Country Synthesis Report on Urban Air Quality Management

Viet Nam

Discussion Draft, December 2006

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Abbreviations

$\mu g/m^3$	micrograms per cubic meter
ADB	Asian Development Bank
AQI	air quality index
CEETIA	Center for Environmental Engineering of Towns and Industrial Areas
CO	Carbon monoxide
CO_2	Carbon dioxide
Danida	Danish International Development Assistance
DONRE	Department of Natural Resources and Environment
DONREH	Department of Natural Resources, Environment, and Housing
GDP	gross domestic product
HCMC	Ho Chi Minh City
HEPA	Ho Chi Minh Environmental Protection Agency
km	kilometer
km^2	square kilometer
LEP	Law on Environmental Protection
MONRE	Ministry of Natural Resources and Environment
MOSTE	Ministry of Science, Technology, and Environment
NEA	National Environmental Protection Agency
NO	Nitrogen monoxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxide
NORAD	Norwegian Agency for Development Cooperation
PM	particulate matter
PM_{10}	particulate matter with a diameter less than or equal to 10 microns
$PM_{2.5}$	particulate matter with a diameter less than or equal to 2.5 microns
QA/QC	quality assurance and quality control
SO_2	Sulfur dioxide
SVCAP	Swiss-Viet Namese Clean Air Program
TSP	total suspended particulates
UNDP	United Nations Development Programme
VEPA	Viet Nam Environmental Protection Agency
WHO	World Health Organization

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

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» Part One

General Information

Geography and Climate

Viet Nam is located in the southeastern side of the Indochinese peninsula, in the heart of Southeast Asia. It occupies a land area of 330,000 square kilometers (km^2) and measures 1,650 kilometers (km) from its northern border with the People's Republic of China to its southernmost tip. Three quarters of its land area is covered with mountains and tropical forests, with flatlands making up most of the heavily populated areas of the country.

Hanoi, the country's capital, is in the north delta along the banks of the Red River while Ho Chi Minh City (HCMC)—formerly Saigon—the largest commercial city, is located in the south. Danang—a port city and the third largest city in the country—is located in the central part of Viet Nam.

Viet Nam generally has a tropical monsoon climate. However, the climate tends to vary from one place to another due to the vast range of latitudes and altitudes in the country. The northern part of the country (including Hanoi) is characterized by average temperature of 21°C and more defined four seasons with a distinct winter. On the other hand, the south (including HCMC) and central regions are generally humid and have an average of 27°C and a tropical climate with dry and rainy seasons. Average annual rainfall is about 223 centimeters (US Library of Congress 2005, Asian Info.org 2000).

Urbanization and Population

About 27% of Viet Nam's population—estimated at 83.1 million (as of July 2005)— lives in the urban areas (Asian Develoment Bank [ADB] 2006). Viet Nam had become the 14th most populous country in the world and the third in the Southeast Asia region, following Indonesia and the Philippines. Viet Nam's population density—252 people/km^2 in 2005—is double that in the People's Republic of China (Viet Nam News 2006). In October 2004, the Hanoi population—estimated at 3.029 million—made up about 3.7% of the country's total (VietNamnet Bridge 2004). In 2002, HCMC had an estimated population of 5.5 million, 3.6 million of which lives in the urban districts and the rest in the rural districts. However, the actual population of HCMC could be more than 7 million if unregistered persons, who work, study, or live in the city, are included. The population of HCMC is also expected to continue to increase rapidly mainly due to rural-to-urban migration (Gubry and Le 2002). The 2005 annual population growth rate of Viet Nam was 1.4%, a decrease from the 1987 figure of 2.2%. The decrease may be attributed to the successful implementation of national government population control programs (Viet Nam News 2003, ADB 2006). HCMC had an annual population growth rate of 2.6%, attributed mainly to migration and reclassification of areas.

Hanoi has a land area of 918 km^2 and is the second largest city in the country. It is Viet Nam's political, economic, cultural, and tourism center and is home to the central offices of the government, social organizations, and embassies. As a rapidly urbanizing city, Hanoi is addressing problems of immigration, traffic congestion, and a growing demand for public services and infrastructure, such as transport (ADB 2001).

HCMC is the largest city in Viet Nam in terms of economic activity and population. The city has an area of 2,095 km^2 and is composed of 24 districts, 17 of which are urban districts. The urban area, however, covers 450 km^2 leaving the remaining area to rural districts (Do 2003). Hai Phong is a big port and industrial city, with an area of 1,507 km^2 and population of 1.71 million (Nang 2003).

Economy and Industry

Since the 1986 Viet Nam reform program (*doi moi*), there has been rapid economic development, with industry, construction, trade, and tourism becoming leading economic sectors. Since 1991, Hanoi has experienced an increase in gross domestic product (GDP) of 12% per year. The industry sector increased 17% and the services sector, 13% per year. The industry sector is a key focus of economic development in Hanoi, where its GDP contribution is expected to increase to 40% from its current 35% level. Investments in trade and tourism are also expected to increase (United Nations Development Programme [UNDP] 2000).

Recent years saw a decline in share of agriculture sector in the national GDP and a dominance of the industry sector. From 1990 to 2005, the agriculture sector contribution to GDP had decreased from 38.7% to 20.9%. On the other hand, the industry sector share had increased from 22.7% to 41.0% in the same period. Services sector contribution had remained relatively stable—between 38.1% and 38.7%—during this period (ADB 2006).

Energy

Viet Nam is naturally rich in oil, coal, and gas resources. The country, in general, has one of the lowest per capita commercial energy consumption in Asia due to its heavy reliance on biomass energy, such as wood, dung, and rice husks. Hydropower is a major contributor (60% in 2002) to the electricity generation mix. However, Viet Nam's demand for commercial energy sources is slowly increasing with the rise in the demand for natural gas, as well as the construction of coal-fired power plants (Energy Information Administration [EIA] 2005). With the rapid increase in energy demand, electric power supply in Hanoi has become inadequate and has been characterized by frequent interruptions. While electricity in Hanoi is still predominantly generated from hydroelectric power, it is expected that fossil fuel plants will be used to meet the rapid expansion of energy requirements (UNDP 2000).

HCMC's electricity consumption is about 25% of the total consumption of Viet Nam. The city has a projected power demand of 12 billion kilowatt-hours (kWh) a year by 2005 and 23 billion kWh a year by 2010. The city's power usage is greatly influenced by the climate. In the first quarter of 2003, HCMC suffered extreme temperatures and power consumption increased by 20%. This condition caused episodes of power outage in the area. The state-owned Electricity of Viet Nam saw this incident as another reason to raise generation capacity by 9,600 megawatts (MW) to meet growing electricity demand in the whole country (Power Engineering International 2003).

Transport

Vehicle fleet in Viet Nam is characterized by a high dominance of motorcycles, which made up 89% of total motorized vehicle registration in 2001, and a very low share of buses (1% only) (Figure 1.0b). The 2001 vehicle registration in the country has grown 4.6 times its original 1991 level, primarily attributed to the high increase in motorcycle number (5.5 times) and cars (2.07 times) its 1991 levels (Figure 1.0a).

HCMC has the largest vehicle fleet in the entire Viet Nam. In October 2002, 2.225 million motorcycles and 189,000 motor vehicles were officially registered in HCMC. Many of the trucks and buses are old, and use obsolete technology. Most of the motorcycles, cars, and vans are relatively new, but tend to use old technology and have no pollution control devices. The public transport (bus) network of the city only meets 3% of the total demand, while 97% is met by motorbikes (56%), bicycles (30%), cars (3%), and by foot (8%) (Viet Nam Register 2002). Transportation infrastructure is poor; the density of traffic system is 0.81 km/km^2 (standards 4–6 km/km^2); and average traffic speed is only 4–5 km/h. Furthermore, buses are operational only from 5 am to 7 pm and do not cater to needs of late travellers. In HCMC, the use of liquefied petroleum gas (LPG), compressed natural gas (CNG), or other alternative fuels for vehicles is mostly limited to some pilot projects.

Hanoi's vehicle fleet is also the second largest in Viet Nam, after HCMC. The total number of motor vehicles in Hanoi is continuously increasing every year. This growth is mainly attributable to the rapid increase in the number of motorcycles. From 1992 to 2001, on average, the vehicle fleet has grown by 11.8% annually while motorcycles increased at 14.9%. Before 1980, about 80%–90% of the population in the city used bicycles; currently, the same percentage of people travel by motorcycle. From 1999 to 2000, vehicle registration data showed a monthly increase of 61.5% (9,941 units) in motorcycles in Hanoi compared with a monthly 35% increase (362 units) for motor vehicles (Viet Nam Register 2002). As of 2003, motorcycle count had reached 1.2 million—a sixfold increase from its 1990 level (Nguyen and Le 2005).

In the past, the public transport system in the city consisted of buses, trams, and wheel trams until the latter two were phased out in 1993 and 1999, respectively. The efficiency of the city's bus system, however, has fallen from meeting 20%–25% of the city's demand in the 1980s to about 3% currently. The buses in operation are limited in number, with 80% aged more than 10 years old. Furthermore, bus companies are also facing operational losses, which forced the city government to allocate subsidies amounting to dong (D)12 billion (or $753,000) annually (Viet Nam Register 2002). Recent investments in public transport activities have spurred the increase in the number of passenger trips carried by bus from 12 million in 2000 to 100 million in 2003—an eightfold increase in just 3 years (Nguyen and Le 2005).

» Part Two

Sources of Air Pollution

Emissions Inventory

Compiling emissions inventory in the country is not well established and institutionalized as a national initiative since this is conducted by the different provinces and cities. Emissions inventories, except for HCMC, are mostly project-based, hence are conducted only on an ad hoc basis. The Center for Environmental Engineering of Towns and Industrial Areas (CEETIA) has conducted a national emissions inventory for the Ministry of Natural Resources and Environment (MONRE) in 2004 but the results have not been published.

There is no comprehensive emissions inventory for Hanoi. Although a number of studies on the contribution of mobile sources to pollution have been undertaken, data is insufficient to realistically identify the pollution levels caused by each kind of fuel and vehicle. Estimates are only based on pollutant coefficients, international statistics, or tests in stationary status. Table 1 presents an estimate of vehicle contribution to air pollution by type. It is based also on monitoring in traffic intersections conducted at Nga Tu So-Hanoi between 7 am and 8 am on 28 July 1999. Motorcycles are a significant source of Carbon monoxide (CO), lead (Pb), and hydrocarbons (HC) as well as dust, closely followed by gasoline vehicles (Table 2.1).

TABLE 2.1

Air Pollution Contribution (%) by Vehicle Type

Pollutant	Motorcycle	Gasoline Vehicle	Diesel Vehicle
CO	54.5	45.2	0.3
HC	54.1	44.9	1.0
Pb	54.5	45.5	
Dust	43.0	35.3	22.0

CO = Carbon monoxide; HC = hydrocarbons; Pb = lead
Source: Viet Nam Register, 2002.

As mandated by MONRE in 2004, CEETIA conducted an emissions inventory for about 300 factories in Hanoi, detailed results of which have not been published. The results of the survey indicated that only 120 of the 300 factories are significant air polluters. The data was calculated based on surveyed fuel consumption of every factory in the area (Swisscontact 2005).

As Viet Nam's industrial and economic hub, the more dominant emission sources in HCMC are industry and transport (see Table 2.2). Industrial plants contribute largely to Sulfur dioxide (SO_2) emissions while mobile emissions are main emitters of CO, Nitrogen oxides (NO_x), and HC (Viet Nam Register 2002). Table 2.3 shows the percent contributions to various air

TABLE 2.2

Emission Sources in HCMC, 2000 (%)

Pollutant	Industry	Transport	Residential	Others	Total
SO_2	92	5	3	-	100
NO_x	38	61	1	-	100
CO	15	84	1	-	100
CO_2	77	12	10	-	100
HC	5	94	-	1	100

HCMC = Ho Chi Minh City; SO_2 = Sulfur dioxide; NO_x = Nitrogen dioxide; CO = Carbon monoxide; CO_2 = Carbon dioxide; HC = hydrocarbons; - = insignificant or zero contribution
Source: Thang, 2004.

TABLE 2.3

Emissions Contribution Caused by Different Vehicle Types in HCMC (%)

Vehicle type	SO_2	NO_2	CO	CO_2	HC	VOC
Motorcycle	20	12	70	44	73	92
Car	5	5	19	12	4	4
Bus	20	6	0	8	0	1
Three-wheeler	0	0	0	0	1	1
Minibus	0	0	3	1	1	1
Truck	55	77	8	35	21	2

HCMC = Ho Chi Minh City; SO_2 = Sulfur dioxide; NO_2 = Nitrogen dioxide; CO = Carbon monoxide; CO_2 = Carbon dioxide; HC = hydrocarbons; VOC = volatile organic compounds.
Source: Thang, 2004.

pollutants from different vehicle types. Motorcycles contribute the most to CO, HC, and volatile organic compounds (VOC). Trucks make the major contribution to SO_2 and NO_X. Both trucks and motorcycles are the major emitters of Carbon dioxide (CO_2).

Table 2.4 shows the amount of pollutants emitted from specific industrial activities. Construction material is a high emitter of total suspended particulates (TSP) while steel mills are the largest emitter of CO. Power plant sector then is the largest source of NO_2, SO_2, and HC pollutants.

Air quality in the city has recently become a serious problem as a result of emissions from these industries, which contribute about 33% to industrial production value of the whole country. Only a small number of industries use the best available technologies while the majority still use outdated and obsolete technologies. The low investments in environmental protection also compound the problem (Do 2003).

To monitor emissions in the city, HEPA also makes use of AirQUIS, a management and decision support system for air quality. All data from nine air quality monitoring stations in HCMC, including meteorological data, are imported to AirQUIS measurement Module automatically every day. The emissions inventory module is just one of the many modules of the AirQUIS tool. As of November 2005, 118 line sources and 125 stacks with a total of 70 industries had been installed in the database of AirQUIS Modeling program.

Table 2.5 shows that the estimated emissions of vehicles in Viet Nam are rapidly increasing. Between 1997 and 2000, TSP, NO_x SO_2, CO and HC emissions increased by about 50%.

Source Apportionment

As with emissions inventory, source apportionment is not well established and institutionalized in Viet Nam. Source apportionment studies are conducted on per project basis by the academics for research purposes only and on an ad hoc basis.

A source apportionment study on coarse and fine particulates was conducted using samples collected from January 2001 to July 2002. The mean coarse mass (particulates with a diameter between 2.2 microns [$PM_{2.2}$] and 10 microns [PM_{10}]) and mean fine mass (particulates with a diameter of less than or equal to 2.2 microns ≤$PM_{2.2}$) concentrations for this period were 37.8 and 31.1 µg/m^3 m^{-3}, giving a total mean PM_{10} concentration of 68.8 µg/m^3. This mean particulate matter (PM_{10}) concentration

TABLE 2.4

Pollution Emissions from Main Industrial Activities in HCMC (tons/year)

Industrial Activities	Capacity	TSP	NO_2	SO_2	CO	HC
Power Plants	1,751 MW	646	8,773	54,633	1,966	727
Boilers and Furnaces	210,000 tons fuel oil/year	578	2,016	78	84	52
Steel Mills	259,00 tons steel/year	1787		466	18,907	
Construction Material (cement, tile)		12,793	1,336	624	153	40

HCMC = Ho Chi Minh City; MW = megawatts; TSP = total suspended particulates; NO_2 = Nitrogen dioxide; SO_2 = Sulfur dioxide; CO = Carbon monoxide; HC = hydrocarbons
Source: Department of Science, Technology and Environment, 2001.

TABLE 2.5

1997 and 2000 Estimates of Pollution Emissions from Transport in HCMC (tons/year)

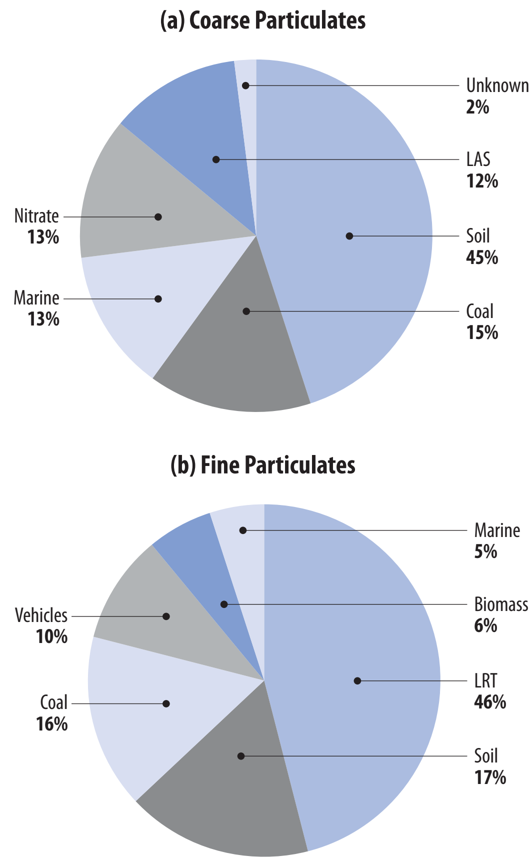
	Number of Vehicles						
Year	2-wheelers	Automobiles	TSP	NO_x	SO_2	CO	HC
1997	1,289,000	105,000	2,014	16,368	4,331	113,255	13,295
2000	1,600,000	123,000	3,182	25,846	6,843	186,843	21,006

TSP = total suspended particulates; NO_x = Nitrogen oxide; SO_2 = Sulfur dioxide; CO = Carbon monoxide; HC = hydrocarbons
Source: DOSTE,2002.

was much lower than the previous 5-year average, which may be due to exceptionally high rainfall for 2001. After corresponding chemical and instrumental analysis and modeling of randomly selected samples, soil dust and coal burning were seen as large contributors to both coarse and fine particulates (see Figure 2.1). At 45% contribution, oil dust is considered to be the top source for coarse particulates, followed by coal fly ash at 15%. Coarse and fine mode ammonium sulfates are distinguished by their sources—coarse local ammonium sulfates (LAS) are emissions from local burning whereas fine mode ammonium sulfates are main components of long-range transport aerosols (Hien 2003).

FIGURE 2.1

Source Apportionment of Coarse and Fine Particulates in Hanoi (Jan 2001–July 2002 Sampling)



LAS = local ammonium sulfate; LRT = long-range transport (LRT) aerosols
Source: Hien, 2003.

» Part Three

Status of Air Quality

Air Quality Monitoring

There is no air quality monitoring network system that links all the cities in Viet Nam. Air quality monitoring is conducted in varying capacities available in the city. Routine air quality monitoring is conducted by the environmental units of the provinces, which are managed under the provincial people's committee with technical supervision from MONRE. The air quality monitoring system in HCMC is the most advanced in the country. Although MONRE conducts air quality monitoring in cities outside HCMC and Hanoi for varying periods and frequency, data is not readily available.

In Hanoi, there are currently seven (five fixed stations, two mobile) automatic air quality monitoring stations. Six of these units were procured within 1999–2002 by MONRE. One unit, however, was purchased by the Ministry of Construction (MOC) in 2004. These stations are able to measure concentrations of PM_{10}, CO, SO_2, NO_x, ozone (O_3), and TSP, as well as meteorological conditions. The stations are managed and operated separately by different organizations where the stations are located (see Table 3.1). The data obtained are reported to three offices: the Hanoi People's Committee, MONRE, and MOC. One mobile station has not been in operation, while the mobile station of MOC is used only on a contract basis to assess large construction projects. Passive sampling is also being conducted at least a minimum of four times a year in various locations (Swisscontact 2005).

The Hanoi Department of Natural Resources, Environment, and Housing (DONREH) is the lead agency mandated to regulate and manage air quality in Hanoi. Unfortunately, it has

TABLE 3.1

Overview of Air Quality Monitoring Facility in Hanoi

	Type and Brand	Starting Date	Location	Investor	Parameter	Operator
Fixed Stations						
1	Automatic continuous monitoring	1999–2000	55 Giai Phong Str. (4th floor)	MONRE	SO_2, NO, NO_2, NO_x, O_3, CO,	CEETIA
2	Automatic continuous monitoring	2001	285 Lac Long Quan Str. (7th floor)	MONRE	SO_2, NO, NO_2, NO_x, O_3, CO, and dust	CTET
3	Automatic continuous monitoring	2002	334 Nguyen Trai Str. (5th floor)	MONRE	SO_2, NO, NO_2, NO_x, O_3, CO, and dust	DONREH
4	Automatic continuous monitoring	1999–2000	Pham Van Dong Str. (2nd floor)	MONRE	SO_2, NO, NO_2, NO_x, O_3, CO, and dust	DONREH
5	Automatic continuous monitoring	Sep 2002	62 Nguyen Chi Thanh (ground floor)	MONRE	SO_2, NO, NO_2, NO_x, O_3, CO, TSP, PM_{10}, CH_4, NMHC, and NH_3	National Centre for Meteo-Hydrology
Mobile Stations						
6	Continuous monitoring	2000	Mobile, street level	MONRE	SO_2, NO, NO_2, NO_x, O_3, CO, and dust	CEETIA
7	Continuous monitoring	Oct 2004	Mobile, street level	MOC	SO_2, NO, NO_2, NH_3, O_3, CO, NMHC, CH_4, TSP, and PM_{10}	Centre for Tropical Architecture

MONRE = Ministry of Natural Resources and Environment; CEETIA = Center for Environmental Engineering of Towns and Industrial Areas; CTET = Center for Environmental Technology Treatment; DONREH = Department of Natural Resources, Environment and Housing; MOC = Ministry of Construction; SO_2 = Sulfur dioxide; NO = Nitrogen oxide; NO_2 = Nitrogen dioxide; NO_x = Nitrogen oxides; O_3 = Ozone; CO = Carbon monoxide; TSP = total suspended particulates; PM_{10} = particulates with a diameter not more than 10 microns; CH_4 = Methane; NMHC = nonmethane hydrocarbons; and NH_3 = Ammonia
Source: Swisscontact, 2005.

no free access to data reports produced by most of the other monitoring stations that are managed by other institutions and ministries. Those stations operated by CEETIA and by the Center for Environmental Technology Treatment (CTET) report according to the requirements of MONRE, the national ministry. There is also no existing network harmonizing the automatic stations in Hanoi. The quality of data may also be difficult to assess due to lack of station journals.

In contrast to the Hanoi air quality monitoring situation, HCMC air quality monitoring network is fairly well-established. The stations, which were formerly managed and maintained by the former MOSTE (at the national level) and by the Provincial People's Committees (at the local city or municipal level), have undergone improvements since 1992. The monitoring stations are now operated and maintained by the Ho Chi Minh City Environmental Protection Agency (HEPA), which is under the People's Committee's Department of Natural Resources and Environment of HCMC.

By the end of 1992, the city's network was composed of the manual monitoring network that consisted of four ambient air monitoring stations (PM, SO_2, NO_2) and three stations for roadside monitoring (PM, NO_2, Pb, noise). Beginning in 2005, the manual air quality monitoring network, which included six monitoring stations located at main roads around HCMC, only focused on roadside air quality and measured TSP, CO, NO_2, Pb and noise.

In June 2000, an automatic air quality monitoring system was installed in HCMC, with support from the United Nations Development Programme (UNDP) and the Danish International Development Assistance (Danida). This system includes two urban background stations (to monitor PM_{10}, SO_2, NO_2, and O_3), and two roadside stations (to monitor PM_{10}, NO_2, CO, and O_3). In November 2002, three new automatic ambient and two new automatic roadside stations were also installed, with support from the Norwegian Agency for Development Cooperation (NORAD), bringing the total number of automatic stations to nine. The location and description of these nine stations are presented in Table 3.2.

At seven locations in Hai Phong, air quality has been monitored since 1998, but with limited frequency only. The monitoring involves measurement of the quality of pollutants SO_2, NO_2, CO, and TSP.

There is no uniform quality assurance and quality control protocol being followed across all the monitoring stations in Hanoi. The Swiss–Viet Namese Clean Air Program (SVCAP), a program of the Swisscontact in Hanoi, has identified some of the major deficiencies of fixed stations that definitely

TABLE 3.2
Location and Description of Automatic Air Quality Monitoring Station System

No	Code	Name	PM_{10}	NO_2	SO_2	O_3	CO	Met	Classification
1	DO	DOSTE		√	√	√	√	√	Traffic
2	HB	Hong Bang		√		√	√		Traffic
3	TD	Thu Duc		√	√				Residential/Industrial
4	TS	Tan Son Hoa		√	√	√	√		Urban background
5	TN	Thong Nhat	√	√	√		√		Traffic
6	BC	Binh Chanh	√	√			√		Traffic
7	ZO	Zoo	√	√		√			Urban background
8	D2	District 2	√	√	√	√			Residential/Industrial
9	QT	Quang Trung	√	√	√	√			Urban background
		Total instruments	5	9	6	6	5	1	

DOSTE = Department of Science, Technology, and Environment; PM_{10} = Particulates with a diameter not more than 10 microns; NO_2 = Nitrogen dioxide; SO_2 = Sulfur dioxide; O_3 = Ozone; CO = Carbon monoxide; Met = meteorological parameters
Source: Sivertsen et al., 2005.

compromise data quality The identified deficits are the following:

- Siting of instruments and stations—sampling in general is too high above ground and partly obstructed by large buildings;
- Low data quality—the instruments are not calibrated by professionals and, in some instances, are using expired gases; large temperature fluctuations inside stations;
- Nonuniform data and poor data storage—stations are not linked as a network and are not linked to a central database, data is presented and reported in various forms, and no data exchange among operating organizations; and
- Limited data availability—malfunctioning instruments causing many gaps in datasets.

During inspection, a number of errors have been observed by SVCAP consultants in the monitoring stations. These errors, including overloading dust-counting unit and expired calibration gases, are factors that compromise the quality of the data (Swisscontact 2005).

In HCMC, the quality assurance and quality control (QA/QC) measures implemented in the city's air quality monitoring system are quite comprehensive, covering measures before monitoring, actual monitoring, and data processing. These procedures follow international standards. Site selection and establishment, as well as calibration, are major components of HCMC's QA/QC protocol for air quality monitoring. QA/QC processes for monitoring station involve weekly checks, calibration, scheduled maintenance, as well as nonroutine visits and calibration. Data collection facilities also undergo routine checks and validation. In addition, at the end of 2005, with support from of NORAD, the Norwegian Institute for Air Research (NILU) has helped HEPA to establish a Reference Laboratory to increase the QA/QC of the whole system.

Air Quality Data

Hanoi. In Hanoi, unfortunately, there is no linkage between the different stations and overall reporting of air quality data. Data exist in various formats. It is, therefore, difficult to provide an overall assessment of air quality in the city. Table 3.3 shows the level of air pollutants in the CEETIA location. The annual averages of the pollutants indicate that mean NO_2, CO, and SO_2 concentrations in the CEETIA vicinity have increased

TABLE 3.3

Annual Air Pollutant Concentrations in Hanoi (CEETIA location) (μg/m³)

Pollutant	Year	1999	2000	2001	2002	2003
CO	Mean	2,456	2,209	2,122	2,468	3,520
	Max	14,410	11,060	8,737	12,391	8,750
NO_2	Mean	6	9	16	29	33
	Max	23	117	160	173	90
SO_2	Mean	6	8	22	38	38
	Max	82	150	261	208	142
PM_{10}	Mean	155	126	122	90	112
	Max	970	1,000	997	777	589
O_3	Mean	14	16	21	22	19
	Max	57	75	86	48	42

CEETIA = Center for Environmental Engineering of Towns and Industrial Areas; CO = Carbon monoxide; NO_2 = Nitrogen dioxide; SO_2 = Sulfur dioxide; PM_{10} = particulates with a diameter of not more than 10 microns; O_3 = Ozone
Source: Khaliquzzaman, 2005.

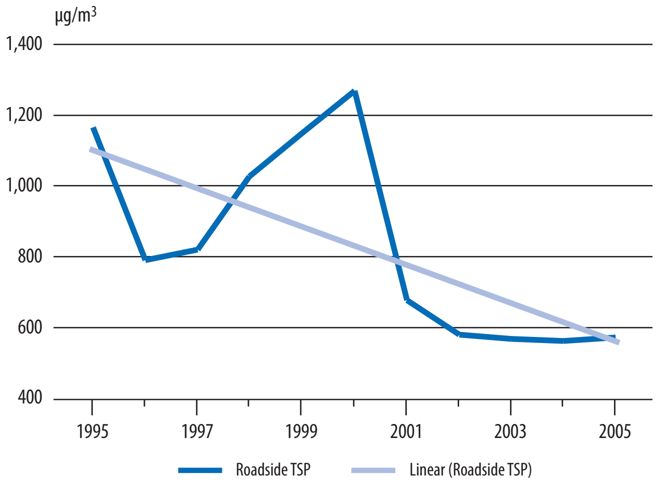
over 5 years, whereas O_3 shows only small variations. Mean PM_{10} data suggest a tendency to decrease. From the CEETIA station, it is evident that the high CO levels in the area make CO a pollutant of concern. PM_{10} and SO_2 are also of high values exceeding the annual guidelines of the World Health Organization (WHO). Mean NO_2 values, on the other hand, all comply with the annual WHO guidelines.

Ho Chi Minh City. The air quality monitoring system in HCMC allows for trend analysis throughout a number of years. Generally, air quality has been improving in HCMC, with almost all of the pollutants showing decreasing trends in concentration. Compared with 2004 data, all pollutants, except for NO_2, have increased in 2005.

The TSP information on HCMC roadside has been showing an increasing trend from 1996 to 2000; however, starting in 2001, the level has been decreasing. During the last 4 years (2002–2005), however, TSP has shown a stabilizing trend (Figure 3.1). Roadside PM also has been showing improvements from its peak level in 2001. As with the case of TSP, despite improvements in the levels of PM_{10} concentrations, both ambient and roadside PM_{10} in HCMC continue to exceed WHO guidelines of 20 μg/m³ (Figure 3.2).

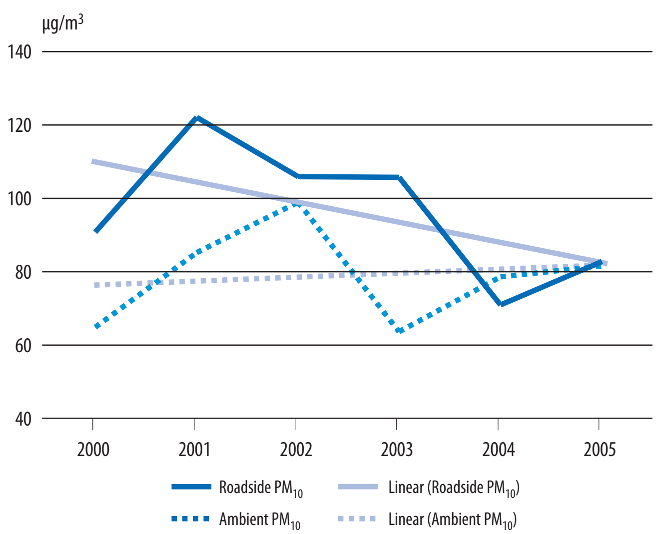
In recent years, ambient and roadside SO_2 in HCMC have shown improvements but still exceed WHO SO_2 guideline of 20 μg/m³ (Figure 3.3). On the contrary, annual NO_2 concentrations

FIGURE 3.1
HCMC Roadside TSP



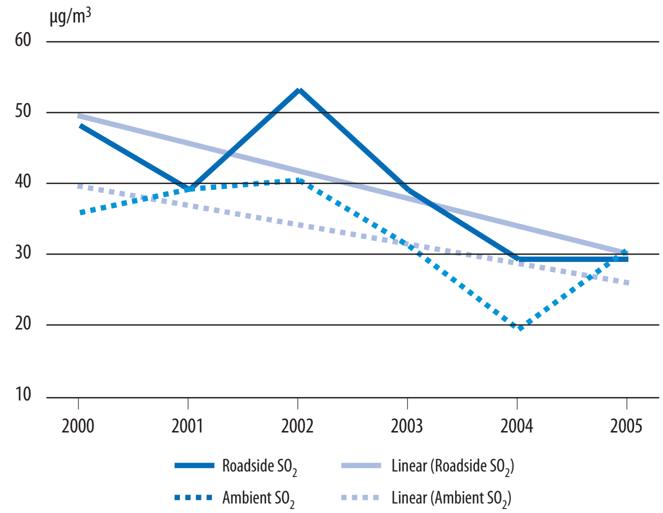
Source: HEPA, 2006.

FIGURE 3.2
Ambient and Roadside PM_{10} Concentrations in HCMC



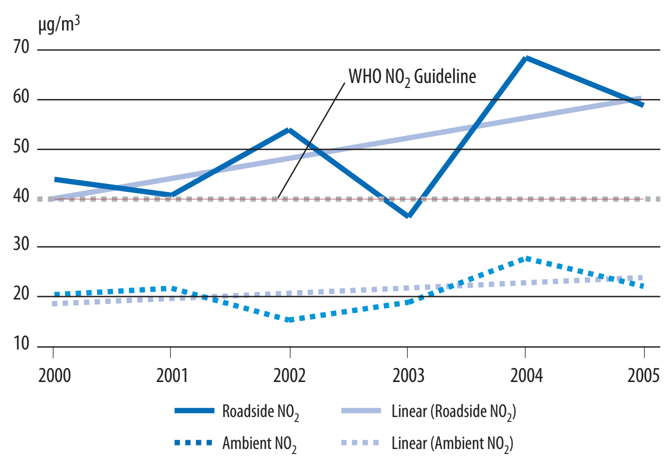
Source: HEPA, 2006.

FIGURE 3.3
Sulfur Dioxide Concentrations in HCMC



Source: HEPA, 2000.

FIGURE 3.4
Nitrogen Dioxide Concentrations in HCMC



in HCMC have shown increasing trends, with roadside NO_2 still exceeding the WHO limit of 40 μg/m³ for NO_2.

Although there is no annual ambient guideline for CO, annual average of CO concentrations in HCMC have shown improvement throughout the years. Ambient CO has decreased from 1,480 μg/m³ in 2000 to 1,250 μg/m³ in 2004. Roadside CO, on the other hand, has decreased from 4,300 μg/m³ in 2000 to 4,050 μg/m³ in 2005.

Reporting of AQ Information

There is no nationally legislated air quality index system in Viet Nam. Except for HCMC, air quality monitoring results are not reported to the public on real-time. HCMC uses an Air Quality Index (AQI) based on US Federal Register guidelines. Each of the five categories in the AQI has corresponding descriptors that are based on potential public health impacts (see Table 3.4). There are two air quality indices reported everyday—one is designated as urban background and the other one as traffic AQI. Air quality indices, as well as monitoring data, are available to the residents and the general public via the HEPA website (see: www.hepa.gov.vn). Air quality indices are also used as a tool to raise public awareness on air quality problems and air quality management (AQM) in the city.

TABLE 3.4

HCMC Air Quality Index

0 to 50	Good
51 to 100	Moderate
101 to 200	Poor
201 to 300	Bad
300 and above	Hazardous

» Part Four

Impacts of Air Pollution

To date, there is still a lack of epidemiological studies conducted in Viet Nam to quantify the impacts of air pollution. Same lack of knowledge is true for the impacts of air pollution on the economy and the environment.

In 1995, the health effects of air pollution on traffic police officers was studied by the Labor Protection Unit of HCMC. Police officers were observed to have higher incidences of ear, nose, and throat infections because of long exposure to high levels of air and noise pollution. Traffic police personnel suffer a higher incidence rate of nose, throat, and ear infections (76%) and 32% of them have reduced hearing abilities (Dang 1995).

A newly implemented project will soon study the impacts of air pollution on the health of HCMC residents and will likewise investigate whether these effects will also be affected by the socioeconomic status of the patients. This project will be a collaboration of Asian Development Bank (ADB), Health Effects Institute (HEI), NILU and the relevant agencies in HCMC such as HEPA, Department of Natural Resources and Environment (DONRE), Department of Health, among others (Mehta and Cohen, 2004).

» Part Five

Air Quality Management

Legislation and Mandate

Although there is no clean air act or law that specifically tackles the air pollution problem, the Government of Viet Nam is working on two important laws—the Law on Clean Air, whereby the Government receives support from SVCAP, and the Decree on Air Pollution Charge in Viet Nam.

Following the adoption of a new constitution in April 1992, the 1993 Law on Environmental Protection (LEP) provided the basic framework for the country's environmental policy. The 1993 LEP government decree provided guidance on the implementation of LEP and outlined the responsibilities of the National Environmental Protection Agency (NEA) (Tan 2002). However, there is still no specific Act addressing air quality.

In 1993, NEA was established by the Ministry of Science, Technology, and Environment (MOSTE) in order to implement nationwide environmental protection on its behalf. In August 2002, MOSTE was divided into two separate ministries—the Ministry of Natural Resources and Environment (MONRE) and the Ministry of Science and Technology (MOST)—to improve the institutional framework of the Government. MONRE was given the main responsibility of protecting the environment at the state level. The responsibilities of NEA were transferred to the Viet Nam Environmental Protection Agency (VEPA). VEPA supports MONRE's leadership to implement the State environmental management activities in terms of environmental inspectorate and supervision, pollution prevention, environmental quality improvement, natural conservation, environmental technology promotion, and public awareness enhancement (VEPA 2005). MONRE is responsible for the state management of environmental protection activities in terms of policy-making and the development of related legislations, strategies, and planning (Swisscontact 2005).

As a state ministry, MONRE has a national environment monitoring network for water, air, and soil through 22 institutions. Two of these institutions—CEETIA and the Institute for Environmental Science and Technology (INEST)—are located in the capital. A number of air quality monitoring stations of the national network are also in Hanoi (Swisscontact 2005).

At the provincial/city level, environmental protection is a responsibility of the People's Republic Committees (e.g. Hanoi or HCMC People's Republic Committee), which are often designated to city-level DONRE (such as the Hanoi or HCMC DONRE). DONREs operate under the direct control of the People's Committees but are likewise under the national MONRE in administrative matters and technical guidance aspects.

HEPA, under DONRE, is the unit that is responsible for operating and managing the air quality monitoring network of HCMC. This institutional system for environmental protection and management was organized for the national government to undertake a unified state management of environmental protection.

Ambient Air Quality Standards

The 1995 Vietnamese Standards TCVN 5937 outlined national ambient air quality standards for six key pollutants. Additional standards to control other hazardous air pollutants were also established in the same year through TCVN 5938. Table 5.1 shows the maximum allowable concentrations for different pollutants on various averaging time measurements. Concentration standards were set for pollutants in three different averaging times—hourly, 8-hours, and 24-hours. In general, Viet Nam standards are more lenient than WHO guidelines. The country does not have any long-term ambient air quality standards (annual) but have indicated plans to update the current standards to include annual standards.

TABLE 5.1

Viet Nam Ambient Air Quality Standards vs. WHO Standards (μg/m³)

Pollutant	Averaging Time	WHO Guidelines[a]	Viet Nam Standards[c]
SO_2	1 hour	500 (10 min)	500
	24 hours	20	300
	Annual	-	-
NO_2	1 hour	200	400
	24 hours	-	100
	Annual	40	-
O_3	1 hour	-	200
	8 hours	100	-
	Annual	-	60
CO	1 hour	30,000[b]	40,000
	8 hours	10,000[b]	10,000
TSP	1 hour	-	300
	24 hours	-	200
	Annual	-	-
PM_{10}	24 hours	50	-
	Annual	30	-
Pb	Annual	0.5 (2)	5 (hourly)

SO_2 = Sulfur dioxide; NO_2 = Nitrogen dioxide; O_3 = Ozone; CO = Carbon monoxide; TSP = total suspended particulates; PM_{10} = particulates with a diameter not more than 10 microns; Pb = Lead; - = not applicable

Source: [a]WHO (2006), [b]WHO (2000), and [c]Sivertsen et al. (2005).

Management of Mobile Sources

Although not fully supported by extensive emissions inventory, mobile sources are considered as one of the major sources of pollution in Viet Nam. A number of measures to tackle emissions from this source had been initiated in the country throughout the years. The measures have been mostly in the form of emissions standards and improvement of fuel quality.

Emissions standards have been established for both in-use and newly registered vehicles in the country. The emissions standards have been updated in 2005 to provide a better road map of implementation of emissions standards in the country for the next years using step-by-step approach (for example, new standards—equivalent to Euro 2—for brand new vehicles will be implemented starting 1 July 2007) (NEA 2005).

Vehicles failing to meet the emission standards set by law can be suspended from operation and their drivers subject to a fine of dong (D)500,000. Inspection of in-use vehicles in the country began in August 1995. Since then, all motor vehicles have been required to undergo periodic inspections before they are given appropriate inspection certificates and be allowed on the roads. Inspection certificates are given out only after the vehicles pass all 55 inspection test items. The compulsory emissions testing in the country started implementation in August 1999 (Viet Nam Register 2002). Unleaded petrol in Viet Nam has been available since July 2001.

A new directive signed by Deputy Prime Minister Pham Gia Khiem on 7 March 2006 and for implementation 15 days after it is published by the Official Gazette, the Government's publishing arm, provides for more stringent fuel standards. Under this new policy, the sulfur content in unleaded transport fuels would be cut to 0.05%, while diesel for industrial use would be cut to 0.25% (Planet Ark 2006). There is no further information on the monitoring of the implementation of these new standards.

Management of Stationary Sources

Stationary sources of pollution, such as industries and power plants, are also subject to standards imposed by law, the most recent of which is the "Obligatory application pf emission standard for Thermal Power Sector – TCVN 7440-2005" issued on 29 September 2005. According to this law, new thermal power plants and existing plants that will extend their capacities will compulsorily implement the standard from the day the standard comes into effect. The allowable emission limits will be calculated specifically for each plant depending on its location.

In addition to standards imposed on industries and commercial establishments, a separate regulation is imposed on emissions from medical solid waste (TCVN 6560-1999: Air quality – the air emission from medical solid waste). Some of the measures to address air pollution from industries also include industrial relocation plan for both Hanoi and HCM.

Viet Nam has established a large number of national standards (TCVN) to limit industrial emissions (Le 2003). To resolve industrial air pollution, Hanoi created industrial parks and required environmental impact assessments before construction of new industries (Giang 2005). Hanoi has five industrial zones to cater the growth of specific industrial sectors and the influx of investments.

Management of Area Sources

A range of national standards regulate emissions from area sources. These standards limit organic and inorganic substance emissions from urban areas and industrial areas. All of these laws were passed in 2001: organic matter (TCVN 6991) and inorganic matter (TCVN 6992) emissions from industries in urban areas; organic matter (TCVN 6994) and inorganic matter (TCVN 6995) emissions from industries in industrial areas; and organic matter (TCVN 6993) and inorganic matter (TCVN 6996) emissions from industries in rural and mountainous areas.

Hanoi authorities are also closely monitoring the air pollution caused by a number of construction projects in the city. A decree was passed by the Hanoi's People Committee in March 2005 requiring individuals and organizations involved in construction and waste disposal activities to ensure that the transport of construction materials does not cause dust pollution (e.g. tightly covering cargo, such as gravel and sand). Fines for violators range from $6.3–$12 plus impounding of vehicles 15–30 days depending on the extent of the violation. Construction sites also need to be well-managed so as not to be a source of dust pollution; otherwise, construction site owners are fined $636–$764 (Viet Nam News 2005). Road washing to prevent dust pollution is also being undertaken in both cities.

» Part Six

Conclusion

Economic reform in Viet Nam has resulted in the rapid development of a number of new sectors and is driving the high economic activities and high annual GDP growth in major urban areas, such as Hanoi and Ho Chi Minh City. Although natural population growth rates have been stabilized in the urban areas, migration to the cities—spurred by work and education opportunities—is an increasing trend. Increased industrial activity and higher population densities also translate to increased demand for energy and mobility.

The rapid rise in the number of motorcycles and motor vehicles has resulted in higher levels of traffic congestion and motor vehicle pollution in the cities. Increased energy consumption and use of motor vehicles resulting from economic development have led to higher emissions of SO_2, CO_2, NO_x, and CO. The dominance of motorcycles—and the continued increase in their number—is expected to result in higher emissions of pollutants, such as hydrocarbons (HC), NO_x, and CO.

The quality and availability of information on air pollution in Viet Nam is variable. There is a lack of a regular air quality monitoring program in Hanoi, as well as a lack of sufficient quality assurance and control mechanisms. On the other hand, HCMC's air quality monitoring system is fairly advanced and well established. Air quality monitoring results indicate that although improvements are generally observed, PM (TSP and PM_{10}) and NO_2 are the pollutants of main concern in the country, primarily because they continue to exceed the limits prescribed by WHO. The basic requirements to monitor air quality in Viet Nam—technical capacity and equipment—are already in place. This capacity, however, is not concentrated in one institution and needs to be streamlined and strengthened.

The impact of air pollution, particularly on people with respiratory illnesses, such as asthma, may be substantial. Lack of epidemiological studies, however, prevents the capacity to quantify the impacts. Poor air quality has been linked with impact on human health in the city. Respiratory illness has been at the top of the list of the seven most common illnesses in HCMC hospitals. The high prevalence of allergy and asthma in Hanoi may also be caused by urban air pollution. It is hoped that the new project that HEI, ADB, and CAI–Asia will be implementing in HCMC will fill this gap.

The Government's move toward solving the air pollution problem has been increasing in the last few years, as indicated by the updating of standards for power plants, fuel standards, and vehicle emissions standards. The Government's plan to update ambient air quality standards is also timely, including its plan for a comprehensive Clean Air Law that will specifically address Viet Nam's growing air pollution problem. The updated laws and the upcoming new ones will hopefully open opportunities for allocation of resources and investments that will help improve the technical capacity and financial allocation of the cities, as well as the national government in air quality management.

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