Table 1.2.1.1(1) Brief Result of the Air Quality Monitoring (SO_2)

(Unit: ppb)

Area	North Area							East-North Area		East Area		
Province	Chiang Mai		Lampang				Nakorn Sawan	Kon Kaen	Nakorn Rachasima	Chomburi		
Station	35T	36T	37A	38A	39T	40T	41T	46T	47T	32T	33T	34T
Hourly Data												
Average	2	2	1	1	1	<1	2	3	3	4	4	4
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	17	16	209	73	230	24	29	66	77	165	157	30
98%	6	6	6	6	6	5	6	10	14	21	23	12
Daily Data												
Average	2	2	1	1	1	1	2	3	3	4	4	4
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	9	10	22	11	7	36	9	26	13	24	31	10

(Unit: ppb)

Area	East Area			Central Area								
Province	Rayong			Bangkok								
Station	29T	30T	31T	01T	02T	03T	05T	07T	09T	10T	11T	12T
Hourly Data												
Average	3	4	5	5	3	4	5	6	11	7	7	11
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	78	71	125	150	94	73	75	93	161	113	136	151
98%	18	18	23	25	13	19	20	17	41	29	24	42
Daily Data												
Average	3	4	5	5	3	4	5	6	11	7	7	11
Min	0	0	0	0	0	0	0	0	1	0	1	0
Max	16	20	22	60	13	16	17	18	51	76	26	45

Table 1.2.1.1(2) Brief Result of the Air Quality Monitoring (SO_2)

(Unit: ppb)

Area	Central Area										
Province	Bangkok				Pathum Thani	Nonthaburi	Samut Prakan				
Station	15T	52T	53T	54T	20T	13T	08T	16T	17T	18T	19T
Hourly Data											
Average	8	7	9	12	4	5	1	8	14	7	3
Min	0	0	0	0	0	0	0	0	0	0	0
Max	85	69	86	120	123	130	41	139	124	104	43
98%	26	23	40	37	22	22	9	32	57	33	14
Daily Data											
Average	8	7	9	12	4	5	1	8	14	7	3
Min	0	1	0	1	0	0	0	0	2	0	0
Max	21	17	38	40	19	22	10	25	53	24	12

(Unit: ppb)

Area	Central Area						South Area		
Province	Sara Buri		Nakorn Patum	Rachaburi	Samut Sakorn		Surat Thani	Phuket	Songkhla
Station	24T	25T	23T	26T	14T	27T	42T	43T	44T
Hourly Data									
Average	2	4	5	4	18	14	3	2	3
Min	0	0	0	0	0	0	0	0	0
Max	72	64	32	60	169	138	85	179	17
98%	7	12	26	16	80	52	7	25	10
Daily Data									
Average	2	4	5	4	18	14	3	2	3
Min	0	0	0	0	0	2	0	0	0
Max	9	9	27	12	70	49	12	35	11

Table 1.2.1.1(3) Brief Result of the Air Quality Monitoring (NO_2)

(Unit: ppb)

Area	North Area							East-North Area		East Area		
Province	Chiang Mai		Lampang				Nakorn Sawan	Kon Kaen	Nakorn Rachasima	Chomburi		
Station	35T	36T	37A	38A	39T	40T	41T	46T	47T	32T	33T	34T
Hourly Data												
Average	7	8	13	3	2	1	12	22	11	14	11	15
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	60	38	131	101	12	20	76	152	106	80	59	88
98%	29	21	44	11	5	5	43	68	39	38	35	49
Daily Data												
Average	7	8	13	1	2	1	12	22	11	14	11	15
Min	0	2	4	0	0	0	1	1	4	3	1	3
Max	20	19	35	13	6	4	32	67	42	33	28	51

(Unit: ppb)

Area	East Area			Central Area								
Province	Rayong			Bangkok								
Station	29T	30T	31T	01T	02T	03T	05T	07T	09T	10T	11T	12T
Hourly Data												
Average	16	11	7	33	24	21	18	20	20	19	32	25
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	167	90	51	125	135	125	126	136	107	105	132	130
98%	86	38	23	86	62	66	62	57	62	56	74	61
Daily Data												
Average	17	11	7	32	24	21	18	20	20	19	32	25
Min	0	0	0	9	9	4	4	5	4	4	10	0
Max	101	32	21	83	57	59	62	49	60	56	90	75

Table 1.2.1.1(4) Brief Result of the Air Quality Monitoring (NO_2)

(Unit: ppb)

Area	Central Area										
Province	Bangkok				Pathum Thani	Nonthaburi	Samut Prakan				
Station	15T	52T	53T	54T	20T	13T	08T	16T	17T	18T	19T
Hourly Data											
Average	20	29	28	50	6	23	20	14	21	22	12
Min	0	0	0	0	0	0	0	0	0	0	0
Max	113	133	110	169	55	134	132	96	149	149	89
98%	62	71	67	114	28	58	59	53	67	68	45
Daily Data											
Average	20	29	28	50	6	23	20	14	21	22	12
Min	4	10	13	10	1	8	3	3	6	4	1
Max	63	80	68	103	29	50	59	48	61	71	34

(Unit: ppb)

Area	Central Area						South Area		
Province	Sara Buri		Nakorn Patum	Rachaburi	Samut Sakorn		Surat Thani	Phuket	Songkhla
Station	24T	25T	23T	26T	14T	27T	42T	43T	44T
Hourly Data									
Average	11	13	7	8	19	24	5	12	10
Min	0	0	0	0	0	0	0	0	0
Max	63	113	52	74	104	82	45	181	88
98%	38	45	31	35	48	59	19	27	24
Daily Data									
Average	11	13	7	8	19	24	6	12	10
Min	2	3	0	1	0	6	0	6	4
Max	33	37	16	24	55	48	19	22	24

Source: PCD, modified by the Study Team

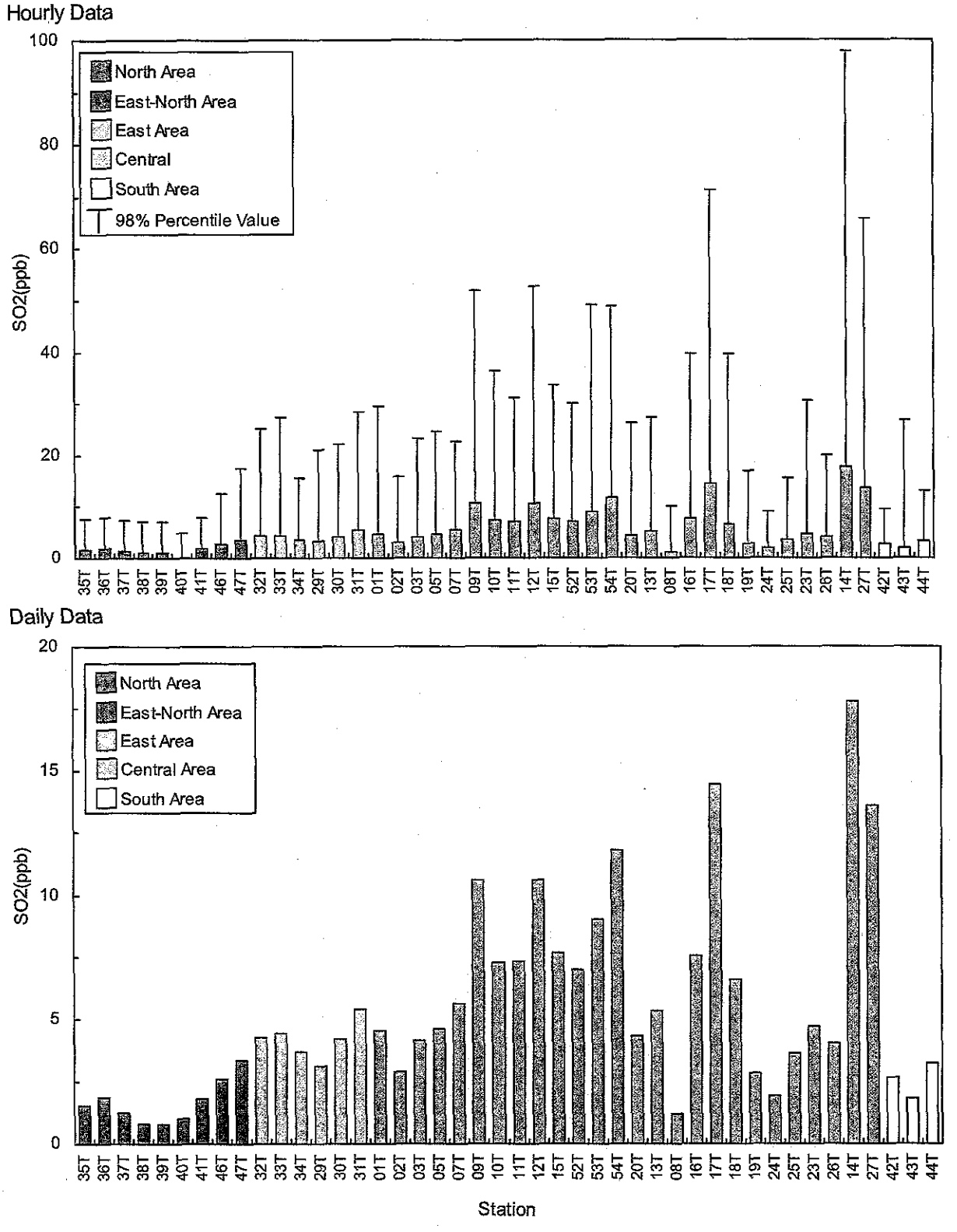
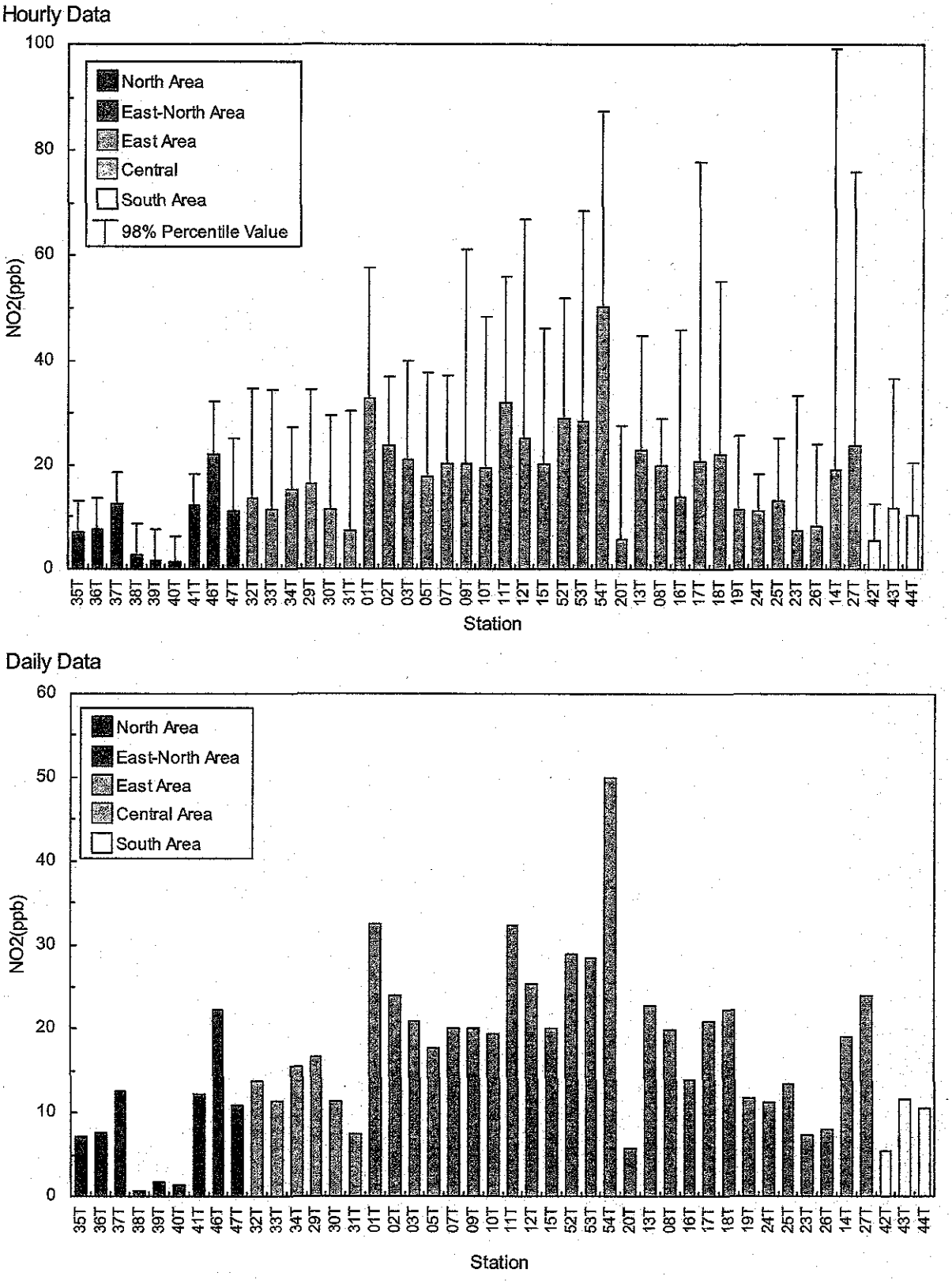


Figure 1.2.1.1(1) Hourly and Daily Average of SO_2 in Ambient Air



Source: PCD, modified by the Study Team

Figure 1.2.1.1(2) Hourly and Daily Average of NO_2 in Ambient Air

1.2.1.1 SO_2

The central area showed the highest value of SO_2 concentration both of hourly and daily data, on the other hand the north area showed a lower concentration. The highest values of hourly data appeared at No. 37 and No.39 located in Lampang Province, their concentrations were above 200 ppb. No. 43T in Phuket also showed a high value, 179 ppb. These were not located in the central area, however 98 % max values were not so high. The results indicated, although extremely high value appeared intermittently, SO_2 concentration in these areas was generally lower than the central area

Comparing average values, No. 14T located in Samut Sakhon showed the highest value, the average of hourly data was 18 ppb. This point is located in the vicinity of a highway, and it suggested influence from mobile source. No. 17T, which is located in the Department of Mineral Resources in Samut Prakan, showed the second highest value. This point is also located in the vicinity of a road and river port.

1.2.1.2 NO_2

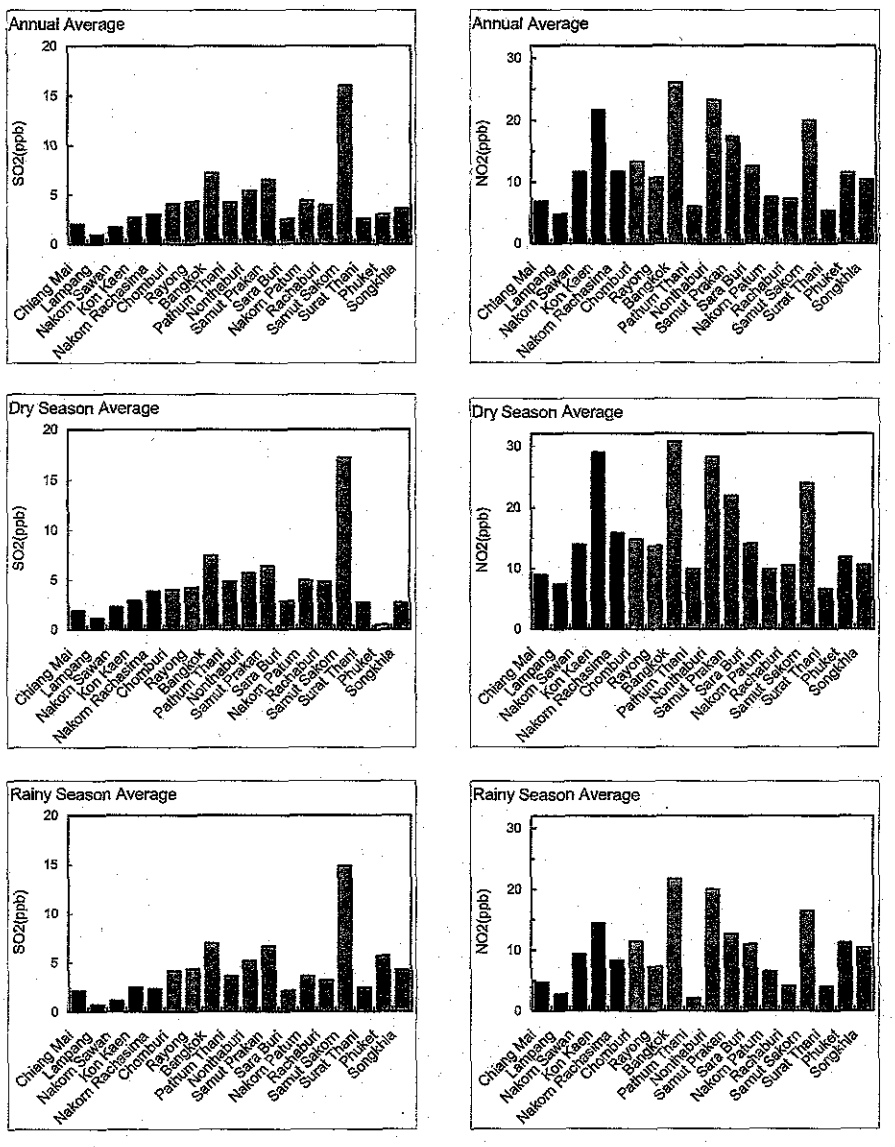
The highest concentration of NO_2 appeared in No. 54T located in Bangkok, along a roadside at Din Daeng area. It should also be added that No. 54T showed the highest average value.

No. 14T and 27T, which were located in Samut Sakhon, showed a high value of SO_2 concentration, however, NO_2 concentration did not show as high value compared to Bangkok area.

Broadly speaking, Bangkok and its surrounding area showed high concentration of NO_2, on the other hand the north and south areas showed comparatively lower value than the other area.

1.2.1.3 Characteristics of Air Quality

Let us compare annual average of each site for evaluating geographic character. Figure 1.2.1.2 shows the annual and seasonal averages (dry season and rainy season) of each monitoring site.

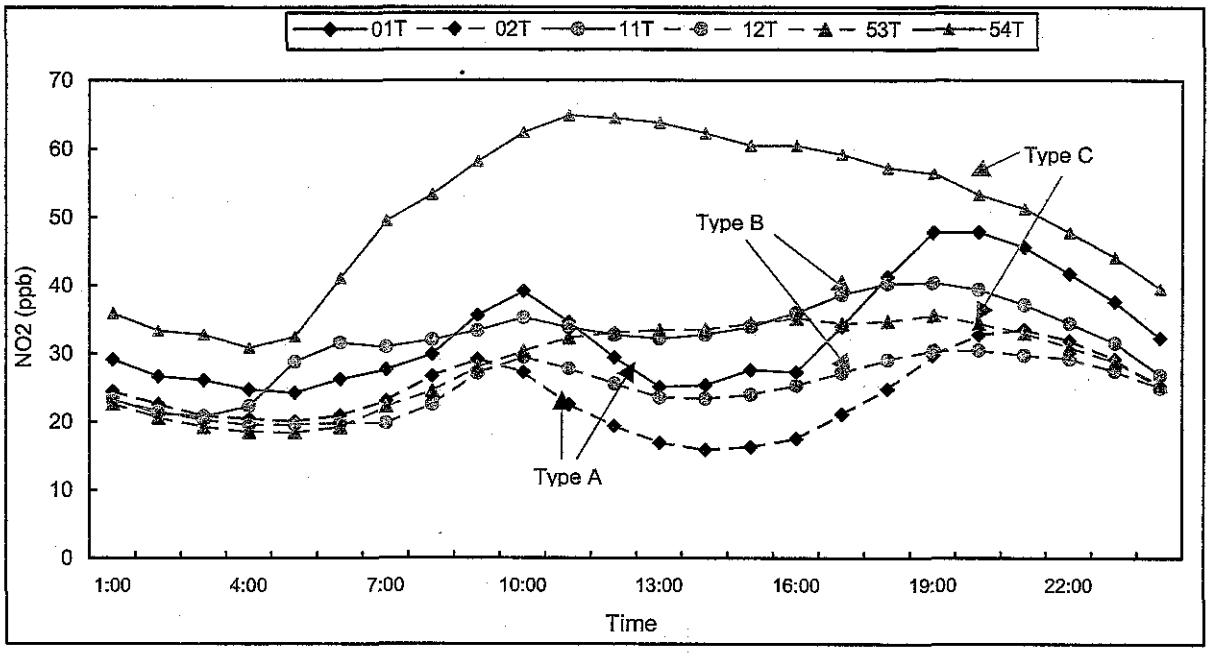


Source: PCD, modified by the Study Team

Figure 1.2.1.2 Annual and Seasonal Average of Each Monitoring Site

It was common character that both the concentrations of SO_2 and NO_2 appeared high in the central area, however concentration of SO_2 appeared high in Samut Sakhon located west of Bangkok and in some of the eastern areas which are also industrial areas. On the other hand, NO_2 concentration showed a high value in Bangkok and the surrounding area (the BMR). It is inferred from these distributions that SO_2 concentration is influenced mainly by stationary sources such as factories and NO_2 concentration is influenced mainly by mobile sources such as road vehicles.

The examination of time trends of NO_2 concentration in a day in detail is a useful evaluation method. As NO_2 concentration is influenced mainly by mobile sources and traffic activity , it has close relation with human activities. Figure 1.2.2.3 shows time trends in a day of NO_2 concentration of typical monitoring points. These values were calculated by average of same measuring period.



Source: PCD, modified by the Study Team

Figure 1.2.1.3 Time Trend of NO_2 concentration

Time trends of NO_2 concentration can broadly be divided into the following three types:

Type A: Two peaks of concentration appeared, one was from the morning to the noon, and another peak was in the evening. After the first peak, concentration once decreased then it increased again. These trends overlap commuting time, namely moving time between houses and offices.

Type B: This distribution also indicated the same character as Type A. However concentration in the afternoon remained as almost the same level.

Type C: The concentration increased from early morning, after that concentration remained at the same level until evening. Concentration decreased during the evening and night.

1.2.2 Evaluation of Ambient Air by Standard

1.2.2.1 Air Quality Standards

SO_2 and NO_2 air quality standards of Thailand (1995) and guidelines for air quality of WHO (1999) are shown in Table 1.2.3.1. Standards and guidelines are listed according to averaging time.

Table 1.2.2.1 Air Quality Standards of Thailand (1995)& Guidelines for Air Quality of WHO (1999)

	10 Minutes		1 Hour		24 Hours		1 Year	
	mg/m^3	Ppb	mg/m^3	ppb	mg/m^3	ppb	mg/m^3	ppb
SO_2								
Thailand	-----		0.78	300	0.30	120	0.10	40
WHO	0.5	175	-----		0.125	44	0.05	18
NO_2								
Thailand	-----		0.32	170	-----		-----	
WHO	-----		0.2	98	-----		0.04	20

1.2.2.2 Evaluation of Air Quality

Current monitoring systems for SO_2 and NO_2 are designed to get one-hour values. Therefore, a 10 minute guideline for SO_2 by WHO cannot be evaluated by the monitoring system. For other respective standards of different averaging times, according to the evaluating method designated by PCD, monitoring data of the year 2000 are reviewed. The results are summarized in Table 1.2.2.2 for SO_2 and in Table 1.2.2.3 for NO_2.

Table 1.2.2.2 SO_2 : Evaluation of Air Quality of the Year 2000

		1 Hour	24 Hours	I Year
Thailand	Standard	300ppb	120ppb	40ppb
	BMR	0/24	0/24	0/24
	Other than BMR	0/22	0/22	0/22
WHO	Guideline		44ppb	18ppb
	BMR		6/24	0/24
	Other than BMR		0/22	0/22

Note: 6/24 means 6 monitoring stations out of the total 24 stations show values exceeding standard or guideline.

Table 1.2.2.3 NO_2 : Evaluation of Air Quality of the Year 2000

		1 Hour	I Year
Thailand	Standard	170ppb	
	BMR	0/24	
	Other than BMR	1/21	
WHO	Guideline	98ppb	20ppb
	BMR	19/24	15/24
	Other than BMR	7/21	1/21

Note: 19/24 means 19 monitoring stations out of the total 24 stations show values exceeding standard or guideline.

Concerning SO_2, all monitoring stations attained Thailand's standard levels in the year 2000. However, the WHO guideline for 24 hours was not satisfied fully. Though the chances of exceeding 44 ppb were not frequent, some stations showed values of concern. These stations are located in the area of high transportation activities.

For NO_2, compared to Thailand's hourly standard, one station, Phuket, showed just one, i.e. one hour out of one year, exceeding value of NO_2. Concerning the WHO guideline of one hour and one year guideline, significant numbers of stations showed the chance of exceeding. The exceeding of guideline is noticeable in the BMR, although not limited in the BMR.

Major sources for NO_2 are attributed to mobile sources in Thailand. The motorization in Thailand is advancing rapidly. In order to reduce NO_2 concentration in the atmosphere, mitigation measures of mobile emission are necessary.

Table 1.2.2.4 shows the locations of exceeded values in comparison with Thailand Standard and the WHO Guideline..

Table 1.2.2.4 Evaluation of Ambient Air Quality, SO2 and NO2, 2000

【SO_2】

Measured Period	1Hr			24Hr					
Standard	Thai			Thai			WHO		
	300 ppb			120 ppb			44 ppb		
	Unsatisfied Point	Max Value (ppb)	Number of Exceeding Data	Unsatisfied Point	Max Value	Number of Exceeding Data	Unsatisfied Point	Max Value (ppb)	Number of Exceeding Data
BMR							OEPP(01T)	60	1
							Ramkhamhaeng (09T)	51	1
							NHA(10T)	76	2
							Prabadan Mnrl Resources(17T)	5	1
							S. Sakhon Thonburi(14T)	70	7
							S. Sakhon(27T)	49	1
Other than BMR									

Measured Period	1 year					
Standard	Thai			WHO		
	40ppb			18ppb		
	Unsatisfied Point	Max Value (ppb)	Number of Exceeding Data	Unsatisfied Point	Max Value (ppb)	Number of Exceeding Data
BMR						
Other than BMR						

【NO_2】

Measured Period	1Hr						1year	
Standard	Thai			WHO			WHO	
	170 ppb			98 ppb			20ppb	
	Unsatisfied Point	Max Value (ppb)	Number of Exceeding Data	Unsatisfied Point	Max Value (ppb)	Number of Exceeding Data	Unsatisfied Point	Average (ppb)
BMR				OEPP(01T)	125	13	OEPP(01T)	33
				Bansomdat(02T)	135	8	Bansomdat(02T)	24
				Ratburana(03T)	125	7	Ratburana(03T)	21
				Met. Depart.(05T	126	8		
				Junkaseme(o7T)	136	11	Junkaseme(o7T)	20
				Ramkhamhaeng(0	107	2	Ramkhamhaeng(0	20
				NHA(10T)	105	3		
				Huai Khwang(11T	132	24	Huai Khwang(11T	32
				None Tree Vittaya(12T)	130	18	None Tree Vittaya(12T)	25
				Singharat – pitayakom(15T)	113	10	Singharat – pitayakom(15T)	20
				Thon Buri(52T)	133	28	Thon Buri(52T)	29
				Traffic Police Residence(53T)	110	3	Traffic Police Residence(53T)	29
				Din Daeng(54T)	169	384	Din Daeng(54T)	50
				Prabadang Rehabilitation(08T)	132	8		
				Prabadang Mnrl Resources(17T)	149	17	Prabadang Mnrl Resources(17T)	21
				Samut Prakan(18T)	149	15	Samut Prakan(18T)	22
				S. Sakhon Thonburi(14T)	104	1	Samut Sakhon	24
				Nonthaburi DEA (13T)	134	5	Nonthaburi DEA (13T)	23
				Nonthaburi	121	3		
Other than BMR	Phuket(43T)	181	1/7564	Lampang 1(37A)	131	3		
				Lampang 2(38A)	101	1		
				Khonkane(46T)	152	30	Khonkane(46T)	22
				Nakhon – ratchasima(47T)	106	2		
				Saraburi Fire Stn(25T)	113	1		
				Rayong 1(29T)	167	59		
				Phuket(43T)	181	7		

Charpter 2

Socio-economic Issues

2. Socio-economic Issues

2.1 Existing Socio-Economic Conditions

2.1.1 Geography

2.1.1.1 Area

With an area of 513,115 square kilometres, Thai is located in the centre of the Southeast Asia Region. Its close neighbours are Myanmar and Laos to the north, Cambodia and Laos to the East, Malaysia and Indonesia to the South and Myanmar to the West. The southern part of the country is a peninsula that divides the Pacific Ocean (i.e. the South China Sea) and the Indian Ocean. Thai are divided into seven areas as indicated below.

Table 2.1.1.1 Area of Regions

Unit: square kilometre

BMR	Central	Eastern	Western	Northern	North Eastern	Southern
7,761.6	16,593.5	35.502.5	43,047.1	169,644.3	168,855.3	70,715.2

Most of the areas are flat and hilly. However, Thailand can be topographically divided into three different areas:

The plains: Mostly the plain areas are in the Central Region of the country, i.e., basins of the Chao Phraya River and its tributaries (Ping, Wang, Yom and Nan), and the Mae Klong, Phetchaburi, Bang Pakong, Thachin, and Pa Sak rivers.

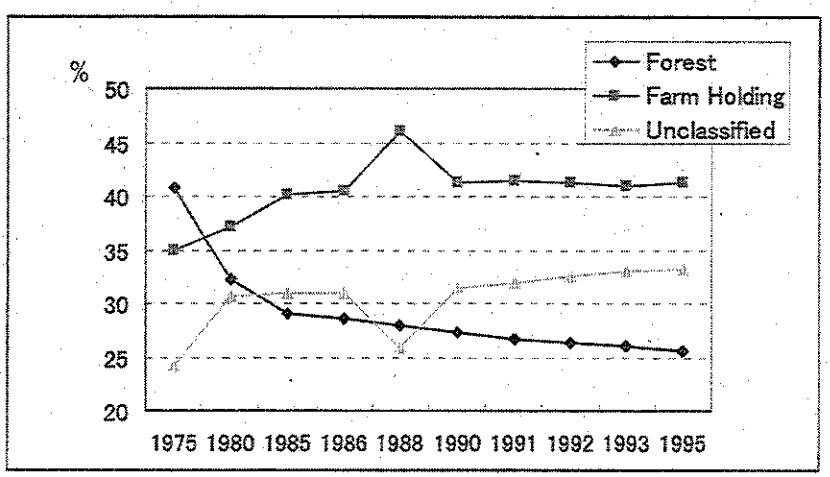
The highlands: The highland areas are mostly in the Northeast, i.e., the Korat Plateau, and the plains along the Mun and Chi rivers.

The mountains: Mostly it is mountainous in the North and the Southeast regions which cover the Ranges of Daen Lao, Luang Phra Bang, Thanon Thongchai, Phetchabun, and Tanao Si.

2.1.1.2 Land Use

Thailand had 273,000 per square kilometre of forest area in 1961. However, during the last thirty years this has been significantly depleted and reduced to 143,000 per square kilometre because of rapid expansion of the agricultural area.

According to introduction of a law for the ban on felling, the depletion of forests has slowed down as shown in Figure 2.1.1.1. Current wood coverage of land is about 131,357 per square kilometre (25.6 percent of the total land area).



Source: ESCAP, FAO, Thai Figures 2000-2001

Figure 2.1.1.1 Land Use In the Whole Kingdom

2.1.1.3 Climate

Thailand has the following three types of climates.

Tropical rain climate in the coastal areas in the East and the South, with heavy rainfalls all year round and tropical rain forests.

Tropical monsoon climate in the southwestern and southeastern coasts with monsoons and a very high average annual rainfall.

Seasonal tropical grassland or savannah climate with a lot of heavy rains in the southwest monsoon season and dryness in the cold season covering most regions of the country, particularly the Central, the North and the Northeast regions.

Prevailing winds include the southwestern monsoon from about mid-May to October and the northeastern monsoon from November to February.

1) Average annual temperature

Average annual temperature in Bangkok was 26.5℃ in January and 28.9℃ in July. As Figure 2.1.1.2 shows, the mean temperature has been increasing gradually over the last 10 years.

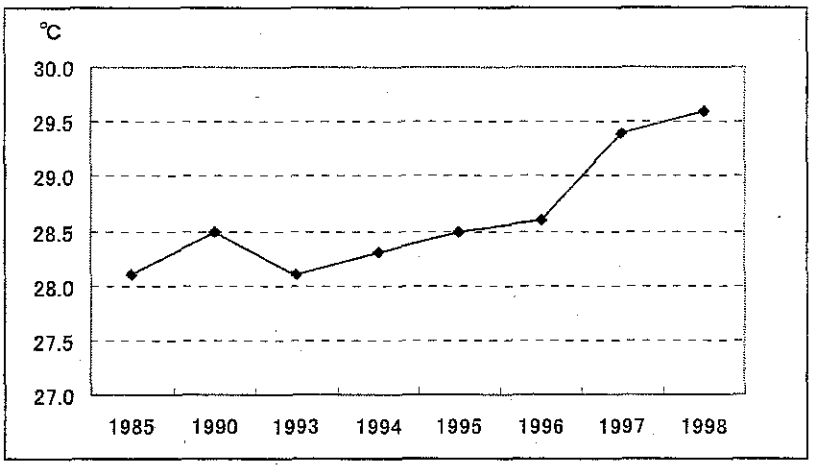


Figure 2.1.1.2 Annual Temperature in Bangkok

2) Average annual precipitation

Average annual precipitation in 1999 was about 1,492 mm in Bangkok. As Figure 2.1.1.3 shows, the average annual rainfall has increased lightly over the last decades.

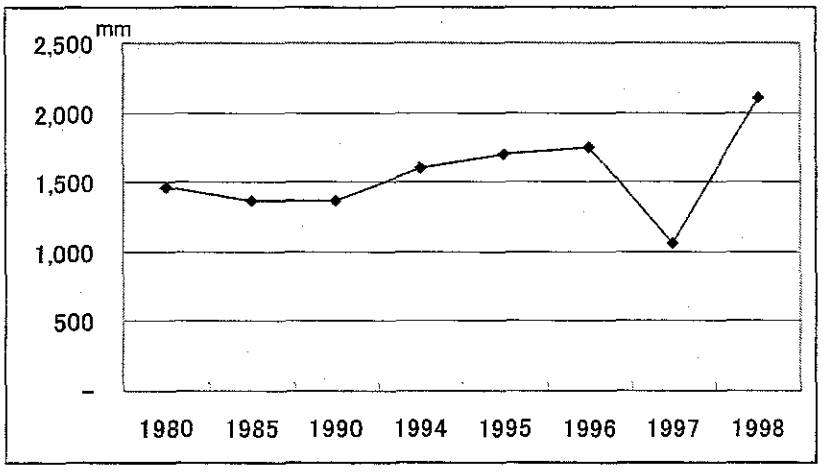


Figure 2.1.1.3 Annual Rainfall in Bangkok

2.1.1.4 Religion

The population of Thailand was 61.5 million in 1998. About 95 percent of the citizens are Thais and the rest are Chinese and Indians as well as other ethnic minorities.

For communications, the Thai language is officially and commonly used for speaking and writing, while English tends to play a greater role particularly in the business sector.

Most Thai people (92.6 percent) are Buddhists, followed by Muslims (5.3 percent) and others.

2.1.2 Demographic Conditions

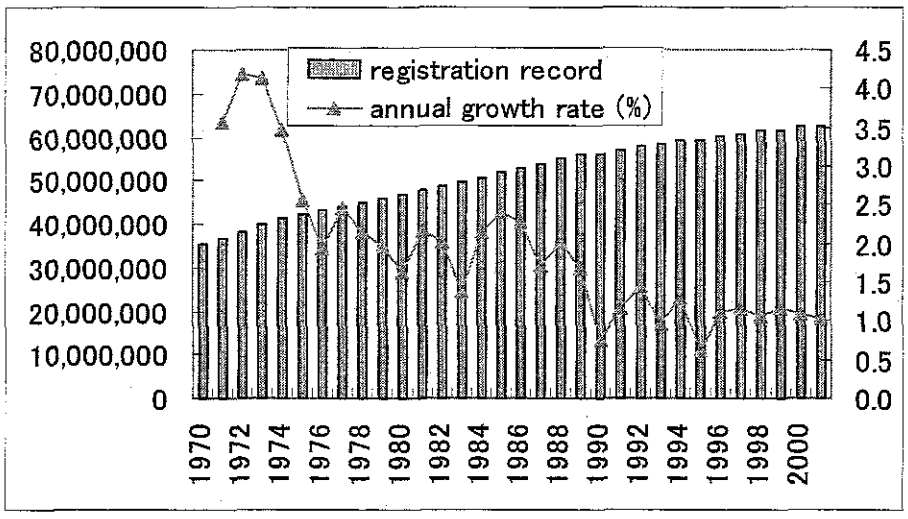
2.1.2.1 Population of Thailand

The past trend of the population of the whole kingdom and the Bangkok Metropolitan Region (BMR) which covers Bangkok metropolitan and its vicinity regions is shown in Figure. 2.1.2.2. Population growth in Thailand has slowed dramatically since the mid 1970's. This has been the result of a steep decline in birth rate which has more than compensated for steady increases in life expectancy. As the smaller demographic cohorts work their way through the system, the population growth rate will continue to decline over the next 15 years.

Total population of the kingdom and BMR as of 1999 are 61,660,701 and 9,308,924 respectively. Total population of BMR is 15.1 percent of the total population of the country. These figures do not include non-registered people and actual population is about 10-20 percent more than this. As Figure2.1.2.1 shows, the population has been steadily increasing over the last decades. But the growth ratio has been gradually decreasing during the last decades mainly due to the decrease of live births. In particular, between 1982 and 1989 the growth ration decreased drastically from 3 to 2 percent. According to data of the National Statistical Office (NSO), there is a significant disparity in demographic situation among the regions. Birth rates are significantly higher in the Northeast and South region (2.4 children per woman) than in the Central (1.7) and North (1.8) region. There is more potential for natural growth declines in the Northeast and the South regions than in the Central and the North region. In fact, the Central and the North regions currently have birth rates below the birth needed to keep the population growth stable (2.1 to 2.2 children per woman).

In addition, significant disparity in population density could be identified between urban and rural areas. As shown in Table 2.1.2.2, the average population density in the whole kingdom (as of 1999) is 120 persons per square kilometre. The most crowded province is Bangkok Metropolitan and its population density is 3,618 persons per square kilometre. The

figure is 30 times that of the whole country. Whilst, the least crowded province is Mae Hong Son (in the North Region) with a density of 18 persons per square kilometre.



Source: Website of the NESDB

Figure 2.1.2.1 Trend of Population in the Whole Country

Table 2.1.2.1 Trend of Population by Region

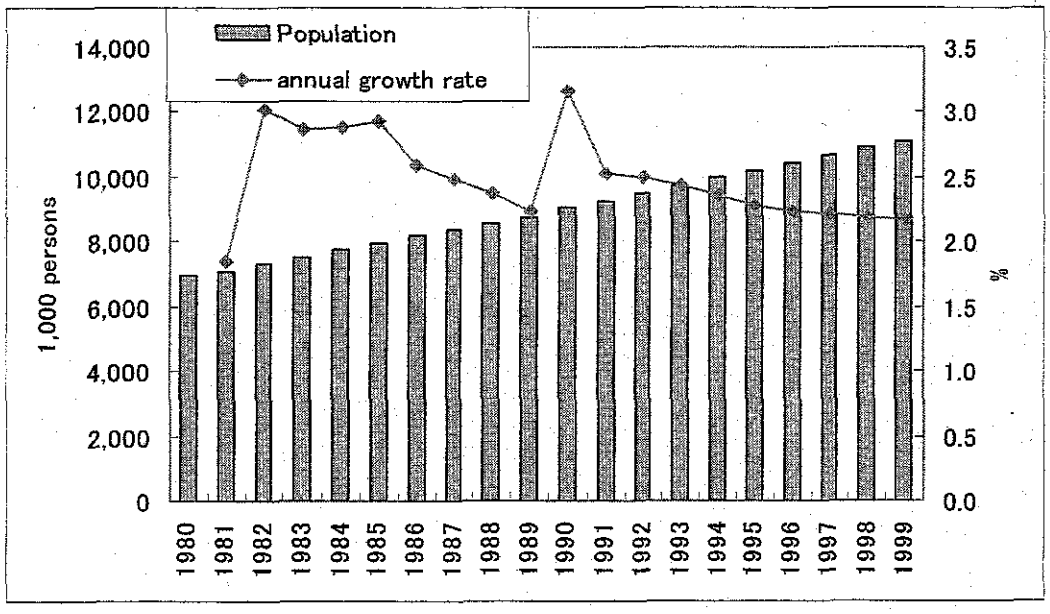
Year	Whole Kingdom	%	Central	%	Northern	%	Northeastern	%	Western	%
1919	9,207,355	100	2,870,450	31.1	1,830,496	19.9	3,253,412	35.3	1,252,997	13.6
1929	11,506,207	100	3,892,804	33.8	2,239,984	19.5	3,887,255	33.8	1,496,164	13.0
1937	14,467,105	100	4,836,461	33.4	2,836,620	19.6	4,952,288	34.2	1,841,736	12.7
1947	17,442,689	100	5,912,524	33.8	3,159,084	18.1	6,210,281	35.6	2,160,800	12.4
1960	26,257,916	100	8,271,302	31.5	5,723,106	21.8	8,991,543	34.2	3,271,965	12.5
1970	34,397,374	100	10,611,877	30.8	7,488,683	21.8	12,025,140	35.0	4,271,674	12.4
1980	44,824,540	100	14,423,343	32.1	9,074,103	20.2	15,698,878	35.0	5,628,216	12.6
1990	54,548,530	100	17,959,135	32.9	10,584,443	19.4	19,038,497	34.9	6,966,455	12.8
2000	60,606,947	100	20,421,704	33.6	11,367,826	18.8	20,759,899	34.3	8,057,518	13.0

Source: Statistical Yearbook Thailand 1997, Preliminary Report of 2000 Population and Housing Census: National Statistical Office

Table 2.1.2.2 Urban Population and Population Density at Regional Level

Region	Area (km^2)	Urban Pop. 1989	Total Pop. 1989	%	Urban Pop. 1999	Total Pop. 1999	%	Pop. Density
Northeast	168,854.3	1,129,964.0	19,575,949	5.8	1,324,771	21,379,428	6.2	126.6
Northern	169,644.3	837,171.0	10,872,752	7.7	908,768	12,124,939	7.5	71.5
Southern	70,715.2	888,772.0	6,986,250	12.7	1,163,096	8,152,638	14.3	115.3
Eastern	35,503.0	424,722.0	3,633,554	11.7	562,296	4,141,046	13.6	116.6
Western	43,047.1	320,191.0	3,269,183	9.8	338,112	3,591,191	9.4	83.4
Central	16,608.8	319,685.0	2,812,370	11.4	335,480	2,963,535	11.3	178.4
BMR	7,761.6	6,282,426.0	8,728,335	72.0	6,801,334	9,308,924	73.1	1,199.4
Whole Kingdom	513,119.5	10,202,931	55,878,393	18.3	11,433,857	61,661,701	18.5	120.2

Source: Statistical Reports of Regions (Northeast, North, South East, Sub-central, BMR), NSO



Source: Gross Regional and Provincial Products 1981-1999 etc, NESDB

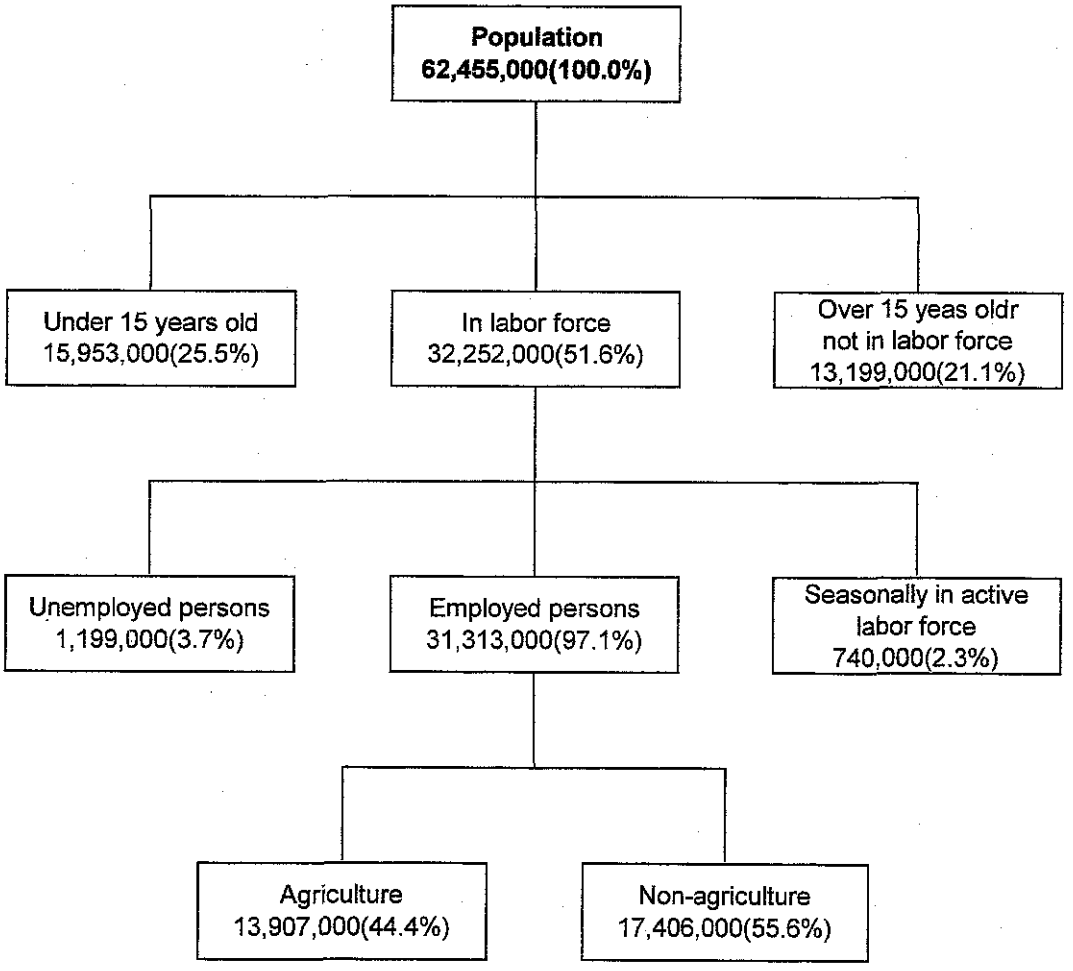
Figure2.1.2.2 Trends of Population in BMR

2.1.2.2 Labour Force

Labour composes of unemployed persons, employed persons and seasonally active labour forces as shown in Figure2.1.2.3. The total labour force in Thailand is 3,286,000 as of 1999, and the figure is 53.2 percent of the total population.

The labour force in the agriculture sector has been decreasing over the last ten years. However, agricultural labour was 14,056 people as of 1998 and amounts to about 50 percent of the total employed persons. It plays important roles in the national and regional economy and provides employment opportunities.

As Table 2.1.2.4 shows, after 1997 the unemployment rate was drastically increased from about 3 percent that was reflected by an economic slow-down. The rate gradually decreased and stood at 3.6 percent in 2000.



Source: Thai Figures 2000-2001

Figure2.1.2.3 Employment Situation in the Whole Kingdom (as of 2000)

Table 2.1.2.3 Structure of Population (as of 1998)

Age Classification	Thousand	%
Total	61,248.4	100.0
Less than 13	13,982.5	22.8
13−19	8,002.3	13.1
20−29	11,377.0	18.6
30−39	9,937.3	16.2
40−49	7,672.3	12.5
50−59	4,988.3	8.1
Over 60	5,288.4	8.6

Source: Statistical Yearbook Thailand (NSO,1998)

Table 2.1.2.4 Labour Force by Sectors

Year	Total labour force	Employed person	Agriculture	Mining & quarrying	Handcraft	Construction	Utility	Commerce & financial service	Transportation	Services & others	Unemployed person	Seasonally in active labour force
1992	NA	29,885	15,941	61	4,055	1,763	125	3,604	857	3,454	NA	NA
1993	NA	30,679	16,270	58	4,179	1,615	146	3,807	909	3,677	NA	NA
1994	NA	29,763	14,304	51	4,348	2,187	176	3,871	936	3,879	NA	NA
1995	NA	30,815	14,389	55	4,608	2,248	181	4,185	1,006	4,132	NA	NA
1996	32,324	31,166	14,137	54	4,651	2,649	152	4,397	995	4,097	498 (1.5%)	661
1997	32,780	31,714	14,315	52	4,644	2,502	176	4,602	1,039	4,371	495 (1.5%)	571
1998	32,409	30,104	13,454	45	4,564	1,630	196	4,611	989	4,615	1,413 (4.4%)	892
1999	32,718	30,663	13,718	64	4,597	1,400	157	4,762	1,008	4,797	1,370 (4.2%)	685
2000	32,252	31,313	13,907	44	4,994	1,486	169	4,866	979	4,868	1,199 (3.6%)	740

Source: Thai Figures: 2000-2002

2.1.3 Income level

Table 2.1.3.1 estimates the average monthly income and expenditure per family and per capita of each region and shows a disparity in income and expenditure amongst the regions. According to this analysis, the average monthly income of the whole kingdom is 12,492 baht. The BMR is classified as top with a household income of 27,424 bahts and the lowest is 9,935 bahts of the Northeastern region. In addition, according to NSO's analysis which calculates the average monthly income at per capita basis, similarly the BMR is the highest with 7,958 bahts which is about three time that of the Northeastern region.

Poverty reduction is one of the core targets in the Ninth National Economic and Social Development Plan that the NESDB set out (refer to Section 2.1.4.5). As Table 2.1.3.2 shows, the poverty ratios in every region decreased drastically for the last two decades due to favourable economic movement. The Northeastern region's rate which was the highest of the whole kingdom and stood at 48.4 % in 1988 was decreased by half. However, 24.0 percent of people in this region were under the poverty line in 1998 and the rate was still the highest.

Table 2.1.3.1 Averaged monthly Income and Expenditure (as of 1998)

Unit: baht

Region	Averaged No. per family	Averaged Income per month		Averaged Expenditure per month	
		per family	per capita	per family	per capita
Whole Kingdom	3.7	12,808	3,442	10,617	2,853
BMR *	3.4	27,424	7,958	20,947	6,079
Central	3.6	12,694	3,562	11,141	3,126
Northen	3.4	9,935	2,883	8,239	2,391
Northeastern	4.1	8,577	2,113	7,320	1,803
Southern	3.9	10,501	2,720	9,412	2,438

Source: Statistical Yearbook Thailand: Household Socio-Economic Survey (NS0,1998)
Note: BMR includes only Nontaburi, Pathom Thani, and Samut Purakhan Provinces

Table 2.1.3.2 Poverty and their ratio of Thailand

Year	Poverty line (baht/month per capita)	Population (million)	%	Percentage of poverty in the region (%)				
				Central	Northern	North-eastern	Southern	BMR
1988	475	17.9	32.6	26.2	32.0	48.4	32.5	6.1
1990	522	15.3	27.2	22.3	23.2	43.1	27.6	3.5
1992	600	13.5	23.2	13.3	22.6	39.9	19.7	1.9
1994	636	9.7	16.3	9.2	13.2	28.6	17.3	0.9
1996	737	6.8	11.4	6.3	11.2	19.4	11.5	0.6
1998	878	7.9	13.0	7.6	9.1	24.0	14.6	0.6

Source: Website of NESDB

2.1.4 Economic Situation

2.1.4.1 Economic Structure

In 1999, the share of the non-agricultural sector is approximately 90 percent of the total GDP, of which the industrial sector accounts for 28.6 percent. Figure2.1.4.1 shows the overall trend of changing economic structure between 1991 and 1999.

1) Agriculture

The share of the agriculture sector had been declining up to the year 1996. After 1997 the figure increased which was mainly reflected by economic recession in Thailand. In 1999 the share is 10.5 percent, which is relatively small. However, agricultural labour consisted of 13,907 people (as of 2000) and amounts to about 50 percent of the total employed persons. Agriculture activities expect to plays important roles in supporting and boosting national and regional economy, and providing employment opportunities.

2) Manufacture

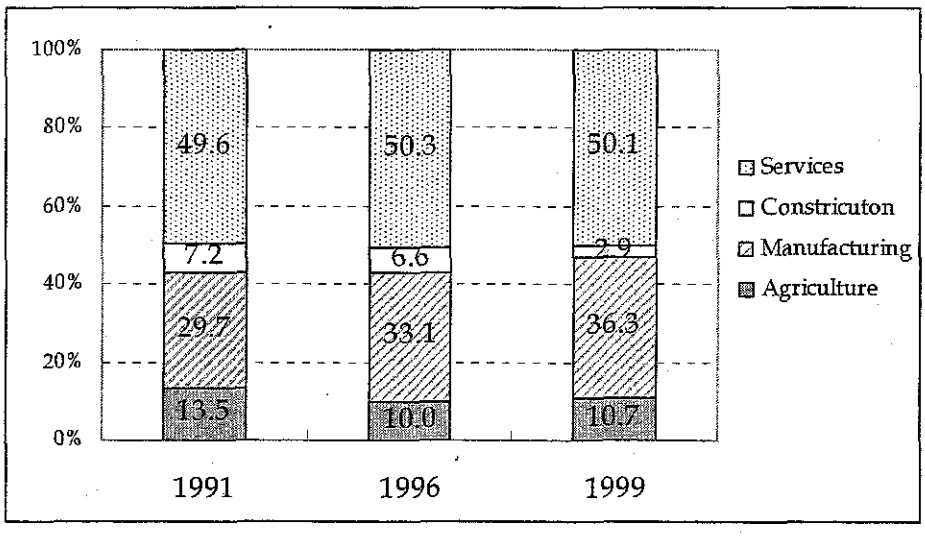
The share of the economy in the manufacturing sector has been increasing steadily over the past 20 years and presents 36.3 percent of GDP in 1999. The NESDB expects that the share will increase constantly in the future.

3) Construction

The share of the economy in the construction sector was 7.2 percent in 1991 but it drastically declined from 1997 and reached 2.9 percent in 1999. This overall decline is mainly reflected by the economy slow-down.

4) Services

The share of economy in the service sector is 50 percent, the internal composition of this sector is changing drastically. The importance of personal service is declining, while knowledge (professional and business) services and tourism are increasing.



Source: National Income of Thailand, 1951-1996 Edition (NESDB)

Figure 2.1.4.1 Economic Structure (as percent of GDP)

2.1.4.2 Regional Economy

There are major regional disparities in wealth in Thailand. These disparities were accentuated by the economic downturn in the years 1997 and 1998. Population is not as concentrated in Bangkok as would be anticipated given the fact that 49% of GDP is generated in the BMR including Bangkok and the Vicinities Region (Table 2.1.4.1 and Table 2.1.4.3). GRP per capita of BMR is more than five times the Northern region, and approximately four times that of the Southern region (Table 2.1.4.2).

Table 2.1.4.1 Population by Region

Unit: 1,000

Region \ Year	1993	1994	1995	1996	1997	1998	1999p
Northeastern	19,866	20,062	20,246	20,405	20,573	20,733	20,904
Northern	10,992	11,057	11,121	11,149	11,171	11,200	11,214
Western	7,630	7,743	7,854	7,961	8,059	8,157	8,253
Eastern	3,658	3,710	3,756	3,805	3,851	3,890	3,942
Southern	3,277	3,312	3,343	3,370	3,396	3,421	3,451
Central	2,844	2,856	2,880	2,884	2,892	2,906	2,911
BMR	9,743	9,973	10,201	10,429	10,660	10,894	11,131
Whole Kingdom	58,010	58,713	59,401	60,003	60,602	61,201	61,806

Source: JICA study team calculated based on the data from the NESDB

Table 2.1.4.2 GDP per capita by Region

Unit: thousand bahts

Region \ Year	1993	1994	1995	1996	1997	1998	1999p
Northeastern	13,660	14,929	16,350	17,092	16,338	14,863	15,132
Northern	20,888	22,247	23,543	25,119	24,075	22,630	22,959
Western	28,220	30,525	32,674	34,274	33,353	31,706	31,191
Eastern	63,803	71,300	81,459	93,558	101,952	95,215	100,383
Southern	32,213	34,023	37,061	37,713	36,472	32,655	33,803
Central	38,211	43,911	47,932	52,245	51,364	44,540	46,444
BMR	134,457	141,478	149,877	151,903	144,058	120,396	124,013
Whole Kingdom*	42,647	45,908	49,599	51,991	50,733	44,825	46,260

Source: JICA study team calculated based on the data from the NESDB
Note: * means the average of whole kingdom

Table 2.1.4.3 GDP by Region

Unit: million bahts

Region \ Year	1993	1994	1995	1996	1997	1998	1999p
Northeastern	271,376	299,498	331,015	348,758	336,114	308,152	316,323
Northern	229,606	245,982	261,825	280,048	268,942	253,452	257,459
Western	215,319	236,357	256,623	272,859	268,794	258,626	257,419
Eastern	233,393	264,524	305,960	355,989	392,617	370,387	395,711
Southern	105,561	112,685	123,894	127,093	123,858	111,713	116,653
Central	108,672	125,410	138,045	150,676	148,545	129,432	135,199
BMR	1,310,011	1,410,956	1,528,891	1,584,199	1,535,656	1,311,597	1,380,394
Whole Kingdom	2,473,939	2,695,412	2,946,252	3,119,621	3,074,528	2,743,359	2,859,157

Source: JICA study team calculated based on the data from the NESDB
Note: p means preliminary value

Table 2.1.4.4 GDP Growth Rate by Region

Unit: per cent

Region \ Year	1994	1995	1996	1997	1998	1999p	Average
Northeastern	10.4	10.5	5.4	-3.6	-8.3	2.7	2.8
Northern	7.1	6.4	7.0	-4.0	-5.8	1.6	2.1
Western	9.8	8.6	6.3	-1.5	-3.8	-0.5	3.2
Eastern	13.3	15.7	16.4	10.3	-5.7	6.8	9.5
Southern	6.7	9.9	2.6	-2.5	-9.8	4.4	1.9
Central	15.4	10.1	9.2	-1.4	-12.9	4.5	4.1
BMR	7.7	8.4	3.6	-3.1	-14.6	5.2	1.2
Whole Kingdom	9.0	9.3	5.9	-1.4	-10.8	4.2	2.7

Source: JICA study team Calculated based on the data from the NESDB
Note: p means preliminary value

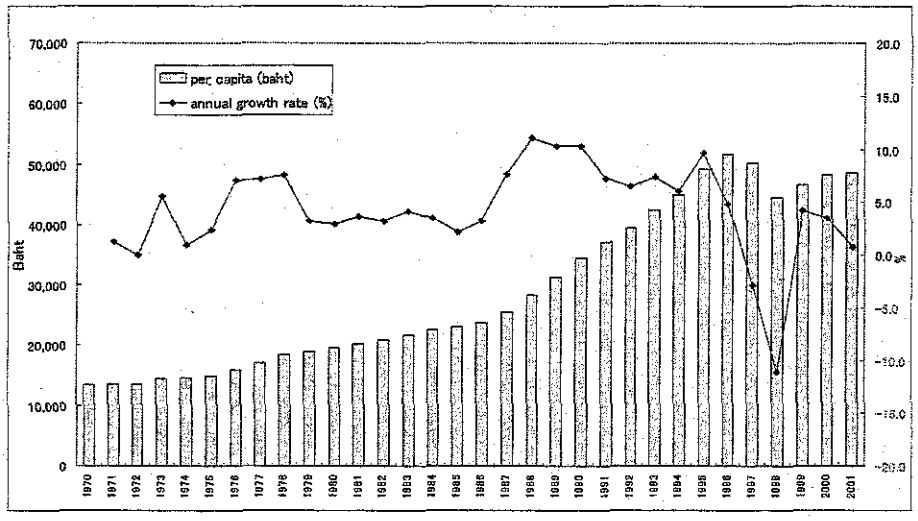
2.1.4.3 Economic Trends of Thailand

Thailand's economic growth between 1984 and 1995 was one of the fastest in the world (refer to Figure 2.1.4.2). Its peak was in year 1988 when the GDP growth ratio reached 13.5 percent. Average annual GDP growth during the period between 1992 and 1996 (the Seventh Development Plan) was 8.1 percent.

This rapid development was fed mainly by successful growth in manufacturing, pushed by enormous foreign direct and domestic investment. At the same time, from the late 1980's knowledge economy in Bangkok grew rapidly, while agricultural activities grew rather steadily. This period is known as the 'Golden Age of Manufacturing' and started with the Baht devaluation.

The economy slowdown began in 1997 caused by a failure of Thailand's economy to restructure fast enough to respond to changing external conditions, in particular, the growth of lower cost competitors, the decline in demand in developed countries and the decline in the value of the Yen. The economic crisis had peaked in March 1999 and began to gradually recover during the last quarter of fiscal year 1999. During the second period, from March to May 1999, economic problems and financial liquidity still remained in a critical condition. The government had introduced new stimulus measures including the stimulation of public spending, and the creation of job programmes in all regions across the country. In order to spur more spending tax and energy policies were implemented such as the reduction of value added tax, cuts of excise tax on fuel oil, the government's subsidy to maintain cooking gas prices, and the exclusion of certain cost elements from the automatic adjustment mechanism resulting in lower electricity tariffs.

Due to the above countermeasures, the economy began to show positive signs of gradual recovery, particularly in the export sector as shown in Table 2.1.4.5. In fact, exports of manufactured and industrial products began to expand and therefore foreign investors had more confidence in Thailand's economic restoration programmes. The Thai baht currency became more stabilised and the inflation rate also decreased (refer to Table 2.1.4.5). Although private investment has started to pick up, it is confined to certain sectors at present, which is limiting economic growth.



Source: National Income of Thailand (NESDB, 2002)

Figure 2.1.4.2 GDP per capita at 1998 prices and Annual Growth Rate

Table 2.1.4.5 Key Indicators of Economic Trends

Year / Key indicators	1997	1998	1999	2000	2001
Real Economic Growth Rate (%)	-1.8	-10.4	4.0	4.3	1.8
Expenditure (%)	5.9	-12	3.5	4.9	3.0
Investment (%)	6.6	-38.1	-4.0	5.4	3.0
Inflation rate (%)	5.6	8.1	0.3	1.6	2.0
Export Value (billion US dollar)	567	529	568	679	632
(growth rate: %)	(3.7)	(-6.8)	(7.4)	(19.5)	(-6.9)
Import Value (billion US dollar)	613	406	475	624	607
(growth rate: %)	(-13.4)	(-33.8)	(16.9)	(31.3)	(4.5)
Current Account Balance (billion US dollar)	-31	143	125	92	44
Current Account Balance/GDP (%)	(-0.9)	(12.8)	(10.2)	(7.5)	(3.6)
Foreign Currency Change Reserve (billion US dollar)	270	295	348	327	—
Fiscal balance/GDP (%)	2.2	-3.0	-5.5	-5.0	—

Source: Central Bank of Thailand and NESDB etc.

The 1980's moved away form the traditional agricultural industry to a more export oriented manufacturing industry based upon labour intensive items such as textile and garments. After 1990, the fast growing market was technological industries such as computer accessories and motor vehicles.

Table 2.1.4.6 GDP Growth Rate by Sector 1995-1999 (%)

Sector \ Year	1995	1996	1997	1998	1999p	Average
Agriculture	3.56	3.79	-0.67	-3.10	2.57	1.23
Manufacturing	12.45	6.71	1.58	-11.44	11.92	4.25
Construction	6.95	6.87	-26.40	-38.95	-5.38	-11.38
Services	7.17	7.08	2.11	-0.37	5.47	4.29
Other	9.47	5.38	-1.01	-11.61	-0.90	0.27
Whole Kingdom	9.31	5.88	-1.45	-10.77	4.22	1.44

Source: NESDB

2.1.4.4 Import/Export

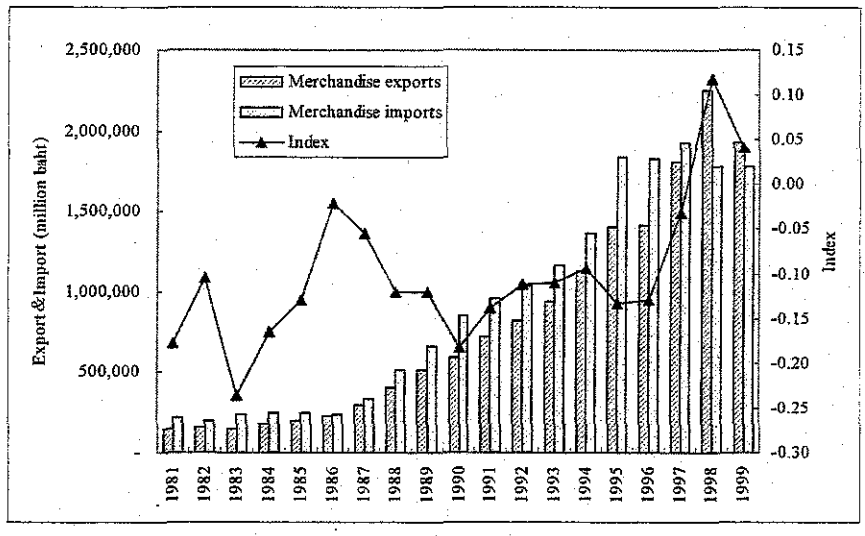
The main engine of economic growth for several decades has been Thailand's exports, since economic policy in Thailand moved from an import substituting policy to a strategy more closely based upon a market.

According to the Economy Monitor (World Bank, 2001), the major exporting commodities are foods which earn 3,186 million baths and is ranked top, following materials and fuels, manufactured products, and fish and aquatic products. The total export value of goods was estimated at 1,924,281 million baht in 1999. While the major importing commodities were food, machineries, vehicle and equipment etc. The total imports value in 1999 was estimated at 1,774,076 million baht.

In 1984, Thailand adopted an aggressive export-oriented development strategy that proved very successful. As indicated in Figure 2.1.4.3 between 1986 and 1998 exports grew by an average annual rate of 21.1 percent. However, exports decreased in both volume and value at the rate of 10.6 and 11.1 percent respectively from 1998, which was mainly caused by the decline in almost every major exporting commodity and in every exporting market except for Chinese and Korean markets. As Figure 2.1.4.3 shows, the index value reached 0.12 in 1998, and was turned over from minus to plus. This indicates that the Thai economy became highly dependent upon export markets.

As the Ninth Economic and Social Development Plan targets annual expansion at the average rate of 6 percent, export of food production is more encouraged as good potential productions to drive the country's economy. According to the Department of Export Promotion, food exports in 2002 are expected to grow by 8 percent. The world economic growth is projected at 3.9 percent and the global trade is likely to expand by 6.5 percent this year. The expected increase in both the world economy and trade will result in more food consumption. The increase of export will provide greater opportunities for Thailand to

export more food products. In addition, the policy would expect to support small- and medium-sized enterprises in the food industry.



Note: Index = (Export value - Import value)/(Export value + Import value)
Source: Thai Figures 2000-2001

Figure 2.1.4.3 Changes in Trade Structure

2.1.4.5 The Ninth National Economic and Social Development Plan and Economic Targets

The Ninth National Economic and Social Development Plan (2002-2006) formulated by NESDB has commenced, in which the following four major items are targeted;

1) Balanced Economic Development
2) Quality of Life
3) Good Governance
4) Poverty Alleviation

According to the plan, annual economic growth is planned to attain 4-5 percent with an average annual current account surplus of approximately 1-3 percent of GDP. Labour productivities are expected to increase at 3 percent annually. Annual growth of population is projected at less than 3 percent.

The total factor productivity in the agriculture and industrial sectors is set to grow at an annual average rate of 0.5 percent and 2.5 percent, respectively.

As for the objectives of economic development, the following points are focussed on;

- Stable and sustainable economic development is required.

- The economy should be strong and self-reliant at grassroots level.
- The government is committed to strengthen the financial sector and fiscal position of the country with economic restructuring.

Table 2.1.4.7 summaries the short-term targets of macroeconomic up to 2006 for the Thai economy set by the NESDB.

Table 2.1.4.7 Macroeconomic Target by NESDB

Items \ Year	2001	2002	2003	2004	2005	2006	Average 2002-06
GDP Growth Rate(%)	2.5	4.0	5.3	5.6	6.0	6.0	5.4
GDP (Billion Baht, current price)	5,116	5,454	5,879	6,361	6,908	7,502	-
Inflation (%)	2.3	2.6	2.6	2.6	2.6	2.6	2.6
Current Account as % to GDP	3.1	1.9	1.6	1.3	0.8	0.4	1.2

Source: Strategy Plan Framework Toward Quality and Sustainability of Thailand Economic Development, Ministry of Finance, as of July 15, 2001

2.2 Socio-economic Framework

2.2.1 Review of Socio-economic Frameworks for Related Studies

Many agencies and studies produce estimates of future growth of GDP and population. Such socio-economic frameworks at national and provincial (changwat) level are used for future demand forecasts such as traffic volume and energy consumption. The transport sector studies below also produced traffic demand forecasts using such socio-economic frameworks. In advance of using the traffic demand forecasts for inventory development it is necessary to ensure what kind of socio-economic frameworks are used. Therefore, the JICA Study Team reviewed and analysed the socio-economic frameworks at national and regional level employed in those studies.

(1) Consulting Services for the Study on the Strengthening of DOH's Management and Updating of the Long-Term Strategic Investment Plan, December 2001 (hereafter 'LTP-2')
(2) Urban Rail Transportation Mater Plan (BMA and Surrounding Areas), November 2001 (hereafter 'URMAP')
(3) The Study on Airport Development Master Plan in the Kingdom of Thailand, January 2000 (hereafter 'Airport Study')
(4) The Master Plan Study for the Coastal Channels and Ports Development in the Kingdom of Thailand, March 2002 (hereafter 'Harbour Study')
(5) Investment of Capacity Constraints and Determination of the Need for Track Doubling of SRT Network (2002) (hereafter 'TDSRT')

2.2.1.1 Population Projection

1) National Level

Table 2.2.1.1 summarises population projections of the related studies above. As Figure 2.2.1.1 shows, each population projection that the related studies produced are almost similar to the NESDB's projection that has been prepared by the Human Resources Planning Division of the NESDB which takes into account fertility and mortality assumptions by region, and inter-region migration.

Table 2.2.1.1 Population Projections of the Related Studies and NESDB

Related Study	Projection period	N.B.
Airport Study	1996-2017	registered population basis
LTP-2	2001-2021	
URMAP	1996-2021	
NESDB	1999-2016	

Source: NESDB, LTP-2 and Airport Study and URMAP

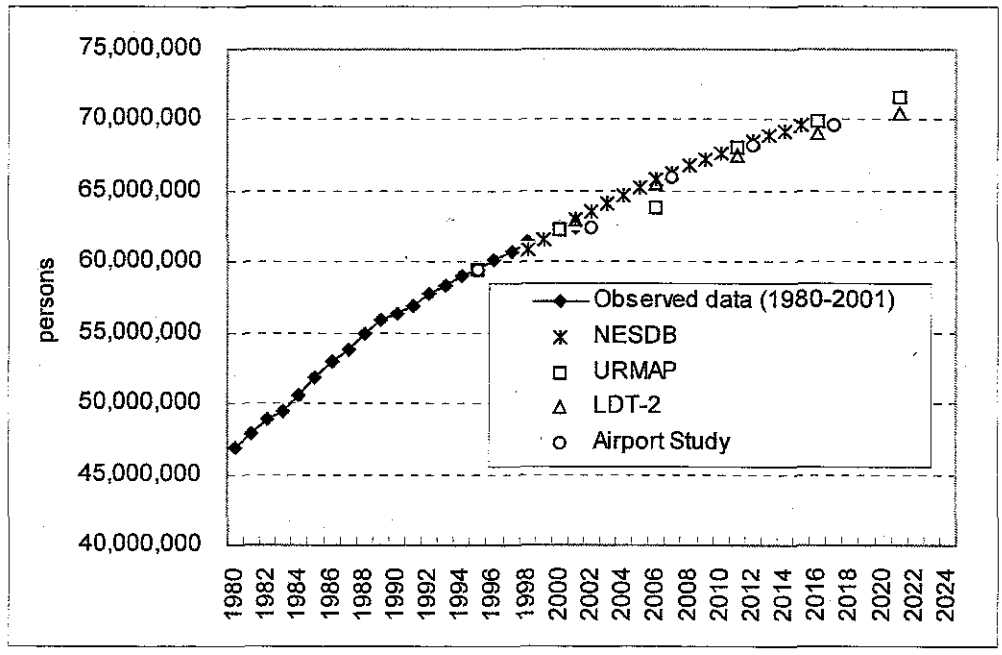


Figure2.2.1.1 Comparisons of Population Projections of the Related Studies and NESDB

2) Regional and Provincial (Changwat) Level

The population projection of the Airport Study is on a provincial basis but the others' are on a regional basis. Table 2.2.1.2 summaries the projections of each study. In addition, Table 2.2.1.3 shows the regional projection produced by LTP-2.

As Figure2.2.1.2 shows population projections for the BMR and the projections for both URMAP and LTP-2 are almost the same but the projection of the Airport Study is lower than those.

Table 2.2.1.2 Population Projections of the Related Studies at Regional Level

Study	Projection period	Projection level
Airport Study	1996-2016	Provincial (changwat) level
LTP-2	2001-2021	Regional level
URMAP	2000-2021	BMR including provincial level

Note: Adjusted population includes unregistered population

Table 2.2.1.3 Population Projections by Region 2002-2021

Unit: 1,000 persons

Region/Country \ Year	2001	2006	2011	2016	2021
BMR	11,574	12,774	13,708	14,562	15,392
Central Region	2,928	2,945	2,927	2,911	2,895
Eastern Region	4,025	4,226	4,423	4,557	4,681
Western Region	3,497	3,610	3,692	3,753	3,809
Northeastern Region	21,215	21,813	22,287	22,591	22,865
Northern Region	11,269	11,289	11,240	11,179	11,112
Southern Region	8,439	8,851	9,215	9,477	9,718
Whole Kingdom	62,947	65,508	67,492	69,030	70,472

Source: LTP-2

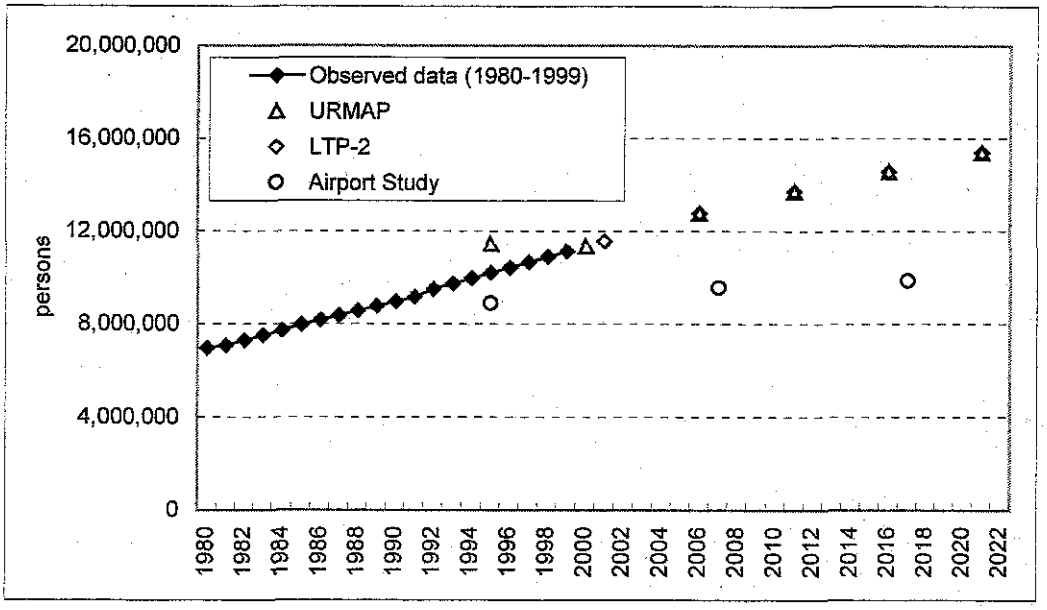


Figure 2.2.1.2 Population Projections for BMR

2.2.1.2 GDP Projections

1) National Level

Table 2.2.1.4 summarises the GDP projections that the related studies produced. The Airport Study set out three scenarios (high, moderate and low) mainly due to the difficulty of identifying single estimate after the economic crisis in 1997. As Figure 2.2.1.3 shows, both the projections for LTP-2 and the moderate-case of the Airport Study are almost the same after 2014. The differentiation in 2011 is 459,420 bahts and is quite small.

Table 2.2.1.4 GDP Projections of the Related Studies

Study	Base year	GDP Growth Scenarios
Airport Study	1995	High (1996-2001: 3%, 2002-2017: 7%)
		Moderate (1996-2007: 4.5%, 2008-2017: 4%)
		Low (1996-2001: 0%, 2002-2017: 3%)
LTP-2	2001	2002-2006: 5.6%, 2007-2011: 5.7%, 2012-2016: 5.3%, 2017-2021: 5.2%

Source: LTP-2 and Airport Study

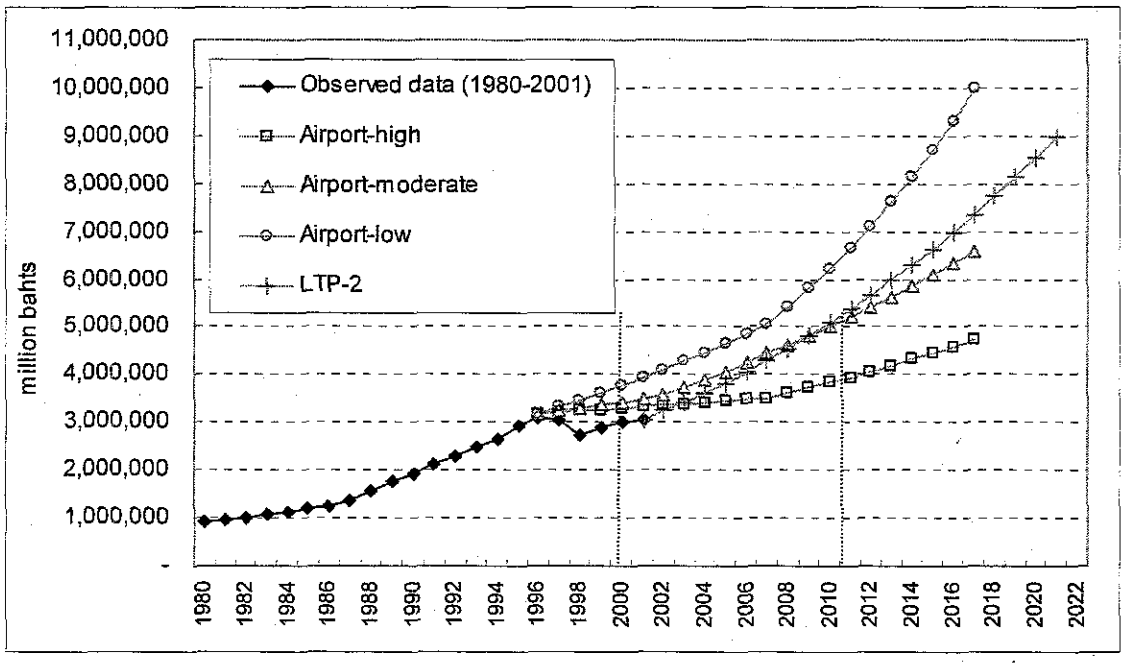


Figure2.2.1.3 GDP Projections of the Related Studies

LTP-2 estimated the GDP projections by sector as shown in Table 2.2.1.5. The agricultural sector is projected to grow more slowly and achieve the level before the financial crisis in 1997, while both the manufacture and service sectors show a slow-down of growing speed during the period between 2002 and 2021 (refer to 2.2.1.5).

Table 2.2.1.5 GDP Projection by Sectors (% per annum)

Year / Sector	2002-2006	2007-2011	2012-2016	2017-2021
Agriculture	2.1	2.3	2.5	2.9
Manufacture	6.5	6.4	6.1	6.0
Services	5.4	5.6	5.0	4.7
Total	5.6	5.7	5.3	5.2

Source: LTP-2 and TDRI

2) Regional and Provincial (Changwat) Level

LTP-2 and URMAP forecasts the future trends of GDP at regional basis. Those two are almost the same. Table 2.2.1.6 shows the example of the regional forecast for LTP-2. These show broadly similar growth throughout the whole kingdom, but with lower rates in the Northeastern, Northern and Southern regions than in the BMR. In the long term, the Eastern region is expected to show the largest growth in GRP. Table 2.2.1.7 summaries the GDP projections of the related studies for BMR. As Figure 2.2.1.4 shows, the GDP projections for BMR, and the optimistic scenario of the Harbour Study, URMAP and LTP-2 are almost the same.

Table 2.2.1.6 GDP Projections for Regions by LTP-2 (% per annum)

Region \ Year	2002-2006	2007-2011	2012-2016	2017-2021
BMR	5.8	5.8	5.4	5.2
Central	5.6	5.9	5.2	4.8
Eastern	5.7	6.0	6.4	6.9
Western	5.5	5.8	5.8	5.0
Northeastern	4.9	5.1	5.1	4.9
Northern	5.0	5.2	5.2	4.5
Southern	4.8	5.1	5.1	4.6
Whole Kingdom	5.6	5.7	5.3	5.2

Source: LTP-2 and TDRI

Table 2.2.1.7 GDP Projections of the Related Studies for BMR

Study	Base year	GDP Growth Scenarios
Airport Study	1995	Project from 1996 to 2017 by province
Harbour Study	1995	Optimistic (1996-2000: 0.2%, 2001-2006: 5.5%, 2007-2011: 5.2%, 2012-2016: 5.4)
		Base (1996-2000: 2.8%, 2001-2006: 4.2%, 2007-2011: 4.2%, 2012-2016: 4.4)
		Pessimistic (1996-2000: 0.0%, 2001-2006: 3.2%, 2007-2011: 3.2%, 2012-2016: 3.5%)
LTP-2	2001	2002-2006: 5.8%, 2007-2011: 5.8%, 2012-2016: 5.4%, 2017-2021: 5.2%
URMAP	1995	1996-1999: -0.60%, 2000-2006: 5.16%, 2007-2011: 6.0%, 2012-2016: 5.2%, 2017-2021: 5.0%

Source: LTP-2, URMAP, Airport Study and Harbour Study

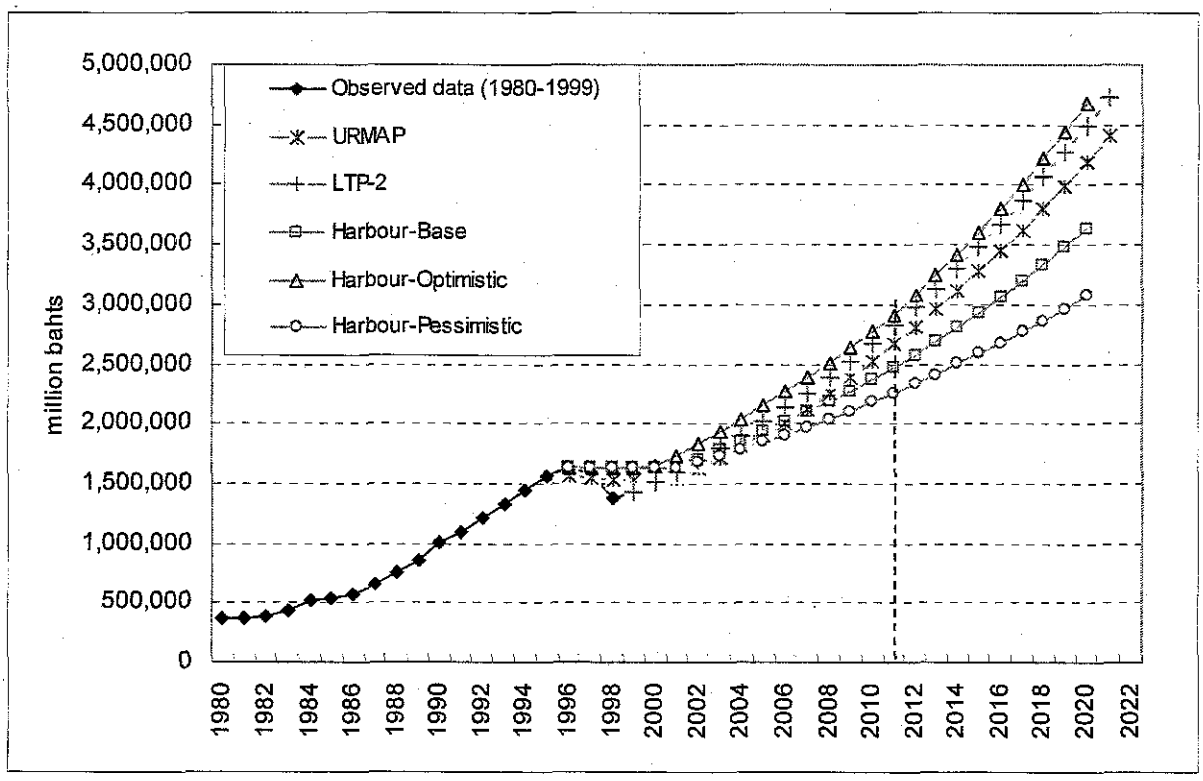


Figure 2.2.1.4 GDP Projections of the Related Studies for BMR

2.2.2 Socio-economic Frameworks Employed in This Study

As mentioned in Section 2.2.1, all population projections are based upon the NESDB's projection and are almost the same as shown in Figure2.2.1.1. Whilst, GDP projection has small differences due to the base year for projection, however, all cases are identified based upon the projection that the TDRI produced.

In addition, the traffic volumes used for the mobile source inventory were calculated based upon the TDRI's GDP projection and the NESDB's population projection (refer to Section 2.2.4 of the Supporting Report). Furthermore, for inventory development, regional and sectoral GDP projections need to be used for the estimation of future energy demand by region and sector and future freight demand in harbours considering regional economic disparity (refer to Section 2.2.3 and 2.2.4.3 of the Supporting Report).

Because of these reasons, the recent TDRI's GDP projections below, that the URMAP used in 2001, were employed as the socio-economic frameworks for this study (refer to Tables 2.2.2.1 and 2.2.2.2).

Table 2.2.2.1 GDP Projections at National and Regional Level (% per annum)

Year / Region	2002-2006	2007-2011	2012-2016	2017-2021
BMR	5.8	5.8	5.4	5.2
Central	5.6	5.9	5.2	4.8
Eastern	5.7	6.0	6.4	6.9
Western	5.5	5.8	5.8	5.0
Northeastern	4.9	5.1	5.1	4.9
Northern	5.0	5.2	5.2	4.5
Southern	4.8	5.1	5.1	4.6
Whole Kingdom	5.6	5.7	5.3	5.2

Source: LTP-2 and TDRI

Table 2.2.2.2 GDP Projections by Sector (% per annum)

Year / Sector	2002-2006	2007-2011	2012-2016	2017-2021
Agriculture	2.1	2.3	2.5	2.9
Manufacture	6.5	6.4	6.1	6.0
Services	5.4	5.6	5.0	4.7
Total	5.6	5.7	5.3	5.2

Source: LTP-2 and TDRI

Charpter 3

Stationary Source Inventory

3. Stationary Source Inventory

3.1 Basic Frame

Thailand was divided into two (2) areas: Country and the BMR. The BMR includes Bangkok, Samut Prakan, Nonthaburi. Pathum Thani, Nakon Pathom and Samut Sakhon. The Country is the area other than the BMR in Thailand. Stationary source inventories of the Country and the BMR are summarized in Tables 3.1.1.1 and 3.1.1.2 respectively.

Table 3.1.1.1 Basic Frame of Stationary Source Inventory of Country

Target Substance	SOx (as SO2)
Target Year	Base year : the year 2000 Target year : the year 2011
Emission Rate	Annual SOx emission (ton/year)

Table 3.1.1.2 Basic Frame of Stationary Source Inventory of the BMR

Target Substance	SOx (as SO2) for ATMOS2 SO2 and NOx (as NO2) for Airviro
Target Year	Base year : the year 2000 Target year : the year 2011
Emission Rate	Hourly emission (ton/hour)
Area Mesh Size	500 m x 500 m

Note : the BMR includes Bangkok, Samut Prakan, Nonthaburi, Pathum Thani, Nakon Pathom and Samut Sakhon

The socio-economic activities as air pollution sources were classified into the following six (6) sectors.

- Power
- Agriculture
- Mining
- Manufacturing
- Construction
- Residential and Commercial

Stationary sources were divided into point source and area source. Area source is subdivided into provincial area source and coal and lignite consuming area (coal area) source in consideration of fuel consumption data. In Thailand, there are several coal consuming areas stretching over more than one province (see Section 3.2.2.5). Emission from small-and-medium-sized sources was treated as an independent area source of ATMOS2. The relation between sector and source type in the Country is shown in Table 3.1.1.3.

Table 3.1.1.3 Relation between Sector and Source Type

Sector	Point	Area	
		Coal	Provincial
Power	O		
Agriculture			O
Mining			O
Manufacturing	O	O	O
Construction			O
Residential and Commercial			O

Major fuels were classified into petroleum products, natural gas, coal and its products and non-fossil fuel. Petroleum products, coal and its products and non-fossil fuel were divided into the following sub-types.

1. Petroleum products
   LPG
   Gasoline (ULG 87, 91 and 95)
   Kerosene
   Diesel oil (High Speed Diesel (HSD) and Low Speed Diesel (LSD))
   Fuel Oil (No. 1, 2, 3, 4 and 5)
2. Coal and its products
   Coal (anthracite, bituminous, coke and briquettes and other coal)
   Lignite
3. Non-fossil fuel
   Fuel wood
   Charcoal
   Paddy Husk
   Bagasse

The relation between sector and fuel used is shown in Table 3.1.4.

Table 3.1.1.4 Sector and Fuels Used

Sector	Petroleum Products	Natural Gas	Coal and its Products	Non-fossil Fuel
Power	O	O	O	O
Agriculture	O			O
Mining	O			
Manufacturing	O	O	O	O
Construction	O			
Residential and Commercial	O			O

3.2 Inventory of the Year 2000

3.2.1 Data Collection

To develop a stationary source inventory, the following data were collected.

Fuel consumption
EIA data
Stack gas monitoring
Fuel analysis (sulfur content and specific gravity)
Socio-economy
Manufacturing industry

To collect data on point sources for the Country and the BMR, the questionnaire survey was conducted between April to June 2002. The questionnaire survey sheet is shown in Appendix 3.1. The recovery of survey sheets in the Country and the BMR is summarized in Table 3.2.1.1. Table 3.2.1.2 shows the basic data used for the development of stationary source inventories.

Table 3.2.1.1 Questionnaire Survey Result

Area	Industries	Number of Surveyed Industries		
		Selected	Recovered	Return
Country	Power plant	36	13	1
	Refinery	7	4	0
	Petrochemical	59	24	2
	Iron/Steel	34	2	3
	Chemical	3	1	0
	Sugar mill	38	8	0
	Cement	17	3	0
	Pulp and paper	15	4	1
	Smelting	1	0	0
	Metal	6	1	0
	Other	34	2	1
	Total	250	62	8
BMR	Power plant	5	2	0
	Refinery	1	1	0
	Petrochemical	3	1	0
	Iron/Steel	63	3	0
	Chemical	18	2	5
	Sugar mill	3	0	0
	Cement	1	0	0
	Pulp and paper	13	1	0
	Smelting	2	0	0
	Metal	13	2	0
	Other	143	10	1
	Total	265	22	6

Table 3.2.1.2 Basic Data Collected and Used

Fuel	Power	EGAT	Fuel consumption in 2000	EGAT
		DEDP oil (1)	Tables 18 to 24	Sector
		DEDP power (2)	Tables 9 and 20	SPP
		DEDP energy (3)	Table 1	
		EGAT's Home Page	SPP list	SPP
		Study Team	Questionnaire survey	
	Agriculture	DEDP oil	Tables 18 to 24	Sector
		DEDP energy	Table 1	Non-fossil fuel
		NESDB	Gross Provincial Product (1999p)	
	Mining	DEDP oil	Tables 18 to 24	Sector
		DEDP energy	Table 1	
		NESDB	Gross Provincial Product (1999p)	
	Manufacturing	DCR	Fuel sale by seller	Petroleum products other than LPG, province
		DEDP oil	Tables 18 to 24	Sector
		DEDP energy	Table 15	Coal and its product
		DMR	Coal consumption area map	Tobacco
		DIW	Cement factory list	Cement
		DIW	Boiler list	BMR, Country, coal and lignite
		DIW's Home Page	Factory list	Chemical, Non-metal, Basic Metal, etc.
				Non-fossil fuel (coal and lignite)
		DEDP energy	Table 1	
		PTT	Gas pipeline route map	
		NESDB	Gross Provincial Product (1999p)	
		Study Team	Questionnaire survey	
		OEPP	EIA reports	
	Construction	DEDP oil	Tables 18 to 24	Sector
			Table 1	
		NESDB	Gross Provincial Product (1999p)	
	Residential & Commercial	DEDP oil	Tables 18 to 24	Petroleum products, sector
		DEDP energy	Tables 18	LPG, Kerosene, BMA and other, residential
		DEDP energy	Table 1	Non-fossil fuel, sector
		NSO	Provincial population	
Fuel analysis Emission factor		DCR	Fuel analysis data	Sulfur content, density
		IPCC	IPCC guidelines	NOx, SOx (cement)
		US EPA	AP-42	SOx
Refinery		Study Team	Questionnaire survey	
		OEPP	EIA Reports	
		OEPP	Stack gas monitoring data	
		DEDP oil	Table 14	Official refinery capacity

(1) DEDP/OIL AND THAILAND 2000
(2) DEDP/ELECTRIC POWER IN THAILAND 2000
(3) THAILAND ENERGY SITUATION 2000

3.2.2 Estimation of Fuel Consumption in the Whole of Thailand

3.2.2.1 Fuel Consumption by sector

Fuel consumption by sector in the whole of Thailand in 2000 is summarized in Table 3.2.2.1. Sectoral share in the total energy consumption is shown in Figure 3.2.2.1. The power sector accounts for 41% of the total energy consumption, followed by industry (27%) and the agriculture sector (19%).

Table 3.2.2.1 Fuel Consumption by Sector in the Whole of Thailand in 2000

(unit: ktoe)

	Power	Agriculture[1]	Mining	Manufacturing	Construction	Residential and Commercial
Coal	483			2,148		
Lignite	3,682			1,479		
Natural Gas	14,015			1,374		
LPG		2		372		1,601
ULG 87 and 91		50		10	0	
ULG 95		2		16		
Kerosene		1		27		12
HSD	36	2,089	9	684	125	
LSD			1	14		0
Fuel Oil	2,286	4	1	3,013	24	8
Fuel Wood	105	6,266		704		2,554
Charcoal						2,277
Paddy Husk	99	886		771		43
Bagasse	181			2,783		
Total	20,887	9,300	11	13,395	149	6,495

(1) Fuel input of wood and paddy husk to produce charcoal was assigned to agriculture sector.
(2) Data shown as "0" means figure is less vthan 0.5.
Source: DEDP/Thailand Energy Situation 2000

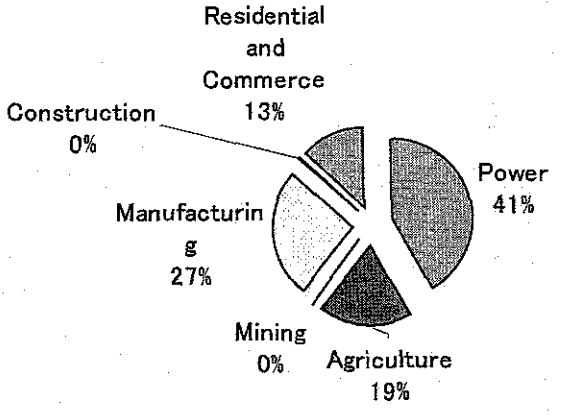


Figure 3.2.2.1 Share of Energy Consumption by Sector in Whole Thailand in 2000

3.2.2.2 Power Sector

The annual fuel consumption of power plants connected to the national grid was estimated from EGAT data, DEDP reports and the questionnaire survey results.

The annual fuel consumption in 2000 of the power plants is shown in Table 3.2.2.2.

Table 3.2.2.2 Fuel Consumption of Power Plants Connected to National Grid (2000)

	Fuel Oil (1000 L)	HSD (1000 L)	NG (MMscf)	Lignite (ton)	Coal (ton)	Fuel wood (ton)	Paddy Husk (ton)	Baggase (ton)
EGAT	2,375,208	35,608	340,391	14,120,569				
IPP	34,955	4,413	164,456					
SPP	19,115	1,808	70,297	53,602	774,548	276,567	288,549	1,014,515
Total	2,429,278	41,829	575,144	14,174,171	774,548	276,567	288,549	1,014,515

3.2.2.3 Agriculture Sector

Provincial fuel consumption of the agriculture sector is calculated by multiplying the total fuel consumption of the agriculture sector (DEDP/Oil and Thailand 2000) by a ratio between each provincial agricultural product and national agricultural product. Table 3.2.2.3 gives the total annual fuel consumption of the agriculture sector in 2000.

Table 3.2.2.3 Fuel Consumption of the Agriculture Sector in 2000

	ULG 91 (KL)	ULG 95 (KL)	Kerosene (KL)	HSD (KL)	Fuel Oil (KL)	LPG (KL)	Fuel Wood (Kton)	Paddy Husk (Kton)
BMR	6,037	279	74	217,209	313	245	1,484	233
Central Region	7,663	355	95	275,683	397	311	1,884	296
Northern Region	12,399	574	153	446,081	643	504	3,048	479
Northeastern Region	13,878	642	171	499,312	720	564	3,411	536
Southern Region	21,762	1,007	269	782,958	1,129	884	5,349	840
Eastern Region	5,611	260	69	201,863	291	228	1,379	217
Total	67,350	3,117	831	2,423,106	3,493	2,736	16,555	2,600

3.2.2.4 Mining Sector

Provincial fuel consumption of the mining sector is calculated by multiplying the total fuel consumption of the mining sector (DEDP/Oil and Thailand 2000) by a ratio between each provincial mining product and national mining product. Table 3.2.2.4 gives the total annual fuel consumption of the mining sector in 2000.

Table 3.2.2.4 Fuel Consumption of Mining Sector in 2000

	HSD (KL)	LSD (KL)	Fuel Oil (KL)
BMR	141	19	17
Central Region	1,392	183	166
Northern Region	177	23	21
Northeastern Region	2,672	351	319
Southern Region	903	119	108
Eastern Region	5,162	679	616
Total	10,447	1,374	1,247

3.2.2.5 Manufacturing sector

1) Petroleum products

(1) Petroleum products other than LPG

There are statistics of provincial fuel sale by seller on Fuel Oil, HSD, LSD, Kerosene, ULG 91 and ULG 95 (DCR, 2000). The purchasers include station, store, wholesale, transport, industry and other. The total fuel sale of the country is shown in Table 3.2.2.5. While, Table 3.2.2.6 shows the national fuel consumption in the manufacturing sector in 2000 (DEDP/Oil and Thailand 2000). The figures of these two tables are very close. So, DCR's statistics on provincial fuel sale in industry were chosen as the fuel consumption in the manufacturing sector with an adjustment of its total figures to those of DEDP (Table 3.2.2.7).

Table 3.2.2.5 Total Fuel Sale in Thailand in 2000

Fuel	Station	Store	Wholesaler	Transport	Industry	others	Total
ULG 87	43,468		32			4,937	48,437
ULG 91	2,529,674	13,295	657,498	167	12,305	73,136	3,286,076
ULG 95	2,955,873	11,180	373,650	1,422	21,477	63,486	3,427,088
Kerosene	7,591	38	5,358	50	33,478	2,243	48,758
HSD	9,461,030	51,980	3,060,222	302,414	822,876	1,169,564	14,868,085
LSD	21		462	87,518	15,768	1,827	105,596
Fuel Oil	168	18	182,303	655,025	2,989,418	2,546,440	6,373,372

Source: DCR

Table 3.2.2.6 Total Fuel Consumption by the Manufacturing Sector in Thailand

(Unit: KL)

ULG 91	ULG 95	Kerosene	HSD	LSD	Fuel Oil
12,563	21,477	33,556	793,832	15,832	3,200,603

Source: DEDP/Oil and Thailand 2000

Table 3.2.2.7 Comparison of DCR Figures and DEDP Figures

(Unit: KL)

	ULG 91	ULG 95	Kerosene	HSD	LSD	Fuel Oil
DCR	12,563	21,477	33,556	793,832	15,832	3,200,603
DEDP	12,305	21,477	33,478	822,876	15,768	2,989,418
DEDP/DCR	1.021	1.000	1.002	0.965	1.004	1.071

(2) LPG

Provincial LPG consumption by the manufacturing sector was calculated by multiplying the total LPG consumption of the manufacturing sector (DEDP/Oil and Thailand 2000) by a ratio between each provincial manufacturing product and national manufacturing product.

2) Natural gas

Natural gas consumption is restricted by its pipeline route. The total national natural gas consumption by the manufacturing sector (DEDP/Oil and Thailand 2000) was allocated to each gas-supplied province according to its share of Horse Power of the gas-supplied industrial estates (see Appendix 3.2).

3) Coal and lignite

Consumption of coal and its products and lignite by the manufacturing sector in Thailand is shown in Tables 3.2.2.8 and 3.2.2.9 respectively. The lignite consumption area by tobacco curing is limited in Thailand (Figure 3.2.2.1). In the Study, coal and lignite consumption by cement industry was assigned to major cement plants (as point source). For the tobacco industry, Coal and lignite consumption by the industry was allocated to 7 areas. The estimation method of provincial consumption of coal and lignite is shown in Appendix 3.3.

Table 3.2.2.8 Consumption of Coal and its Products in the Manufacturing Sector in 2000

(ktoe)

Sub-sector	Consumption
Food and Beverages	50
Textiles	78
Wood and Furniture	-
Pulp and Paper	323
Chemical	646
Non-Metal	2,252
Basic Metal	207
Fabricated Metal	-
Other (unclassified)	71
Total	3,627

DEDP/Thailand Energy Situation 2000

Table 3.2.2.9 Lignite Consumption by the Manufacturing Sector in 2000

(Kton)

Industry	Consumption
Cement	2,512
Tobacco Curing	31
Others	869
Total	3,412

DEDP/Thailand Energy Situation 2000

Source: Department of Mineral Resources

Figure 3.2.2.1 Lignite Consumption Area for Tobacco Curing

4) Non-fossil fuel

Provincial consumption of non-fossil fuel by the manufacturing sector was calculated by multiplying the total fuel consumption of the manufacturing sector (DEDP/Oil and Thailand 2000) by a ratio between each provincial manufacturing product and national manufacturing product.

5) Fuel consumption of the manufacturing sector

The fuel consumption of the manufacturing sector in 2000 is summarized in Table 3.2.2.10.

Table 3.2.2.10 Fuel Consumption of the Manufacturing Sector in 2000

	ULG 91 (KL)	ULG 95 (KL)	Kerosene (KL)	HSD (KL)	LSD (KL)	Fuel Oil (KL)	LPG (KL)
BMR	1,107	9,997	30,803	284,886	6,503	2,055,924	337,470
Central Region	191	389	1,560	143,709	2,690	314,856	53,829
Northern Region	2,544	2,964	30	86,155	105	50,291	19,700
Northeastern Region	4,041	1,015	21	72,854	208	107,817	32,514
Southern Region	1,783	1,982	82	79,548		183,201	11,932
Eastern Region	2,898	5,130	1,061	126,679	6,326	488,513	135,053
Total	12,563	21,477	33,556	793,832	15,832	3,200,603	590,497

	Coal (ton)	Lignite (ton)	Natural gas (MMscf)	Fuel wood (kton)	Paddy husk (kton)	Bagasse (kton)
BMR	170,854	141,953	20,666	1,064	1,293	8,917
Central Region	2,500,244	2,337,525	1,549	170	206	1,422
Northern Region	95,794	511,918		62	75	521
Northeastern Region	294,865	79,729		102	125	859
Southern Region	68,387	255,060		38	46	315
Eastern Region	274,957	86,018	34,590	426	518	3,569
Total	3,405,101	3,412,203	56,805	1,861	2,263	15,603

3.2.2.6 Construction sector

Provincial fuel consumption of the construction sector was calculated by multiplying the total fuel consumption of the construction sector (DEDP/Oil and Thailand 2000) by a ratio between each provincial product in the construction sector and national product in the construction sector. Table 3.2.2.11 gives the total annual fuel consumption in 2000 of the construction sector.

Table 3.2.2.11 Fuel Consumption of Construction Sector in 2000

	ULG 91 (KL)	HSD (KL)	Fuel Oil (KL)
BMR	4	62,842	10,954
Central Region	1	13,333	2,324
Northern Region	1	18,243	3,180
Northeastern Region	2	24,229	4,224
Southern Region	1	14,654	2,554
Eastern Region	1	11,057	1,927
Total	9	144,359	25,164

3.2.2.7 Residential and Commercial Sector

1) LPG, kerosene, and non-fossil fuel

The residential consumption patterns of LPG, Kerosene and Renewable Energy differ between Greater Bangkok (Bangkok, Nonthaburi, Pathum Thani and Samut Prakan) and other provinces. Besides, this sector also includes commercial sector and is dominant in the BMR. Therefore, consumption of these fuels were calculated separately in the residential and commercial sectors using the provincial population (see Appendices 3.4, 3.5 and 3.6).

2) Other fuels

Consumption of HSD, LSD and Fuel Oil was calculated by assigning the total fuel consumption of the residential and commercial sectors (DEDP/Oil and Thailand 2000) by a ratio between each provincial population and national population.

3) Fuel consumption of the residential and commercial sectors

Table 3.2.2.12 gives the annual fuel consumption in 2000 of the residential and commercial sectors.

Table 3.2.2.12 Fuel Consumption of the Residential and Commercial Sectors (2000)

	Kerosene (KL)	LSD (KL)	Fuel Oil (KL)	LPG (KL)	Fuel wood (kton)	Charcoal (Kton)	Paddy husk (Kton)
BMR	951	74	1,421	494,475	157	85	3
Central	1,695	52	994	256,332	826	407	15
Northern Region	3,121	95	1,830	471,860	1,520	748	28
Northeastern Region	5,521	169	3,237	834,632	2,688	1,324	50
Southern Region	2,119	65	1,243	320,429	1,032	508	19
Eastern Region	1,078	33	632	163,023	525	259	10
Total	14,486	488	9,357	2,540,750	6,748	3,330	126

3.2.3 Method for the Development of the Stationary Source Inventory for the Country

3.2.3.1 Procedure for the Development of the Stationary Source Inventory for the Country

The method for the development of the stationary source inventory should be suitable for ATMOS2. The method is shown in Figure 3.2.3.1. The JICA Study Team estimated SOx emission from point, and area sources in consideration of the following matters.

1. To avoid double counting of SOx emission between sources.
2. To avoid overestimation or underestimation of SOx emission.

Origins of SOx emission discharged into the air from stationary sources are fuel sulfur and sulfur contained in raw materials. In general, total sulfur in liquid or gas fuels are regarded to be emitted as SOx in the combustion process. A certain part of sulfur in coal or lignite remains in ash. In case of cement production, the greater part of sulfur in fuels and raw materials remains in the produced cement.

Emission shown in EIA reports does not always show actual emission. Usually it corresponds to maximum operation. Therefore, in case emission in EIA reports is used, actual emission should be calculated by multiplying the operation ratio between actual production and assumed production in EIA reports.

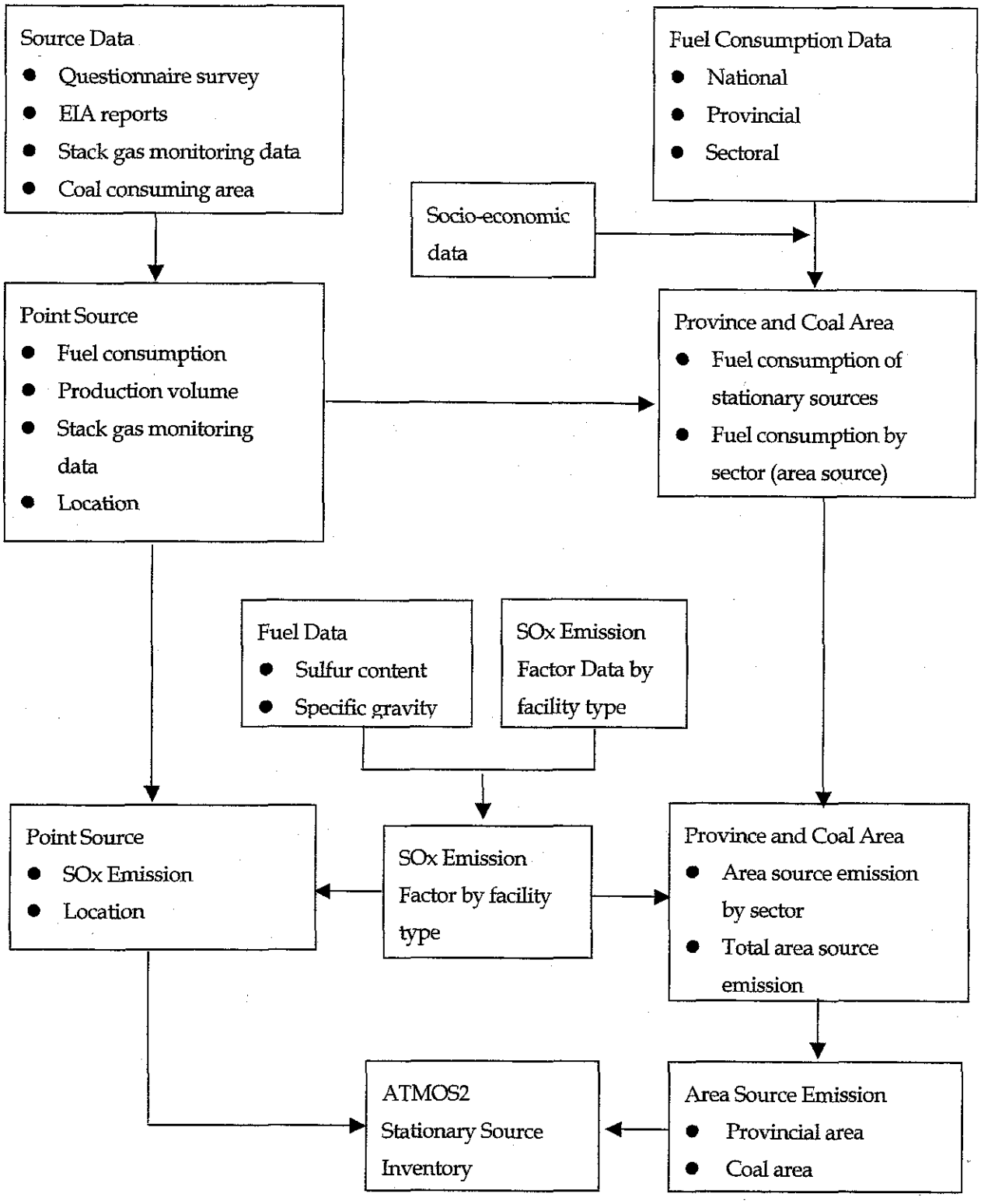


Figure 3.2.3.1 Flowchart for Development of Stationary Source Inventory for ATMOS2

3.2.3.2 SOx Emission Calculation Method

1) Point Source

(1) Combustion facility

SOx emission was calculated by the following equation.

SOx emission = Fuel consumption x Emission Factor

For fuel oil, otherwise designated, was used emission factor of Fuel Oil 2 because it is the most used fuel oil in Thailand.

(2) Sulfuric acid plant

Emission factor was used.

SOx emission = Sulfuric acid production x Emission Factor

(3) Refinery

Stack gas monitoring data was used.

SOx emission = Gas volume x SO2 concentration in the stack gas

(4) Cement kiln

Emission factor was used.

SOx emission = Cement production x Emission Factor

2) Area Source

The same method for combustion facility of point source was used.

3.2.3.3 Emission Factor

1) Fuel Composition

Table3.2.3.1 shows specific gravity and sulfur content (weight %) of each fuel used in Thailand.

Table 3.2.3.1 Fuel Composition

Fuel	Density (D)	Sulfur Content (S) (w %)
LPG		0.343 g/m3 (DCR Spec)
Gasoline	0.7422 kg/L (DEDP)	0.0382 (Oil companies)
Kerosene	0.7961 kg/L (DCR)	0.15 (MOI, 1994)
HSD	0.8358 kg/L (DCR)	0.0348 (Oil companies)
LSD	0.8501 kg/L (DCR)	0.458 (DCR)
Fuel oil 1	0.9402 kg/L (DCR)	1.7 (DCR)
Fuel oil 2	0.9487 kg/L (DCR)	1.7 (DCR)
Fuel oil 3	0.9752 kg/L (DCR)	2.5 (DCR)
Fuel oil 4	0.9492 kg/L (DCR)	2.3 (DCR)
Fuel oil 5	0.8880 kg/L (DCR)	0.1 (DCR)
Natural gas	9.5 ppm of H2S for general use	(PTT)
	430 ppm for Nam Phong PP	(EGAT)
Coal and its products		0.5 (DMR)
Lignite for power		3.0 (DEDP))
Lignite for industry		2.0 (DEDP)

Note : ( ) means the data source

2) Emission Factor

(1) Combustion facility

Table 3.2.3.2 shows emission factor for combustion facility.

Table 3.2.3.2 SOx Emission Factor for Combustion Facility

Fuel	SOx Emission Factor
LPG	2S kg/1000 m3
Gasoline	20S*D kg/ kL
Kerosene	
HSD	
LSD	
Fuel oil 1	
Fuel oil 2	
Fuel oil 3	
Fuel oil 4	
Fuel oil 5	
Natural gas	27.14 kg/M m3 for general use 1228.44 kg/M m3 for Nam Phong PP
Coal and its products	19S kg/ton (US EPA, AP-42 (1996))
Lignite for power	15S kg/ton (US EPA, AP-42 (1996))
Lignite for industry	15S kg/ton (US EPA, AP-42 (1996))
Fuel wood	0.2 kg/ton for Residential and Commercial sector 0.0375 kg/ton for other sector (US EPA, AP-42 (1996))
Charcoal	
Paddy husk	
Bagasse	

(2) Other plants

Table 3.2.3.3 gives the emission factor for the sulfuric acid plant and cement plant.

Table 3.2.3.3 SOx Emission Factor for Sulfuric Acid Plant and Cement Plant

	Emission Factor	Conversion Efficiency (%)
Sulfuric acid plant (1)	13.00 kg/Ton H2SO4	98 %
	10.00 kg/Ton H2SO4	98.5%
	2.00 kg/Ton H2SO4	99.98 %
Cement plant (2)	0.30 kg/Ton Cement	

(1) US EPA, AP-42 (1996)

(2) Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories : Reference Manual

3.2.4 Method for the Development of the Stationary Source Inventory for the BMR

3.2.4.1 Estimated Sectoral Fuel Consumption in the BMR in 2000

1) Power sector

Provincial fuel consumption by the power plants in the BMR is shown in Table 3.2.4.1.

Table 3.2.4.1 Fuel Consumption by the Power Plants in the BMR in 2000

	Fuel Oil (KL)	HSD (KL)	Natural Gas MMscf
Bangkok		1,441	
Nonthaburi	85,428	120	
Pathum Thani			
Samut Prakan	1,156,856	1,155	61,988
Samut Sakhon			
Nakhon Pathom			
Total	1,242,283	2,716	61,988

2) Agriculture sector

Provincial fuel consumption by the agriculture sector in the BMR is shown in Table 3.2.4.2.

Table 3.2.4.2 Fuel Consumption by the Agriculture Sector in the BMR in 2000

	ULG91 (KL)	ULG95 (KL)	Kerosene (KL)	HSD (KL)	Fuel Oil (KL)	LPG (KL)	Fuel Wood (Kton)	Paddy Husk (Kton)
Bangkok	1,241	57	15	44,647	64	50	305	48
Nonthaburi	257	12	3	9,242	13	10	63	10
Pathum Thani	390	18	5	14,047	20	16	96	15
Samut Prakan	1,763	82	22	63,416	91	72	433	68
Samut Sakhon	1,478	68	18	53,166	77	60	363	57
Nakhon Pathom	909	42	11	32,692	47	37	223	35
Total	6,037	279	74	217,209	313	245	1,484	233

3) Mining sector

Provincial fuel consumption by the mining sector in the BMR is shown in Table 3.2.4.3.

Table 3.2.4.3 Fuel Consumption by the Mining Sector in the BMR in 2000

	HSD (KL)	LSD (KL)	Fuel Oil (KL)
Bangkok			
Nonthaburi			
Pathum Thani	7	1	1
Samut Prakan			
Samut Sakhon	125	16	15
Nakhon Pathom	9	1	1
Total	141	19	17

4) The manufacturing sector

Provincial fuel consumption by the manufacturing sector in the BMR is shown in 3.2.4.4.

Table 3.2.4.4 Fuel Consumption by the Manufacturing Sector in the BMR in 2000

	ULG91 (KL)	ULG95 (KL)	Kerosene (KL)	HSD (KL)	LSD (KL)	Fuel Oil (KL)	LPG (KL)
Bangkok	729	6,383	22,904	131,370	4,234	708,946	206,218
Nonthaburi	26	221	212	7,383	71	37,416	9,946
Pathum Thani	85	1,486	233	35,155	437	229,287	40,676
Samut Prakan	129	1,806	6,566	48,363	1,761	522,209	44,177
Samut Sakhon	53	1	706	42,956	0	447,340	24,703
Nakhon Pathom	85	100	181	19,659	0	110,725	11,750
Total	1,107	9,997	30,803	284,886	6,503	2,055,924	337,470

	Coal (ton)	Lignite (ton)	Natural Gas (MMscf)	Fuel Wood (Kton)	Paddy Husk (Kton)	Bagasse (Kton)
Bangkok	24,669	6,298	373	650	790	5,449
Nonthaburi				31	38	263
Pathum Thani	4,955	1,265	688	128	156	1,075
Samut Prakan	8,362	48,042	19,605	139	169	1,167
Samut Sakhon	112,737	81,211		78	95	653
Nakhon Pathom	20,130	5,138		37	45	310
Total	170,854	141,953	20,666	1,064	1,293	8,917

5) The construction sector

Provincial fuel consumption by the construction sector in the BMR is shown in 3.2.4.5.

Table 3.2.4.5 Fuel Consumption by the Construction Sector in the BMR in 2000

	ULG91 (KL)	HSD (KL)	Fuel Oil (KL)
Bangkok	3.2	51,182	8,922
Nonthaburi	0.2	3,846	670
Pathum Thani	0.1	1,876	327
Samut Prakan	0.2	2,971	518
Samut Sakhon	0.1	1,509	263
Nakhon Pathom	0.1	1,458	254
Total	4	62,842	10,954

6) Residential and commercial sector

Provincial fuel consumption by the residential and commercial sector in the BMR is shown in 3.2.4.6.

Table 3.2.4.6 Fuel Consumption by the Residential and Commercial Sector in the BMR in 2000

	Kerosene (KL)	LSD (KL)	Fuel Oil (KL)	LPG (KL)	Fuel Wood (Kton)	Charcoal (Kton)	Paddy Husk (Kton)
Bangkok	443	45	859	310,213	3	7	0
Nonthaburi	67	7	130	46,944	1	1	0
Pathum Thani	51	5	99	35,754	0	1	0
Samut Prakan	78	8	151	54,384	1	1	0
Samut Sakhon	111	3	65	16,721	54	27	1
Nakhon Pathom	201	6	118	30,459	98	48	2
Total	951	74	1,421	494,475	157	85	3

3.2.4.2 Procedure for the Development of the Stationary Source Inventory for the BMR

Based on the stationary source inventory of Airviro 1997, the questionnaire survey and the preliminary analysis, the stationary source inventory for the BMR was developed in 2000. The review of Airviro 1997 and preliminary analysis to develop the inventory of Airviro 2000 is shown in Appendix 3.7.

The flowchart to develop the stationary source inventory of the manufacturing sector for ATMOS2 and Airviro 2000 is shown in Figure 3.2.4.1.

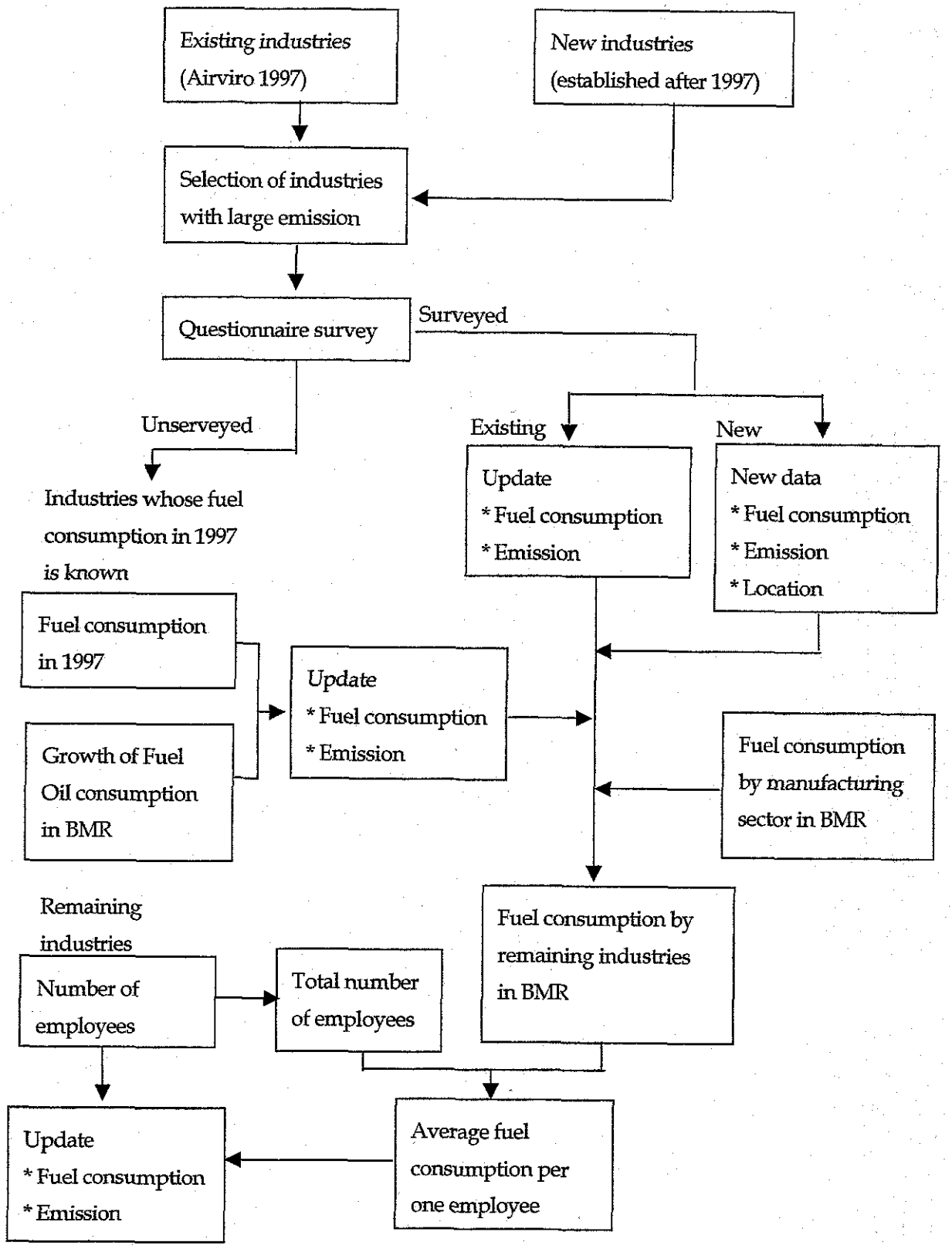


Figure 3.2.4.1 Flowchart to Develop Inventory of Manufacturing Sector for ATMOS2 and Airviro 2000

3.2.4.3 Estimation of the Fuel Consumption of Point Sources of the Manufacturing sector

1) Point sources with new information from the year 2000

The fuel consumption was updated.

2) Point sources with no new information but with information on fuel consumption from 1997

The fuel consumption of point sources with no new information but with fuel consumption from1997 was estimated by the following equation. as Fuel Oil is the dominant fuel of the manufacturing sector in the BMR.

Fuel consumption in 2000 = Fuel consumption in 1997 x Fuel Oil sale growth in the BMR between 1997 and 2000

Here,

Fuel Oil sale growth between 1997 and 2000 in the BMR is 0.831 (See Table 3.2.4.7).

3) Point sources with no information on fuel consumption

The fuel consumption of point sources with no information both from 1997 and 2000 was estimated by the following equation.

Fuel consumption in 2000 = (fuel consumption in the BMR – total fuel consumption of industries whose fuel consumption is known)/Total number of employees of point sources with no information on fuel consumption) x Number of employees

Table 3.2.4.7 Petroleum Fuel Sale in the BMR in 1997 and 2000

(1000KL)

Year	Province	Gasoline	Kerosene	Jet Fuel	High Speed Deasel	Low Speed Diesel	Fuel Oil	LPG 1000 ton
1997	Bangkok	2,584.743	26.724	3,000.209	3,641.076	115.789	3,587.278	293.511
	Nonthaburi	222.367	0.027		246.278	0.625	58.525	72.616
	Pathun Thani	169.462	2.538	297.514	614.156	1.201	318.769	75.579
	Sumut Prakan	270.131	7.666		829.441	0.988	616.813	170.627
	Nakhon Patom	93.505	0.859	0.390	325.100		148.378	41.234
	Samut Sakhon	67.437	3.880		185.738	3.476	379.351	69.329
	Total	3,407.645	41.694	3,298.113	5,841.789	122.079	5,109.114	722.896
2000	Bangkok	2,443.867	29.280	3,278.443	3,531.022	72.971	2,534.776	329.079
	Nonthaburi	203.923	0.226		205.363	0.071	35.199	65.866
	Pathun Thani	171.470	0.427	0.003	385.749	0.435	215.512	86.653
	Sumut Prakan	175.796	6.976		423.726	2.791	537.459	179.695
	Nakhon Patom	101.153	0.329	0.000	309.395		109.377	57.905
	Samut Sakhon	82.373	1.546		296.433	2.615	815.759	76.794
	Total	3,178.582	38.784	3,278.446	5,151.688	78.883	4,248.082	795.992
2000/1997	Bangkok	0.945	1.096	1.093	0.970	0.630	0.707	1.121
	Nonthaburi	0.917	8.370		0.834	0.114	0.601	0.907
	Pathun Thani	1.012	0.168	0.000	0.628	0.362	0.676	1.147
	Sumut Prakan	0.651	0.910		0.511	2.825	0.871	1.053
	Nakhon Patom	1.082	0.383	0.000	0.952		0.737	1.404
	Samut Sakhon	1.221	0.398		1.596	0.752	2.150	1.108
	Total	0.933	0.930	0.994	0.882	0.646	0.831	1.101

Source: Department of Commercial Registration

3.2.4.4 Emission Calculation Method

1) SOx

The emission estimation method and emission factor are the same as used for the Country (Section 3.2.2.2).

2) SO2

In general, SO2 emission depends on fuel composition and combustion condition in which it is combusted. The major fuel in the BMR is Fuel Oil. For Fuel Oil, more than 95% of SOx is emitted as SO2 (US EPA AP42 (1996)). So, in this Study, 95 % of SOx is assumed to be emitted as SO2 for all fuels used in the BMR.

3) NOx

For power plants and refineries, stack gas monitoring data was used. For other industries NOx emission factor shown in Table 3.2.4.8 was used. The net calorific value by fuel is shown in Table 3.2.4.9.

Table 3.2.4.8 NOx Emission Factor

Sector	Fuel Type	NOx emission factor (kg/TJ)	Note
Power Sector	Natural Gas	190	Gas turbine
Agriculture Sector	Gasoline	1500	Equipment
	HSD		
	Kerosene	65	Boiler
	Fuel Oil	170	
	LPG	97	
	Fuel Wood	5	Charcoal production
	Paddy Husk	5	Charcoal production
Mining Sector	Gasoline	1200	Equipment
	HSD		
	LSD		
	Fuel Oil	170	Boiler
Manufacturing Sector	Gasoline	1200	Eqipmemt
	Kerosene	65	Boiler
	HSD	65	
	LSD	65	
	Fuel Oil	170	
	LPG	97	
	Natural Gas	64	
	Coal	240	
	Lignite	100	
	Fuel Wood	65	
	Paddy Husk	68	
	Bagasse	68	
Construction Sector	Gasoline	1200	Equipment
	HSD		
	LSD		
	Fuel Oil	170	Boiler
Residential and Commercial Sector	Kerosene	65	Boiler
	LSD	65	
	Fuel Oil	170	
	LPG	71	
	Fuel Wood	120	Stoves
	Charcoal	120	Fuel wood
	Paddy Husk	120	Fuel wood

Source: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, volume 3