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Transportation Research Challenges In Thailand

Sub-Project on

Urban Transport Energy and environment for Bangkok

November 2008

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Abstract

In relation to studies and understanding of transport issues, energy and environments are subjects which are strongly related to the consideration of transport system. The energy can be viewed as a crucial input to transport system, which is run in the ecological environments. The recent concerns in transport matters are the effects of such input and output (environments) on the planning and management of transport system; the global competition for scarce energy and disproportionate impact on personal and global environmental health. Ones must build transport system which is energy-efficient and produce less harmful consequences to others. The transport system should then promote equity within and between generations. To understand the existing transport system conditions, and the right direction of the development, one must understand the outlooks of transport system, and its associated energy and environment prospects. This study aims at making more understanding on transport-energy-environment matters in Bangkok, Thailand.

The thorough investigation in the field of transport energy and environment reveals that Thailand lacks the comprehensive study in this subject. Related available data are imperfect. The number of strategic analyses is also limited. This discloses that solid policies and right attainment cannot be ensured without any completion of study and systematic deliberation. A lot of research work should be done in this field. Several researches are proposed to make understanding and to consider this subject systematically. The results from these researches can assure the right direction for transport system development and management.

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1. Introduction

1.1 Why are we concerned about the energy and environment issues?

Urban transport is the movement of a large volume of people, freight, and vehicles in complex patterns. Transport is indispensible as the results of the derived demand to connect human activities and to interlink with other sectors (Figure 1.1). In the Figure, transport is presented as one element (component) that is composed of the urban activity system. Transport is interrelated with urban, industry, energy, and environment sectors. Thus, urban transport can be viewed as the facilitator of the urban and industry sectors, at the same time it must be harmonized with energy and environment sectors.

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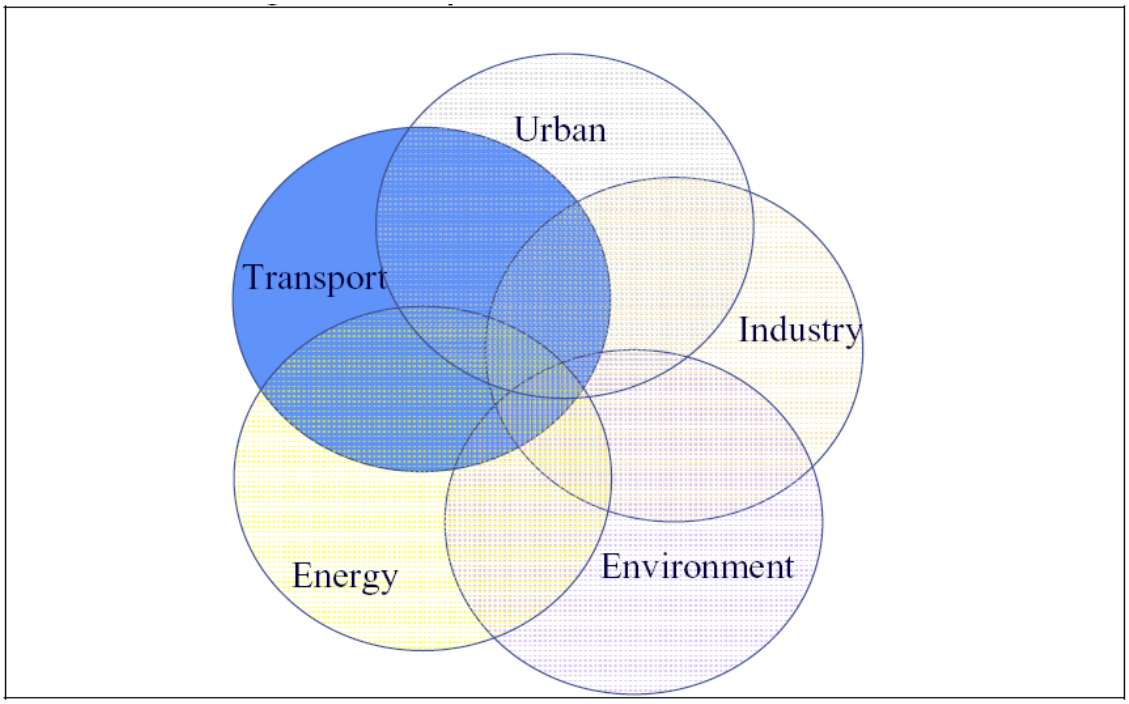


Figure 1.1 Transport Interlinks with other sectors

Source: Asian Development Bank (ADB), 2006

Majority of urban transport is Motorization and popularity is still increasing. From the fact that most cities have a wide geographical expansion, it is necessary to have motorized means to travel from one place to another. With over 10 kilometers to commute on average (e.g. Bangkok average trip length is 16 km), people in the city need one of motorized modes to travel (Asian Development Bank

(ADB), 2006). Private vehicles (cars) are the dominant mode in most cities in the developing (developed) world. Buses are also a major public transport mode in

most cities. In this study, the motorized transport modes on roads (private cars, buses, trucks, motorcycles, etc) are concerned since they use fossil-fuel and they are the main polluters in the city. This group of transport modes has the highest share of urban travel in many cities,
including Bangkok, and is the concern on energy and environment issues related to the use of it. Most important, this group of modes is popular and constantly gains a number of users. The increasing number of usage directly implies the higher use of energy (fossil fuel) and adverse effect to environments.

Energy is generally required to transport. Specifically, motorized transport requires natural oil products, mainly gasoline. This study focuses on the "fossil fuel" since it is the growing concerns in several issues related to the use in urban transport:

- For individuals, energy means travel cost. The fuel is required to complete the trips. The amount of energy use directly depends on the amount of travel and fuel efficiency of the mode
- For urban economy, the aggregate amount of energy consumed is enormous and is viewed as the resource for urban activities. The aggregate figure can show inefficient use of energy for transport. Simply speaking, a more productive city must consume less resource (energy) to support the same amount of transport activities.
- The amount of fuel consumption is also the global environmental concern. The use of fuel means the depletion of natural resource. The transport sector is the largest and fastest-growing energy user, with a forecast annual increase of 2.1% worldwide and 4.3% for East Asia and the Pacific in 2002–2030 (International Energy Agency [IEA], 2004). This concern calls for the consideration of energy use for urban transport in order to find a way to level (or at least to slow down) the growth of the oil consumption.

Motorization creates negative externalities, such as congestion, air pollution, and global green house gas (GHG) emission. Air pollution from motorized transport is mainly local tailpipe emissions: carbon monoxide [CO], oxides of nitrogen [NO_x], sulfur oxide [SO], hydrocarbon [HC], and particulate matter [PM]. These substances are proved as they have negative impact to citizen's health and are harmful to urban environments. The amount of pollution and emission is generally related to the amount of transport. With the growing trend in motorization (road transport), local emissions and their associated harmful health

impacts are expected to increase at a similar rate. It is the concern that urban transport could produce the unacceptable level of pollution. As a matter of fact,

transport activities, especially passenger traffic, are concentrated in cities; making them the most heavily polluted and congested areas. Another global emission (carbon dioxide [CO2]) creates global warming effect. Environment sector is concerned with the degradation of ecology. Air pollution and green house gas emission are the major concern since the road transport is the major contributor to lower urban air quality and the trend in the amount of pollution and emission is generally growing as the function of amount of road usage.

To transport society, It is at large accepted that the only future trend of transport development and management must be based on "sustainable transport concept". This concept is also known as Environmentally Sustainable Transport or EST. EST can be defined as the system that:

- **allows the basic access needs and development of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between generations;**
- **is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy, and regional development;**
- **limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and, uses non-renewable resources at or below the rates of development of renewable substitutes and minimizes the use of land and the generation of noise. (Integrating the Environmental Dimension. A strategy for the Transport Sector. A status report. Oct.1999)**

If one considers the true matters to reach sustainable transport, it can be simply said 1) to reduce the energy used and 2) to reduce the adverse environment impacts by transportation usage (while maintaining the level of mobility). These two matters are the real core of sustainable transport since one reduces the exhaustible key natural resources, and the other reduces negative impacts to others in the ecosystem.

Transport energy and environment is a serious consideration. The attempts to cope with these issues have been done by academic, practitioners, policy makers, and other stakeholders. Many pieces of research work as well as implementing plans can be observed. Yet, comprehensive understanding of these matters has not been reached or even summarized. It is believed that once we could gather all information and make understanding of the transportation energy and

environments, we can discover a lot of research challenges that will get forward through more sustainable transport system.

Although many research and practical work has been done to consider energy and environment issues for transport, not so many work has been done in Thailand.

1.2 Aims of this research report

The real move to cope with transport energy and environments requires much knowledge, and convert the policy implementation into the real practice before any advancement can be realized. However, not much work is done for Thailand and in particular Bangkok. This research attempts to find the facts and some directions on how the transport energy and environment consideration being proceed, and the course it should go for Bangkok, Thailand. The research study involves many literature search to find the common practice on the clarification of the "urban transport energy and environment problem", the availability and "how far" this consideration is in Bangkok, the collection of "thoughts" and "proposed measures and their discussion". The ultimate goal of the research is to address the research needs in this field in order to achieve the accomplishment in urban energy and environment goals.

This study aims at searching for the

1). To explore the situations of "facts and figures" and understanding on transport, energy, and environments in Bangkok
2). To search for how to come up with policy directions to concern with urban transport energy and environments problems in literature
3). To collect practical work and determine the problems of data availability and logical conclusion of existing transport-related energy and environments study
4). To gain insight understanding of energy and environment issues through on case study of Bangkok transport infrastructure development (Case study of Rail Transit Development -- Blue line extension)
5).To draw conclusion on the challenges on transport energy and environments in Bangkok, Thailand.

1.3 Research Methods

In order to identify research needs on energy and environment related to urban transport in Bangkok, Thailand, several tasks must be carried out.

- Status of the literature and data availability
- Needs by authorities and stakeholders involved with the matters
- Status of research and current plans for future research

It is stressed that transport energy and environment consideration in Thailand is relatively new. Although these matters are of great importance, the progress on the research and study in this field is quite limited. It is the first challenge to gather all information related to the matter in Thailand. The core interest in this study is to synthesize the available data and information to yield the gaps and directions of future research. Thus, this study is more focused on synthesis rather than the analysis or determination of the particular matter. An appropriate research methodology is therefore introduced and illustrated in Figure 1.2.

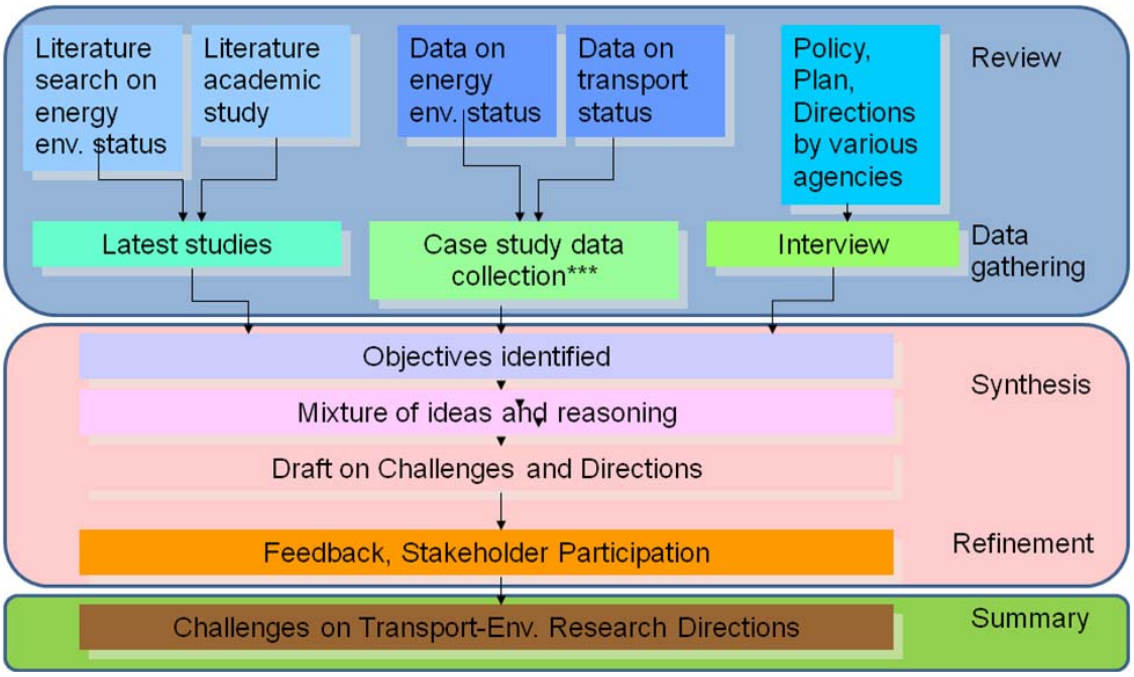


Figure 1.2 Research methodology to identify the challenges in Transport-Energy-Environment in Bangkok, Thailand

Since the consideration on energy and environment in transportation sector in Thailand is very limited. The focus is then first on the scanning of the literature and past studies in Thailand.

Literature on energy and environment consideration can be found from the related authorities. Although numerous agencies and institutions are involved with these matters, only some pieces of past researches specifically about Bangkok are found. These works are carried out by academia and contracted projects by related agencies. Many valuable pieces of work are also done by international researchers, and are published in various proceedings and publications.

Data gathering is conducted at the same time, when a team of researchers visited the related authorities. Not only the statistical data are found at these offices, the interview with officers gives an inside of the study activities and their final

applications. To most government authorities, the valuable information about transport related energy and environment is the unbiased data for policy and plan decision. Thus, most of the work done or contracted by government offices would gear toward the understanding as well as the proposal of the policy directions. Moreover, the compilation of the current plans and actions gives another important information on the needs for particular knowledge. Unbiased policy/action requires supportive data from research. The study on the current policy/action would show the research needs to obtain this supportive information.

Once the data are gathered, this study would compile all the data and presented the "situation of transport-energy-environment" in Bangkok. This is the first reported picture of the status of the consideration in Bangkok. Then the gaps and research needs would be identified. These proposed gaps and research needs were crossed check by groups of experts through seminars and workshops.

The conclusion from this study was the list of research topics that should be conducted for studying transport-energy-environment in Bangkok, Thailand. This can be a good list of research area which should be done in the near future.

2. Transport, Energy and Environment Situations

2.1 Transport

Bangkok is the capital city of Thailand, containing 1,568.7 square km of land and approximately 10 million in population. The urban transport system is mixture, from road network, rail network, bus network, etc. The road network is more than 4,700 km in length. Bangkok has 5.7 million registered vehicles (2007). The motorcycle is the largest proportion of the vehicle fleet, accounting for 41 percent. Excluding motorcycles, Figure 2.1 shows the proportion of total registered vehicles in Bangkok in 2007. Private vehicles and for-hire vehicle passenger car (taxi) has the highest share in the vehicle groups. Figure 2.2 shows that the total number of registered vehicles is 5.7 million units and the number of vehicle registration increases at the rate of 140% during 1998 and 2007.

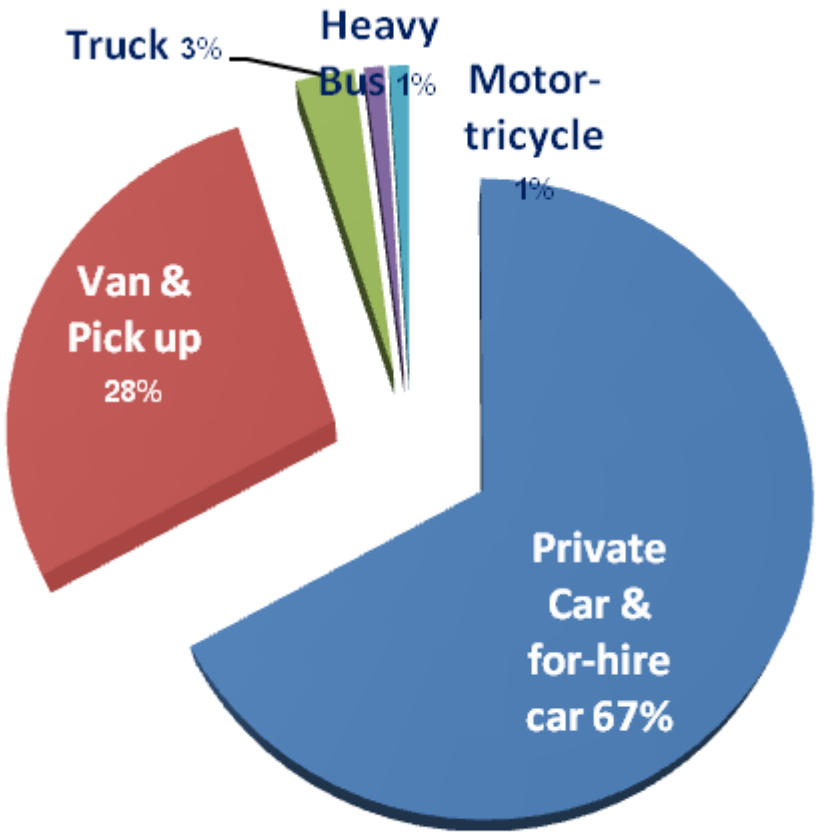


Figure 2.1 Proportion of vehicles in Bangkok (excluding motorcycles) in 2007
Source: Department of Land Transport, 2007

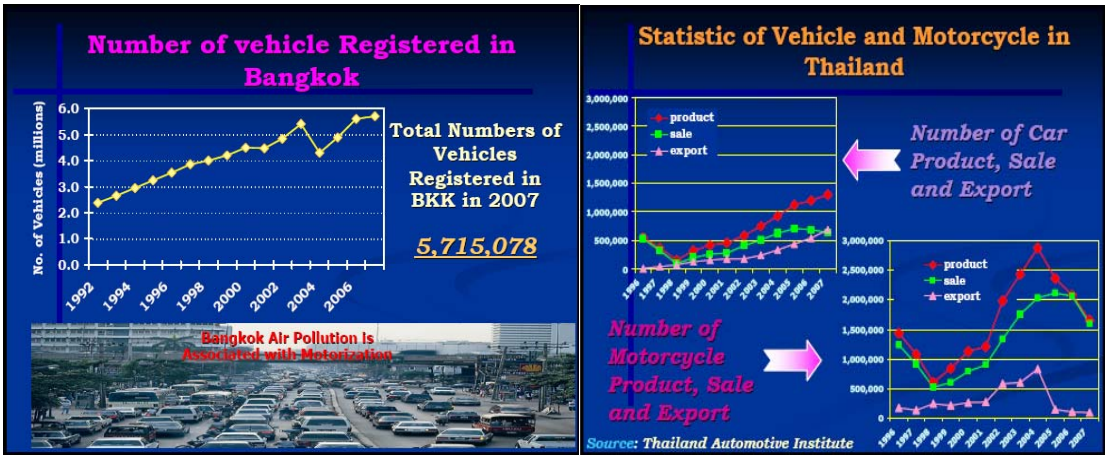


Figure 2.2 Number of Registered vehicles in Bangkok and Statistics of Private Vehicles and Motorcycles in Thailand

Source: Department of Land Transport and Thailand Automobile Institute, 2007

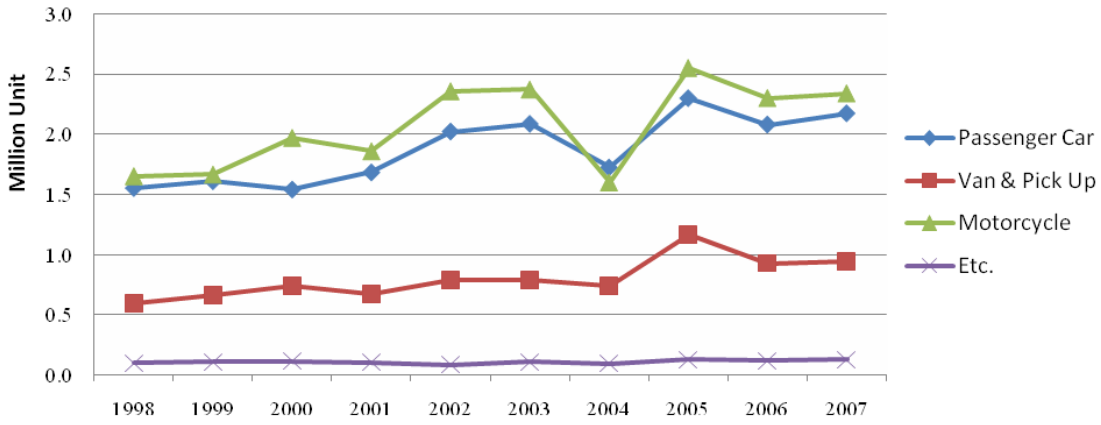


Figure 2.3 Trend of Number of Passenger Vehicle Registration[1] in Bangkok by Type

Source: Department of Land Transport, 2007

Figure 2.2 and 2.3 show the trend of motor vehicles: growth is 4.8%, 7% and 6.7% per year for passenger car, van & pick up and motorcycle respectively. The figure shows three main modes of private transport: passenger cars, van and pick up truck (1-ton truck), and motorcycle. All three modes have upward trend. This implies that we will see more cars on roads in Bangkok. Thus, based on this trend, it is expected the number of vehicle registration will increase each year. Figure 2.4 shows the increase in number of vehicles in Bangkok up to 2030.

[1] Under Motor Vehicle Acts. Passenger cars are those with 7 seats or less.

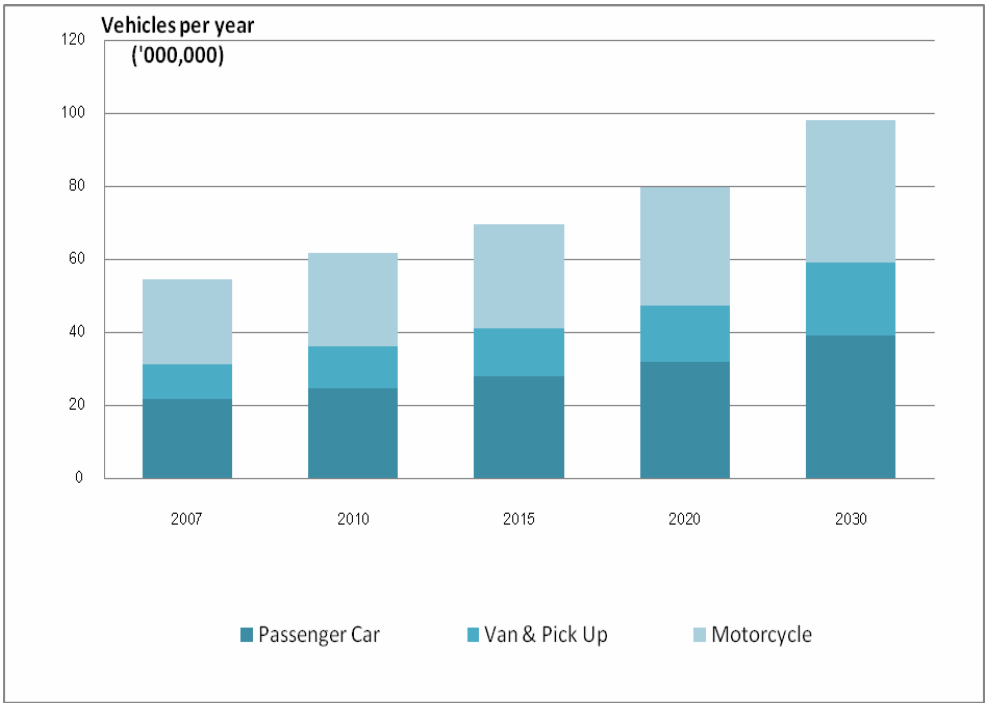
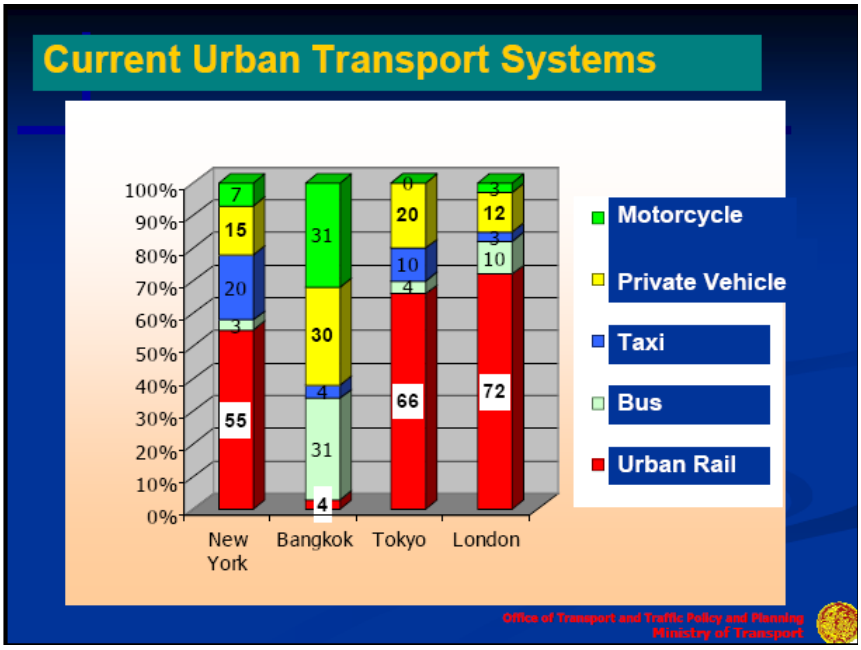


Figure 2.4 Forecasts for Growth in the Number of Motor Vehicles in Bangkok
Source: Analysis by Author: Calculated by No. of vehicles in Bangkok, 1998-2007

Considering modes of personal movement in Bangkok, Approximately 60 percent of trips are made by private modes while the rest are made by public transport. This can clearly show that private vehicles are predominant mode in Bangkok. Figure 2.5 compares the mode share of Bangkok with other mega cities in other continents. These cities are more than 10 million in population. From the Figure, trips in Bangkok heavily rely on private modes.



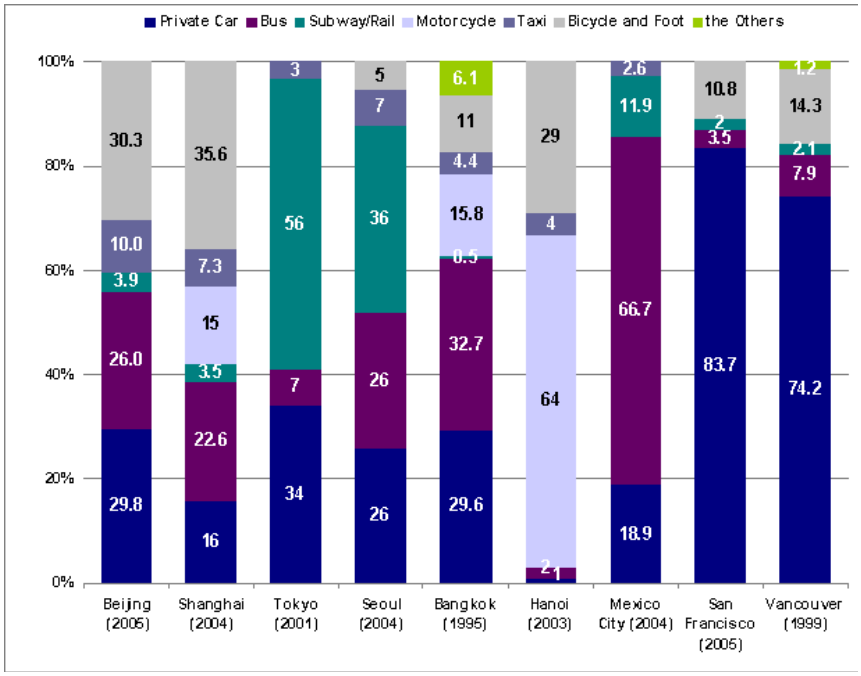


Figure 2.5 Current Urban Transport Systems
Source: OTP, APERC 2007

One can argue that the level of private transport usage may be dependent to the provision of public transport in the city. This is true that Bangkok may not have extensive and easy-to-access public transport, e.g. rail or bus service (many blame the lack or delay of urban rail transport development). Thus, the mode share by private cars may be less when more public transport services are provided.

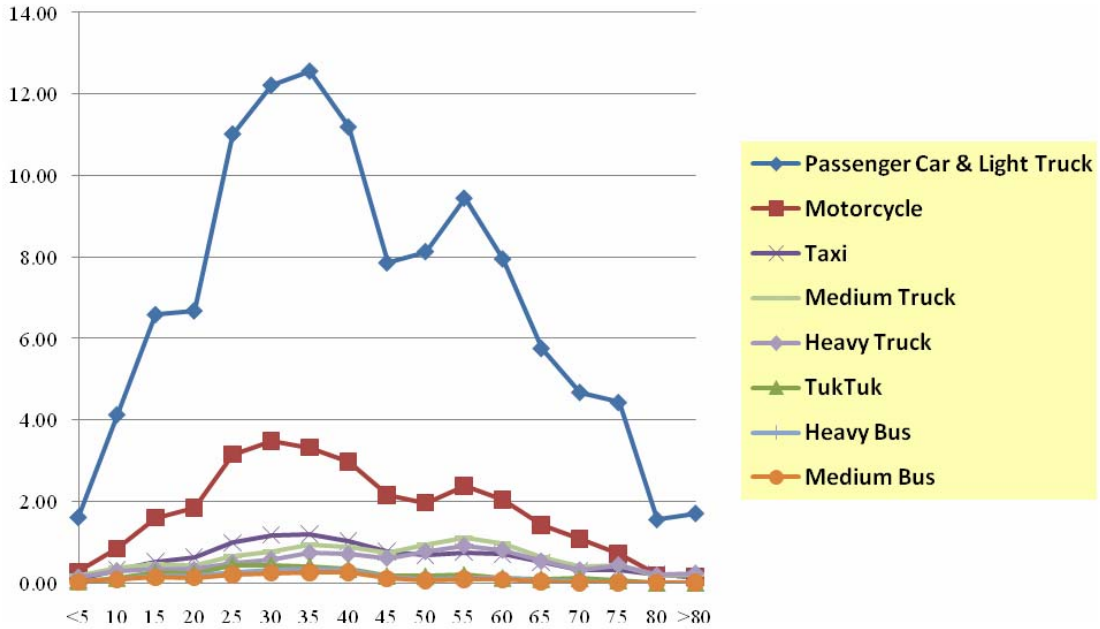


Figure 2.6 Prediction of Vehicle Kilometer of Travel of each vehicle type in Bangkok Source: Office of Transport and Traffic Policy and Planning,2007

Figure 2.6 shows the latest analysis by OTP on the amount of travel (VKT) and estimated proportion of speed. It is seen that the majority of trips travels between 15-65 kph. This kind of analysis can be used to compare the trip characteristics across several years. It can be suspected that a larger portion of trips will be carried out in a slower speed in the future travel in Bangkok.

A portion of Bangkok population travels by bus service. In 2006, Bangkok Mass Transit Authority (BMTA), a state enterprise, served 1.8 million bus trips per day. Unfortunately the number of patronage constantly declines. This demonstrates that the private cars can gain more popularity even though public transport is provided (there might be other contributing factors such as poor services, less reliable, and thus become less attractive compared with private transport).

A BTS sky train, one of two urban rail system in Bangkok, starts the service in 1999 and had 102 million trips per day in 2003. Three years later the patronage went up to 140 million trips per day or 12.3 percent increase per annum. as shown in Table 2.1.

Table 2.1 Ridership of BTS Sky train, 2003-2006

Year	Ridership (trips/year)	% increase per annum
2003	102,346,231	-
2004	115,375,347	12.73%
2005	127,349,940	10.38%
2006	140,051,302	9.97%

Source: Transport and Traffic Department, BMA(2007)

Table 2.2 shows the number of ridership on urban rail system when it was first opened and operated. It is seen that Bangkok rail system slowly picks up ridership and still comparatively has low level of usage. This could imply possible patronage and then mode share that Bangkok may have. Although Bangkok has some rail services in operation, but the number of patronage is slowly increasing, and may not as great as systems in other cities.

Table 2.2 Ridership comparison (APERC,2007)

City	First section opened	Route length (km)	Number of Stations	Yearly Ridership (million)
Bangkok	2004.7	19.7	18	3.65
Singapore (SBS Transit, North East Line)	2003.6	20.0	16	65.00
Hiroshima, Japan	1994.8	18.4	21	17.82
Incheon, Korea	1999.10	21.9	22	74.30
Shenzhen, China	2004.12	22.0	19	189.8

The Rail Transit development project in Bangkok may not curb the popularity (and the congestion) on road network in Bangkok. According to OTP forecasting, the mode share of public transport will decline from 46% to 40% in the next 20 years. This could imply in several ways. First, the amount of rail transit may not meet the increase in level of demand for travel. The increase in personal income (affordability to private vehicle) the increase in number of population, and the lifestyles are all directing toward the private car use.

The popularity of road transport, especially private vehicles can be reflected from the increase in actual traffic volume on streets. Despite heavy congestion in the city, the amount of traffic volumes increases. Based on comparison at selected locations in Bangkok, the actual traffic volumes on streets have increased by approximately 2.4 percent per annum during 2003-2006.

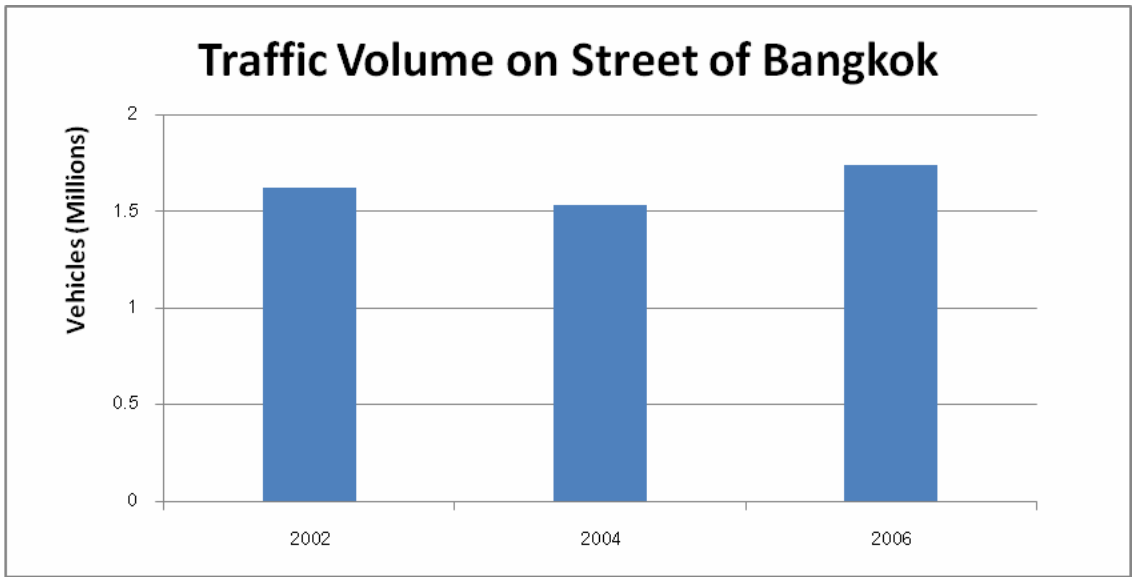


Figure 2.7 Traffic Volume on Streets[2]

The traffic prediction indicates that the amount of vehicle movement, in terms of passenger car unit (PCU)-km, will increase by 50% from 2005 to 2025 or 20 year period.

2.2 Energy

From the search for literature and data, it is found that many important data are not available for Bangkok energy consumption. Most of the data are summarized for the whole country rather than the breakdown by cities. The Energy Policy and Planning Office (EPPO) and the Energy Research Institute of Chulalongkorn University (ERI) are the most resourceful places to find the statistics. However, the only available data for Bangkok are the amount of fuel sold from the gas station in Bangkok area.

[2] The data come from the summation of available link volumes in Bangkok. Original data come from BMA Traffic Statistics report 2003 and 2006

The data and some analyses are gathered by Asia Pacific Energy Research Centre (APERC). The data came from several sources. The report in 2007, containing Bangkok data, compares energy consumption in many cities in the Asia-Pacific area. The illustrations from the report could demonstrate the energy consumption in Bangkok as well as comparison among cities in the region.

Bangkok consumed 2,842 ktoe of gasoline and 6,247 ktoe of diesel in 2003. The trend of fuel consumption is at the rate of 5 percent between 2000-2003 as displayed in Table 2.3.

Table 2.3 Gasoline and diesel consumption in Bangkok (APERC,2007)

	Absolute Level (ktoe)					Annual Growth Rate (%)				
	1986	1990	1995	2000	2003	1986-1990	1990-1995	1995-2000	2000-2003	1986-2003
Gasoline	868	1,399	2,271	2,475	2,842	12.7	10.2	1.7	4.7	7.2
Diesel	1,732	3,131	4,313	4,054	6,247	16.0	6.6	-1.2	15.5	7.8

As shown in Table 2.3, 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.

And 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.

It is noted that the Table 2.3 indicates that the Diesel sale is 2.5 times of Gasoline sale. This is contradictory to what happens at gas stations. From the telephone interview with Department of Energy Business, Ministry of Energy, it is found that the amount of consumption in Table 2.3 includes all sales, not the sale to vehicles [3]. Another source of data (Faculty of Engineering, Chulalongkorn University) indicates that the amount of diesel used for

[3] The amount of sales (expressed in ktoe) is from the aggregate amount of sale from delivery, not the gas pump. It includes the sale type 10.

transport should be 850 million ktoe in 2003, not 2522 million ktoe as shown in the Figure 2.8.

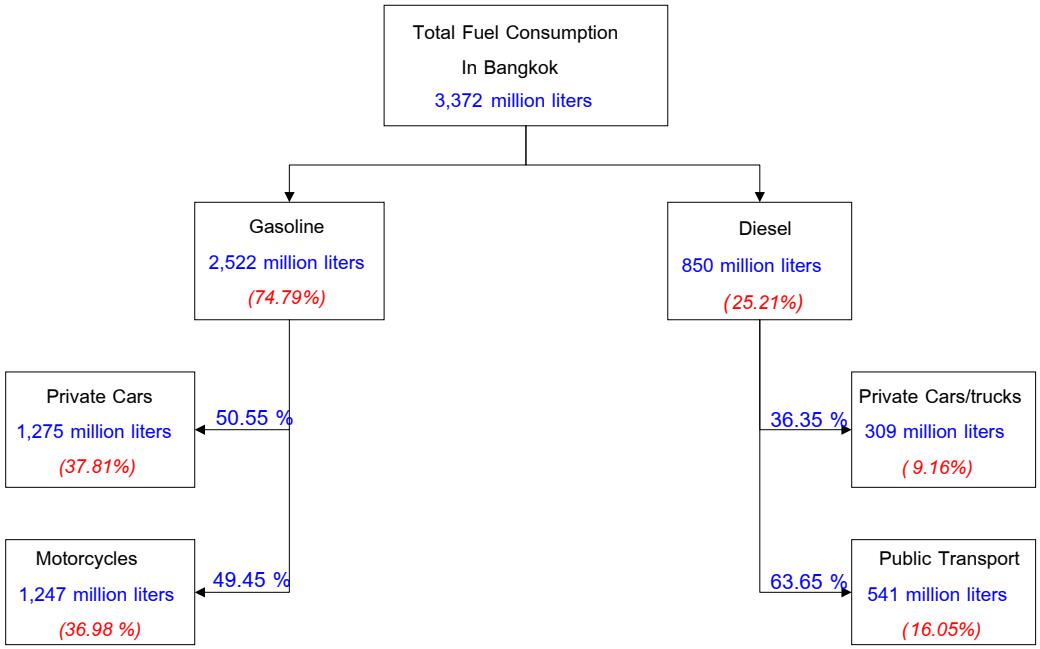


Figure 2.8 Estimated amount of gasoline used for transport in Bangkok by types of fuel[4] Source: Faculty of Engineering, Chulalongkorn University, 2006

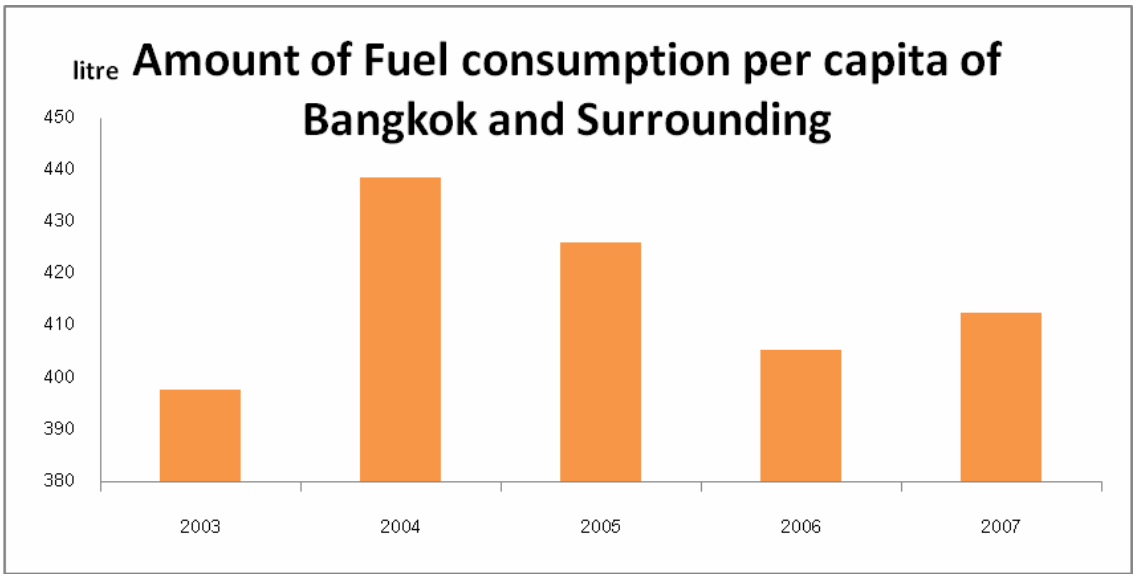


Figure 2.9 Amount of Fuel consumption per capita of Bangkok and Surrounding Source: Ministry of Energy

[4] Data for 2003. Adapted from Report entitled Potential on Energy saving and efficiency improvement in transport sector.

Since the fuel consumption for transport in Bangkok is not available or the reliability is still in question, it is difficult to observe the trend of fuel consumption directly. The simple trial is to see the amount of fuel used for transport per population. This can show the efficiency of individual's consumption for travel. Figure 2.9 is calculated and shows the amount of fuel consumption per person. The trend of inefficiency is not observed from the Figure.

To compare the fuel consumption with other cities, the fuel consumption can be converted into gasoline consumption per capita and gasoline per capita per income. These comparisons are shown in Figure 2.10 and 2.11

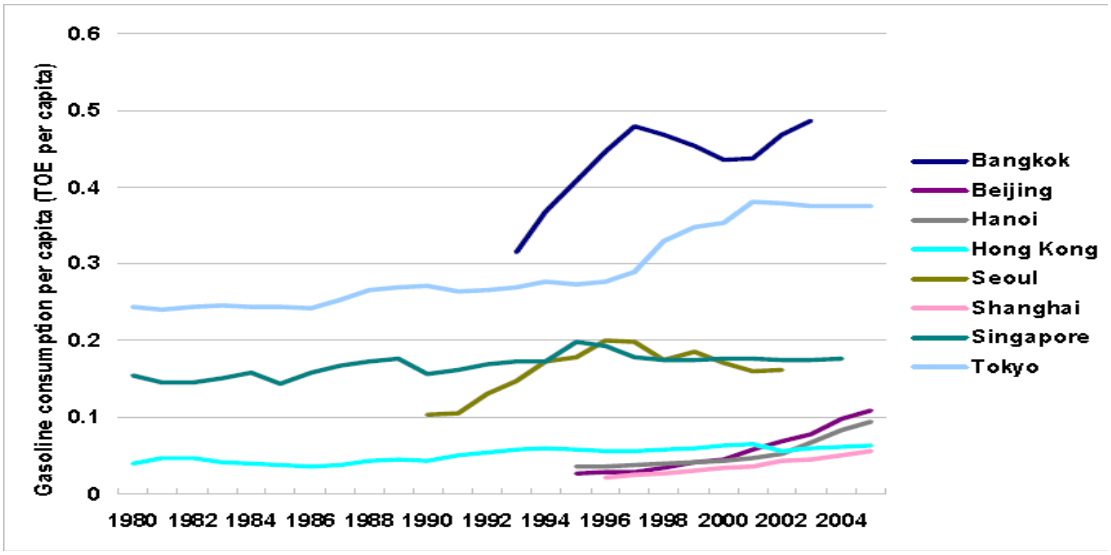


Figure 2.10 Gasoline consumption per capita in cities of Asia (toe per capita)
Source: APERC,2007

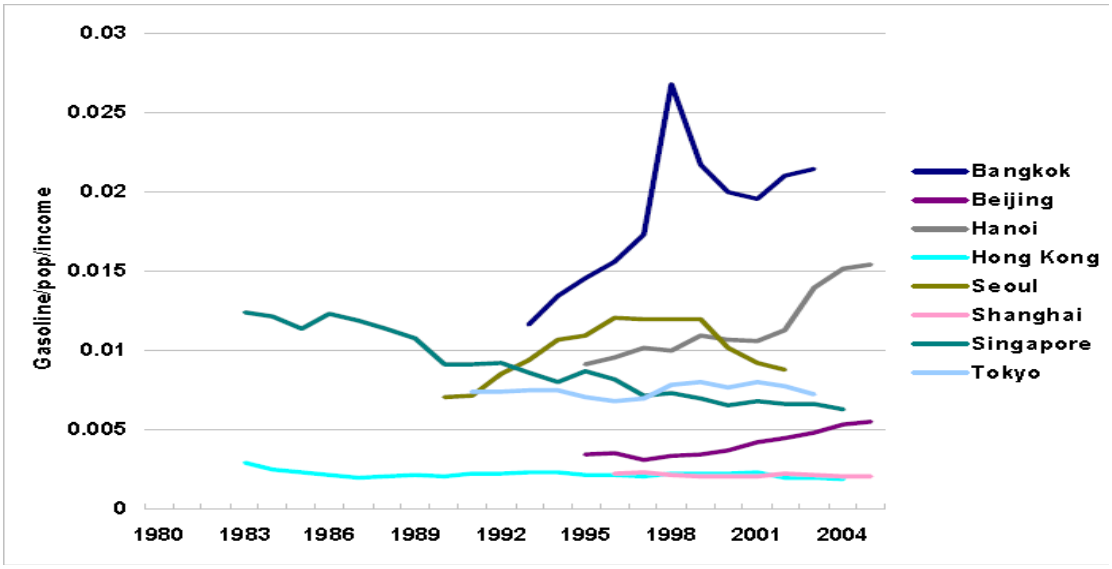


Figure 2.11 Income-normalized gasoline consumption per capita in the cities of Asia (toe per capita) (Source: APERC,2007)

From Figure 2.10 and 2.11, it is evident that Bangkok has the highest gasoline consumption per capita and per population per income. This may imply several ways. First, Bangkok is the most dependent to gasoline due to the popularity of private vehicles. At the similar level of income (i.e. Bangkok vs Seoul), Bangkok consumes gasoline more than other population in other cities. Moreover, the upward trend of gasoline consumption of Bangkok is the highest compared with other cities in the Figures.

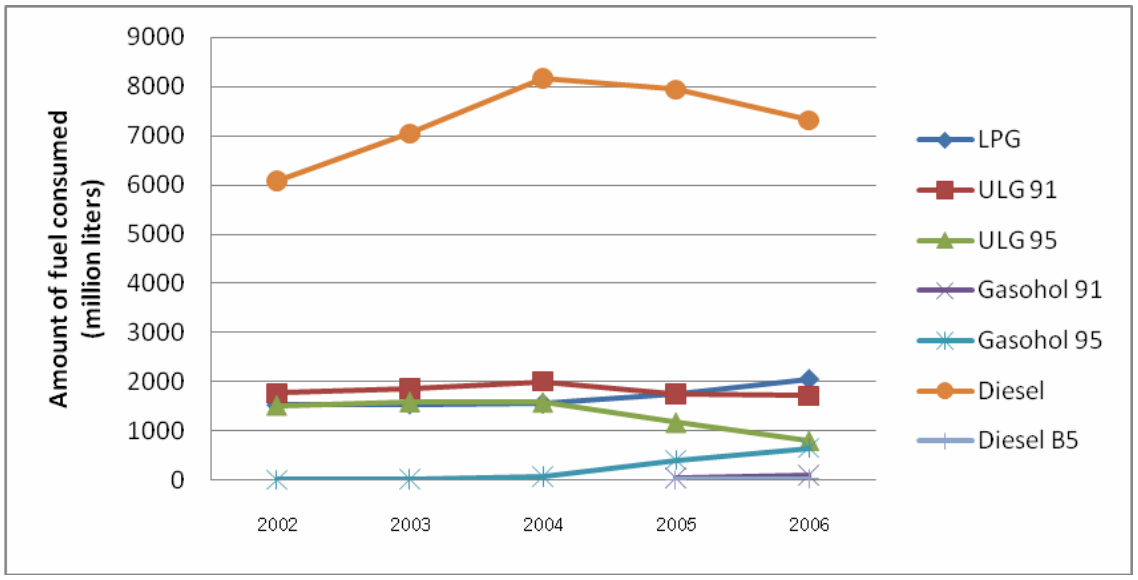


Figure 2.12 Amount of fuel consumption of Bangkok and Surrounding (include HSD)
Source: Ministry of Energy

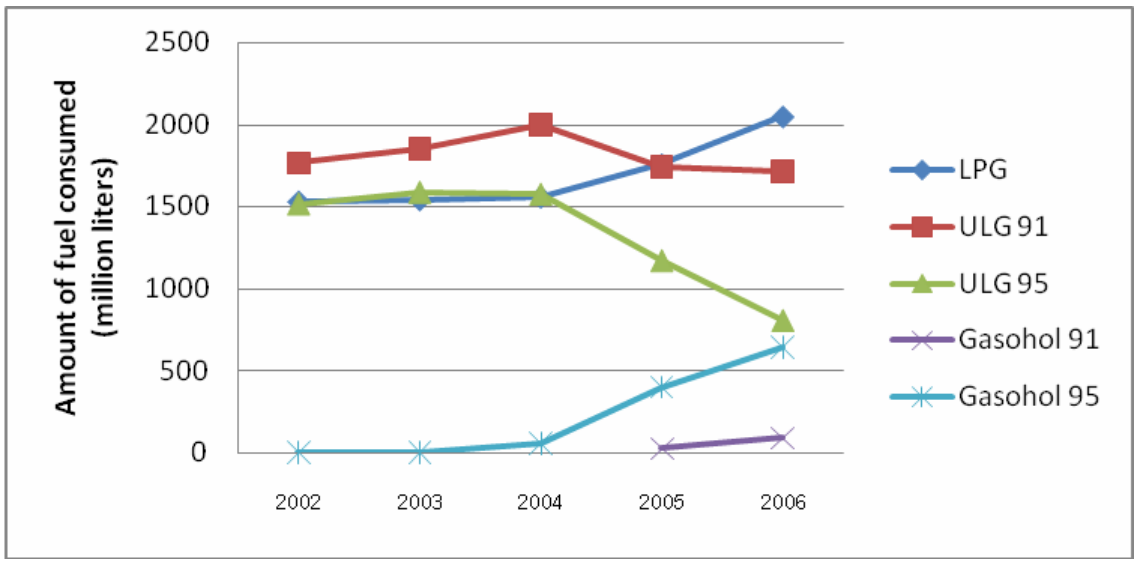


Figure 2.13 Amount of fuel consumption of Bangkok and Surrounding (exclude HSD)
Source: Ministry of Energy

Figure 2.12 and 2.13 elaborate the types of fuel that are sold in Bangkok. Same as Table 2.3, one can see the high proportion of HSD (Diesel) in the Ministry of Energy database, which is not reliable. The interesting point in Figure 2.12 and 2.13 is that the Gasohol and LPG have recently become more popular since the prices are comparatively lower that diesel and regular unleaded gasoline.

Recently (especially 2007-8), world fuel price has been unstable and increasing. Thai government has put effort to consider several options for increasing energy efficiencies. Nonetheless, tangible actions are mainly on the promotion of alternative fuel. Gasohol, biodiesel, and Compress Natural Gas (CNG) have been introduced and highly promoted. These alternative fuel types give motorists very good fuel options as they are relatively cheaper. As the result, many motorists switch to these fuel types. Figure 2.13 shows that users switch from ULG (unleaded gasoline) to Gasohol due to lower price. However, the total amount of fuel consumption is 900,000 barrels per day during 2002-2007. It is noted that LPG is gaining more popular since the comparatively lower price.

One useful information for consideration is the oil price. Figure 2.14 shows that the Thailand oil price has risen lately. This year (2008) the oil price fluctuates with the highest values of 141 dollars per barrel.

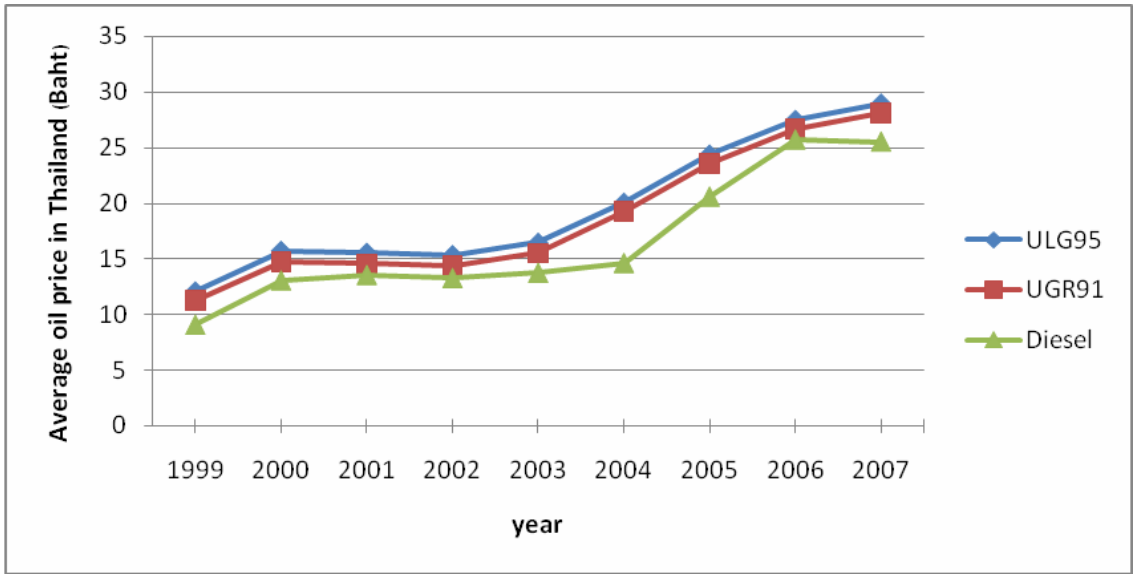


Figure 2.14 Average oil price in Thailand

Another interest piece of information is the promotion of CNG (NGV). As a result of the furious promotion of CNG use , the prediction of CNG use indicates the steep increase in the use of CNG in the future. (Figure 2.15).

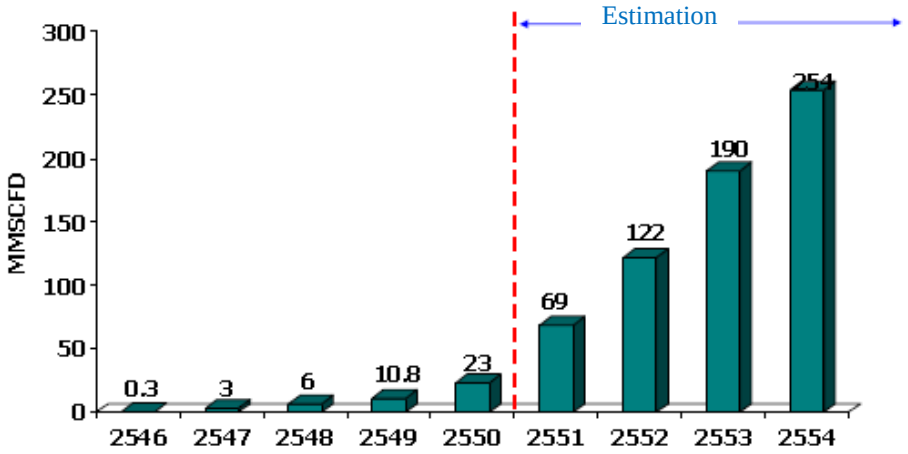


Figure 2.15 Estimation of NGV consumption

2.3 Environment

The environment situation can be observed by two methods. One is the direct monitoring of air quality from ambient environment. In Thailand, Pollution Control Department has collected such data from several field data collection stations throughout the country. Focusing Bangkok, many air quality measuring stations are situated around Bangkok, some of the sites are considered roadside and can show the air pollution from motor vehicles on roads. Then these data can be directly reported or brought to further estimate the emission load (amount of pollution).

The latest comprehensive estimation of air pollution in Bangkok was reported by Pollution Control Department (PCD) in 1997. Statistics indicate that the mobile sources (mainly from transportation) contribute highly to air pollution in Bangkok. From Figure 2.11, transport sector emits the highest amount for PM, CO, NO_x, and HC.

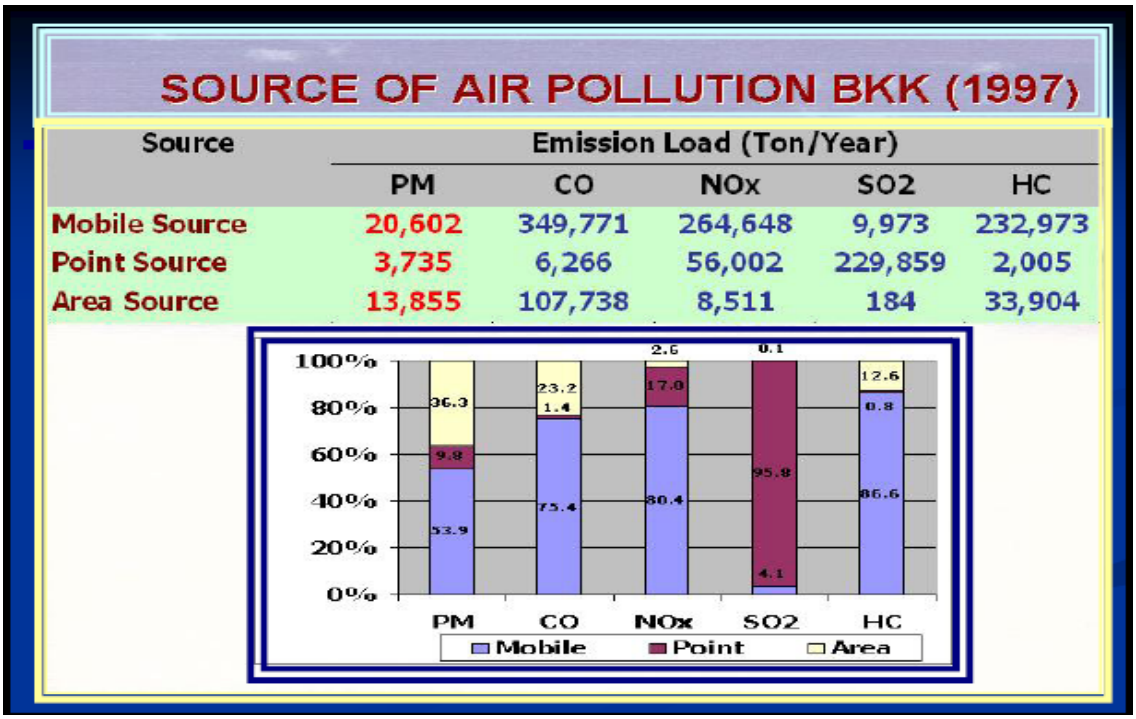


Figure 2.16 Source of air pollution in Bangkok (Source: PCD,1997)

In summary, the air pollution in Bangkok was serious in 1990s as indicated from that several levels of Pb, CO, SPM, and PM10 exceeded the standards. One study showed that the level of Pb in blood of subjects who were students and traffic police in Bangkok exceeded standards. Since 1990s, Thai government has very compelling actions on improving air quality in urban areas. Such actions are cleaner fuels and gasoline reformulation. In 1995, leaded gasoline was banned and diesel was planned re-formulated to have sulfur compound less than 0.035% (EURO3) in 2004 and 0.005% (EURO4) in 2010. The improvement in the fuel production process makes less PM fuel. On automotive technology standard, the new cars in 2010 must meet EURO4 standard. Government passed the regulation that vehicles must pass Inspection and Maintenance (I&M) every a given period (such as passenger cars older than 5 years must have I&M every year). Vehicles are required to install Three-Way Catalytic Converter or Diesel Particulate Filters.

Due to strict regulation and actions, the air quality in Bangkok has been improved since 1990s. Table 2.4 and 2.5 show the air quality improvement between 1993 and 2007. The tables show that the concentration of air pollution substance is reduced (lead(Pb), carbon monoxide (CO), nitrogen dioxide(NO_2), Sulfur dioxide (SO_2, yet some substances are still over the standard (Total Suspended Particulate(TSP), Particulate Matter 10(PM_{10}), especially at the roadside with busy traffic. In conclusion, the air quality in Bangkok is much improved from the past

and is in good condition. Although some substances may exceed standard, they are in the minimal proportion.

Table 2.4 Air Quality in Bangkok in 1993

Pollutants	Ambient Air Quality in Bangkok in 1993				
	Range	95 Percentile	Annual Average	Standards	Exceeding Standards %
TSP (24-hr) mg/m3	0.02 - 0.46	0.35	0.17	0.33	6.9 (23/333)
CO (1-hr) ppm	0.00 - 22.00	3.00	0.97	30	0/9667
CO (8-hr) ppm	0.00 - 15.61	2.58	0.97	9	0.4 (36/9396)
Pb (24-hr) ug/m3	0.05 - 1.03	0.48	0.22	--	--
Pb (monthly) ug/m3	0.10 - 0.45	0.36	0.21	1.5	0/45
Pollutants	Roadside Air Quality in Bangkok in 1993				
	Range	95 Percentile	Annual Average	Standards	Exceeding Standards %
TSP (24-hr) mg/m3	0.09 - 1.53	0.84	0.39	0.33	48.9 (128/262)
PM-10 (24-hr) ug/m	29.5 - 206.6	155.7	79.9	120	11.3 (40/354)
CO (1-hr) ppm	0.00 - 29.88	8.93	3.24	30	0/20009
CO (8-hr) ppm	0.00 - 18.01	8.14	3.26	9	2.9 (564/19452)
Pb (24-hr) ug/m3	0.06 - 1.66	1.00	0.49	--	--
Pb (monthly) ug/m3	0.18 - 1.11	0.83	0.45	1.5	0/14

Source: Pollution Control Department

Table 2.5 Air Quality in Bangkok in 2007

Pollutants	Ambient Air Quality in Bangkok in 2007				
	Range	95 Percentile	Annual Average	Standards	Exceeding Standards %
TSP (24-hr) mg/m3	0.02 - 0.41	0.17	0.09	0.33	0.43 (2/460)
CO (1-hr) ppm	0.00 - 6.4	1.70	0.7	30	0/79,818
CO (8-hr) ppm	0.00 - 4.9	1.60	0.7	9	0/82,712
Pb (monthly) ug/m3	0.10 - 0.28	0.17	0.07	1.5	0/119
PM_{10}(24-hr) mg/m3	10.8 - 188.9	90.6	46.6	120	1.1 (22/1,957)
O_3(1-hr) ppb	0.0 - 186.0	56.0	17.2	100	0.2 (133/58,411)
SO_2(1-hr) ppb	0.0 - 43.0	10.0	4.1	300	0/75,757
SO_2(24-hr) ppb	0.0 - 16.2	8.7	4.1	120	0/2,995
NO_2(1-hr) ppb	0.0 - 148.0	52.0	21.7	170	0/77,014

Pollutants	Roadside Air Quality in Bangkok in 2007				
	Range	95 Percentile	Annual Average	Standards	Exceeding Standards %
TSP (24-hr) mg/m3	0.03 - 0.76	0.31	0.15	0.33	4.33 (26/600)
CO (1-hr) ppm	0.00 - 16.30	3.40	1.4	30	0/62,091
CO (8-hr) ppm	0.00 - 9.40	3.00	1.4	9	0.01 (9/62,364)
Pb (monthly) ug/m3	0.02 - 0.19	0.13	0.07	1.5	0/103
PM_{10}(24-hr) mg/m3	9.8 - 242.7	118.1	60.9	120	4.7 (92/1,970)
O_3(1-hr) ppb	0.0 - 102.0	39.0	11.6	100	0.004 (1/24,561)
SO_2(1-hr) ppb	0.0 - 42.0	12.0	5.3	300	0/23,523
SO_2(24-hr) ppb	0.4 - 19.0	9.6	5.3	120	0/11,014
NO_2(1-hr) ppb	0.0 - 150.0	68.0	32.5	170	0/24,586

Source: Pollution Control Department

Annual Roadside and Ambient emission levels in Bangkok

(Source: Pollution Control Department,2007)

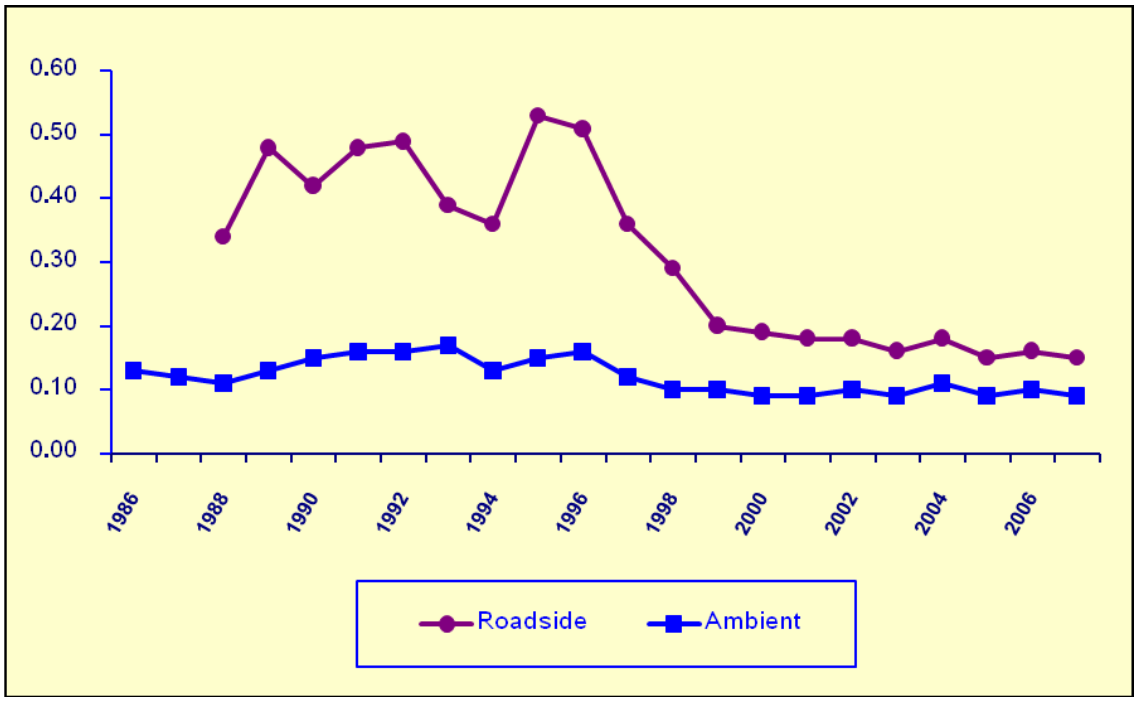


Figure 2.17 Annual Average TSP in Bangkok 1986 - 2007

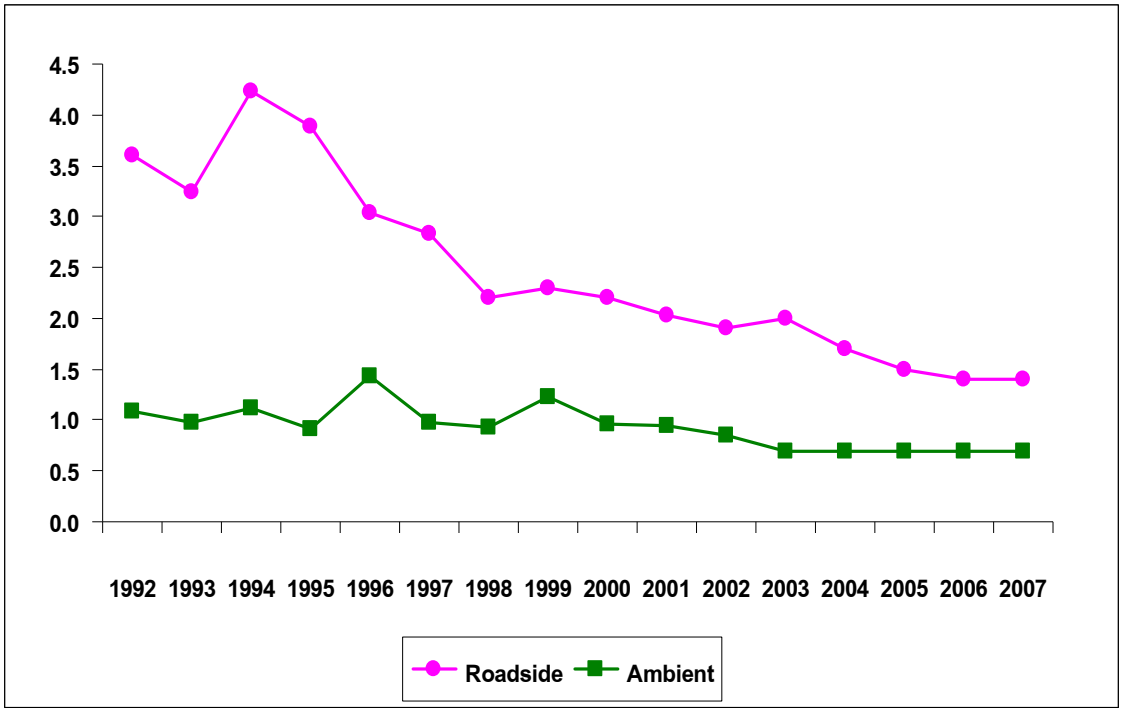


Figure 2.18 Annual Average CO in Bangkok 1992 - 2007

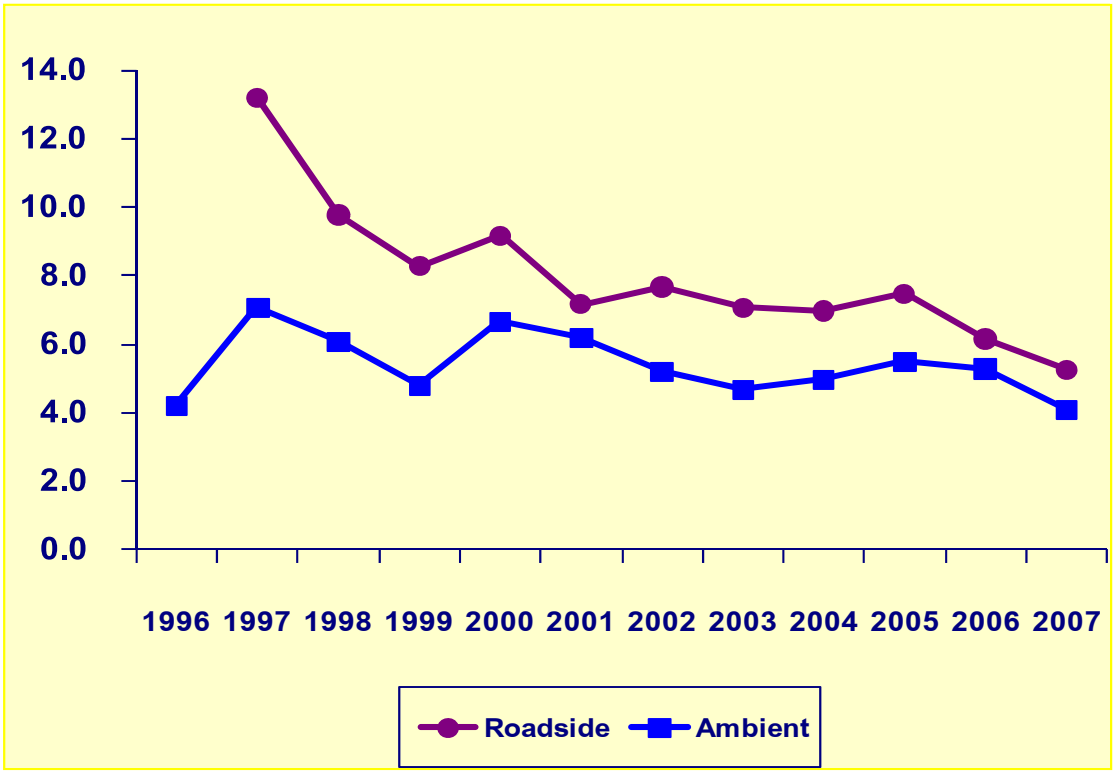


Figure 2.19 Annual Average SO_2 in Bangkok 1996 - 2007

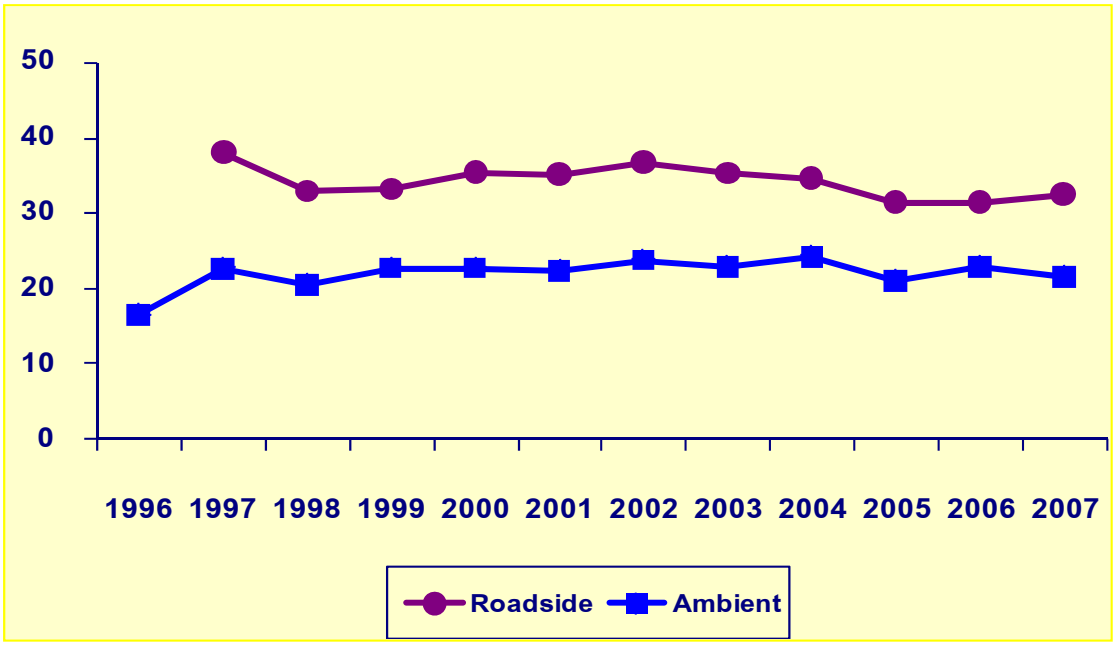


Figure 2.20 Annual average NO_X in Bangkok 1996 - 2007

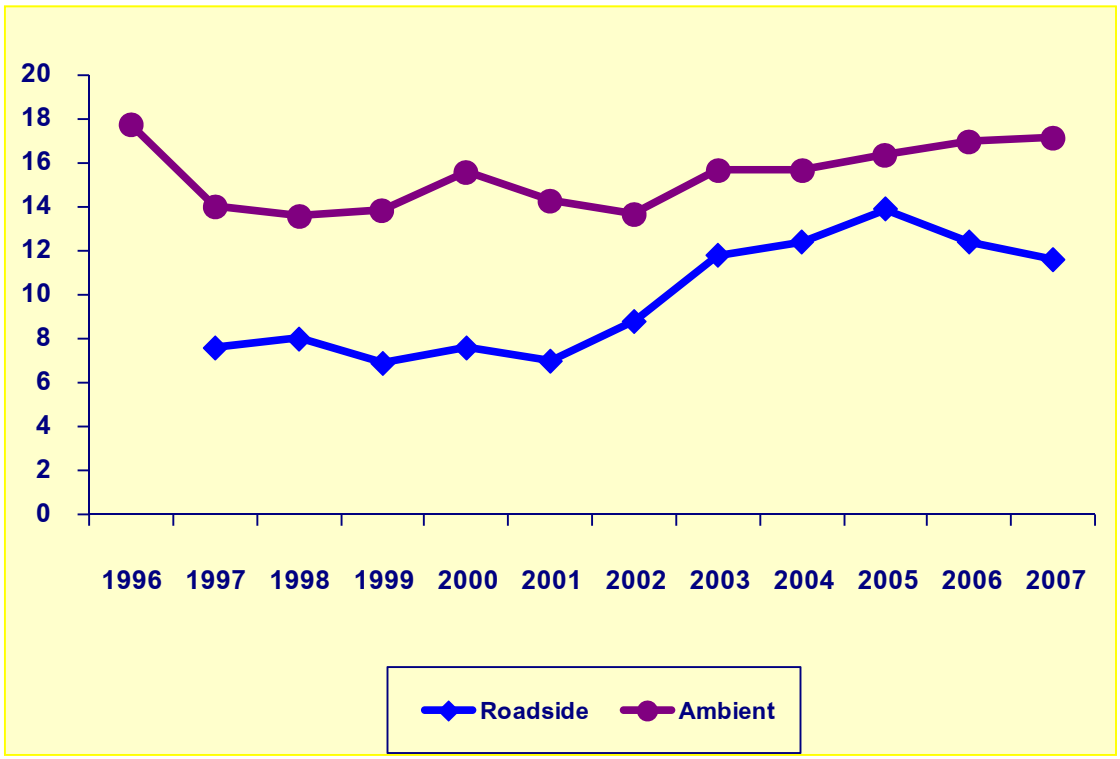


Figure 2.21 Annual Average O_3 in Bangkok 1996 - 2007

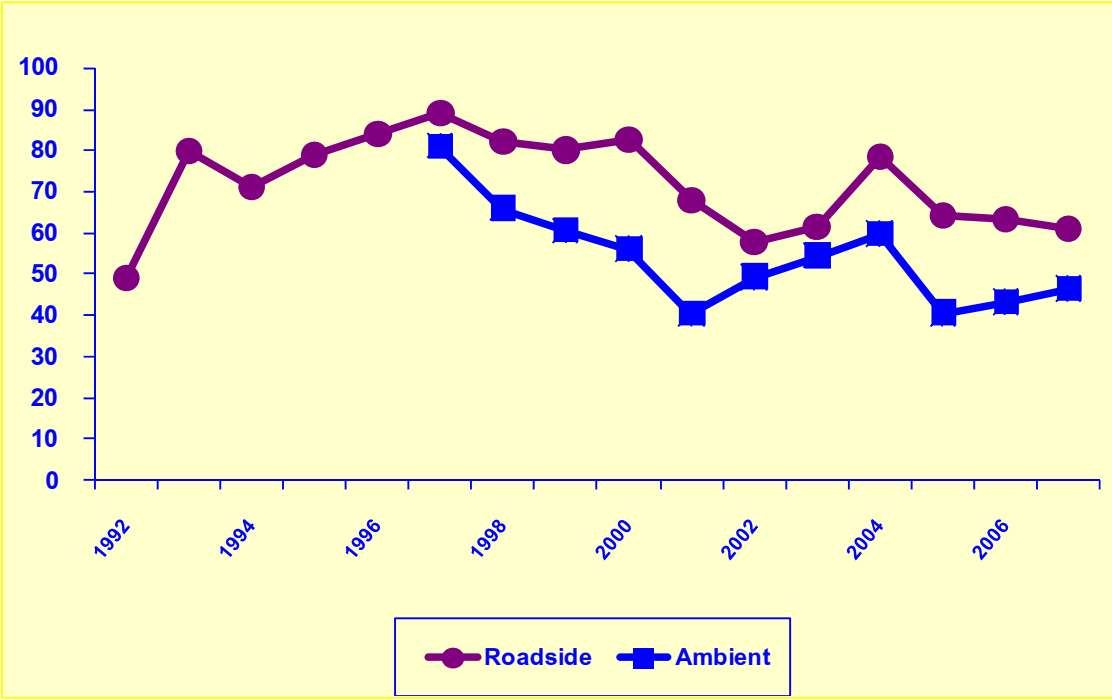


Figure 2.22 Annual Average PM_{10} in Bangkok 1992 – 2007

The amount of pollution generated by road transport can also be estimated from Road Transport Model. Office of Transport and Traffic Policy and Planning has estimated the emission of pollution by road sector in Bangkok. Transport planning model was used to estimate the amount of vehicle travel (passenger car unit- kilometer of travel, PCU-KT), speed of traffic, and then estimate the emission from aggregate emission model. The results from integrated transport and vehicle emissions model can be concluded as shown in the Tables below.

Table 2.6 Results of integrated transport model and vehicle emission model (Daily)

Base Year	PCU-Km per day	Speed	NO2	CO	PM_{10}
		Km/hr	g/km	g/km	g/km
2005	6,544,860	17.2	15,707,664	3,861,467	458,140
2010	7,688,940	16.4	19,222,350	4,920,922	692,005
2025	9,959,460	13.5	27,886,488	7,668,784	1,195,135

Table 2.7 Results of integrated transport model and vehicle emission model (A.M. peak)

Year	PCU-Km per day	Speed	NO2	CO	PM_{10}
		Km/hr	g/km	g/km	g/km
2005	458,140	15.4	1,099,536	250,995	34,361
2010	522,848	17.3	1,326,342	344,465	47,748
2025	717,081	15.6	2,091,487	529,146	95,611

Source: Office of Transport and Traffic Policy and Planning,2007

The Tables show that the amount of emitted CO and PM_{10} is doubled from 2005-2025. This will be serious concern if we let the situation in the near future as BAU.

3. Effect of future Bangkok transport on energy and environment : development of rail transit

3.1 Case Study: Effect of future Bangkok transport project on energy and environment : The development of rail transit system

This part of the report considers the impact of transport project on energy and environment. The attempt does not intend to perform extensive analysis on the impact quantification, rather intend to present the consideration on energy and environment in the transport infrastructure development project and to compare the saving in energy and environments, with the trends and issues discussed in the previous section.

The case study is the rail transit development project in Bangkok. Rail transit is the hope for many to reduce traffic congestion and save energy, thus increasing the economic competitiveness by more economic saving and less import dependence. Currently Bangkok has two rail transit systems; BTS Sky train and MRTA subway. More rail systems had been planned and approved in principle by the authority in 2003, yet no line has been realized. The original lines have been discussed and revised for many times. Recently in 2008 the government announces that 9 more rail lines will be implemented and several impact assessments were carried out to see the project justification and project priority.

In the impact analysis, energy saving is calculated as the part of benefits from the project. Environmental Impact Assessment was thoroughly conducted. One study aims particularly on the quantification of emission saving from the project (CDM project, OTP 2008). Moreover, GHG saving is also estimated.

The case study is the Blue line extension that extends the downtown terminal station of Hua Lumpong to Bang Kae and the Bang Sue to Tha Phra. The total length of the project is 27 kilometers. It is expected to finish the construction and to be inaugurated in 2012. By the opening date, another three rail extensions will be also finished and operated as well.

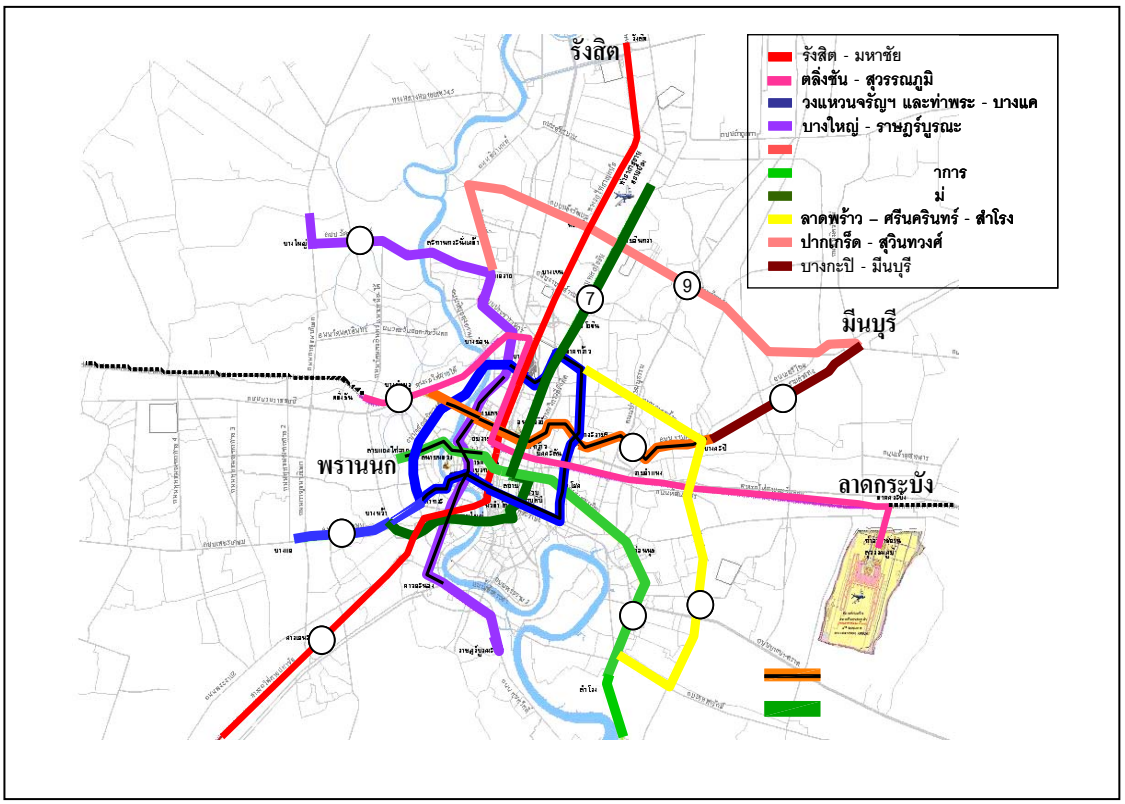


Figure 3.1 show transport network in 2012

Results from transport model prediction are shown in Table 3.1

Table 3.1 Transport Conditions in Bangkok

(Source: OTP, TDMC VI , 2007)

Transport Conditions		
	2010	2025
Private Vehicle Trips (million trips/day)	10.7	15.7
Public Transit Trips (million trips/day)	8.1	10.1
Total Trips (million trips/day)	18.9	25.8
Proportion of trips by private cars (%)	56.81	60.84
Vehicle Operating Cost (million baht/day)	1,032.785	2,348.705
Total distance made by private vehicles (million km/day)	213.874	328.355
Total distance made by all vehicles (million km/day)(year)	226.058 (2012)	321.241 (2027)
Total time made on private vehicles (million hours/day)	8.536	15.413
Total Time made on all vehicles (million hours/day)(year)	9.999 (2012)	14.408 (2027)
Average Traffic Speed (kph)	25.1	21.3
Proportion of trips made on rail transit system (%)	6.0	8.5

Table 3.1 Transport conditions after the completion of Blue line extension (case study)

To recap Bangkok transport energy and environment situation, important figures are summarized in Table 3.2 below (this is BAU)

Total Bangkok Transport energy consumption (ktoe/year)			**= n/a**
Total emission	**NOx**	**(ton/year)**	**= 89,460**
	CO	**(ton/year)**	**= 489,800**
	PM	**(ton/year)**	**= 5,900**
Total GHG		**(k ton/year)**	**= 1,388**

The introduction of the Blue line rail extension is expected to gain 739,156 riders on the section in year 2025. From mode share estimation, 8.5 percent of the total trips are made on rail transit system. The project ridership cannot cope with the increase of road traffic demand and thus there are still an increasing number of vehicles on streets. Thus, the roads face more congestion and accommodate more vehicle-distance. After the new "equilibrium" route adjustment by the motorists, a new scenario on road mobility is determined.

From impact analysis of the feasibility study, the saving of fuel is not directly reported in detail. However, the saving of Vehicle Operating Cost (VOC), a determinant of fuel saving, show that the project can save 94.3 billion baht per year in 2025. This number comes from saving by passenger cars, motorcycles, taxis, trucks, and buses on road network.

At this new operating condition on the road, the environmental situation can also be improved. This improvement comes from the reduction in traffic demand as well as better road traffic operations. In general, the demand shift to the subway makes less congestion on roads, and the roads are operated at higher average speed. The higher speed operation will produce less emission and GHG. Note that the impact of speed improvement on the reduction of the emission varies by types of vehicles. Finally, the saving in emission and GHG can be determined.

The summary of Air pollutants saving and greenhouse gas emissions saving in Bangkok is shown in Table 3.2

Table 3.2 Air pollutants and greenhouse gas emissions in Bangkok
(Source : Summary Report-Study for development of atmospheric environmental impact assessment methodology on the Extension of Subway Blue Line in Bangkok,19 September 2006,Japan Transport Cooperation Association in the collaboration with Japan Weather Association and Nihon University)

	Parameters	Total Emissions (kg/day. Ton/day for only CO_2)	
Air Pollutants	NO_x	2006	259,115
		2011 (without extension)	276,499
		2011 (with extension)	276,307
		Emission Reduction (without – with)	192
	CO	2006	1,112,459
		2011 (without extension)	1,014,177
		2011 (with extension)	1,012,33
		Emission Reduction (without – with)	1,744
	PM	2006	9,844
		2011 (without extension)	12,023
		2011 (with extension)	12,022
		Emission Reduction (without – with)	1
Greenhouse Gas	CO_2	2006	50,808
		2011 (without extension)	54,114
		2011 (with extension)	54,073
		Emission Reduction (without – with)	41

From the Table, it is seen that the emission saving is 192 kg/day for NO_x or 0.17 percent, 1,744 kg/day for CO or 0.25 percent, 1 kg/day for PM or 0.0083 percent and the GHG saving is 41 ton/year or 0.075 percent.

Referring to the action plan prepared by Bangkok Metropolitan Administration (BMA) who participated in the Large Cities Climate Summit in 2007, BMA has set the target on the reduction in the reduction in GHG by at least 15 percent by 2012.

From the table above indicates that the rail development project can contribute to the saving in the GHG by 120,450 ton/year in 2010 and 312,440 ton/year in 2020. This project could help Bangkok to reach the goal by approximately 1 percent in the year 2012.

The case study illustrates an example of how to consider energy and environments for a transport project development. Apart from the results of the project improvement, the procedure on how to consider energy and environment issues in transport is learned. Some points can be commented:

(1)Energy saving by transport system improvement is a common procedure in the impact analysis. It is the main element in the Vehicle Operating Cost saving.

(2)The aggregate fuel consumption by road users has not practically been calibrated or compared with the actual fuel sales.

(3)Common procedure does not pay attention on the details of the saving, e.g. what types of fuel is saved.

(4)The energy saving is not compared with the energy saving target

(5)The estimation of the emission is not generally performed (at least in Thailand), thus the achievement on environmental saving cannot be shown.

(6)Very limited number of studies shows the impact of emission (saving) by geographical area. This may be important when one wishes to solve environmental problems at a specific location

(7)The procedure on emission and GHG impact calculation is complex which needs close examination and validation

(8)The emission and GHG savings are not practically compared to the environmental goals or standards.

(9)The impact analysis on the emission and GHG will be used to assess the environmental condition. At the moment, this is considered in the Environmental Impact Assessment. The emission and GHG is not considered in the project justification

CHAPTER 4 EXITING DATA AND CONCERNS WITH TRANSPORT, ENERGY, AND ENVIRONMENTS

4.1 Data Collection

The study searched for literature related to transport-energy-environment in Bangkok. It is quickly found that the number of literature is very limited. Some key studies and details are shown in Table 4.1.

Table 4.1 Selected key studies/literature on transport-energy-environment in Bangkok

	Key studies	Source	Usage
Transport	Overall Transport Policy in Environment and Energy (presentation material)	OTP	Description of existing policy
	Feasibility study, detailed design and tender document preparation for the remaining extensions and new routes	MRTA	Consideration of Emission in the feasibility of transport project
Energy	Potential assessment of energy saving and improving efficiency in transport sector	Academic	Estimation of energy consumption in detail and formulate policy directions. Partly have Bangkok consideration
	Automobilisation and urban form—planning to balance railways and roads to achieve higher quality of life (presentation material)	Academic	Compare Bangkok transport consumption with other cities. Use available secondary data source
	Urban transport energy use in the APEC region	APERC	Compare Bangkok transport consumption with other cities. Comprehensive analysis using secondary data sources
Environment	Development and Improvement of emission sources and impact assessment on air quality in Bangkok	Pollution Control Department	Analysis of amount of emission in Bangkok. Transport emission is a part of total emission. Rather old (1984)
	Strategies to mitigate air pollution and reduce energy consumption in the transport sector of Thailand	Academic	Quantify the total energy consumption and emission from transport sector and address appropriate strategies. Done at national level. Use crude but available data sources
	Summary on Pollution Situation in Thailand	Pollution Control Department	Annual report on status of pollution in Thailand. National level
	Vehicle emission reduction in Thailand (presentation materials)	Pollution Control Department	Description of existing policies
	Feasibility of CDM in transport sector	OTP	Quantification of emission for a specific project and seek possibility to make it as CDM proposal
	Action plan on reduction in Global Warming	BMA	Description of action plan. Specifically for Bangkok

From the collection of available data, energy and environment in transport sector are described in general based on some statistical data collected by some government agencies. Some key available data are listed in Table 4.2. Most of the statistics are at national level. For Bangkok, most of the data came from specific (ad-hoc) studies. At this point, it is promptly learned that Bangkok is lack of many important statistics to show the status of transport, energy, and environments. Moreover, many data on energy consumptions and environmental status are not classified to reflect the relationship with transport sector. Energy consumption is aggregated to the total amount of gasoline used in the area. The impacts of environment due to transport can be measured through a limited number of data from roadside monitoring stations. Most of available data show aggregate status of energy and environments rather than specific classification into transport-related figures.

Table 4.2 Available statistical data on transport-energy- environment in Bangkok

	Key available data	Source	Usage/Limitation
Transport	Travel Demand - Vehicle ownership - Forecast of future road use - Forecast of future public transport use Operating condition - Estimated speed - Actual volume counts	Registration Model Model Model/sampling on road test Periodical count	+ Have forecast for future demand + Do not have statistical significant data to show actual operating conditions + Do not have statistics to show the vehicle performance conditions + Do not have statistics to show the drivers behaviors
Energy	Amount of fuel consumption Aggregate by type of gasoline	Actual record	+ The data is available as the total amount + Cannot represent the relationship with the actual travel condition
Environment	Roadside emission monitoring - Ambient emission Automotive laboratory test data	Actual record on limited locations Sampling	+ Data are available at only selected sites, cannot quantify the total environment situation due to transport + Very limited road and lab test

Most of the studies addressed the quantification of impact on energy and environments.

This study also interviewed some officers who are responsible for energy and environment in transport sectors. The objectives of the interview were to gather information about the past and present studies in this matter, to learn the expectation and needs from research, and to pinpoint the interest by authorities.

The major concerns by the all authorities are the identification of the magnitude of the energy consumption and environment situations in Bangkok. This is actually the problem identification step in the scientific system analysis process [5]. Although the policies and actions are the consequences of the final step of decision making, the situations on data availability and reliability place the most concern in the very first step. The lack of the data and proper estimation of the problem hinders a good determination in the following steps and therefore many times the policy directions can be developed with less confidence.

The search for data and studies give some valuable status on data availability and needs for data improvement. The search for data shows that many data are not available and thus systematic and routine data collection is needed. The collection of studies shows that the number of studies is very limited. Confirmed with the interview and final concerns on energy and environment related to transport, it is found that the direct consideration is to confirm and/or properly develop policy and actions for improving energy efficiency and reduce adverse environmental conditions due to transport.

4.2 Responsible Organizations

The study investigated the consideration and execution of transport energy and environments by many organizations. Main responsible authorities in these matters are

Table 4.3 Transport Energy

Organization	Responsibility
Ministry of Transport, Office of Transport and Traffic Policy and Planning	Consider the policy and planning of transport system improvement. Assess the impacts on energy as a part of outcomes and impacts of transport system. Policy guidance and performance monitoring
Ministry of Transport, Operating (Executing) Departments	Take the energy concerns as the direction of execution. Plan, operate (regulate), and monitor transport system so that it takes less energy use.
Ministry of Energy	Set energy policy and monitor the use of energy in the country. Seek coordination with transport sectors to manage the energy use in transport sector

[5] Typical steps in scientific system analysis are Problem identification, Objective setting, development of alternatives/measures, Alternative (impact) analysis, and decision making.

Table 4.4 Transport Environment

Organization	Responsibility
Ministry of Transport, Office of Transport and Traffic Policy and Planning	Consider the policy and planning of transport system improvement. Assess the impacts on environment as a part of outcomes and impacts of transport system. Policy guidance and performance monitoring
Ministry of Transport, Operating (Executing) Departments	Take the environment concerns as the direction of execution. Perform Environmental Impact Assessment. Plan, operate (regulate), and monitor transport system so that it takes less environment degradation.
Ministry of Natural Resource and Environments, Pollution Control Department	Set Pollution and GHG standards. Monitor environments in the country. Seek coordination with transport sectors to manage environment related to transport sector

4.3 Data Availability

The study investigated the data availability and reliability. The lack of basic data becomes serious issues that hinder the proper consideration process. The data are required to correctly identify the problems and their seriousness, the selection of proper solutions, and the efficient monitoring of decision and on-going execution. Recalled from the previous sections, the basic data indicating the trends in transport situations, the energy and environment conditions related to transport are not available. The surrogate data are not reliable. This can lead to the accuracy of further analysis. Although some data are available, these data are not continuously collected and thus the monitoring of situations is not possible. Examples of problems with data are shown in Table 4.4.

Table 4.5 Problems with data (examples)

Description	Last year	Organize Responsibility	Criticize
Proportion of Modal Share and Trend in Urban Transportation	1995	OTP	Old and Not update
Source of air pollution by measure in Bangkok	1997	PCD	Not update The most is National scale
Volume of emission level in Bangkok	-	PCD	Not available
No. of Vehicle In-Use in Bangkok	2003	BMR	Not update
Trend of Ozone emission in Bangkok & Thailand	-	PCD	Not available

4.4 (Immediate) Actions to respond energy and environment related to transport

At policy level, the energy and environment concerns are taken into consideration. The results of the decisions can be found from the cabinet resolution, ministry and department action plans. The actions pertaining to energy have changed rapidly and thus there might be new resolutions frequently. Anyway, the collected actions can be summarized as follows:

Table 4.6 Transport Energy

Organization	purpose	Action	Date
Ministry of Energy	Solve increasing diesel price	Compensate the price	18/03/2008
Ministry of Energy	Promote CNG	Freeze CNG price	18/03/2008
Ministry of Interior	Promote CNG	Ease regulation for CNG station	18/03/2008
Ministry of Finance	Promote CNG	Decrease excise tax	18/03/2008
Ministry of Finance	Promote CNG	Reduce CNG equipment tax	18/03/2008
Ministry of Energy	Give disincentive to LPG	Monitor and regulate LPG use	18/03/2008
Ministry of Energy	Promote Ethanol	Seek raw material plan to reduce transportation cost	18/03/2008
Ministry of Energy, Department of Energy Business	Promote Ethanol	Assess the potential to produce and set up Gasohol station	18/03/2008
Ministry of Energy, Energy Policy and Planning Office	Promote Ethanol	Promote gasohol	18/03/2008
Ministry of Agriculture and Cooperatives	Promote Bio-diesel	Find raw materials for Bio-diesel	18/03/2008
Ministry of Energy, Department of Energy Business	Promote Bio-diesel	Promote Bio-diesel B2/B5	18/03/2008

Table 4.7 Transport Environment

Organization	purpose	Action	Date
Pollution Control Department, Thai Industry Standard Institute, Office of Industrial Economics, Department of Land Transport, Department of Energy Business, Thai Automotive Industry Association	Reduction in emission from vehicles	Emission Reduction from New Vehicle - Set up standard for new vehicles to EURO IV	Regulated in 2012
Pollution Control Department	Monitor emission	Emission Reduction from In-Use Vehicle - Inspect vehicle roadside on CO, HC, PM	Regulated in 2012
Pollution Control Department	Promotion on Reduction in Transport Demand	- Land-use control - Control of suburban development - Development of public transport facilities - Parking control - Road pricing	On-going Public Relation
Office of Transport and Traffic Policy and Planning	Improvement of Traffic Flow and Car Driving	- Reinforcement of traffic rule	On-going Public Relation
Transportation and Traffic Division, Bangkok Metropolitan Administration	Improvement of Traffic Flow	- Promotion of green Bangkok	On-going Public Relation
Department of Energy Business	Betterment of Quality of Car and Fuel	- Control of emission - Fuel tax - Promote better driving - Promote Inspection and Maintenance	On-going Public Relation

It is noticed that many organizations have carried out actions to respond to energy and environment concerns. Coordination among these organizations is necessary. Although the level of coordination cannot be assessed and the coordination problems are not reported in this report, one can perceive institutional problems and thus can expect obstacles to the integrated achievements. It is suggested that this problem should be mentioned and solved.

4.5 Trends, Targets, and Proposed Actions

4.5.1 Energy

The trend for energy use in transport sector in Thailand is available for nationwide. JGSEE (2007) used Long-range Energy Alternatives Planning system (LEAP) to study the trend of energy consumption in the case of Do-nothing (Business as usual or BAU) during 2006-2026. It is found that the total amount of energy use will increase by 5.5% per annum. Transport sector consumes 37% of the total energy (the highest over industry, residential, and business sector).

Through several measures to reduce energy use, Thailand can save a lot of energy and reduce the growth from 5.5% (BAU) to 4.1%. Transport sector can contribute to the largest saving, accounting for 12% and 16.2% in 2021 and 2026. The saving (nationwide) is illustrated in Figure 4.1 .

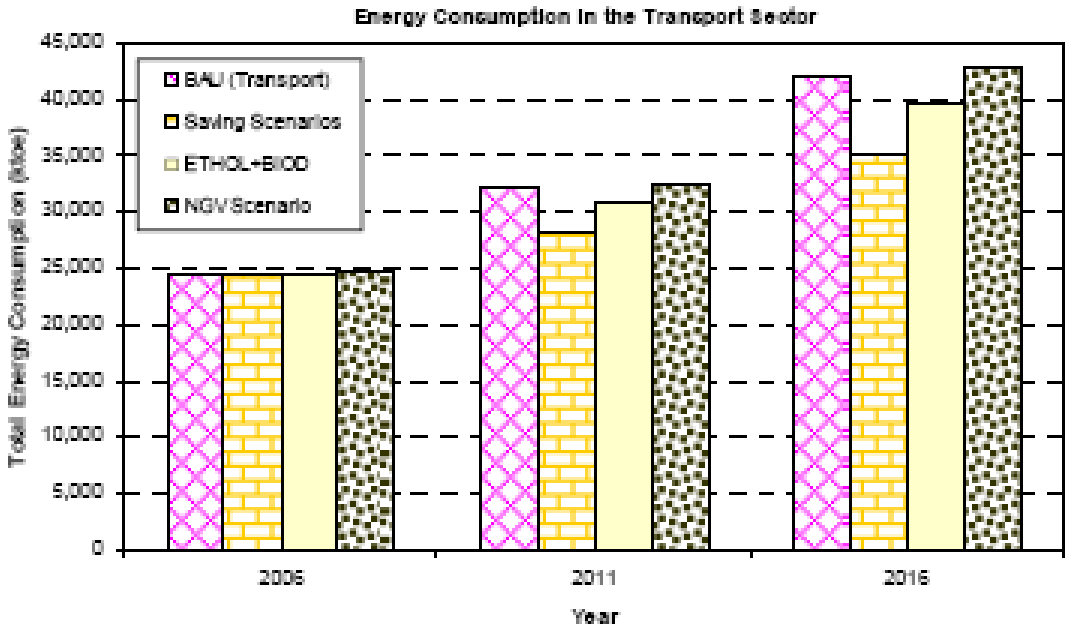


Figure 4.1 Energy Consumption in the Transport Sector

Source: JGSEE,2007

The study also examined the impact of energy measures in transport sector. The highest saving comes from Travel demand management (TDM) (1,583 ktoe saved in 2011 and 2,066 ktoe saved in 2016). While Improved fuel economy(IFE), Emission fee, Fuel tax, Hybrid car and Car labeling will save 1,630 1,171 1,006 601 และ 322 ktoe in 2016, respectively (Figure 4.2).

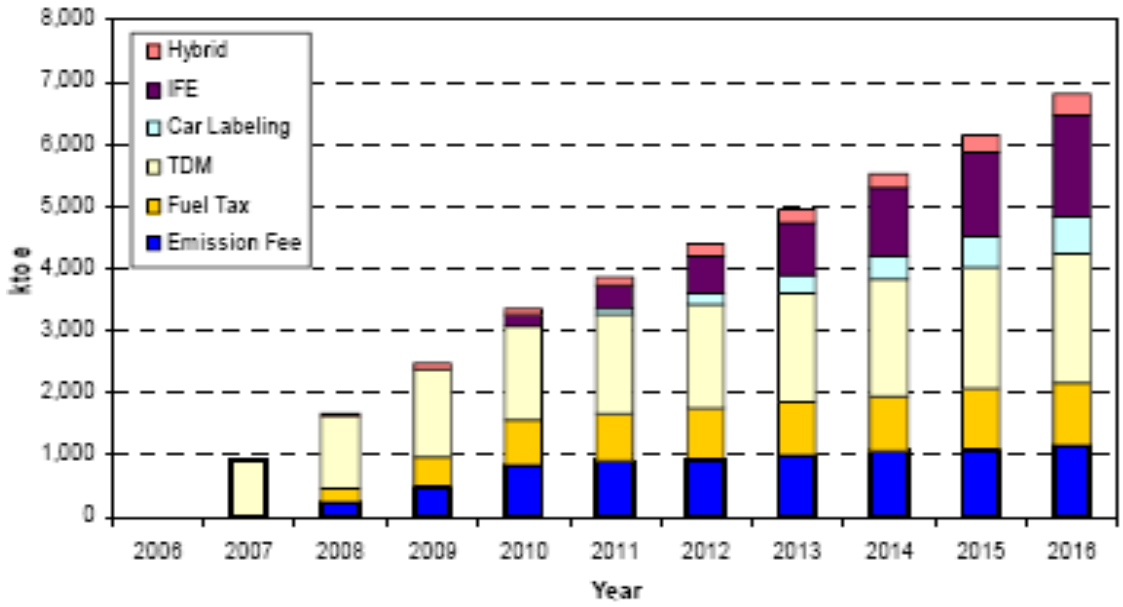


Figure 4.2 Energy Saving in the Transport Sector

Source: JGSEE,2007

4.5.2 Environment

Bangkok Metropolitan Administration (BMA) announced that the Global Warming effect as a result of green house gas will be more severe. APERC (2006) estimated that the amount of CO_2 in 2030 can doubled the figure in 2010 if nothing has been done. BMA responds to this problem by inaugurating the Bangkok protocol to reduce GHG in May 2007. This was announced during C40 Large Cities Climate Summit. The meeting also summarized 5 ways to reduce urban environment problems: 1) Improve Public Transport and traffic system, 2) Promote alternative fuel, 3) Improve energy efficiency in building, 4) Manage waste and waste water, and 5) Increase green area. The target is set so that CO_2 will be decreased by 20% in the year 2012 (from year 2007).

Transport in Bangkok contributes approximately 20 million tons of CO_2 in 2007, the improvement of public transport and traffic system can curb 5.33 million tons in 2012 (BAU 25 million tons). Measures to reach this target[6] include the expansion of rail transit, integration of public transport, ease of traffic congestion, auto restriction, and promotion of non-motorized transport (walk, bicycle). The promotion of alternative fuel can also lessen CO_2 emission. If Gasohol and Bio-diesel can replace the gasoline and diesel by 100 million liters per year, 0.61

6 **Comes from opinions of ways to improve environments in Bangkok**

million CO_2 can be saved in 2012. The promotion of alternative fuel includes the production of quality alternative fuel and gain acceptance by public.

At the moment, only Bangkok Metropolitan Administration has seriously been concerned with Global warming in Bangkok. Recently, A public organization responsible for global warming in Thailand has been established but has not got any focus about Bangkok transport.

The automotive regulation has played important role to reduce air pollution substances in Bangkok. The regulation will be even tighten in the future. Notably, emission reduction from New Vehicle : EURO IV in 2012.

The LEAP energy model analysis (JGSEE, 2007) also estimate national CO_2 saving. In short, the reduction in energy consumption and alternative fuel could contribute largely to CO_2 reduction. The CO_2 emission per population can decrease from 4.79 to 3.79 in 2016 (Figure 4.3).

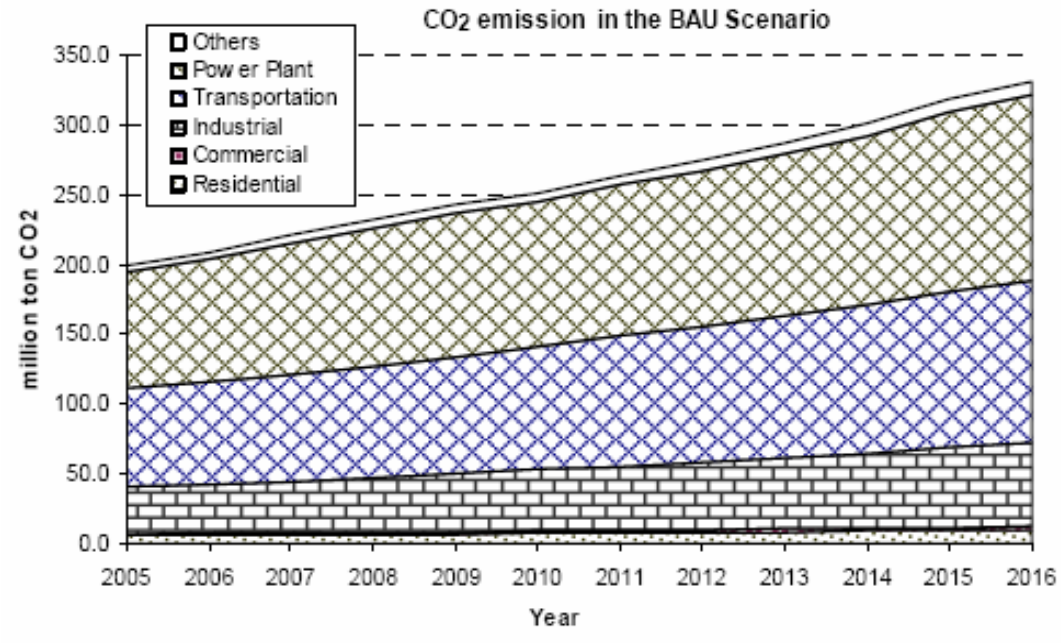


Figure 4.3 Potential Reduction of CO2 from Energy policy action

Source: JGSEE,2007

CHAPTER 5 RESEARCH GAPS AND NEEDS

5. Research Gaps and Needs

From the studies on literature, it is found that there are very limited pieces of research work and studies about energy and environment related to transport in Bangkok, Thailand. The related data are also limited. In practice, it is highly requested that many data must be collected for understand the situations and problems in this matter in Bangkok. From the interview, the key practical questions that require basic knowledge from the research and development at the moment are the quantification of the energy and environment situations, and the implication to the policy direction in the fields.

From data synthesis, it can be found that Bangkok lack data and analyses to give understanding on the present and future situation of energy and environment in Bangkok. With limited data, it is not easily or fully incorporate energy and environment in transport consideration. The data cannot give clear view on present status and thus it is difficult to find the impact of an alteration in transport system on energy and environment. Thus, the existing analyses cannot fully utilize the understanding and knowledge to develop policy direction in these matters.

The author lists possible research needs here.

Transport

- **Impact of road transport development on energy and environment conditions**

  Practical analysis on the impact of road transport development does not focus on the impact of energy and environment conditions. Basic research on the relationship between the amount of road transport and energy consumption is needed. This consideration must reflect a unique traffic operating condition and characteristics of transport system in Bangkok. Namely, vehicle fleet characteristics, level of demand and capacity, operating condition, etc. A sufficient amount of data and accuracy of data is also required to construct a good relationship between the energy/environment and transport.
- **A clear construction of trend in Bangkok transport and its implication on road transport and energy/environment. The trend of Bangkok transport by mode is currently forecast by transport model. The trend of Bangkok transport should be refined and announced as an indicator for the future**

status. It is a key data for envisioning the energy and environment situation in the future

- An introduction of exclusive consideration of energy and environment in transport planning is needed. In order to focus on energy and environments related to transport, the current transport consideration must explicitly concern with these matters. A transport planning process must incorporate the exclusive consideration. A methodology to consider energy and environment in transport planning should be introduced. The research to these matters can be the study on the methodology in transport planning, and the behaviors of travelers in relation to energy and environment. A better methodology that specifically focuses on the energy and environment can help transport planning consider the impact of transport on energy/environment. Any consideration of transport, such as the relationship between transport and land use in Bangkok, could show the impact on energy and environment as well.

Energy

- Research on the data collection technique to collect many important energy related to transport data for Bangkok. Since these data are not currently collected, it is necessary to collect all these data using a good method to yield highest quantity and accuracy.
- Research is needed to construct the energy efficiency in transport sector, especially in Bangkok. This requires detailed data on energy consumption in Bangkok, and the status of efficiency. The efficiency is one of important information to show the current status and opportunity for improvement. It also suggests the ways to improve energy efficiency in transport.
- The research that reflects the basic understanding of the effectiveness of energy efficiency improvement measures. The measures to reduce the amount of energy used in transport sector in Bangkok as well as to improve energy efficiency require a lot of knowledge through research. The measures range from vehicle fuel economy, the improvement of traffic operations, economic measures to improve efficiency such taxation and regulation, and the alteration of transport system usage such as the promotion of public transport and non-motorized transport (more efficient mode). The determination of the effectiveness of each measure needs thorough information that could be gained from research. Examples are
    - To announce a proper action on vehicle fuel economy, one must collect a lot of data on current status of vehicle performance and characteristics. In general, this data is unique for the area, and thus Bangkok should have a specific study in the area. Status of fuel

economy and automotive technology can be good data for proper determination and decision

- Improvement of energy efficiency through better road traffic operational management. A detailed analysis of traffic operation and its impact on energy is needed. Development of a tool, such as microscopic traffic simulation, that could show the impact of traffic management on energy consumption is requested. The study using this tool can show the potential on energy reduction by this measure.
- To promote more efficient mode of transport, one could study the concern of travelers on the energy and environment situation. This traveler behavior research could give better understanding on the impact of energy and environment condition on how a traveler travels. The price of energy can have impact on the mode choice and amount of travel. The concern with environments by travelers can show level of cooperation to use public transport, or voluntarily change their behaviors.

These understandings could support the consideration and decision of proper transport system modification in order to improve energy efficiency.\

Environment

- Research on the data collection and analysis technique to collect many important transport-related environment data for Bangkok is needed. Although some data are currently collected, it is necessary to update all these data to reflect the most recent condition. The data quality should be researched to improve its accuracy.

Research on how to raise awareness to public is needed. Environment problem must be concerned by public at large. The status of the problem and impact to society should be

- sought and presented to public. This picture could also be a good information for developing proper measures that gain acceptability by public.
- Accurate quantification of pollution from transportation is needed. A methodology to accurately calculate the amount of pollution is needed. This methodology should be detailed enough to reflect Bangkok unique transport system characteristics. A model to estimate the volume of emission and the model to estimate the diffusion of the pollution must be developed specifically for Bangkok.
- Researches to identify proper measures to reduce adverse environmental effect due to transportation in Bangkok are needed. Many measures are available, ranging from vehicle emission regulation, new types of vehicles

(such as electric vehicle), the modification of transport system usage, etc. Specific study should focus on the applicability of these measures in several ways.

CHAPTER 6 CONCLUSION

6. Conclusion

This study considers energy and environments issues related to transport in Bangkok, Thailand. The purposes of the study are to explore the current practices by various sources to see the level of development of such consideration and to suggest research needs and challenges in this field. In the study, several data sources are gathered, synthesized, and then conclusions are drawn. The attention is made at present situations on energy (fuel) and environments of road vehicles in Bangkok. The study also reveal several points in the present practices, such as the data availability, current methodologies that are used to consider these matters, existing actions to cope with the matters.

Present transport, energy (fuel consumption), and environment related to transport in Bangkok are illustrated. Transport is focused to motor vehicles since they bring the most contribution to energy and environment in Bangkok. The trend of traffic demand is clear, the popularity of private vehicles is growing. There will be more vehicles in Bangkok and thus traffic congestion in Bangkok will persist, the solution by public transport improvement, i.e. new rail service may not lessen the congestion and popularity as fast and at the amount as expected. The amount of fuel consumption in Bangkok is growing, despite the souring fuel price. Transport contributes to major portion of air pollution in Bangkok. Air quality is much improved due to tight measures and strict implementations.

The investigation on data, studies, and the implication from the synthesis reveals that many researches are needed to yield more understanding and develop proper methodology to address energy and environment from Bangkok transport. Since the current practice by authority requires the use of understanding and information to develop a proper set of policy directions, a set of research needs is proposed so that the end results. Mainly the improvement of data collection and analysis is needed. The detailed data analysis must be done to assess the future conditions as well as quantification of impact due to a measure. The development of tools to find the effectiveness of a measure is also needed. This research ranges from the study on travelers behavior in relation to energy and environment condition to the estimation of global impact to the city.

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