Country Synthesis Report on Urban Air Quality Management

Thailand

Discussion Draft, December 2006

ADB

CLEAN AIR INITIATIVE for Asian Cities

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ADB facilitated this study through its Regional Technical Assistance 6291: Rolling Out Air Quality Management in Asia.

The Study was led by the CAI-Asia Secretariat and the information contained in this report was developed by the CAI-Asia Secretariat with inputs by a range of organizations and air quality experts from across Asia and elsewhere.

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Abbreviations

ADB	Asian Development Bank
AQM	air quality management
B	baht
BMR	Bangkok Metropolitan Region
BMTA	Bangkok Mass Transit Authority
CAI	Clean Air Initiative
CO	Carbon monoxide
CSR	country synthesis report
DIW	Department of Industrial Works
ECNEQ	Enhancement and Conservation of National Environmental Quality Act
GDP	gross domestic product
HC	hydrocarbons
IEA	International Energy Agency
LTD	Land Transportation Department
MFA	Ministry of Foreign Affairs
MoNRE	Ministry of Natural Resources and Environment
MoPH	Ministry of Public Health
MRT	mass rapid transit
MRTA	Mass Rapid Transit Authority
NAAQS	National Ambient Air Quality Standards
NEB	National Environment Board
NESDB	National Economic and Social Development Board
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxide
O_3	ozone
Pb	lead
PCD	Pollution Control Department
PM	particulate matter
PM_{10}	particulate matter with diameter not more than 10 microns
$PM_{2.5}$	particulate matter with diameter not more than 2.5 microns
SO_2	Sulfur dioxide
TSP	total suspended particulate
ug/m^3	micrograms per cubic meter
ULG	unleaded gasoline
US	United States
US EPA	United States Environmental Protection Agency
VOC	volatile organic compound
WHO	World Health Organization

Note: "$" means "US dollar" in this publication.

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» Part One

General Information

Geography and Climate

Thailand has a total land area of 513,000 km² and is bordered by the Lao People's Democratic Republic (Lao PDR) and Cambodia to the east, Malaysia to the south, and Myanmar to the west. Its shape and geography divide the country into four natural regions: the mountains and forests of the north; agricultural areas of the central plains; the semiarid farmlands of the northeast plateau; and the tropical islands and long coastline of the peninsula south. The country comprises 76 provinces that are further divided into districts, subdistricts, and villages. Bangkok is the nation's capital and the center of political, commercial, industrial, and cultural activities.

The country has a tropical climate with three distinct seasons—hot and dry from February to May (average temperature of 34 °C and 75% humidity); rainy with plenty of sunshine from June to October (average day temperature of 29 °C and 87% humidity); and cool from November to January (temperatures range from 32 °C to below 20 °C with a drop in humidity). Much lower temperatures are experienced in the north and northeast during nighttime. The south has a tropical rainforest climate with temperatures averaging 28 °C almost all year-round.

Population and Urbanization

As of 2004, Thailand has a total registered population of 62 million. The country's population density is 121 persons per km². Approximate 33% of the total population resided in municipal areas. The annual population growth rate has been stable at less than 1% since 2000 and is estimated to be at 0.8% for 2005.

Bangkok is the capital city. Bangkok and its five vicinity-provinces are so-called Bangkok Metropolitan Region (BMR), namely; Samut Prakan, Nonthaburi, Pathum Thani, Nakorn Pathom and Samut Sakhon. In 2004, the population registered in BMR is 9.6 million with Bangkok accounting for about 5.6 million (NS0, 2005). Population density in BMR is 1,242 persons per square kilometer while three times more in Bangkok.

The population in the municipal area (except Bangkok) ranged from about 200,000 to 2.5 million. Thailand has 19 provinces with a population of more than 1 million. Urbanization has steadily progressed in Thailand (although the growth rate is somewhat moderate than that of other Southeast Asian countries, such as Indonesia, Philippines, or Malaysia). The World Bank estimates that 32.2% of the population lives in the urban areas (World Bank, 2006). According to the United Nations, the urban population growth rate for 2000–2005 was 2.7% and is estimated to increase the rate to 40% of the population by 2030.

Since the early 1970s, an extensive program of infrastructure development accelerated urban development. Urbanization is following the major road corridors and the neighboring provinces are rapidly suburbanizing.

Economy and Industry

The economic structure of Thailand has changed dramatically since the late 1980s because of rapid industrialization. The economy more than tripled in the decade after 1986, achieving approximately 9% real growth annually from 1989 to 1996, before it became an epicenter of the 1997 Asian financial crisis. The gross domestic product (GDP) declined 1.4% in 1997, and then plunged to 10.5% in 1998. The share of its agricultural sector in GDP has fallen from 23.2% in 1980 to less than 10% in 2000. On the contrary, ratio of GDP increased in the manufacturing, commercial, and service sectors. Thailand's

economic growth trend has improved from—10.2% in 1998 to 6.3% in 2003.

In the past 3 years, Thailand's economy has been impacted negatively by the Asian tsunami, droughts, bird flu, and large increases in oil prices. GDP experienced a slow down from its 6.1% growth rate in 2004 to only 4.5% in 2005 (National Economic and Social Development Board [NESDB], 2006). The country has also been experiencing a slowdown in the manufacturing sector due to high oil prices and falling consumption and housing demand. (World Bank, 2006).

In 2006, the economic momentum is expected to gain strength on the back of increasing investment, continued recovery in tourism, and further expansion in private consumption underpinned by rising real income both in the private and public sectors as the inflationary pressures are expected to cool down in the latter half. The 2006 economic growth is projected at 4.7–5.7% (Ministry of Foreign Affairs [MFA], 2006).

During 2005, the agricultural sector contributed 9.9%, industry 44.1%, and services 46% of the GDP. Although economic growth in 2006 is gaining support from robust exports, private investment and consumption are moving slowly due to high oil prices and political uncertainties. Moreover, public infrastructure projects planned for 2006 have also been delayed, and the slowdown in investments has further decreased imports growth (NESDB, 2006).

Data from the Pollution Control Department (PCD) shows that there are more than 65,000 factories registered and most of the manufacturing facilities are located in the central region, with 45,000 factories (including those 20,000 in Bangkok).

Economic challenges include the recent bird flu outbreak, which could affect the profitable tourism and poultry sectors, and the continuing instability in the south of the country. However, growth is expected to increase to 4.8% in 2007 as confidence returns. The Government is also developing its 10th National Economic and Social Development Plan,[1] covering the country's development agenda for the next 5 years (2007–2011). The priority areas include human and social capital development, community strengthening, economic restructuring, environmental diversity, and good governance (World Bank, 2006). The plan aims to create balance and sustainability in all areas of Thailand's national development, and focuses on effectively using the country's economic, social, and natural resources to empower Thai society at all levels, and further strengthen institutional capacity throughout the country.

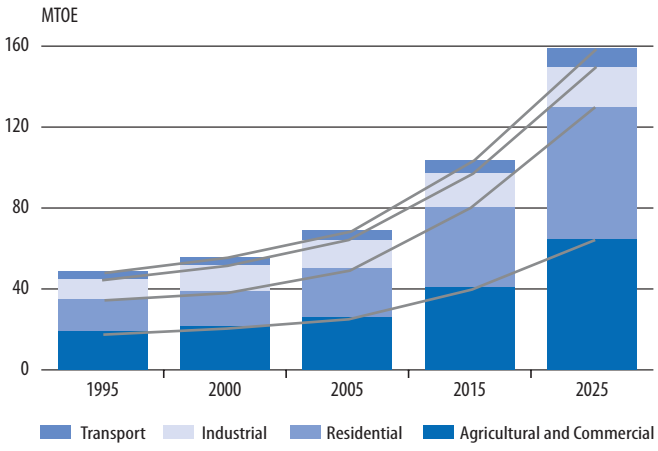
[1] Development plan of Thailand is drawn in National Economic Social Development Plan. The 5-year plan is prepared by NESDB. In response to a recommendation of the World Bank in 1957, the first 5-year development plan was prepared in 1961, and since then, the development plan scheme has continued for more than 40 years. The Thai government is implementing its ninth 5-year development plan (from Oct. 2001 to Sep. 2006).

Energy

Thailand's energy sector is undergoing a period of restructuring and privatization. The Thai electric utility and petroleum industries, which historically have been state-controlled monopolies, are being restructured. Total energy consumption in 2003 is equivalent to 3.1 quadrillion British thermal units (BTUs), comprising oil (53%), natural gas (33%), coal (12%), hydroelectricity (2%), other renewables (1%). Thailand contains 600 million barrels of proven oil reserves as of 2005 but still imports most of its oil as the country produced only 297 thousand barrels per day, of which 38% was crude oil. Majority of the energy in Thailand is predominantly consumed in the transport sector that accounts for 79.4% of all fuel consumption that year, or about 25.4 billion liters. Of this, road-based vehicles used more than 99% of total fuel consumed. The main fuel types are gasoline, diesel oil, and jet fuel. To look forward to 2025 (Figure 1.1), the energy demand forecasting shows that the demand of the transport sector is expected to reach 64.7 million tons oil equivalent (MTOE), nearly 2.5 times increase from 1995 (Srisurapanon, V., undated).

FIGURE 1.1

Final Energy Demand per Sector in the Business-as-Usual Case



MTOE = million of tons oil equivalent

Source: Energy Policy and Planning Office, Ministry of Energy, 2006.

Figures 1.2 to 1.5 show fuel consumption by the transport sector. BMR accounts for more than 60% of the total gasoline consumption and 70% of the total diesel consumption of the country, one third of which are consumed in Bangkok alone. Energy demand growth from transport has slowed somewhat since 2003, largely because of increasing substitution of natural gas in electricity generation and increased use of ethanol in motor fuels.

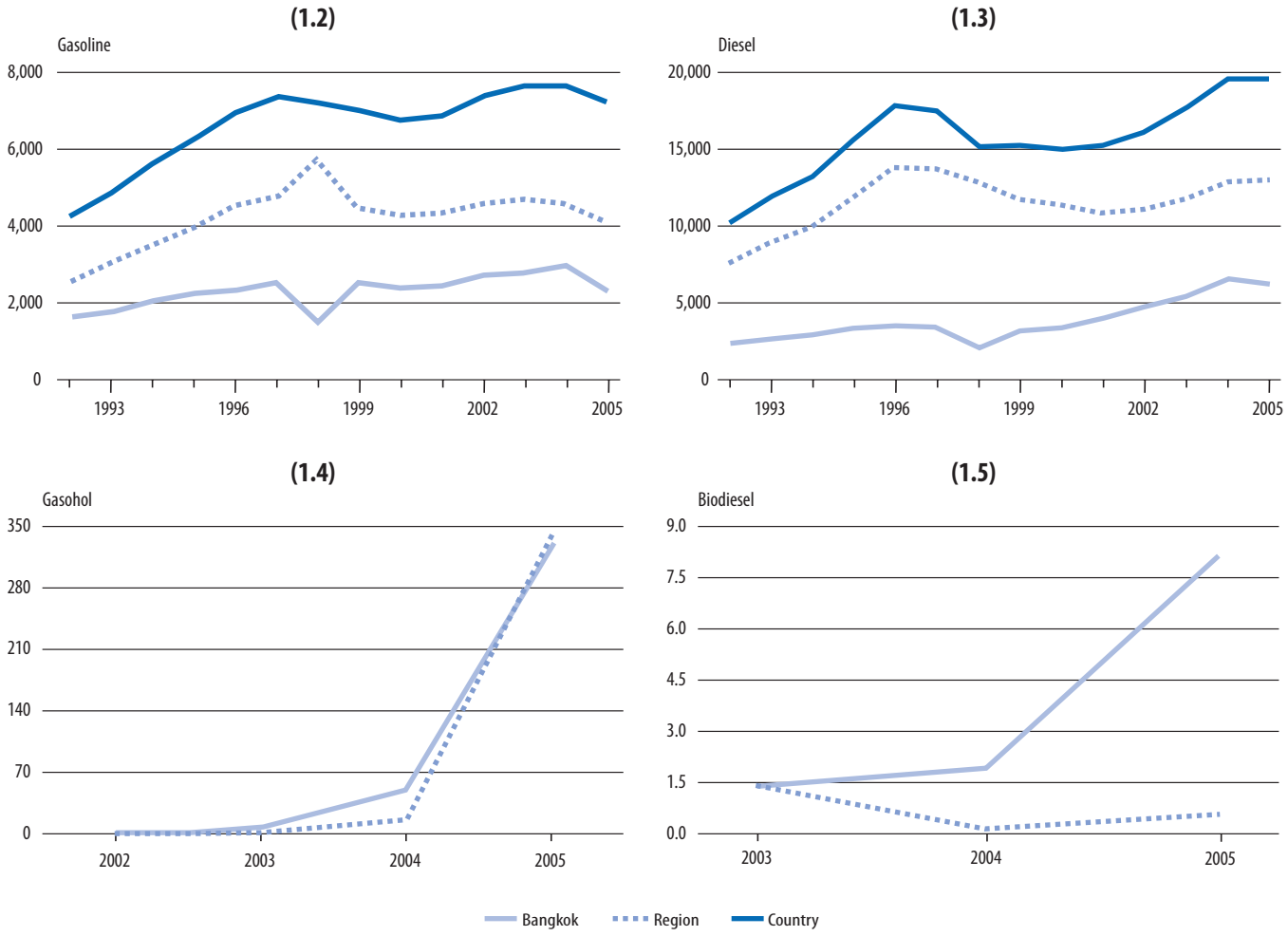
Natural gas. Thailand has about 13.3 trillion cubic feet of proven natural gas reserves, of which it produced 787 billion cubic feet in 2003. The country consumed 1,029 billion cubic feet in 2003, including imports from Burma. Much of the country's natural gas is used for generating electricity. In 2001, Thailand completed its program for the conversion of almost all oil-fired electric power plants to natural gas. Demand for natural gas is expected to rise at a 5–6% annual rate over the next 5 years. The development of Thailand's domestic natural gas resources and imports from Myanmar are expected to cover anticipated demand for the next several years, though liquefied natural gas remains a long-term option for Thailand.

Coal. Thailand has an estimated recoverable coal reserves of 1.5 million short tons.[2] In 2003, the country produced

[2] A unit of weight equal to 2,000 pounds (0.907 metric ton or 907.18 kilograms). Also called net ton, short ton.

FIGURES 1.2–1.5

Fuel Consumption by the Transport Sector in BMR and Bangkok (million liters)



BMR = Bangkok Metropolitan Region, PCD = Pollution Control Department
Source: PCD, 2006.

20.7 million short tons, mostly lignite[3], and imported 7.8 million short tons of hard coal and coke. The country's coal consumption during the same period is estimated to meet the country's consumption of 26.4 million short tons, which is utilized by the power sector.

Renewable Energy. The Government's energy policies/programs that are related to renewable energy over the past decade includes the Ministry of Energy's strategy for competitiveness that aims to promote a more efficient use of energy in the transport sector and conservation in the industrial sector. The goal is also to increase the share of renewable energy in commercial primary energy use from 0.5% in 2002 to 8% by 2011 by enforcing the Renewable Portfolio Standard, which requires power plants to have 4–5% of their generating capacity coming from renewable sources and by using other fiscal incentive measures.

Gasohol and biodiesel. The New Energy Strategic Plan approved in 2005 targets about 25% of petrol consumption for the transportation sector to be replaced with the use of natural gas, gasohol, and biodiesel by 2009. Currently, biofuels are increasingly being used for transport. Both gasohol (E10: mixing 90% of gasoline and 10% of ethanol) and biodiesel (B3: 3% of biodiesel in diesel) were actively promoted. Gasohol consumption has increased from less than 100 million liters in 2004 to more than 600 million liters in 2005 and biodiesel consumption increased at a slower rate of 2 million liters in 2004 to 8 million liters in 2005. Thailand plans to reduce its consumption of petroleum and imports of gasoline additive methyl tertiary butyl ether by promoting domestic production and consumption of ethanol. The Thai government approved a package of tax incentives in December 2000 to encourage more production of ethanol for fuel use, and gasoline containing 10% ethanol was introduced in the greater Bangkok area in late 2005.

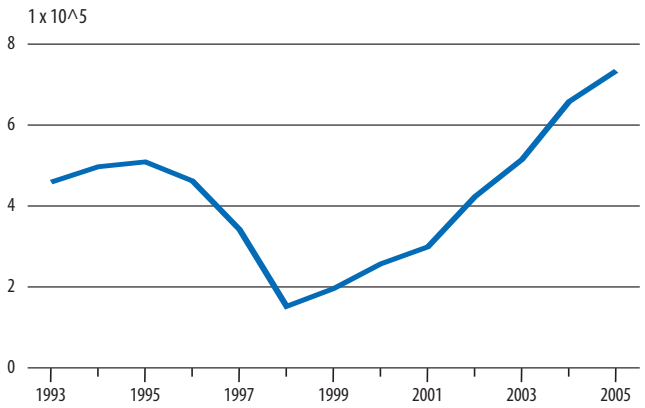
[3] A brownish black, low-rank coal with a heating value of less than 8,300 Btu/lb (4,611 kcal/kg). The quality of Thai lignite, currently fired in 150-MW and 300-MW power plant units, is quite low and rather variable. This low-rank coal is characterized by high contents of fuel sulfur (up to 7% in ultimate analysis) and ash (up to 35% in proximate analysis) as well as elevated fuel nitrogen content (up to 3% in ultimate analysis). (KOUPRIANOV, V.I. , et. al. 2003. Effects of Fuel Quality on Emission Rates and Specific Emissions of Major Pollutants from Lignite-Based Power Generation In Thailand. Paper presented in the 12th International Conference on Coal Science. November. Cairns, Australia.

Transportation

In 2005, the total number of registered vehicles in Thailand was more than 25,000,000, of which 25% are registered in Bangkok. The trend of new vehicle registration in Bangkok has been decreasing since 1993 (with the lowest in 1998) due to the Asian economic crisis. New vehicle registration started to increase in 1999 at an average rate of approximately 22% annually with more than 700,000 new units added in Bangkok alone for 2005 (Figure 1.6).

FIGURE 1.6

Number of New Vehicles Registered in Bangkok, 1993–2005



Source: Pollution Control Department, 2006.

However, it is estimated that more than 60% were actually used in the area (Environmental Policies in Thailand and their Effects, undated). It is approximated that in-use vehicles (on the road) are about 53% of the Land Transportation Department (LTD) reported values.[4] However, more than 60% were actually used in the area. This implies that most of transportation problems were intensive in Bangkok and the surrounding areas. Motorcycle contributes more than 40% of the vehicle population in Bangkok, followed by cars, vans and pickup trucks, and buses and trucks. Before 2000, more than 90% of the in-use motorcycles were 2-stroke. Currently, the number of in-use 2-stroke has decreased to 35% and 4-stroke has increased to 65%. The increase in the number of vehicles in Bangkok has not been matched by a proportional increase in road construction leading to traffic congestion, transportation delays, and added pollution.

[4] The annual data published by the Land Transportation Department (LTD) provide cumulative registrations and not the number of vehicles on the road.

Mass Transit System. In an effort to reduce the level of traffic and air pollution, the city of Bangkok built its first elevated rail system, which has been in service since December 1999. Bangkok Mass Transit System Public Company Limited, commonly known as the BTS Sky Train, operates the system. Currently, there are two lines totaling 23.5 kilometers which cover much of the central city and many of its commercial, residential, and tourist areas, with extensions planned for outlying areas. Each train can carry over 1,000 passengers, while a similar number of people use 800 cars, making the BTS Skytrain the most environmentally friendly mass transit system in Thailand. Passengers are approximately 400,000 per day. In 2006, the extensions of the present 2 BTS lines for 2.2 and 8.9 km (totaling 11.1 km) are under construction and expected to be completed in 2009. Additional extensions of four routes have been approved for 33.4 km and are being constructed further.

The other mass rapid transit (MRT) system operated by a private consortium under concession to the Mass Rapid Transit Authority (MRTA) of Thailand—MRT Chaloem Ratchamongkhon Line or the Blue Line subway—is the first 20-km underground system and was opened in 2004. Currently, there are approximately 170,000 passengers per day.

The MRT Chaloem Ratchamongkhon Line, together with BTS, can provide approximately a 44-km core network of mass rapid transit system, which is considered inadequate for improving the traffic circulation in Bangkok. In 2004, the Commission Management for the Land Traffic came up with a resolution to implement the 291-km extension of the MRT network as proposed by the Office of Transport and Traffic Planning and Policy. A part of the extension network, 91-km long, has been assigned to MRTA. This extension network consists of three lines including both elevated and underground: blue (27 km), orange (24 km), and purple (40 km). In accordance with the Government's policy, the extension of the MRT network is to be completed within 6 years (2004–2009). Construction of all MRTA extension projects are planned to begin in 2005 and to be partly opened to the public by the end of 2009.

Public transportation. Buses are the backbone of the passenger transportation system in Bangkok, accounting for more than 50% of all passenger trips, and 75% of trips during the peak period. Urban bus services are managed by the Bangkok Mass Transit Authority (BMTA), which operates a fleet of 3,650 of its own buses and controls the operation of 3,400 buses run by subcontractors. BMTA operates a fleet of non-air-conditioned and air-conditioned buses. It has been reducing the number of its buses. In 1999, it operated 4,200 of its own buses. There is no evidence that the number of subcontractor buses are increasing to fill the void. In fact, they may be decreasing. In 1999, BMTA private subcontractors represented 3,428 buses but data provided by the BMTA Private Bus Association and Club suggests that private buses subcontracted to BMTA represented 2,530 buses in 2003 of which 339 were A/C. BMTA is not permitted to operate buses older than 10 years.[5] These are sold to the private sector. Bus manufacturers handle much of BMTA's maintenance. There is a variety of contract types whereby manufacturers supply buses, operate, and maintain them; maintenance is being paid on a daily rate per bus. Intercity bus operations are controlled by a state-enterprise—The Transport Co, Ltd. It directly operates 770 buses, mostly air-conditioned, on premium routes that connect Bangkok to the main regional cities. Private subcontractors operate a further 5,600 buses.

Since the 1997 financial crisis, there has been a growth in the use of air-conditioned vans for point-to-point commuter services. Initially, they functioned illegally but are now regulated by BMTA. In July 2002, there were 5,330 of these vans.

[5] However, in 2001, BMTA renewed the maintenance contract for an additional 3 years on 300 10-year old (pre-Euro) Mercedes Benz buses supplied and maintained by Thonburi Automotive Assembly Plant Co Ltd.

» Part Two

Sources of Air Pollution

The major sources of air pollution in Thailand are industries, power plants, transport (primarily automobiles), and area sources that include agricultural wastes and biomass burning. Key air pollutants include particulate matter (PM) ☒ with diameter not more than 10 microns (PM_{10}) and with diameter not more than 2.5 microns ($PM_{2.5}$), Sulfur dioxide (SO_2), lead (Pb), Carbon monoxide (CO), Nitrogen oxides (NO_x), hydrocarbons (HCs), and ground-level ozone (O_3). The main pollutant of concern is PM_{10}.

Emissions Inventory

PCD has been estimating emissions for Bangkok and the other regions of Thailand with assistance from consultants. There is a need for capacity building to improve the mobile, stationary, and area source emission inventory process. Emission factors for pollutants emitted from vehicles driven at different speeds for given vehicle types and characteristics were calculated by using the US EPA MOBILE 5 emission factor model. The Department of Energy Development has also been conducting mobile emissions inventories by applying emission factors to the estimated fuel use by the transport sector.

In 2005, emissions inventories in Samutprakan and Saraburi were studied for mobile, stationary, and area sources. Source apportionment studies in such areas were also carried out at the same time. Those studies were made because of high concentrations of PM as observed from monitoring data (particularly during the dry season) and repeatedly exceeded National Ambient Air Quality Standards (NAAQS).

Collaboration and data sharing within government agencies should be enhanced to share the use of a common database of other national and local government agencies as well as other interested parties.

Special studies have estimated emissions in Bangkok and other major sectors of Thailand. Despite the availability of a number of emission estimates, some have limited and different scopes of work. Developed emission inventories must have the same technical basis (principal approach, estimation software and method, and coverage year). However, there may be significant discrepancies in these inventories as some studies sometimes differ by a factor of 20 (PCD, 2006a).

Existing inventories in BMR should be expanded to take into account the pollution generated outside its airshed, the emissions from open burning, or agricultural residues, or open cooking. Emission factors used for vehicles could be improved by developing them and considering the prevalent conditions in Thailand. The distance traveled for each class of vehicle must be estimated more accurately. Likewise, there is a need to use more than one method to address uncertainty issues and to strengthen confidence in the inventories.

Mobile sources. Cars are major sources of CO, HC, and NO_x. 2-stroke motorcycles are a dominant source of HC and contribute significantly to PM and CO emissions but are decreasing in number. Diesel trucks—both heavy and light duty—are responsible for high emissions of PM, NO_x, HC, and CO. Aging bus fleets in urban areas, including Bangkok, are large emitters of PM. A study[1] conducted in 2001 showed diesel vehicles account for only 28% of in-use vehicle fleet registered in Bangkok, but are estimated to emit 89% of inhalable (PM_{10} or finer) emissions from the fleet. An estimated 10,000 tons per year of PM can be attributed to light-duty trucks (31%), city buses (30%), city trucks (23%), motorcycles (10%), long-haul trucks and buses (5%), and passenger cars (1%).

Stationary sources. As large sources such as power plants and refineries have been controlled over the last decade, small and medium industries have increased in importance as major

[1] Parsons International Final Report for the Air Quality Management Project to BMA. 2001.

sources of PM and NO_x pollution. The central region—the most industrialized area—accounts for 60 to 70% of all industrial emissions. The World Bank[2] identified the key sources of PM, SO_2, and NO_2 within the central region as cement, lime and plaster manufacturing, iron and steel making, and other medium to heavy industries. Within the region, BMR accounts for more than 50% of SO_2, volcanic organic compounds (VOCs), and CO and over 30% of the total NO_2 from industries. Latest data from PCD reports that out of the 20,119 factories in BMR, one fourth are causing air pollution (PCD, 2006b).

Area sources. Important area sources include resuspended road dust, open cooking using fossil fuels, and biomass burning such as agricultural and community wastes burning. These sources of pollution are widespread, difficult to cover in inventories, and thus, often underreported and overlooked. The forest fires in Thailand in 2000 were estimated to have generated approximately 40,000 tons of total suspended particulates (TSP)—equivalent to the total emissions for Bangkok from all sources. The burning of agricultural residues generated 319 tons of TSP each year, causing widespread subregional haze. Other pollution sources that are usually overlooked are residential and commercial open cooking and refuse burning. Estimates for Chiang Mai show that CO and VOC emissions from these sources are estimated to contribute 693 tons of CO and 627 tons of VOC in 2001.

[2] World Bank. 2002. Thailand Environment Monitor 2002: Air Quality. Available at: www.worldbank.or.th/monitor.

Source Apportionment

Source apportionment studies are limited only in research and academic institutes. Many institutions are actively involved in conducting these studies, focusing on PM_{10}, $PM_{2.5}$, and VOC.

Several source apportionment studies have been conducted in recent years such as the one by Nouchpramool et al. (1999) which characterized airborne particulates in the Bangkok urban area. Chueinta et al. (2000) investigated the sources of atmospheric aerosol in urban and suburban residential areas in Thailand. Wangkiat et al. (2004) studied the chemical characteristics of fine and coarse aerosols in northern Thailand. Jinsart et al. (2005) characterized urban and suburban PM_{10} and $PM_{2.5}$ in Bangkok. Suwattiga and Limpaseni (2005) studied the seasonal source apportionment of ambient air VOCs in Bangkok. A recent source apportionment study of $PM_{2.5}$ in ambient air in Chang Mai was conducted by Sangon and Pengchai (2006).

Recently, source apportionment studies were gradually applied for management perspectives. For instance, PCD conducted source apportionment studies in specific polluted areas. In 2004, there was a study of airborne particles source apportionment in Mae Moh, Lampang—where the Mae Moh Power Plant is located—using lignite as the main fuel. This study provided support information on appropriate control measures from major sources in the area and gave scientific explanations to the local community on the fate and behavior of PM. Other studies in 2005 included source apportionment of PM in Samutprakarn and Saraburi—the other two polluted areas facing serious pollution problems from PM.

» Part Three

Status of Air Quality

Air quality in Thailand has improved significantly in the past decade (World Bank, 2002). Lead, particulates, and CO in Bangkok and other urban centers had decreased to an acceptable level and 2005 data shows decreasing trends (World Bank, 2004).

Ambient Air Quality Monitoring

Monitoring the ambient air quality in Thailand has been carried out since 1983. This has been improved, upgraded, and expanded from time to time to cover various areas of the country. The primary responsibility for monitoring rests with PCD. Its monitoring network currently consists of 53 sites nationwide (Table 3.1), which are linked to PCD's central computer system in Bangkok. Majority of the sites in all five regions (north, northeast, east, central, and south) monitor particulates, CO, NO_2, SO_2, and ground-level O_3. However, not all stations monitor all these pollutants; some monitor other pollutants in addition to those already mentioned. Concentrations of air pollutants are measured, collected, and analyzed by a data acquisition system in each station and subsequently data are transmitted daily to the central data processing system at PCD through a dial-up telemetric communication system.

Moreover, PCD has five mobile ambient air quality monitoring units for emergency response to air pollution episodes and other special air pollution studies. PCD is also establishing ambient air monitoring standards for $PM_{2.5}$. Background information is being collected for the consideration of standard levels. In addition, planning for the ambient air monitoring of $PM_{2.5}$ is being undertaken. There have been two continuous monitoring sites for $PM_{2.5}$ in Bangkok since 2001 and two more stations in other provinces are being considered.

TABLE 3.1

Spatial Distribution of Air Quality Monitoring Stations

Region	Province	Number of Stations
Central region (31 stations)	Bangkok	17
	Samut Prakarn	5
	Patum Thani	1
	Nonthaburi	2
	Ayutthaya	1
	Saraburi	2
	Ratchaburi	1
	Samut Sakorn	2
Northern region (7 stations)	Chiang Mai	2
	Lampang	4
	boveNakorn Sawan	1
Northeastern region (2 stations)	Khon Kaen	1
	Nakorn Ratchasima	1
Eastern region (8 stations)	Chachengsao	1
	Chonburi	3
	Rayong	4
Southern region (5 stations)	Yala	1
	Narathiwat	1
	Surat Thani	1
	Phuket	1
	Songkhla	1

Source: Pollution Control Department, 2006.

Since early 2004, the continuous monitoring of VOCs in ambient air has been conducted at five stations around Bangkok and the surrounding area with special attention given to mobile sources emission. Concentrations of certain VOCs were found to be at levels were risks to health could not be ignored. The Royal Thai Government recognized the need to act on this serious matter. Thus, a systematic procedure of monitoring VOCs in Thailand was implemented to develop

its environmental and emission standards. This project was carried out in collaboration with JICA or Japan International Cooperation Agency and PCD. Since August 2006, several sites for the continuous monitoring of VOCs have been set up in Map Ta Phut district and another four in Bangkok and the surrounding area, particularly those near industrial areas.

The Ministry of Public Health (MoPH) used to maintain air quality monitoring stations throughout Thailand but stopped operations for routine monitoring. They are now used only for specific research. A fleet of mobile units is maintained by MoPH to respond to area-specific pollution complaints. The primary focus of MoPH monitoring is to study the health effects of air pollution.

Bangkok's city government, the Bangkok Metropolitan Administration, has four permanent air and noise monitoring stations and one mobile monitoring unit. Under the decentralization process mandated by the Constitution of the Kingdom of Thailand—B.E. 2540 (1997)—the Bangkok Metropolitan Administration and other city governments in Thailand will assume responsibility for air quality monitoring functions, while policy making and setting of standards will remain with national level agencies such as PCD and MoPH.

Ambient Air Quality

The government has set ambient air standards and implemented countermeasures for PM_{10}, SO_2, NO_2, CO, O_3, and Pb. This resulted in the improvement of emission concentrations of NO_2, SO_2, and others to a certain level. Ozone exceeds the standard value in some monitoring locations, mainly in the BMR and the eastern region. The three most seriously polluted areas in Thailand, especially PM levels, are Samutprakarn, Bangkok, and Saraburi.

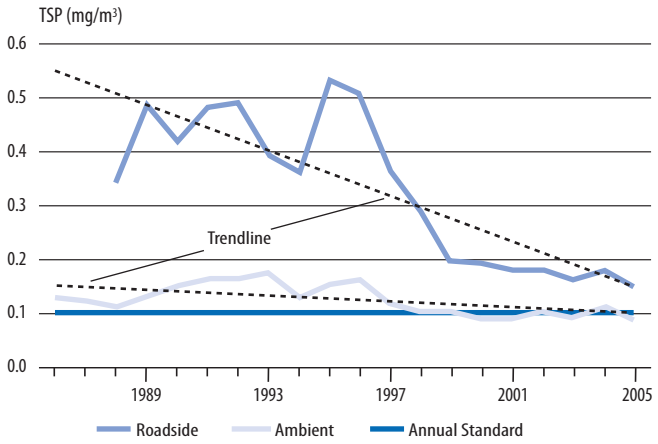
Although the vehicle population in Bangkok has increased by an average of 300,000 vehicles per year since 1990, roadside CO, SO_2, and NO_x concentrations in Bangkok have been decreasing since 1993.

Total Suspended Particulates

Figure 2.1 shows annual roadside and ambient TSP levels have been monitored from 1996 to 2005. The annual TSP levels for roadside monitoring have decreased over the years, while ambient levels are within the Thai standard of 0.1 mg/m^3. Increases are more likely to occur from November to April. Temperature inversions that trap pollutants close to the ground usually occur at the onset of the cool season, which is toward the end of the year. From February to April, the burning of rice paddies and other agricultural residues results in higher variability of TSP concentrations in Bangkok and the other urban areas.

FIGURE 2.1

Roadside and Ambient TSP Levels in Bangkok, 1996–2005



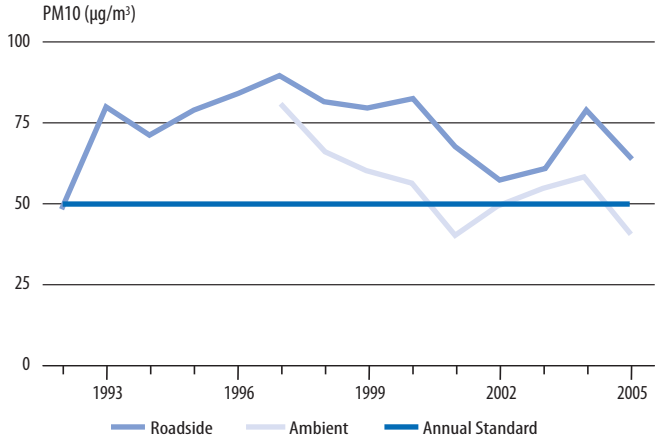
mg/m^3 = milligram per cubic meter, TSP = total suspended particulates
Source: Pollution Control Department, 2006.

PM_{10}

Thailand's air quality is still centered on the problem of PM_{10}, which is generally exceeded in several areas such as Samut Prakarn Province, Bangkok (at roadsides), and Tambon Na Phra Lan, Chaloem Phra Kiat District, and Saraburi Province. Other areas such as the provinces of Chiang Mai, Lampang, Phra Nakhon Si Ayutthaya, Chonburi (Si Racha District), and Rayong (Pluak Daeng District) have elevated PM_{10} levels during winter (PCD, 2004). Figure 2.2 shows the ambient and roadside PM_{10} levels in Bangkok from 1992 to 2005. Control measures and the Asian economic crisis of 1997 contributed to the decline of average ambient PM_{10} since 1997. However, both levels have increasing trends from 2002 until 2004. This improved in 2005. Ambient PM_{10} level in 2005 is within the standard of 50 micrograms per cubic meter (ug/m^3), while roadside ambient PM_{10} concentrations exceeded the standard. Longer-term trends in Bangkok's TSP concentrations (measured at the roadside) show that TSP levels mirror trends in ambient PM_{10}.

FIGURE 2.2

Ambient and Roadside PM_{10} Levels in Bangkok, 1992–2005



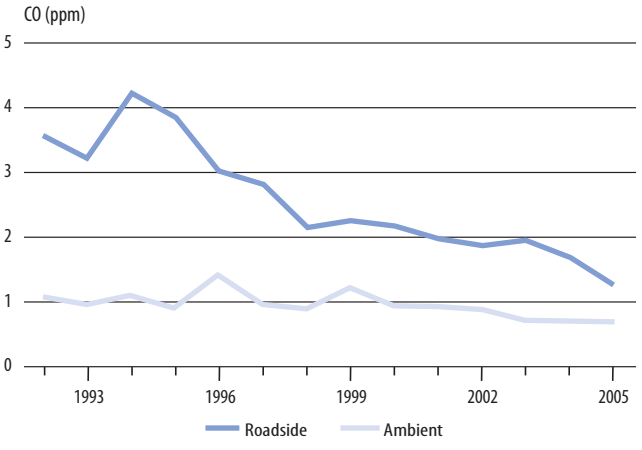
ug/m³ = micrograms per cubic meter, PM_{10} = particulate matter with diameter not more than 10 microns
Source: Pollution Control Department, 2006.

CO

Despite huge increases in the number of vehicles, CO levels have declined slightly over the last few years due to fleet modernization, enforcement of emissions standards, reduced traffic congestion, and improvements in fuel quality. Roadside measurements of CO levels in Bangkok from 1992 to 2005 show a steady reduction over a 14-year period (Figure 2.3). Annual ambient levels were not very different from the 2003 and 2004 values, while annual roadside level increasingly decreased over the same period. The average concentrations in Bangkok's adjoining provinces were similar to those observed in Bangkok. In the rest of Thailand, CO levels were very low and exhibited a downward trend similar to that of Bangkok. This decline is due for the most part to the catalytic converters in automobiles, which were mandated in 1993 after the introduction of unleaded gasoline (ULG). Peak CO concentrations typically occur during the colder months of the year, that is, when CO automotive emissions are greater and nighttime inversion is more frequent.

FIGURE 2.3

Annual Roadside and Ambient CO Levels in Bangkok, 1992–2005



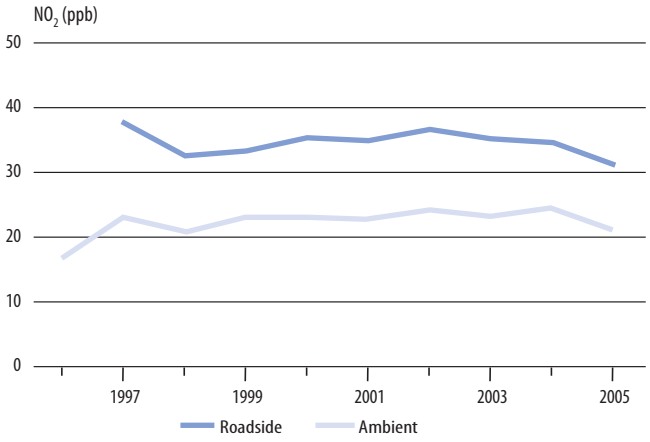
CO = Carbon monoxide, ppm = parts per million
Source: Pollution Control Department, 2006.

NO_2

Nitrogen dioxide (NO_2) levels in Bangkok have not been changing much over the years (Figure 2.4). SOE 2004 stated that NO_2 concentration levels in Bangkok's suburban provinces were similar to those recorded in the city.

FIGURE 2.4

Annual Roadside and Ambient NO_2 Levels in Bangkok, 1996–2005



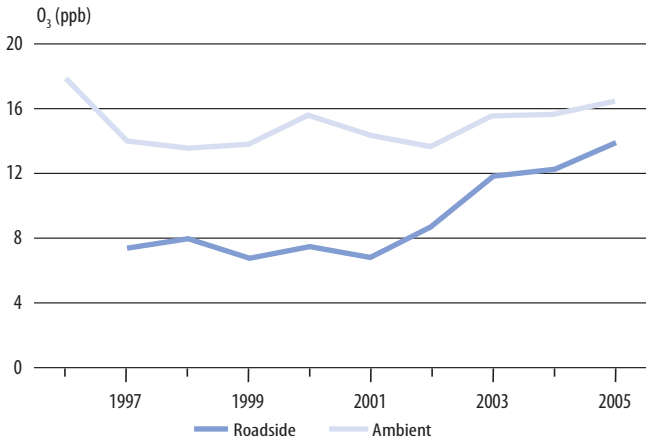
NO_2 = Nitrogen dioxide, ppb = parts per billion
Source: Pollution Control Department, 2006.

O_3

Ozone levels in Bangkok are a cause for concern as shown in Figure 2.5. Similar trends have been observed in other BMR provinces and the eastern region of Thailand. Rising emissions of VOCs and NO_x, which are precursors for O_3 along with meteorological conditions, are causes of increasing maximum levels downwind in urban centers. However, several studies have indicated that the O_3 problem in Bangkok is controlled by VOCs and not by NO_x. This means that VOCs emissions will have to be reduced to lower the levels of O_3.

FIGURE 2.5

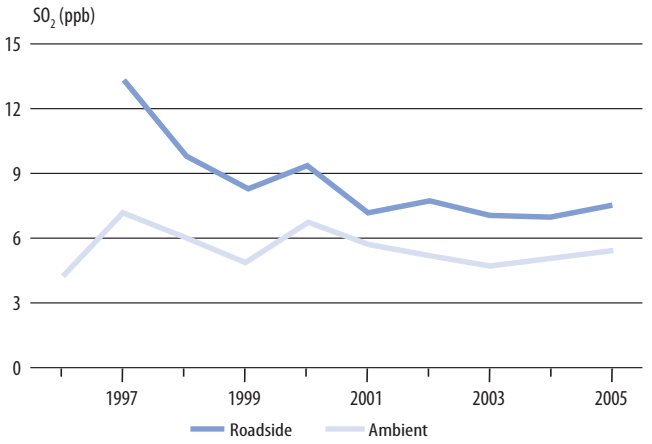
Annual Roadside and Ambient Ozone Levels in Bangkok, 1996–2005



Source: Pollution Control Department, 2006.

FIGURE 2.6

Annual Roadside and Ambient SO_2 Levels in Bangkok, 1996–2005



Source: Pollution Control Department, 2006.

SO_2

PCD has identified power plants as the major source of SO_2. Thus, measurements are made near power stations around the country. In Mae Moh, 13 lignite power plants are responsible for the excessive levels of SO_2. Following a serious incident in its power plants in 1992, the Electricity Generating Authority of Thailand introduced a comprehensive policy for environmental protection. Desulfurization technology has been progressively installed in power plants that resulted in the declining level of ambient SO_2 in Mae Moh. With EGAT's power generating plants' improved compliance with the environmental policy, emissions have begun to decline.

Ambient levels of SO_2 around cities have been within standard levels for a long time (Figure 2.6). In 2005, ambient and roadside measurements in Bangkok showed that average measurements of SO_2 were well below the national standard. In Bangkok's adjoining provinces, SO_2 concentrations were similar to those of Bangkok.

Lead

Lead in ambient air is not an issue in Thailand anymore. Since Thailand's complete phaseout of leaded gasoline at the end of 1995, lead levels were observed to have fallen to almost nil.

Reporting of AQ Information

PCD distributes information about environmental issues in general through different means and media including the internet to suit different categories of users. General information on environmental and pollution issues in Thailand—including air pollution—can be found in PCD's homepage, www.pcd.go.th.

PCD's Air Quality and Noise Management Bureau has developed an internet-based Air Quality and Noise Information System (www.aqnis.pcd.go.th) intended to disseminate information related to air quality management in Thailand. The system includes a daily air quality update and next-day air quality forecast.

Data has been published in several reports such as the Environment Statistics of Thailand (web.nso.go.th), State of Thailand's Environment, and Pollution in Thailand (www.pcd.go.th). Air quality data is mainly reported in basic statistics forms such as range, percentiles, and timing average.

» Part Four

Impacts of Air Pollution

Most health studies conducted in Bangkok and its surrounding areas have focused on three main air pollutants: PM_{10}, Pb, and CO. The health effects examined centered on respiratory-related illnesses. A World Bank-funded project in Bangkok in 1998 showed an association between respiratory problems and PM_{10}. This study found increases in daily incidence of upper respiratory problems per 30 µg/m^3 increase of PM_{10} of 9% for children, 26% for adults who worked and lived by the roadside, and 9% for adults who worked and lived in more protected environments. Similar exposure-response relationships were found for lower respiratory problems. The study also found that a 30 µg/m^3 daily increase in PM_{10} resulted in a 5.3–17.6% daily increase in hospital admissions. (Radian International, 1998) In 2001, airborne PM was estimated to have caused 3,300 premature deaths that led to almost 17,000 hospital admissions, at a total health care cost of up to $6.3 billion (EIA, 2003).

A number of recent studies show that air pollutants have increased mortality and morbidity rates, most notably in BMR. One study reports that Bangkok's population has been affected adversely by increases in PM—with an estimated 5,000 premature deaths annually. The Mae Moh valley has recorded an unusual number of deaths from heart failure and a high incidence of chronic respiratory problems. In one 1998 incident, 400 villagers were hospitalized as local SO_2 levels of 2,200 µg/m^3 per hour were reported (compared to the standard value of 1,300 µg/m^3). Public exposure to air pollution in Bangkok is estimated to cause thousands of premature deaths and several million cases of ailments every year. Some preliminary studies on the health costs associated with increases in air pollution were conducted. One recent study examined the relationship between PM and acute daily respiratory problems on a sample group of 251 subjects in Bangkok. It was estimated that a 10 µg/m^3 reduction in annual average of PM_{10} concentrations would result in reduced health problems and an improved quality of life valued between 35 and 88 billion baht (B) ($1.4–3.55 billion) (World Bank, 1999).

An analysis of the cost on health of exposure to PM_{10} in six major cities in Thailand—Bangkok, Chiang Mai, Nakhon Sawan, Khon Kaen, Nakhon Ratchasima, and Songkhla —was undertaken for the World Bank Environment Monitor (released in 2002). The total cost of the exposure to PM_{10} in these cities for excess deaths and bronchitis is estimated at $644 million per year and is a lower bound of the health damage (EIA, 2003).

Economic evaluation of air pollution in Bangkok has been well documented compared to other Asian cities. The World Bank-funded study found that Bangkok residents spent an average of 12.5 per cent of their total medical expenses on respiratory illnesses alone. It was also determined that a 20 µg/m3 reduction in annual average PM_{10} concentrations in Bangkok would result in an estimated savings of B65–175 billion. These savings largely outweigh the costs of mitigation measures used to reduce PM (Radian International, 1998).

BOX 4.1

Benefits of Unleaded Gasoline (ULG) Phase-out

The leaded gasoline phaseout policy brought about health benefits to the population in Thailand. A 1996 study on health benefits after the implementation of the ULG Policy showed that blood lead levels in traffic police officers decreased dramatically from 28.14 ug/dl in 1993 to 5.58 ug/dl in 2000. The study also calculated the monetary value of health benefits resulting from reductions in IQ loss effect on lifetime earning in children, and in hypertension, heart disease, stroke, and premature mortality in adults. The monetary value of health benefits was calculated to be B7,000 million, while the costs of the phaseout are only B200 million (Chulalongkom University and PCD, 2002).

Public Perception

The Thai Society of Environmental Journalists, in collaboration with United States-Asia Environment Partnership Program and Mahidol University, surveyed 643 Bangkok residents between March and May 2002 to gauge their perception of air pollution (World Bank, 2002). The public's views are consistent as to the sources, causes, and impacts of air pollution across age and gender.

Nearly three out of four Bangkok residents considered air pollution as the main environmental problem. Ninety percent identified transport as the main source, while road dust, construction dust, and industrial emissions ranked next. Uncontrolled urbanization, overpopulation, inadequate city planning, poorly maintained vehicles, and the widespread use of 2-stroke engines were thought to be the causes. Bangkok residents were well aware of air pollution. Eighty-five percent had witnessed what they believed to be motor vehicle emissions violations. Such violations were not reported to the authorities because either they did not know how to make a report, or they did not feel it was their duty to report. Thirty-one percent indicated they did not believe the Government would act even if they reported a violation. The survey indicated that while government authorities and air quality experts believed that Bangkok's air quality is improving, the public believed the situation has continued to deteriorate, or has remained the same.

Control measures were perceived inadequate. Citizens were aware of government pollution control measures and campaigns and felt these are on the right track although enforcement was weak and inconsistent. They would welcome more integrated policies and closer coordination among responsible authorities. The majority indicated that solving Bangkok's air pollution problem requires action not only from the Government, but also from citizens, civil society groups, and the private sector. Those with a relatively higher level of education believed more strongly that individual citizens have a greater responsibility in helping develop solutions. Public transport commuters also believed that public transportation is an important component in any solution. Additionally, while respondents recognized that effective solutions include mass transit and clean technologies, many cited the importance of creating the right incentives.

» Part Five

Air Quality Management

Both the central Thai Government and BMA have developed clear policies to improve air quality. Improving air quality is highly prioritized and the government's general policy is to mitigate air pollution problems in non-attainment areas and to keep air quality in attainment areas within ambient air quality standards.

Legislation and Mandate

The ECNEQ of 1992 is the most significant environmental legislation. It repealed and replaced the Enhancement and Conservation of National Environmental Quality (ECNEQ) Acts of 1975, 1978, and 1979. The 1992 ECNEQ Act continues and expands the responsibilities of the National Environment Board (NEB) that was created by the 1978 amendment to develop environmental policy and coordinate issues relating to environment and quality standards. This comprehensive legislation elevates NEB to ministerial level, creates incentives for environmental promotion and preservation, prescribes penalties for polluters, provides for the establishment of a fund for promotion and preservation of environmental quality, and gives the public a greater participatory role in addressing environmental problems.

Other acts that also contain provisions related to motor vehicle air pollution control include the Land Transport Act of 1992; Motor Vehicle Act of 1979; Traffic Act of 1992; Announcement of the Revolutionary Party No. 16 of 1971; and Liquid Fuel Act of 1978. The government agencies responsible for implementing these acts are the Land Transport Department, the police department, and the Department of Commercial Registration (Wangwongwatana S., undated).

The setting of ambient standards for air quality, emissions, and fuel quality is primarily the responsibility of the national Government. Emissions standards are set by the central Government and enforced mainly through the local governments, although the national government controls emissions for stationary sources. The main role of the local government in air quality management is to enforce existing policies through inspection and public awareness raising.

Enforcement of environmental laws in Thailand remains a significant challenge due to overlapping authorities and capacity and financial limitations. Although NEB is the primary institution responsible for environmental governance in Thailand, several ministries also play major environmental roles:

- **Ministry of Science, Technology, and Environment (MoSTE).** Responsible for environmental policy/planning and quality; carries out NEB's mandate. This is comprised of the Office of Environmental Policy and Planning (OEPP), PCD, and the Department of Environmental Quality Promotion (DEQP).
- **Ministry of Natural Resources and Environment.** Created in October 2002 to administer/manage environmental issues and concerns and air quality. This new ministry creates an opportunity for improving coordination, integrating environmental functions across agencies, and enhancing service delivery. OEPP, PCD, and DEQP are under the Ministry of Natural Resources and Environment.
- **Ministry of Agriculture and Cooperatives (MoAC).** Responsible for the management of key natural resources and habitats through the following: Royal Forestry Department, Department of Fisheries, Land Development Department, and the Natural Resources and Biodiversity Institute.
- **Ministry of Industry.** Monitors individual factory pollution control and assists firms (including the Department of Industrial Works, Office of Industrial Environment Management, and Industrial Estate Authority of Thailand), in solving environmental problems.
- **Ministry of Transport and Communications.** Responsible for overall planning and implementation of transport

and highway infrastructure in Thailand. Through LTD, it undertakes vehicular emission control programs.

- **Ministry of Public Health.** Responsible for overseeing the delivery of health services in the country. Has a direct role in raising awareness relating to environmental health issues.
- **Ministry of Interior.** Oversees local governments including the Bangkok Metropolitan Administration (BMA). BMA plays a significant role in the upkeep of the city's environment and provision of basic services. Other key departments include the Departments of Local Administration and of Public Works through which many investments in environmental infrastructure have been channeled.

Ambient Air Quality Standards

The 1981 NAAQS were revised in 1995 under Section 32 of the ECNEQ of 1992. The revised standards took into account the latest information on human health impact of key pollutants within the constraints of specific environmental, socioeconomic, and technological conditions that exist in Thailand. Table 5.1 compares Thailand's standards with those of the World Health Organization (WHO) implemented in the US. It shows that the NAAQS is more lenient than the guidelines set by WHO and the United States Environmental Protection Authority (US EPA).

TABLE 5.1

Thailand's NAAQS vs. WHO Guidelines and US Standards (µg/m³)

Pollutant	Average Time	Thailand	WHO	US EPA
TSPs	24 hours	330	–	–
	1 year	100[a]	–	–
PM_{10}	24 hours	120	50[b]	150
	1 year	50[a]	20[b]	revoked
Pb	1 month	1.5		
	1 year	–	0.5[c]	
SO	24 hours	300	20[b]	365
	1 year	100[a]	–	78
NO_2	1 hour	320	200[b]	
	1 year	–	40[b]	100
O_3	8 hours	–	100[b]	157
	1 hour	200		235
CO	8 hours	10,260	10,000[c]	10,000
	1 hour	34,200	30,000[c]	40,000

Guidelines refer to the safe level of a pollutant, for a given average time, to protect the public from acute health effects.
CO = Carbon monoxide, NAAQS = National Ambient Air Quality Standards, NO_2 = Nitrogen dioxide, O_3 = Ozone, Pb = lead, PCD = Pollution Control Department, SO = Sulfur dioxide, TSP = total suspended particulates, US EPA = United States Environmental Protection Agency, WHO = World Health Organization, µg/m³ = micrograms per cubic meter
[a] Arithmetic mean
Source: [b]WHO Global Update 2005, [c]WHO 2000, PCD, 2006c, US EPA, 2006.

Management of Mobile Sources

The Thai Government has been attempting to respond to environmental problems by initiating several effective pollution control measures. These measures not only aim to control exhaust gas emission but also to improve fuel and vehicle specifications, implement in-use vehicle inspection and maintenance programs, mass transit systems, and traffic management. The measures directed at reducing vehicle emissions include:

Fuel reformulation. This has two types, gasoline and diesel. Since 1 January 1996, leaded gasoline is no longer available in Thailand. The benzene content of gasoline is limited to less than 3.5% by volume and the aromatic content is set to be lower than 35% by volume. For diesel fuel, sulfur content is reduced from 1.0 to 0.5% by weight

BOX 5.2

The Success of Lead Phaseout

Thailand was the first developing country in the region to address the issue of lead (Pb) in gasoline, phasing it out completely by 1995. Due to this phaseout, the ambient Pb levels in Thailand are negligible today. Thailand's remarkable success has inspired other countries in the region, such as Vietnam and the Philippines, to prioritize the phasing out of leaded gasoline. Thailand's ambitious program to eliminate Pb in gasoline was completed after only 4.5 years, 1 year ahead of schedule. This achievement was the result of a collaborative approach involving key stakeholders, including government agencies, representatives of oil companies, and automobile manufacturers. ULG was introduced as part of a broader strategy to reduce vehicular emissions. The Government began establishing more stringent ambient air quality standards and new emissions standards for motor vehicles, along with improved vehicle maintenance and inspection. New vehicles are now required to be fitted with a catalytic converter. Traffic management measures to raise vehicle speeds were strengthened, and measures to reduce the distance traveled per vehicle were implemented.

Because of this program, airborne Pb dramatically declined from 1.55 micrograms per cubic meter (ug/m³) in 1991 to 0.1 (ug/m³) in 1996. Net costs of introducing the capability to refine ULG were estimated at less than $0.02 per liter (B0.5). The slightly increased production cost of ULG is offset by reduced maintenance costs and by potential health benefits (estimated at $ 0.12 per liter for a 20% reduction in airborne Pb in Bangkok).The benefits from the 93% reduction actually obtained in ambient Pb levels are commensurately greater.

Source: World Bank. 1998. Successful Conversion to Unleaded Gasoline in Thailand, World Bank Technical Paper. 410.

Control of Vehicle Emissions. Control of CO and NO_x levels in gasoline vehicles are performed using catalytic converters. After 1 January 1993, all cars with an engine size greater than 1600 cc must be installed with catalytic converters, those with lesser than 1600 cc are required to install catalytic converters after 1 June 1 1993.

Emission Standard. As proof of its commitment to improve air quality, Thailand has adopted the vehicle emission standards of the European Union as reference standards for light-duty gasoline vehicles, light- and heavy-duty diesel vehicles. Implementing dates in Thailand are generally 2 years after the same standards have been enforced in Europe. Due to the large number of motorcycles in Bangkok, Thailand has adopted Taipei, China's second and third stage motorcycle emission standards—the world's most stringent. Standards are implemented through new-car standards set by the central Government in addition to the requirements of routine inspection and maintenance of vehicles by the municipal administration.

Shifting to 4-Stroke Engines. Responding to increasingly strict emissions standards, awareness raising campaigns, and motorcycle clinics, over 80% of Thai motorcycle production have shifted to 4-stroke engines. These 4-stroke motorcycles are less polluting, have better fuel efficiency, and are priced similarly to the 2-stroke ones. The Thai Federation of Industry and manufacturers may implement a program to phase out the highly polluting older 2-stroke motorcycles to further encourage the switch to 4-stroke ones. The legendry Tuk-Tuk used to be one of the biggest polluters in Bangkok; however, their numbers were reduced and those remaining were required to run on liquefied petroleum gas (LPG) in the 1980s.

Inspection and Maintenance Program. To pass inspection, emissions of in-use vehicles must meet the emission standards for in-use vehicles. The current decentralized inspection and maintenance program for in-use vehicles is being criticized for its effectiveness because authorized private inspection centers or garages are also allowed to repair and inspection procedure is questionable. The program will be evaluated and improved to increase its effectiveness

Roadside Inspection. Roadside inspection for smoky vehicles in Bangkok is carried out every day by four agencies, i.e., the police department, LTD, Department of Pollution Control, and BMA. Drivers violating emission standards for in-use vehicles are fined and vehicles are not allowed to be used unless they have been repaired and have passed reinspection.

Use of Natural Gas. The government began to promote the use of natural gas in the transport sector in earnest in 2003. Today, fewer than 10,000 vehicles out of registered 26 million use natural gas for fuel, the most notable of which are taxis, city buses, and municipal garbage-collection trucks. Obstacles standing in the way of natural gas going mainstream (as the fuel of choice among motorists and trucking companies) include the severely limited number of natural-gas stations—currently only about 30 and mainly serving the Bangkok metropolitan area. End-users felt there were enough economic incentives to make it worth their while to switch from petrol and diesel to natural gas. Other barriers include the relatively high initial cost of installing engines specifically designed for natural gas and of modifying existing petrol and diesel engines.

Other measures. Recent pollution control measures are being implemented:

- Alternative fuel such as LPG, electricity, bio-diesel, ethanol;
- Public campaign such as car pools, car-free-day, walking;
- Tax penalties and incentives for promoting the use of cleaner vehicles and fuel;
- Controlling the use of used engines; and
- Special inspection and maintenance for bus fleet.

Management of Stationary Sources

The Factories Act B.E. 2535 (A.D. 1992), including certain regulations and notifications issued under the 1969 Factories Act, is the principal law controlling air pollution by factories.

Environmental Impact Assessment. Major industries of certain categories and sizes are required by the ECNEQ Act of 1992 to prepare and submit an environmental impact assessment report with their permit applications. A permit will be given only if it is demonstrated that the proposed source will not have any adverse impact on the environment, including air quality, and if measures for the prevention of and remedy for adverse effects on the environmental quality are proposed.

Emission Standards. All new and existing stationary sources are required to comply with the emission standards of the Ministry of Industry of Thailand under the Factory Act and of the Ministry of Science, Technology, and Environment under the ECNEQ Act. It is DIW under the Ministry of Industry, which is mandated to monitor and enforce standards on industrial operations. DIW has the authority to revoke a factory's operating license if the standards set are not being followed. In addition to providing penalties for a company operating a factory in violation of stipulated requirements, the company's directors, managers, and operators of the factory may also be individually liable for damages and criminal violations; unless, they can prove they did not have knowledge of the acts related to air pollution.

Fuel Oil Standard. Bangkok and Samut Prakarn, which is a heavily industrialized area located to the east of Bangkok, has been using reduced sulfur content in fuel oil since the middle of 1994. At present, fuel oil numbers 1 and 2 that are used by most industries have sulfur content of not more than 2% by weight.

Monitoring Requirement. Section 80 of the ECNEQ Act requires the pollutant to have facilities for the treatment of polluted air, equipment, or instruments for the control of discharges of air pollutants, to collect statistics and data showing the daily functioning of the facility or equipment, and instruments, and keep detailed notes to be kept as on-site evidence. A report summarizing the functionability of the facility, equipment, or instruments shall be submitted to the official of the locality where the stationary source is situated at least once a month.

Integrated Area Management. Groups of various industries are located in industrial estates or complexes. They are being administered by the Industrial Estates Authority of Thailand. Carrying-capacity concept has been studied in some specific industrial areas and is under consideration for air pollution control in terms of measurement of emissions and issuance of new permits. For instance, Laem Cha Bang and Map Ta Phut industrial complexes are two priority sites for carrying-capacity studies.

Emission Trading. Emission trading is one of the economic incentive tools for air pollution management of industrialized areas. From the review study conducted by PCD in 2004, the Cap and Trade System is the recommended system for Thailand. Map Ta Phut, the huge industrial complex in the eastern coast is one of the possible focus areas for implementation. The development of a detailed procedure for conducting emission trading in Thailand is in progress.

Management of Area Sources

Nowadays, major air pollution from area sources consists of construction and biomass burning such as agricultural waste and garbage burning and forest fires.

BMA and other local governments have issued a code of practice to the construction industry to control dust, which has resulted in reduced construction dust. Bangkok and other major cities also have an extensive street cleaning program to reduce road dust.

The problem of open garbage burning has significantly declined in recent years in Bangkok, but continues to be a problem in other urban centers. Two sanitary landfills receive the bulk of Bangkok's waste, and this has largely alleviated the problem. However, localized burning still takes place.

Controlling haze. Thailand is deeply aware of the haze situation and stands ready to cooperate with member countries of the Association of Southeast Asian Nations (ASEAN) to tackle this problem. Thailand is supportive of efforts to strengthen regional cooperation, especially with regard to the implementation of the ASEAN Agreement on Transboundary Haze Pollution, which was entered into force in November 2004.

At the national level, Thailand formulated the National Master Plan on Open Burning Control which is aimed at being used as the national framework and strategy to prevent and control land and forest fires and smoke resulted therefrom. The Cabinet approved the National Master Plan in July 2003.

The Open Burning Control Plan of Implementation (2004–2008) was formulated to implement the National Master Plan of Open Burning Control effectively. The main strategies of the Implementation Plan are the reduction of forest fire areas, reduction of waste burning by introducing alternative methods for waste elimination, promotion of alternative techniques for land preparation as well as public awareness raising, law enforcement, and public dissemination.

» Part Six

Conclusion

Thailand's air pollution situation has significantly improved over the past few years because of the vast improvement in Thailand's air quality management capabilities in recent years. Overall improvement has been effective but there is more room to grow. The key air pollutant of concern is still PM.

Air quality abatement programs to improve ambient levels of air pollution, with the use of effective and systematic monitoring equipment, have increased in the past years. Today, the national air quality-monitoring network enables Thailand to effectively deal with air pollution problems and to determine the focus areas for necessary mitigation measures. However, Thailand requires additional air monitoring systems to fulfill overall needs. The government also needs to strengthen capacity building on air pollution analysis and staff training.

With several successes in addressing air pollution, the Government should now build on recent gains through an integrated program that involves all segments of society. Comprehensive environmental legislation in Thailand also contains specific articles and clauses addressing air quality. However, the enforcement of laws remains weak due to lack of political will, capacity constraints at the local level, lack of incentives, and insufficient coordination among agencies. There is a need to strengthen institutional effectiveness by improving coordination among agencies and building capacity at the local level and broaden public involvement in air quality management activities and improving public participation and disclosure. Investments in air quality-related activities and projects are focused mostly in BMR. With the trend in urbanization, other local government capabilities in implementing air quality management should be strengthened.

Mobile sources have been identified as one of the major sources of pollutants in Thailand, especially in major cities. Notwithstanding several control measures to mitigate pollution from mobile sources, further reductions can be considered by improving public transport and traffic management by increasing the number of priority bus lanes, controlling smoke emissions from buses, and encouraging the use of nonmotorized transport systems. In addition, there are the imposition of taxes on fuels and vehicles, development of more stringent emission standards and fuel quality specifications, promotion of cleaner fuels such as CNG, and strengthening of the Inspection and Maintenance system.

Current strategies to reduce emissions from stationary sources are often still short term, thus, failing to address the problem adequately. More stress is given to end-of-pipe treatment and best available technology rather than implementing solutions that prevent pollution. Notwithstanding that economic instruments are in place, there is a need for improved implementation to encourage industries to adopt cleaner technologies and other conservation practices. Cost-benefit studies are needed to be conducted before implementing new strategies and further studies are needed to assess and evaluate the impact on air pollution after the implementation of various interventions.

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