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National Environmental & Sustainability Strategies for Automobiles in Thailand

by

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Bachelor of Science with Distinction in Engineering
and the Concentration in Public Policy
Swarthmore College, 1996

Submitted to the Department of Civil & Environmental Engineering
in Partial Fulfillment of the Requirements for the Degrees of

MASTER OF SCIENCE IN CIVIL AND ENVIRONMENTAL ENGINEERING

and

MASTER OF SCIENCE IN TECHNOLOGY AND POLICY

at the
Massachusetts Institute of Technology
June 1998

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ABSTRACT

In 1961 the Thai government's first National Economic and Social Development Plan identified automobile assembly as a critical industry for ensuring the successful economic and social development of Thailand. Over the last 37 years Thailand has focused almost exclusively on economic development, and as a result it is now one of the most powerful economies in Southeast Asia. During this period, Thailand's economy has grown considerably and the nation has emerged as the regional leader in automotive technology and automobile production. Unfortunately, the accompanying increase in automobile ownership has plagued the capital and primary city of Bangkok with severe traffic congestion and air pollution, each of which are considered to be among the worst in the world. As a result, motor vehicles appear to have, at least partially, had adverse effects on the economic development and quality of life that the automobile industry was originally intended to bring to the people of Thailand. This thesis focuses on developing an integrated, comprehensive strategy that the Thai government could use to pursue a more balanced form of sustainable economic development through the reconciliation of the economic development potential of a strong automobile industry with the motor vehicle related urban problems of traffic congestion and air pollution.

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Acknowledgments

I would like to thank Professor David H. Marks for his unwavering support and guidance over the last two years. As a result of his faith, trust, and endless good will, I have had an MIT experience which far exceeds what I had thought possible. The experiences, people, and concepts to which I have been exposed have greatly expanded my understanding of the world, the challenges it faces, and how I might contribute toward making it a better place.

I would also like to thank all of the participants of the Thailand Automotive Technology Conference/Workshop held in Bangkok between March 30th and April 3, 1998. The many presentations, meetings, and conversations during those five days and beyond were instrumental in gaining the insights needed to begin appreciating the full scale of Thailand's interrelated challenges and how it might be possible to begin solving them.

I would also like to thank the professors, mentors, and friends which have encouraged, challenged, and supported me throughout my life at home, school, and everywhere in between. In particular I would like to thank Josiah Bunting, Kevin Crowley, Fred Orthlieb, Faruq Siddiqui, Juergen & Sabine Sommer, Don Swearer, Darian Unger, Rick Valelly, and Dale Whittington. Each of you have given me encouragement and inspiration while further opening my mind and helping me to see from the perspective of others.

And a special thanks goes to my grandmother Elva Irwin who gave me the opportunity to build my confidence and rise to my full potential long before I ever knew what she had given me.

Lastly I would like to thank my parents, Jeff & Laura, and my sister, Susie, for endless support and love. I hope you all realize how grateful I am to have you as family even though I don't say it often enough.

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1.1 Introduction

In 1961, Thailand adopted its first National Economic and Social Development Plan which was intended to direct government policy towards the goal of economic development through 1966. Under this original plan and seven subsequent five-year plans, Thailand's economy has grown at an average rate of 7.8% per year, its annual population growth rate has fallen from 3.4 to 1.2% per year, and per capita income has grown from 2,100 to 68,000 Baht[1] per year (Wanisubut, 1998, p.2-3). By 1995, Thailand had become the 30th largest economy in the world and was considered to be one of Asia's 'tiger' economies. This growth was severely interrupted in early 1997, however, when several sectors of the Thai economy collapsed following the Thai central bank's near default[2] on short-term foreign loans amounting to nearly one-third of GDP. By the end of 1997, the Baht had lost 40% of its value, the Thai stock market had plunged 65%, and the national GDP had shrunk by nearly 1% (Economist, 1998, p. 5).

While financial experts are hopeful that Thailand's economy will recover, they believe that long-term growth and stability will require Thailand to correct many of the fundamental problems which were either unknown or ignored when the economy was booming. These observations are not limited to the financial sectors alone however. There were and still are many other problems in Thailand that were either ignored or simply assumed to be inherent in 'doing business in Thailand.' Of these problems, one of the most severe is the country's lack of mobility in general, but especially in Bangkok which is known to have among the worst traffic congestion in the world. Aside from the inconvenience and decline in the quality of life for the citizens of Bangkok, traffic

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[1] The Baht is basic unit of Thai currency. For much of the early 1990s, US $1 was equal to roughly 25 Baht.
[2] Prior to The Bank of Thailand defaulting on these loans, the International Monetary Fund (IMF) provided US $11 billion in loans in exchange for Thailand completing significant reforms in its investment and banking policies.

congestion restricts the movement and transport of goods, services, and people which is essential to a functioning economy. By failing to provide such mobility, the economic cost of Bangkok's congestion has been estimated at one-third of the potential gross city product (Strickland, 1993, p.4). Unfortunately, the effects of traffic congestion extend even further because the average car in Bangkok spends the equivalent of 44 days each year motionless in traffic jams, yet each of these cars continuously emit air pollutants into the highly-developed, densely-populated streets of Bangkok (Strickland, 1993, p.4). The result is severe urban air pollution which threatens the public health and lowers the quality of life of Bangkok residents while at the same time imposing additional direct, indirect, and opportunity costs on the economy, business, and individuals.

On the surface it seems that Bangkok's congestion and poor air quality are the result of too many automobiles and too few roads and highways. However, a deeper analysis suggests that Bangkok's causes are more complex than just cars and roads, but also that the fundamental problem may be have a rather simple 'theoretical' answer. To shed a bit of light on the additional complexities, one of the most influential causes of Bangkok's traffic congestion and air pollution problems lies in its own history. This is because as the city of Bangkok developed, its formerly agrarian layout has been transformed into a massive urban sprawl which extends for more than 50 kilometers in all directions and which is highly incompatible with efficient roadway systems (Strickland, 1993, p.1). During this rapid growth, however, adequate public transportation was never established thereby forcing Bangkok's citizens to turn to motor vehicles to meet their growing need for mobility. In light of this more comprehensive examination, it seems that the cause of Bangkok's traffic congestion and air pollution is not motor vehicles *per se*, but the lack of viable transportation alternatives (BMA/MIT, 1995, p.3).

This finding is reassuring because it suggests that motor vehicles will continue to play an important role in Thailand and even in Bangkok, but more importantly it reaffirms the Thai government's long-standing policy of encouraging the development of a domestic automobile industry. As part of the 1961 National Economic and Social Development Plan, the Thai

government identified the 'automobile assembly' industry as a preferred industry to bring to Thailand to further economic development, and with it, improved quality of life for all Thais. Over the past 37 years, Thailand has remained steadfast in its commitment to the automobile industry and extended its policy to include significant investment incentives to related parts and support industries. As a result of these and more recent policy changes aimed at distributing industrial production throughout Thailand as well as producing a strong export market for both automobiles and automotive parts, Thailand now has a globally competitive industry which it hopes will further economic development and the attendant increase in quality of life for all Thais.

At the same time, however, the government must address the fact that automobiles are hindering economic development and eroding the quality of life within Bangkok itself. As previously explained, the underlying problem is not automobiles *per se*, but providing viable transportation alternatives. However, developing and implementing such alternatives is a long-term process and, even if successful, will not eliminate the problems of traffic congestion and air pollution. For this reason, the government must begin to develop an understanding of how mobility, air pollution and public health interact with the automobile and its related industries, as well as the government's own ability to manage and guide these interrelationships.

It is within this context that this thesis focuses on developing an integrated and comprehensive strategy that could potentially be used by the Thai government to pursue a more balanced form of sustainable economic development, made possible by reconciling the economic development potential of a strong automobile industry with the urban problems of traffic congestion and air pollution which are present in Bangkok.

1.2 Developing a Solution

The first step towards developing a solution begins with obtaining a sufficient understanding of Thailand's physical, political, and socioeconomic background, the development and significance of the automotive industry, as well as the current economic conditions which are

affecting Thailand at the moment (Chapter 2). Next, it is important to understand the environmental impacts of motor vehicles on Thailand and particularly Bangkok and its citizens. This information is critical to understanding the urgency of Thailand's pollution problems, the unsustainable nature of "business as usual" (Chapter 3). It is then beneficial to explore the challenges, tradeoffs, and opportunities which are inherent in balancing mobility, air pollution, emissions control technologies, the economic development potential of the automobile industry as well as the capacity of the government to effectively and efficiently manage all of these concerns. Developing this level of understanding is best accomplished by describing the status quo, highlighting the inherent tradeoffs, and revealing likely future demands and opportunities (Chapter 4). Finally, recommendations for a sample comprehensive, integrated strategy are presented in the form of goals and tactics which are intended to guide Thailand toward a more balanced form of sustainable economic development--made possible by balancing and managing the economic development potential of a strong automobile industry with the urban problems of traffic congestion and air pollution which are present in Bangkok (Chapter 5).

1.3 Overview of Findings

Based on the broad-based review contained in this thesis there are numerous opportunities for improvements in the status quo. Some of these are small and easily attainable, but others are more significant and much more difficult to accomplish. Most importantly, however, numerous opportunities were identified where Thailand can direct the automobile industry towards new areas and markets which will continue to provide growing economic opportunities, while at the same time increasing efficiency, sustainability, as well as the health, quality of life, and desirability of living in Bangkok.

The following recommendations provide a strong foundation for a new integrated, national strategy for balancing the economic development potential of the automotive industry against the urban environmental problems of air pollution and traffic congestion.

- Mobility to should be provided for all socioeconomic groups.
- Government should focus be on moving people and and not vehicles (Vongpivat, 1998a).
- Encourage private sector participation in the provision of public transportation (both bus and rapid transit).
- Increase the usage of public mass transit in Bangkok through a vastly improved bus system which includes additional designated bus lanes and additional, and cleaner buses.
- Increase government willingness to subsidize mass rapid transit.
- Use infrastructure to guide development into sustainable urban forms (including both mass transit and roads).
- Increase the cost of driving by appropriate taxes to maker mass transit more attractive, reduce externalities of private automobile use, raise revenues for public transit.
- All vehicles should well maintained over the course of their life to ensure low emissions.
- Encourage further development of two-stroke motorcycle catalyst technology and industry.
- Encourage alternative fuel vehicle research.
- Provide safe ambient air quality throughout all of Thailand.
- Do not adopt excessively stringent emissions standards.
- Promote cooperative educational ventures between industry and government.
- Encourage the harmonization of regional and global standards.

2. Background

Before one can begin to contemplate the interrelationship between mobility, pollution, and economic development in Thailand, one must develop an understanding of the country itself in terms of its basic geography, politics, government, history, and economy. In addition, one must understand the history of the development of Thailand's automotive industry, the industry's recent growth, how it has been affected by the economic crisis that has spread throughout all of Southeast Asia.

2.1 General Information

2.1.1 Physical Profile

Thailand is located midway between China and India, thereby positioning Thailand almost exactly in the center of Southeast Asia. It is bordered by Myanmar to the north and west, Laos to the northeast, Cambodia to the east, and Malaysia to the south. Thailand's southwestern coast abuts the Andaman Sea, and its southeastern coast borders the Gulf of Thailand (See Figure 2.1). Thailand's total area is 518,000 sq km or 180,000 sq mi (roughly the size of France) which can be divided into roughly six different regions. (See Figure 2.2). These regions are as follows (Levy & McCarthy, 1994, p.1-2; Phantumvanit & Sathirathai, 1988, p.11-13):

- North: Northern Thailand is very mountainous and forms the foothills of the Himalayas. It is also the location of forestry, mining, and farming.
- Northeast Plateau: Relatively infertile, this is the least developed region in Thailand. It is bordered by the Mae Khlong River on the north and northeast boundaries, separating it from Laos. Other than potash mining and subsistence farming, there is little economic development, although the government has made efforts to shift industry to this region.

- Central Plain: Blessed by the Chao Phraya River, this region is extremely fertile and is home to the Thailand's massive rice crop. This region is also home to Bangkok which is the capital and the largest city in Thailand as well as Southeast Asia.
- Southeast Coast: The southeast coast is home to numerous seaside resorts, sapphire and ruby mines in the mountains to the east, and natural gas deposits off the coast.
- West: To the west of Bangkok are mountains and valleys as well as the River Kwai.
- Southern Peninsula: This long narrow peninsula extends to the Malaysian border and separates the Andaman Sea and the Gulf of Thailand. This is Thailand's most tropical region and it receives heavy rains during the monsoon season. Major industries include tourism (numerous resorts which are popular during the dry season), mining, rubber production, and fishing.

Figure 2.1: Map of Southeast Asia.


0 50 100 km
0 50 100 mi
CHINA
VIETNAM
BURMA
LAOS
Chiang Mai
Udon Thani
Mekong
Phitsanulok
Khon Kaen
Nakhon Sawan
Khorat Plateau
Ubon Ratchathani
Nakhon Ratchasima
BANGKOK
Andaman Sea
Si Racha
Laem Chabang
Sattahip
CAMBODIA
Mekong
Gulf of Thailand
VIETNAM
Surat Thani
Phuket
Songkhla
Hat Yai
Pattani
INDONESIA
Strait of Malacca
MALAYSIA
South China Sea

Figure 2.2: Map of Thailand.

2.1.2 Political Profile

The nation which came to be known as Siam was founded in 1238 AD by the unification of the three separate Thai kingdoms which had coordinated their military efforts to repel the armies of Kublai Khan and the Khmer empire located to the east. In 1939, the country changed its name to the Kingdom of Thailand so that it could more easily break from tradition and move toward a more dynamic future. Translated literally, Thailand means "Land of the Free" which reflects the fact that Thailand is the only country in Southeast Asia which was never colonized or conquered by another nation since its founding in the 13th century. Due to their history of protecting their nation and lands, the people of Thailand take great pride in their self-reliance and fierce independence. (Levy and McCarthy, 1994, p.1).

Modern Thailand is shaped by the combination of a democratic constitutional monarchy; an assertive military; an officially powerless but highly respected, influential, and benevolent King; as well as the Buddhist religion which is followed by 95% of the population. In general, the national government is parliamentary in form and it has recently been headed fragile five and six party coalitions. Administrative power is firmly centralized in a series of ministries which distribute resources and services through representatives to the 73 provinces located throughout Thailand. As a result of the ministry coordinated distribution of resources and services, city and provincial governments play a limited role in directing their own development and future. The only exception to this nationally-directed, provincial development program is the capital of Bangkok. Within Bangkok, most of the city's programs and services are managed and coordinated by the Bangkok Metropolitan Administration (BMA), but even these actions frequently require the approval of the national government (Potter, 1994, p.54). In light of recent cases of government corruption and

the interventionist military, it is important to stress that King Bhumibol Adulyadej[3] and the Royal family provide a sense of continuity and reason to the nation's governance.

2.1.3 Socioeconomic Profile

In 1996, Thailand's population was estimated to be roughly 60 million people, 11 million of which lived in the Bangkok metropolitan area. Approximately 75% of the population are ethnically Thai, 11% Chinese, 3.5% Malay, with the remainder consisting of Mon, Khmer, Phuan, and Karen minorities. The age distribution is slanted toward the young with 29% of the population under 15 years of age, 66% between 15 and 64, and 6% over 65 years of age. Life expectancy in Thailand is 65 years for males and 72 years for females.

Throughout the 1980's and early 1990's the economy grew at an average annual rate of roughly nine percent, and in 1995 the country's GDP was more than US $400 billion which ranked it as the 30th largest economy in the world. While this growth was occurring, Thailand also began to shift away from agriculture and transformed its industrial and process sectors from basic assembly and food processing toward higher technology engineering, manufacturing, and chemical processes such as electronics, fabricated metals, and the basic chemical industries (Potter, 1994, p.52). Figure 2.3 provides a time series illustration of how different sectors the Thai economy have evolved between 1990 and 1994. In addition, Figure 2.4 shows the relative contribution of these various sectors to Thai economy in 1994.

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[3] King Bhumibol Adulyadej recently celebrated the 50th anniversary of his accession to the throne. He became King on June 9, 1946 at the age of 19.

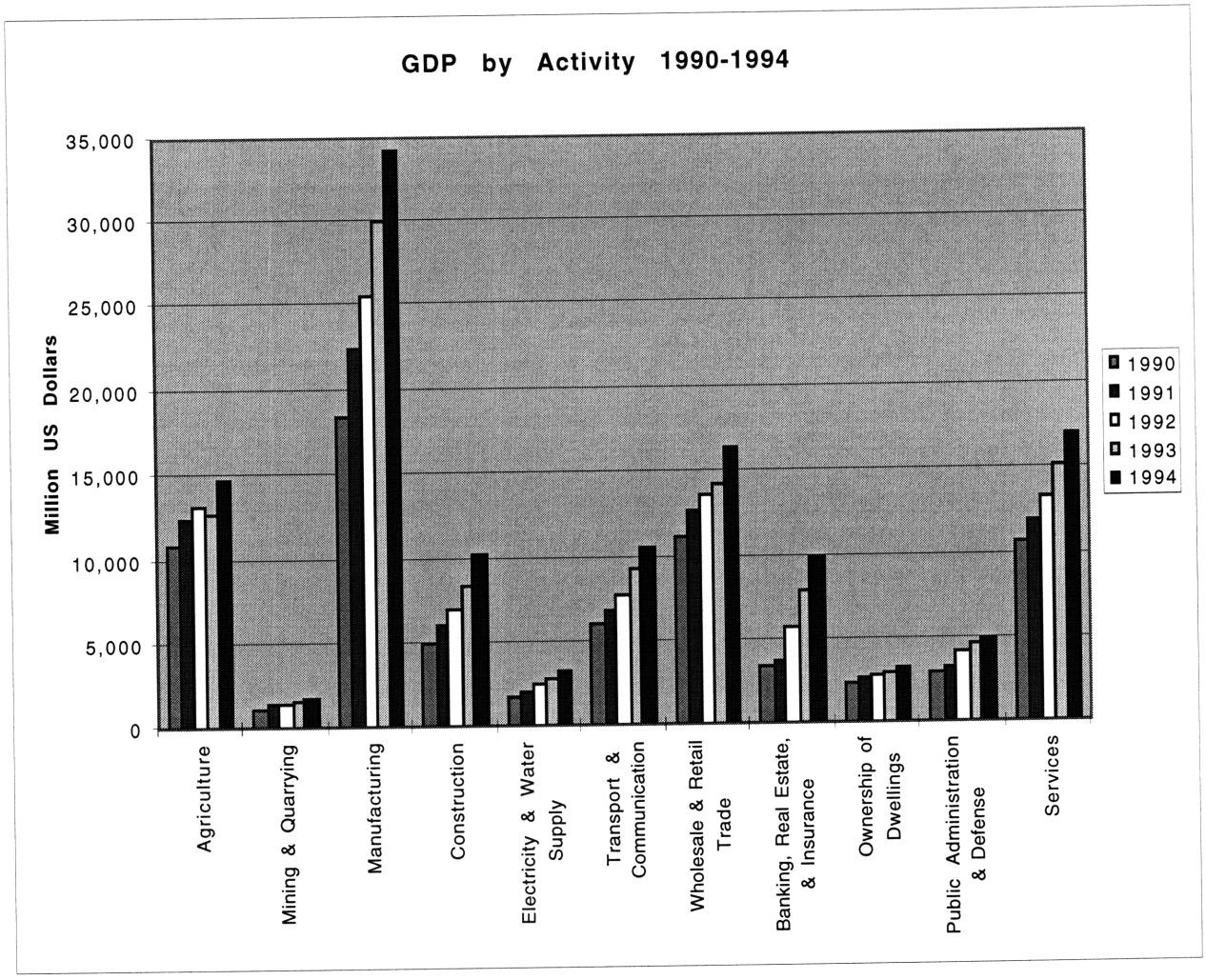

Figure 2.3: GDP by Activity for 1990-1994 (Euromonitor, 1998, Table 15.17).

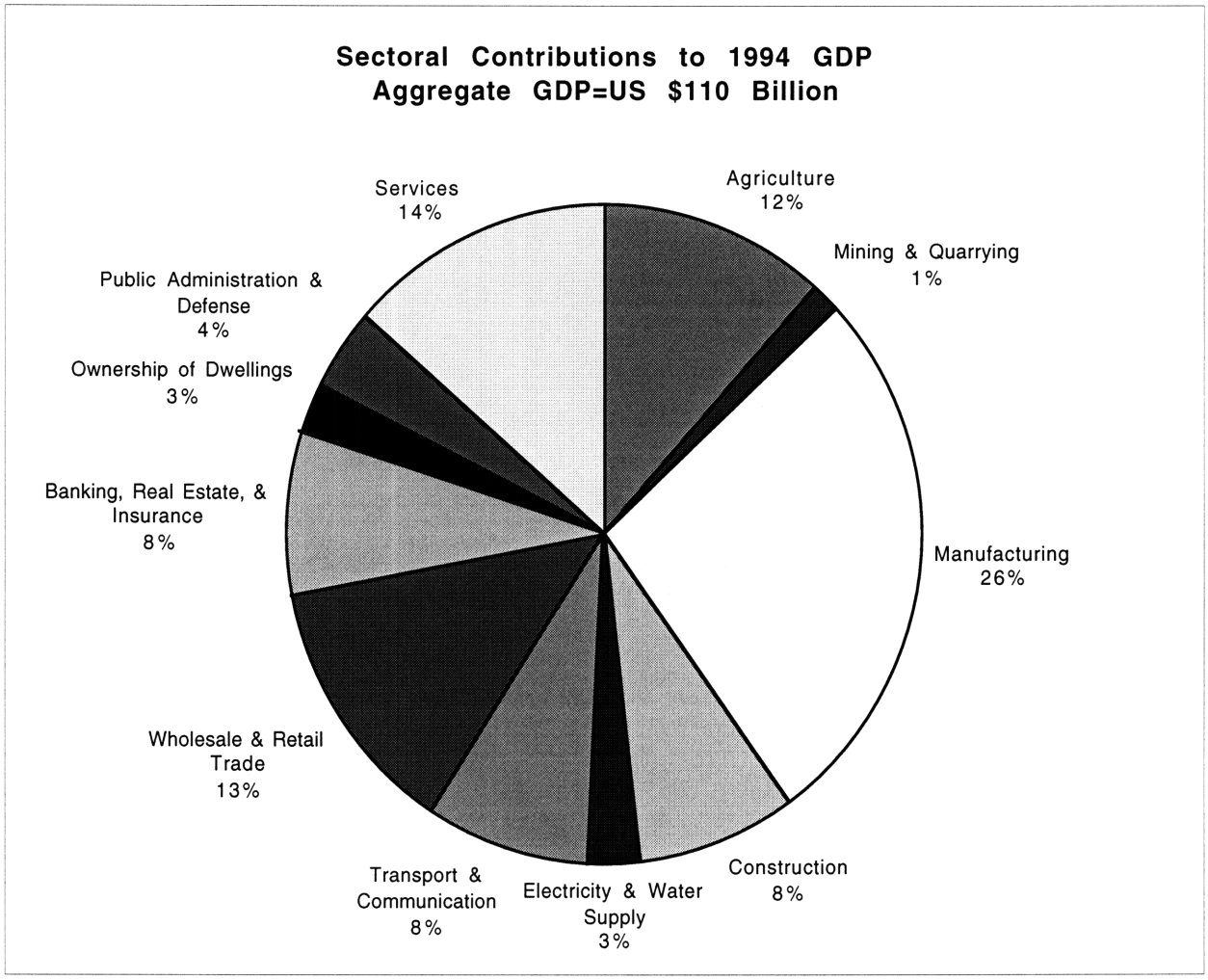

Figure 2.4: Sectoral Contributions to 1994 GDP (Euromonitor, 1998, Table 15.17).

Over the last twenty year, much of Thailand's growth occurred in the industrial and service sectors, and as a result the traditionally agrarian population began to move toward the rapidly industrializing Bangkok metropolitan area in search of higher paying jobs. As a result, Bangkok now has roughly one-fifth of the population but more than 50% of the national GDP. As Table 2.1 illustrates, the discrepancy in income between Bangkok and the other regions of Thailand still exists today and is more than double the national average. For this reason, there is a continued migration into Bangkok from the surrounding areas despite government efforts which began in the

mid-1970s to channel urbanization into growing satellite cities and industrial parks outside of the greater Bangkok area. (Potter, 1994)

Region	Average Yearly Income per Household (US $)	Average Yearly Income per Person (US $)
Whole Kingdom	$3,980	$1,047
Greater Bangkok	7,909	2,397
Central Region	4,196	1,134
Northern Region	2,996	856
Northeastern Region	2,718	663
Southern Region	3,856	940

Table 2.1: Average Yearly Income by Region 1994 (Euromonitor, 1998, Table 15.45).

2.2 Development of the Thai Automotive Industry

2.2.1 Pre-1990: Creation, Protectionism, Liberalization

In 1961 the Thai government adopted the first National Economic & Social Development Plan. This plan represented the government's first official strategy for furthering Thailand's economic growth and improving the quality of life for all Thai citizens. One component of this plan was a policy of encouraging and providing economic incentives for the development of a private sector[4] domestic automobile assembly industry. (Phasukavanich, 1998, p.1).

The economic incentives extended to automobile assemblers included a five-year corporate income tax exemption and a five-year 50% reduction on import duties for disassembled autos ('completely knocked down' automobiles or CKD units). By reducing the import duties on CKD units, this legislation sent a clear message to the world's automobile assemblers that 1) Thailand wanted to develop an automobile industry and 2) it wanted to build the industry from the top-down by beginning with the domestic assembly of automobiles from imported parts. In addition, the substantial economic incentive of a five-year corporate income tax exemption assured potential

[4] Thailand's focus on attracting private sector industry is unique relative to its primary competitors, Malaysia and Indonesia, focus on a public national motor vehicle industry (SAE, 1998b).

investors that the government was committed to developing a private sector automotive industry over the long-term, but they were going to do it in stages so as to reduce risk to potential investors. With this in mind, the government's first step was to encourage private sector investment in domestic assembly plants which would assemble vehicles ('completely built up' automobiles or CBU units) from imported parts (CKD units) and then sell them domestically. This new government policy was an immediate success when in 1961 Anglo-Thai Motors, a partnership between Ford Motor Company and a Thai company, became Thailand's first vehicle assembly operation. In the next four years Toyota, Nissan, Fiat, and one other company also opened assembly operations in Thailand. (SAE, 1998b)

Six years later, in 1967, the Thai government gave a boost to domestic assemblers by increasing the import duty on CBU units to 60% and further reducing the import duties on CKD units as follows: import duties for CKD cars were reduced by an additional 30%, CKD trucks by an additional 20%, and CKD heavy trucks by an additional 10%. (SAE, 1998b-CHECK LANGUAGE). By raising the price of imported vehicles at the same time they lowered the price of domestically assembled vehicles, the Thai government made domestic automobile assembly more lucrative to investors. As a result, several large Thai industrial corporations including Siam Cement Group and Siam Iron and Steel soon entered the vehicle assembly market. By 1977 Thailand's assemblers had expanded to include General Motors, BMW, Peugeot, Citroen, Volvo, and Mazda. (SAE, 1998b).

In the late 1970s, the government took its next step towards a complete automobile industry by extending similar economic incentives and investment privileges to the any company which would begin manufacturing automobile engines within Thailand subject to strict criteria set by the government. Numerous companies applied for these incentives and privileges, but only a few received them due to failing to meet the government's criteria. Nevertheless, most of these companies opened, thereby giving creating Thailand's automotive parts industry (Vongpivat, 1998a).

In order to assure a market for Thailand's new fledgling domestic automotive parts industry, the government soon passed local content laws which required that all automobiles assembled in Thailand be composed of a minimum percentage of domestically manufactured parts. Initially these content laws were set very low, but as the Thai automotive parts industry grew (largely due to the requirements themselves), the percentages increased several times. Unfortunately, as successful as these policies were at creating a domestic parts industry, not all assemblers were willing to subscribe by these laws and as a result Ford, GM, and Fiat all closed their assembly plants in Thailand. (SAE, 1998b).

In 1978 Thailand found itself in the midst of both an energy crisis and a recession. As a result, the government sought to protect the existing domestic automobile assemblers and parts manufacturers during this time of heightened vulnerability. This was accomplished by a comprehensive set of policies which included prohibiting the establishment of new automobile assembly plants, banning the import of CBU passenger cars, increasing import duties on CKD units to between 50 and 80%, and raising the local parts content requirements even further (SAE, 1998b; Sukondhasingha, 1998).

By closing the market to new domestic assemblers and imported automobiles while at the same time requiring higher local content and increasing the cost of imported parts, the government had largely closed Thailand's market to the rest of the world. While this inevitably increased the percentage of the market held by Thai industry, these acts also lessened the competitive pressures which had forced the industry to keep costs low.

In 1984 the government, perhaps in an effort to begin reversing the course set in 1978, attempted to promote economies of scale within the domestic industry by reducing the number of approved passenger car series from 84 to 42. Similar rules were also adopted for the blossoming

pickup truck market[5] in order to prevent fragmentation among the assembly and manufacturing sectors. In addition, by 1986 an additional increase in local content laws brought domestic content requirements to 54% for passenger cars and 63% for commercial vehicles.

As a result of Thailand's new policies which favored domestic production as well as a strong yen, the major Japanese manufacturers began shifting their Japan-based, Thai export-oriented parts manufacturing and assembly facilities directly to Thailand for domestic manufacturing and assembly. This helped to increase Japanese profits by significantly reducing import costs as well as utilizing lower wage rates and land costs that existed in Thailand relative Japan. Specific investments by Japanese manufacturers included the opening of engine manufacturing facilities for pickup trucks by Toyota, Nissan, Isuzu, and Mitsubishi opened domestic as well as new factories for the assembly of Honda's Civic and Accord models (SAE, 1998b).

In 1988 the government abolished its import ban on passenger cars with engines larger than 2300 cc but replaced it with a 300% duty, which together with appropriate taxes, increased the cost of such vehicles by roughly 600% (see Table 2.2).

Near the end of the 1980s, the government began to consider redirecting the Thai automobile industry's domestic focus towards the much larger export market. However, the government quickly realized that Thai industry, and especially the automotive parts industry, was not capable of competing in the global market place. This was recognized to be the result of Thailand's highly protected and closed market. The high import duties and other taxes had greatly reduced competition with other countries as well as within Thailand itself. As a result, domestic manufacturers had not acquired new technology or expertise and as a result, domestically produced automobiles had low quality and high prices.

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[5] Pickup trucks were rapidly becoming the largest segment of automotive sales due to their much lower cost relative to other vehicles (see Table 2.2 for import duties and total taxes) as well as their dual-use as both personal and business vehicles.

In 1991, the government replaced its policy of protection with one of liberalization. This change was the result of the desire to 1) force the domestic automobile and parts industries to become more efficient, lower costs, and become globally competitive; 2) create a more lucrative, export-oriented national policy which would attract additional foreign investment; and 3) provide Thai consumers with more and better choices than what was currently provided by the non-competitive, Japanese-dominated industry (Sukondhasingha, 1998; Vongpivat, 1998a). The primary means of accomplishing these changes were removing barriers to competition, simplifying import and export procedures, providing larger economic incentives to industry, and most importantly, radically restructuring import duties to restore 'fairly competitive' global competition between CBUs and CKDs (see Table 2.2). In addition, the government announced that it would begin to consider reducing or eliminating local parts requirements. (SAE, 1998c, p.2-3;). These policy changes quickly resulted in a flood of imported vehicles into Thailand, but more importantly, it forced domestic manufacturers to lower their prices by 15-20% for passenger cars and 2-4% for pickup trucks (which were already much cheaper). (Vongpivat, 1998a)

	Pre-1990 'Protectionist' Policies		Post-1991 'Liberalized' Import Policies	
Vehicle Type	Import Duty	Effective Tax (Duty + Tax)	Import Duty	Effective Tax (Duty + Tax)
Passenger car, engine >2300 cc				
Petrol/Gasoline				
CBU	300%	617%	100%	211%
CKD	112	125	20	106
Diesel				
CBU	180	696	100	211
CKD	112	170	20	106
Passenger car, engine <2300 cc				
Petrol/Gasoline				
CBU	180	411	60	138
CKD	112	125	20	88
Diesel				
CBU	180	457	60	138
CKD	112	170	20	88
Pickup trucks and vans				
CBU	120	159	60	98
CKD	72-94	38-43	20	26
Trucks				
CBU	40	58.02	40	57.46
Note: All duties and taxes are % of actual value.				

Table 2.2: Comparison of Import Duties and Effective Taxes Before and After 1991 (Vongpivat, 1998a, p.13-14).

The following year, the government adopted its first significant environmental legislation. Part of the legislation required that all new passenger cars sold in Thailand include catalytic converts in order to reduce emissions of CO and NOx[6]. This requirement was also likely supported by public health concerns about lead as well as the recognition that emissions control equipment would be required in many parts of the global market. (Sukondhasingha, 1998; Phasukavanich, 1998).

Two years later, in 1994, the Board of Investment decided to offer further incentives to make Thailand more attractive as a base for automobile export in Southeast Asia. To do this, they provided incentives for expanding existing production facilities as well as the construction of new facilities for both automobile assembly and the supporting parts industry. The specific package

[6] By 1991, Thailand was in its third year of a leaded fuel phase-out program. The program was completed in 1995 by which leaded fuel had been completely banned.

included an 8-yr corporate income tax exemption, elimination of import duties on all imported manufacturing equipment, and provision for foreigners to hold all the shares in an export-oriented project. (BOI, 1997).

Within the last several years, the government has continued to demonstrate its commitment to liberalizing the Thai automobile industry in order to facilitate a strong export-industry. The most significant development is that the government will eliminate all local parts content requirements as of July 1, 1998 (Phasukavanich, 1998). In addition, other export-oriented announcements include government assurances that it will continue to reduce industrial protections in accordance with WTO and ASEAN Free Trade Area (AFTA) requirements (Phasukavanich, 1998). Another promising development behind speeding government reform is that elected officials have begun to suggest that the Thai automotive parts industry should become the regional production base for all of Asia as other countries begin assembling vehicles domestically (BOI, 1995).

As a result of these changes, by the mid-1990s, as production neared 600,000 unit/year, there were roughly 2,000 Thai parts manufacturing companies in Thailand which employed more than 100,000 workers. Together these companies provided roughly 70% of all part components for domestic assemblers even though local parts requirements were 54%, 60%, and 72% for passenger cars, petrol pickup trucks, and diesel pickup trucks, respectively (SAE, 1998b; Sutabutr, 1998, p.1).

Based on almost 40 years of experience, it is clear that Thailand's automotive history is both rich and that the government is singularly committed to developing strong domestic private-sector assembly and parts industries. In addition, the government has demonstrated that it is committed to open markets and an increasingly global, export-oriented industry which simultaneously provides Thai citizens with high quality and low prices.

2.2.2 *Market Trends in the mid-1990s*

During the mid-1980s, Thailand's economic boom had finally produced a middle class able to afford purchasing an automobile. The first evidence of this occurred in 1987 when automobile sales increased by 23%, 46% in 1988, 22% in 1989, and 38% in 1990 (SAE, 1998b). This trend continued into the 1990's as shown by the increasing annual sales of passenger cars and commercial vehicles in Figure 2.5. Substantially more impressive, however, is the increase in registered vehicles, including motorcycles and all other forms of motor vehicles, in Bangkok and particularly throughout Thailand. This information for the period 1987 to 1994 is shown in Figure 2.6.

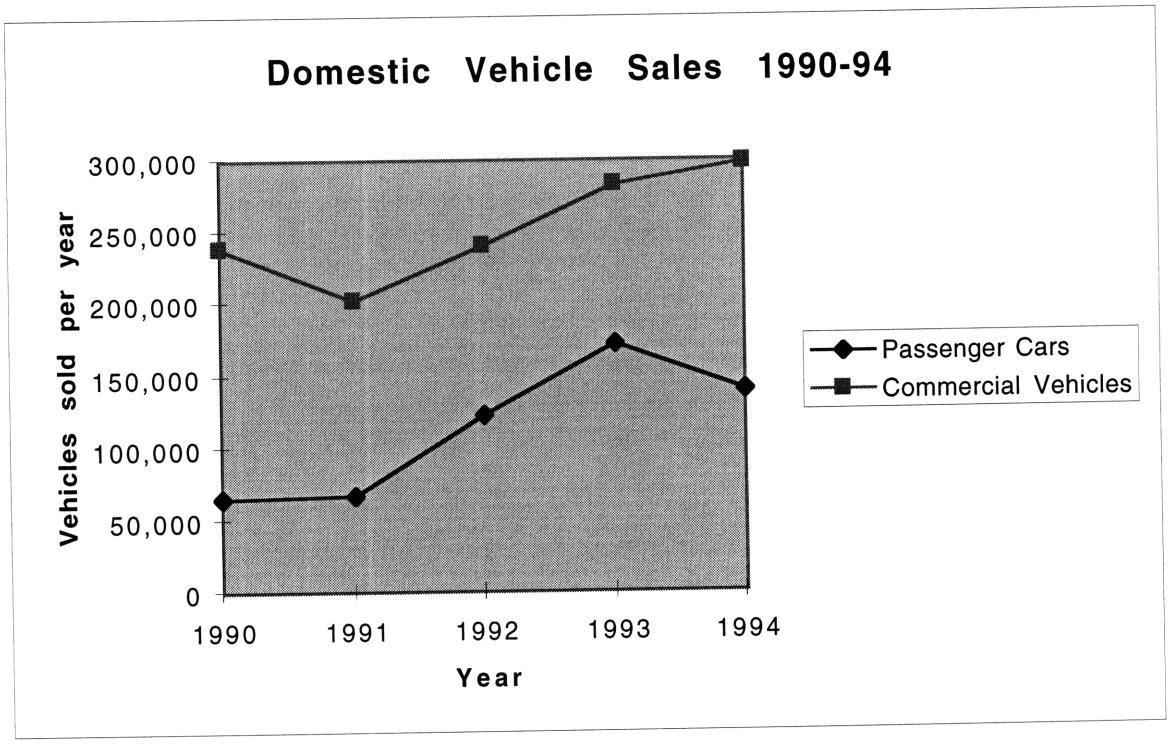

Figure 2.5: Domestic Vehicle Sales 1990-94 (Euromonitor, 1996, Table 15.47).

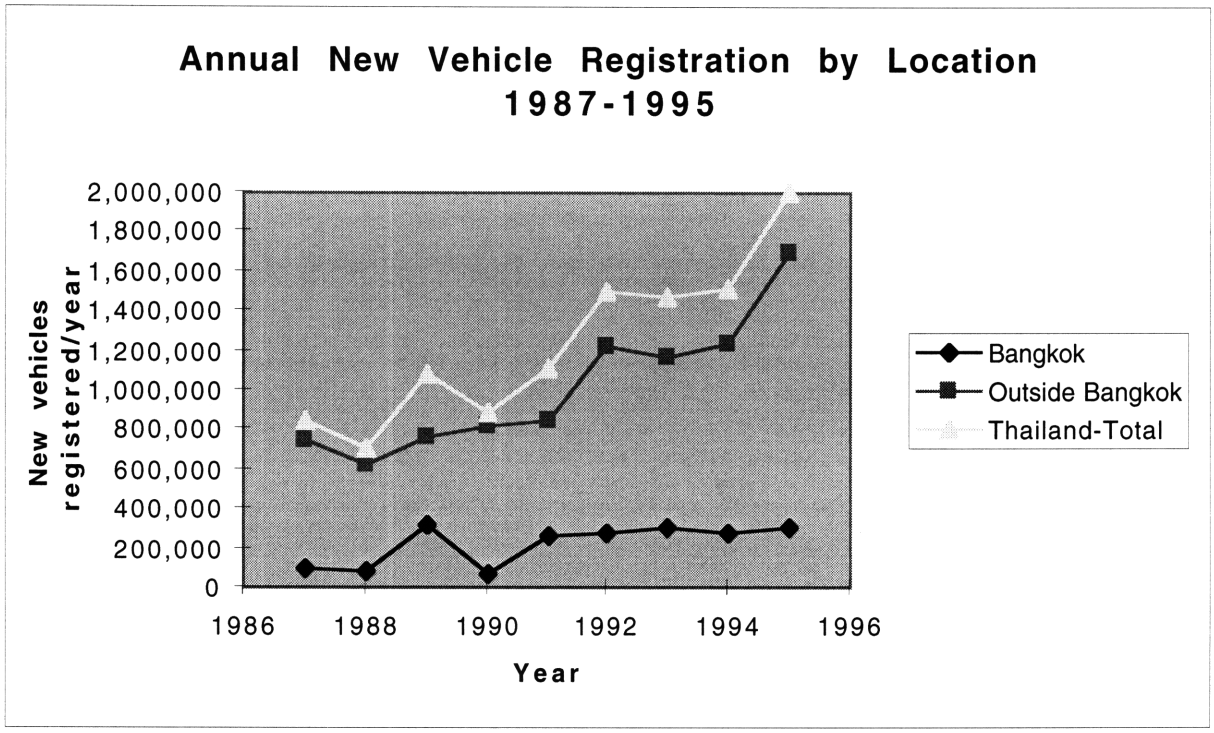

Figure 2.6: Annual new vehicle registration by location 1987-1995 (Department of Land Transport as cited in Vongpivat, 1998a, p. 17).

As impressive as the growth in sales and registrations were, Thailand's sales represented just over half of the larger Association of Southeast Asian Nations (ASEAN) market which had regional sales in excess of 1.17 million vehicles in 1996 (AP, 1/19/98). As ASEAN demand grew, Thai manufacturers began to make inroads into this market through its increasingly competitive assemblers and parts manufacturers. Between 1992 and 1993 Thai manufacturers more than doubled exports to 12,000 vehicles which were shipped to countries throughout ASEAN , Pakistan, and the Middle East. By 1995 total Thai production approached 600,000 vehicles and exports had surpassed US $1 billion (Automotive Industry News, 1995). And even more promising was the long-term future which, according to Ford Motor Company Executive Vice President W. Wayne Booker, should see a ten million unit per year increase in global demand for automobiles by 2007, with most of that growth occurring in Asia (Taylor, 3/17/97).

2.2.3 Assemblers Invest in Increased Capacity

Based on these market trends, nearly 30 years of sustained regional growth, and the realization that the ASEAN market consists of 350 million people with a current person-to-vehicle ratio of 25:1 (the US ratio is roughly 2:1), analysts projected that annual demand for Thai automobiles would approach 1 million vehicles by 2000 (Associated Press, 1/19/98). In light of these large projections, Japanese manufacturers began a flurry of new investments in Thai production facilities so that they would be able to meet the anticipated demand within Thailand as well as increase exports to the growing ASEAN market.

In the early 1990's, Honda Motor Company led the charge by announcing the construction of its second Thai plant which would cost US $100M and begin production in April, 1995. The plant would be located to the north of Bangkok and would produce the Honda City, Honda's first "completely Asian car" assembled outside of Japan. This factory would have an initial production capacity of 60,000 vehicles/year which would bring Honda's total Thai production capacity to 80,000 vehicles/year (Automotive Industry News, 1995; Taylor, 3/17/97).

Shortly after Honda's announcement, the other major Japanese manufacturers announced similar expansions. Specifically, Nissan decided to increase production at its Thai plant by 50% to 140,000 cars and trucks per year. Mitsubishi announced it would relocate its pickup truck assembly operations from Japan to Thailand's eastern seaboard. And finally, Toyota announced it would build its second assembly plant at a cost of $350 million to boost its Thai production capacity to 200,000 vehicles/year (Taylor, 3/17/97).

In 1996, after several years of researching market conditions and negotiating terms with several Southeast Asian nations, the three major US automobile manufacturers each followed suit and independently announced plans to produce automobiles in Thailand. Ford Motor Company led the way in 1996 by declaring Thailand its regional headquarters which entitles Ford to additional economic privileges under the Thai Board of Investment. As part of this move, Ford chose a site

along the southeast coast which would be home to a new US $500 million complex including a pickup truck[7] assembly plant as well as two comprehensive component supplier facilities. This plant was planned to open in March, 1998 with a production capacity of 135,000 vehicles/year (which would consists 100,000 CBUs to be sold domestically; 20,000 CBUs to be exported; and another 35,000 CKD units for export). Ford also announced plans to open a second plant in 1999 which would focus on a new small car designed for the Asian market (Taylor, 3/17/97; Automotive Industry News, 1995). Shortly after Ford's announcement, General Motors announced that it would build a US $750 million assembly plant adjacent to Ford's complex on the southeast coast. The plant would produce a version of the subcompact Opel Astra and have an initial 100,000 unit production capacity which could be expanded to 150,000/year. Lastly, Chrysler also announced that it would begin producing automobiles in Thailand, but at the much smaller scale of 3,000 vehicles/year instead opting to continue to import vehicles into Thailand from the US. (Taylor, 3/17/97).

Based on these investments by Japanese and US automobile makers it is clear that Thailand has become the *de facto* automobile production center for Southeast Asia, and quite possibly the doorway to entering the Asian market including the large, but currently less mature markets of India and China.

2.3 Economic Collapse & Industry Response

2.3.1 Collapse of the East Asian Miracle

In early 1997, Thailand's economy collapsed when the Bank of Thailand (the Thai central bank) nearly defaulted on foreign short-term loans equivalent to one-third of its annual GDP. These loans had been needed as a result of significant over-investment in the Thai stock market and real estate (largely financed through an inefficient, poorly regulated banking system) rather than

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[7]Pickup trucks represent 60% of all new vehicles sales in Thailand (SAE, 1998b).

based on more productive sectors based on production augmentation and domestic employment (Economist, 3/7/98, p.6; Vongpivat, 1998a, p.3) As the extent of Thailand's economic problems became clear, individual investors began to withdraw their money before the Baht devalued. This resulted in a massive outflow of Thailand's capital just as the short-term foreign loans the Bank of Thailand had been using to sustain the economy came due (The Economist: SEA, 3/7/98, p.6).

As investors throughout Southeast Asia became wary over Thailand's problems, they began to inspect the banking and monetary practices of their own institutions and found many of the same problems. As a result, a similar outflow of capital began for most of Southeast Asia. Overall, these events led to an economic downturn which spread rapidly through the increasingly interconnected economies of Southeast Asia in 1997.

Fortunately, this regional collapse seems to have stabilized due to a quick and focused $16 billion bailout organized by the International Monetary Fund (IMF), a newly elected (November 1997) government which is committed to financial reform, and demonstrated progress including the closing of more than half the country's finance companies, new banking regulations, opening the economy to further foreign ownership, and improved financial transparency rules (Pollack, 8/11/97).

Despite the quick actions of the IMF and the ongoing reforms, many experts are predicting that conditions will get worse in 1998 as reforms continue, bankrupt companies are forced to close, people lose their jobs, and finally, confidence begins to be re-established in the Thai economy. Nevertheless, beginning in 1999 experts believe the Thai economy should be on its way to recovery. Unfortunately, the degree to which this is true is largely dependent on how two of the regions' most important economies fare during the coming months. The first is Japan, the region's most powerful economy, which is just beginning to reform its seriously flawed banking practices. The second country of concern is Indonesia which currently stands on the brink of revolution. As the fourth most populous country in the world (over 200 million people), Indonesia has a substantial effect on the ASEAN economy. Despite these uncertainties as well as the demonstrated

economic interconnectednes of Southeast Asia, the reforms which are already in place in Thailand should reduce the effects of these crises should they occur.

2.3.2 Impacts on the Automotive Industry

In 1996, Thai automobile production reached an all-time high of 589,126 vehicles. This represented just over half of the total ASEAN vehicle production of 1.17 million vehicles. Moreover, analysts projected that Thai sales would exceed 1 million vehicles by 2000. However, as a result of the economic downturn which began in Thailand and spread steadily throughout Southeast Asia, 1997 Thai auto sales fell 38% from 1996 levels to 363,156 units (AP, 1/19/98).

More specifically, commercial vehicle sales fell by 44.5% to 231,000. Passenger car sales fell by 23.5% to 132,000. And 1-ton pickup sales fell by 42.5% to 188,000 (AP, 1/19/98). The worst hit company was Nissan whose sales decreased from the previous year's by 54.3% to 42,000. Market giant Toyota's sales ended down by 34.7% to 107,000. Isuzu dropped 32.4% to 82,500, and Honda dropped a mere 12.4% to 37,000 (AP, 1/19/98).

Based on these changed conditions, analysts have revised their predictions for the coming years as a way to help industry plan for the future. In a report released by Automotive Resources Asia Ltd. in February 1998, they conclude that "light vehicle production (defined as passenger cars, pickup trucks, sport-utility vehicles, Asian-utility vehicles, and vans) in Southeast Asia's four major vehicle producing countries -- Thailand, Malaysia, Indonesia, and the Philippines -- will only reach 718,000 units in 1998, a 38 per cent decline from the 1.17 million vehicles produced in the region in 1997...by 2002, however, light vehicle production in the region will reach 1.049 million units" (Automotive Resources Asia Ltd, 1998).

2.3.3 Cautious Commitment

As a result of these newly revised predictions and other related concerns, the auto industry has responded conservatively but firmly. They have been conservative in that they have scaled back production capacity and rates in order to hedge their short-term risks in this reduced and

uncertain market, but all of the major manufacturers have remained firm in their commitment to produce automobiles in Thailand for the ASEAN market and beyond.

Specifically, General Motors has announced that it has scaled back its US $750 million plant to $500 million and delay opening until late 1999. In addition, plant's initial production capacity will be reduced to 40,000 units/year from the originally planned 100,000 units/yr. Ford has chosen to complete its original investment but to use 1 shift rather than two. Toyota, Nissan, and Honda have also cut back production and in some cases closed entire factories. Honda has tentatively announced that by 1999 it's plant will likely produce only 30,000 units of its 60,000 capacity (AP, 1/19/98; Taylor, 3/17/97).

Finally, rounding out these efforts at reducing risk, in late 1997 the government

made a slight reversal of its liberalization policies by raising the duty on all CBU passenger cars to 80% and setting the duty on CKD parts to 20% through the end of 1999 as a means to protect the domestic auto industry from foreign competition during this time of vulnerability (SAE, 1998b).

3. Environmental Impact of Motor Vehicles

3.1 Overview

One would expect that the greater the level of human activity, the greater the impact would be on the environment. For this reason, urban areas would tend to concentrate pollution while at the same time increasing the number of people exposed to that pollution due to the increased population densities that characterize the urban environment. For this reason, Thailand's urban areas should be of great concern from an environmental and public health point of view (though there are certainly other serious environmental problems which can be unrelated to the urban areas– deforestation, contamination of ground water and/or surface water, unsustainable aquaculture). And given that Bangkok is more than 50 times larger than Thailand's second largest city, Chiang Mai, one would expect that the bulk of Thailand's urban public health and environmental problems will occur in the Bangkok metropolitan area.

In general, urban areas, and especially those in developing countries, are afflicted with numerous environmental problems of different forms and magnitudes. For this reason, it is often difficult to generalize the types of conditions which give rise to them. Nevertheless, one insightful means of categorization was proposed in a publication jointly authored by the World Resources Institute, the United Nations, and the World Bank. This report suggested that "[urban] environmental problems...can be grouped into two broad classes: those associated with poverty and those associated with economic growth or affluence." However, the report goes on to concede that due to the complex and inequitable distribution of resources, both types of problems often coexist within the same city (WRI et al., 1996, p.1).

The environmental impacts of motor vehicles in Bangkok provide an ideal example of a problem of growth and affluence. As the standard of living in Bangkok rose, more people moved into the city seeking a better life. However, the influx of people quickly exceeded the capacity of

the city to absorb these people and more importantly their acquisition of motorcycles and automobiles. As a result of this rapid growth and affluence, the residents of Bangkok are now subject to a wide variety of air pollutants and motor vehicle noise. As one begins to consider how to improve mobility in Thailand and what role the automobile should play, it is necessary to develop an understanding of these problems and their implications for the environment, human health, and the economy.

3.2 Air Pollution

3.2.1 Physical & Climatic Characteristics

Bangkok is very fortunate with respect to air pollution because it has numerous natural characteristics which minimize the severity of the air pollution problems its hot (mean temperature varies from 25 to 30°C) and humid climate would otherwise enhance. First and foremost, Bangkok's topography is uniformly flat and without mountains which can trap pollutants and facilitate the formation of inversion layers which trap pollutants for anywhere from hours to days. Also, Bangkok is located 20 km north of the Gulf of Thailand which means that it receives continuous land-sea breezes[8]. In addition, Bangkok benefits from seasonal winds which are northeasterly from October through January and southwesterly from February through September. And finally, much of Bangkok is surrounded by the Bangkrajao forest which together with these winds provides a buffer and cleaning mechanism for air pollutants which would otherwise persist for longer periods of time (Phantumvanit and Liengcharernsit, 1989, p.36-37; WHO/UNEP, 1992, p.49)

Bangkok is also the beneficiary of a sound planning policy which was implemented in the mid-1970's. This policy shifted industrial growth out of Bangkok and into newly created

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[8] Land-sea breezes are winds induced by the diurnal heating of the land by the sun during the day and subsequent cooling at night.

industrial parks on the outskirts of the city. As a result, Bangkok has small and medium-sized industrial facilities dispersed throughout the city, but the bulk of the industrial activity (e.g. large stationary sources) is located 20 km to the southeast of Bangkok in the industrial town of Samut Prakan. Given its geographic position off of Bangkok's northeast/southwest wind axis, Bangkok is rarely affected by these emissions (WHO/UNEP, 1992, p.49).

Despite these numerous beneficial conditions, Bangkok still has severe air pollution problems primarily due to motor vehicle emissions. A recent study by Thailand's Pollution Control Department (PCD) estimated that in Bangkok, 87% of carbon monoxide, 41% of hydrocarbons, and 64% of nitrogen oxides were emitted by the transportation sector (Wangwongwatana, circa 1993, p.3). While these statistics are impressive on their own, the implications become more serious when one recognizes that motor vehicle pollutants are emitted at curb level and in the urban context of narrow streets surrounded by tall buildings. This physical configuration reduces mixing, dispersion, and advection of airborne pollutants, and as a result the phenomenon has been termed the "street canyon" effect.[9]

The most deleterious implication of the 'street canyon' effect is that urban roads provide the means by which the majority of Bangkok's population commute to and from work by either foot, motorcycle, or open-air bus. Moreover many people suffer from the street canyon effect for extended periods of time due to: (1) working in retail stores on the ground-floor of stores which open onto the street, (2) living in open-air apartment buildings along-side these roads, and (3) working as street-car vendors and food preparers (many of which prepare meals a few feet from the exhaust pipes of automobiles stuck in grid-locked traffic).

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[9] The term 'street canyon' is due to an urban city street's similarity to a deep, narrow canyon which has poor air circulation due to the large vertical distance between the canyon floor and the lateral movement of air above the top of the canyon.

3.2.2 Public Health Impacts

Based on the substantial opportunities for both acute and chronic exposure to high concentrations of automobile pollutants, it seems likely that Bangkok's residents are experiencing adverse health effects due to the direct inhalation of pollutants either in their homes, at work, or during their commute-- or even indirectly through the consumption of contaminated foods or liquids. Unfortunately, there is very little data which can be used to determine the true impacts of air pollution, and the data that does exist appears to severely under-represented the magnitude of Bangkok's problems. Nevertheless, a few health surveys have been performed including one in 1995 which found that the occurrence rate of pollution-related disease was 19% in Bangkok, but only 8% in rural areas (Wangwongwatana, 1998, p.34).

Despite this lack of Bangkok-specific data, there is a wealth of public health knowledge regarding the effects of motor vehicle emissions. This information can aid in qualitatively assessing the impacts of air emissions.

3.2.2.1 Lessons from Around the Globe

> Throughout the world, studies have consistently found that urban air pollution adversely affects both the respiratory and cardiovascular systems and can result in both acute and chronic illnesses such as asthma and bronchitis. In addition, a consensus is emerging that the most dangerous pollutants are small suspended particles which have a diameter of less than 10 microns, hence they are called PM-10, and can be easily breathed into the lungs (WHO/UNEP, 1992, p.11; WRI et al., 1996, p.46).

In order to better quantify the impacts of such pollution, numerous public health studies have been conducted throughout the world. According to epidemiological studies conducted in United States' cities it has been consistently suggested that since the 1970s, "air pollution kills—primarily through respiratory or cardiovascular disease—about 30,000 to 60,000 people per year, [which accounts] for 2 to 3 percent of all [urban] deaths" (WRI et al., 1996, p.46-47). Similar studies from the cities of the developing world have found more extreme effects. For example, in Jakarta, of its population of 10 million, it was determined that roughly 600,000 childhood asthma

attacks and 125,000 cases of childhood bronchitis would be prevented each year if ambient air concentrations met WHO standards (Ostro, 1994, p. 114).

Finally, on a global level, the World Bank has estimated "that if particulate levels alone were reduced to WHO guidelines, between 300,000 and 700,000 premature deaths per year could be avoided globally. That is the equivalent of roughly 2 to 5 percent of all deaths in urban areas that have excessive levels of particulates. In addition, chronic coughing in urban children under the age of 14 could be reduced by half, or about 50 million cases annually, [thereby] reducing the chance that these children will face permanent respiratory damage. Improving urban air quality should also reduce the incidence of chronic and infectious respiratory diseases." (WRI et al., 1995, p.22).

3.2.2.2 Probable Impacts & the Legislative Response

In light of the public health community's substantial experience in assessing the likely consequences of air pollution (as reflected above), in 1990 the US Agency for International Development estimated "that each year there are 10-50 million person-days of restricted activity for respiratory reasons in Bangkok which are not reported" (USAID, 1990). In 1992 the WHO/UNEP reached the similar though less quantitative conclusion that "the population exposed to these levels of automotive pollutants are likely to suffer pulmonary impairments leading to some restrictions on activity. Susceptible individuals will have increased rates of respiratory illness." (WHO/UNEP, 1992, p.15).

In 1981, in light of the emerging global consensus regarding the seriousness of urban air pollution as well as what was undoubtedly prudent and proactive leadership, Thailand passed national ambient air quality standards for the six main pollutants: carbon monoxide, ozone, sulphur dioxide, suspended particulates, nitrogen dioxide, and lead (Phantumvanit and Liengcharernsit, 1989, p.36). In almost all cases these were roughly equivalent to the WHO standards (WHO/UNEP, 1992, p.221-226).

As well-intentioned as the passage of these standards may have been, however, the absence of a clear enforcement authority within Thailand (the Pollution Control Department was formed in 1992) coupled with the rapid growth in both the economy and the automobile fleet, these standards went largely unenforced. In the following sections each of these pollutants will be discussed in greater detail and the current concentrations and state of compliance presented.

3.2.3 Suspended Particulate Matter

> "Results of air quality monitoring over the past eleven years indicate that the air pollutants of greatest concern in Bangkok are suspended particulate matter (SPM), especially respirable particulate matter (PM10) and carbon monoxide...the principal concern with these air pollutants is along major roads in Bangkok where pollutant concentrations are high enough to cause significant adverse health impacts on the population. Levels of SPM and PM10 in Bangkok's air, especially along congested roads, have far exceeded Thailand's primary ambient air quality standards. In 1996, curbside 24-hour average concentrations of suspended particulate matter exceeded the standard of 0.33 mg/m3 at all monitoring sites with the annual mean of 0.48 mg/m3 and the range of 0.03 to 2.42 mg/m3. There were 168 days out of 288 observation days (58% of the total observations) having daily PM10 concentrations exceeding the standard."
>
> Dr. Supat Wangwongwatana, Director
> Air Quality and Noise Management Division, Thai Pollution Control
> Presented at Thailand Automotive Technology Conference, 3/30/98
> (SAE, 1998c, p.12).

As described above, the most serious threat to the public health in Bangkok is suspended particulate matter (SPM). SPM consists of small grains of solid material whose mass is so small that they are able to remain suspended in the air for extended periods of time. While suspended, they can be inhaled into the human respiratory system and become lodged in the lungs. Based on current research, the threshold for respirable particulate matter (particles small enough to be able to be drawn into the lungs) is believed to be 10 microns which has given rise to the designation PM10. Once these particles become lodged in the lungs, they impair the functionality of the immediate area and irritate the surrounding tissue which can facilitate other medical problems. As a result, elevated concentrations of SPM can increase the rate of death, disease, and impaired pulmonary function (WHO/UNEP, 1992, p.11). Finally, these effects can be magnified if the particulate or sorbed chemicals are toxic in nature.

As with almost all pollutants, SPM comes from both natural (e.g. sea salt, wind-suspended dust) and anthropogenic sources (such as automobiles and industrial emission) but Bangkok's two air pollution monitoring networks (one maintained by the Ministry of Health, the other by the Office of the National Environment Board or ONEB) confirm that at roadside locations, anthropogenic sources contribute between 70 and 90% of all particulate matter (ONEB, 1989). While monitoring activities are not detailed enough to identify specific anthropogenic sources, the primary suspected sources are diesel-engine exhaust and emissions from light industry (WHO/UNEP, 1992, p.52). Moreover, SPM emissions have been estimated to have doubled from 40,000 ton/year in 1980 to roughly 80,000 tons/year in 1990 (WHO/UNEP, 1992, p.51). Finally, studies conducted by the PCD and the ONEB over the last ten years have confirmed that 60% by weight of Bangkok's particulates qualify for the harmful PM-10 designation (SAE, 1998c, p.12; ONEB, 1989). This suggests that aside from the measured trends in SPM, the threat from the more difficult to measure PM10 continues to increase thereby exposing the population to progressively higher concentrations. For a more detailed time series of three Bangkok SPM monitoring sites, refer to Figure 3.1 and Figure 3.2 which show annual mean and annual 98 percentile SPM concentrations between 1976 and 1990, respectively.

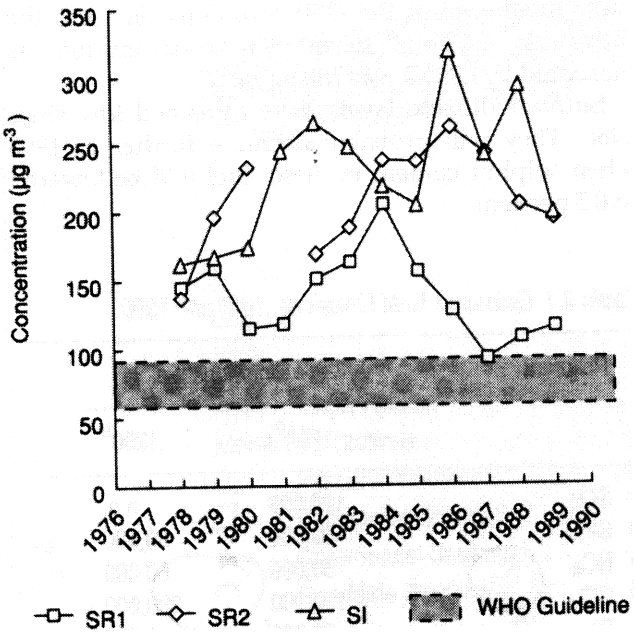

Figure 3.1: Annual mean suspended particulate matter concentrations for three Bangkok sites (WHO/UNEP, 1992, p.52).

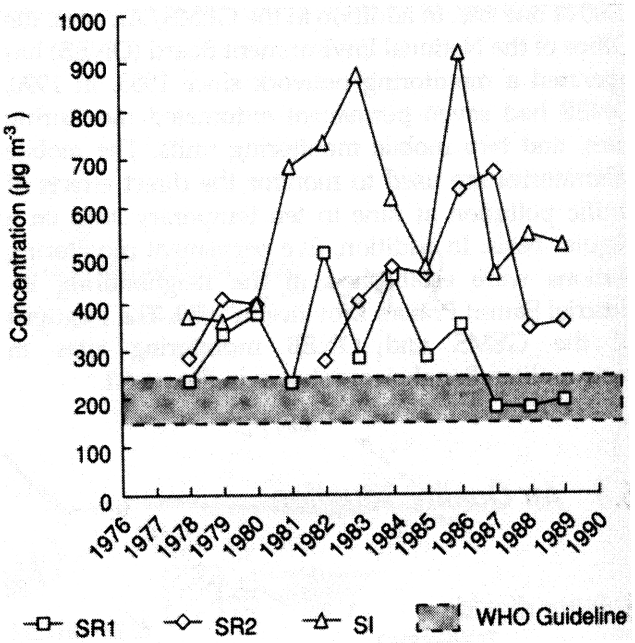

Figure 3.2: Annual 98 percentile suspended particulate matter concentrations for three Bangkok sites (WHO/UNEP, 1992, p.52).

3.2.4 Carbon Monoxide

As presented in the previous quote by Dr. Wangwongwatana, carbon monoxide is the second most serious pollutant in Bangkok. This is because even low concentrations of carbon monoxide, which is formed as a result of the incomplete combustion of fossil fuels, has a strong adverse impact on the ability of red blood cells to carry oxygen throughout the body. This is the result of the fact that carbon monoxide has a high affinity for hemoglobin and is able to displace oxygen in the blood, which can potentially lead to the development of severe cardiovascular and neurobehavioural problems. (WHO/UNEP, 1992, p.11)

According to the PCD, 1996 curbside 8-hour average carbon monoxide concentrations reached a maximum of 22.81 mg/m3 with an annual average of 4.38 mg/m3. Only 129 of 7,599 concentration measurements (1.7% of total) for the year exceeded the Thai standard of 10.26 mg/m3 which is in line with the WHO recommendation of 10 mg/m3 (SAE, 1998c, p.12; WHO/UNEP, 1992, p. 12). In addition, the 1996 maximum 1-hour concentration was 29.38 mg/m3 which is below the Thai standard of 34.2 mg/m3 and the WHO standard of 30 mg/m3 (SAE, 1998c, p.12; WHO/UNEP, 1992, p. 12).

While there is little comprehensive data available on the sources of carbon monoxide in Bangkok, the year-round warm temperatures mean that there is no domestic heating and therefore the bulk of carbon monoxide emissions can be attributed to the incomplete combustion of fuels in motor vehicles. Using this knowledge, 1980 emissions were predicted to have been between 120,000-160,000 tons/year (Faiz et al., 1990). The WHO/UNEP later adjusted this estimate to 280,000 tons/year in 1990 and is projecting emissions of 420,000 tons/year by the year 2000 (WHO/UNEP, 1992, p.53).

3.2.5 Sulphur Dioxide

Similar to suspended particulate matter, elevated concentrations of sulphur dioxide (SO_2) can result in increased rates of death, disease, and impaired pulmonary function (WHO/UNEP,

1992, p.11). Unfortunately the ability to quantify these effects is restricted by limited information regarding the source and distribution of SO2 as well as the more important street level concentrations which determine the effective urban exposure. Despite the lack of detailed information, city-wide annual trends are available for 1980 to 1987 (shown in Figure 3.3). This data, while collected at fixed sites which are not necessarily representative of urban exposures, demonstrate that ambient concentrations of SO_2 in Bangkok are consistently significantly below the Thai and WHO standards (1-year mean of 100 µg/m3 and 60µg/m3, 24-hour mean of 300 µg/m3 and 150µg/m3, respectively). Moreover, throughout the 1980s the mean concentrations were relatively stable and the annual maximum concentration decreased throughout the decade. While no studies have been done regarding the cause of these trends, they are likely the result of Bangkok's year-round winds, improved emissions controls at factories, and the relocation of SO2 emitting industries to industrial estates located off the NE/SW wind axis.

In the past, the lack of data regarding SO2 sources has resulted in studies which predict emissions based on theoretical assumptions. However, these studies have utilized different assumptions and accordingly produced very different conclusions. For this reason, the true sources of SO2 emissions are still unknown, but experience and intuition suggest that major sources include industries which use fuel oil and high-sulphur lignite as well as diesel-fueled vehicles. While experts suspect that diesel-fueled vehicles are currently contributing less than 5% of the total SO2 emissions, it is these emissions which produce elevated road-side conditions and result in serious exposure (WHO/UNEP, 1992, p.51). Moreover, as industry continues to leave Bangkok for industrial parks and the size of the automobile fleet further increases, the aggregate emissions of SO2 and especially the ground level concentrations will likely continue to increase.

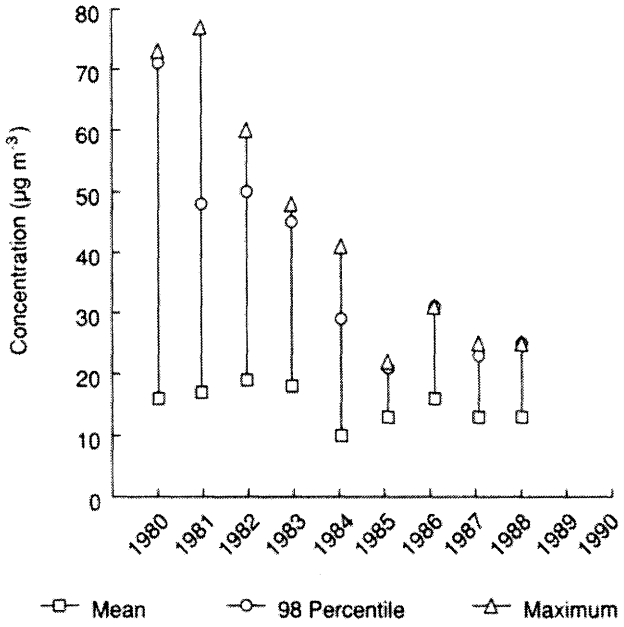

Figure 3.3: Annual mean, 98 percentile, and annual maximum sulphur dioxide concentrations at the GEMS site (WHO/UNEP, 1992, Figure 6.2).

3.2.6 Oxides of Nitrogen

Another common pollutant in automobile emissions are oxides of nitrogen. The most common is nitrogen dioxide which is known to affect the respiratory system including diminished lung function, increased inflammation, and increased airway reactivity (WHO/UNEP, 1992, p.11). There is very little information regarding the concentrations of oxides of nitrogen (NOx) and of the studies that have been done, the findings have been inconsistent with observation. For this reason, the existing data must be viewed with suspicion. With this in mind, it has been observed that the ambient NOx concentrations currently meet the 24-hour mean WHO guideline of 150 µg/m3 NO_2 equivalents. Likewise, the ONEB monitoring sites find that the one-hour concentration of NO2 has never exceeded the Thai one-hour standard of 320µg/m3 since monitoring began in 1987, though it did get close with 270 µg/m3 occurring at one site in 1989. (WHO/UNEP, 1992, Section 6.3).

3.2.7 Ozone

Ozone (O3) is perhaps the most complex air pollutant to address because it is not a component of vehicle exhaust itself. Rather it is the product of a complex reaction between NOx and hydrocarbons[10] in the presence of sunlight. Ozone is most commonly known due to its primary role in the production of photochemical smog which obscures visibility and lowers the quality of life in many large cities around the world. More importantly though, ozone can cause a wide range of adverse human health effects, especially in the respiratory system. Sample effects include increased rate of asthma attacks, severe respiratory irritation including inflammation of the lungs, decrease in lung function, and increase in airway reactivity as well as less serious problems such as headaches and irritation of the eyes, nose, and throat (WHO/UNEP, 1992, p.11).

Ozone is typically a serious problem in warm, sunny urban areas, however, Bangkok's year-round land-sea breezes continuously ventilate the city, thereby transporting the resultant ozone to either the less populated region to the northeast (which could be experiencing deleterious effects) or to the Gulf of Thailand to the southwest. As a result of these favorable conditions, the 1989 maximum one-hour mean ambient ozone concentration was 100 μg/m3 which is well below the Thai and WHO guidelines of 200 μg/m3 (WHO/UNEP, 1992, p.54).

3.2.8 Lead

Lead has historically been recognized as one of the most harmful automobile pollutants. This is because lead, which was frequently used as an additive in automotive fuels, is emitted into the air along with other pollutants. If it is subsequently inhaled into the body, the lead enters the blood stream where it inhibits the ability of red blood cells to produce hemoglobin and thereby reduces the body's ability to deliver oxygen throughout the body. Moreover, lead damages the

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[10] Hydrocarbon, also termed volatile organic carbon or VOC in this context, is the leftover unburnt fuel (due to incomplete combustion) which exits the vehicle tail pipe along with other pollutants.

liver and kidneys reducing their ability to function and it can also result in irreversible neurological damage (WHO/UNEP, 1992, p.11).

Through the experiences of the developed nations, the world has learned the dangers posed by lead to children and adults in terms of learning disabilities and mental impairment. Based on these lessons as well as the 1992 requirement that catalytic converters be installed on all new vehicles, Thailand has recently completed (1989-1995) a major phase-out of leaded gasoline. As a result of the newly unleaded fuels and the fact that there are currently no major lead-emitting industrial sources, ambient lead levels have dropped from a maximum roadside 24-hr average lead concentration of 7.56 μg/m3 and an annual average concentration of 1.52μg/m3 in 1991 to 0.52μg/m3 and 0.1 μg/m3, respectively, in 1996. Similar reductions have also been observed in non-roadside, general areas. Accordingly, ambient lead concentrations in Bangkok are now well below the WHO guidelines for average annual lead concentration. (Wangwongwattana, 2/20/98).

3.2.9 Environmental & Other Impacts

Aside from the effects already discussed, automobile pollutants have other effects on both society and the natural environment. These effects cover a broad range and they occur on both spatial and temporal time scales of which we are still beginning to understand. One of the more well-known problems is that of acid-deposition which can occur on local-, medium-, or long-range scales. Acid deposition is more commonly known of as acid rain (i.e. wet deposition), but dry deposition also occurs. The problem can be traced back to automobile emissions of sulphur dioxide and oxides of nitrogen which serve as precursors to acid formation. The result of acid deposition are generally thought to be the acidification of soil and lakes, but the end ecosystem effects are very difficult to assess given the highly variable responses that different systems have to small changes in acidity (WRI et al., 1996, p.23; WHO/UNEP, 1992, p.12).

Another serious problem is that of crop and forest damage. Sulphur dioxide, nitrogen dioxide, and ozone are all phytotoxic which means they are poisonous to plants. As a result, these

automobile pollutants have been implicated in decline of agricultural crop production and natural forests. These same three pollutants also damage human-made buildings and works of art including historic monuments such as The Grand Palace and the numerous wats which are increasingly in need of restoration to counteract air pollution-induced damage (WRI et al., 1996, p.23; WHO/UNEP, 1992, p.12).

As scientists have learned more about these pollutants, the regional and global nature of the urban plumes which emanate from cities have become better understood as well. This is because these pollutants often take a great deal of time to decompose or transform, if in fact they ever cease causing damage. The most recent discovery which falls along these lines is the possibility of global climate change as a result of the production of greenhouse gases such as carbon dioxide (which is emitted by the burning of fossil fuels such as gasoline and diesel). In this case, the problem is truly global both in terms of emissions and adverse effects, and the time scales are equally daunting because they may extend into the hundreds of years.

3.3 Noise Pollution

Throughout Bangkok, the sound of traffic is heard around the clock. During the day the streets are clogged with cars, buses, motorcycles, and small trucks. At night, tractor trailers, which are forbidden in Bangkok during the day, fill the roads to both replenish the city's supplies for the next day and to bring out what it has consumed and/or produced that day. For this reason, Bangkok's roads are heavily utilized around the clock by a fleet of generally poorly maintained vehicles or even 'powertuned' vehicles which have been tampered with to increase performance at the cost of louder operation and decreased fuel economy (which both increases emissions and requires more fuel). Finally, aggressive driver behavior which is encouraged by the highly congested streets leads to the excessive use of braking and horn-honking. All of this adds tremendously to the ambient noise levels that those who live and work in Bangkok must endure.

Unfortunately, like air pollution, such noise has harmful effects of its own. These include hearing damage and loss as well as adverse impacts on the psychological well-being of citizens. In addition, lands which are exposed to excessive noise pollution typically suffer a loss in property value due to the loss in utility which accompanies such unwanted noise (WRI et al, 1996, p86-87). In 1983, after receiving numerous complaints regarding excessive ambient noise, Thailand's ONEB began monitoring noise levels throughout Bangkok. After four years of monitoring (1983-87), the ONEB found that many locations frequently exceeded the US EPA standard for long-term hearing protection of 70 decibels almost exclusively due to nearby truck, bus, and motorcycle traffic. In addition, the ONEB found a school classroom whose ambient noise level ranged from 76 to 95 decibels as well as a home with a noise level of 77.9 decibels. In all cases, the ONEB's observations found that ambient noise levels in Bangkok significantly exceeded the 65 decibel level that most OECD countries believe represents the limit of human comfort (Phantumvanit and Liengcharernsit, 1989, p.37)

While the ONEB found that trucks, buses, and motorcycles cause the bulk of noise pollution, the other primary sources of noise pollution in Bangkok include industry and construction, and to a lesser degree the many boats and water taxis which travel the klongs and the Chao Phraya River. Consistent with the identification of motor vehicles and boats as producing the bulk of ambient noise, Thailand adopted a vehicle noise emission standard in the early 1980's of '85 decibels at 7.5 meters.' During its 1983-87 studies, however, the ONEB found that nearly 20% of vehicles fail to meet this standard (Phantumvanit and Liengcharernsit, 1989, p.37). Additional corroboration of these findings was further provided by a 1985 study conducted by Chulalongkorn University which found that roughly 21% of motorcycles violated the noise standard and that 80% of motorboats exceeded the less stringent pre-1985 standard of '90 decibels at 7.5 meters.' As part of this later study, Chulalongkorn University researchers surveyed 85 motor-boat operators and found that 80% of the them had experienced hearing loss (Phantumvanit and Liengcharernsit, 1989, p.38).

Based on the ONEB and Chulalongkorn studies it is clear that noise pollution is a severe problem for Bangkok's citizens who must endure ambient noise levels which are not only uncomfortable, but can lead to permanent hearing loss. As disturbing as these finding are, however, perhaps even more disappointing is the acknowledgment that the existing rules which are intended to prevent this serious problem are not enforced.

4. Current Challenges, Tradeoffs, and Opportunities

Thailand's rapid growth, strong pro-business environment, and non-interventionist government together with low wages and the huge regional market brought billions of dollars of investment to Thailand over the last 30 years including US $14 billion in 1996 alone (BOI, 1997). Unfortunately, the government's laissez-faire policy also resulted in inaction, or at best limited action, to address a number of serious challenges which all developing countries must confront as their economies grow and acquire new and changing needs. After nearly 30 years of inadequate attention, many of these challenges have evolved into serious problems which impose substantial costs on Thailand's economy and limits the government's ability to develop and provide improved quality of life to its citizens. Throughout Thailand this has resulted in very limited mobility for people, goods, and services; significant contamination of the environment including air, water, and land; as well as a growing income gap between the nation's rich and poor. These problems are especially pronounced in Bangkok where 11 million people live in close proximity despite having an unsafe water supply system, no wastewater collection or treatment system (though one is being constructed in phases), and a severely limited transportation infrastructure.

During the rapid growth of the past, many of these challenges were downplayed or ignored given the massive prosperity and the speed of Bangkok's development. This response was reasonable given the fact that many in society could afford these inefficiencies and costs. Moreover, it was easy to dismiss such concerns as simply being part and parcel of living in Bangkok. However, now that Thailand's economy has weakened, these problems are more visible and the inefficiencies are too costly to be ignored or written off as unavoidable by eve the wealthiest individuals, firms, or the government at large. For that reason, these problems require that government, industry, and citizens all do their part to contribute toward the long-term objective of solving these problems, as well as the more modest objective of mitigating these problems and improving quality of life. However, in order to address these problems effectively, it is necessary

to improve one's understanding of each of these problems, how they are interconnected, and where opportunities exist to shift toward a more sustainable balance between economic development and the urban environmental problems caused by automobiles. In this chapter each of the key concerns are presented and the relevant issues discussed.

4.1 Mobility & Transportation Infrastructure

4.1.1 Status Quo

Throughout the world, Bangkok is legendary for having traffic congestion and a general lack of mobility which is among the worst in the world. According to a 1996 World Bank study, traffic speeds in central Bangkok decreased by 2 percent per year throughout the late 1980s which resulted in the average car being stationary in congestion for 44 days per year (World Bank, 1996, p.16). A separate 1994 study examined congestion within different regions of the Bangkok Metropolitan Area (BMA) and found that the 24-hour average vehicle speed in the core of the city center was 7.2 km/hr (see Table 4.1).

Region of the Bangkok Metropolitan Area	Average Speed (km/hour)
Core of Center City	7.2
Center City	8.9
City	12.1
Surrounding Areas	11.7

Table 4.1: Average private vehicle speed, evening rush hour 1994 (Vongpivat, 1998a, p.16; Vongpivat, 1998b).

This congestion, however, is not just an inconvenience which must be endured--it is a constraint upon the quality of life and the national economy. As such, it has substantial direct and indirect costs, only a few of which are easy to calculate. The Thai Office of the Commission for the Management of Road Traffic (OCMRT) has estimated that 3.5 billion liters of fuel are wasted each year simply due to congestion. This alone corresponds to 0.5% of the 1995 national GDP or nearly US $880 million/yr at a rough pre-1996 exchange rate of 25 Baht to US $1 (OCMRT, 1997). Another study estimated that 5.9 billion person hours are consumed by traffic congestion

(Vongpivat, 1998a, p.21). Placing an aggregate value on the cost of congestion is very difficult due to the number of assumptions and considerations involved. Among others, this also includes assessing the additional auto emissions and their impacts, the resultant health effects, the opportunity cost of the lost fuel and worker time, the decreased quality of life and labor productivity of the worker related to added stress and frustration, and shorter working lives (WRI et al, 1996, p.24). Despite these difficulties, the cost of congestion in Bangkok have been estimated to be as large as 33% of the potential gross city product or more than US $1.46 billion in 1992 (Strickland, 1993, p.4).

4.1.1.1 Vehicles

Perhaps most indicative of the cause of congestion problem is the rapid increase in registered vehicles in Bangkok. In 1980 there were 600,000 vehicles. By 1993 this had soared to 3.6 million vehicles. This corresponds to nearly 15% annual growth for 13 years. During the same period, however, the supply of roads in Thailand grew between 1.0 and 1.5% per year (OCMRT, 1997, p.4). Despite this divergence between the supply and demand for roads, the Bangkok fleet continued to grow. In 1996, growth was maintained at roughly 10% or 300,000 vehicles, of which 162,000 were motorcycles. This represented an 11% increase in motorcycle sales from the previous year (Vongpivat, 1998a, p.20).

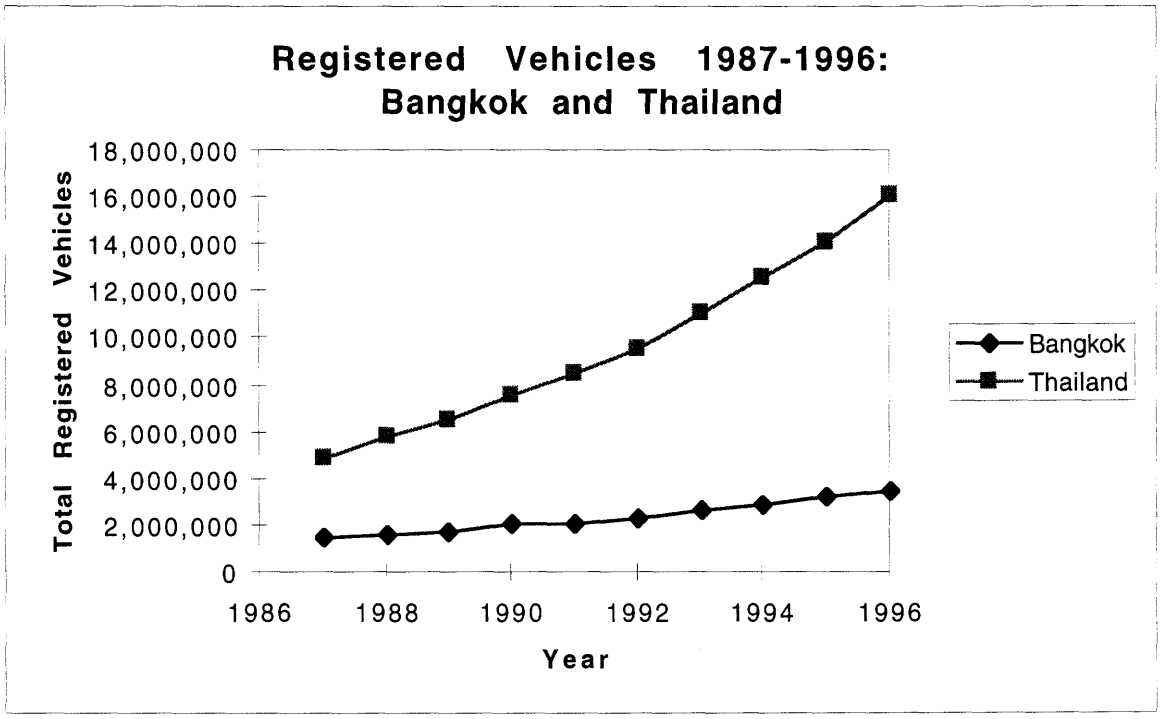

Figure 4.1: Total Registered Vehicles in Bangkok and Thailand 1987-1996 (Department of Land Transportation, 1997).

As of 1996, Thailand had more than 9 million motorcycles and 4 million automobiles. Of this 13 million total, 3.5 million were located in Bangkok. The vehicle fleet in Thailand is rather diverse with motorcycles being the largest group at 1.5 million motorcycles, 1 million personal automobiles, 770 thousand vans, 100 thousand trucks, 35 thousand buses and 100 thousand other taxis, tuk-tuks[11], and miscellaneous vehicles (Suksod, 1998).

[11] Currently there are 7,300 tuk-tuks or three-wheeled taxis. Due to a government decision they are being eliminated and no new units are being produced.

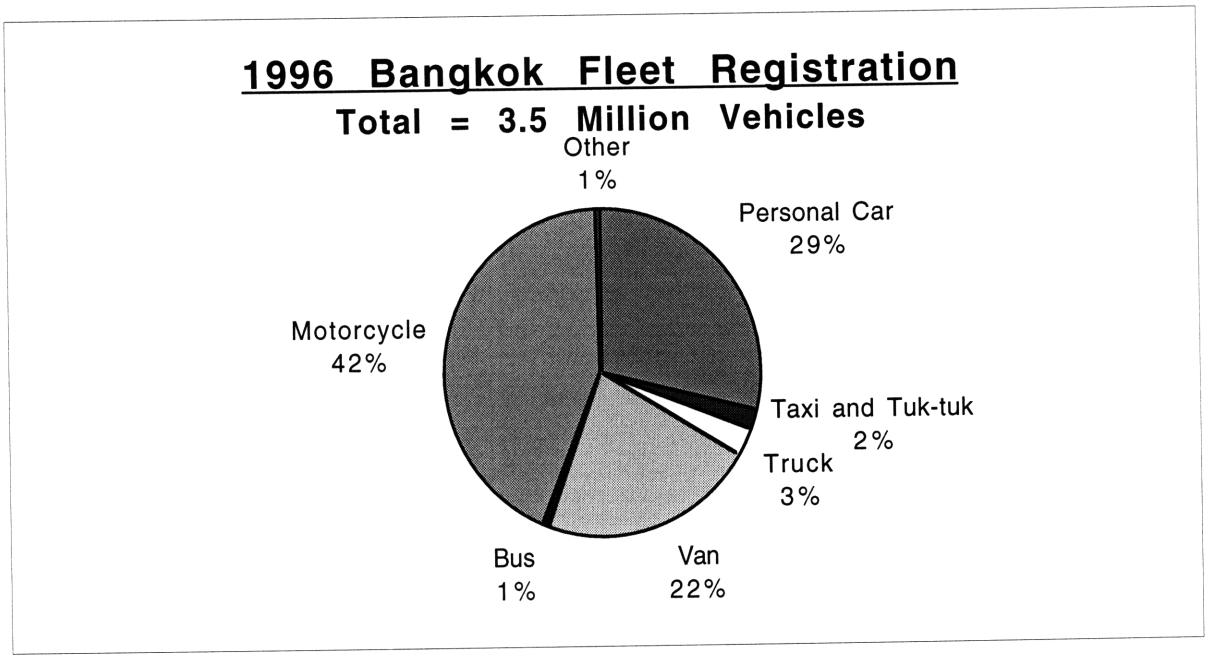

Figure 4.2: Bangkok vehicle fleet registration (Suksod, 1998).

4.1.1.2 Physical Infrastructure

The complementary cause of Bangkok's congestion is a lack of physical transportation infrastructure. This lack of infrastructure is also the country's largest impediment to increased mobility. As previously noted, new road construction had not kept pace with the vehicle growth experienced in Bangkok between 1980 and 1993. However, the true state of Bangkok's mobility situation is better assessed by a comparison between Bangkok and an average of numerous US and European cities as well as an average of Singapore, Tokyo, Hong Kong (referred to as 'Asian Cities') as shown in Table 4.2.

	US Cities	European Cities	Asian Cities	Bangkok
Urban Density (people/ha)	14	50	164	144
Road Length per capita (meters)	7.2	2.4	1.1	0.6
Passenger Cars/ 1000 people	602	392	123	153
Total Vehicles/ 1000 people	755	452	217	348
% workers using foot and bike	4.7	16.7	20.3	10

% of total passenger km on public transit	3.2	22.9	64.1	36.6

Table 4.2: Transportation infrastructures throughout the world, 1990 (Kenworthy & Laube, 1996, p.282-4).

As this information shows, Bangkok's population density is slightly less than typical Asian cities, yet it has roughly half the road length per capita, almost 25% more personal vehicles, and 60% more total vehicles. Moreover, many fewer people walk or bike to work because of dangerous travel conditions or undesirable, impractical commutes. Finally, the percentage of total passenger kilometers traveled on public transit reveals that Bangkok uses 40 percent less public transportation than other Asian cities. In short, these statistics show that Bangkok has more cars, fewer roads, and uses less public transportation than other Asian cities with similar urban densities.

As serious as the lack of infrastructure is, the most pervasive problem for Bangkok lies in the small amount of space reserved for roads in Bangkok. Relative to the international standard of 20 to 25%, Bangkok has only 11% of total space reserved for roads. This low percentage is the direct result of Bangkok's agrarian beginnings which were based around large common agricultural areas surrounded by a network of roads. As development took hold, the interior of these 'superblocks' were replaced with new buildings which continued to be served by the traditional small, narrow, winding roads called 'sois' which extend only part way into these superblocks. As a result of this development pattern, the large number of people which can be located within a single superblock are all forced to use the surrounding road network not only to travel to/from distant locations, but also to travel within the same superblock. In other words, they must travel from 'sois' to the surrounding primary road and then re-enter the superblock at the appropriate 'sois.' For this reason, the primary roads are forced to accommodate purely local traffic in addition to the substantial volumes of city and regional traffic. (Gakenheimer, 1998; Vongpivat, 1998a, p.11). This puts excessive loads on roadway systems which should typically be designed for either the movement of goods and persons or for access to buildings,

pickup/dropoff areas, and parking areas. Unfortunately, due to the extent of development and the high cost of land in Bangkok, it is extremely unlikely that this will change (Wangwongwatana in SAE, 1998c, p.11).

4.1.1.3 Public Transportation

Despite this lack of infrastructure and perhaps more importantly, the lack of physical space for new infrastructure, a collaborative team of experts from the Bangkok Metropolitan Administration's (BMA) Department of City Planning and MIT's Department of Urban Studies and Planning concluded that "Bangkok is suffering not so much from a lack of road space as from a lack of viable transport alternatives" (BMA/MIT, 1996, p.3). In other words, Bangkok's most serious problem results from the fact that the only practical form of travel is by personal car or motorcycle. In 1992 the government recognized this problem and modified the 7th National Plan (1992-1996) accordingly. Under this plan, the five-year budget increased by 680% to 335 billion Baht (or US $13.4 billion over five years at a 25 Baht : US $1 exchange rate). Of this allocation, 42% was devoted to public transportation projects. Then in 1997, the 8th National Plan further increased the five-year transportation budget to 528 billion Baht with public transit designated to receive 47% of the total. (Vongpivat, 1998a, p.23-24). Despite these expenditures, there are currently only three forms of public transportation available to the citizens of Bangkok: buses, taxis (both car and motorcycle), and boat. However, the first of several planned and partially constructed mass rapid transit systems is expected to open in 1999 which will provide another option (Wanisubut, 1998b). Table 4.3 provides a brief summary of the current distribution of daily travel modes.

Travel Mode	Number of Person-Trips	Percent of all Trips
Car and Pickup Truck	7.7 million	36 %
Private Motorcycle	4.2	20
Taxi, motorcycle taxi, tuk-tuk	2.5	12
Bus	6.3	30
Boat, Train	0.4	2
Total	21.0	100

Table 4.3: Daily Travel Mode Distribution, Bangkok Metropolitan Region, 1995 (OCMRT, 1997).

The Public and Private Bus System

As shown by Table 4.3, of all forms of public transportation in Bangkok, the public and private bus systems are by far the most frequently used providing more than 6.3 million person-trips per day (30% of the total) and 68% of all public transportation. Bangkok's bus system began more than 80 years ago and was originally completely provided by the private sector, but in 1976 the 25 existing private companies were consolidated and transferred to the public sector under the management of the Bangkok Mass Transportation Authority (BMTA). Since then, the BMTA has operated at a deficit and is currently more than 10 billion Baht in debt. In light of this poor performance and more importantly due to unreliable, low-quality service, the government encouraged private bus companies to re-enter the market and augment the public bus system around 1980 (Wanisbut, 1998b). As a result, today there are roughly 5,000 public open-air (non-air-conditioned) buses with a fare of 3.5 Baht per trip; 1,200 public air-conditioned buses with a

fare of 7.0 Baht; and roughly 1,000 private air conditioned buses with a fare that ranges from 15 to 30 Baht (Wanisubut, 1998b; BMTA *as cited in* Vongpivat, 1998a, p.36)[12] .

In addition to being severely in debt, the public bus system is inefficient, poorly managed, and provides low quality services as the following characteristics demonstrate (Vongpivat, 1998a, p.6; Wanisubut, 1998b):

- There is an inadequate supply of buses which often results in: 1) dangerously overloaded buses with passengers struggling for space and sometimes hanging from the bus, and 2) buses skipping stops due to lack of passenger room;
- Buses and bus stops are dirty and unpleasant, the open-air buses are particularly bad due to Bangkok's heat and the poor air quality in the street due to motor vehicle emissions and congestion;
- The average age of the entire bus fleet is six years old, but individual buses range from 2 to 14 years old;
- The fleet is in such disrepair that 20% of it is in for maintenance each day, and the repairs are haphazard and of poor quality sometimes resulting in the endangerment of passengers;
- Buses often block traffic for long periods of time (thereby worsening congestion) as people attempt to pay the boarding fee which is often difficult to make change for;
- Bus drivers do not maintain their schedules and often drive dangerously causing passengers to fall.

Finally, an additional drawback to all of Bangkok's bus systems is that the buses move more slowly through congested streets than smaller, more agile cars, thereby making bus travel more time consuming and even less desirable for those who can afford taxis, motorcycle taxis, or a private automobile or motorcycle of their own.

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[12] There is a surprisingly large disprepancy between different sources regarding the number of different types of buses and their fares. This represents the author's best assessment of the current services provided based on communications with two partially conflicting government sources.

Waterway transportation

Waterway transportation is generally regarded as a far superior form of transportation when the river/klong system suits the travel need. This is because there are far fewer boats on the water meaning that a commuter can avoid the traffic congestion of the streets. However, this system is also poorly operated and often considered unsafe due to poorly maintained docks and piers, severe overloading of passengers (boats sometimes reach three times the legal limit), and drivers who travel at unsafe speeds and depart before all passengers are fully loaded. For these reasons as well as the occasional passenger falling into the highly-polluted waters below, it is well known that boat travel is not for everyone. (Vongpivat, 1998a, p. 7-8).

Planned Mass Rapid Transit Systems

Beginning with the 7th National Plan in 1992, Bangkok has committed itself to constructing a Mass Rapid Transit (MRT) system throughout the Bangkok metropolitan region (BMR). While attempts have been made to coordinate the MRT with existing and new bus feeders and light rail trains, the different 'lines' (there are five) of the MRT have not been thoroughly well coordinated. More importantly, the government has required that the MRT be privately financed and constructed. This has resulted in the different 'lines' being awarded to different contractors as individual concession projects. Due to the economic collapse, however, several of the companies and their financing partners have become insolvent or otherwise unable to complete their contracts on schedule or at all. Most notable is the Hopewell project, which combined an MRT line to the Don Muang Airport (Bangkok's main airport) with an additional overhead expressway, which has completely collapsed despite significant construction being completed. Nevertheless, the first MRT line is expected to open in 1999 and the government hopes, although they concede it is optimistic, that the MRT system will be completed by 2001. At that time, it is estimated that the

system will provide 1.5 to 6 million passenger-trips per day[13]. (Khomnamool in SAE, 1998c, p.49; Wanisubut, 1998a; Wanisubut, 1998b; Vongpivat, 1998a, p.56).

Public Perceptions and Observed Behavior

Finally, in light of the poor quality of the available public transportation services, it is clear why people desire to own their own private motorcycle or car. However, there are other reasons which prompt those who can afford a motor vehicle of their own to do so, in the words of the BMA/MIT study:

> "Public transportation is simply not a realistic alternative for anyone with access to a car. The only people traveling by car are those who have no other choice...people perceive large benefits in owning a private car: freedom and comfort...dramatic increase in accessibility to social, recreational and economic opportunities... wider choice of residential and employment locations... and status in the community which those who depend on buses do not enjoy" (BMA DCP/MIT, 1996, p.2).

Finally in addition to this qualitative suggestion that it will be difficult to overcome the psychological benefits of owning a vehicle a recent OCMRT study provides further confirmation:

> "Once a [household has] its own car, they rarely go back to using public transport: the proportion of work trips by public transport for the average household falls from 89 percent to 28 percent once a car is available" (OCMRT, 1997b).

4.1.2 Tradeoffs

As significant as Bangkok's congestion and mobility problems are, one must recognize that the population is currently able to get to and from work while providing for their family to varying degrees. Finding a solution which maintains this current level of mobility to the entire population, especially the poor, in the present while vastly improving conditions in the future is complex to say the least. Nevertheless, it is evident that Bangkok's mobility requirements are not and cannot be met by a system which is exclusively based on motor vehicles. The current situation has severely restricted the economy and greatly deteriorated the quality of life in Bangkok. For this reason, the

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[13] Estimates of ridership vary widely depending on the source.

government must shift Bangkok's transportation infrastructure towards compact transportation corridors with high-occupancy, high-efficiency forms of public transit and away from sprawling roadways and interchanges used by low-occupancy, less efficient forms of transport such as the motor vehicle. This is not to say that there should not be streets--rather streets must be maintained but they should be used to fulfill those mobility demands which cannot be met by public transit, such as the transport of goods and services throughout the economy as well as those individuals and businesses who require high levels of mobility.

4.1.3 Future Demands & Opportunities

While it is very difficult to determine what the proper balance between public and private infrastructures should be, it has been estimated that the extreme density which is common throughout Asia's largest cities will require that 45% of all traffic volume be provided by public transportation (Shafer and Victor, 1998, p.59). In light of Bangkok's 'superblocks' and the lack of space available for roads, however, it is seems likely that Bangkok will need to provide an even larger amount of public transportation than other Asian cities.

Accordingly, Bangkok should consider ways to further encourage private sector participation in the provision of public transit with respect to both bus and mass transit systems. This is especially true in light of the collapse of several of the MRT concession projects. In order to speed the provision of public transit, the government must increase its willingness to finance/subsidize these projects on a more equal basis. This is because the value of public transit far exceeds that of the transport service alone. Rather public transit enables the roads to remain free for commerce and high-mobility demands, rather than the alternative which exists today of severe congestion, pollution, and tremendous direct, indirect, and opportunity costs for all members of society. For this reason, the government must realize that pubic transit is highly unlikely to ever be profitable based on fares alone. Rather, since its true economic value comes overall increased mobility of passengers as well as the road network, its economic value is many

times larger than the fares alone. Accordingly, the government must be willing to finance or provide larger subsidies to the private sector for improved bus and rapid transit service.

And as growth continues to be channeled away from Bangkok and toward satellite cities and other rural areas, it is important that these areas have sufficient infrastructure planned and possibly even constructed before substantial development occurs. Most important, however, is that this infrastructure be chosen not necessarily to supply roads or to meet demand, but rather to guide development into more sustainable urban forms. This necessarily requires that affordable public and mass transit be planned from the outset along with a suitably designed road network. In general, providing for multiple and high-density transportation alternatives will ensure that the mobility needs of dense urban populations are met while the streets are able to convey commercial vehicles vital to the economy as well as those personal automobiles which are needed to provide a higher degree of mobility than is offered by the competing forms of transportation.

Unfortunately, providing improved transportation alternatives alone will not prompt people to take public transportation rather than their car or motorcycle. Such a change in behavior will only occur if people decide independently that taking public transportation is more convenient, comfortable, or affordable than taking their personal vehicle. These are difficult standards to meet given the comforts of today's cars. And this problem will become especially difficult if congestion on the roads decreases thereby tempting people back into their cars.

For this reason, additional incentives need to be provided to people to encourage them to willingly change their behavior and take public transportation even though it is unlikely to provide the level of service and comfort that is inherent in an automobile. The easiest means of altering an individual's decision is by increasing the cost of driving their personal vehicle. This can be done through a variety of mechanisms, but more important than those increases is the rationale behind them and how they change behavior.

First and foremost, increasing the cost of driving forces drivers to face a more accurate reflection of the social costs of driving, where the social costs include contributing to congestion,

air emissions, road wear/consumption, the need to provide parking, and even the danger of causing an accident to oneself or others). These are all worthwhile and important goals in and of themselves. In addition, such an increase also encourages people to take public transit and freeing the road space they would have otherwise occupied. In addition, the increased costs can go towards subsidizing the costs of public transit which has already been shown to increase the value of public roadways. Finally, specific means of imposing such costs include increased vehicle taxes at time of purchase, increased fuel taxes, a parking tax on those who commute to work by car and leave their car parked during the day, increased road tolls, and even congestion (time of day/traffic level) pricing.

Each of these forms of tax accomplish all of the aforementioned concerns, but with differing degrees of implementation. For this reason, Bangkok should consider which of these are most suitable and able to be implemented in the Bangkok metropolitan region. No matter which of these they choose, the results will be real and magnified by the fact that such incentives not only raise revenue but they encourage more sustainable behavior while financing a more sustainable infrastructure.

4.2 Air Quality, Emission Controls, & Fuels

The lack of mobility in Thailand has other impacts which go beyond the direct costs of lost time and fuel. This is because the lack of mobility is linked in complex ways to many other problems which have adverse impacts of their own. One of the most serious consequences of congestion is the increased motor vehicle emissions which result from the slow speeds, dense traffic, and added running time of the hundreds of thousands of low-occupancy motor vehicles. These emissions have local, regional, and global effect which can all be mitigated through any variety of emissions controls, fuel modification of substitutes, and the increased use of public transportation.

4.2.1 Status Quo

4.2.1.1 Automobile Emissions & Air Quality

Unfortunately, the specific relationship between vehicle emissions and average traffic speed is not currently known for Bangkok's vehicle fleet. This means that it is impossible to precisely know the effect of congestion on emissions. However, Ellis & Stedman have constructed a computer model which has found that carbon monoxide emissions vary non-linearly with declining speed as shown in Figure 4.3. Specifically, as the average speed drops from 20 to 2 km/hour, they estimate that emissions increase ten-fold (Ellis & Stedman, 1994, p.12). However, this relationship was derived for a fixed number of vehicles whereas during congested conditions, the number of cars in a given area is much larger than during faster speeds. For this reason, emissions will be further increased beyond that reflected in Figure 4.3.

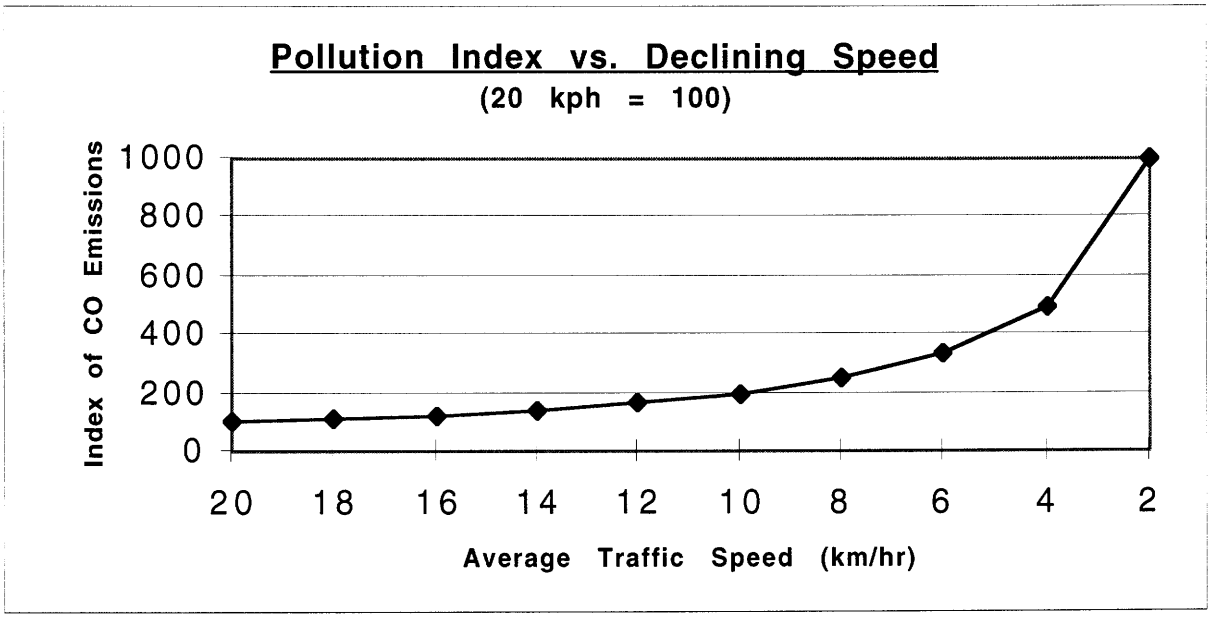

Figure 4.3: Effect of Congestion on Automobile Emissions (Ellis & Stedman, 1994).

Next, this generalized relationship is likely to be conservative in that it does not account for the characteristics of the Bangkok vehicle fleet which is generally perceived to be old and poorly maintained. Ellis & Stedman in conjunction with other researchers have used the FEAT (Fuel

Efficiency Automobile Test) remote sensing technique to measure a variety of different pollutants for vehicle fleets in several different Asian cities. In the case of Bangkok, the hydrocarbon emission results revealed that Bangkok's fleet has high emissions throughout the entire distribution unlike the observations made in Seoul, Hong Kong, and Taipei[14] which revealed that the worst 5% or 10% of the fleet is generally responsible for the bulk of the emissions. Unfortunately, the results obtained in Bangkok must be viewed with mild skepticism because they were based on a rather small sample size of 1,300 vehicles. Accordingly, this profile may not be representative of the aggregate fleet, nevertheless it does suggest that highly polluting vehicles may be the norm rather than the exception in Bangkok (Ellis & Stedman, 1994, p.4).

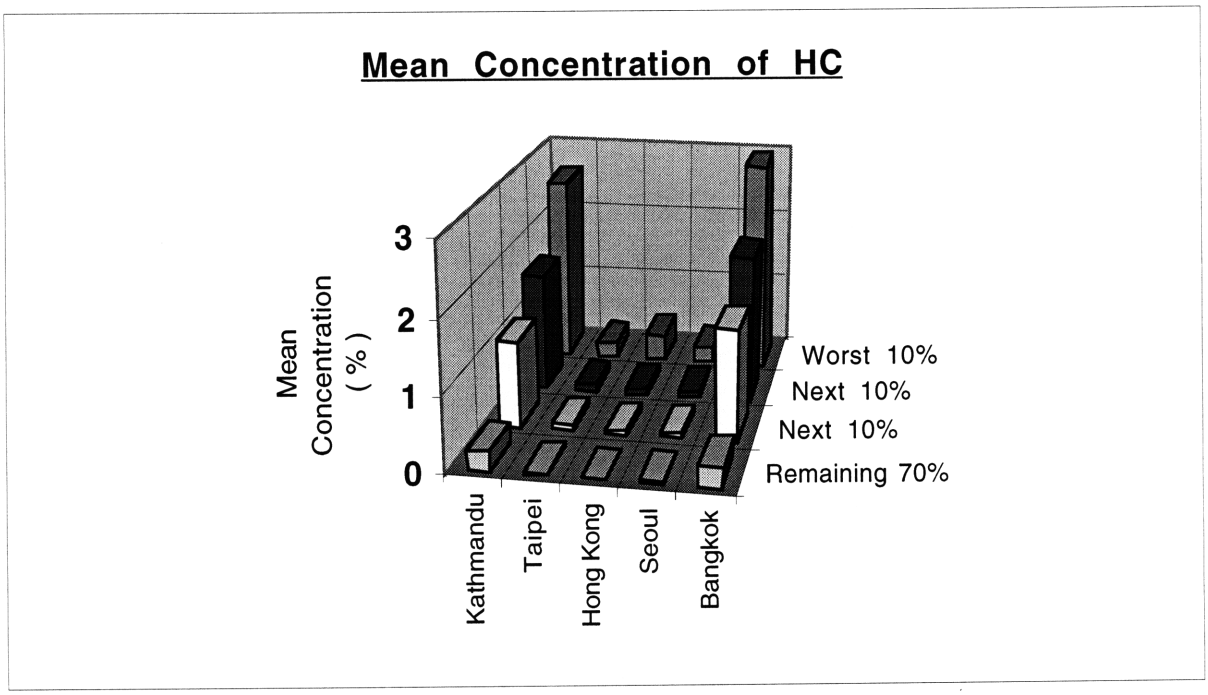

Figure 4.4: International comparison of the distribution of hydrocarbon fleet emissions (Ellis and Stedman, 1994).

Finally, it is useful to determine which portions of the vehicle fleet are most responsible for each of the major pollutants. As presented earlier, in 1996, Bangkok had more than 3.5 million

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[14] Ellis & Stedman note that the testing locations used in Taipei were highways which did not allow motorcycles. As a result, these measurments are not representative of the Taipei fleet (Ellis & Stedman, 1994).

registered vehicles including 1.5 million motorcycles, 1.0 million personal cars, 770 thousand vans, 100 thousand trucks, 35 thousand buses and 100 thousand other taxis, tuk-tuks, and miscellaneous vehicles. The Thai Pollution Control Department has determined the percent contribution of four different vehicle categories for PM-10, carbon monoxide, hyrdrocarbon, and oxides of nitrogen. These findings include absolute emissions and percent contributions and are displayed in tabular form in Table 4.4 as well as in graphical form in Figure 4.5 through Figure 4.8. While the PCD study does not classify vehicles according to the convention used by the Registry of Motor Vehicles, strong parallels exist, especially for small vehicles/passenger cars and motorcycles (the later is common to both conventions) thereby making the statistics easy to compare.

	PM-10	CO	HC	NOx
Small Vehicles	74%	78%	64%	31%
Medium Vehicles	1%	1%	1%	7%
Large Vehicles	5%	2%	3%	61%
Motorcycles	20%	19%	32%	1%
Total Emissions	31,691 tons	2,313,556 tons	494,246 tons	134,249 tons

Table 4.4: 1994 Bangkok vehicle emissions characteristics (Suksod, 1998).

As the above data shows, the emissions of motorcycles and small vehicles (which together represent 78% of the Bangkok fleet) when taken together represent the source of 94% of PM-10 emissions, 97% of carbon monoxide, and 96% of hydrocarbons. In addition, large, medium, and small vehicles are responsible for 99% of NOx emissions. These findings are largely consistent with the expectations that: 1) petrol/gasoline fueled four-stroke vehicles (primarily small vehicles) produce CO and NOx; 2) diesel-fueled vehicles produce SPM, SO2 and NOx; and 3) two-stroke

gasoline motorcycles[15], which are widely known to be much more polluting than four-stroke automobiles[16], produce SPM, HC, and CO (Wangwongwatana in SAE, 1998c, p.11).

Taken as a whole, this data shows that Bangkok's air pollution is the direct result of the tremendous number of highly-polluting motor vehicles which compete for limited road space. The resulting congestion significantly worsens ambient air quality due to non-linearities in emissions as well as vehicle density. These emissions are then introduced into Bangkok's 'street canyons' where they expose the population and produce health effects which are known to vary non-linearly with exposure.

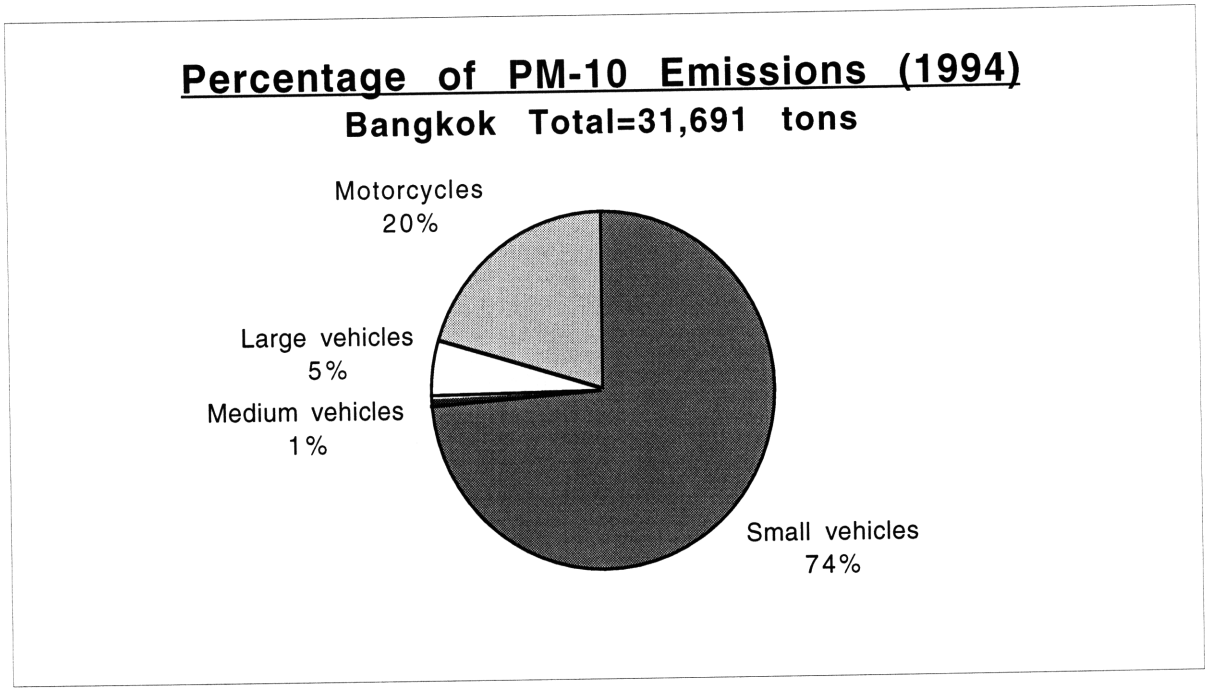

Figure 4.5: 1994 Bangkok vehicle PM-10 emissions (Suksod, 3/10/98).

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[15] Less than ten percent of existing motorcycles are estimated to be of the four-stroke variety (Wangwongwatana in SAE, 1998b, p.11).

[16] According to the World Bank, "The fuel economy of two-stroke engines is about half of that from four-stroke engines. HC emissions from four stroke engine motorcycles are 12-15 times higher than emissions from new four-stroke engine motorcycles and over 10 times higher than emissions from in-use cars" (Carbajo, 1992, p.5).

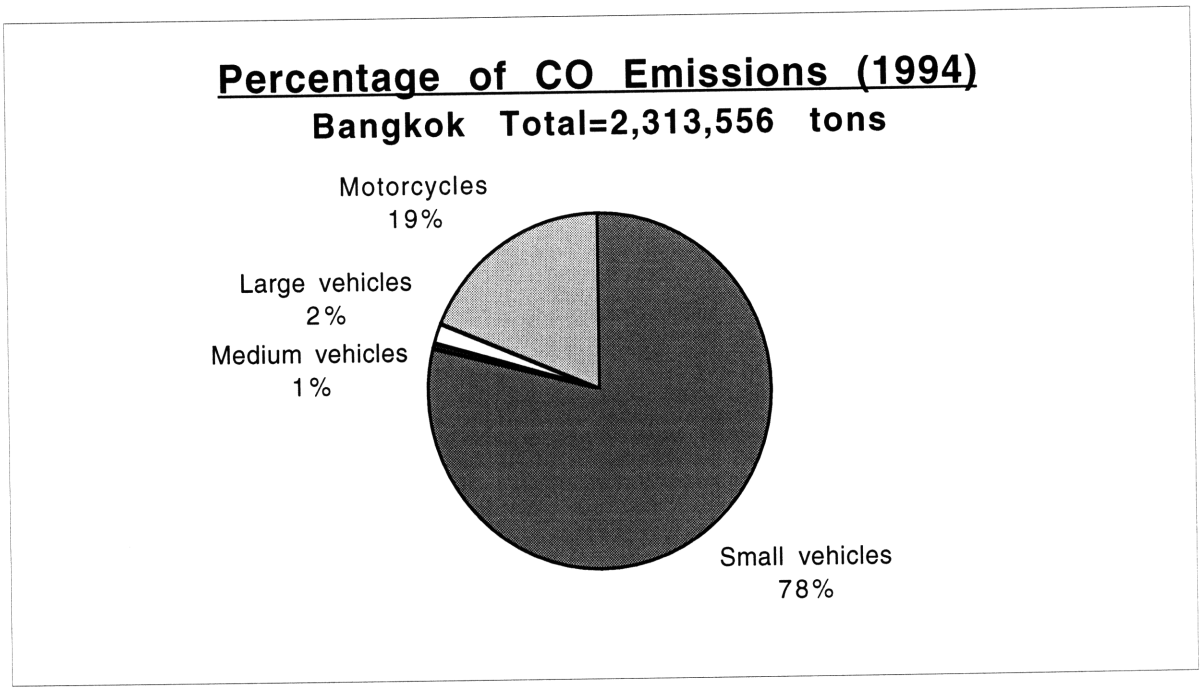

Figure 4.6: 1994 Bangkok vehicle CO Emissions (Suksod, 3/10/98).

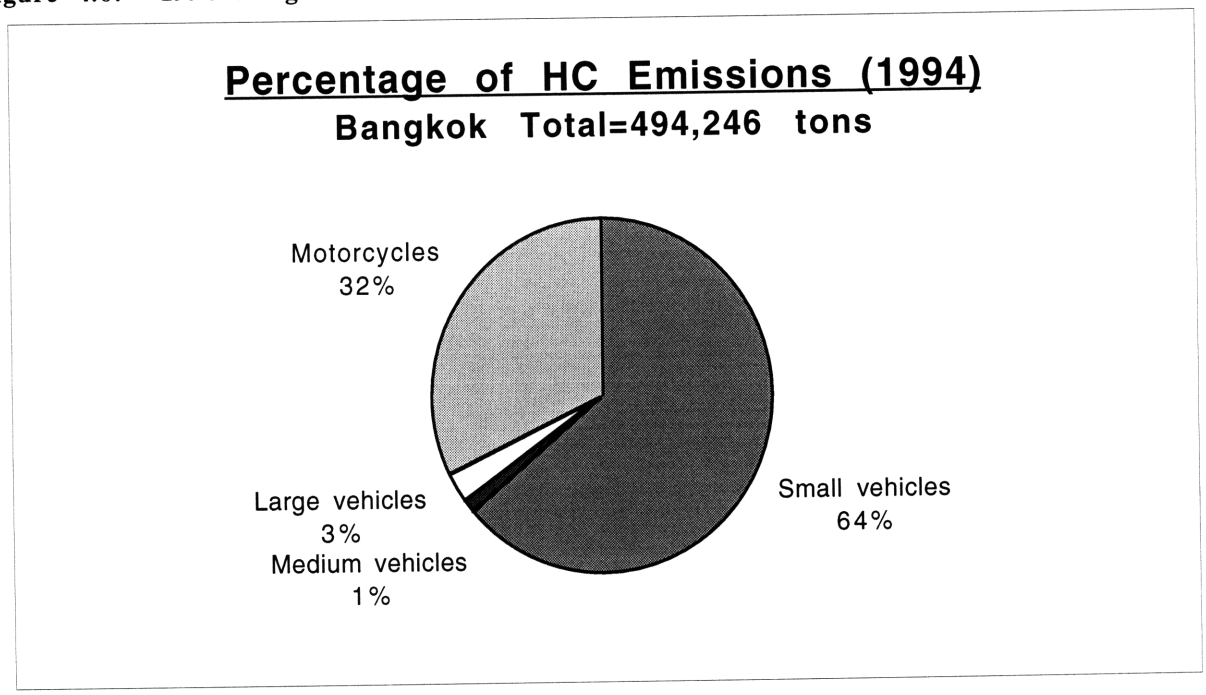

Figure 4.7: 1994 Bangkok vehicle HC Emissions (Suksod, 3/10/98).

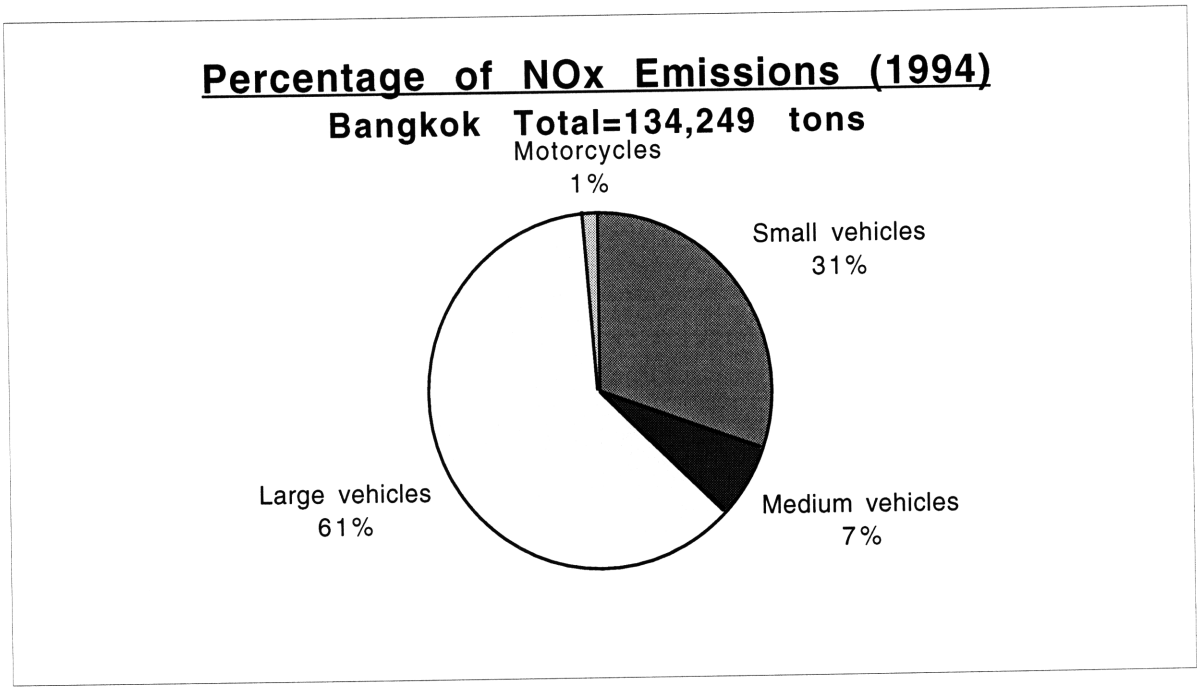

Figure 4.8: 1994 Bangkok vehicle NOx Emissions (Suksod, 3/10/98).

4.2.1.2 Greenhouse Gas Emissions & Global Climate Change

One of the products of the combustion of fossil fuels in motor vehicles is carbon dioxide. Research has found that CO2 and other 'greenhouse' gases are likely contributing to a complex process of global climate change. If such change is underway, it is likely that the consequences will be both severe and irreversible. For this reason many developed nations have, through the United Nations Framework Convention on Climate Change, begun to consider how to avert such a possibility and how various countries must reduce their greenhouse gas emissions if such change is to be avoided or at least mitigated. At present, Thailand is thought to produce between 1 and 2%

of global greenhouse gases[17]. However, because the UN FCCC members have currently decided that developing countries do not have to reduce greenhouse gas emissions, Thailand does not need to be overly concerned about its emissions of CO2 and other greenhouse gases. However, this could change as new evidence comes to light.

4.2.2 Tradeoffs

The widespread distribution of fleet emissions suggests that control measures must extend over the entire Bangkok fleet rather than just new vehicles. However many of those who own vehicles do so because they have no other means of getting to and from work. Accordingly, many of them may just barely be able to afford their vehicles at present. Any additional costs to reduce emissions may be exceptionally burdensome, especially in light of the economic crisis. For this reason, preserving equity must be a primary concern as one determines how to reduce pollution.

Unfortunately the primary means for reducing the standard automobile pollutants as well as greenhouse gases (CO2) all entail added costs. These include repair and maintenance of the vehicle, emissions control technologies, reformulated fuels, and alternative fuel vehicles. Repair and maintenance obviously entails the costs of the necessary repairs which are likely to be regressive towards the poor (e.g. the poor may have the largest repair bills) given that they have the least money to devote to maintaining their vehicle.

With respect to emissions control technologies, there a number of such technologies available for cars and trucks whether they run on petrol/gasoline or diesel. Technologies also exist for both two- and four-cycle motorcycles. However, each of these technologies has an associated cost as well, and the costs increase rapidly as the emissions reductions becomes larger.

Reformulated gasoline is another option by which to lower vehicle emissions. By reducing the amount of impurities in the fuel many of the harmful byproducts can be reduced. The true

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[17] This information came from discussions within the National Automotive Strategies and Policies Group at the Thailand Automotive Technology Workshop on April 1, 1998 in Bangkok.

benefit of reformulated fuels is that even a small percentage in emissions reduction is quickly spread throughout the entire fleet which can lead to significant reductions in the aggregate. However, these high-performance fuels work best in conjunction with high-performance engines which are well maintained. Unfortunately, Thailand has neither of these and more importantly, such fuels require additional processing which increases the cost of a fuel.

Lastly, alternative fuel vehicles provide an additional opportunity to reduce emissions through the purchase of new vehicles or the conversion of old ones. While the necessary technologies exist to make these vehicles possible, they too require added expense for the conversion as well as more expensive fuels.

4.2.3 Future Demands & Opportunities

Because there are so many options available for reducing pollutants and yet none of them meet the desire for equity, there are numerous opportunities for new and refined technologies as well as creative financing mechanisms which can be used to finance them both.

In general, many of the technologies which exist for emissions reduction are fairly new and still in the development stage. This is especially true for the new breeds of high-end catalysts which are being mandated in the US and other developing countries. However, there are other technologies which are just as advanced but have much lower marginal costs with respect to emissions reductions. One example is the 'tube' type catalyst for two-stroke motorcycles. As a Press Release from Degussa AG states "A Degussa Hot Tube® catalyst attached to the customer's motorcycle, for less than 1% of the total current motorbike sales price, will enable that bike to have more than 60% cleaner emissions" (Degussa AG, 1998). Also available as a retrofit technology, this type of technology is currently under development by numerous companies including several in Thailand (Bickle, 1998). As such, if the government were to work with industry to promote not just research and development, but also the deployment of such technology (through incentives or subsidies) within Thailand not only would Thailand benefit from cleaner air but the technology

could be demonstrated as a dramatic success. Accordingly, based on such experiences Thai industry would be better able to compete in the markets for such technology throughout Southeast Asia.

Of all of the options Thailand has regarding emissions reduction, alternative fuel vehicles are one of the most intriguing. While several functional and demonstrated technologies currently exist, the fuels are simply too expensive relative to fossil fuels to justify their use. In medium- to long-term, however, the cost of fossil fuels are expected to rise as global petroleum reserves begin to decrease. For this reason Thailand has the opportunity to begin further refining technologies which utilize resources which already exist in Thailand (as opposed to oil which is completely imported). These domestic energy sources include natural gas and the biomass which is left behind from the countries massive rice crop.

While these technologies are not currently viable, they are destined to become so as new and improved technologies lower the costs of using these fuels and the cost of petroleum begins to increase some time in the future. For this reason, the government currently has the opportunity to work with industry to bring about research, development, and deployment of viable alternative fuel vehicles today so that in the near future it can sell such vehicles to the many dense urban areas throughout Southeast Asia. In other words, Thailand has the opportunity to use its automotive industry base to advance to the next level of automotive technology and be the regional leader.

Finally, returning to the issue of greenhouse gases, in light of the fact that Thailand will eventually need to reduce its CO2 emissions, it would be prudent for Thailand to encourage the use of low-carbon intensive technologies when the difference in cost is small.

4.3 Public Health

4.3.1 Status Quo

In general, there is very little information regarding the state of public health in Thailand, and what little information does exists suffers from severe under-reporting. This is largely the result of the low wage rate which that many people cannot afford health care, and as a result the quality of their health is never known. As wages continue to rise, however, health care will become more common and more data will be available. In the meantime, it is clear that the poor air quality in Bangkok is having adverse impacts on quality of life, worker productivity, worker health, and it is causing elevated morbidity and mortality, not to mention increased frustration and poor mental health. Each of these effects has direct and indirect economic costs, some of which accrue to the employer (e.g. lost time and productivity) while others accrue to the individual (e.g. decreased quality of life, costs of medical treatment, shorter life span).

Once again, in light of the paucity of the data, it is very difficult to approximate the economic losses which occur as a result of diminished public health due to air pollution, however, this does not mean that the costs are not significant. Much of what is known about the state of health in Thailand has been discussed in greater detail in Section 3.2.2. However, one additional study which sheds light on the possible magnitude of Bangkok's losses was based on Mexico City which has been deemed to have comparable air quality to Bangkok by Ellis & Stedman (Ellis and Stedman, 1994, p.6). This health study found that in Mexico City, "economic damages due to the health impacts of air pollution are estimated at $1.5 billion per year. Particulates are estimated to cause 12,500 extra deaths and 11.2 million lost workdays per year, both due to respiratory illness" (WRI et al, 1996, p.24). While Bangkok's population is less than half of Mexico City's and it has roughly one-third of the cars, this study shows that failing to protect the public health, while not only impinging on one's right to live a healthy life, is also extremely costly-- and it only becomes more so as wages rise.

4.3.2 Tradeoffs

Once again, similar to the tradeoff discussed in Chapter 2, failing to protect the public health is in part due to the conception that such protection is too costly and would have negative impacts on the economic growth. While it is possible and indeed likely that at very low wage rates it is 'economically efficient' not to protect the public health, this oversimplication of the relationship between economic development and public health becomes increasingly costly as wages rise. For this reason, once an economy experiences significant economic development and wage increases, human resources become more valuable than material resources. Once this occurs, it become both cost-effective and economically efficient to invest in protecting the public health. Of course this entire discussion regarding the cost-effective and economically efficient protection of the public health becomes a secondary issue if a country decides that all humans are entitled to a clean environment and good health. Practically, however, such idealistic statements are never enforced, especially until society places long-term health concerns over much shorter-term concerns such as the adequate provision of food, clothing and shelter.

4.3.3 Future Demands & Opportunities

As Thailand continues to develop it wages and quality of life are likely to continue to increase. As a result, continuing to neglect the public health will get progressively more costly to business, individual citizens, and the national economy as a whole. For this reason Thailand needs to begin investing in improving public health through improved urban air quality in Bangkok and other urbanizing areas. While these changes will have clearly measurable direct costs for both business and consumers, provided such changes are soundly based, they will result in net gains in the economy rather than a loss.

4.4 Economic Development & the Automobile Industry

4.4.1 Status Quo

In 1961 the Thailand's 1st National Economic & Social Development Plan identified the automobile industry as critical to Thailand's economic and social development. Over the last 37 years the government has maintained that position and become increasingly committed to globally competitive free trade. This long history of wanting to attract and work with the automotive industry is most likely largely motivated by the tremendous economic (and resultant social) benefits that a strong automobile industry can provide.

For example, the top US-based automobile companies are the largest industrial companies in the US, they have revenues in excess of $100 billion dollars, and they routinely invest billions of dollars annually into research and development. In addition, when the large global automobile manufacturers invest in a new facility, their investments are usually quite substantial ranging from several hundred million US dollars to over one billion. Such investments can provide thousands of jobs to any country during initial construction and subsequent operation, thereby significantly contribute to improving the local and national quality of life. And once in place, these companies diffuse and transfer numerous high-technologies and skills to both the work force and the economy. In addition, since the automobile industry is typically a long-term commitment, these companies are willing to invest in the long-term, continuous education of their employees. For all of these reasons it is clear that the automobile industry has a great deal to offer Thailand.

Fortunately for Thailand, its favorable business conditions, low wage rates and land costs, as well as its demonstrated commitment to the industry have won it significant investments from global automobile manufacturers. Most recently, between 1993 and early 1998, Japanese, US, and European automobile makers have invested US $7 billion in Thailand (The Nation, 2/27/98). For this reason, Thailand is very well positioned for future demand growth in both automotive parts and automobiles for all of Asia. And as the government continues to lower import and export

duties in accordance with international and regional agreements Thailand's competitiveness should continue to increase.

4.4.2 Tradeoffs

As mutually beneficial as the relationship between Thailand and the automobile companies sounds, however, there are additional issues which each side needs to be addressed in the medium- to long-term. One such need is that of increased roadway infrastructures throughout Thailand. As demonstrated earlier in this thesis, Thailand has a severe shortage of roads both in Bangkok and throughout the entire country. Until Thailand has a roadway infrastructure which allows motor vehicles to travel efficiently and reliably over long-distances the demand for automobiles will not be realized.

Another need is education. While Thailand's wage rates are low, the supply of workers is large. As a result, there is a high turnover of factory employees which means that worker training becomes a very high priority for the industry. For this reason, Toyota has already invested in a US $20M in a training center north of Bangkok. Similarly, Thailand's lack of a highly-educated work force means that the automobile companies will need to invest significantly in the education of their management staff.

As this thesis has demonstrated, the air pollution problems in Thailand are both severe and costly. However, even as alternatives to motor vehicle transport become available, it is almost certain that as the quality of life rises, Thais will want cleaner air even as congestion related emissions hopefully decrease. For this reason, one can anticipate that government regulations will require industry to install additional emissions control equipment which will increase vehicle prices possibly hurting competition.

Finally, another concern for industry regards how Thailand sets its regulatory standards (emissions control and otherwise) relative to other countries to which Thai industry hopes to export. If Thailand adopts regulations different from potential trading partners or vice-versa, Thai

industry will be required to produce additional models for each market rather than one for all. This will result in increased prices for all and decreased competitiveness for Thai industry. For this reason, regional or global harmonization of standards is of great concern to both industry and government. Clearly the domestic automobile industry and its global competitiveness has a significant amount at stake in regard to how such standards are set. As a result, Thailand needs to balance its environmental and safety regulations against those of its neighbors so that it does not impose significant costs on its export-minded, domestic industry.

4.4.3 Future Demands & Opportunities

While several of the tradeoffs identified above appear to put industry and government at odds along the narrow dimensions presented, there are opportunities where each could work with the other for mutual gains.

First and foremost is the need for improved infrastructure for automobiles. However, as this thesis has demonstrated, increasing the quantity or otherwise improving the quality of roads is not a sustainable solution for Bangkok or other urban and developing areas. While automobiles play an important role within dense urban areas, they cannot be the exclusive form of transportation. For this reason, facilitating the development, construction, and operation of integrated, multi-modal transportation systems composed of automobiles, buses, mass rapid transit, light-rail systems and boats is in the best interests of both the automobile industry and government.

Furthermore, Asia represents a huge potential market, but it is becoming increasingly urban. This suggests that Bangkok's problems will be repeated numerous times in the future. If industry and government are to provide the mobility necessary for a growing economy in Bangkok and elsewhere, they need to work cooperatively and use all of their collective resources to ensure that efficient transportation is available to all, even though that necessarily means that automobiles will contribute less to transportation than they otherwise would.

A second opportunity for mutual gain arises from the low degree of education which exists in the Thai labor market. Before industry can employ many of its future workers it realizes it must invest in their education at the factory, manager, and engineer levels. Such general and specific education of the work force is clearly in the interests of the government in that it increases the skill set of workers and therefore their potential for higher paying jobs and a stronger economy and quality of life. For this reason, government should work with industry to find ways of cooperatively investing in and providing financial incentives for such investments.

Next, Bangkok's severe pollution problems require that it act to reduce vehicle emissions. While there are many ways to do this, it is important that these actions not restrict the domestic industry's ability to export goods to other regions. This suggests that it would be in the interests of both government and industry to push for the adoption of reasonable harmonized standards[18].

In addition, the government needs to consider the possibility of accepting standards which are not as stringent as it would like in order to facilitate the export of automobiles to other countries which have less stringent emission control standards. This, however, suggests a complementary action on behalf of industry to work with government to find additional ways of pursuing the goals of emissions reduction through other approaches including market incentives/mechanisms (e.g. fuel tax), improved public transportation, and improved land-use planning which is more compatible with urban development and sustainable automobile use (See Section 4.1.3).

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[18] 'Reasonable' refers to the need to moderate harmonized standards by ensuring that the marginal costs required by such standards are comparable of those to the market the vehicle is being sold in. For example, the marginal cost of near zero-emission control technology is not justified in a market such as Bangkok's where such reductions can be obtained through other means at much lower marginal cost.

4.5 Government Institutions & Capacity

4.5.1 Status Quo

In response to Bangkok's growing mobility problems, in 1992 the 7th National Plan increased the budget allocation for transportation related agencies by 680%. This represented an increase in the five-year budget from 43 billion Baht to more than 335 billion Baht. In addition, the 8th National Plan has further increased this to 528 billion Baht (Vongpivat, 1998a, p.23-24).

As a result of these unprecedented increases, numerous agencies which had previously been struggling to maintain their budgets much less grow, responded enthusiastically by submitting mobility related proposals to the Cabinet for funding. All in all, eleven organizations applied for national funding: eight government services and four state enterprises which together spanned three different ministries. These agencies and their respective ministries are as follows (Vongpivat, 1998a, p.24-25):

Ministry of the Interior:
- Police Department
- Department of Public Works
- Office of City Planning
- Expressway and Rapid Transit Authority of Thailand (ETA)

Ministry of Transport & Communication:
- Department of Land Transportation
- Department of State Highways
- Railway Authority of Thailand
- Bangkok Mass Transit Authority

Office of the Prime Minister:
- Office of the Commission for the Management of Road Traffic
- Office of the Committee for National, Social, and Economic Development
- Bangkok Rail Transit Authority.

As this list and especially its shear number of government related organizations suggests, Thailand lacks a centralized agency or authority which is responsible for coordinating and ensuring

integrated, cooperative services between the numerous transportation modes and services. As a result, it is almost certain that efforts are duplicated throughout the agencies but more disturbing is that the substantial budgets being devoted to solving Bangkok's mobility problems are not being coordinated and therefore not having the maximum effect (Vongpivat, 1998a, p.52). In fact, individual projects could be conflicting with each other and creating new problems.

4.5.2 Tradeoffs

Based on this assessment the need for clarifying government responsibilities is clear. At present there is no lead institution whose role is to coordinate the others. In addition, there is undoubtedly repetition of services or mis-allocation of responsibilities within these eleven organizations. For this reason, clarifying roles and consolidating services and responsibilities would be highly-beneficial. However, such reorganization are always disruptive in the near-term, especially given that they could potentially span three different ministries. For this reason, the degree of disruption needs to be weighed against the possible gains in efficiency of services.

4.5.3 Future Demands & Opportunities

Despite the difficulties which are posed by this decentralization of power, improving communication and cooperation between agencies as well as providing a single organization to act as the lead integrating agency for transportation and mobility issues could result in vastly improved services provided the reorganization was orchestrated by strong leaders with well supported goals and feasible tactics. In light of extreme lack of success in improving transportation and mobility, however, a well integrated strategy for improving mobility within Bangkok could very well provide an excellent opportunity to reorganize and provide the public with much enhanced transportation services. Gaining such support is especially true given that the first Mass Rapid Transit line will begin operation in 1999 and will hopefully provide the first positive improvement in mobility the population has seen in many years.

5. A Proposed Integrated National Strategy

The following recommendations provide a strong foundation for a new integrated, national strategy for balancing the economic development potential of the automotive industry against the urban environmental problems of air pollution and traffic congestion.

- Mobility to should be provided for all socioeconomic groups.
- Government should focus be on moving people and not vehicles (Vongpivat, 1998a).
- Encourage private sector participation in the provision of public transportation (both bus and rapid transit).
- Increase the usage of public mass transit in Bangkok through a vastly improved bus system which includes additional designated bus lanes and additional, and cleaner buses.
- Increase government willingness to subsidize mass rapid transit.
- Use infrastructure to guide development into sustainable urban forms (including both mass transit and roads).
- Increase the cost of driving by appropriate taxes to maker mass transit more attractive, reduce externalities of private automobile use, raise revenues for public transit.
- All vehicles should well maintained over the course of their life to ensure low emissions.
- Encourage further development of two-stroke motorcycle catalyst technology and industry.
- Encourage alternative fuel vehicle research.
- Provide safe ambient air quality throughout all of Thailand.
- Do not adopt excessively stringent emissions standards.
- Promote cooperative educational ventures between industry and government.
- Encourage the harmonization of regional and global standards.

- Designate a centralized transportation authority for coordinating all other related agencies.

6. References

Antaseeda, Poona. 6/18/97. "Shuttle boats being poorly run: Drivers in a hurry to empty boats," Bangkok Post. *As cited in* Vongpivat, 1998a, p.8.

Associated Press, Boston Globe, 1/19/98, "Thai auto sales down almost 40% last year."

Automotive Industry News, Thailand. 1995. http://www.thaiindex.com/news/industry/indauto.htm

Automotive Resources Asia Ltd. (ARA). 1998. ASEAN Automotive Production Outlook 1998-2002. Bangkok. *As cited in* The Nation, 2/27/98, Business Section, "Auto producers in lull ahead of boom."

Bangkok Metropolitan Administration (BMA) Department of City Planning (DCP), Massachusetts Institute of Technology (MIT) Consulting Team, EC/BMA Project Team. 1996. The Bangkok Plan: A Vision for the BMA Area, 1995-2005.

Board of Investment (BOI). Circa 1995. Investment Opportunities Study: Automotive and Autoparts Industries in Thailand - Executive Summary. http://www.boi.go.th/f/f7a.html

Board of Investment (BOI). Speech delivered at Thailand Business Conference, Berlin, Germany, October 2, 1997. http://www.baanthai.com/boie.htm

Board of Investment (BOI). "Overview of Thailand's Automotive Industry," Presented at Thailand Automotive Technology Conference, 4/1/98.

Bovonsombat, Pakorn; Pipon Boonchanta; George Hohn. 1998. "Technical Feasibility Study of Two-Way Catalytic Convertr for Two-Stroke Motorcycle in Thailand" *in* SAE, 1998c, p.27-32.

Bickle, Garry (International Catalyst Technology/Degussa AG, Tokyo, Japan). Personal Communication, March 31, 1998.

California Air Resources Board (CARB). 1997. "California's Air Quality History-Key Events." From <http://arb.ca.gov/html/brochure/!history.htm>.

Carbajo, José and Asif Faiz. "Motor vehicle emissions control: Some policy options for developing countries,' (Washington: World Bank Transport Division, Infrastructure and Urban Development draft, 1992). *As cited in* Ellis & Stedman, 1994, p.4.

Department of Highways. *As cited in* Vongpivat, 1998a, p.21.

Department of Land Transportion, 1997. *As cited in* Vongpivat, 1998a, p.17.

Degussa AG. 1998. "Degussa/ICT 2-T Motorbike Hot Tube® Catalysts" Press Release.

Economist, The. Frozen Miracle: A Survey of East Asian Economies, 7 March 1998.

Ellis, Gene and Donald Stedman (University of Denver). Mobile-Source Emissions in Five Asian Urban Areas: Some Findings and Policy Implication. Paper presented at the 1994 Annual Meeting of the International Studies Association, Washington, DC. March, 1994.

Euromonitor Plc. 1996. Consumer Asia 1996. London, England.

Euromonitor Plc. 1998. Consumer Asia 1998. London, England.

Faiz, A., K. Sinha, M. Walsh, and A. Varma (Eds.), 1990 *Automotive Air Pollution: Issues and Options for Developing Countries*, World Bank Policy and Research Working Paper WPS 492, World Bank, Washington DC.

Gakenheimer, Ralph. 3/30/1998. Personal Communication.

Kenworthy, Jeffrey R. and Felix B. Laube. (Murdoch University, Perth, Australia). Automobile Dependence in Cities: An International Comparison of Urban Transport and Land Use Patterns with Implications for Sustainability. Environmental Impact Assessment Review 1996; 16: 279-308.

Khomnamool, Nara. "Road Infrastructure in Thailand," *in* SAE, 1998c, p.41-53.

Lave, Lester B. and Chris T. Hendrickson, Francis Clay McMichael. "Environmental Implications of Electric Cars" in Science, Vol. 268, 19 May 1995. p.993-995.

Levy, John and Kyle McCarthy. 1994. Frommer's Comprehensive Travel Guide: Thailand, 2nd Edition. New York: Macmillon Travel.
Marczewski, Richard W. "Developments and Economics of Biomass for Fuels and Chemicals," *in* SAE, 1998c, p.111-116.
Mooney, John J. 1998. "Past and Developing Emission Control Technologies for Light and Heavy Duty Vehicles" *in* SAE, 1998c, p.19-25.
Ministry of Public Health. 1989. Reportable Cases and Deaths by Disease and Poisoning in Thailand; Preliminary Annual Summary, Division of Epidemiology, Ministry of Public Health, Bangkok.
Neuzil, Mark and William Kovarik. 1996. Mass media & environmental conflict : America's green crusades. Sage Publications (Thousand Oaks, Calif.).
Newman, Peter. 1996. "Reducing Automobile dependence," in Environment and Urbanization, Vol. 8, No. 1, April 1996, p.67-92.
Newman, Peter; Jeffrey Kenworthy and Peter Vintila. 1995. "Can we overcome automobile dependence? Physical planning in an age of urban cynacism," in Cities, Vol. 12, No. 1, p.53-65.
The Nation, 2/27/98, Business Section, "Auto producers in lull ahead of boom period.", Bangkok.
Office of the National Environmental Board (ONEB). 1989. *Air and Noise Pollution in Thailand 1989.* No. 07-03-33. *As cited in* WHO/UNEP, 1992, p.53.
Office of the Commission for the Management of Road Traffic (OCMRT). 1997a. "Estimated Economic Losses from Traffic Congestion," Internal Memo, July 18, 1997. *As cited in* Vongpivat, 1998a, p.21.
Office of the Commission for the Management of Road Traffic (OCMRT). 1997b. "Improving Public Transport–An Action Plan for Helping to Resolve the Economic Crisis," Internal Memo, July 18, 1997. *As cited in* Vongpivat, 1998a, p.8.
Office of the Commission for the Management of Road Traffic (OCMRT). 1997c. Solutions to the Traffic Problem. January, 1997.*As cited in* Vongpivat, 1998a, p.17).
Office of the Commission for the Management of Road Traffic (OCMRT). 1997d. "Fact Sheet of BMR Transportation," *as cited in* Vongpivat, 1998a, p.19.
Ostro, Bart, "Estimating the Health Effects of Air Pollutants: A Method with and Application to Jakarta," Policy Research Working Paper No. 1301 (The World Bank, Washington, DC, 1994).
Phantumvanit, Dhira and Liengcharernsit, Winai. 1989. "Coming to terms with Bangkok's environmental problems," Environment and Urbanization, Vol. 1, No. 1, p.31-39.
Phantumvanit, Dhira and Sathirathai, Khunying Suthawan. January/February, 1988. "Thailand: Degradation and Development in a Resource-Rich Land," *Environment*, Vol. 30, No. 1.
Phasukavanich, Chakramon. 1998. "Thailand's Investment Promotion Policy" *in* SAE, 1998c, p.1-4.
Pollack, Andrew. 8/11/97. "I.M.F., With the Help of Asians, Offers Thais $16 Billion Bailout," Business Day, The New York Times.
Potter, Joanne R. (1994). *Dilemmas in Water and Wastewater Pricing: The Case of Bangkok, Thailand.* Master of City Planning Thesis, Department of Urban Planning, Massachusetts Institute of Technology.
Rabinovitch, Jonas and Josef Leitman. "Urban Planning in Curitiba," in Scientific American, March 1996, p.46-53.
Shafer, Andreas and David Victor. "The Past and Future of Global Mobility" in *Scientific American*, October 1997, p.58-61.
Society of Automotive Engineers (SAE). 1998a. Thailand Automotive Technology Conference Program.

Society of Automotive Engineers (SAE). 1998b. Thailand Automotive Technology Workshop Program.
Society of Automotive Engineers (SAE). 1998c. Thailand Automotive Technology Conference-Extended Abstracts.
Society of Automotive Engineers (SAE). 1995. China Automotive Technology Workshop Recommendations.
South Coast Air Quality Management District (SCAQMD), California. 7/1/96. Smog and Health. From <http://www.aqmd.gov/smog/inhealth.html>.
Shin, Euisoon et al., "Valuing the Economic Impacts of Environmental Problems: Asian Cities," Urban Management Programme Discussion Paper (draft) (The World Bank, Washington, DC, 1992), p.139. *As cited in* J. David Foster, *The Role of the City in Environmental Management: 1994 Edition* (U.S. Agency for International Development, Washington, DC, 1994), p.20.
Strickland, Rod. "Bangkok's Urban Transport Crisis," in The Urban Age, Vol. 2, No. 1, Fall 1993, p.1-6.
Stubbs, Christopher. (1996). *Integrated Water Resources Management in the Chao Phraya River Basin, Thailand.* Dual Masters Thesis, Department of Civil & Environmental Engineering/Technology & Policy Program, Massachusetts Institute of Technology.
Sukondhasingha, Khemadhat. "Automotive Industry Policy Development." *Addendum to* SAE, 1998c.
Suksod, Janejob. Thailand Pollution Control Department. Personal Email Communication, March 10, 1998.
Sutabutr, Harit. "Key Automotive Parts Manufacturing Technologies in Thailand," in SAE, 1998c, p.145-150.
Taylor III, Alex. 3/17/97. "Danger: Rough Road Ahead," Fortune Magazine Online. http://www.pathfinder.com/fortune/1997/970317/aut.html
United Nations. 1989. *Prospects of World Urbanization 1988*, Population Studies No. 112, New York.
United Nations (UN). 1997. *Urban and Rural Areas 1996.*
US Agency for Internation Development (USAID). 1990. *Ranking Environmental Health Risks in Bangkok, Thailand*, Washington, DC. *As cited in* WHO/UNEP, 1992, p.55.
Vongpivat, Pratana. February 2, 1998. Bangkok Traffic Problem and the Solutions. Master of Arts Thesis, Fletcher School of Law and Diplomacy, Tufts University, Massachusetts, USA.
Vongpivat, Pratana. 1998b. Personal communication, May 12, 1998.
Wangwongwattana, Supat. "Addressing Air Pollution Problems from Mobile Sources in Bangkok," circa 1993, p.3 *as cited* in Ellis and Stedman, 1994, p. 7.
Wangwongwattana, Supat. "Unleaded Air in Bangkok," 2/20/98. http://www.pcd.go.th
Wangwongwattana, Supat. "Thailand's Automotive Air Pollution Control Strategies," Presented at Thailand Automotive Technology Conference, 3/30/98, Bangkok. Paper included *in* SAE, 1998c.
Wanisubut, Suwat. 1998a. National Land Transportation Policies of Thailand. Presentation at Thailand Automotive Technology Conference, Bangkok, Thailand, March 30, 1998.
Wanisubut, Suwat. 1998b. Personal communication, May, 16, 1998.
World Bank (WB). 1996. Sustainable Transport: Priorities for Policy Reform. World Bank (Washington, DC). *As cited in* Gakenheimer in SAE, 1998c, p.55.
World Health Organization and United Nations Environment Programme (WHO/UNEP). 1992. *Urban air pollution in megacities of the world: earthwatch: global environmental monitoring system.* Blackwell Publishers, Cambridge, Massachusetts.

The World Resources Institute, The United Nations Environment Programme, The United Nations Development Programme, The World Bank (1996). *World Resources 1996-97: A Guide to the Global Environment: The Urban Environment.* Oxford University Press, New York.