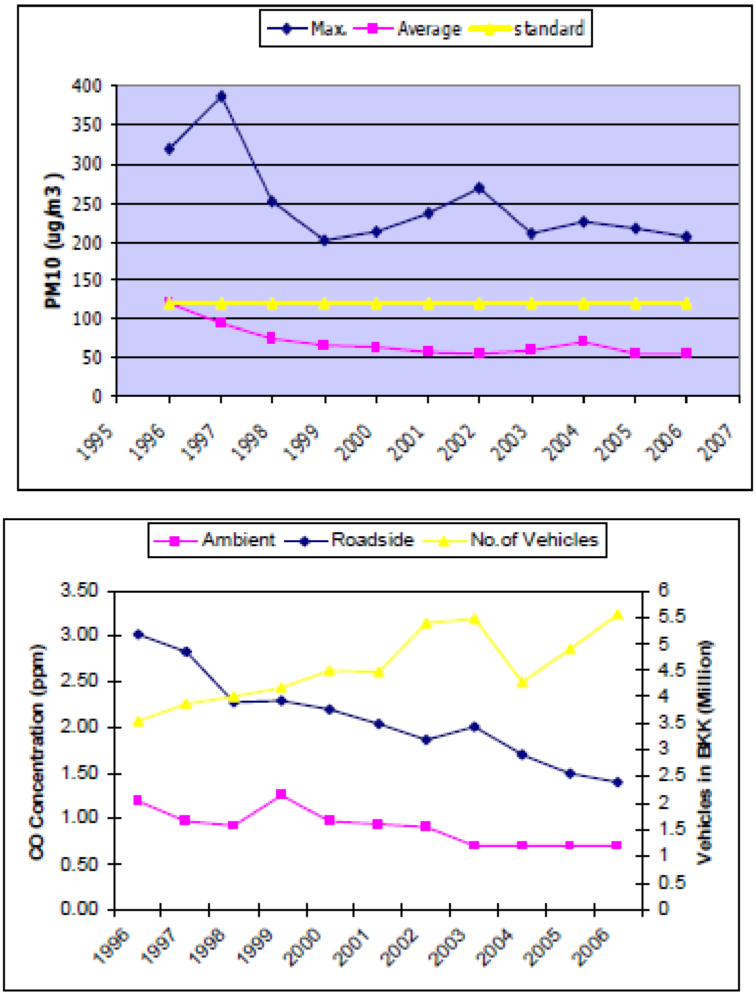


Source: Thailand Environment Monitor 2002

Figure A 1.13: PM2.5 concentration map (2003) for Bangkok

Average ambient concentration of PM10 in Bangkok has declined steadily in recent years. Control measures and the Asian economic crisis of 1997 contributed to this decline. Ambient PM2.5 in other urban areas has also declined steadily. The excess in PM2.5, as measured by the number of observations exceeding the standard, are more likely to occur from November to April. Toward the end of the year, temperature inversions that trap pollutants close to the ground commonly occur due to the onset of the cool season. From February to April, the burning of rice paddy residues results in higher variability in TSP concentrations in Bangkok and other urban areas.

Maximum recorded concentrations, although lower than before, still exceed standards in many places (Figure A 1.14). Longer-term trends in Bangkok's TSP concentrations (measured at the roadside) show that TSP spiked in the early 1990s, declined, and spiked again around 1996. After 1997, levels declined further, mirroring trends in ambient PM10.



Source: PCD, 2007. Data came from 5 sites.

Figure A 1.14: Trends of PM10 and CO concentrations in Bangkok, 1996-2006

5.2 Baseline Vehicular Emission Estimates

Analysis and comparisons indicate that the DIESEL Project data provides the basis for developing a set of speed-related emission factors with profiles that closely match those of other established diesel emission factor models. A baseline emissions inventory was developed for PM10, SO_2, NOx, and CO_2 using the emission testing results for LDV, HDT, and HDB, from the DIESEL program and other categories from past studies.

For years 2010, 2015, and 2020, projections were made using the growth trends between 1996 and 2006, and based on the discussions with the department of transport. Table A1.16 presents a summary of baseline vehicular population distribution and emissions estimates for Bangkok Metropolitan Region.

The vehicle kilometers traveled (VKT) is estimated from the transport surveys conducted under DIESEL. Average VKT per day used for this analysis are 60 km for Cars, 120 km for MPV, 100 km for VPU, 400 km for Urban Taxi, 80 km for Urban MC Taxi, 50 km for MC, 240 km for Trucks and Buses, and 20 km for other categories.

Table A 1.16: Summary of baseline vehicular emission estimates (tons/year)

	No of Vehicles	PM10	SO2	NOx
1996	2,447,231	13,949	27,348	125,126
2003	3,174,529	18,537	41,725	180,876
2006	4,274,241	21,031	43,154	193,021
2010	4,640,735	24,858	49,764	256,492
2015	4,780,996	24,987	49,360	250.085
2020	5,242,613	26,692	53,484	265,479

Source: ESMAP, Developing Integrated Emissions Strategies for Existing Land-transport (DIESEL), 2008.

5.3 Impact of Pollution Control Options

Finding a sustainable and acceptable set of interventions – technical, policy, institutional, economic, and legal, solutions for better environmental quality requires cities to address transportation investments and transportation demand management together. A methodology for evaluating these strategies was developed in the form of ERIA project. The methodology is designed to address transportation and modal mix, vehicle emission and energy use characteristics. Figure A 1.1 develops a series of policy options to address the growing air pollutants from transport sector and are compared and briefly evaluated.

For reducing emissions from in-use vehicles, consideration must be given to incentive-based programs, as well as the traditional "command and control" inspection and maintenance inspections. Technical solutions, which simply impose a cost on operators, tend to create an adversarial situation, where avoidance or evasion becomes the driver, rather than compliance. Nevertheless, for some sectors of the vehicle population, there are few if any options. To be successful, these mandatory inspection programs must be rigorously enforced and designed to minimize the potential them to be undermined by for fraud or petty corruption.

For larger fleets, some jurisdictions have successfully introduced incentive-driven programs based on a partnership, as opposed to an adversarial relationship between government and fleet operators. Accredited participants in such schemes may, for instance, be rewarded through reduced registration charges, waivers from periodic inspections, or granted access / extended operating hours in certain environmentally sensitive regions of a city. In all cases, effective and equitable management of the program is essential for successful outcomes. It is also important not to set a bar too high, especially in the early stages of an emission reduction program. For instance, it is a good policy to initially establish emission standards that can realistically be met by about 80% of all diesel vehicles with reasonable efforts, and then gradually increase the standards' stringency over a period of time.

This would require-

(1) Identifying reasonably reproducible procedures for measuring emissions;
(2) Carrying out a fleet-wide study to estimate current emission levels,
(3) Pilot testing to see if the standards were set to enable about 80% to pass,
(4) Revising the standards after pilot testing as needed.

These actions can be readily incorporated into the next project plan.

A series of policy options to address the growing air pollutants from transport sector are identified, compared and briefly evaluated. The model along with the assumptions is available for reader to download and use.

Proposed Interventions

- Inspection and Maintenance
- Improved Traffic Management
- CNG buses
- Euro IV Diesel buses
- Increase MRT
- Increase BRT use
- Walking improvement.

Three combinations of the scenarios were developed under medium and long-term strategy based on the interventions listed below and evaluated for their affectivity in reduction of air and GHG emissions. Thai Government summaries the two scenarios and expected level of reductions in corresponding emissions from business as usual scenario.

Congestion pricing

Largest share in the reduction of pollutant emissions is attributed to travel demand management and change in traffic speeds because of introduction of better public transport resulting in lesser VKT for passenger cars, improved traffic management resulting in improved traffic speeds, and economic incentives such as congestion pricing also resulting in lesser VKT for passenger cars. A more detailed sustainable urban transport strategy is presented in World Bank, 2007.

Table A 1.17: Evaluation results for transport emissions reduction scenarios

Time Frame	Strategy	Emission Reductions
Short term through 2010	• Introduction on 2000 Euro IV Buses • Improving I&M program for cars, vans, pickups, and buses • Improving traffic management	**PM_{10} = 3.3 %** **SO_2 = 3.3 %** **NO_x = 4.3 %** **CO_2 = 5.1%**
Medium term through 2015	• Introduction of 2000 Euro IV and 2000 CNG Buses • Improving I&M program • Increasing MRT share • Increasing BRT share • Improving Walkability • Congestion Pricing • Reduce retirement age to 8 years	**PM_{10} = 11.4 %** **SO_2 = 9.4 %** **NO_x = 14.3 %** **CO_2 = 14.0%**
Long term through 2020	• Converting 50% of bus fleet to CNG • Improving I&M program • Improving traffic management • Increasing MRT share • Increasing BRT share • Improving Walkability • Congestion Pricing	**PM_{10} = 20.5 %** **SO_2 = 15.4 %** **NO_x = 24.0 %** **CO_2 = 21.9%**

Source: Developing Integrated Emissions Strategies for Existing Land-transport (2008)

6. Concluding Remarks

This study focused on Automobile Strategy towards Environmental Impact Abatement in Bangkok city. The socioeconomic characteristics and trip of people in Bangkok were employed to analyze the vehicle usage in the city. This would be beneficial to provide some useful information in the implementation of guideline in abetting environmental impacts of vehicle usage.

Air pollution from mobile sources does cause substantial adverse health impacts and economic costs to society in Asia. These adverse impacts will increase in the years to come if no effective action is taken. These guidelines contain a large number of suggestions to help policymakers in Asia develop and implement effective policies to reduce emissions from vehicles.

Actions are to be taken in an integrated manner, involving all the groups that are mentioned in these guidelines. It is the policymakers of Asia that hold the key to the formulation and successful implementation of strategies to implement the actions called for in these policy guidelines. If they can display the political will and perseverance required, governmental organizations tasked with the formulation and implementation of vehicle emission reduction strategies will have a good chance to succeed, because they will have the resources to do the job. Strong political leadership and perseverance will also send a clear signal to all who are now contributing to the pollution that the time has come to act and to change their attitude.

Finally we want to convey the following:

Integrated policy for sustainable transport in Bangkok and Asia

Substantial improvements required with respect to following in Bangkok:

- Build up I&M Programs
- Strengthen Emission Regulations
- Promote Clean Vehicles
  (CNG,LPG,EV,HEV)
- Air Quality Monitoring
- Public Campaign and Education for improved Environmental Awareness

"Air with Good Quality Leads People to a Healthy Society".

Conclusion:

ERIA Initiative for Better Air Quality in Asia

- Needs Effective Policies
- Needs Consensus
- Needs Public Awareness
- Needs better implementation /enforcement.