ERIA Research Project Report 2008
No. 7

Sustainable Automobile Society in East Asia

Edited by

Arianto A. Patunru

Kiyoyuki Minato

Masahiko Hori

Keiko Hirota

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With contribution by

Amita Baikerikar (ARAI)
Crispin Diaz (Univ. of Philippines)
George Sun (LTA)
Iman K. Resksowardojo (Institute of Technology Bandung)
Kiyomi Okiyama (JARI)
Li Wei (CATARC, Tianjin)
Lixin Fu (Tsinghua University)
Mazrura Sahani (National University of Malaysia)
Nguyen Thi Ha (Hanoi University of Science)
Nitin Labhsetwar (NEERI)
Nuwong Chollacoop (MTEC)
Seung Young Kho (Univ. Seoul)
Threepol Boonyamarn (TAI)

(alphabetical order)

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Preface

Project toward the
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At the time of this writing the world is facing a financial and economic slowdown to the extent comparable to that happened in 1930s. The region, East Asia had its part attacked by an economic crisis in 1997/98 started in Thailand and hit other neighboring countries, most notably Indonesia. It took years before the hardest hit countries recovered to their pre-crisis economic stands. And today another catastrophe emanating from lax financial management in the United States has spread to the entire world. If in the 1997/98 Asian crisis the affected countries might be helped by other, non-affected countries, in the current one almost every individual country needs help. Many believe the only solution to this problem is a concerted effort in a global level, or at least at regional level. Tackling the crisis alone will not be long lasting at best. At worst, it will only give leeway to the rise of protectionism, beggar-thy-neighbors policies, etc. The consequence would be dire: an imploding world economy.

The paragraph above might be sufficient to summarize how the world economy today. But it obviously misses the big picture: the sustainability of economic development. Reducing the scope of concern is natural, and might even be acceptable, especially in a non-normal time, like in the current crisis. But one should not entirely dismiss the bigger platform of social, economic, and environmental nexus. These three interrelated dimensions make the backbone of the so-called sustainable development: a process that develops for the current generation while leaving the future generation with an option to enjoy at least the same as what the former has today. There is no doubt, this concept is very big and might even sound too idealistic. Therefore it is understandable that any attempt to realize it has to go through small, sometimes marginal steps. Even so, that would involve many conflicting interests that require political will of each party to make compromises so as to agree on some middle ground or common goal.

The project of "Sustainable Automobile Society in East Asia" is one such attempt. What the project really is described in the first chapter. Here, it suffices it to say that the project takes the notion of sustainable development seriously and uses it as a viewpoint to a particular, important sector in the growing economy of East Asia: automotive. The initiative came from Japan Automobile Research Institute (JARI) whose concept fit very well with planned research projects of the Economic and Research Institute for ASEAN and East Asia (ERIA). The key words in the working group that imply the marginal, yet important pieces of the grander sustainable development are: better public and private modes of transportation, improved air quality, and hence improved economy. While all this can fall into a narrow, manageable focus, the group inevitably had to face larger-than-expected complexity. First, as sketched above, the region is again facing a difficult economic time. It is a big challenge to convince ourselves, not to mention those outside the group, about the importance of this issue, whilst the buzzword today is economic crisis. Second, even when we all agreed that yes this issue is nonetheless important, almost every member from different countries had to face another big problem: data availability.

Against the two main constraints, however, we were determined to continue. The current report should be seen as a very initial stage to set up the platform for building the sustainable automobile society in East Asia. It is humble in its objective, therefore. That is, to set the common tone that would be used in the stages that follow. Identifying and recognizing problems and threats at this level is natural. Solving them is a longer term objective. This was vindicated in the workshops: we have discovered more problems and challenges than solutions. We however see it as an achievement. As wisemen have put it: knowing problems is part of success.

On behalf of the group, I would like to thank ERIA, especially Professor Fuku Kimura and JARI, especially Dr. Masahiko Hori and Dr. Kiyoyuki Minato to make this project possible – of course with an equally important role of Ms. Keiko Hirota. Each individual member of the working group, from various countries and different backgrounds, has been contributing significantly. Finally, I am very grateful to have been part of this important project.

Jakarta, March 28, 2009
Arianto A. Patunru, Working Group Leader

Executive Summary of ERIA Research Project on Sustainable Automobile Society in East Asia

I. Background and Objective of the Research

Asian region has been facing air pollution and energy problems due to the rapid economic growth, urbanization and motorization. The "Project of “Sustainable Automobile Society" in East Asia” aims at sustainable development seriously from a viewpoint of automobile sector in the growing economies of East Asia. First, it is required to investigate actual condition on environment and energy issues in order to achieve the object of our project. Second, emission regulations and fuel quality requirement corresponding to the emission level need to be integrated in the Asian region. Third, based on these actual conditions of each area, countermeasure should be introduced. This research will contribute to not only economic development, but also fundamental development for regional integration.

II. Result of Workshops

ERIA Working Group (WG) on "Project toward the "Sustainable Automobile Society" in East Asia" had discussed the environment and energy situation in Asian countries in two ERIA workshops (WS). Our outstanding ERIA WG members lead the field of automotive and environment research. Country reports had been prepared for our report and supporting studies to share updated information by ERIA WG members at the 1st and the 2nd ERIA WS. In order to draw viable policy recommendations, the project coordinator had collected vehicle related information as a database from ERIA WG member countries.

Concerned with the increasing levels of air pollution caused by motor vehicles in Asia’s major cities, Japan Automobile Research Institute (JARI) developed a methodology for the research in the supporting study. The results of the supporting study were reported at the 2nd ERIA WS.

In the supporting study, air pollution in Bangkok was estimated using the collected data by themselves and from ERIA WS. Based on vehicle type, traffic volume, average speed, and emission factor, air concentration were estimated in Bangkok. This analytical method recommended by JARI will be adopted for a collaborative research project. There is still room for improvement, but it is

considered to be applicable for research for next year.

The database result showed that vehicle related policies were diverse by country. More popular vehicle type are, more detail category exists. With respect to I&M (Inspection and Maintenance), commercial vehicle is inspected with top priority. In some countries, inspection for private vehicle is applied after certain vehicle age. ERIA WG member countries have FQM (Fuel Quality Management), but sometimes the problem is operation and implementation. However, there was still lack of information from several ERIA WG member countries. It is still necessary to improve the quality and quantity of database to establish a common database of vehicle related issues for policy recommendation.

III. Conclusion:

Many policies have been proposed in each country, but they have not been implemented in a feasible and an effective ways. The proposal includes an integrated policy to establish environmentally sustainable development and to improve upon both air pollution and economies. The report concludes the improvements of I&M system, FQM system, emission regulation, AQM (Air Quality Management) system and PCE (Public Campaign and Education). In order to support these feasible and efficient policy recommendations for the wide variety of actual condition in Asia, it is very important to to establish a common database of vehicle related issues.

Taking into consideration the health costs and economic development, earlier implementation of air pollution reduction policies will gain better economic development in the future. In other words, early political implementation will prove to be a cost-effective method in the long run. As conclusion, initiatives of feasible and effective policy implementation in Asia should be the followings.

- Needs effective policies
- Needs consensus
- Needs public awareness.
- Needs better implementation/enforcement.

At the 2nd ERIA WS, it was agreed that a forum would be held on November or December 2009. The forum aims to share the future projection by automobile companies and ERIA.WG members.

1. Introduction

Recent economic growth in Asian region is remarkable as compared to other regions. This economic growth leads to the improvement of the quality of life. One of the key developments is improved transportation such as motor cycle, car and commercial vehicles. However, increased personalized transport leads to rapid and uncontrolled growth of vehicles. This eventually results in adverse impacts on air quality, energy security and traffic accidents. This also contributes to global warming as it has already become an important issue in developing countries. Air quality improvement and energy security are more important priorities than traffic accident and global warming at the first step of the motorization.

Measures to improve the air quality include automobiles with latest and advanced technology, which are relatively much cleaner on the road. However, it is often difficult to introduce them. The reasons are high cost of the latest automobiles, insufficient infrastructure such as car maintenance system, supply of reliable spare parts and optimum fuel quality, which must correspond to the level of emission regulations and vehicle technology. There are many type of vehicles in the market and it needs much time to switch to the latest model. In general, it needs about ten years to exchange to the latest one and therefore this option can not be considered as an immediate solution for "Sustainable Automobile Society".

The "Mobility 2030" published by the World Business Council for Sustainable Development (WBCSD) reported that two-stroke engines, widely used for two- and three-wheelers in developing countries, are likely to disappear over the course of the next decade, to be replaced by more efficient, cleaner four-stroke engines. For example, a moppet equipped with 50 CC two stroke cycle spark ignition engine can emit up to hundred times more HC emissions of latest car with 2000 CC displacement of spark ignition engine. Automobiles and light-duty trucks, catalytic converter-equipped motorized two- and three-wheelers will require unleaded and low sulfur fuel, raising issues of affordability and correct fuel use as well as vehicle maintenance. In the developed world these challenges seem surmountable. The prognosis is much more uncertain in developing countries and therefore an important issue for Asian region.

The member countries of this WG are consisted of developed and developing countries, so that suitable collaboration between working members is possible to discuss the issues for improving air quality in Asian big cities. This is a purpose of this WG, and in the first step of 2009 project, it is decided to assess actual situation on environment and energy issues, in order to achieve this objective. At the same time, optimum fuel quality standard and emission regulations are needed to be integrated in the Asian region. Based on these actual conditions of each area, countermeasure should be introduced in the second step. This research project will contribute to not only economic development, but also fundamental development for regional integration. This is clearly in line with the mandate of ERIA to "support ASEAN's endeavor to build the ASEAN Economic Community and support its role as the driver of the wider economic integration." [The Statement on the Establishment of ERIA, June 3, 2008].

2. WG Structure

Members are supposed to be outstanding researchers in the field of automotive and environment research, and lead supporting studies in respective fields. The member list of the WG is shown in Table 1. Country reports have been prepared as supporting studies to share up-to-date information on the progress. In order to draw viable policy recommendations, the project coordinator will work closely with the ASEAN secretariat.

Table 1: ERIA WG research members

Country	Organization	Name	Research Field	Title
The Republic of Indonesia	LPEM-FEUI University of Indonesia	□ Arianto Patunru	Economics	Research Director
Japan	JARI	○ Kiyoyuki Minato	Environment	Senior Chief Researcher
Australia	Murdoch University	Frank Murray	Engineering	Associate Prof.
The People's Republic of China	Tsinghua University	Lixin Fu	Air pollution	Professor
The People's Republic of China	CATARC	Li Wei	Engine/ Environment	Director
The Republic of India	NEERI	Nitin Labhsetwar	Air Pollution	Senior Researcher
The Republic of India	ARAI	Amita Baikerikar	Automotive Engineering	Senior Assistant Director
The Republic of Indonesia	ITB	Iman K. Reksowardojo	Engine	Professor
Japan	Chuo University	Shigeru Kashima	Traffic Planning	Professor
The Republic of Korea	Soeul National University	Seung Young Kho	System Engineering	Professor
Malaysia	National University of Malaysia	Mazrura Sahani	Health Sciences	Program coordinator
The Republic of the Philippines	University of Philippines	Crispin Diaz	Urban and Regional Planning	Associate Prof.
The Republic of Singapore	LTA	George Sun	Traffic Engineering	Deputy Director
The Kingdom of Thailand	MTEC	Nuwong Chollacoop	Traffic/ Environment	Researcher
The Kingdom of Thailand	TAI	Threepol Boonyamarn	Engine	Engineering Section Manager
The Socialist Republic of Viet Nam	Hanoi University of Science	Nguyen Thi Ha	Traffic/ Environment	Associate Prof.
Japan	ERIA WG Secretariat	Masahiko Hori		
Japan	ERIA WG Secretariat	Kiyomi Okiyama		
Japan	ERIA WG Secretariat	Keiko Hirota		

□ Leader ○Sub-leader

Supporting study has been conducted to suport and encourage the WS. An analytical measure to improve air pollution in Asian big cities that is data collection, evaluation of emissions from each category of vehicle and estimation of air pollution, has been conducted as supporting study in 2008. The trial study conducted by Japan Automobile Research Institute (JARI) was introduced at the second WS held in Bangkok during Feburuay 18, 19, 2009. Information about vehicles, traffic flow, regulations, standards, statiscal data, evaluation method and others were provided by members as a part of country reports and technical presentations. However, these data were different from each contry and in some cases, there was lack of data and anlytical methods, and it appeared that common and precise data, statistical treatments and analytical measures are needed to plan appropriate strategies to improve air quality in Asian big cities.

3. Approach to Clean Air in Asia (Based on the supporting study)

3.1 Summary on Air Pollution in Asia

Global environment issues are being addressed as a pressing matter these days, and tackling them is considered to be an urgent need. However, difficult global challenges such as global warming are not the only current environmental issues making the daily lives of people at stake. Air pollution, a serious social issue as one of the environmental problems on a rather local scale, has been aggravated yet further, rather than solved.

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. The nature and manner of the advances of these city activities differ among countries, and the resulting environmental issues vary as well.

The improvement of living and income standards, among others, has encouraged the use of automobiles, and accelerated rapid motorization. On the other hand, poor public transportation systems have increased private use of cars (personalized transport), which has significantly contributed towards deterioration of the urban environment. Emission from motor vehicles is certainly affecting public health. 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 preserve the healthy and productive environment in society.

If the motorization enters into its full-scale stage and things are left as they are, aggravated energy problems and deteriorated urban environments will bear heavily in Asia. The main factors that motor vehicles 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 immediately address this issue and implement environment-friendly transportation systems. Under the progress of motorization, Asian countries share similar problems related to automobiles. The main issues are as follows:

(1) Worsening air pollution and increasing health impacts
(2) Deterioration of living environment due to traffic noise and road

vibration.
(3) Increasing deaths and injuries from traffic accidents
(4) Traffic congestion from increasing traffic demands, leading to indirect health impacts and loss of man-hours.

We propose various technical and non-technical measures for tackling the present problem. These are based on some surveys and discussions during the various meetings of experts. To build up better automobile society in Asia, we should work on these issues:
Technical measures:

(1) Reduction of emissions from motor vehicles by upgrading inspection and maintenance systems
(2) Reduction of emissions from motor vehicles by improving the quality of fuels
(3) Strengthening the restriction on emissions from motor vehicles
(4) Popularizing clean energy and clean-energy vehicles
(5) Promotion of harmonization of technical regulations.

Non technical measures:

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

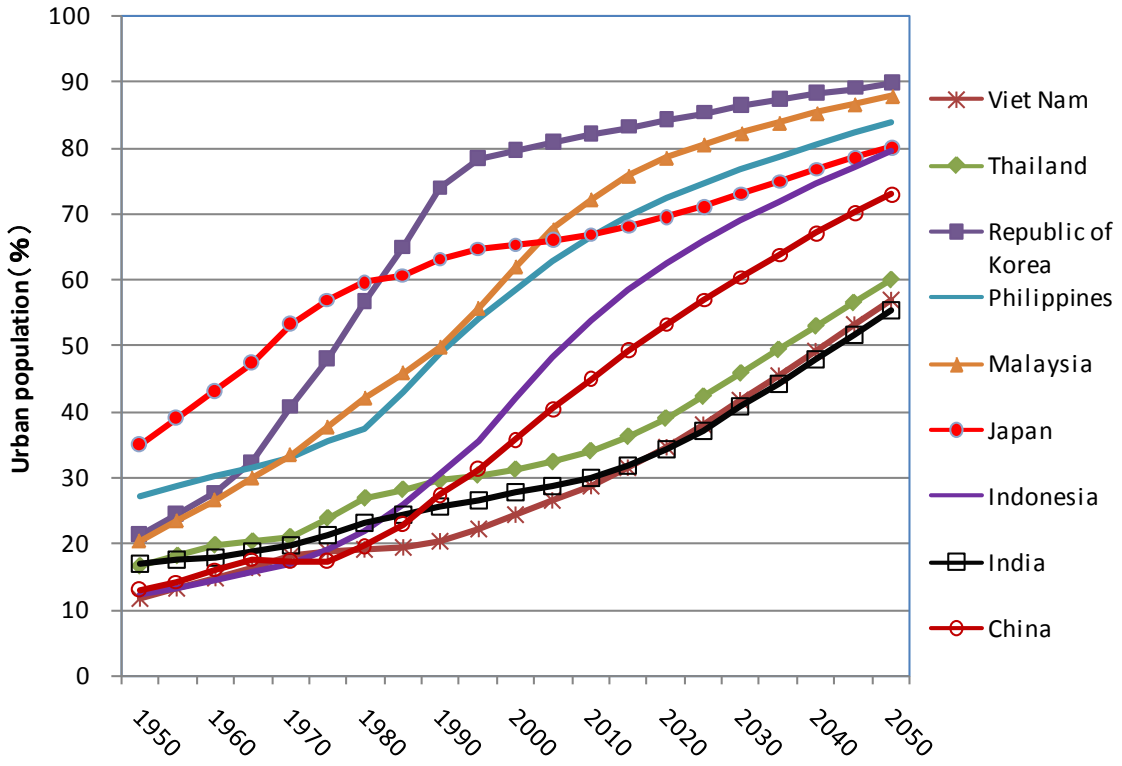
To deal with urban environments, it is essential to implement effective means such as accurate understanding of real traffic conditions and exact problems in each city and country. The measures stated above may show excellent cost effectiveness for Asian countries, and these policies and measures could prove techno-economically effective in improving urban air pollution. 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. One of the most important objectives of this WG is to understand the success and failure of different measures to control the automobile pollution in different Asian countries and learn better implementation. This could be the first systematic exercise of its kind, dealing with the exploitation of experience from various Asian developing countries, rather than developed countries, which has so far been the trend in auto-emission management.

3.2 Asian scenario

(1) Urbanization in Asia

Indicators of air quality in the largest cities of Asia show that although many of these cities are among the most polluted in the world, air quality in many cities has generally been improving over the past few years. To improve air quality further, Asian cities must respond to the combined pressures of rapid growth in urban population, motorization, economic development, and energy consumption. Asia is expected to account for most of the growth in world economic activity by 2030. Asia currently has about 1.5 billion people living in urban areas, and this number is growing at an average of 4% per

year. Increasing urbanization presents considerable problems in Asia. Growing numbers of people are being attracted from rural areas to towns and cities with growing populations, where emissions are concentrated and air quality is most degraded. This results in increased exposure of population to air pollutants. The future urban population growth in most Asian countries will drive increasing motorization and will have serious consequences for urban road congestion and air pollution as vehicle numbers continue to grow.



Source: http://esa.un.org/unpp/p2k0data.asp

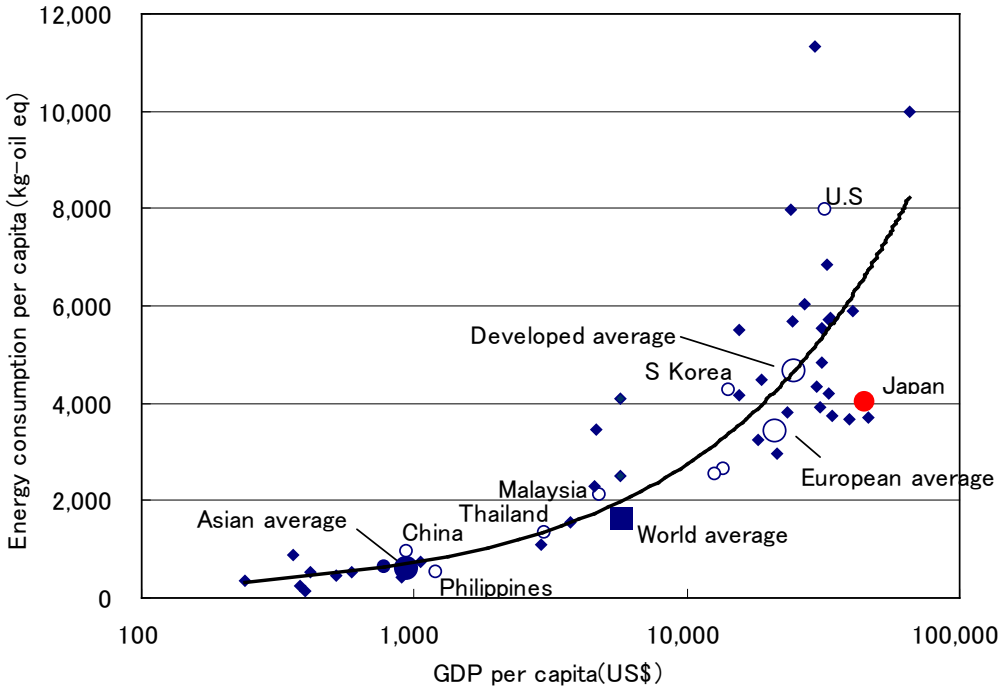
Figure 1: Urbanization in Asia

(2) Economic growth and energy consumption

As the populations of large cities is rapidly growing, increased demand is placed on the capacity of the city to provide energy, housing, employment, resources, and transportation (generally motor vehicle)—with potential to further increase emission load to already deteriorated air quality. Much growth in the world's economic activity in 2030 is expected to be in Asia. The gross domestic product (GDP) in Asia has increased at a rapid pace over the last years and is expected to expand at an annual average rate of 5.7% compared with 3.3% per year for the world as a whole(IEA World Energy Outlook 2008).

The growth in GDP is leading to even stronger growth in energy consumption, with Asia expected to account for 40% of the total projected increase in world energy

consumption and 70% of the increase in developing country consumption by 2030. Population and economic growth have the potential to increase emissions in the absence of increasingly stringent measures to control these emissions. However, the most rapidly growing economies are generating the economic wealth and specialized knowledge needed for effective air quality management, fuel quality, emissions control technologies, and industrial restructuring, etc.



Source: IEA Energy Balances of Non-OECD Countries

Figure 2: Energy consumption and GDP

(3) Air pollution in Asian cities

The major sources of air pollution in Asian cities are motor vehicles, large stationary sources such as power stations and other major industries. Public demand for motorization in Asian countries is growing at different but usually at rapid rates. The types of motor vehicles in Asia are diverse, which affect the setting of emission regulations. Action to control emissions from motor vehicles has been impressive in many countries of Asia, but considerable challenges remain in some countries with the proliferation of old vehicles. The growth in vehicle population and the relatively large emission rates from certain types of vehicles in Asia represent particular challenges. The growth in motorization has the potential to increase emissions of HC, NOx and particulate matter (PM) (See: Appendix 2-1, Table A 2.1), including particles with diameter not more than 2.5 microns (PM2.5) if not effectively controlled. This can then lead to the production of photochemical smog and other air pollution as well as health problems extending far beyond the boundaries of cities. This would potentially have severe effects on food security

and biodiversity in agricultural and natural areas.

(4) Major issues to be implemented

(a) Reduction of motor vehicle emissions by upgrading Inspection and Maintenance (I&M) system

Combustion-powered vehicles naturally tend to deteriorate with age and usage, and as a result emission levels can rise significantly. Relatively inferior fuel quality and cheaper vehicle technology further contribute to I& M requirements. Good maintenance is required to keep emissions levels at or near design levels. Targeted I&M programs, however, can identify problem vehicles and assure their repair, thereby contributing substantially to lower emissions and improved air quality.

Without appropriate maintenance and check-ups, the performance and safety of motor vehicles will inevitably deteriorate, which will increase the environmental pollution. In Asia the ratio of used motor vehicles is high, and the longer a motor vehicle is used the more emissions it emits. While trading in used vehicles for new ones may be an effective solution, a motor vehicle I&M system or restrictions on motor vehicles emitting excess emissions can also reduce generation of emissions by 30 or 40%, at a much lower cost. Governments should establish at least the minimum number of items for motor vehicle I&M to ensure the safety of motor vehicles in use and prevent pollution. It has been identified during the present study that there are several issues and possible improvements with respect to I&M in many Asian countries. This could be an immediate recommendation towards achieving a Sustainable Automobile Society.

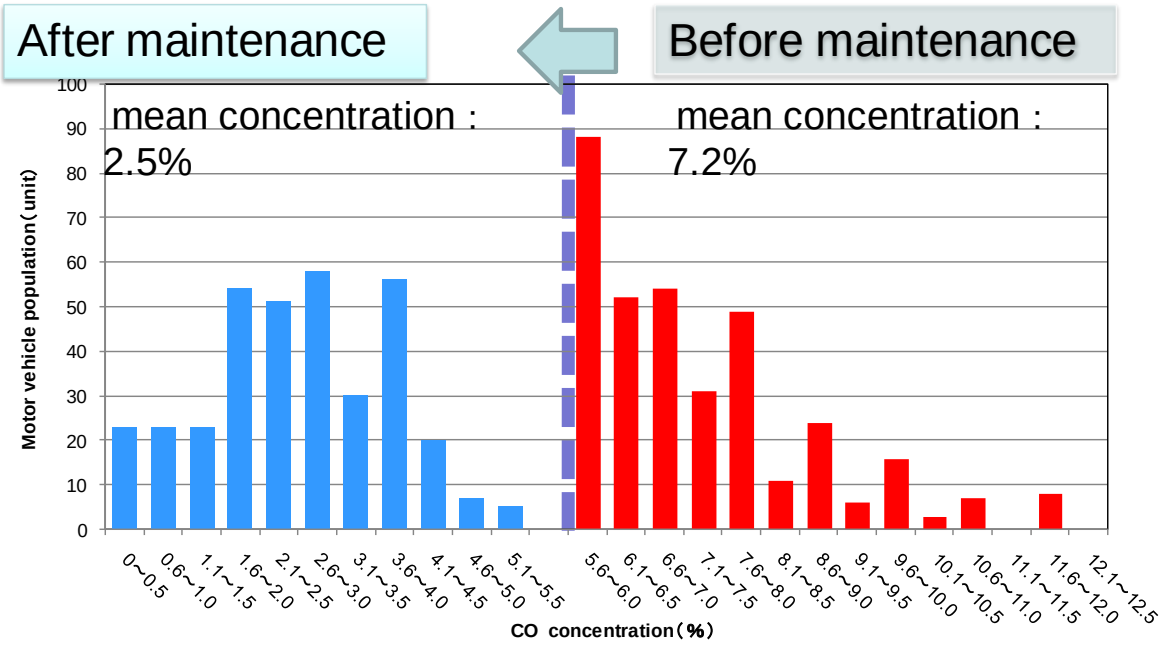


Figure 3: Non-I&M vehicles vs. I&M vehicles (CO)

(b) Strengthening the restriction on emission from motor vehicles

In Asia, motorization has caused air pollution in vast areas and has deteriorated living conditions. It is expected that the further increase of population and motor vehicles could 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 motor vehicle emissions.

Though several countries have been addressing this issue aggressively, Asian countries at present do not have harmonized emission regulations. Many countries began to develop emission regulations in the 1990s, some countries, especially the smaller ones, do not yet have emission regulations for new vehicles. The emphasis thus far has been on the development of emission regulations for light-duty four-wheeled vehicles, followed by emission regulations for heavy-duty vehicles. Table 2 indicates that the average lag time between Asia and Europe is gradually being reduced to less than 5 years for countries such as China, India; and Thailand. It may also be important to start implementing tougher regulations with respect to CO_2 emissions, considering the importance of global warming challenge.

Table 2: Current and proposed emission standards for new vehicles in Asia

Country	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14
European Union	E1	Euro 2					Euro 3				Euro 4				Euro 5					E6
Bangladesh[a]											Euro 2									
Bangladesh[b]											Euro 1									
PRC[a]							Euro 1			Euro 2			Euro 3			Euro 4				
PRC[c]							Euro 1		Euro 2			Euro 3			Euro 4 Beijing only					
Hong Kong, China	Euro 1		Euro 2				Euro 3					Euro 4			*Euro 5*					
India[d]							Euro 1				Euro 2					Euro 3				
India[e]					E1		Euro 2				Euro 3					Euro 4				
Indonesia											Euro 2									
Republic of Korea												Euro 4			Euro 5					
Malaysia			Euro 1											*Euro 2*				*Euro 4*		
Nepal						Euro 1														
Pakistan	No conclusive information available																			
Philippines									Euro 1				Euro 2							
Singaporc[a]	Euro 1						Euro 2													
Singapore[b]	Euro 1						Euro 2					Euro 4								
Sri Lanka									Euro 1				*Euro 2*							
Taipei,China					US Tier 1									US Tier 2 Bin 7[f]						
Thailand	Euro 1						Euro 2			Euro 3								Euro 4		
Viet Nam													Euro 2							

Source: ADB A Road Map for Cleaner Fuels and Vehicles in Asia, 2008

(c) Reduction of motor vehicle emissions by improving the quality of fuel

Over the course of the past 30 years, pollution control experts around the world have come to realize that cleaner fuels must be a critical component of an effective clean air strategy. Fuel quality is now seen as not only necessary to reduce or eliminate certain pollutants (e.g., lead) directly, but also a precondition for the introduction of much important pollution control technologies.

The most important impediment to adopting state-of-the-art new vehicle emission technology (equivalent to Euro 3 and 4) in Asia is the fuel quality, especially the level of lead and sulfur in gasoline and the level of sulfur in diesel. These parameters should receive highest priority in the development of medium- and long term strategies for fuel standards. The long-term vehicle emissions regulations strategy is to adopt Euro 4 regulations for light duty vehicles, and Euro 4 and 5 regulations for light duty and heavy duty diesel vehicles, respectively.

Setting fuel standards will require institutional mechanisms that actively include a variety of stakeholders (government, private sector, and civil society) and extensive consultations to discuss on various aspects. In countries where such an institutional mechanism is not yet in place, it should be created. With respect to the involvement of the private sector, it is important that both the oil and the auto industry are fully involved in such discussions. Because the environment and public health concerns are the driving force behind improvements in fuel quality, the Government should have a major role in setting fuel standards. In order to implement stricter fuel standards and increase the acceptability of the associated costs to consumers, countries should institute more and better awareness campaigns. Such campaigns must emphasize the public health consequences of not improving fuel quality.

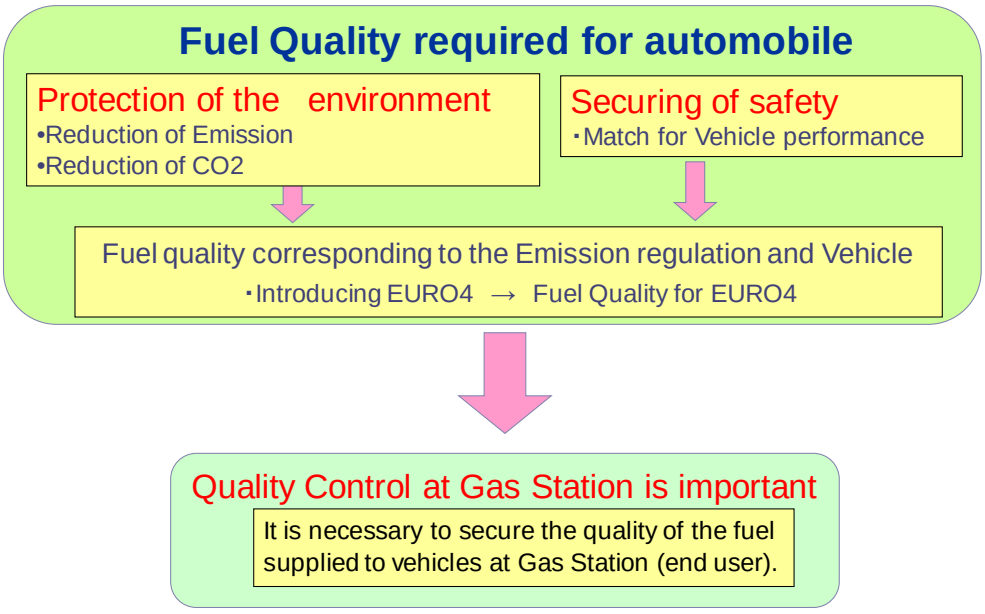


Figure 4: Requirement of automotive fuel quality control

Table 3: Current and proposed sulfur levels in Diesel in Asia, EU

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
European Union					500					50(10)[a]				10			
United States	500										15						
Bangladesh							5,000										
Cambodia					2,000				1,500								
PRC (nationwide)[a, b]	5,000						2,000			500							
PRC - Beijing	5,000						2,000		500	350			50				
Hong Kong, China		500					50					10[c]					
India (nationwide)	5,000				2,500					500					350		
India (metros)	5,000				2,500	500				350[c]					50[c]		
Indonesia	5,000										3,500				350		
Japan[d]	500									50		10					
Republic of Korea	500							430	100		30	10					
Malaysia	5,000		3,000				500[e]			500[f]							50[c]
Pakistan	10,000						7,000[e]										
Philippines	5,000					2,000			500								
Singapore	3,000		500								50						
Sri Lanka	10,000							5,000[d]			500						
Taipei,China	3,000			500			350		100				50				
Thailand	2,500			500					350		150				50		
Viet Nam	10,000											500					

Source: ADB A Road Map for Cleaner Fuels and Vehicles in Asia, 2008

(d) Monitoring system for air pollution

There is no organized information collection system for danger and direct effects of air pollution to the health. This is generally because of the lack of monitoring networks and data processing capacities to monitor appropriate data on the air quality, and composition of pollutants or epidemiological data in relation to sources of pollution. Measures against automobile emissions must contribute to reduction of air pollutant concentration, but without appropriate data, it is impossible to assess, which measure is preferable being most effective. Epidemiologic research and basic observation of the atmosphere are necessary.

4. Measures for Sustainable Future

In future, increase of motor vehicle use can negate the effort towards emission reduction in Asia. It is important to introduce an integrated policy for sustainable transport system in Asia. When we introduce a strict emission regulation, without availability of fuel of adequate quality for the technology to correspond to the level of regulation, it is difficult to maintain the better air quality. If we do not maintain or exclude high emitter vehicles that emit harmful gases in volumes several fold (gross polluters), than that of latest car air quality will not be improved to the desired level. If we do not monitor air quality in urban settlements continuously, we can not reliably evaluate the impact of implementation of environmental policies. If environmental and energy policy, regulations and standard are introduced already; lack of awareness of people to implement these policy can lead to ineffective implementation. In order to implement

these policies, it is very important to collect common data such as vehicles, traffic conditions, other fundamentals, to have common measure to statistical analysis and also to introduce effective education for administrators and technocrats. We, therefore, propose the integrated policy as shown below:

- **Build up appropriate I&M programs**
- **Improving Fuel Quality**
- **Strengthen Emission Regulations**
- **Proper Air Quality Monitoring**
- **Public Campaign and Education for Environmental Awareness**
- **Establishment of Common Data Base.**

Air with good quality brings people to a healthy society

5. Summary and Conclusion:

ERIA WG on Project toward the "Sustainable Automobile Society" in East Asia" has discussed the environment and energy situation in Asian countries, and has collected vehicle related data from the member countries. Additional data were supplied to the supporting study by Japan Automobile Research Institute (JARI), while JARI has also estimated air pollution in Bangkok using these data and their own data. The results of the supporting study were reported at the 2nd ERIA WS and an analytical method recommended by JARI has been discussed for next year collaborative research project, when the project is adopted. However, it was clear that the data base concerning vehicles and other related items is insufficient to assess the air quality in all Asian countries with reasonable reliability. We, therefore, propose to the ERIA for a data collection system and establishment of a common automobile data base in Asia.

Many policies have been proposed until now, but effective and feasible plan has not been often implemented, which made these policies ineffective. We, therefore, propose an integrated policy to establish environmentally sustainable development to improve upon both air pollution and economics. This includes improved I&M (Inspection and Maintenance) system, FQM (Fuel Quality Management) system, Emission Regulation, AQM (Air Quality Management) system and POE (Public Campaign and Education).

ERIA Initiatives for Better Air Quality in Asia

- **Needs Effective Policies**
- **Needs Consensus**
- **Needs Public Awareness.**
- **Needs better implementation.**

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:

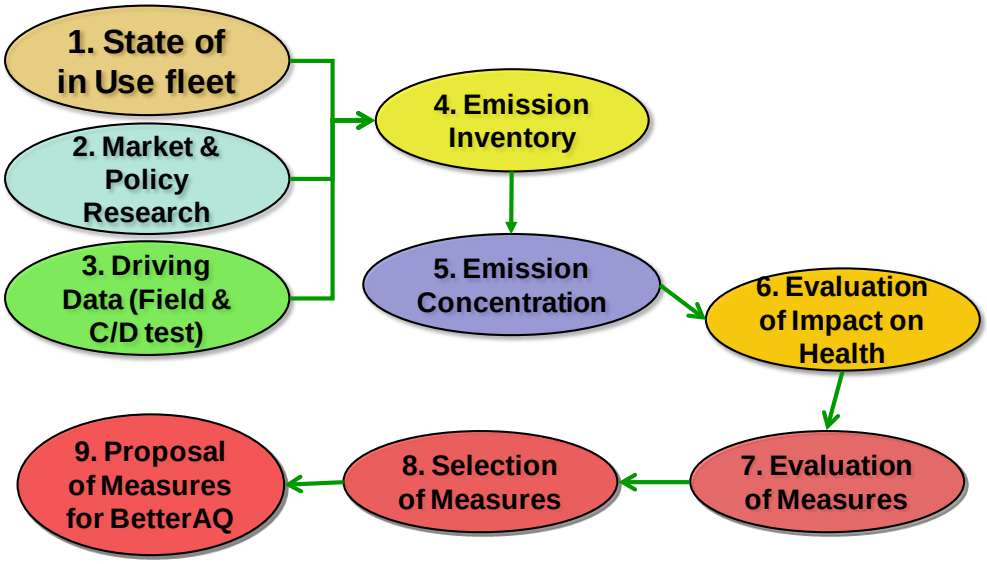


Figure A 1.1: The approach of the study

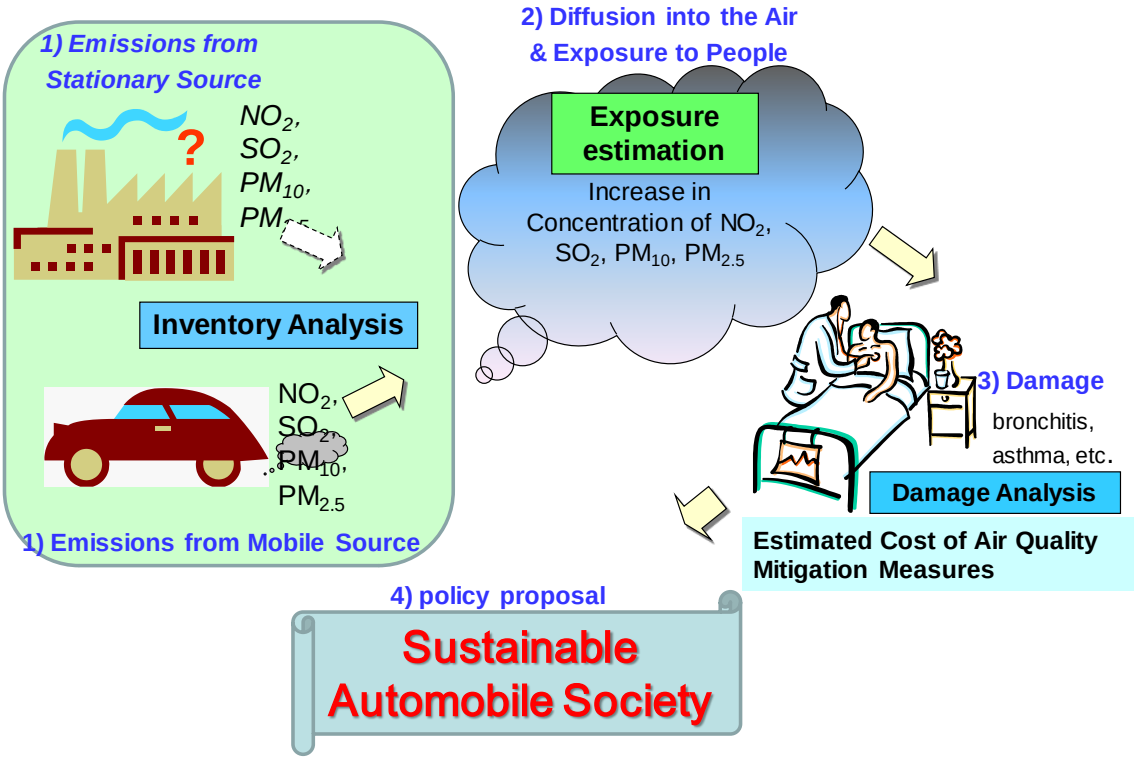


Figure A 1.2: Scheme of the study

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.

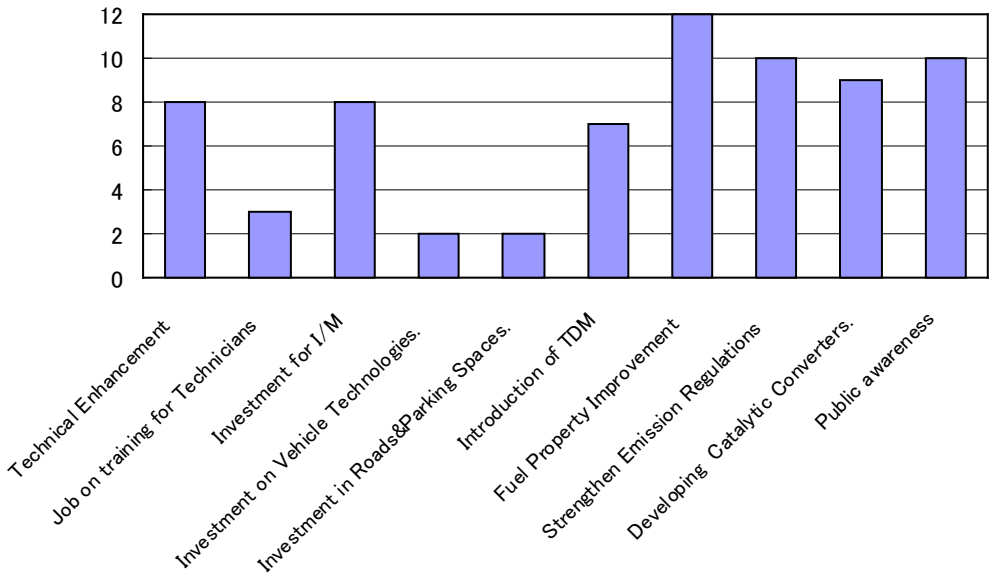


Figure A 1.3: Results of APEC questionnaire survey

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

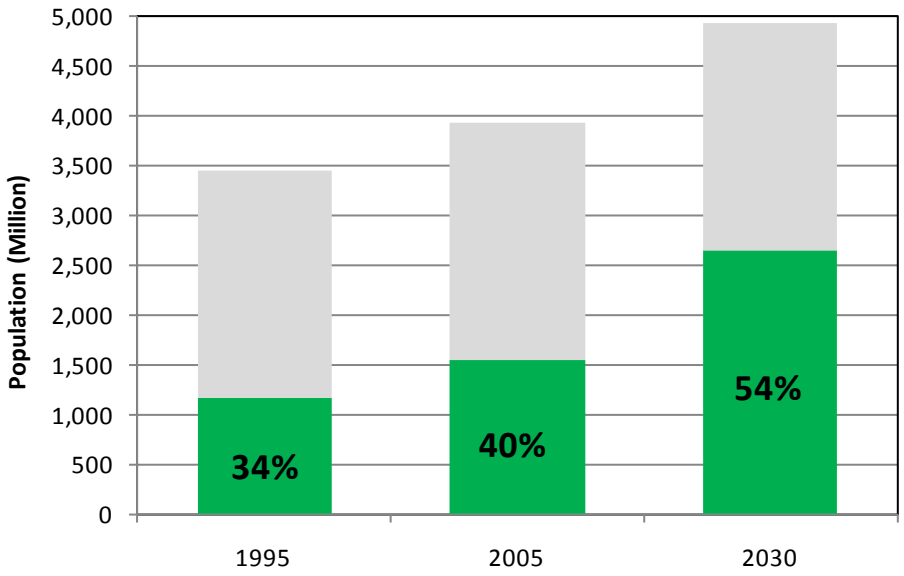
There is no organized information collection system to reliably assess the adverse effects of air pollution to human health. This is generally because of lack of adequate monitoring networks and data processing capacities to monitor air quality and composition of pollutants or epidemiologic data to extract 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.

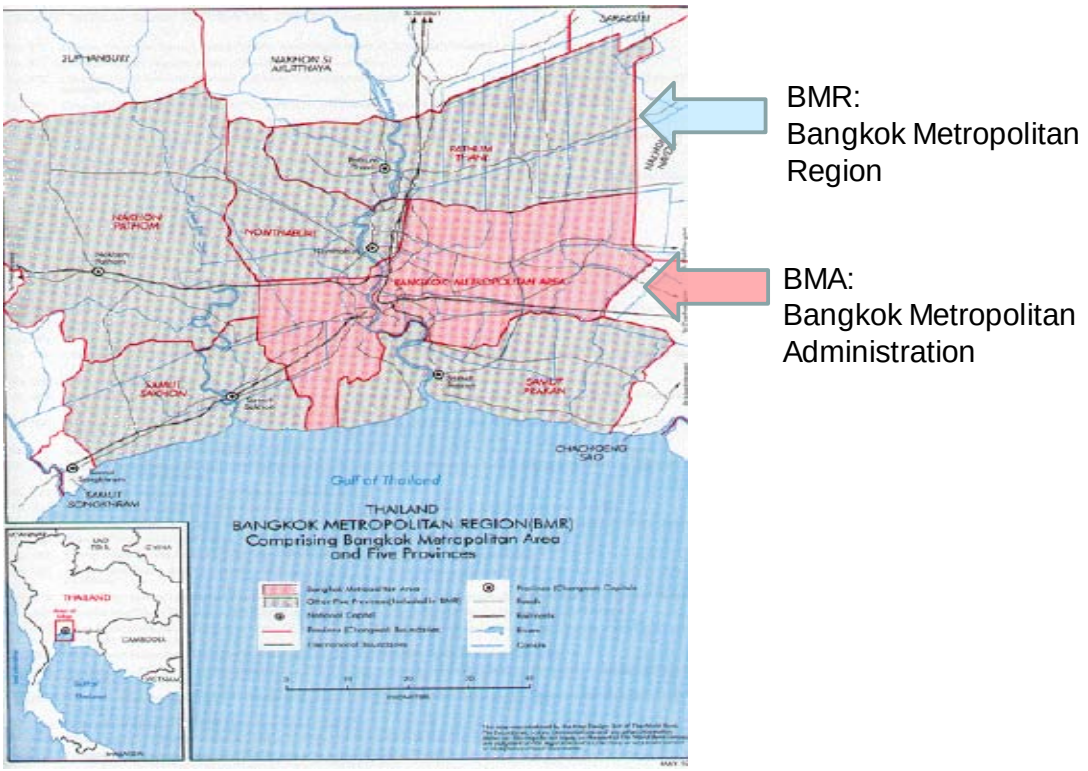


Figure A 1.5: Map of study area (Bangkok, Thailand)

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)*		*Growth Rate*
	2003	*2017*	*(% 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

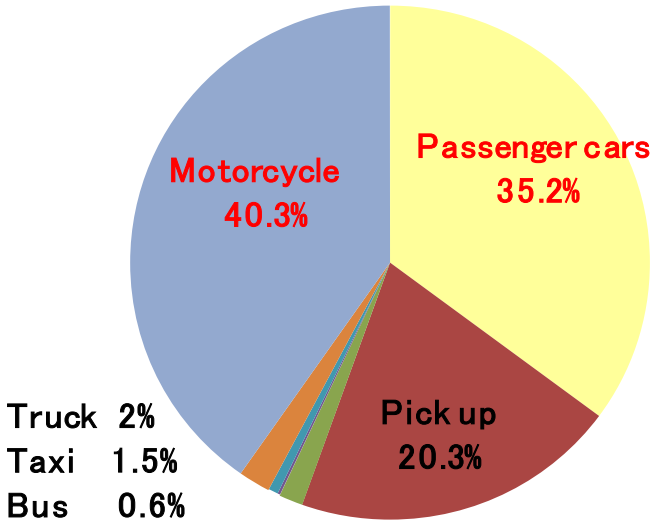
The dynamics of car ownership are affected by economic, technological and social factors. We can use the word "dynamics" to describe this aspect of motorization since ownership patterns can be expected to change because of change in income, urban structure, vehicle technology as well as social norms. 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.

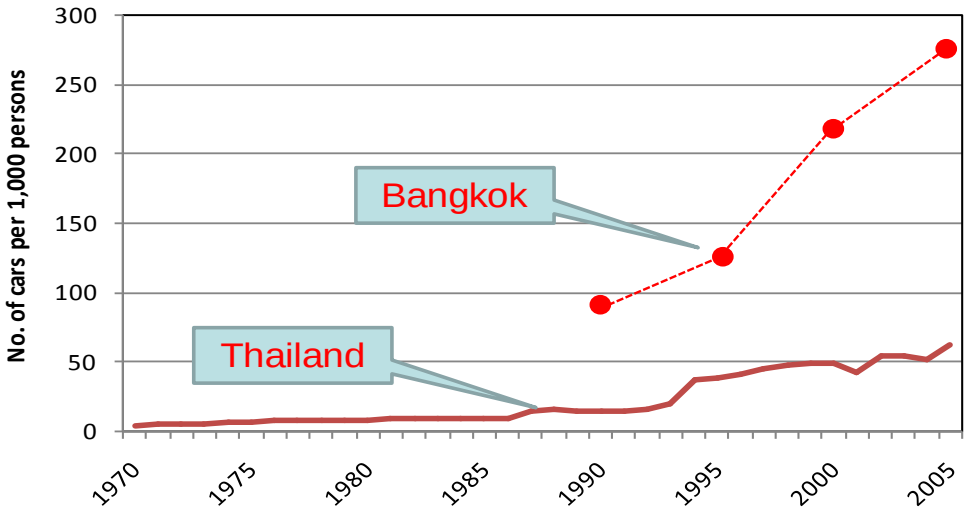
Table A 1.6: Number of in-use vehicles in Bangkok (1994 & 2006)

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.

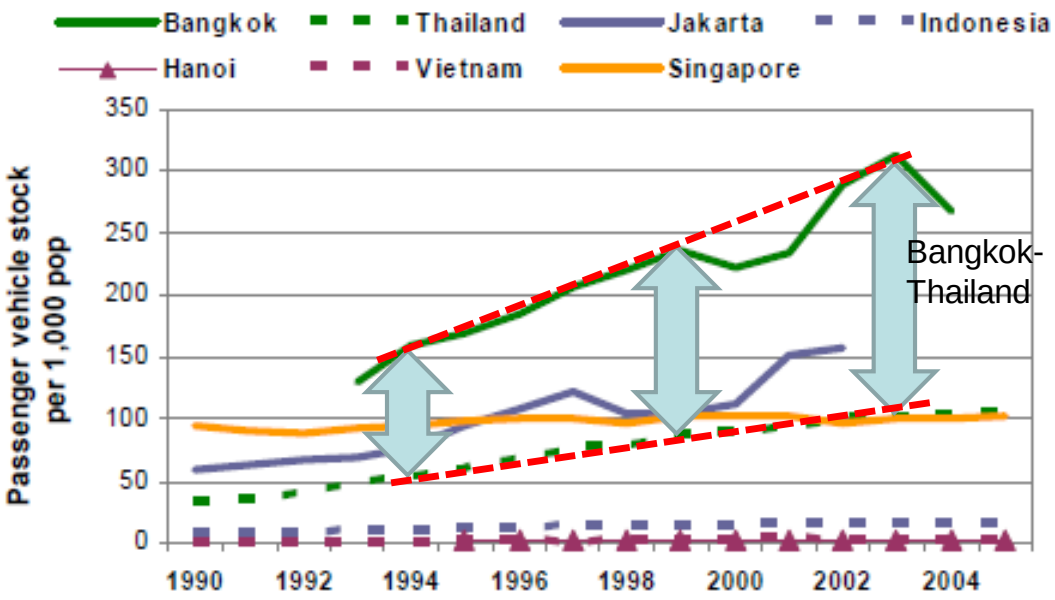


Source: APEC report 2007

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.

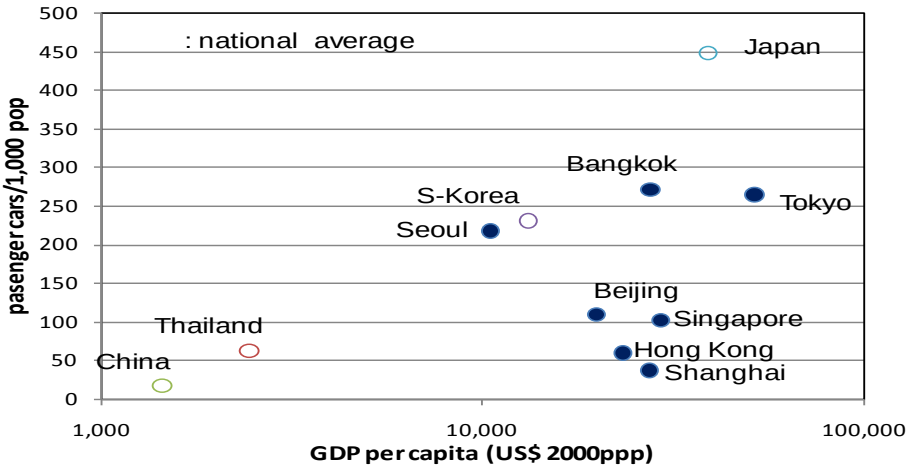
In Asia, a wide gap between the national and the city levels is also seen between Bangkok-Thailand, and Jakarta-Indonesia. Passenger vehicle stocks in Jakarta have been increasing while those in Indonesia have remained low. In Hanoi–Vietnam, however, passenger vehicle stocks have remained low at both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

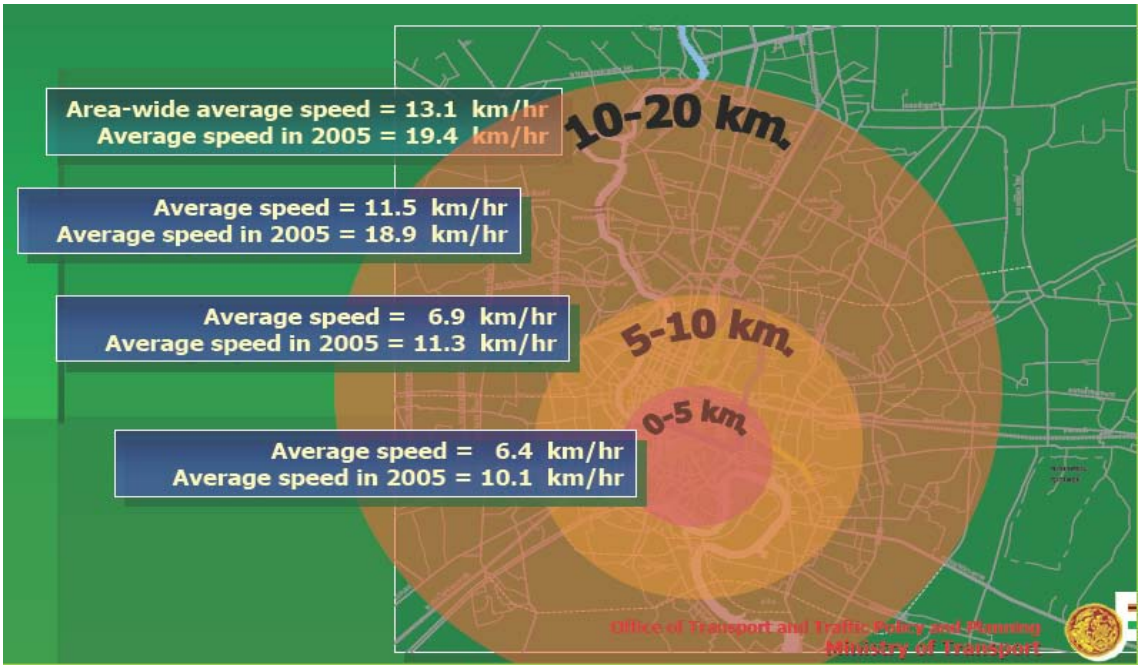
4.6 Trends in Vehicle Speed

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	Thailand	BMR shares (%)
	(million liter)	(million liter)	
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.

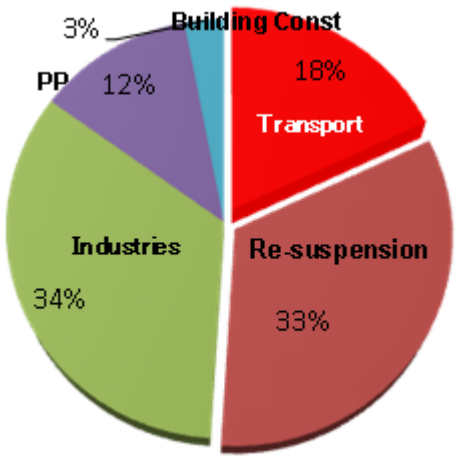
After Thailand's economic crisis occurred in 1997, the country was facing a negative value of GDP. In 1998, the transport fuel consumption in Bangkok was down by 67 percent from the previous year and by 83 percent from 1990. This has asserted a significant effect on Bangkok air quality and it is interesting 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.

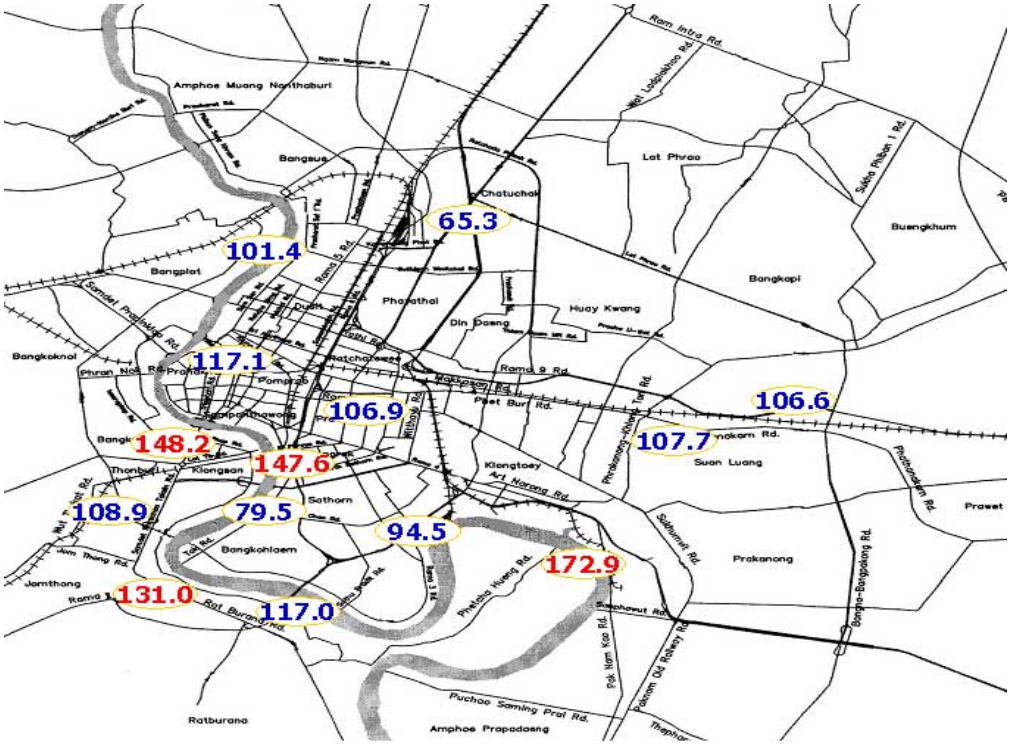
A recent 2007 study of PM source apportionment for five sites in the Bangkok Metropolitan Region (BMR) summarized shows that PM2.5 is the major component of PM10 comprising about 60% of PM10 mass in dry season and over 50% in the wet season. The major contributors to PM2.5 are traffic emission (diesel 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

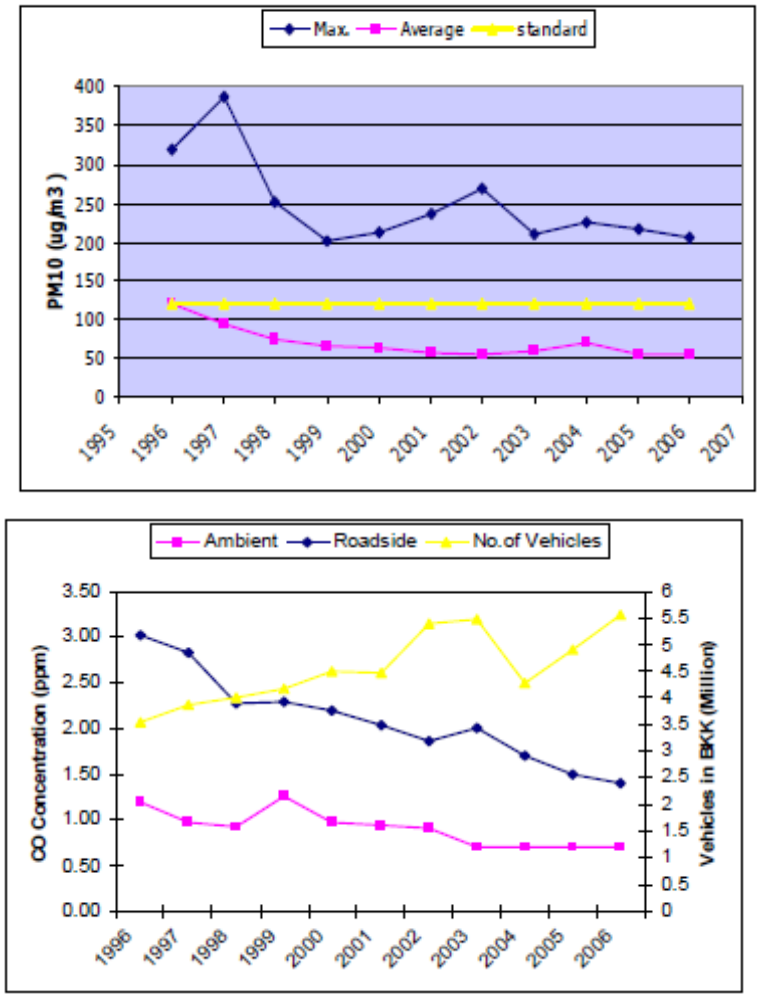


Source: Thailand Environment Monitor 2002

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.

Appendix 2-1: Database Results

Database Results of ERIA Research Project

on

"Project toward the "Sustainable Automobile Society" in East Asia"

Economic Research Institute for ASIAN and East Asia (ERIA)

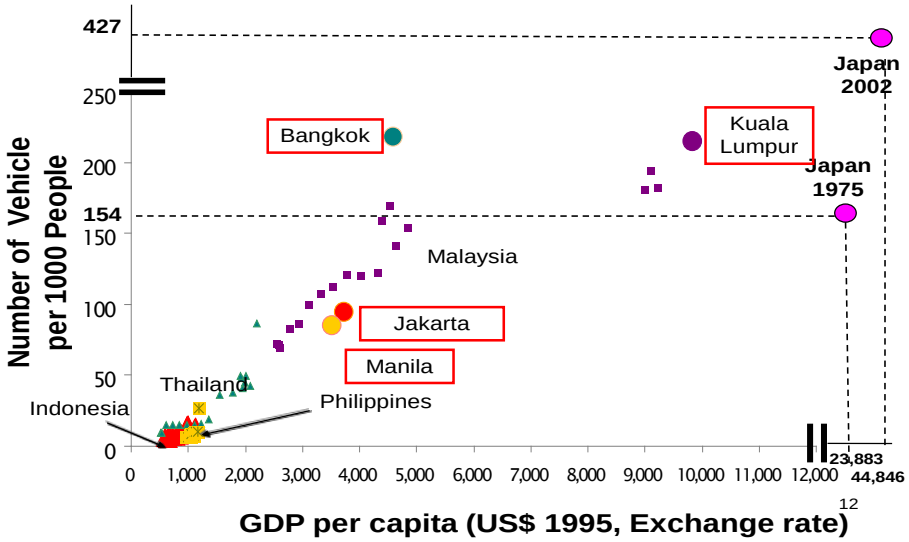
1. Introduction of Database Result

Asian countries are facing major air pollution problems due to rapid economic growth, urbanization and motorization. Mortality and respiratory diseases caused by air pollution are believed to be endemic in cities of these countries. Regulations and standards are the first requirement for reducing emissions from both fixed and mobile sources. In order to reduce vehicle emissions, governments of the four countries are making efforts to introduce vehicle emission regulations for new vehicles. This database results attempt to compare the implemented policies for air pollution reduction and CO_2 reduction. This report emphasizes monitoring problems such as vehicle registration systems, inspection and maintenance (I/M) systems and fuel quality monitoring systems for vehicles in use. Monitoring problems in developing countries share similar characteristics such as a weakness in government initiatives and inadequate operation of government agencies, which results from a lack of human resources and availability of adequate facilities.

Finally, this database results propose a method to assure air quality improvement under the different shares of emission regulations in these Asian countries and introduces an example of an evaluation method based on a policy survey to improve air quality. For the proposal, the database needs to improve data quality and quantity.

2. Background of Air Pollution

Asian countries have been facing a major air pollution problem due to rapid economic growth, motorization and urbanization. Figure A 2.1 shows GDP per capita[43] and number of vehicle per 1000 people over the period 1985-2002 for Bangkok[4],[47], Kuala Lumpur[54], Jakarta[14], Manila[45], and Japan[37]. As the first observation, compared to Japan (1975), Bangkok (2002) and Kuala Lumpur (2002) are already beyond it in terms of vehicle numbers per 1000 people. These Asian cities have a faster process of motorization in terms of GDP per capita. As the second observation, the national average level [32][37] follows the city level in accordance with economic growth. In the future, there is a high probability of achieving at Japanese level (427 units per 1000 people) at the national level in Asian countries.



● : City level, ▲ : National Level

Data sources: Alfa Research Co.Ltd.,[4] ,BPS[13][14] ,National Statistics Office[47],Land Transport Office[45],NSCB[46] JARI[37], JETRO[43], Statistical Bureau[54], UITP[44]

Figure A 2.1: GDP per capita and number of vehicle per 1000 people

Table A 2.1 shows air quality monitoring in large Asian cities using the criteria of WHO guidelines[22] [57] as of 1990 and the most recent years of 2002-2005[3][8][9][10][11][58][59][60]. The air pollutants PM_{10} and NO_2 become serious concerns from 1990 to the most recent years. Catalyst based after-exhaust treatment technology, can reduce HC, CO, and NO_x according to vehicle emission regulation levels. However, rapid motorization may negate out the efforts of air pollution reduction policies. Lead concentration in air was reduced in Bangkok from 1990 to 2005[11], in Manila from 1990 to 2002 [8] and in Kuala Lumpur from 1990 to 2004 [3][54] because lead had been phased out from automobile fuel in these cities [24][25] (Table A 2.1). Lead concentration in air increased in Jakarta from 1990 to 2004[2][15][60] because lead was phased out from automobile fuel in 2006 [27] [29](Table A 3.1).

Table A 2.1: Air quality monitoring in four Asian Large Cities

Latest Year（2002-2005）

City		CO	NO_2	PM_{10}	O_3	SO_2	Lead
Jakarta	2004	E	C	E	C	D	D
Kuala Lumpur	2004	C	D	D	C	B	A
Manila	2002	C	E	E	D	C	B
Bangkok	2005	A	D	D	B	C	B

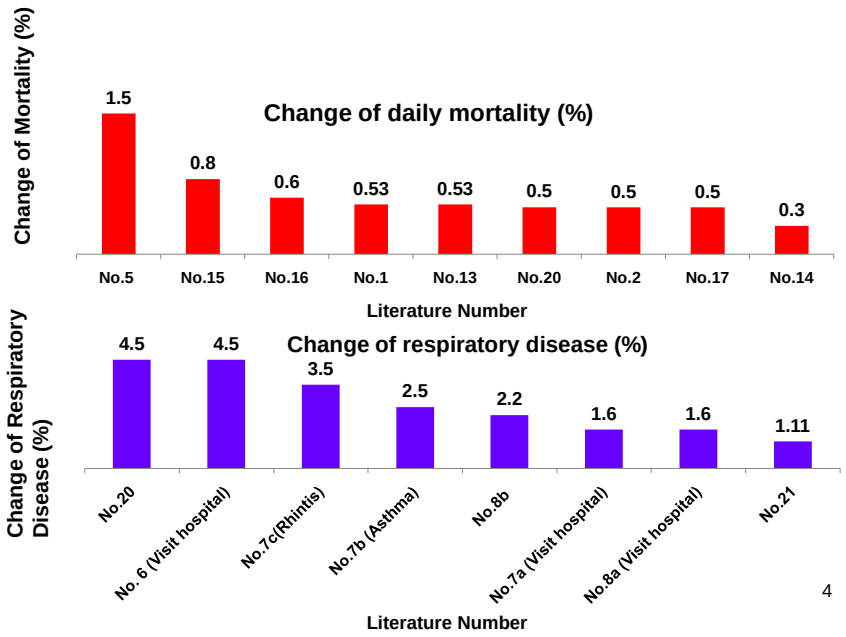
1990

City		CO	NO2	PM10	O3	SOx	Lead
Jakarta	1990	C	B	D	C	C	C
Kuala Lumpur	1990	C	C	B	C	B	C
Manila	1990	D	D	D	D	B	C
Bangkok	1990	B	B	E	B	B	C

A	50 % below from WHO standard
B	Within WHO standard
C	Within 200 % from WHO standard
D	Within 300 % from WHO standard
E	300 % over from WHO standard

Data sources:ACFA[2], ADB [8] [9][10][11], Alam Sekitar Malaysia Sdn.[3], BPS [15],Hirota[24] [25][27][29], WB,[58][59][60],WHO[57]

According to the World Health Organization (WHO)[57], mortality caused by air pollution in large cities is estimated to be 800,000 people[22]. Two-thirds of the deaths are concentrated in Asian cities. With these concerns of mortality and respiratory disease caused by air pollution in large cities, it is an urgent matter to reduce air pollution in Asian cities. Figure A 2.2 shows the 21 reports/literatures from HEI surveys [22] on changes in mortality and respiratory disease by increase of PM_{10} in Asia during 1990-2006. When PM_{10} increases at 10 ug/m^3, mortality change increases at a rate of 0.3% to 1.5% from natural mortality. When PM_{10} increases at 10 ug/m^3, of respiratory disease change increases at a rate of 1.1% to 4.5% from the normal probability of respiratory disease. Taking into consideration the future health costs [49], policy implementation of emission regulations for new vehicles in early motorization can reduce the cost of air pollution reduction. If the cost of air pollution is reduced at present, the cost of health care is reduced in the future.



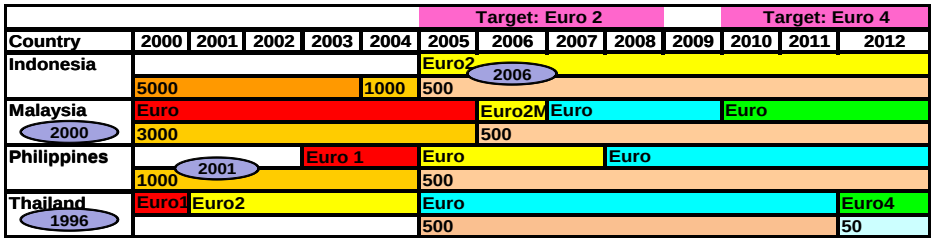
Data sources: HEI[22]

Figure A 2.2: Change of daily mortality and respiratory disease with respect to PM emissions (Total number of literature =21)

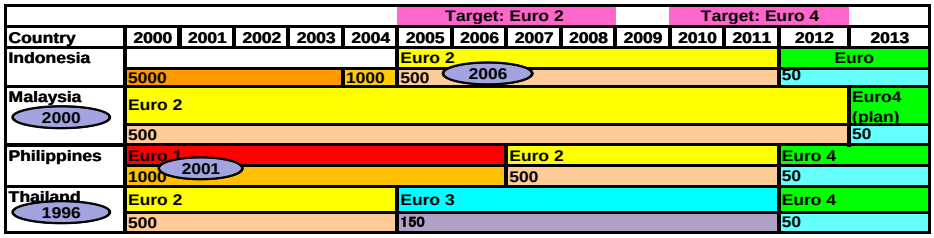
3. Introduction of Vehicle Emission Regulations and Fuel Quality

The introduction of emission and fuel regulations are merely the first step toward political implementation of air pollution reduction policies. In recent years, governments in Asian countries have been introducing vehicle emission regulations for new vehicles[7]. Table A 2.2 shows the time schedule of the vehicle emission regulations and sulfur content for new gasoline-driven passenger vehicles in Asian countries. The common target is the introduction of EURO 2 by 2008 and EURO4 by 2012[6]. In fact, the time schedule of 2007 is delayed compared to the time schedule of 2004 [28][38][39]. In order to meet the EURO 2 standard level, it is important to install catalytic converters to meet the emission regulation level (CO, HC, NO_x etc). Since lead in gasoline cause the catalytic converter to malfunction [19], leaded gasoline in ASIAN countries have been phased out already [23][24][25]. As the next step, lowering the sulfur content (below 500 ppm) is the focus for introducing stricter emission regulations [26][27].

2004



2007



Emission level and requirement of sulfur reduction
Euro2 : < 500 ppm
Euro3 : <150 ppm
Euro4 : < 50 ppm

Year of ULG : Unleaded Gasoline

Target : Target year agreed by AMEICC2004

Data Source: Governmental documents, AMEICC 2007 [1] AMEICC 2004[6], AAF[7]

Table A 2.3 shows availability of clean vehicles in Asian countries. Most of Asian countries introduced bio fuel, natural gas, hybrid vehicle, electric vehicle and LPG vehicles. DME is introduced only in Japan and Vietnam.

Table A 2.3: Availability of clean vehicles[1]

	IDN	CN	SG	TH	PH	IN	JPN	KR	VN	ML
Bio-fuel vehicle	Yes	Yes-E10	Yes	Yes	Yes	Yes	Yes	No (On trial run)	Yes (pilot)	Yes (*)
Natual gas	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes (pilot)	Yes
DME	No	No	No	No	No	No	Yes	No	Yes (pilot)	No
Hybrid vehicle	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes (On trial run)	Yes (pilot)	Yes (imported car)
Electric vehicle	No	Yes	Yes	Yes (but not yet available)	Yes	Yes	Yes	No (On private roads)	Yes	No
LPG	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes(For Taxi, Rental Car, Cars for the disabled)	Yes	Yes

(*)Malaysia has National Biofuel policy

Source: ERIA database

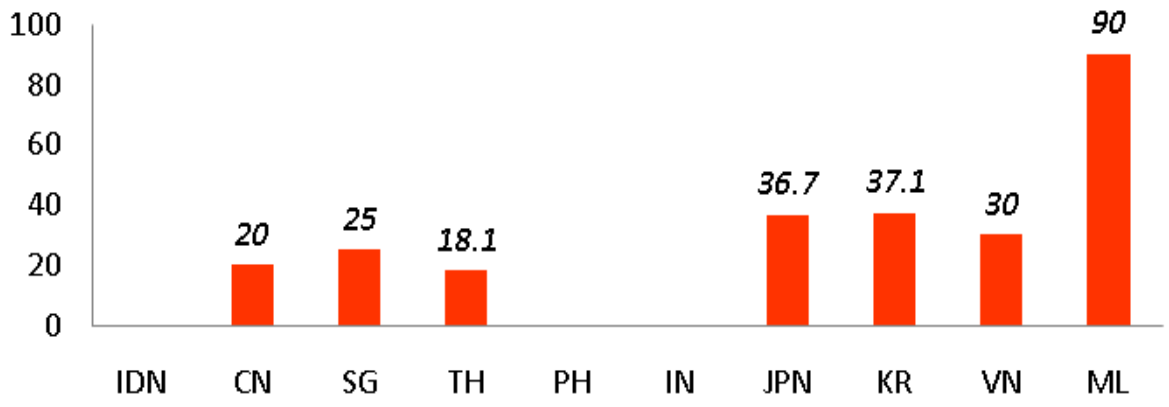
[1] CN: China, IDN: Indonesia, PH: Philippines, SG: Singapore, TH: Thailand IN:India, JPN: Japan, KR:Korea, VN: Vietnam, ML:Malaysia

Not only implementation of emission standards for new vehicles, but also regular inspection and maintenance of vehicles with uncontrolled emissions are effective for emission reductions. For example, the annual passenger vehicle kilometers traveled (VKT) is higher by 2-3 times in other Asian countries than that of Japan (Table A 2.4). Figure A 2.3 show average vehicle speed on road in urban area. The average speed is diverse among various Asian countries.

Table A 2.4: VKT in Asian countries

		IDN	CN	SG	TH	PH	IN	JPN	KR	VN	ML
VKT: Annual travel distance per vehicle (km/year)	Passenger vehicle	No data	26000	20,000	14,853	No data	No comprehensive and recent data could be accessed	10,000	18225km(avg. of all reg veh.) , 64321km(avg.commercial only)	15,000-20,000km/year	NA
	Bus	No data	45000	85000	39,268	No data		55,000	29950km(avg. of all reg. bus) , 86674 km(avg. commercial only)	15,000km/year	NA
	Truck	No data	65000	35000	45,744	No data		70,000	20892km(avg. of all reg veh.) , 53399km(avg. of all commercial)	50,000km/year	NA
	Motorcycle	No data	7500	13000	5,627	No data		3,000	N/A(not collected)	5000-9000km/year	NA
Have you heard how to measure driving distance (km/vehicle) in your country?		No data	Investigation in the parking lot, 3S shop and etc.	The average kilometres travelled per vehicle are estimated based on mileage survey of in-use vehicles conducted at mandatory periodic vehicle inspections.	This figure is from secondary calculation of 2003 data	No existing program for measuring driving distance.	This is often based on the surveys involving data collection from the drivers, vehicle owners, based on the odometer readings and other records. Also there may be some estimates based on the fuel consumption data, road usage data etc.		Collected during vehcle inspection by Inspection Authority, KOTSA(www.kotsa.or.kr)	Estimation from the fact	

Source: ERIA database



Source: ERIA database

Figure A 2.3: Average speed of vehicle on road (urban area)

4. Monitoring system (I&M, FQM)

Asian countries have legislation regarding registration and inspection systems. However, operation of the registration, I/M (inspection and maintenance) systems and fuel quality monitoring system used in developing countries are observed to share similar characteristics, such as a weakness of government initiative and inadequate operation by government bodies, which results from shortages of human resources and analysis facilities[27][31].

A better operation of I&M system enables used vehicles to be regularly checked for defects in vehicle parts and improve them by replacing them with better parts and also by tuning the engine etc. A better operation of inspection system can definitely phase out high-emission vehicles. According to a GTZ report [17], vehicles which did not pass an inspection test emitted 1.7-7 times higher CO levels than vehicles which did pass. As a successful example, in 2000 a voluntary I/M bus project called the "Blue Sky project" in Jakarta reduced HC by 49%, CO by 53%, soot by 61%, and increased fuel saving by 5%[55][53].

A better operation of I/M system is based on a better operation of registration system. A better operation of registration confirms the track record of vehicle registration by year, model, and vehicle age, which assure tax revenue from the vehicles. Less-efficient operation of registration system allows these four Asian countries to keep old vehicles on the road for longer. Table A 2.5 shows the type of vehicle inspections, intervals and deregistration processes. Due to less-efficient operation of registration systems, the number of inspected vehicles is very limited, so that the system is unable to reflect the overall emission quality situation in the real world. Less-efficient operation of registration system can hardly protect consumer rights from recalls and stolen vehicles. The lack of deregistration is another problem [18][33][42][52] in registration system. Deregistration process can clarify the track record of discarded vehicles by number and year.

One of the problems is related to vehicle tax system (Table A 2.6). If vehicle related tax is differentiated by vehicle performance related to emission or energy saving, air pollution including CO_2 can be reduced by the system. Many Asian countries have introduced vehicle related taxes. Some countries have also introduce environmental taxes. Another problem is regional differences in technology levels between auto dealers and local factories. In order to support I/M system, it is necessary to identify the technology level by a nationwide certification system for engineers, inspectors and mechanics. Asian countries do not have a nationwide certification for mechanics, while some local private maintenance shops do not have adequate skills for tuning EURO 2 vehicles. If technical skill is identical, vehicle users can send vehicles to any dealers or maintenance workshop. While car dealers have the knowledge and technology to tune EURO 2 level or higher vehicles, local factories do not sometimes have either knowledge or the technology to tune EURO 2 vehicles. A nationwide certification system can smoothly guarantee and monitor more stringent emission standards in the future. With the nationwide certification system, more stringent emission regulation than EURO 2 can also be introduced with better effectiveness. This certification system can create a new business opportunity of maintenance shop, thereby creating job opportunities.

For policy recommendation, operations of registration and deregistration should be improved similar to that of developed countries. In the future, the better operation of registration system will be essential for monitoring the vehicle recycle process. It enables us to collect tax revenue properly. It can also differentiate vehicle tax levels by technical performance.

Table A 2.5: Inspection and maintenance guidelines for different categories of vehicles Asian countries

	Inspection interval			
	Passenger	Bus	Truck	Motorcycle
CN	Vehicle age (VA)≤6 0.5-0.5-0.5- 6<VA≤15 1-1-1- VA>15 2-2-2-	VA≤5 1-1-1- VA>5 2-2-2-	VA≤8 1-1-1- VA>8 2-2-2-	VA≤4 0.5-0.5-0.5- VA>4 1-1-1-
IDN	No	0.5-0.5-0.5-	0.5-0.5-0.5-	No
TH	VA ≤ 7 not required VA > 7 1-1-1- Taxi:0.3-0.3-0.3-	≤ 20 seats: 3-3-3- Others: 0.5-0.5-0.5-	Unloaded vehicle ≤ 3.5 t: 3-3-3- Others: 0.5-0.5-0.5-	VA ≤ 5 not required VA > 5 1-1-1-
SG	VA ≤ 3 not required 3 ≤ VA ≤ 10 2-2-2- VA > 10 1-1-1-	0.5-0.5-0.5-	VA ≤ 10 1-1-1- VA > 10 0.5-0.5-0.5-	VA ≤ 3 not required VA > 3 1-1-1-
PH	1-1-1-	1-1-1-	1-1-1-	1-1-1-
IN	Fittness: Commertial vehicle: 2-1-1- Private vehicle VA > 15 years: 2-1-1- PUC:0.5-0.5-0.5- (Commercial vehicle only)	Fittness: Commertial vehicle: 2-1-1- Private vehicle VA > 15 years: 2-1-1- PUC:0.5-0.5-0.5- (Commercial vehicle only)	Fittness: Commertial vehicle: 2-1-1- Private vehicle VA > 15 years: 2-1-1- PUC: 0.5-0.5-0.5- (Commercial vehicle only)	Fittness: Commertial vehicle: 2-1-1- Private vehicle VA > 15 years: 2-1-1- PUC: 0.5-0.5-0.5- (Commercial vehicle only)
JPN	3-2-2-	1-1-1-	1-1-1-	2-2-2-
KR	Private : 4-2-2- Commercial : 2-1-1-	VA ≤ 5 1-1-1- VA > 5 0.5-0.5-0.5-	Middle scale : 1-1-1- commercial large scale : VA ≤ 2 1-1-1- VA>2 0.5-0.5-0.5	NA
VN	VA ≤ 7 1-1-1- 7< VA ≤20 0.5-0.5-0.5- No usage after 20years			NA
ML	VA> 10 years old 5-5-5-	1-1-1-	1-1-1-	No inspection

* Valid period until next inspection. Number shows "First inspection year-Second inspection year-Third inspection year".
Ex) 1-1-1- : Annual inspection

Data sources: ERIA database
Data reference: JARI-UN conference [42]
AIT[12], Ministry of Industry, Indonesia[18] Aminuddin[33],JASIC[40][41]Ovasith[52]

Table A 2.6: Vehicle related tax system in Asian countries

Stage		IDN	CN	SG	TH	PH	IN	JPN	KR	VN	ML
Aquisition	Acquisition (registration fee)	Yes	Encourage smaller engine capacity	COE, Additional Registration Fee (ARF)				Green tax	City compact car (under 1000cc) : 50% tax cut , Registration fee: cut Bus: $1000 tax cut, subsidy for NGV Hybrid car (by 2009 July) : acquisition tax cut up to $1000	Registration tax: 12% Registration fee: 2-3mil VND/case	
	Excise tax,V	Yes	Yes	Exercise Duty, Goods & Services Tax (GST = 7%)	HEV (<3,000cc), EV, FCV = 10% Eco-Car =17% E20 & E85 ≤ 2,000 cc. = 25%, E20 & E85 2,001-2,500 cc.= 30% NGV =20% Otherwise, <2,000cc = 30% 2,001-2,500cc = 35%	Yes	Yes	Yes	Yes	VAT: 5% (before 10%)	
	Import tax	Yes	Yes		Yes	Income Tax Holiday Tax & duty-free	Yes		No		
Ownership	Local tax	Yes	Yes- Local tax paid annually		Yes		Yes		Hybrid car : (by 2009 July) registration tax cut up to $1000		
	Ownership (Annual tax)			Road Tax, Road Tax Surcharge (for vehicles over 10 years), Special tax for diesel-driven vehicles		Yes		Green tax			
Motoring	Fuel	Subsidy for fuel	Heavier tax for leaded G	Tax on Petrol (Gasoline)	Cheaper bio fuel tax			Yes	Compact car: fuel tax refund up to $80 per year taxi : fuel tax refund Fuel subsidy for compact car, truck, taxi	Road and Bridge fee (separated and sometime included in Fuel price)	
	Incentive		Eraly scrappage	Partial Additional Registration Fee (PARF) Rebate, Green Vehicle Rebate	Clean energy vehicle			Low emission better fuel Economy	Compact car: Parking fee 50% cut		Yes, incentives for public transport companies

Source: ERIA database

The delay in introduction of more stringent emission regulations is caused by a short supply of appropriate fuel quality [28][38]. The more stringent is the fuel quality (EURO2, 3 and 4), usually more limited is the supply. In Asian countries, FQM law and monitoring system do exist (Table A 2.7), however, the pace of implementation needs to be matching with the proposed implementation of progressive emission norms. The following three examples show the results of fuel quality monitoring. First, the fuel monitoring results for lead content, obtained by the Ministry of Environment in Indonesia and an Indonesian environmental NGO called KPBB[27], have been observed to increase off-specification fuel after the introduction of EURO 2 in 2005. In 2003 and 2004, prior to its introduction, all samples (number of samples = 31 per year) were observed to meet the lead standard at national level. In 2005, after the introduction of EURO 2, 12 out of 31 samples were noted to have exceeded the lead content as compared to the designated

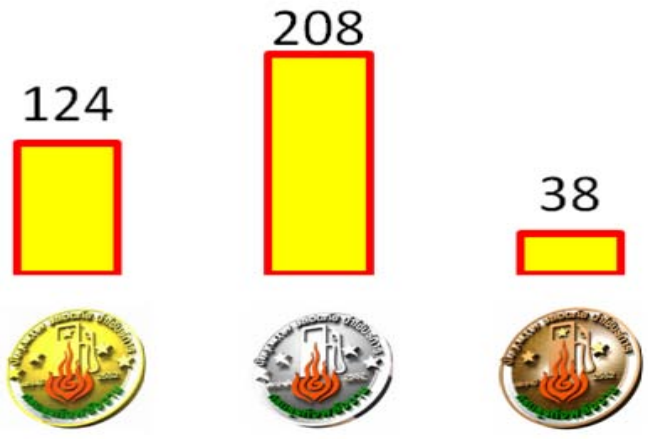
standards.

In Thailand, Ministry of Energy Business takes an initiative of a campaign for fuel quality and safety service at petro station. Ministry of Energy Business evaluates fuel quality and safety from 1 to 5 points. If a petro station is rated at full point, it received a gold sticker. If it is rated at 4 point, it receives a silver medal. If it is rated at 3 points, it receives a bronze deal. One thousand two petro stations participated out of 18902 petro station in 2008. One hundred twenty four petro stations received a gold medal sticker. Two hundred eight petro stations received silver medal sticker. Thirty eight petro stations received bronze medal. In total, 370 out of 1002 gas stations, which is 40% of participated petro stations, were certificated. This campaign promotes awareness of fuel quality and safety issue at petro station. By showing these sticker at petro stations, it promotes awareness for consumers.

Table A 2.7: FQM in Asian countries

	IDN	CN	SG	TH	PH	IN	JPN	KR	VN	ML
FQM	Yes	Yes	Yes/No	Yes	Yes	Yes	Yes	Yes/No	Yes	Yes
Which governmental institute is in charge of FQM?	Directorate General Oil and Gas	State Quality Supervision Bureau : FQM	National Environment Agency (NEA)	Department of Energy Business, Ministry of Energy	Department of Energy (DOE)	Ministry of Petroleum and Natural Gas	MITE	Ministry of Environment Ministry of Knowledge and Economy	Vietnam Directorate for Standards and Quality (STAMEQ) - MOST - Technical Center for Standards and Quality No 3.	the Malaysian Center for Energy in the Ministry of Transportation, Communication and Energy
Is there regulation or law of FQM?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: ERIA database



Source: http://www.doeb.go.th/bfbs/index.html

Figure A 2.4 Fuel quality and safety gas station campaign in Thailand

5. Policy instrument of air quality improvement

How to assure air quality improvement under the different share of vehicle types in Asian countries? After an air pollution act, vehicle emission and fuel quality regulations are introduced, and policies of monitoring such as better operation of monitoring systems like registration, inspection, fuel quality monitoring and air quality monitoring should be introduced[28][29][31]. Based on a simulation of emission volume from these policies [5], it is necessary to evaluate if the total emission volume can be ultimately below the prescribed standards.

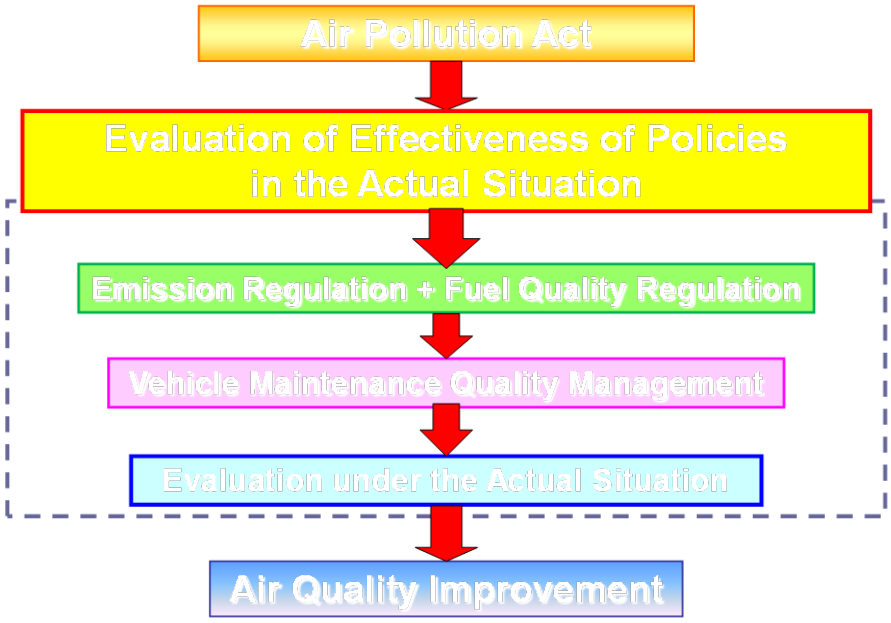


Figure A 2.5: How to assure air quality improvement?

Figure A 2.5 shows an example of an evaluation method based on a survey of policies to improve air quality. First, real vehicle usage such as car stock by vehicle age, vehicle speed and emission factors on-road should be measured as quantitative data. By use of modeling, driving cycle and proper methodology, with quantitative data, the total emission volume is estimated by simulations. This is usually referred as preparation of emission inventory, which often also involved estimates using fuel consumption, VKT travelled and even through actual monitoring of VKT. These data can be validated by air monitoring studies, followed by source apportionment, which can reliable conclude about the contribution from different sources including that mobile sources. After the problem estimation, a list of countermeasures can be worked out as potential options and their techno-economic feasibility can be worked out. From the list of control options, the potential policies/options need to be revised at the activities level and prioritized from the point of cost performance, health impact and other criteria. Finally, the best solution with regard to the actual situation will be proposed to support the political recommendation. Proper implementation of control options and policies remains the last important issue, which will ultimately determine the benefits of emission control efforts.

6. Conclusion toward political recommendations

In order to reduce automobile emissions, governments of Asian countries have been making efforts to introduce stringent vehicle emission regulations. It is also necessary to match the fuel quality to which is necessary for the application of suitable technology for emission control. Vehicle emissions have detrimental effects on air quality, and consumers/users should cover the costs related to emission control. The present results show that early implementation of emission regulations for new vehicles are important. Besides emission regulation implementation, fuel quality monitoring systems, registration systems and I/M systems should support vehicle emission regulations and fuel quality standards.

Finally this database report proposes an example of an evaluation method based on a survey for policy to effectively improve air quality in Asian countries, as these countries to some extent have different challenges of vehicular emission problems with different shares of vehicle type, different emission regulation levels, fuel quality, enforcement issues, environmental awareness, economic considerations etc.

Fortunately, Japan has long experience dealing with air pollution especially related to automobile usage. Japan also has state-of-art technologies related to automobiles as well as emission control. This experience, knowledge and technology should be exploited into Asian countries to ensure improved air quality, leading to a "Sustainable Automobile Society".

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Appendix 2-2: Vehicle category in Asian countries

Table A 2.8: Vehicle category in Asian countries (1)*

Category of definition	CN	IDN	PH	SG	TH
Passenger	Mini cars: EDV(Engine Displacement Volume)<1L; Medium cars: 1L≤EDV<1.6L; Large cars: EDV>1.6L	N.A	Passenge car Light (L), Medium (M) and Heavy (H) by engine capacity, UV, SUV,	Cars <=1600cc and Cars >1600cc	Sedan, Passenger van, Interprovincial Taxi,Urban Taxi,Fixed Route Taxi,Hotel Taxi,Tour Taxi,Car for Hire
Bus	Mini bus: TVL (Total Vehicle Length)<3.5m; Light duty bus: 3.5m≤ TVL<7m; Medium duty bus: 7m≤ TVL<10m; Heavy duty bus: TVL≥10m	N.A.	Passenger seat > 18	Public Bus and private buses	Fixed route bus, Non fixed route bus, Private bus
Truck	Mini truck: GVW(Gross Vehicle Weight)<1.8 t; Light duty trcuk: 1.8t≤ GVW<6t; Medium duty truck: 6t≤ GVW<14t; Heavy duty	N.A.	Pick up, Trucks GVW>4.5 t	Light Goods Vehicles (<= 3.5 tons),Heavy Goods Vehicles (3.5-16 tons),Very Heavy Goods Veh. (> 16 tons)	
MC	Moped: EDV<50ml; Motorcycle: EDV≥ 50ml	N.A.	Motorcycle, moped without 3 wheelers neither side car	All Motorcycles	

Source: ERIA database

*CN: China
IDN: Indonesia
PH: Philippines
SG: Singapore
TH: Thailand

Table A 2.9 Vehicle category in Asian countries (2) **

Category of definition	IN	JPN	KR	VN	ML
Passenger	GVW < 3.5 t Ex. sedan, van, MUV, Taxi	MiniCars <=660 Cars >660cc	1450kg/1997cc/sedan	4; 7; 9; and 12 seats/ 1.8-2.5L/ 1400-3000kg	< 3000 kg (motor cars heavy) > 3000 kg (motor cars)
Bus	Minibus, public bus	Public Bus and private buses	minivan : 2200kg/2700cc large-bus : 14000~15000kg/8000cc	16-46 seats/	> 5000 kg (tractors heavy) < 5000 kg (tractors light)
Truck	GVW >3.5t, 12t, more than 12 t	Light Goods Vehicles (<= 5 tons) Heavy Goods Vehicles (5-11 tons) Very Heavy Goods Veh. (> 11tons)	mini(1t capacity) : 1800kg(approx.)/2497cc/mini truck middle(5t capacity) : 6000kg(approx.)/ 6600cc / medium-duty large(over 15t capacity) : 13500kg(approx.)/ 12300cc/heavy-duty	Truck: 500kg, 795kg, 860kg, 990kg, 1T25, 1T4, 1T9, 2T5,2T9, 3T5, 5T, 8T, 9T4, 12T, 15T, 17T Heavy Truck (Ben): 660kg, 990kg, 1T25, 1T98, 2T5, 3T45, 4T5,	
MC	2wheelers: Speed, engine capacity, electric motor 3 wheelers: goods/person, GVW	Mopeds 50cc or less Two-whelle 50cc< engine displacement< 400 Lage two-whelle >400cc	100~110kg(approx.)/99cc/mini-bike	49cc; 70; 90; 110; 125; 350; 1000 (1300)cc	< 450 kg

Source: ERIA database

**IN: India
JPN: Japan
KR:Korea
VN: Vietnam
ML:Malaysia

Appendix 3: Proceedings of the 1st Workshop

Workshop of ERIA Research Project

on

"Project toward the
"Sustainable Automobile Society" in East Asia"

Economic Research Institute for ASIAN and East Asia (ERIA), Indonesia

Jakarta, Indonesia
Dec. 15-16, 2008

1. Keynote speech: "Economic Interpretation of Sustainable Automobile Society"

ERIA
Fuku Kimura

The characteristics of public goods (bads) are non-rivalry and non-excludability. Sum of the private marginal benefits should be equal to social marginal benefit. Due to externalities, air pollution is not fully internalized in the market because private marginal cost is less than social marginal cost. It is often hard to measure in the real world. “Back to the original” or “complete removal of pollution” is often too costly. There is room for the government intervention. Pollution abatement at the level of marginal benefit is equal to marginal cost.

2. Keynote speech: "The global politics of climate change"

Member of Indonesian Academy of Sciences & the President’s Council of Advisors
Emil Salim

Market system fails to reveal values of global environmental issues, which is considered external to the economic process and create issues, such as depletion of ozone layer, erosion of bio-diversity and climate change. To correct market failures, UN involves member states in conventions & legal binding arrangements on the basis of multilateralism & 1 country 1 vote democracy, which developed countries dislike; In handling climate change, national political interests supersede global Environmental Needs; Raise public transportation, railways, river boats, compact cities oriented vehicles; Promote low carbon fuel (gas, electricity, coal, liquefaction, gas-to-liquid, fuel hydrogen, fuel cell, natural gas hydrate, 2nd gen. bio-fuel;). Applying fuel efficiency standards rationalize energy prices, fiscal and non-fiscal economic incentives to promote efficiency; promote technology sharing globally & bilaterally are important.

As common developing countries face the challenges of poverty eradication, mitigating and adapting to climate change whose main causes are not under their control but harms their development. Developed countries have not met Kyoto bench-mark but are demanding developing countries also to reduce GHG emissions without technology transfer and funding. The crux of debate is in the principle of “common but differentiated responsibilities and respective capacities” between the two with legal commitments for developed countries through UN multilateralism. Agreements; Gaps in income level, financial resources, trade, technology, control and voting rights in World Bank, IMF, WTO and lack of adherence to multilateralism building democracy between nation states are inhibiting global cooperation to meet global challenges like climate change; The current trends of global CO_2 emissions will definitely change climate within 25-50 years. The future catastrophe of climate change must act as integrating factor for global cooperation through democratic multilateralism between nation states to achieve sustainable Asia & World. Asia will become the engine of global growth in 21st Century with different growth patterns with emphasis on ec-sos-ecol sustainability; Focus is on Millennium Development Goals with co-benefits in reducing CO_2 emissions in inter-sectoral development in the Asia Region. Crucial is transfer of technology from developed to developing countries through cooperative efforts supported by financial transfer and capacity building to enable

developing countries to grow with low carbon.

3. Country report: Vietnam "Transportation and the Environment in Viet Nam"

Hanoi University of Science
Nguyen Thi Ha

In the last ten years, Vietnam has been transformed from a country with relatively few motorized vehicles to a country with a large number of motorized vehicles, especially in urban areas. Unlike other countries, where automobiles dominate, motorcycles occupy by far the largest share of transport in Vietnam. In this presentation, the automobile use and air pollution in Vietnam is overviewed. The fuel quality specifications and emission; managing the transport system; policies, solutions and incentives to protect air environment are also discussed.

4. Country report: Thailand

Thailand Automotive Institute
Threepol Boonyamarn

The vehicle population in Thailand has increased since 1999. Even though, last year domestic sale slightly dropped compared to 2007, over 600,000 units of automobiles and 1.5 million units of motorcycle have been sold each year since 2003, and total number of registered vehicle in 2007 was around 25 million units. The average emission emitted by in-used vehicle in Bangkok area is considered under set limit. However, there were some types of vehicles such as van and mini bus that have shown higher emission levels with respect to black smoke. Considering activities related to environmental protection from automobiles, Thailand has controlled auto-exhaust emissions by using Euro III standards for newly produced automobiles and also enforced in-used vehicles to perform inspection and maintenance before annual vehicle tax. The government also reduced excise tax for environment friendly automobiles, for instance, automobiles that can consume E20 or E85, or hybrid electric vehicles.

The emission standard for the heavy-duty diesel vehicles shall be advanced to Euro III by March 2009. The emission standards for gasoline vehicles and light-duty vehicles will be relocated to Euro IV in 2012; however, it will be very much depend on the oil companies if they could provide the matching fuel quality. The new emission standards for motorcycle will also be effective from March 2009, which will comply with Euro III norms. To promote lower emitting vehicles, Bangkok Mass Transit Authority (BMTA) providing route bus services to serve commuters in Bangkok and vicinities is in the process of changing diesel driven buses to CNG buses. 4,000 New CNG-buses will replace conventional diesel engine buses by this year.

Since, the number of vehicles was drastically increased but there were limited number of inspection sites (controlled by Department of Land Transport's), Private Inspection Centers (PIC) were initiated in 1993. At the beginning, only PICs in Bangkok were authorized by DLT. Up till Dec. 2007, there were 2,500 PICs in every province around country.

To promote Thai automotive industry, the government of Thailand has promoted eco-car manufacturing by giving incentive to manufacturers, who can produce cars

according to required specification. The specification of eco-cars is not only concerned for less fuel consumption but also safety of driver and environmental friendliness. The eco-car must consume fuel not more than 5 liters per 100 kilometers, emit exhaust emission under Euro IV regulation limit, and produce CO_2 less than 120 gram per kilometer. For the safety aspect, car must pass frontal and lateral crash test according to ECE Regulations or better.

5. Country report: Singapore

LTA Academy Singapore
George Sun

Singapore's ambient air quality compares well with other cities in developed countries, achieved through continuous efforts over many years. In land transport, this includes the tightening control of automotive fuel quality and vehicular emissions. However, Singapore faces increasing challenges in maintaining good ambient air quality as population and economy grow further. For example, the fine particulate matter PM2.5 level exceeds the USEPA standard. To reduce PM2.5, Singapore has introduced ultra low sulphur since Dec 2005, and mandated new diesel-drive vehicles to meet Euro IV emission standards since Oct 2006.

Singapore has been active in the global community to mitigate climate change, as a party to UNFCCC since 1997 and the Kyoto Protocol since 2006. To set clear directions, Singapore has published the Singapore Green Plan 2012, Energy for Growth (the National Energy Policy Report) and the National Climate Change Strategies. In the transport sector, it has launched the Land Transport Master plan (LTMP) in March 2008.

The LTMP outlined 3 strategies as a sustainable development plan for the land transport systems, they are: Making public transport a choice mode; Managing road usage; Meeting diverse needs. As mass transit is the most efficient means of transport, one of the key targets in the LTMP is to increase public transport modal share (AM peak) from the current 63% to 70% by 2020.

Singapore has pioneered many innovative transport policies to manage transport demand. The vehicle quota system implemented through certificate of entitlement (COE) and electronic road pricing (ERP) have kept Singapore roads relatively congestion-free, despite its limited land, rapid urbanisation and economic growth. Singapore is committed to more sustainable development policies, which include green vehicle rebate, facilitating non-motorised transport, and engaging the public to achieve the long-term targets.

6. Country report: Philippines

University of the Philippines
Crispin Emmanuel D. Diaz

The Philippines is moving toward greater energy self-sufficiency in the transportation sector while addressing safety and emission concerns. However, it is hampered by a lack of close coordination between different agencies and non-government organizations, despite legislation mandating such. Two factors for success have been identified from the experience in the Philippines:

(1) Based on the experience of taxi companies adopting LPG fuel systems, when the economics are beneficial, the shift to alternative energy sources will proceed, even with minimal direct government intervention.

(2) Promoting community ownership through the political will and skill of the political leadership at the local government (municipality) level, which promoted active participation by civil society groups, allowed the success of an environment-oriented programs such as in Puerto Princesa.

7. Country report: Malaysia "Air Quality Management in Malaysia"

National University of Malaysia
Mazrura Sahani

In Malaysia, the Department of Environment (DOE) monitors the country's ambient air quality through a network of 51 stations. These CAQM monitoring stations are strategically located in residential, urban and industrial areas to detect any significant change in the air quality which may be harmful to human health and the environment. The continuous air quality monitoring (CAQM) stations are equipped with continuous automatic analyzers for SO2, NOx, CO, O3, PM10 and HCO. In April 1995 Alam Sekitar Malaysia (ASMA) secured a 20 years concession for the privatization of the air and water quality monitoring and assessment.

The Pb levels monitored in the atmosphere were high in the eighties mainly due to the motor vehicles emissions. However, as a result of Government efforts to promote the use of unleaded petrol since 1991 and the total phase out of leaded petrol in 1998, the Pb level in the atmosphere had declined significantly.

The sulfur content in diesel and petrol will be reduced from 3,000 ppm to 500 ppm and from 1,500 ppm to 500 ppm respectively, with the adoption of EURO 2 specifications. New emission standards based on EURO 2 for diesel vehicles and EURO 3 for petrol vehicles will also be introduced to reduce emission of air pollutants from mobile sources. In addition, the capacity and ability to fight peat swamp fires, a domestic source of haze, will be strengthened.

In order to reduce Emission From Transportation Sector, government review motor vehicles emission standard to adopt EURO 2 standard for diesel vehicles and EURO 3 for petrol vehicles. To improve fuel quality, EURO 2 specifications are proposed. For diesel: sulfur content to be reduced from 3,000 ppm to 500 ppm. For petrol, sulphur content to be reduced from 1,500 ppm to 500 ppm. Implement effective public transportation system to achieve reduction in emission passenger per km, fuel consumption and emission per vehicle –km driven. Followings actions are proposed:

① Integrate Clean Air strategies into land-use planning
② Improved data management
③ Improved R&D programs on air dispersion modeling,
④ Environmental epidemiology, transport and environmental impact
⑤ Improved fuel quality

⑥ Further reduction below 500 ppm S in near term possible and roadmap towards 50 ppm.

⑦ Reduce emission from transportation and industrial sectors

⑧ Promote public awareness.

8. Country report: Indonesia

Institut Teknologi Bandung
Iman K. Reksowardojo

This report consists of two parts, discussing air pollution and energy in Indonesia. In first part, analysis of air pollution and strategy for air quality improvement are discussed. The analysis of air pollution is explained about:

1. Causes of air pollution mainly by population growth and rapid urbanization, which increase travel demand; unbalanced spatial development, which increases travel distance; change in lifestyle due economic growth; higher energy consumption and dependency on oil; and lack of environmental awareness.
2. Sources of air pollution are low quality of fuel and increases in motor vehicle ownership.
3. Ineffective monitoring of air pollution.
4. Impact of air pollution.
5. Institutional factors' contribution to poor air pollution management.

Strategy for air quality improvement are strategy to prevent air pollution, strategy to control air pollution, strategy to monitor exposure, strategy to mitigate the impact of air pollution and strategy to strengthen institutional capacity. The second part is discussed the unbalanced energy mix and the policy to balance the energy mix in Indonesia.

9. Country report: China "Vehicular Emissions and fuel consumption in China"

Tsinghua University
Lixin Fu

With the fast growing economy, the automobile ownership is soaring in China in recent years. According to the projection, although the overall urban air quality has improved, 39.5% of the cities don't attain standard. As per Gompertz model, the automobile stock will reach 227 million in 2030, among which 147 millions are private cars. In summer, several large cities which have severe traffic pollutions showed violations of ozone level already. Exposure concentrations: roadside level is 2-3 times higher than the general level which has significant health implications.

Emission standards for new vehicles are the basis to determine emission factors. Driving characteristics, Fuel quality, Geography and Environment, Load, Inspection and maintenance (I/M), etc. all have impact on real-world emission level. Beijing-Tianjin-Hebei region, the Yangtze River Delta and the Pearl River Delta, which cover only 6.4% of the Chinese territory, generate about 41% of the total vehicular emissions of each pollutants in 2005.

From 1997 to 2002, the share of road transport system's fuel consumption out of

the national total oil consumption increase from 23% to 32%. According to the projection, this share will further increase to over 50% in 2030. Proper land use can improve the traffic conditions and reduce VMT. Increase the share of public transportation will lower the traffic congestions and conserve the energy and environment.

For Emission control of in-use vehicle, I/M is the most effective means. Acceleration retirement of old and high-emitting vehicles can be done by restricting their use in city-center.

10. Country report: India "Air Pollution Control in India"

National Environmental Engineering Research Institute (NEERI-CSIR)
Nitin Labhsetwar

Air Pollution Control has been addressed through various acts and laws in India, the most important being - Air (Prevention & Control of Pollution) Act, 1981 and Environment (Protection) Act, 1986. With forecast of an impressive growth rate for India, the increased automobile usage is a certainty, which would eventually lead to emission issues. Therefore transport and auto-emission management will be even more important in years to come.

There is a comprehensive National Air Quality Monitoring Program in India with about 340 stations covering 126 cities/towns. Several criteria pollutants and other gaseous and PM emissions are being monitored regularly. The recent trends shows higher concentrations of PM emissions, while SOx and NOx are not of serious concern in the recent years. Different shares of automobiles towards overall air pollution are projected under different studies, however, their contribution appears to be considerable with in-use (particularly old vehicles) contributing more. A separate source apportionment study has been conducted recently in major Indian cities, which would lead to the assessment of air pollution from automobiles.

There is a regulatory framework in place and several actions have been taken including implementation of Euro norms, fuel quality standards and I&M (Pollution Under control with roadside emission testing etc) to control the automobile pollution in India. More needs to be done to address the emissions from in-use vehicles.

Though some improvement in air quality status has been reported, desired results in air quality improvement are probably not achieved mainly due to the unprecedented vehicle growth in the recent years and some enforcement issues related to I&M program. These issues are being addressed.

11. Country report: Japan

Japan Automobile Research Institute
Kiyoyuki Minato

In the Kyoto Protocol, Japan promised to reduce its greenhouse gas emissions by 6% from 1990 to 2010. In order to achieve this target, Japan has to knock the increase in CO_2 emissions from the energy sector down to 0.6% over 1990. In 2007, CO_2 emissions from the transportation sector occupied 20% of CO_2 from the total energy sector, reducing the volume by 4.2% by 2010 is required. Thanks to the cooperative efforts made by every stakeholder, CO_2 emissions in Japan's transport sector took a downward turn after

peaking in 2001. All these three factors contributed almost equally to the CO_2 reduction. Popularization of eco-friendly driving habits among vehicle users and promotion of efficient goods distribution have led to the decrease in travel distance. Development and introduction of advanced technologies by auto makers succeeded in increasing fuel efficiency. Upgrading of road infrastructure, including signal control systems, has alleviated traffic congestion. These results show the potential for CO_2 emissions reduction, each sector taking a bottom-up approach.

12. Technical report: Thailand "R&D in Biodiesel for Vehicle"

National Metal and Materials Technology Center (MTEC)
Nuwong Chollacoop

Since one-third of domestic energy consumption comes from transportation sector with overall twice consumption on diesel compared to gasoline, Thai government aims to reduce diesel consumption by other alternative energy sources. Blessed with tropical climate suitable for year-round agriculture, Thailand has surplus of food production so biodiesel has been considered as renewable energy option to diesel need.

To assess various diesel engines compatibility with biodiesel fuel in terms of engine performance, fuel consumption and emission.

Various engine tests with biodiesel generally show improved emission results, especially on black smoke, on the expense of slightly reduced torque/power and increased fuel consumption due to lower heating value. With biodiesel, thermal efficiency is also slightly improved since more fuel consumption of lower heating value is offset by not too much drop in power output. Slight engine modification can help fine tune engine performance and improve emission. However, long term endurance test must be performed to ensure full compatibility in addition to promising short term tests. More importantly, fuel of acceptable quality must be used.

13. Technical report: India

Automotive Research Association of India
A. A. Baikerikar

The Technical report presented was about the activities and over view of "The Automotive Research Association of India" based in Pune, India. The main responsibilities and activities carried out by the institute was briefed, which included R& D Activities, certification activities, preparation and harmonization of standards, facility creation, deliberation of policy matters etc. The special projects handled in various automotive fields were also narrated. The Indian automotive scenario, history of emission norms, fuel standard along with certification was also covered. Details of ARAI study on in-use vehicle and existing inspection system for in-use vehicle was also described. The presentation concluded with way forward for control strategy for India to achieve better air quality.

14. Technical report: China "Ethanol/Methanol and Diesel Fuel"

China Automotive Technology & Research Center
Li Wei

CATARC has done a lot of research in ethanol and methanol fuels since year 2000. Based on our technology reports, national standard of ethanol gasoline fuel(E10) has been implemented since 2001 and NDRC promoted E10 in 10 provinces step by step. The research on methanol fuel is still in progress. Comparatively high quality diesel fuel is a big challenge to our central governments and Beijing local government.

15. Technical report: "Automotive Emission Reduction Technology"

Japan Automobile Research Institute
Masahiko Hori

CO_2 from motor vehicles has been reduced in this decade by fuel consumption improvement Fuel Economy Standards in Japan: Fuel consumption improvement is still an important issue in the next decade to reduce GHG

With respect to emission regulations, NOx has been improved up to 1/100 by emission regulation since 1970s.

16. Technical report: "Approach to Clean Air in Asia"

Japan Automobile Research Institute
Kiyoyuki Minato

Serious environmental problems are caused by rapid motorization and Urbanization in Asia. According to WHO report (2002), 2/3 of death by air pollution is concentrated in Asia. Trends in emissions: Transport activity is projected to grow much more rapidly in most developing countries. As the measures for air pollution control, I&M programs, improving fuel quality, strengthening emission regulations, promotion of clean vehicles (CNG,LPG,EV,HEV), air quality monitoring, public campaign and education for environment are important.

Appendix 4: Proceeding of the 2nd Workshop

Workshop of ERIA Research Project

on

"Project toward the
"Sustainable Automobile Society" in East Asia"

Economic Research Institute for ASIAN and East Asia (ERIA), Indonesia

Bangkok, Thailand
Feb. 18-19, 2009

1. Presentation from ERIA WG Leader "Sustainable Development and Economic Valuation"

University of Indonesia LPEM-FEUI
Arianto A. Patunru
ERIA Leader for Working Group on Sustainable Automobile Society

Economics and the environment are not supposed to be independent one another. In fact, economic activities take place in environment and their outcomes are both affected and affecting the environment. This is true particularly because both consumption and production - the two basic economic activities - use resources from the nature as their inputs. Furthermore, those activities generate both output and waste. The capacity of the environment to assimilate waste will determine the future condition of the environment and hence its ability to support economic activities. Finally it should be mentioned that economic activities end up at the provision of utility to economic agents. Here too, the environment can have direct impact. That is, amenity may or may not enter directly into one's utility function. Recognizing the interrelationship between environment, natural resources, consumption, production, and utility is necessary to put economics into the realm of sustainable development, i.e. development that strikes the balance between economic activities and environmental preservation as well as between generations.

In order to appreciate the role of the environment and natural resources in economic context, one needs to have a framework. This framework would preferably be able to lend itself into the widely used cost-benefit analysis. Here the problem lies: it might be easy to calculate the cost of improving the environmental condition (e.g. building up a giant air purifier, water treatment, etc). But that is just half of the materials to come up with sensible cost-benefit assessment. To justify spending of public money for say, cleaning up the air, there has to be a justification to the proposed costs. That is, we need to calculate the expected benefit of such action. Alas, this is no easy task. Measuring the economic benefits of consuming food or clothes is easy, for they are 'market goods': goods traded tangibly and have price tags on them. The direct proxy of their benefits is simply their market price. But for environmental goods, this is not the case. One needs to apply a particular technique to attach a value to such 'non-market' goods as a proxy of the benefit that later can be contrasted against the cost. That is the objective of economic valuation.

Economic valuation can be based on two different sources of data. First, stated data set. This information is collected via direct question to respondents. Second, revealed data – information is obtained by observing what an economic agent does. There was a time when economists tend to be skeptical on the former, as economics is a 'science of observation'. However, experience has dictated that not every time and for every case historical data are available. This is particularly true for the cases of non-market goods such as environmental quality. Therefore, economists have to rely on stated data: surveys, questionnaires, interviews are employed. Recently, there has been an increasing amount of researches using both resources in combination. One message from these studies is that whatever data resource is employed, what matters is how one can come up with a sensible measure of the value of improving the quality of the environment. The principle here is that, you cannot preserve the environment if you have no idea what it is worth. To know

the value, you need to calculate how much benefit people will enjoy on top of the cost of the improvement. That again is the use of valuation.

2. Keynote Speech: "Sustainable Transportation in Asia"

CAI-Asia Center
Sophie Punte

The Clean Air Initiative for Asian Cities (CAI-Asia) was established as by ADB, WB and USAID in 2001 as a multi-stakeholder initiative to improve the air quality in Asian cities through sharing experiences and building partnerships. In 2007, the CAI-Asia Center began operating as an independent organization with headquarters in Manila, Country Networks in 8 Asian countries and over 120 partner organizations.

Trends in transport for developing Asian countries are pointing in the wrong direction: the number of vehicles is growing exponentially between now and 2035, vehicles on the road will become bigger and more powerful, and as it takes about 15 years for the vehicle fleet to turn over the options to do something about improving fuel quality and greenhouse gas and air pollutant options are limited. Furthermore, the share of public transport and non-motorized transport compared to that of private vehicles is going down in virtually all developing Asian cities.

As a result, CO_2 emissions that cause climate change are rising steeply. While average urban air pollution levels will reduce until about 2025 due to stricter vehicle emission and fuel standards, pollution levels are set to rise again after 2025 due to the exponential increase in vehicle numbers and the uncertainty of additional policies. This adds to health costs associated with air pollution. A key barrier to fuel efficiency and emission reduction is the fuel subsidies that are still available in several developing Asian countries, especially for diesel, although some countries have or are eliminating these.

A sustainable transport framework is needed that includes actions at the individual and government/policy levels, with 4 components: transport planning and demand management; inspection and maintenance, cleaner fuels; and emission standards and vehicle technologies. The "Road Map for Cleaner Fuels and Vehicles in Asia" provides a good starting point for government agencies that want to address transport issues. Case studies show that many measures to improve the fuel economy and reduce the emissions from vehicles are cost effective. Some of the key trends relate to electric bikes/vehicles, mass rapid transit systems, alternative fuels (e.g. NGV), and transport demand management.

For policies to be effective, three things must be considered. First, policies and fuel pricing need to be managed hand-in-hand. Second, policies that combine addressing CO_2 and air pollution at the same time are more effective and cost-efficient because both emissions show a strong correlation in growing Asian cities (and thus it is important to catch cities before they grow!). Third, transport measures in cities should be considered in the context of sound urban planning, and take into account the ability to scale the adoption of measures up from a few cities to many cities in Asia.

3. Keynote Speech : " Air Pollution Reduction”

Pollution Control Department
Supat Wangwongwatana

With respect to Emission standards, ASEAN Countries in general Adopted the European Standards. Representatives of ASEAN countries met in a workshop in Singapore in 1992 in an effort to harmonize standards related to air pollution. It was decided to adopt European emission standards for new vehicles as reference standards for ASEAN countries. Implementing date of emission standards might be different from one country to another.

For introduction of emission standard, it is very important to give oil refineries field a lead time before emission standard introduction. It is also important to promote stakeholders an achievable level of emission standard.

Reviewing fuel economy and greenhouse gas emission standards around the world is important. Collecting fuel economy data from light duty diesel vehicle and passenger vehicle, discussion about fuel economy value, test method and implementation with car manufacturer and other government agency (Current status) are some of the efforts towards managing auto-exhaust emissions.

4. Keynote Speech: "Technology for Air-Quality Improvement in Thailand"

The Automotive Industry Club, The Federation of Thai Industries
Thanawat Koomsin

To reduce pollution from automobile, following items are essential:

- Driving behavior improvement
- Proper maintenance of vehicle as recommended in owner booklet.
- Improve tailpipe emission by implementing ECE standard, step by step.
- Improve fuel quality especially Lead and sulfur content. (Emission level and Fuel quality must match)

The purpose of the World Wide Fuel Charter is to promote greater understanding of the needs of motor vehicles for fuel quality that minimizes emissions and obtains the best vehicle performance. The sulfur and emission standards are reviewed due to the recent progress of engine and emission control technologies. The Charter recommends fuel specifications for four categories of vehicle technologies, emissions standards and markets around the world. The quality upgrades would be associated with fuels targeted for markets with minimal, stringent, advanced and further advanced requirements for emissions control. Category 4 has been defined as 10 ppm sulfur fuel to meet the needs of advanced and future vehicle technologies. With respect to effect from ethanol and biodiesel, normally ethanol and biodiesel will be less harmful than gasoline and diesel fuel. However, cost and technology on both of them need to be further studied and need continued development. Ethanol needs to be viewed in relation to food & energy balance. Biodiesel – if more than 5% mix, the need to consider using 2nd generation biodiesel (GTL or BHD).

As next step, new automobile technology should improve emission and reduce CO_2. FFV vehicles, which can fill-up with E85, Hybrid car which can use both fuel & electric

Plug-in or EV, which only powered by electric should be promoted. It is necessary to target ZEV in the future.

5. Country Report : Korea "Policies for Air Quality Improvement in Korea"

Seoul National University
Seung-Young Kho

Energy consumption of Korea in 2007 was 236,454 thousand toe (Tonnage of Oil Equivalent) and had increased 214% since 1988. 84.5% of the total energy consumed is fossil energies. Transport sector consumed 37,068 thousand toe, which is 20.4% of the total energy consumption of Korea in 2007. 78.8 % of the transport sector's energy consumption is from road transport sector. No electric- and Bio-energies are used for road transport and special effort s should be given to introduce and propagate the use of these energies in Korea.

CO_2 emission of Korea in 2006 was 599.5 million CO_2-eq tons and had been more than doubled the emission in 1990. 18% of CO_2 emission comes from the transport sector. Even though the CO_2 emission of Korea is quite substantial, Korea was classified as a Non-Annex I country in 1997 Kyoto Protocol. But, post Kyoto, it is expected for Korea to be inevitable to avoid to reduce GHG mandatorily. In spite of some measures to reduce GHG in Korea, especially in Seoul Metropolitan Area, further efforts should be given to adopt effective and mandatory measures to reduce GHG.

6. Technical report: India "Air Pollution Reduction Policy in India"

National Environmental Engineering Research Institute (NEERI-CSIR)
Nitin Labhsetwar

Indian automobile industry is steadily growing and produces a variety of vehicles (more than 10 million vehicles produced during 2007-08), while the Government policies do not allow the import of re-conditioned / used vehicles. Production of two-wheelers still dominates with more than 75% share. The Central Motor Vehicle Rules (CMVR) defines four different categories of vehicles and other rules including that for fitness of commercial and non-commercial vehicles, taxation etc.

The estimated and projected vehicle km/distance suggest continued growth for taxis and personalized transport, while Delhi shows some impact of introduction of metro (mass transportation). There exists good scope for improved mass transportation in many Indian cities.

Fuel quality management is done by the related Ministry and Oil companies, while local Government is also responsible for enforcement issues. Use of CNG is steadily increasing in National Capital Region and also being introduces in other areas. Other alternative fuel options are mostly at demonstration stage.

An "Automotive Mission Plan 2006-2016" has been prepared, while an ambitious I&M project called NATRIP is also being implemented, which will prove useful to improve I&M issues in India.

Considerable efforts are being made in India, an integrated approach and effective implementation will be important to meet future challenges related to automobile pollution management.

7. Technical report: China "Air Pollution Reduction Policy in China"

Tsinghua University
Lixin Fu

Since 1999, Beijing has been working hard to push forward stricter emission standard for new vehicles sold and used in Beijing, from Euro 1 implemented in 1999 to Euro 4 in 2008. Fuel quality standards in Beijing have also been set in parallel with emission standards following the EU specifications, with 50 ppm sulfur in both gasoline and diesel in 2008. Starting from 2001, Beijing has introduced a loaded test for the application in I/M program. Scrap page of old dirty vehicles are also largely achieved by restricting their use in city center, together with a fiscal incentive to encourage earlier retirement. Beijing has already set up a CNG bus fleet of 3750 by 2008, diesel hybrid bus and hydrogen fuel-cell bus has been operated in pilot program. The subway system is planned to be significantly expanded in the future, from 200 km in 2008 to 560 km in 2015. The fleet average emission factors in Beijing have decreased by 23% to 76% for various vehicular pollutants after 10 years effort. However, due to the effect of motor vehicle number increase, the total emissions are almost stabilized during this period. Ambient air quality has been improved by 10-30% for vehicular pollutants. A whole package of air pollution control measures have been implemented during the 2008 Beijing Olympic Games period, with special focus on traffic control. All yellow-labeled vehicles (dirty vehicles) are not allowed to drive, while other vehicles have to follow odd/even numbers of their license plate to reduce half driving days. A 32% reduction of traffic volume and an increase of average speed from 25 to 37 km/h are observed. From monitoring campaign at roadside during different period in 2008, air pollution reduction related to traffic emission are reduced by 21% to 75%, as a fact of all control measures and favorable meteorological conditions.

8. Technical report: Malaysia "Health Effects in Malaysia"

National University of Malaysia
Mazrura Sahani , Er Ah Choy

Among the various environmental risk factors, indoor smoke from burning biomass fuels or coal for cooking and heating is the most significant risk factor in the Western Pacific Region, causing some 500,000 deaths every year. The second significant risk factor is urban air pollution attributing to some 370,000 deaths. The third one is unsafe water and poor sanitation with an estimated 77,000 deaths annually.

The WHO (2002) estimated that urban air pollution contributed to approximately 800,000 deaths and 6.4 million lost life-years worldwide in 2000, with two-thirds of these losses occurring in rapidly urbanizing countries of Asia.

A study on 'The Health Effects of the Ambient Air Pollution, in Klang Valley, Malaysia' aims to build a statistical model that could predict the risk of daily criteria air pollutants variation to mortality in Klang Valley. From preliminary result, it is found that

the total mortality and the natural mortality produced excess risk of 0.0031 and 0.0038 respectively for every 10ug/m^3 increment in PM10 at lag 1. This indicate that the effect of today's every increment of 10ug/m^3 PM10 could lead to the excess in 0.31% and 0.38% of tomorrow's total and natural mortality.

9. Result of Supporting Study

Japan Automobile Research Institute
Kiyoyuki Minato

Concerned with the increasing levels of air pollution caused by motor vehicles in Asia's major cities, JARI initiated a project on reducing vehicle emission in 2004. In supporting study, based on vehicle type, traffic volume, average speed, and emission factor, air concentration is estimated. This estimation method is applied in Bangkok. There is still room for improvement, but it is applicable for research for next year.

10. Result of the Database

ERIA coordinator
Keiko Hirota

The results of database were shared with all the members. With respect to vehicle category, more popular vehicle type, more detail category exists. In general vehicle type is categorized by engine displacement, vehicle model and use purpose. With respect to I&M, commercial vehicle is inspected with top priority. In some countries, inspection for private vehicle is applied after certain vehicle age. All member countries have FQM, but sometimes the problem is operation and implementation. There is still lack of information from several countries. It is necessary to improve the quality and quantity of database. Following operation problem, a seminar of FQM needs to be organized to share information.

11. Proposal for Next Year

Japan Automobile Research Institute
Kiyoyuki Minato
ERIA coordinator
Masahiko Hori

ERIA WG secretariat explained overview of research collaboration and a forum. Budget is not decided yet so that scale of research could not be explained. As soon as the budget is decided, ERIA WG secretariat will select some candidate country. For the improvement of database, it is necessary to request submission of data, which was not collected this time. Next forum would be held in November or December of 2009. Considering the economic recession, the forum aims to share the future projection by Mr. Okuda, (Toyota Motor), Mr. Tata (TATA Motor) and ASEAN secretariat. FQM and other issues will be discussed in the proposed forum.