Thailand

Reducing Emissions from Motorcycles in Bangkok

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Acknowledgments

This report summarizes the findings of a study partially financed by the joint United Nations Development Programme (UNDP)/World Bank Energy Sector Management Assistance Programme (ESMAP). The study aims to assist the Bangkok Metropolitan Administration (BMA) to design an implementation plan for the reduction of emissions from two-stroke engine motorcycles in Bangkok, Thailand. This study designed a plan to phase out in-use old motorcycles in partnership with the government agencies and private sector (manufacturers and local banks) and formulated a project concept. While the World Bank Project was not pursued by the Government, the Association of Thailand Motorcycle Manufacturers is currently pursuing financing to implement the concept.

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Abbreviations and Acronyms

BAQMP	Bangkok Air Quality Management Project
BMA	Bangkok Metropolitan Administration
BMR	Bangkok Metropolitan Region
CH_4	Methane
CO	Carbon Monoxide
CSC	Community Service Cooperative
EOI	Expression of Interest
ERR	Economic Rate of Return
ESMAP	Energy Sector Management Assistance Programme (World Bank)
FI	Financial Intermediary
GSB	Government Savings Bank
HC	Hydrocarbons
I/M	Inspection and Maintenance
LTD	Land Transportation Department
LPG	Liquefied Petroleum Gas
LTA	Local Transport Authority
MC	Motorcycle
MUP	Bangkok Motorcycle Upgrade Project
MVA	Motor Vehicle Administrator
NDIR	Non-Dispersive InfraRed analyzer
NEPO	National Energy Policy Office
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxide
OEM	original equipment manufacturers
PDK	Project Development Unit
PM	Particulate Matter
PCD	Pollution Control Department
PMU	Project Management Unit
ppm	Parts per million
ppb	Parts per billion
RTG	Royal Thai Government
SO_2	Sulfur Dioxide
SOI	small side street
SRT	State Railway of Thailand
TAI	Thailand Automotive Institute
TSP	Total Suspended Particulates
UNDP	United Nations Development Programme

VOC	Volatile Organic Compound

Units of Measure

cc	Cubic centimeter
g/km	Grams per kilometer
Km/hr	Kilometers per hour
km/liter	Kilometers per liter
$\mu g/m^3$	Micrograms per cubic meter
mg/m^3	Milligrams per cubic meter
ppm	Parts per million
ppb	Parts per billion

Currency Equivalents

currency unit = baht

Executive Summary

1. Increasing economic activity in and around the Bangkok Metropolitan Administration (BMA) has led Thailand's three-decade, impressive growth. However, this rapid growth resulted in increased motorization, rise in traffic congestions, and deteriorating air quality. The fine particulates (<10 microns) or PM_{10}, which have been known to cause serious health impacts such as premature mortality and morbidity, are identified as main concerns. One of the major contributors to PM_{10} emissions in Bangkok and many other Asian cities is the use of two-stroke motorcycles. During the year 1999, 80 percent of the motorcycle fleet in Bangkok had two-stroke engines, and posing a significant threat to present and future human health. This report presents a plan to assist the BMA to reduce emissions from two-stroke engine motorcycles in Bangkok.

2. Two motorcycle clinics were organized in Bangkok in May and July 2000 to improve the knowledge base, to promote awareness, to encourage interagency coordination and public–private partnerships, and to pilot the approach in generating lessons for the proposed Bangkok Motorcycle Upgrade Project (MUP). During these clinics, significant lessons were learned and observed on the issues of public and private sector involvement, the effectiveness of publicity campaigns and advertisements, interview questionnaire preparation and design, and the relevance of reconditioning for emissions. The design of the MUP is based on the experience gained through these project trial clinics, which tested processes for encouraging testing, repair, and replacement of the motorcycles. The MUP uses an innovative approach in accelerating the phasing-out of polluting motorcycles by targeting gross-polluting motorcycles in Bangkok. The MUP is designed to "buy back" pollution from the polluters by partnering private and public sectors, namely, the motorcycle manufacturers, the Government, the motorcycle owners, and donors.

3. The emissions characteristics of the motorcycle fleet will gradually improve as new motorcycles are purchased and old motorcycles are scrapped or relocated from Bangkok. The project will contribute to significant improvement in the maintenance of current motorcycles and replacement of irreparable, excessively polluting motorcycles by providing incentives. With the net present value of US$9.7 million for the costs, the benefits were estimated at US$29.9 million—yielding a net benefit of US$20.2 million and a benefit-to-cost ratio of 3.1 and Economic Rate or Return (ERR) of 102 percent. Benefits that have been valued include public health improvement and greater fuel economy. The costs for the motorcycle upgrade and associated components include project management; Inspection and Maintenance (I/M) program for the MUP; Land Transportation Department (LTD) I/M program strengthening; and tune-ups, major repairs, scrappage, bringing forward the date of new vehicle purchase, and offering incentives.

4. The MUP design is replicable and flexible. The project concept is not specific to motorcycles or Thailand. It can be applied to other mobile sources of air pollution in other countries. Moreover, the incentives and the components can be adjusted based on the amount of funds available. For example, the value of incentives may be decreased if the project needs to target a smaller number of polluting vehicles; or scrap allowance may be eliminated if the trade-in vehicle is allowed to be sold elsewhere.

5. Key lessons learned from the MUP can be grouped into three main categories: institutional development, enforcement, and global experience. On the institutional front, project design similar to the MUP needs to consider the following components: the lack of institutional capacity in developing countries, fraud and corruption, involvement of the private sector, strong leadership, and transparent community and public consultation process. Enforcement is a key to the success of this type of project. The key issues to be considered are establishing the knowledge base and analytical capacity throughout the technical and executive levels, obtaining appropriate legal basis for the needed improvements, instituting public awareness and educational campaigns, and implementing on-street enforcement as an integral part of the traffic management program. Global experience has shown that air quality management is complex and requires cross-sectoral responses; source control and fuel quality improvements are more effective than tail-pipe exhaust control; public participation and partnerships with relevant stakeholders should be supported; and institutional capacity building is complex and requires cross-sectoral collaboration, flexibility, and clear targets and responsibilities.

1

Air Quality in Bangkok and Transport Source

1.1 Increasing economic activity in and around the Bangkok Metropolitan Region (BMR) has been a predominant force in Thailand's growth over the past 30 years. The BMR comprises Bangkok City and its five surrounding provinces. Over 15 million people live in this region, with 5.7 million living in the City of Bangkok alone. The population and transportation sector increase with rapid economic growth have raised concerns for acute air pollution in Bangkok.

1.2 The air pollution in Bangkok is categorized as "severe" with regard to suspended particulate matter (PM), with concentration levels reaching up to two times the ambient air standards, especially during the mid to late 1990s. Particulate matter, especially the very fine particles, is a major health threat to the population, for when inhaled, it can cause a range of cancers and neurological disorders. However, recent data in Bangkok show a substantial decrease in PM concentration.

1.3 Although the Carbon Monoxide (CO) level may not be an immediate concern for Bangkok, Nitrogen Oxide (NO_x) and Volatile Organic Compounds (VOCs)—the key ingredients of photochemical smog—may emerge in the future as a significant problem. A reliable pollutant inventory is very important to assess this problem in the future. Currently there is clearly a problem in the methodology used to prepare and report emission inventory in Thailand. This is evidenced by significant discrepancies in inventories reported by different agencies—in some cases by a factor of 20.

1.4 Tables 1.1 and 1.2 summarize Bangkok's 2001 ambient air quality and curbside air quality, respectively. The most threatening pollutant in Bangkok is PM_{10}, which accounts for 50 percent of Total Suspended by Particulates (TSP), by weight, in the city. At the curbside, there were 169 out of 1,614 observations, representing about 10 percent of the total observations, where the ambient air quality standard was exceeded. However, in recent years (especially after 1999) the percentage of PM_{10} exceeding standards has fallen to about two percent of total observations in Bangkok.

Table 1.1: Ambient Air Quality in Bangkok, 2001

	Concentration				
Air pollutant	*Range*	*95th Percentile*	*Average*	*Standards*	*Frequency of exceedance*
TSP (24-hr) mg/m^3	0.03 – 0.49	0.19	0.09	0.33	(0.54) 2/370
PM_{10} (24-hr) ug/m^3	6.6 – 142.1	73.2	40.5	120	(0.12) 2/1550
CO (1-hr) ppm	0.0 – 8.50	2.57	0.94	30	0/67368
CO (8-hr) ppm	0.0 – 5.87	2.28	0.94	9	0/68654
Pb (24-hr) ug/m^3	0.01 – 1.32	0.50	0.13	—	0/372
Pb (monthly) ug/m^3	0.02 – 0.69	0.40	0.12	1.5	0/107
O_3 (1-hr) ppb	0.0 – 183.0	49.0	14.3	100	(0.14) 75/54764
SO_2 (1-hr) ppb	0.0 – 103.0	16.0	5.6	300	0/69272
SO_2 (24-hr) ppb	0.0 – 50.2	12.5	5.6	120	0/2899
NO_2 (1 hr) ppb	0.0 – 164.0	54.0	22.5	170	0/73290

Source: Pollution Control Department (PCD) (2001); — data not available; n.a. data not applicable.

Table 1.2: Curbside Ambient Air Quality in Bangkok, 2001

	Concentration				
Air pollutant	*Range*	*95th Percentile*	*Average*	*Standards*	*Frequency of exceedance*
TSP (24-hr) mg/m^3	0.05 – 0.46	0.31	0.18	0.33	(2.78) 15/540
PM_{10} (24-hr) ug/m^3	21.3 – 233.9	140.5	67.9	120	(10.5) 169/1614
CO (1-hr) ppm	0.0 – 22.0	4.90	2.03	30	0/51243
CO (8-hr) ppm	0.0 – 12.0	4.44	2.03	9	(0.08) 39/51762
Pb (24-hr) ug/m^3	0.02 – 0.81	0.25	0.11	—	0/381
Pb (monthly) ug/m^3	0.03 – 0.49	0.25	0.12	1.5	0/95
O_3 (1-hr) ppb	0.0 – 100.0	26.0	7.0	100	0/23614
SO_2 (1-hr) ppb	0.0 – 109.0	18.0	7.2	300	0/22032
SO_2 (24-hr) ppb	0.3 – 54.3	13.9	7.2	120	0/946
NO_2 (1-hr) ppb	0.0 – 197.0	77.0	35.2	170	(0.04)10/23728

Source: PCD (2001).

1.5 Evaluation of the latest emissions inventory provides a more detailed picture of emissions rates from mobile, point, and area sources in Bangkok. Tables 1.3 and 1.4 show that mobile sources are major emitters of NO_x (80 percent), CO (75 percent), particulates (54 percent), and hydrocarbons (100 percent).

Table 1.3: Annual Emissions of Air Contaminants in the BMR, 1997

Emission source	*Emission rate (tons/yr.)*						
	NO_x	*SO_2*	*CO*	*PM*	*VOC*	*HC*	*CH_4*
Point source	56,002	229,859	6,266	3,735	2,005	—	—
Mobile source	264,648	9,973	349,771	20,602	—	232,973	—
Area source	8,511	184	107,738	13,855	33,904	—	177,370
Total emissions	329,161	240,016	463,775	38,192	35,909	232,973	177,370

Source: PCD (2000).

Table 1.4: Percentages of Emissions in BMR, 1997

Emission source	*Percentage of total emissions*						
	NO_x	*SO_2*	*CO*	*PM*	*VOC*	*HC*	*CH_4*
Point source	17.01	95.77	1.35	9.78	5.58	—	—
Mobile source	80.40	4.15	75.42	53.94	—	100.00	—
Area source	2.59	0.08	23.23	36.28	94.42	—	100.00
Total of all sources	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: PCD (2000).

1.6 Motor vehicles generate a significant percentage of total PM pollution, especially the most dangerous particulates, which are both toxic and very small (and hence numerous). Diesel engines and two-stroke motorcycles account for over 95 percent of all vehicle-related PM emissions. Gasoline and Liquefied Petroleum Gas (LPG)-powered cars, common in the city streets, produce only very low levels of PM.

1.7 Two-stroke motorcycles contribute significantly to fine particulate emissions, the health impact of which is estimated to be over US$100 million per year. The government has passed tighter regulation—while considering and rejecting a ban of this type of motorcycle. In response, manufacturers since 1997 have switched their motorcycle production overwhelmingly to four-stroke engines. In 2000, an estimated 70 percent of the new motorcycle sales were four-stroke engines; by 2002 the share had grown to 85 percent. But the large in-use two-stroke engine motorcycle fleet of 560,000 (80 percent of the total registered) will not be completely

eliminated from Bangkok for many years, and will end up being a significant contributor to the area's air pollution.

1.8 Current in-use motorcycle emissions standards are not enforced effectively because of a weak institutional capacity and a poor motorcycle inspection and maintenance culture. This is in part due to the financial inability of especially poorer motorcycle owners to pay for improvements required under a more stringent enforcement regime. Box 1 describes existing characteristics of the motorcycle market and in-use fleet in 2000. Box 2 presents findings from a study of the socioeconomic characteristics of motorcycle drivers in Bangkok and their motorcycle usage.

1.9 In an attempt to tackle the above problems, in 1998 the Bangkok Metropolitan Administration (BMA) and the World Bank developed the Bangkok Air Quality Management Project (BAQMP). Studies under the BAQMP, conducted in 1998 to 1999, identified air pollution from mobile sources, particularly the two-stroke motorcycles, as one of the key air quality issues. Motorcycle clinics were conducted in 2000 to gather both emissions and socioeconomic data from the motorcycles and their users, which contributed significantly to the concept and design of the Bangkok Motorcycle Upgrade Project (MUP). The detailed MUP design and appraisal was completed in 2001.

1.10 Section 2 of this report describes the motorcycle clinics and the tests conducted on the participating motorcycles during and after the clinics, and presents an analysis of the information obtained from these activities, which were used as inputs to the design of the MUP. Section 3 describes the concept and original design of the MUP and the associated costs and benefits of the project. Section 4concludes with lessons learned from the clinics and preparations of the MUP.

Box 1: The Bangkok Motorcycle Market

The legally registered in-use motorcycle fleet in Bangkok declined 25 percent, from 961,800 motorcycles in 1995 to 716,700 by 1999. This decline is a result of the economic stagnation which greatly reduced new motorcycle sales in the late 1990s. Sales of new motorcycles peaked at 244,000 in 1994 and slowed to 86,000 by 1999. In 2000, sales of new motorcycles rebounded and grew to 109,000. With sustained economic recovery, motorcycle sales will continue to increase, resulting in renewed growth of the in-use fleet. The registered in-use fleet is forecasted to grow to 864,000 by 2004.

In 2000, the total in-use fleet in Bangkok was estimated to be 800,000, of which 690,000 were legally registered and of which approximately 80 percent were powered by two-stroke engines with the balance being four-stroke. However, the trend is shifting; in 2000, 70 percent of all new motorcycles sold in Bangkok were four-stroke.

Table 1.5: Legally Registered In-Use Motorcycle Fleet in Bangkok (End-of-Year)

Year	*1995*	*1996*	*1997*	*1998*	*1999*	*2000 (Estimate)*	*2004 (Forecast)*
Total fleet	961,800	963,000	893,900	756,300	716,700	690,700	864,000

Source: *LTD for data* (1995–99); *Forecast for 2000 and 2004. See annex 1 for further details of forecasts*.

Table 1.6: Characteristics of the In-Use Motorcycle Fleet in Bangkok

Characteristic	*Statistic or estimate (million)*
No. of registered motorcycles, 1999[1]	1.6
Estimated no. of registered motorcycles, 2000[1]	1.7
Estimated in-use (legal and illegal) motorcycles in Bangkok, 2000	0.8
Estimated in-use (legal and illegal) motorcycles in adjacent provinces within BMR 2000	0.1
Estimated legally registered in-use motorcycles in Bangkok, 2000	0.69
Annual growth rate in legally registered in-use fleet Bangkok, 1995–2000	–5.7% per year
Estimated 4-stroke / 2-stroke fleet split in Bangkok, 2000	20% / 80%
Estimated percentage of new motorcycle sales in Bangkok in 2000 that were 4-stroke	About 70%
Estimated percentage of legally registered in-use motorcycles in Bangkok aged > 5 years in 2000	42% or 293,300 motorcycles

[1] Includes all motorcycles registered and those formally de-registered, but not those whose registration has lapsed.

Box 2: Socioeconomic Characteristics of Motorcycle Drivers and Motorcycle Usage

Five focus groups and a survey of 923 interviews were conducted in Bangkok between June and September 2001 to obtain information on the socioeconomic characteristics of the area's motorcycle users and the motorcycles' usage.

Motorcycle usage in Bangkok falls in most cases into one of the five following groups: (1) motorcycle taxis, (2) messenger services, (3) delivery services, (4) independent business operators, and (5) general mode of transportation such as commuting to and from the office and grocery shopping.

The largest group of motorcyclists for occupational purposes appears to be motorcycle taxis followed by messenger and delivery services. Out of the 923 motorcycles in these interviews, 431 were motorcycle taxis, 122 were messenger service motorcycles, 100 were delivery service motorcycles, 36 were independent business operators, and 222 were used for general mode of transportation. Motorcycle taxi motorcyclists were the most organized group of users when compared to other groups.

Source: Narongsak Jukrkorn, 2001, *Social Assessment: Group of Motorcycle Users for Occupational Purposes*. An internal report prepared for this study.

Other findings from the study can be summarized as follows:

Age and Marital Status. The majority of motorcyclists are males between 21 and 30 years of age who are married and have one to two children.

Level of Education. The majority of motorcyclists have completed primary education, secondary education, or earned junior college certificates.

Domiciles. The majority of motorcycle taxi, messenger service, and delivery service motorcyclists have domiciles in the provinces while independent business operators and those using motorcycles as modes of transportation have domiciles in Bangkok.

Income and Expenses. The income of the majority of motorcyclists falls between 5,000 and 10,000 baht a month and expenses are between 5,000 and 10,000 baht as well.

The findings show that the group with the highest average monthly income is that of independent business operators with 18,000 baht/month; followed by users of motorcycles as mode of transportation; and motorcycle messenger services and delivery services with 15,000, 11,000, and 10,000 baht/month respectively. The group with the lowest average monthly income is that of the motorcycle taxi with 9,000 baht/month.

As for average monthly expenses, findings show that users of motorcycles as mode of transportation have the highest average monthly expenses with 16,000 baht/month, followed by independent business operators and motorcycle delivery services with average monthly expenses of 10,000 baht/month. Motorcycle messenger services and motorcycle taxis have the lowest average monthly expenses of 7,500 and 5,700 baht/month, respectively.

Costs of Motorcycle Usage. Motorcycle usage costs are associated with gasoline, engine oil, and auto lube. An additional cost that is included here is that associated with motorcycle taxi vest rental. Findings show that the group that has the highest monthly cost for motorcycle operation is the motorcycle taxis group with a monthly average of 3,490 baht/month, followed by motorcycle messenger services and motorcycle delivery services with 1,990 and 1,895 baht/month, respectively. Independent business operators and users of motorcycles as mode of transportation have the lowest monthly cost for motorcycle operations at 1,800 and 1,335 baht/month, respectively.

Indebtedness. Forty-two percent of the interviewed motorcyclists have debts between 5,000 and 10,000 baht, of which the majority were obtained from moneylenders with the rest being spread out among relatives, groups/savings cooperatives, and commercial banks.

The findings show that the users of motorcycles as mode of transportation have the highest average debt among other groups with an average debt of 50,000 baht/case, followed by independent business operators with an average debt of 40,000 baht/case. Motorcycle taxis, motorcycle delivery services, and motorcycle messenger services have the lowest average debt at 20,000 baht/case.

Motorcycle Brands. Motorcycle brands used by interviewees (listed in order of the largest to the smallest number of motorcycles) are (1) Honda, (2) Kawasaki, (3) Suzuki, (4) Vespa, and (5) Yamaha. Cylinder size of 110 cc is the most popular choice, followed by 125 and 150 cc.

Age of Motorcycle. Thirty-five percent of the motorcycles are between 6 and 10 years old and 4.6 percent are more than 10 years old.

Motorcycle Purchase. The majority of motorcycles currently being used were cash purchases and most of the motorcycles purchased through installment payments have been paid off. There is only a small minority of motorcycles for which installment payments are still being made.

Pollution Awareness. The majority of motorcycle users are aware that white smoke is a health hazard affecting the respiratory system of both the motorcycle user and others.

Maintenance and Testing Practice. Sixty-six percent of the interviewees take their motorcycles to repair shops for maintenance, 27 percent perform their own repairs, while only 7 percent go to a manufacturer service center owing to the high service cost at the service centers.

Sixty-two percent of the interviewees reported that their motorcycles emit white smoke; however, only 19 percent had taken their motorcycles to be tested for white-smoke. Among those who reported that their motorcycles do *not* emit white smoke, 66 percent have never had their motorcycles tested.

Interest in Upgrades. The majority of motorcyclists in BMR expressed interest in upgrading their motorcycles, particularly those that are over three years old. Forty-six percent of those owning motorcycles that are three to five years old have plans to purchase new motorcycles while over 50 percent of those owning motorcycles over six years old have similar plans. Groups interested in upgrading motorcycles (listed in descending order) are motorcycle messenger services, motorcycle delivery services, motorcycle taxis, and independent business operators.

The majority of those interested in upgrading motorcycles are interested in upgrading to four-stroke motorcycles because these are gasoline efficient and do not require the use of auto lube, thereby reducing air pollution. In addition, some motorcycle users are aware that in the future there may be legislation to outlaw two-stroke motorcycles. Some motorcycle users want to acquire new two-stroke motorcycles because the engines are more powerful, more durable, and are easier to maintain and repair.

Ability to Pay. Those who want to upgrade their motorcycles have the capacity to make monthly installment payments of 2,000 baht.

2

Bangkok Motorcycle Clinics

2.1 To implement the initial design of the Motorcycle Upgrade Project (MUP), two clinics were organized with support from the Bangkok Metropolitan Administration (BMA), the Pollution Control Department (PCD), the private sector, academia, and the ESMAP/World Bank.

2.2 The objectives of the clinics were as follows:

- ?? Improve the knowledge base;
- ?? Promote awareness;
- ?? Encourage interagency coordination and public–private partnerships; and
- ?? Pilot the approach to generate lessons for the proposed Motorcycle Upgrade Project.

2.3 The first motorcycle clinic was held from May 15 to May 17, 2000 near the BMA II office complex while the second motorcycle clinic was held from July 10 to July 12, 2000 at Chulachomklao Royal Military Academy School. The locations were in different parts of the Bangkok Metropolitan Area and easily accessible.

2.4 Approximately 3,000 motorcycles participated in the clinics. They were tested for emissions, tune-ups, and minor repairs. Gifts (T-shirts, caps, coupons for future repair, and so on) were given, trade-ins were offered, and information on the characteristics of the motorcycles and motorcycle owners in Bangkok and emissions results were gathered.

2.5 The steps conducted in the clinics as presented in the schematic of the clinics in figure 1 were as follows:

(1) Registration and interviews of participants

(2) Conducting emissions test 1[2] and giving free lube oil[3]

(3) Free tune-ups, minor repairs, and free spark plugs—provided by manufacturers[4]

(4) Conducting emissions test 2

(5) Results:

[2] The BMA staff performed emissions test 1. Pollution Control Department staff performed emissions test 2.
[3] Several oil products manufacturers participated in the clinics, namely Shell, Pennzoil, Castrol, and Total.
[4] Principal manufacturers participating in the clinics included Honda, Kawasaki, Suzuki, and Yamaha.

(5.1) Pass: participant receives a gift (end of process)

(5.2) Fail:

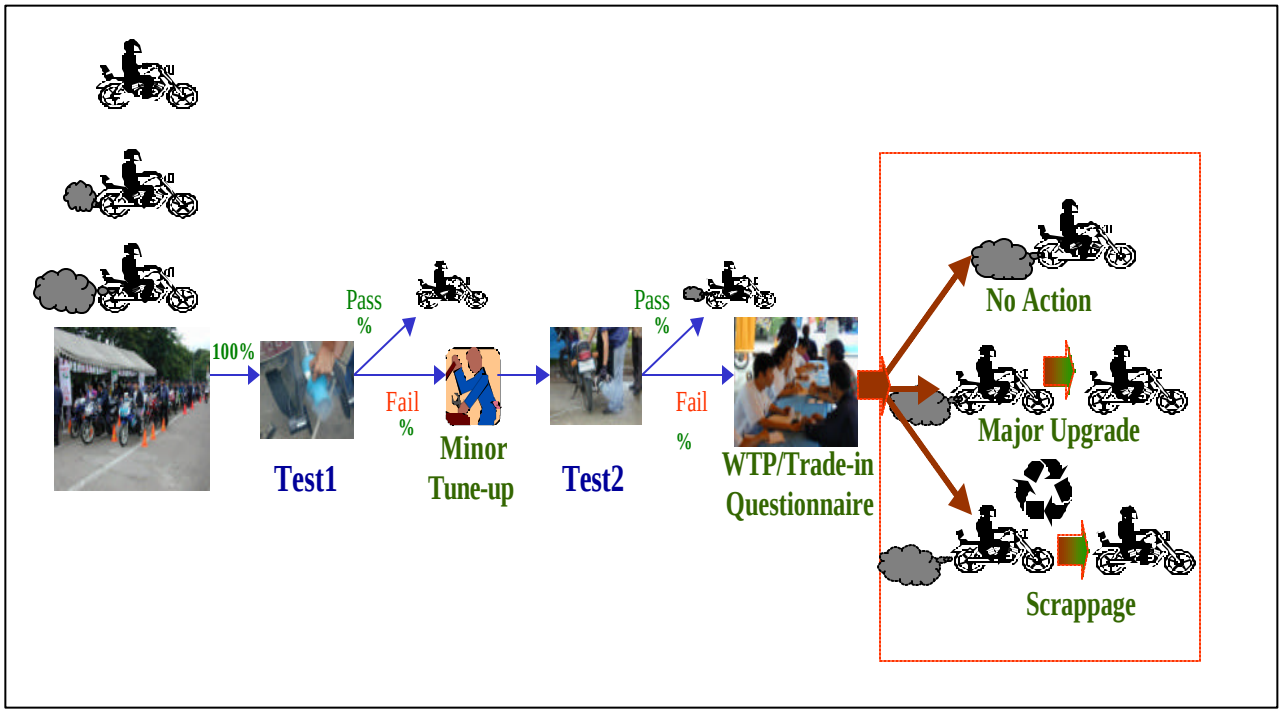
(5.21) Special interview on:

(5.21a) Willingness to pay

(5.21b) Willingness to accept trade-in

(5.22) Extensive discussion on trade-in program; participant receives a gift (end of process)

Figure 1: The Schematic of the Clinics



2.6 During registration, participants were interviewed about their motorcycle, their motorcycle usage, and their socioeconomic profile. The information was largely entered and quality-checked by trained students from Chulalongkorn University. Emissions testing stations recorded data on emissions testing results prior to and after the tune-ups and minor repairs, while the tune-up stations recorded tune-ups and minor repairs that were made on each motorcycle. If the participants' motorcycles failed test 2, the participants were interviewed on their willingness to pay for improved maintenance to keep their motorcycles or, if the motorcycle was not repairable, their willingness to accept incentives to give up their motorcycles. In addition, they were given the information on the motorcycle trade-in program in which they are eligible to participate. Incentives provided at the clinics for trading motorcycles are presented in Table 2.1.

Table 2.1: Trade-In Incentives

Contributing parties	*Type of contribution*	*Contribution (in baht)*
Motorcycle manufacturers	Discount on purchase	1,000–3,000
	Waiver of 1-year insurance	2,500
Leasing companies	0.5% discount on interest rates	1,000–5,000
World Bank/ESMAP	Incentive toward purchase	3,000

Findings from the Motorcycle Clinics

2.7 The clinics yielded a wealth of data on both the motorcycles and motorcycle owners, which could be analyzed from various viewpoints. The data set generated is rather unique, as it is one of the largest data sets on motorcycle pollution relating to technical, socioeconomic, and preference aspects. Table 2.2 summarizes basic information from the clinics, while Table 2.3 summarizes the results of the interviews. The clinics' data set is provided on the CD that accompanies this report.

Table 2.2: Summary of Clinic Information

Clinic	*Day*	*No. of motorcycles tested*	*No. of motorcycles that passed Test 2*	*No. of motorcycles that failed test 2*	*No. of motorcyclists interested in a possible upgrade*
Clinic 1	15–17 May 2000	1,400	1,100	300	90
	Day 1: July 11, 2000	390	285	97	42
	Day 2: July 12, 2000	502	378	111	57
Clinic 2	Day 3: July 13, 2000	626	466	125	71
	Total	1,518	1,129	333	170
Total (both clinics)		**2,918**	**2,229**	**633**	**260**

Table 2.3: Results of the Clinic Interviews

Characteristics	*Results*
Motorcycles and their use	?? 83 percent of the motorcycles are 2-stroke. ?? 72 percent have been in use for more than 4 years. ?? 79 percent already use low-smoke 2T lube oil. ?? 93 percent are claimed by their owners to be able to travel at speeds greater than 60 km/h. ?? More than half travel more than 50 km/day. ?? 93 percent are reported to be used for business purposes. ?? 54 percent have engine capacity of 125 cc or less, with 1 percent having capacity greater than 126cc.
Motorcycle owners	?? About half the motorcycle owners are below the age of 30, and typically have 1–2 children. ?? 85 percent earn 10,000 baht per month or less (average of 8,000 baht per month, and median of 7,000 baht per month), with average household income a little over double that of the motorcycle owner. ?? 75 percent of the owners bought their motorcycles new while the remainder purchased secondhand motorcycles. ?? Within an income range of 2,000–20,000 baht per month, the income of motorcycle owners is not strongly correlated with features of motorcycle ownership and use (for example, income explains 2 percent of emission levels, 9 percent of motorcycle age, and 8 percent of whether the motorcycle was purchased new or secondhand).
Emissions of motorcycles[5]	?? 20 percent of motorcycles aged five years or fewer failed an initial emissions test, rising to a relatively even rate of 35 percent for older motorcycles. ?? Minor repairs such as tuning, cleaning air filters, and cleaning or replacing spark plugs were able to reduce emissions sufficiently for 60 percent of motorcycles that failed an initial test to pass a subsequent test, and reduced the opacity of emissions by 50 percent.

[5] Emissions tests were performed before and after tune-ups and minor repairs by the BMA staff. Emissions tested were for carbon monoxide, hydrocarbon, and white smoke. Motorcycles that do not meet the legal standards of any one of the three emissions above failed the test.

Willingness to pay	??	About half of motorcycle owners are willing to pay an average of 2,500 baht/year for improved maintenance.
	??	79 percent are willing to pay for improved air quality and up to 4,800 baht/year to be able to continue to use their motorcycle, but only 150 baht/year if not faced with this restriction.
	??	66 percent would be willing to accept compensation to give up their motorcycle.

Note: The analysis is based on 2,071 interview questionnaires as only 600 questionnaires from the first clinic are complete and accurate and can be used for analytical purposes.

Motorcycle Trade-Ins and Testing Results

2.8 Owners of the motorcycles that failed the second test were informed of the trade-in program for which they are eligible. If interested, the motorcycle owners sell their highly polluting motorcycles to the program and purchase new four-stroke motorcycles; the program provides the owners to purchase incentives as presented previously in Table 2.1.

2.9 Of the 633 motorcycle owners whose motorcycles failed the second test, 260 expressed interest in participating in the trade-in program. Motorcycle owners who had expressed interest were invited to join the trade-in program, after which 43 traded in their motorcycles.

2.10 The 43 motorcycles traded in ranged from 3 to 20 years old, with an average age of 8 years.[6] The engine size ranged from 100 to 150 cc. One-third of these motorcycles were 150 cc and another third were 125 cc with an average trade-in value of 27,000 baht and 34,000 baht, respectively (see annex A, Table A3.1). The average trade-in values for all trade-in motorcycles and the contribution of the different stakeholders are presented in Table 2.4.

[6] The number of years is calculated based on the year 2000 when the clinics took place.

Table 2.4: Trade-in Values and Contribution of Stakeholders

Factors	*Amount (baht)*
Average wholesale price of new motorcycle (w/o discounts provided by manufacturers)	46,818
Average trade-in value of the old motorcycles (based on the motorcycle's brand, age, and conditions)	25,276
Discount contributed by the manufacturers (estimated)	5,000
Discount contributed by the World Bank (actual)	3,000
Outstanding amount required for the purchase of a new motorcycle by owners	13,542
Additional cost due to financing (for the 36 owners selecting this option)	11,816

2.11 From the 43 motorcycles, 20 were selected for the fuel consumption and emissions tests were conducted before and after being reconditioned.[7] The criteria for the selection are as follows:

?? Motorcycles used for more than three years; or

?? Motorcycles that had traveled more than 30,000 km.

2.12 The 20 motorcycles were categorized into two groups. Each group had samples of 10 motorcycles. Details of the motorcycles in Group 1 and Group 2 are presented in Tables 2.5 and 2.6, respectively. Different sets of testing were done on Group 1 and Group 2. Tests performed on motorcycles in Group 1 included emissions test at idle, fuel consumption test, and mass emissions, using facilities at Thailand Automotive Institute (TAI). Tests done on Group 2 are identical to those conducted on Group 1, but excluded the mass emissions test at TAI. The motorcycles in both groups were tested twice: before and after reconditioning.

[7] All samples were two-stroke motorcycles since there was only one four-stroke motorcycle participating in the trade-in program.

Table 2.5: Details of Motorcycles in Group 1

No.	*Brand / model*	*Chassis number*	*Model year*	*Registered number*	*Swept volum, cc*	*Accumulated distance*[8]*, km*
1	Y / BELLE-R	3PP031831	1990	9?-3697	102	73,448
2	Y / CONCORDE	29M-16247K	1984	?¨? 195	135	5,332
3	H / DASH	NZ125N-0181632	1995	5®-6625	125	50,209
4	H / NOVA	NZ110L-134312	1993	9 -0300	110	39,203
5	H / NOVA DASH	NZ125TS-0060967	1997	?¬ 599	123	72,469
6	H / DASH	NZ125TS-0027126	1996	???-144	125	76,183
7	H / DASH	NZ125N-0013365	1993	8¡ -7283	125	99,568
8	H / NSR	NS150-018642	1991	??ª 338	150	32,304
9	H / NOVA DASH	NZ125TS-0045416	1997	?? •91	123	98,180
10	K / KR150	KR150B-A22467	1993	9 -3108	150	89,686

[8] Mileage displayed by the speedometer of motorcycles.

Table 2.6: Details of Motorcycles in Group 2

No.	*Brand / model*	*Chassis number*	*Model year*	*Registered number*	*Swept volume, cc*	*Accumulated distance, km*
1	S / CRYTAL	BE12A-TH230202	1991	8?-0338	119	15,150
2	S / AKIRA	BE13B-TH110979	1991	5•-0711	109	51,945
3	Y / RXZ	3XX-044106	1993	??? 762	135	40,669
4	Y / TZR	3RR-059106	1993	??? 114	150	17,236
5	Y / JR-S	4AC-069971	1993	1¢-9355	120	52,787
6	K / GTO	GTO-M-62186	1992	9?-6536	125	18,934
7	H / DASH	NL125N-0014787	1993	¦-2162	125	51,037
8	H / NOVA	NZ110K-134833	1991	9•-9736	110	37,567
9	K / GTO	GTO-M55344	1991	??? 953	125	48,099
10	K / NEON	AH110A-A13005	1995	??¬ 254	107	73,985

Pre-Reconditioning Fuel Consumption Test

2.13 Before reconditioning, motorcycles were tested to monitor the fuel consumption rate. This test was carried out at the PDK[9] test site in Samutprakarn. The test procedures were as follows: First the speedometer of each motorcycle was adjusted to work properly, and then the devices to measure fuel consumption were installed on the tested motorcycle. This allowed the driver to turn the fuel switch on at the starting point and off at the end point. The test site was a straight private track longer than 200 meters. The tests were set at constant speeds of 30, 50, and 80 km/hr. The motorcycles with engine sizes smaller than 125 cc were tested at 30 and 50 km/hr, while those between 126 and 150 cc were tested at all three speeds. For each speed, the

[9] PDK is a Thai motorcycle importer and manufacturing company.

motorcycles were tested twice and the average fuel consumption rate was computed and recorded. The results of the fuel consumption rates for 20 motorcycles are shown in Table A2.7 and 2.8. At 30km/hr and 50 km/hr, the fuel consumption rates of the motorcycles in Group 1 were in the range of 25–74 km/liter and 21–60 km/liter, respectively. For Group 2, the fuel consumption rates were in the range of 32–56 km/liter and 28–51 km/liter for the speeds of 30 and 50 km/hr, respectively. Generally, at higher speed, the fuel consumption rate increased.

Table 2.7: Results of Fuel Consumption Test—Group 1

(Unit: km/liter)

No.	*Registered no.*	*Before reconditioning*			*After reconditioning*		
		30 km/hr	*50 km/hr*	*80 km/hr*[10]	*30 km/hr.*	*50 km/hr*	*80 km/hr*
1	9?-3697	74.1	60.6		44.9	63.5	
2	?¨? 195	48.2	39.2		40.8	32.5	
3	5®-6625	66.7	55.6		35.4	44.4	
4	9 -0300	48.8	39.2		34.2	29.6	
5	?•¬ 599	46.5	42.6		28.8	32.3	
6	???-144	55.6	43.5		40.0	34.8	
7	8¡ -7283	25.0	21.1		23.0	23.1	
8	??ª 338	58.8	58.0	44.4	44.4	38.1	34.2
9	??•91	47.1	44.0		41.2	44.0	
10	9 -3108	41.7	35.4	31.3	30.8	34.5	34.8
		Average = 51.25	Average = 43.92		Average = 36.35	Average = 37.68	

[10] The motorcycles tested at 80 km/hr have a swept volume of 126–150 cc.

Table 2.8: Results of Fuel Consumption Test—Group 2

(Unit: km/liter)

No.	*Registered no.*	*Before reconditioning*			*After reconditioning*		
		30 km/hr	*50 km/hr*	*80 km/hr*[a]	*30 km/hr*	*50 km/hr*	*80 km/hr*
1	8?-0338	37.0	30.3		46.0	43.5	
2	5•-0711	43.5	36.0		47.6	29.0	
3	??? 762	56.3	45.5		38.8	38.1	
4	??? 114	43.0	40.8	32.3	21.3	22.3	30.3
5	1¢-9355	41.7	38.1		26.7	25.6	
6	9?-6536	34.2	35.4		50.0	55.6	
7	¦-2162	47.6	50.6		48.8	45.5	
8	9•-9736	43.5	40.8		44.9	38.1	
9	??? 953	32.8	28.6		42.1	44.0	
10	??¬ 254	54.1	51.3		46.0	47.6	
		Average = 43.37	Average = 39.74		Average = 41.22	Average = 38.93	

[11] The motorcycles tested at 80 km/hr have a swept volume of 126–150 cc.

Pre-Reconditioning Emissions Test

2.14 Carbon monoxide and hydrocarbon emissions of the 20 motorcycles at idle were measured using the Non-Dispersive InfraRed (NDIR) emissions analyzers. Two analyzers were used: Horiba MEXA 554JA and the Hermann. The limits of CO and HC were 4.5 percent and 10,000 ppm, respectively. For white smoke, the measuring device was a full-flow opacity type, which has two photo-sensors—a light-emitting sensor and a light-receiving sensor. The white smoke was allowed to flow between these sensors. The amount of light received by the receiving sensor was inversely proportional to the opacity of the white smoke. The opacity limit was set at no greater than 30 percent on the device scale. Only motorcycles in Group 1 were tested for white smoke. Results of emissions at idle are shown in Tables 2.9 and 2.10. Results of Group 1 show that CO levels were in the range of 1.1–4.3 percent and HC levels were 3,460–9,310 ppm (except motorcycle number 7). White smoke levels of six motorcycles were in the range of 0–21 percent and another four motorcycles emitted white smoke exceeding the limit of 30 percent.

Table 2.9: Results of Emissions Test at Idle—Group 1

No.	*Emissions at idle before reconditioning*			*Emissions at idle after reconditioning*		
	CO (%)	*HC (ppm.)*	*White smoke (%)*	*CO (% vol.)*	*HC (ppm.)*	*White smoke (% vol.)*
1	4.3	9,310	67	4.4	7,390	75
2	1.5	4,600	14	1.8	5,250	9
3	3.8	7,530	91	3.1	8,240	14
4	1.3	4,870	48	1.9	5,710	23
5	1.1	3,460	0	3.1	7,340	16
6	2.3	5,850	3	2.9	13,990	18
7	3.0	14,540	100	3.6	12,780	42
8	2.6	8,700	17	2.9	7,570	12
9	1.5	4,870	7	1.7	5,640	10
10	1.3	5,100	21	2.1	7,710	2

Note: The staff of BMA at the PDK factory in Samutprakarn conducted the tests. The instrument was the HERMANN NDIR gas analyzer.

Table 2.10: Results of Emissions Test at Idle—Group 2

No.	*Emissions at idle before reconditioning*		*Emissions at idle after reconditioning*	
	CO (%)	*HC (ppm.)*	*CO (% vol.)*	*HC (ppm.)*
1	2.44	8,460	3.96	13,587
2	1.61	5,070	0.11	6,070
3	1.49	5,330	3.55	10,460
4	0.85	5,220	1.47	5,820
5	1.14	3,420	4.05	9,300
6	2.59	8,870	4.66	15,493
7	1.22	4,670	2.59	8,000
8	1.00	5,250	1.53	9,360
9	2.47	12,050	5.15	11,687
10	1.89	4,570	2.70	6,040

Note: The PDK staff conducted the tests and the white smoke was not monitored.

Pre-Reconditioning Mass Emissions Test

2.15 Only 10 motorcycles in Group 1 went through the mass emissions test. The facilities at Thailand Automotive Institute in Samutprakarn were used for this test. The test cycle was an ECE R-40 driving pattern. For the ECE test, two types of testing were conducted. The type 1 test was the mass emissions test and the results were in g/km. The type 2 test was the emissions concentration at idle, which was measured following the driving cycle. The results of the two tests are shown in Table 2.11, which reveals that CO emissions of three motorcycles were above the limit of 16 g/km and HC emissions of eight motorcycles were above the limit of 7.0 g/km.

Table 2.11: Results of the Emissions Tests on Chassis Dynamometer—Group 1

No.	*Before reconditioning*					*After reconditioning*				
	Type 1 (g/km)[a]			*Type 2*[12]		*Type 1 (g/km)*[12]			*Type 2*[13]	
	CO	*HC*	*NOx*	*CO (%)*	*HC (ppm)*	*CO*	*HC*	*NOx*	*CO (%)*	*HC (ppm)*
1	8.0	4.5	0.030	5.9	8,704	4.7	3.4	0.020	4.8	6,550
2	2.9	9.4	0.010	3.9	8,418	10.5	8.8	0.010	4.6	9,020
3	10.3	8.8	0.010	4.8	10,285	6.3	8.9	0.010	3.7	8,510
4	19.8	7.0	0.010	6.9	19,050	8.8	7.0	0.010	5.2	11,060
5	6.4	10.0	0.010	3.9	9,155	3.8	6.8	0.010	2.6	6,770
6	4.6	7.3	0.020	3.6	6,043	6.6	7.4	0.010	4.0	6,120
7	18.2	10.2	0.010	6.1	17,290	18.1	12.2	0.010	5.3	10,890
8	11.6	10.8	0.005	5.1	11,784	8.8	9.0	0.010	4.0	9,030
9	10.3	10.5	0.010	2.2	14,350	2.6	8.3	0.020	2.5	8,590
10	17.9	13.9	0.005	5.7	14,600	8.5	13.4	0.010	5.1	14,580
Average value	11.0	9.24		4.81	11,968	7.9	8.52		4.18	9,112

[12] Followed the ECE. R-40 Type 1 test procedure. Mass emissions of CO and HC should not exceed 16.0 and 7.0 g/km, respectively.

[13] Followed the ECE. R-40 Type 2 test procedure. CO concentration should not exceed 4.5% and HC should not exceed the limit announced by the Ministry of Science, Technology and Environment (HC < 10,000 ppm).

Motorcycle Reconditioning

2.16 After conducting emissions and fuel consumption tests on the 20 trade-in motorcycles, all 43 motorcycles were cleaned, adjusted, and reconditioned. The reconditioning process varied from one motorcycle to another depending on the motorcycle's condition. Engine parts such as cylinder jacket, cylinder head, piston, crankshaft, spark plug, oil pump, carburetor, air filter, and exhaust pipe were cleaned, checked, adjusted, or changed. The details of the reconditioning processes for motorcycles in Group 1, Group 2, and the rest are shown in Tables 2.12, 2.13, and 2.14, respectively. The reconditioning costs are also listed in the Tables. These costs can be estimated as follows: the oil change cost 82 baht/motorcycle (for 2T-oil change approximately 86 baht/motorcycle) and a spark plug replacement cost 36 baht. The labor cost for cleaning and checking a motorcycle was 100 baht if the engine size was smaller than 125 cc, and 150 baht if it was larger than 126 cc. The costs of other spare parts were determined by studying market prices.

Table 2.12: Details of Adjusting and Reconditioning of Motorcycles in Group 1

No.	*Details of adjusting and reconditioning the motorcycles*										*Cost (baht)*
	Jacket	*Piston*	*Cylinder head*	*Crank shaft*	*Spark plug*	*2T oil pump*	*Carbur etor*	*Exhaust pipe*	*Air filter*	*Note*	
1	Clean	Clean	Clean		Change	Adjust	Clean	Clean	Clean	Change ignition coil. Change 2T oil, lube oil. Set air-adjusting screw at 2 turns.	454
2		Clean	Clean		Change	Adjust	Clean	Clean	Clean	Change a rubber seal for the air filter. Change 2T oil, lube oil. Set air-adjusting screw at 2.5 turns.	319
3	Clean	Clean	Clean	Clean	Change	Adjust	Clean	Clean	Clean	Set air-adjusting screw at 2.5 turns. Change 2T oil, lube oil.	404
4	Clean	Clean	Clean	Clean	Change	Adjust	Clean	Clean	Clean	Change 2T oil, lube oil. Set air-adjusting screw at 1.75 turns.	304
5	Clean	Clean	Clean	Clean	Change	Adjust	Clean	Clean	Clean	Change 2T oil, lube oil. Set air-adjusting screw at 2.5 turns.	354
6	Clean	Clean	Clean	Clean	Change	Adjust	Clean	Clean	Clean	Change a rubber fuel line. Change 2T oil, lube oil. Set air-adjusting screw at 1.75 turns.	354
7	Clean	Clean	Clean	Clean	Change	Adjust	Clean	Clean	Clean	Change a crankshaft seal. Change 2T oil, lube oil. Set air-adjusting screw at 2 turns.	404
8		Clean	Clean		Change	Adjust	Clean	Clean	Clean	Change 2T oil, lube oil. Set air-adjusting screw at 2turns.	354
9		Clean	Clean		Change	Adjust	Clean	Clean	Clean	Change 2T oil, lube oil. Set air-adjusting screw 1 ¾ turns.	354
10		Clean	Clean		Change	Adjust	Clean	Clean	Clean	Change 2T oil, lube oil. Set air-adjusting screw at 2.5 turns.	354

Table 2.13: Details of Adjusting and Reconditioning of Motorcycles in Group 2

	Details of adjusting and reconditioning of the motorcycles								*Cost*
No.	*Jacket*	*Piston*	*Cylinder head*	*Crank shaft*	*Spark plug*	*2T oil pump*	*Carburetor*	*Exhaust pipe*	*Air filter*	*(baht)*
1					Clean		Clean		Change	136
2					Clean		Clean		Clean	-
3					Clean		Clean		Clean	-
4					Change		Clean		Change	136
5					Clean		Clean		Change	100
6					Clean		Clean		Change	100
7					Clean		Clean		Clean	-
8					Clean		Clean		Clean	-
9					Clean		Clean		Change	100
10					Clean		Clean		Clean	-

"-" denote negligible costs.

Table 2.14: Details of Estimated Values, Reconditioning Costs, and Sale Prices of the Remaining 23 Motorcycles

No.	*Registered number*	*Estimated values (baht)*	*Reconditioning costs (baht)*	*Sale prices after reconditioning (baht)*
1	1ª-3245	23,300.00	3,927	18,500
2	?¥? 949	21,100.00	3,061	20,000
3[14]	1¦-6695	12,000.00	---------	---------
4	1?-3402	27,500.00	2,921	23,000
5[15]	7?-6001	4,000.00	--------	---------
6	7¦-7341	23,000.00	2,898	20,000
7	8 -5068	21,000.00	3,136	19,000
8	6?-6838	8,500.00	6,187	9,000
9[15]	3•-1910	5,000,00	---------	---------
10	??¬ 307	46,800.00	1,123	30,000
11	7¢-8154	35,100.00	1,745	23,500
12	1®-9757	38,400.00	1,885	22,500
13	5¦-5791	38,300.00	11,882	23,000
14	5¥-4262	40,800.00	2,414	27,000
15	??¡ -35	36,000.00	11,224	26,000
16	4- -4382	36,000.00	5,694	23,500
17	???-333	46,875.00	756	27,500
18	??? 490	39,000.00	6,615	19,000
19	2ª-2052	30,000.00	667	21,500
20	7?-9436	26,000.00	2,414	18,500
21	??? 195	14,000.00	643	14,000
22[16]	8ª-6872	35,000.00	2,177	--------
23	??ª 79	8,000.00	1,485	8,000

[14] The motorcycle was stolen while it was kept at the PDK factory.
[15] The reconditioning costs of these two motorcycles were so high that they might not be worth repairing.
[16] This motorcycle is waiting for spare parts.

Post-Reconditioning Fuel Consumption Test

2.17 After all the motorcycles were cleaned, checked, adjusted, or replaced with parts, the reconditioning processes were completed. To investigate the effects of reconditioning motorcycles on fuel consumption and emissions, the tests that were conducted before the reconditioning were repeated. Table 2.7 and 2.8 showed the results of fuel consumption tests before and after the reconditioning for the motorcycles in Group 1 and Group 2, respectively. After the reconditioning process, the fuel consumption rates of the motorcycles seemed to increase moderately. It is noted that in Group 1, the average fuel consumption rates changed from 51.25 km/liter to 36.35 km/liter at the speed of 30 km/hr and 43.92 km/liter to 37.68 km/liter at the speed of 50 km/hr. For Group 2, the average fuel consumption rates changed from 43.37 km/liter to 41.22 km/liter at the speed of 30 km/hr and 39.74 km/liter to 38.93 km/liter at the speed of 50 km/hr.

2.18 The reconditioning process involves adjusting motorcycle carburetors to the manufacturing set point, which usually yields good engine performance and produces certain concentrations of CO and HC at idle. This is why following reconditioning, motorcycles tend to increase fuel consumption rates and produce slightly higher CO and HC when idling.

Post-Reconditioning Emissions Test

2.19 The emissions test at idle was also repeated after the reconditioning process. The results before and after the reconditioning for motorcycles in Groups 1 and 2 were shown previously in Tables 2.9 and 2.10, respectively. After the reconditioning process, CO and HC levels at idle generally increased, while white smoke levels decreased.

Post-Reconditioning Mass Emissions Test

2.20 For the mass emissions test at Thailand Automotive Institute in Samutprakarn, only motorcycles in Group 1 were tested. The results of the mass emissions (type 1) expressed as g/km and the emissions concentration (type 2) before and after reconditioning were shown in Table 2.11. It is shown that the reconditioning process can help reduce CO mass emission modestly. Three motorcycles failed CO mass emissions test reduction from three units to one unit after the reconditioning process. Although the reconditioning process can reduce the HC mass emissions slightly, its amount, both before and after reconditioning, is still higher than the limit of 7.0 g/km. The results of the type 2 test show that CO and HC concentrations are reduced slightly after the reconditioning process.

Observations and Lessons

2.21 Some of the observations and lessons learned from the motorcycle clinics with implications of reconditioning motorcycles can be summarized as follows:

- During the process of testing, maintenance awareness, and motorcycle trade-ins, it can be determined that the commitment of key stakeholders—both public and private sectors—is vital for the success of the program. In the case of Thailand, key stakeholders included the Bangkok Metropolitan Administration, the Land

Transport Department, which grants testing stations licenses in Thailand; the Pollution Control Department, which examines the air quality in Thailand; and the motorcycle manufacturers and oil producing companies.

- Publicity campaigns and advertisements are important not only for attracting participants to the clinics but also for raising awareness of vehicle maintenance, inspection, and air pollution. Publicity campaigns should be carried out both before and after the clinics, in the form of leaflets, press conferences, or television and radio announcements and news.
- Training of staff to undertake the interview questionnaire is extremely important in order to obtain accurate information. Training should include understanding of the questionnaire as well as interview techniques, for some questions can be sensitive (for example, one's willingness to pay).
- Pretests of the questionnaires are also vital. Pretests should be conducted until a good questionnaire is obtained.
- It is important to note that the design of the questionnaire should also take into account of the cultural context of the country. For example, the questions on one's willingness to pay and willingness to accept trade-in must be culturally sensitive in order to obtain accurate information from interviewees.
- Emissions and fuel testing of the traded-in motorcycles indicated that it is not clear that reconditioning of the polluting motorcycles would help reduce overall emissions and fuel consumption of old, polluting motorcycles. Upgrading the motorcycles is the best way to achieve reduced emissions and fuel consumption.

3

The Bangkok Motorcycle Upgrade Project (MUP)

3.1 Using an innovative public-private partnership approach, the Bangkok Motorcycle Upgrade Project (MUP) lays the basis for the implementation of an effective system of motorcycle inspection and maintenance in Bangkok for the longer term. Under the MUP, greater enforcement of tightening regulations will hold future motorcycle owners more accountable for the condition of their motorcycles.

3.2 The project will use a voluntary demonstration upgrade program for registered in-use motorcycles and will focus on motorcycles five years or older (which presently matches the Land Transportation Department's [LTD] current age for mandatory annual inspection). The project involves inspection of motorcycles, increasing public awareness of the benefits of good maintenance, minor and major repair of motorcycles, and accelerating the upgrading of the motorcycle fleet through remanufacture or scrapping of highly polluting vehicles. The estimated 250,000 motorcycles entering the program over the life of the three-year project will benefit from testing, and where required, minor improvements. About 21,000 of the oldest, highly polluting motorcycles (3 percent of the registered in-use fleet estimated at 700,000 in 2000) will be replaced with new ones.

3.3 Incentives provided under the project are designed to achieve a one-time "buy back" of pollution. They are designed to ease the burden on owners of old, polluting motorcycles who will comply with official regulations and are legally registered by the LTD as the stricter emissions regulations are enforced. For the owners of the most polluting motorcycles[17], the program will encourage and accelerate the purchase of new motorcycles by providing a financial incentive (for example, a trade-in coupon) to decrease the financial gap between their available down payment and the purchase price. The traded-in motorcycles that cannot be economically remanufactured to meet prevailing in-use emission standards will be scrapped. Careful design of the project will minimize fraud.

3.4 Motorcycle manufacturers and dealers will be integral partners for the project and will contribute significantly in financing and executing the motorcycle upgrade, including

[17] Motorcycles aged five years and above that have been legally registered in Bangkok for at least one year at the commencement of the project will be eligible to enter the program. Eligibility to receive a trade-in coupon will be more stringent and is likely to be set based on year of manufacture as two-stroke motorcycles manufactured prior to 1995 were unduly polluting by design. These criteria may be changed during the course of the project subject to actual implementation experience.

provision of financial and in-kind incentives to encourage owners to improve motorcycle maintenance and to purchase new motorcycles.

3.5 The design of the project is based on experience gained from project trial clinics undertaken in Bangkok in May and July 2000, which tested processes for encouraging testing, repair, and replacement of motorcycles (section 2). The MUP has two main components: (a) Motorcycle Upgrade Demonstration and (b) Improved Capacity for Pollution Management.

Project Components

Motorcycle Upgrade Demonstration

3.6 The component includes the following sub-components:

- Inspection to identify motorcycles with excessive emissions[18] and to encourage motorcycle owners to undertake regular maintenance and repairs to reduce emissions;
- Raising public awareness of motorcycle pollution and health impacts, beneficial effects of regular maintenance, and importance of using proper 2T lubricant in the correct quantities;
- Motorcycle manufacturer and dealer promotion and incentives to encourage motorcyclists to enter the upgrade program;
- Accelerated upgrading of the motorcycle fleet by providing financial incentives to owners of old, polluting motorcycles and strengthening enforcement of in-use emissions regulations; and
- Remanufacturing or scrapping of the traded motorcycles.

Description

3.7 The upgrade demonstration process includes the following: (i) encouraging owners of in-use motorcycles under five years old to have the emissions level of their motorcycles tested; (ii) undertaking repairs to reduce emissions from motorcycles that fail the test; and (iii) facilitating trade-in of motorcycles that produce excessive emissions and which cannot be repaired for a new motorcycle, with traded-in motorcycles subsequently remanufactured to meet current in-use emissions standards (Box 3) or, where this is not financially viable, scrapped. The process will be complemented by stricter enforcement of emissions standards for motorcycles, and supported by promotion and information to encourage

[18] Recent internal Bank research has shown that there is a lack of correlation between vehicle condition-related PM and white smoke, and there is further evidence that white smoke measured under no load is not representative of smoke under driving conditions (that is, under load). In addition, white smoke measurements have large standard deviations (that is, poor reproducibility). Because white smoke is more strongly correlated with lubricant use rather than the mechanical condition of the vehicle, even motorcycles known to emit high amounts of PM may show little visible smoke if they use low-smoke lubricants. These observations have two implications. One is that this project will help strengthen the enforcement of lubricant standards. Second, in selecting gross emitters to be scrapped, vehicle age and total kilometers traveled should be two key parameters aside from smoke measurements.

motorcycle owners to improve maintenance of their motorcycles. A structured process of test, minor repair, retest, possible major repair, and retest is expected to reduce the emissions of participating motorcycles. This process will also identify those motorcycles whose emissions cannot be brought in line with present in-use emissions standards. Current in-use emissions standards will be met by major repair, rehabilitation of the old motorcycles, and by encouraging replacements with new motorcycles. Improved community awareness will lead to sustained improvement in motorcycle maintenance and increasing compliance with emissions standards, leading to improved air quality and health outcomes.

3.8 Motorcycle owners will be encouraged to participate in the inspection and repair of motorcycles through the provision of financial and in-kind incentives by the private sector and promotion by industry, the Royal Thai Government (RTG), and BMA. Owners of motorcycles that produce excessive emissions and which cannot be repaired will be provided with incentives to trade-in their motorcycles for new ones through financial and in-kind incentives offered by the private sector supported by a financial incentive from the RTG. Traded-in motorcycles will be returned to manufacturers, which will either remanufacture or scrap them. Scrapping will be facilitated by the project paying the difference between the trade-in and scrap value of these motorcycles. Careful design and monitoring during project implementation will minimize fraud. The incentives are described in more detail later in this section.

3.9 Dealer outlets, with the backing of manufacturers, will be the entry points for the process. At the dealer outlets motorcycles entering the process will be tested by official testing stations (those authorized by the Land Transport Department) associated with participating dealers, or if test stations are not available, the same test procedures will be used by dealers.[19] Depending on final negotiations with dealers and manufacturers, the project envisages utilizing some 20 outlets throughout Bangkok. Motorcycles that have been traded in will be passed on to the manufacturers for remanufacturing and scrappage. The penetration of the project will be extended by complementary involvement of Community Service Cooperatives (CSCs) as described in the sub-section below on the second component of the project.

[19] Under discussion at present is the possibility that dealers will be required to establish official inspection stations. The incremental cost over the criteria currently proposed is low and mainly consists of the permit fee of 20,000 baht. There are considerable benefits to motorcyclists entering the program, for they can do so as part of the normal annual testing and receive an official test certificate. In addition, the network of official inspection stations established under the project is the base from which the wider, high quality LTD-authorized inspection stations can be expanded.

Box 3: New and In-Use Motorcycle Emission Standards for Thailand

A) Emission Standards (Air Pollution) for New Motorcycles

Standard no.	Level	Reference standard	Gazetted	Enforced
TIS.1105-1992	1	ECE R 40-00 (all types)	25 Aug. 1992	10 Aug. 1993
TIS.1185-1993	2	ECE R 40-01 (all types)	13 Sep. 1993	15 Mar. 1995
TIS. 1360-1996	3	CO ? 13g/km HC? 5g/km		
		? 110 cc	27 Sep. 1995	-----
		? 125 cc	26 Mar. 1996	-----
		All types	26 Mar. 1996	1 July 1997
TIS.1650-1998	4	CO ? 4.5g/km HC + NOx ? 5g/km - White smoke ? 15% - Evap. ? g/test	20 Jul 1999	
		for 150 cc and up		
		? 110cc	---------	1 July 1999[a]
		? 125cc	---------	1 July 2000[a]
		All types	---------	1 July 2001[a]
TIS.----	5	Select A or B		
		A) –Evap. ? g/test CO ? 3.5g/km HC + NOx ? 2g/km - White smoke ? 15%		
		B) –Evap. > 2 and ? 6 g/test CO ? 3.5g/km HC + NOx ? 1.8g/km - White smoke ? 15% for ? 110 cc		
		All types	-----	1 July 2003*
			------	1 July 2004*

[20] Dates originally planned. Standards gazetted in July 1999 not enforced as of March 2001.

B) Emission Standard for In-Use Motorcycles (Air Pollution Only)

	Standard	Measuring system	Measuring method
1. CO	4.5%	NDIR	Idle test
2. HC	1000 ppm	NDIR	Idle test
3. White smoke	30%	Full flow opacity	Fast accelerate at ¾ of maximum rpm.

Source: PCD (2001).

3.10 Management and monitoring of the MUP will involve the following: (i) a Project Management Unit (PMU) within BMA, which will have overall responsibility for guiding the project; (ii) a contracted organization reporting to the PMU but otherwise independent of other organizations involved in the MUP, which will be responsible for managing a database of motorcycles tested, test results, and eligibility for payment for financial incentives and allowances; and (iii) a Financial Intermediary (FI), which will disburse funds for approved incentives and allowances.

3.11 The MUP process, which will be supported by monitoring, auditing, and a financial settlement system, is described in figure 2 and includes the following steps:

- Step 1—Establish the MUP program and support capability;
- Step 2—Initiate partnerships:

  Step 2A—Get community organizations involved;

  Step 2B—Get dealers and manufacturers involved;
- Step 3—Attract motorcycle owners through promotion and marketing;
- Step 4—Test and repair;
- Step 5—Trade-in;
- Step 6—Remanufacture traded-in motorcycle; and
- Step 7—Scrap traded-in motorcycle.

Figure 2: The Motorcycle Upgrade Process

Source: Project Study Team.

Step 1—Establish the MUP program and support capability

3.12 This involves documentation of essential activities. The documents include:

- ?? Administrative procedures;
- ?? Marketing and promotional strategy for BMA (and other relevant government bodies) within which individual dealer promotions may operate; and
- ?? Expression of Interest (EOI) by which to solicit dealer and manufacturer involvement.

Step 2—Initiate partnerships

Step 2a—Get community organizations involved; and

Step 2b—Get dealer-led consortia involved.

3.13 The activities in this step would seek and assess expressions of interest from community service cooperatives and dealers (backed by manufacturers) for participation in the upgrade process, and would establish agreements with participating bodies. Initial discussions have commenced. Approximately 20 dealer outlets were targeted for enhancement.

Step 3—Promotion and marketing

3.14 The activities in this step are designed to (i) promote the MUP, publicize eligibility criteria, and encourage participation in the program; (ii) increase public awareness of motorcycle pollution and the individual financial and community benefits of improved maintenance and driving behavior to encourage improved behavior; and (iii) increase public acceptance of stricter enforcement of current emissions standards.

Step 4—Test and repair

3.15 The activities in this step, which are illustrated in figure 3, are designed to reduce emissions using a step-by-step approach. Each of the participating dealer outlets undertaking testing (including official dealer-run inspection stations) will be required to purchase modern computerized testing equipment to meet the specifications set under the project, which will minimize operator discretion. The resources will include the following:

- ??? Emissions measuring equipment;
- ??? Computers and associated software;
- ??? Enforcement cameras;
- ??? Capability to automatically print test results on controlled stationery; and
- ??? Communications links.

3.16 As part of the contract for the provision of resources, the supplier will be required to provide a three-year maintenance contract including training in correct use of the equipment. The test results will be linked online to the independent monitoring body (contracted by BMA's PMU) and LTD where links to LTD's driver licensing and vehicle registration system will be established to monitor the following:

- ??? The eligibility of motorcycles entering the program;
- ??? Whether eligible motorcyclists are entering more than once per year; and
- ??? The integrity of test results with alerts on abnormal results.

Figure 3: Step 4 - Test and Repair

Source: Project Study Team.

3.17 The features of the test and repair process include the following:

- A small socioeconomic survey of motorcyclists entering the system to permit monitoring and management (based on the survey undertaken during the clinics).
- Requirements that motorcycles that are eligible to enter the MUP:
  - Be more than five years old (matching current LTD regulations requiring these motorcycles to undertake mandatory testing prior to re-registration);
  - Have been registered in the Bangkok Metropolitan Area for at least one year prior to the start of the MUP to avoid incentives being obtained for out-of-use motorcycles and motorcycles imported to Bangkok from elsewhere in Thailand; and
  - Not enter the program more than once per year.

3.18 It may be necessary to limit access to the MUP to motorcycles whose registration is to be renewed in the same month to smooth out demand. This requirement will fit well with the possibility of requiring all dealer outlets to establish official LTD inspection stations.

Eligibility for a trade-in coupon will be limited to old two-stroke motorcycles and be established as follows:

- After Test 1, which all motorcycles entering MUP will be required to go through, two-stroke motorcycles that have failed the test and are over 10 years old (prior to 1991) will automatically be eligible to qualify for a trade-in coupon for the purchase of a new four-stroke motorcycle; and
- Other motorcycles eligible to receive a trade-in coupon will be those two-stroke motorcycles that fail Test 2.

3.19 It is estimated that there are about 44,000 motorcycles currently in use in Bangkok that were manufactured prior to 1991.

3.20 The initial emissions test (Test 1) can be carried out by any of the official inspection stations involved in MUP[21] or by tests conducted in approved dealers using official standards. Motorcycle owners will pay the standard LTD fee of 60 baht for this test. Incentives for minor and major repairs to motorcycles failing tests[22] will only be offered at approved dealers. A test result[23] will be issued after all tests on motorcycles to provide an auditable trail for all transactions under the MUP and to aid analysis of project impacts. Test 2, and minor repair and major repairs are to be offered by all participating dealers. Minor repairs and Test 2 (no charge to be applied) shall be done together at dealers (in other words, in one place). Major repairs should ideally be done at the same place or with same dealer but may take place at a different time. Major repairs are defined as providing up to any two of the following items: cylinder lining, new piston rings, replacement of oil pump, and replacement of the exhaust system.

3.21 Eligibility to receive a trade-in coupon (and therefore assumed to fail Test 3) will probably not depend solely on the test results but, as discussed above, on year of manufacture and type of motorcycle.

3.22 It is essential for the tests, minor repairs, and major repairs to be done by the dealers (however, motorcycles can leave the system and be taken to other dealers). This is essential for six reasons:

- Repair skills sets are guaranteed to be at least at the minimum desirable level;
- Minor repairs and tests should be able to be done by same body;
- Major repairs skills are needed in order to decide upgrade options;

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[21] At present, of the more than 200 official private inspection centers in the Bangkok Metropolitan Region (BMR), only 71 inspect motorcycles, none do white smoke tests, and about 14 inspection stations are with the motorcycle dealerships.

[22] A motorcycle will be deemed to have failed an emissions test if: (i) white smoke exceeds 30 percent opacity and any of the following are exceeded: (a) CO exceeds 4.5 percent, or (b) HC exceeds 10,000 ppm. These are the present in-use emissions standards for air pollution. The white smoke test is not a good proxy for a test to identify particulate matter (PM). It will fail to identify a motorcycle that emits high PM if the motorcycle uses, for example, JASO FC lube oil which is designed to eliminate white smoke.

[23] This will be the test result automatically printed out by the computerized test equipment. If official LTD-registered inspection stations are involved after Tests 2 and 3 an official test form will also be issued.

- ?? Once a dealer has the motorcycle in its system it would wish to keep it there—which is part of the dealer's rationale for joining the program;
- ?? It will be more practical and economical for each dealer to provide the required resources at its own on-site inspection stations;
- ?? It is not desirable to promote inspection stations not participating in the program to do tests and repairs for the upgrade demonstration because of the inherent conflict of interest; and
- ?? It will be easier to monitor several dealers rather than many inspection stations.

3.23 For each motorcycle results of all tests will be communicated online to the independent monitoring body contracted to the PMU.

3.24 Careful monitoring of reported test results will be required through comparisons of test statistics and the possible occurrence of abnormal results. Also required is supervision and monitoring by a team of six staff members including a suitably qualified mechanical engineer and motorcycle inspection specialist who will check each center randomly and at least once per week. A hotline will be maintained for motorcyclists to report improper test practices.

3.25 Violations of test procedures and falsifying test results will be minimized by using the computerized test equipment with automatic printing of results; placing full responsibility for performance of the test equipment with the supplier; monitoring test quality by on-site random inspections; publicizing violations; refusing to reimburse the value of the trade-in coupon that dealers will claim in arrears; and in extreme cases, expelling the dealer from the program.

Step 5—Trade-in

3.26 Key features of the trade-in process are as follows:

- ?? Dealers will issue the trade-in coupon. To minimize fraud, the coupon will be computer generated with the following clearly printed on it:
- ?? A unique serial number with date and time of issuance generated;
- ?? Date/time at which eligibility commences (24 hours after issue—this provides a "cool off" period, during which the participant can change his or her mind) and expires (30 days later);
- ?? Details of the serial number of the associated motorcycle registration book with details of the brand and model of motorcycle, the details of the owner, motorcycle registration plate number, the period in which the motorcycle has been registered in Bangkok, and the serial number of the engine (and head pipe);
- ?? Results of Tests 1, 2 and 3;
- ?? The value of the coupon (incentives provided by the RTG/World Bank loan plus manufacturer incentives); and
- ?? The declaration that the coupon can be used at all participating dealers to ensure that the value of the incentive is retained by the eligible motorcycle owner. (A coupon issued by a third party would be just as vulnerable to fraud as one issued by a dealer—the main way fraud could occur would be for dealers to have the test

results faked. Monitoring and auditing of test procedures and results will be required. See above).

3.27 To ensure that traded-in motorcycles are actually transferred to manufacturers to be remanufactured or scrapped after a trade-in deal has been negotiated, reimbursement to the dealer of the value of trade-in coupons by the Financial Intermediary will take place after evidence of the transfer to the dealer of the traded-in motorcycles is provided. The best arrangement is that the motorcycle is sold to the manufacturer in the first instance (which avoids both the dealer and the manufacturer buying the motorcycle). That is, the dealer is authorized to purchase the motorcycle for the manufacturer. In addition to being efficient this mechanism is expected to assist in achieving a fair market price for the consumer as the manufacturer is expected to be averse to paying too much for the traded-in motorcycle and the dealer's incentive is to give the prospective buyer the best price at the manufacturer's expense. Hence, a fair price is expected to be achieved by the balancing of these two competing effects.

Step 6—Remanufacture

3.28 Manufacturers will assess traded-in motorcycles to determine those for which remanufacturing to meet current in-use emission standards is financially viable. Remanufactured motorcycles will be tested and have their test results reported to the independent monitoring body contracted to the PMU prior to being resold.

Step 7—Scrap

3.29 Traded-in motorcycles for which remanufacturing is not financially viable will be scrapped. The motorcycle will be officially de-registered, disassembled, and the engine and head pipe transferred to the independent monitoring body of the PMU after which they will be destroyed. Other parts of the motorcycles will be sold in the used parts market or scrapped. After that a claim to the financial intermediary for the scrap allowance can be made by the manufacturer.

Outcomes

3.30 Through the MUP motorcycle inspection and maintenance process and public awareness program, owners of motorcycles will learn about good maintenance practice and the financial savings to be gained in addition to reduced emissions. In the long term, this improved awareness will lead to increasing compliance with the emissions standards. In addition, the new cleaner technology motorcycles in the market will improve air quality and reduce negative health impacts. The purchase of new motorcycles and remanufacturing or scrapping of traded-in motorcycles will remove a significant proportion of the most polluting motorcycles from the fleet. It is forecasted that a combination of economic recovery and the MUP will reduce the number of motorcycles that are more than five years old from over 290,000 in 2000 (42 percent of the motorcycle fleet in Bangkok) to about 180,000 in 2004 (21 percent of the forecasted fleet in that year).

3.31 Motorcycle improvement clinics conducted in 2000 indicate that 20 percent of motorcycles aged five years or fewer failed emissions tests, with the share rising to 35 percent for those older than five years. While the MUP will focus on the latter group, the public awareness program is expected to result in an improvement in the maintenance of younger motorcycles as well. It is expected that the share of older motorcycles failing emissions tests will

decline more substantially under the MUP because of the inspection and maintenance program, with the proportion failing expected to decline from the current 35 percent to 25 percent by the end of the project—the failure rate will be higher for older motorcycles because of mechanical wear.

Improved Capacity for Pollution Management

3.32 A sustainable reduction in motorcycle emissions requires the active involvement of the responsible agencies in the project. This second component of the project involves the following: (i) improved LTD inspection system; (ii) participation of community service cooperatives, community groups, and others in motorcycle testing and repair and finance to both broaden the reach of the current project and to develop an increased capability to support lower-income groups, in particular with regard to access to resources that will help them own and operate motorcycles that meet emissions standards; and (iii) project implementation support.

Improved LTD inspection system

3.33 The regulatory system for controlling emissions from motorcycles (and other vehicles), has been progressively improved through stricter emissions standards for new motorcycles, and stricter standards for 2T lubricant and fuel quality. Effective enforcement of in-use emissions standards has been lacking despite the establishment by LTD of the privately operated system of annual inspection for motorcycles older than five years as a condition for renewal of registration. The Land Transportation Department's system of private test centers involves a larger number of transactions and organizations, and there is a need to improve its effectiveness, in particular with regard to the extent to which designated vehicles are tested and the quality of the inspections that are undertaken. Technical assistance will be provided to the LTD to achieve the following:

- Implement an effective program of emissions tests at all official private testing stations in Bangkok. This will require a review of the current standards and proposed testing procedures.
- Link to the online test database and inspection stations initially operated under the Motorcycle Upgrade Demonstration Component as a prototype for the expansion of the LTD inspection system including the adoption of computerized emissions testing equipment.
- Integrate inspection results, driver licensing, vehicle registration, and on-road enforcement systems.
- Implement an improved management information system to monitor performance.
- Improve the system of random checks and periodic monitoring of inspection stations.
- Identify and expunge motorcycles that are no longer in use from the registration system.

Expanded community services

3.34 The penetration of the project will be extended by complementary involvement of Community Service Cooperatives (CSCs), which will become involved in improvements in the quality and the range of repair services, and associated emissions testing provided in local communities. The ability for owners of excessively polluting motorcycles to purchase a new motorcycle will be further facilitated by improving their access to community-based credit.

3.35 Technical assistance will be provided to CSCs in appraising local community capabilities, preparing proposals to participate in the MUP, raising standards for motorcycle inspection and maintenance; and building possible partnerships with motorcycle manufacturers and dealers.

3.36 The cost of obtaining credit for motorcycle purchases is high, reflecting in part the limited sources of financing and high costs (Box 4). Overall, the present high borrowing cost effectively doubles the cost of purchasing a new motorcycle and impedes the ability of owners to replace old motorcycles that cannot comply with emissions standards. To date there has been only limited finance available to motorcycle purchasers through community credit organizations. Such lending would have markedly lower, though still commercial, interest rates by reducing the need for high-risk premiums. The project will encourage the provision of finance through community credit organizations by fostering interest in the sector, using measures such as workshops, networking, and provision of standard paperwork. It will not become directly involved in the provision of finance.

3.37 The Government Savings Bank (GSB) will foster the provision of financing to community credit cooperatives that can demonstrate satisfactory performance in loan supervision. These cooperatives would then lend (on-lend) to their members for motorcycle purchases. This would substantially improve the capacity of lower-income groups to purchase new motorcycles by utilizing the characteristic ability of community credit cooperatives to use peer pressure and support through small groups to minimize arrears and defaults on loan repayments and, thereby, substantially reduce the effective cost of capital for such a program. GSB lending to qualifying community credit cooperatives would be at a rate of about eight percent per year. Cooperatives would, in turn, lend at rates of 15–20 percent per year (that is, less than half the current rate of interest on loans from finance companies) to meet the cost of origination and supervision costs as well as default risks and to support a desirable expansion of community credit. It may be possible for well-organized community groups to secure greater benefits for their members, negotiating contracts with manufacturers for the provision of motorcycles at discounted prices[24].

[24] Similar schemes have been implemented in the past to reduce the cost of financing for new motorcycle acquisition. The most notable is a scheme of the Teachers Association, which established a one-year contract with a motorcycle manufacturer (set on the basis of competitive tenders) for set, discounted prices for motorcycles to members, and provision of financing.

Box 4: Motorcycle Financing

About three-quarters of motorcycle purchases in Bangkok involve commercial financing. Most of this is provided by eight private companies—two of which hold about 50–60 percent of the market. These financing concerns are currently unlicensed; obtain their capital primarily from equity investors; and to a lesser extent, acquire commercial loans from other capital markets and banks. The companies have relationships with numerous dealers that usually have connections with several finance companies. Financing companies hold their own records on the repayment risk of borrowers, but share some information, in cases in which fraud may be involved.

The features of loans for motorcycles include the following:

- Loans are up to about 85–90 percent of the cost of a four-stroke motorcycle, a little less for two-stroke motorcycles because of their higher depreciation rate, and about 70 percent for motorcycles with large engines. Borrowers commonly draw on the maximum loan amount.
- Theft and total loss insurance is required for the duration of the loan. (This is a recent innovation, and is reported to have lowered interest rates by removing a previously added risk premium.)
- Loan terms are 12–30 months, with an average duration of 22 months.
- Principal is repaid in each monthly installment.
- A flat interest rate is used, currently between about 2.0 and 2.4 percent per month, on the initial principal for loans (equivalent to interest rates on the outstanding principal of 50–60 percent per year, respectively). The actual interest rate is linked to the share of the motorcycle cost being financed with the loan.

Bad debts resulting from stolen and written off motorcycles and fraud may occur in up to about five percent of the loans. In addition, some 20–25 percent of motorcycles are repossessed as a result of loan default. Consumer protection legislation requires that a borrower be given a three-month grace period for debt service before repossession occurs.

Borrowers are reported to generally seek to minimize the down payment for a new motorcycle (and thus use the maximum loan), and to focus on the total cost of debt service rather than the interest rate or loan structure. This may be linked to the lower income of borrowers (who live in households with income that is below the average for Bangkok) and the use of a high proportion of motorcycles for business purposes (in which case the cost of the motorcycle is compared with income generated from its use).

Incentives under the MUP

3.38 The emissions characteristics of the motorcycle fleet will gradually improve as new motorcycles are purchased and old motorcycles are scrapped or relocated from Bangkok. Providing incentives will accelerate this process, to achieve a more rapid and significant improvement in the maintenance of current motorcycles and replacement of irreparable, excessively polluting motorcycles. The incentives respond, in particular, to two market imperfections:

- The current weak regulatory system that enables some motorcycles not meeting emissions standards to be re-registered; and
- The current use of motorcycles in poor mechanical condition, which indicates that owners do not judge the financial savings of trade-in allowances or improved maintenance to be sufficient in justifying the needed expenditure.

3.39 However, the major costs to be financed from the proceeds of the bank loan relate to incentives at an estimated 4,000 baht (equivalent to US$95) for 30,000 old, two-stroke-engine motorcycles expected to be traded in for new motorcycles; and at 5,000 baht (equivalent to US$120) for 15,000 of these that cannot be modified economically to meet present emissions standards required to be scrapped and removed from LTD's vehicle register. Cost estimates for the trade-in and scrappage allowances are based on significantly lower estimates of the number of currently operating motorcycles in Bangkok than is indicated by LTD's vehicle register. However, a physical contingency has been included to provide a five percent increase in the number of motorcycles eligible for these allowances. A five percent price contingency has also been included to enable these allowances to be adjusted upwards, if necessary, in light of consumer response.

Incentives for the Inspection and Repair of Existing Motorcycles

3.40 Data from the motorcycle clinics held in May and July 2000 indicate that almost half of participating motorcycle owners considered their vehicles to be in poor or very poor condition, even though a smaller proportion failed tests. Therefore it is expected that owners will participate in the program voluntarily and a publicly provided incentive for testing and minor repair will not be made available since (i) the public awareness program under the project is expected to further improve the motorcycle owners' perception of financial and environmental costs; and (ii) the combination of industry-provided incentives and the realistic prospect of reduced motorcycle operating costs will further contribute to voluntary participation. The incentives will include free spark plugs, oil, tuning, and other gifts with an average value of about 30 baht per motorcycle that is tested. In addition, the industry will provide spare parts at discounted costs (20–50 percent off) in cases in which a major repair is required. Motorcycle and spare part manufacturers and dealers have confirmed that the industry remains willing to provide these incentives, at least on a periodic basis, as part of its marketing programs directed to increasing sales volume and market share for its products. It is expected that all motorcycles that are more than five years old will pass though the process of inspection and repair at least once, and possibly twice during the project. Based on the experience with the motorcycle clinics conducted to date, it is expected that 60 percent of motorcycles that fail an initial test will pass the test after a minor repair, with a further 10 percent being able to meet current emissions standards with a major repair. The remaining 30 percent that fail the initial test will need remanufacturing to meet current emissions standards or scrapping: owners will be provided a coupon that entitles them to receive incentives if they should trade in the motorcycle for a new one.

Incentives for the Trade-In of Existing Motorcycles

3.41 Incentives to be made available to owners of motorcycles that cannot be restored to meet current emissions standards with a major repair will be redeemable through participating dealers when the motorcycle to which the coupon is linked is traded in for a new motorcycle. The incentives will not be provided if a new motorcycle is not purchased, or if the motorcycle to be traded in does not have an eligible coupon. The incentives available to an owner trading in their motorcycle will include the following:

- A Trade-in Incentive worth 4,000 baht (equivalent to US$95), financed by the RTG using proceeds of the Bank loan and domestic resources. Owners of an eligible motorcycle will be able to redeem the value of the coupon at any of the participating dealers, which operate in a competitive market, to ensure that the full value of the Trade-in Incentive offered through the project is passed on by the dealer to the motorcycle owner. Having established the cost of a new motorcycle and the trade-in value of the old motorcycle, the dealer will reduce the net cost to the person of trading up to a new motorcycle by 4,000 baht, and will subsequently be reimbursed the money from the project.
- Discounts offered by dealers, largely drawing on industry support. The discounts will include the following:
  - A discount of about 4,400 baht drawing on (a) a discount offered by manufacturers and dealers equal to about 5 percent of the cost of motorcycles (estimated value 2,100 baht per motorcycle), reflecting corporate interest in the potential increased sales volume (and resulting lower average supply cost) from participation in the project, and (b) a 50 percent discount on the cost of the theft and write-off insurance and cancellation of the usual 1,000 baht security deposit for loan repayment, financed by dealers and finance companies (with an estimated value of 2,300 baht); and
  - A reduction in the interest rate for credit financing, from 2.4 percent at present to about two percent, provided by financing companies in recognition of the amount to be financed because of the other discounts offered to borrowers, and hence the lower risk of default (with a present value of up to about 1,300 baht).

3.42 Based on the experience with the motorcycle clinics, it is expected that about half of the owners of motorcycles for which coupons are issued will take advantage of these discounts and trade in their motorcycles for a new one. All traded-in motorcycles will be sold to manufacturers to be remanufactured to meet current emissions standards, or scrapped.

Recycling Traded-In Motorcycles

3.43 No financial incentive will be provided for the remanufacturing of traded-in motorcycles. Remanufacturing is likely to be viable only when (i) replacement parts can be obtained at wholesale prices; and (ii) the work is undertaken by a company with a market presence that provides subsequent purchasers with the confidence that the remanufactured motorcycles are of good quality. Motorcycle manufacturers are best qualified for this, and are able to work with dealers to ensure that the trade-in cost is appropriate.

3.44 Average costs associated with remanufacturing and reselling motorcycles and of corresponding new motorcycles are shown in Table 3.1. The maximum potential resale price for remanufactured motorcycles of the type expected to be traded in is expected to be around 70 percent of the cost of an equivalent new motorcycle, if supported by a manufacturer. Given typical depreciation schedules for motorcycles, the trade-in values shown in Table 3.1 represent motorcycles that are, on average, about six years old (for motorcycles with engine capacity of up

to 125 cc) and five years old (for motorcycles with engine capacity between 126 and 150 cc). That is, it appears that the motorcycles likely to be traded in through the project will not have such high value that remanufacturing will not be financially viable to manufacturers.

3.45 In some instances, however, remanufacturing will not be financially viable because either (i) it is not possible to remanufacture traded-in motorcycles originally manufactured in 1993 or earlier to meet current emissions standards because of engineering constraints—these motorcycles will be at least eight years old by the time the project commences; or (ii) the cost of remanufacturing and reselling motorcycles that are about eight years old or older will generally exceed the price at which they can be sold. The average trade-in value of motorcycles aged eight years or older is expected to be about 6,000 baht and 10,000 baht, respectively for motorcycles with engine capacity of up to 125 cc and 126–150 cc giving a weighted average of about 7,000 baht. By contrast, the value of spare parts that can be salvaged from these motorcycles, after removal of the engine and head pipe, is about 2,000 baht per motorcycle. A scrappage allowance of 5,000 baht (US$117) will therefore be paid to manufacturers to scrap these motorcycles, that is, to compensate industry for disabling the engine and head pipe, thereby preventing the old polluting motorcycle from being resold. It is expected that about 50 percent of traded-in motorcycles will be scrapped, and the remaining 50 percent will be remanufactured.

Table 3.1: Cost of Remanufacturing Motorcycles

Activity	*Average cost (baht)*[25]	
	up to125 cc	*126–150 cc*
Cost of traded-in motorcycle	13,000	27,000
Cost of remanufacturing:		
(a) Engine upgrading (that is, resleeving the cylinder, a new piston and piston rings, replacing the oil pump and exhaust system, and other small items)	5,000	7,000
(b) marketing-oriented improvements (for example, new seat, handle grips, painting, and the like)	8,000	10,000
Administration and resale costs	4,000	4,000
Resale price for remanufactured motorcycle	30,000	48,000
Cost of new motorcycle	35,000–50,000 (average 42,500)	60,000–75,000 (average 67,500)

[25] Costs can vary among individual motorcycles. Higher-value motorcycles will generally require less extensive remanufacturing, and vice versa. At present, about 90 percent of sales are for motorcycles with engine capacity up to 125 cc and the remainders are for larger motorcycles.

3.46 The incentives provided under the motorcycle-upgrading program by various stakeholders are summarized in Table 3.2.

Table 3.2: Financing of Various Stakeholders to the Motorcycle Upgrade Program

Step	*No. of MCs*	*Individuals*	*Government/World Bank*	*Manufacturers/Dealers*
Promotion	n.a.	No	Yes	Yes
Test	250,000	60 baht	50 baht per entering MC to manufacturer	No net cost
Minor repair	80,000	0	0	30 baht per MC
Major repair	3,000	At cost (discount)	0	Discounted parts and labor
Trade-in	21,000	Old MC	4,000 baht for MC to individual via coupon	Matching incentives for new MC
Remanufacture	10,500	0	0	No net cost—recover through sales
Scrap	10,500	0	5,000 baht per scrapped MC to manufacturer	No net cost

n.a. Not applicable.

Costs and Benefits of the MUP

3.47 There are large economic benefits from reductions in health care costs and resulting productivity gains (decreased incidence of illness and premature deaths due to respiratory and cardiovascular diseases). Information regarding health studies and economic

estimates suggests that the health impact (morbidity and mortality) of air pollution exposure is in the range of US$0.5 to 3 billion per year. All studies indicate that substantial benefits are likely, in terms of improved health, productivity, and quality of life, from reducing exposure to ambient PM_{10} in Bangkok. Fuel savings of about 40 percent are expected to result from replacing old, two-stroke-engine motorcycles with new, four-stroke-engine motorcycles. Additional benefits include improved transport services and better institutional capacity.

3.48 The major health benefits will accrue to the residents of Bangkok who spend time along the transport corridors (motorcyclists, street-side vendors, public transport drivers, traffic police, and others on the road) and people living in the BMR who make daily trips to and within the city. The poor are particularly vulnerable, owing to above-average physical exposure to the air pollution, especially particulate matter. Motorcyclists are expected to achieve significant fuel economy savings owing to maintenance improvements and the switch to newer technology (generally four-stroke). Some of the policy changes will benefit areas well beyond Bangkok.

3.49 Overall, the net present value of the costs is US$9.7 million, that of the benefits is US$29.9 million, and therefore that of net benefits is nearly US$20.3 million, yielding a benefit-to-cost ratio of 3.1 and ERR of 102 percent. Because assumptions used in estimating benefits are very conservative, these results can be presented with much confidence for the benefits of this project. The actual benefits are expected to be comparatively higher (see Annex 2).

3.50 Benefits that have been valued include public health improvements and greater fuel economy. The costs involved for the motorcycle upgrade and associated components include project management; I/M program for the MUP; LTD I/M program strengthening; and tune-ups, major repairs, scrappage, bringing forward the date of new vehicle purchase, and incentives offered.

4

Conclusion

4.1 Traffic congestion and associated poor air quality have traditionally been major problems in Bangkok. According to the PCD, the transport sector accounts for the majority of air pollution in the BMR. Although there has been a decrease in the recent years, results monitored over the past 10 years indicate that the ambient levels of particulates smaller than 10 microns (PM_{10}) and carbon monoxide (CO), are of the greatest concern in Bangkok. Owing to increase in nitrogen oxides (NO_x) and hydrocarbons (HC) emissions, potential of increasing ozone levels exists.

4.2 A series of extensive studies has demonstrated a clear association between the ambient PM_{10} concentrations and various health-related issues—mortality, hospital admissions, emergency room visits, time off school or work, respiratory symptoms, exacerbation of asthma, and changes in lung function.

4.3 Motorcycles, especially those with two-stroke engines, are significant sources of PM. These engines mix lubricating oil with fuel. The oil is often partly burned and is emitted through the exhaust as a mixture of toxic liquid and carbon-based particles.

4.4 There are approximately 700,000 in-use motorcycles in Bangkok, of which 80 percent are two-stroke. Although sales of four-stroke motorcycles have picked up significantly over the past few years (with sales growing about 70 percent in 2000), it will take many years before the polluting stock of motorcycles is phased out.

4.5 The Bangkok Motorcycle Upgrade Project (MUP) uses an innovative approach to accelerate the phasing-out of polluting motorcycles by targeting gross-polluting motorcycles in the city and surrounding region. The MUP is designed to "buy back" pollution from the polluters, through the partnership of private and public sectors—namely the motorcycle manufacturers, the government, the motorcycle owners, and donors. The project also aims to improve capacity for air pollution management through improved inspection and maintenance systems on both the government and the community levels. With careful project design and a diligent selection process, incentives provided by various stakeholders will assist in the upgrading of the gross-polluting motorcycles to new nonpolluting ones. Improved inspection and maintenance capacity will help reduce emissions in the medium to long term.

4.6 The cost of the project will mainly consist of the incentives provided for the upgrade. Other costs include management expenditures and costs associated with establishing a new inspection and maintenance system. The benefits of the project are, nevertheless, approximately three times the project costs, taking into account the improved health and reduced

mortality resulting from reduced motorcycle emissions. If the gains were to include the profits that manufacturers will receive based on increased sales or the reduced costs to motorcycle owners based on decreased motorcycle maintenance and repair expenses, the benefits of the project would be expressed in even higher figures.

4.7 In designing the MUP, motorcycle clinics were conducted in 2000. The clinics provided a wealth of socioeconomic and motorcycle usage information on owners and emissions information on the motorcycles. The clinics not only provided valuable inputs to the design of the MUP, but also raised air pollution awareness and, most important, initiated collaboration among stakeholders in an innovative manner. There were many insightful lessons learned from the motorcycle clinics. The main lessons learned and how these are being addressed in the design of the MUP are summarized in Table 4.1.

4.8 The MUP is highly replicable and flexible. The project concept is neither motorcycle nor Thailand specific; it can be applied to other mobile sources of air pollution. Moreover, the incentives and the components can be adjusted based on the amount of funds available. For example, the value and number of incentives may be decreased if the project needs to target a smaller number of polluting vehicles, or scrap allowance may be eliminated if vehicles that are traded in are allowed to be sold elsewhere.

Table 4.1: Lessons Learned from the Motorcycle Clinics and MUP Design Considerations

Lessons learned	*MUP design considerations*
1. Thailand	
a. Institutional development	
Institutional fragmentation hampers coordinated approach to air quality management in Bangkok	This requires a long-term approach. In the immediate and limited context, the MUP is designed to demonstrate interagency cooperation
Lack of capacity in the public sector constrains operational performance of agencies responsible for enforcement and monitoring of air quality	MUP design includes capacity building for staff to improve operational performance of relevant government agencies
Corruption and fraud are major concerns	Careful design, supervision, independent monitoring and audits, coverage by news media, along with computerized record keeping is expected to minimize illegal activities
Community and public consultation process positively shapes the design and promotes integrated approaches and ownership	Communities and media are being consulted as a part of the MUP preparation and will be integral to the project design to provide feedback through implementation
Involvement of the private sector is important	Involvement of manufacturers and dealers is an integral part of the project design
Defining clear targets and responsibilities is desirable	Integrated Air Quality Management Plan for Bangkok to be prepared and endorsed by the BMA and sector agencies
Strong leadership is important	Successive Bangkok governors have committed to tackling the air pollution problem and have indicated their support publicly, especially concerning pollution from motorcycles
b. Enforcement	
The knowledge-base and analytical capacity need to built up throughout technical and executive levels	The Motorcycle Clinics and other preparatory activities have initiated this process and the project builds upon existing studies and data to strengthen procedures, systems, and analytical capacity for integrated air quality management at all levels
The appropriate legal basis for needed improvements has to be obtained	This is to be pursued through policy dialogue
Public awareness and education campaigns are important	Awareness raising is being undertaken by BMA and GSB and is included in the project
There is a lack of incentives to comply with regulations	This concern is included in the project design

Lessons learned	*MUP design considerations*
Implementation of regulatory measures suffers from weak monitoring and enforcement	MUP proposes to increase compliance through implementation of a traditional regulatory and enforcement mechanism with innovative market approaches
Involvement of the private sector is important	The project will promote its enforcement mechanism through the private sector
On-street enforcement should be an integral part of the traffic management program	The police will be involved in project design; design of incentive scheme will reward enforcement efforts
2. Global experience	
Air quality management is complex and requires cross-sectoral responses	The Integrated Air Quality Management Plan for Bangkok will involve all key agencies
Source control and fuel quality improvements are more effective than tailpipe exhaust control	Investment component will focus on engine upgrades and shift from two-stroke to four-stroke. Thailand has made substantial progress in improving fuel quality and is keen to continue its good track-record
Public participation and partnerships with relevant stakeholders should be supported	Included in the MUP design
New approaches to pollution control are designed to be flexible, be efficient, promote eco-reforms, and fit specific characteristics of individual countries	MUP promotes implementation of innovative approaches and building of staff skills for improving air quality
Institutional capacity building is complex and requires cross-sectoral collaboration, flexibility, and clear targets and responsibilities	The project sets our clear targets with incentives and relies on public–private partnership to demonstrate usefulness of collaboration within and outside the government agencies

Annex 1

The Bangkok Motorcycle Market

Introduction

A1.1 The purpose of this working paper is to describe key features of the market for new and second-hand motorcycles in Thailand but particularly in the Bangkok Metropolitan Area (BMA) or Bangkok. The Bangkok Metropolitan Region (BMR) is a larger area covering the four neighboring provinces of Pathum Thani, Nonthaburi, Samut Prakan, and Samut Sakon. Since BMA represents some 90 percent of all registered motorcycles in the BMR as shown below, this paper refers mainly to the BMA.

A1.2 The scope of the paper is as follows:

- The domestic market for new motorcycles, major brands and market shares, dealership structure, and sales margins;
- Consumer preferences for new and second-hand motorcycles—in particular the cascading effect of older motorcycles from Bangkok to up-country provinces;
- Key features of the second-hand market;
- Taxes and official charges to get a new motorcycle on the road (that is, on-road costs);
- What happens to old or written-off motorcycles;
- The existing in-use motorcycle fleet—its volume and characteristics including estimated age distribution, and the role of motorcycle taxis and other major motorcycle fleets (covering the most intensively used motorcycles);
- Sources of motorcycle financing and aspects of financing credit; and
- Data on second-hand motorcycle prices, which are used to determine typical depreciation schedules for motorcycles.

The New Motorcycle Market

A1.3 New motorcycle production and sales data for 2000 is set out in Table A1.1. In 2000, 1.126 million motorcycles, up from 0.846 million in 1999, were assembled in Thailand mostly by the four major Japanese brands of Honda, Kawasaki, Suzuki, and Yamaha. There are

at least four other companies that currently assemble or are considering assembly in Thailand including Cagiva (Italy) and potentially one or two Chinese manufacturers.

A1.4 In 2000, of total motorcycle production, 784,000 were officially sold into the Thailand domestic market although some 150,000 motorcycles were exported to neighboring countries (these are often called “gray” exports). Hence, total domestic sales of new motorcycles are estimated to be around 630,000 for the year 2000.

Table A1.1
Motorcycle Production and Export Record by Month, 2000

	Production record			*Export record*					
Month/Units	*Total units*	*Moped units*	*Sport units*	*Total amount*	*CBU&CKD units*	*Value baht (million)*	*OEM&parts sets*	*Value baht (million)*	*Spare part baht (million)*
JANUARY	87,280	83,637	3,643	617.05	16,958	450.97	81,690	162.46	3.62
FEBRUARY	98,095	94,7885	3,210	634.17	17,361	452.74	151,000	174.34	7.09
MARCH	114,936	112,415	2,521	822.52	20,844	563.05	133,960	248.88	10.59
APRIL	90,899	88,940	1,959	892.35	23,931	651.88	106,040	231.89	8.58
MAY	106,797	103,309	3,488	1,085.70	29,418	872.34	167,357	201.44	11.92
JUNE	102,778	98,988	3,790	455.57	23,086	228.45	81,120	210.04	17.08
JULY	80,369	77,475	2,894	883.71	19,724	690.11	68,000	177.66	15.94
AUGUST	87,215	84,987	2,228	1,178.12	32,173	879.07	87,680	280.86	18.19
SEPTEMBER	81,573	79,261	2,312	942.20	23,932	694.40	51,880	223.76	24.04
OCTOBER	84,078	80,586	3,492	885.09	23,055	654.64	81,520	207.68	22.77
NOVEMBER	98,074	94,907	3,167	1,226.08	26,986	973.51	80,960	237.25	15.32
DECEMBER	93,629	90,086	3,543	1,167.55	9,780	309.88	75,430	824.07	33.60
TOTAL (2000)	**1,125,723**	**1,089,476**	**36,247**	**10,790.11**	**267,248**	**7,421.04**	**1,166,637**	**3,180.33**	**188.74**
TOTAL (1999)	**846,426**	**810,920**	**35,506**	**8,506.48**	**214,310**	**6,330.10**	**41,446**	**2,012.62**	**163.76**

Source: *Automotive Industry Club, Federation of Thai Industries.*

A1.5 In 2000, as shown in Table A1.2, LTD's official registration statistics show that 107,856 new motorcycles were registered in BMA. While significantly higher than figures in 1997 and 1998 (when the effect of the Asian economic and financial crisis were most severe), this volume is only 68 percent of the average annual new motorcycle registrations for BMA over the period 1989–2000 as shown in Table A1.3.

Table A1.2
Number of New Motorcycles Registered in BMA, 1997–2000

Year	*No. of new registrations*	*Growth rate per year (% pa)*
2000	107,856	+25.0%
1999	86,299	+12.2%
1998	76,915	-49.7%
1997	152,905	- 29.23%
1996	216,054	-20.10%
1995	270,345	-

Source: LTD (2001).

Table A1.3
Number of New Motorcycles Registered in BMA by Engine Type, 1989–2000

Year	*No. of new motorcycles registered in BMA*			*Growth rate (% pa)*
	Two-stroke	*Four-stroke*	*Total new registrations*	
Average over 1989 to 2000	143,817	15,573	159,390	n.a.
2000	43,686	64,170	107,856	+22.8%
1999	49,748	38,074	87,822	+24.8%
1998	50,998	19,381	70,379	–47.7%
1997	119,792	14,738	134,538	–29.5%
1996	179,032	11,744	190,776	–21.9%
1995	233,624	7,585	241,209	–1.4%
1994	239,159	5,466	244,625	+11.5%
1993	213,455	5,884	219,339	+31.4%
1992	163,786	3,205	166,991	+6.1%
1991	154,009	3,348	157,377	+92.7%
1990	164,437	5,321	169,758	+38.4%
1989	114,081	7,954	122,035	n.a

__. Not available; n.a. Not applicable.
Notes: Totals do not include approximately 900 vehicles registered under the "other" category.
Source: Honda (1998 data) and LTD (1999 and 2000 data).

A1.6 Data shown in Table A1.3 indicate that in BMA the share of four-stroke motorcycles in new registrations has rapidly increased since 1996. In 2000, four-stroke motorcycles represented some 59 percent of all new registrations (and hence new motorcycle sales). For Thailand as a whole in 2000 the share of four-stroke motorcycles was almost 70 percent of new motorcycle sales as shown in Table A1.4.

Table A1.4
Number of New Motorcycles Sales, Thailand, by Engine Type, 1996–2000

Year	*No. and % of new motorcycles sales, Thailand*		
	Two-stroke	*Four-stroke*	*Total new sales*
2000	238,000	551,000	789,000
	(31.2%)	(69.8%)	(100.0%)
1999	287,000	311,000	598,000
	(48.0%)	(52.0%)	(100.0%)
1998	288,000	233,000	521,000
	(55.3%)	(44.7%)	(100.0%)
1997	677,000	233,000	910,000
	(74.4%)	(25.6%)	(100.0%)
1996	1,016,000	221,000	1,237,000
	(82.1%)	(17.9%)	(100.0%)

Notes: Sales figure of 789,000 slightly differs from the figure of 784,000 shown in annex Table 1.5.
Source: Automotive Industry Club, Federation of Thai Industries (2001).

A1.7 Data for 2000 for Thailand shows that Honda has the overwhelming market share (72 percent); followed by Suzuki (13.6 percent), Yamaha (11.9 percent), and Kawasaki (2.3 percent) (Table A1.5). In Bangkok, the picture appears to be slightly different as shown in Tables A1.6 and A1.7 that show data on January 2001 and December 2000 motorcycle registrations. Here Honda appears to have a market share approaching 85 percent. Since 2000, Honda has only been manufacturing four-stroke motorcycles in Thailand and hence, because of it dominates four-stroke motorcycle production, sales are expected to grow rapidly. By 2002, sales of four-stroke motorcycles are likely to reach 80 percent. Other manufacturers are following suit with four-stroke motorcycle production.

Table A1.5
Domestic Motorcycle Sales, Thailand, 2000

Brand	*Total units sold*	*Market share (%)*
Honda	565,294	72.1
Yamaha	93,520	11.9
Suzuki	106,541	13.6
Kawasaki	18,261	2.3
Cagiva	62	NS
Total	**783,678**	**100.0%**

Source: Automotive Industry Club, Federation of Thai Industries (2001).

Table A1.6
New Motorcycle Registrations in BMA, January 2001

Manufacturer	*Engine size (cc)*				*Total*	*Market share*
	< 100	*101–125*	*126–150*	*> 151*		
Baco	0	0	1	0	1	NS
Cagiva	0	14	0	0	14	NS
Healey	0	0	0	2	2	NS
Honda	278	7,749	167	1	8,195	87%
Harley Davidson	0	0	0	2	2	NS
Kawasaki	0	344	240	149	733	7.8%
Mnnek	0	1	0	0	1	NS
Piaggio	0	0	10	0	10	NS
Piaggio	0	0	5	0	5	NS
Suzuki	43	184	7	0	234	2.5%
Yamaha	0	200	15	1	216	2.3%
Total	**321**	**8,492**	**445**	**155**	**9,413**	**100%**
% by Engine Size	**3.4%**	**90.2%**	**4.7%**	**1.6%**	**100%**	

Source: LTD (2001).

Table A1.7
New Motorcycle Registrations in BMA, December 2000

Manufacturer	*Engine size (cc)*				*Total*	*Market share*
	< 100	*101–125*	*126–150*	*> 151*		
Autobianchai	0	1	0	0	1	NS
BMW	0	0	0	5	5	NS
Honda	140	4,300	98	1	4,539	82.6
Harley Davidson	0	0	0	11	11	NS
Kawasaki	0	203	152	106	461	8.4
Mnnek	0	1	0	0	1	NS
Piaggio	0	0	1	0	1	NS
Piaggio	0	0	1	0	1	NS
Suzuki	58	277	4	0	339	6.2
Yamaha	0	117	20	0	137	2.5
Total	**198**	**4,899**	**276**	**123**	**5,496**	**100%**
% by Engine Size	**3.6%**	**89.1%**	**5.0%**	**2.2%**	**100%**	

Source: LTD (2001).

A1.8 Over 90 percent of new motorcycle sales are for motorcycles with an engine size less than 150cc. This is true of the existing fleet as well. The main reasons that these small-engine motorcycles are popular here appear to be because:

- Prices for smaller motorcycles are lower (than for larger-engine motorcycles)—a typical new 110 cc motorcycle costs 40,000 baht compared to 65,000 baht, for example, for a motorcycle with an engine size of 150 cc;
- Smaller motorcycles are more maneuverable and therefore better suited to Bangkok's congested traffic conditions; and
- Smaller motorcycles are better matched to the physique of most Thai motorcycle riders.

The Second-Hand Motorcycle Market

A1.9 As shown in Table A1.8, since 1997, sales of second-hand motorcycles have held up better than new motorcycle sales, but overall sales (of new and second-hand motorcycles) have declined. Second-hand sales exceeded new motorcycle sales by 47 percent in 1998 and 72 percent in 1999 for Thailand as a whole. Total sales of second-hand and new motorcycles declined from 2.15 million in 1996 to 1.27 million in 1999. For Bangkok, sales of second-hand motorcycles were 77 percent of new motorcycle sales in 1995 but exceeded new motorcycle sales by 44 percent in 1997, 131 percent in 1998, and 74 percent in 1999. Total sales of second-hand and new motorcycles in Bangkok declined from 0.478 million in 1995 to 0.444 million in 1996, to 0.372 million in 1997, to 0.255 million in 1998, and to 0.236 million in 1999.

Table A1.8
Estimated Volume of Second-Hand Motorcycle Sales, Thailand and Bangkok, 1997–99

Location / Year	*No. of transfers of ownership of in-use MCs (equals sales of second-hand MCs)*	*No. of new MCs registered (equals new MC sales)*
Thailand		
1999	804,368	465,705
1998	883,143	602,647
1997	896,408	1,086,175
1996	871,653	1,281,186
1995	736,469	1,283,771
Bangkok		
1999	149,997	86,299
1998	178,412	76,915
1997	219,304	152,905
1996	228,072	216,054
1995	207,581	270,345

Source: LTD (2000).

A1.10 Owing to consumer preferences for purchasing a new or relatively new motorcycle (that is, under two years old), there is a large flow of motorcycles out of Bangkok to the up-country provinces. Table A1.9 shows that each year approximately the registrations of 200,000 motorcycles are transferred between provinces with over half attributable to motorcycles being transferred from Bangkok. From 1995 to 1999, the number of motorcycles transferred out from Bangkok has declined from 116,207 to 75,786—or by 35 percent—indicating, with reduced motorcycle purchases, that during the economic crisis Bangkok motorcyclists were holding on to their motorcycles longer.

Table A1.9
Number of Geographic Transfers of Motorcycle Registrations, Thailand and Bangkok, 1997–99

Year	*Bangkok*		*Thailand*	
	In	*Out*	*In*	*Out*
1999	3,752	75,786	175,725	184,807
1998	2,969	99,946	197,383	202,858
1997	2,331	117,580	205,940	220,854
1996	2,188	129,181	211,307	235,710
1995	2,391	116,207	199,910	223,705

Source: LTD (2000).

A1.11 The effects of a decline in new motorcycle sales since the mid-1990s has led to a decline in the size of the in-use motorcycle fleet since 1995. From 1995 to 1999, the registered (that is, legal) in-use motorcycle fleet declined from 961,782 to 717,129 or by 25 percent (Table A1.10).

Table A1.10
Estimated In-Use Motorcycle Fleet and Annual Change in Bangkok, 1995–1999

Year	*No. of new MCs registered*	*No. of re-registrations*	*Total (legal) in-use MC fleet*	*Annual change in in-use MCs*
1999	86,299	630,380	716,679	–39,602
1998	76,915	679,366	756,281	–137,580
1997	152,905	740,956	893,861	–69,227
1996	216,054	747,034	963,088	+1,306
1995	270,345	691,437	961,782	n.a.

n.a. Not applicable.
Source: LTD (2000).

Retirement and Scrap

A1.12 For Bangkok, as shown in Table A1.11, the estimated normal retirement (and possibly more than normal illegal use) is estimated to have been 87,755 in 1996, 106,883 in

1997, 117,180 in 1998, and 53,867 in 1999—or 9, 11, 13, and 7 percent of the in-use fleet, respectively. This estimated retirement is in addition to the effects of moving of motorcycles older than two or three years up-country. The retired motorcycles may be:

- Left unregistered or be formally de-registered and be retained in private or company yards—some may be used very occasionally; or
- Scrapped for parts.

Table A1.11
Estimated Retirement of In-Use Motorcycle Fleet in Bangkok, 1995–99

Year	*1 No. of new MCs registered (equals new MC sales)*	*2 Transfers to Bangkok*	*3 Transfers out of Bangkok*	*4 Net change (1+2–3)*	*5 Annual change in in-use MCs*[26]	*5–4 Estimated no. of MCs retired or additional illegal use*	*% of estimated retirement or additional illegal use of previous year's fleet*
1999	+86,299	+3,752	–75,786	+14,265	–39,602	–53,867	–7.1%
1998	+76,915	+2,969	–99,946	–20,062	–137,580	–117,180	–13.1%
1997	+152,905	+2,331	–117,580	+37,656	–69,227	–106,883	–11.1%
1996	+216,054	+2,188	–129,181	+89,061	+1,306	–87,755	–9.1%
1995	+270,345	+2,391	–116,207	+156,529	n.a.	n.a.	n.a.

n.a. Not applicable.
[26] See annex Table A1.8.
Source: LTD (2000).

A1.13 Based on data received from auction data of repossessed motorcycles (from the Highway Finance Company) details of 50 traded-in motorcycles from a dealer and his estimates, and about 60 potential trade-ins from Clinics 1 and 2, the following generalized depreciation schedule for motorcycles was estimated:

- After one year—75 percent of the new price
- After two years—55 percent
- After three years—47 percent
- After four years—45 percent
- After five years—40 percent
- After six years—38 percent
- After seven years—28 percent
- After eight years—25 percent
- After nine years—17 percent

A1.14 There is evidence that two-stroke motorcycles are depreciating faster than four-stroke motorcycles. Financing companies will only finance a smaller percentage of a new two-stroke motorcycle's price(up to 75 percent) compared to that of four-stroke motorcycles (up to 85 percent).

A1.15 There is a well-established motorcycle refurbishing industry in Thailand. When motorcycles are traded in by dealers and are considered to be in good condition, they are normally cleaned up and sold as they are. If the engine needs overhauling and the model of motorcycle can be sold relatively easily (which usually means it is a fairly recent model), the dealer would overhaul the engine typically by boring out the cylinder and fitting a slightly larger new piston and rings. This is relatively a cheap process—usually costing less than 800 baht. Motorcycles that are too old to be remanufactured cost-effectively are scrapped. It is understood that these motorcycles would be sold as they are to motorcycle scrap merchants. There are a number of motorcycle market areas (for example, Klong Tom) where second-hand parts and new parts (from original equipment manufacturers [OEM] as well as non-OEM) may be purchased. It is estimated that the non-engine parts in the average scrapped motorcycle are worth 1,000 to 2,000 baht.

Characteristics of the In-Use Motorcycle Fleet

A1.16 The authors estimate, as described in more detail below, that the total in-use (legal and illegal) motorcycle fleet in Bangkok for 2000 had 800,000 motorcycles. Of this total, 690,000 were legally registered in Bangkok. Table A1.10 presented information on the legally registered in-use motorcycle fleet in Bangkok from 1995 to 1999. The Table showed that the total registered in-use fleet in Bangkok declined by 25 percent from 962,000 motorcycles to 717,000 from 1995 to 1999. This decline appears to be due to the following:

- A decline in new motorcycle sales since 1994;
- High retirement rates of motorcycles and/or increased illegal use (for example, by not annually re-registering motorcycles[27]); and
- A slight decline in population in the BMA from 1995 to 1999.

A1.17 At a national level the number of legally registered in-use motorcycles also declined by 3 percent over the period 1997 to 1999 as shown in Table A1.12. About 200,000 four-stroke motorcycles have been sold since 1994 in Bangkok—of which it is assumed there are still 140,000 in use and registered in Bangkok. Hence about 80 percent of Bangkok's 690,000 registered in-use motorcycles in 2000 are estimated to have two-stroke engines.

[27] The LTD registration system is quite lenient—the maximum fine is 20 baht/year or 20 percent of the annual re-registration fee. LTD catches such illegal use when a motorcycle is sold (that is, the registration is transferred).

Table A1.12
Estimated In-Use Motorcycle Fleet and Annual Change in Thailand, 1997–99

Year	*No. of new MCs registered*	*No. of re-registrations*	*Total (legal) in-use MC fleet*	*Annual change in in-use MCs*
1999	465,705	5,565,513	6,031,218	+45,649
1998	602,647	5,355,922	5,985,569	–208,370
1997	1,086,175	5,107,764	6,193,939	n.a.

n.a. Not applicable.
Source: LTD (2000).

A1.18 The two motorcycle clinics held on May 15–17 and July 10–12, 2000 and which 4,000 motorcycle owners attended yielded a considerable and unique data set on technical, socioeconomic, and preference aspects of motorcycle pollution. Some of the results of the clinics are as follows:

- ?? Eighty-three percent of the motorcycles at the clinic were two-stroke;
- ?? Seventy-three percent of the motorcycle drivers already use low-smoke 2T lube oil;
- ?? Ninety-three percent of the owners claim to ride at speeds greater than 60 km/hr;
- ?? More than half the motorcycles travel more than 50 km/day;
- ?? Ninety-three percent of the motorcycles are reportedly used for business purposes; and
- ?? Fifty-four percent of the motorcycles had engine capacity of 125 cc or less, and 1 percent had capacity greater than 150cc.

A1.19 The clinic data yielded an age distribution that is expected to have been similar to the overall age distribution except it was under-represented with motorcycles aged one year or less (Table A1.13). The authors' spreadsheet model of vehicle age distribution for near-end-1999 is quite similar to the clinic-derived age distribution when the lag in the latter of six months to a year is accounted for.

Table A1.13
Estimated Age Distribution of Motorcycles (1999) from the MUP Model and Based on Data from Clinics 1 and 2

Age	Total end-1999 and estimated age distribution using the MUP model	Cumulative % of age distribution estimated using spreadsheet model, 1999	Cumulative % of age distribution based on data from clinics 1 and 2, 2000
1	86,300	14%	3%
2	58,600	23%	13%
3	93,000	33%	22%
4	109,300	47%	31%
5	113,800	61%	46%
6	93,400	74%	61%
7	66,000	84%	73%
8	38,200	90%	82%
9	25,700	94%	89%
10	17,600	97%	92%
>10	14,800	100%	100%
Total registered in-use fleet	**716,700**		
Average age (years)	4.5	4.4	5.0
Fleet size summary			
- 5 years old or newer	461,000		
- More than 5 years old	255,700		
- **Total estimated fleet**	**716,700**		
- Share of motorcycles more than 5 years old	36%		

A1.20 Table A1.13 shows that by late 1999, the average age of the registered in-use motorcycle fleet was estimated at 4.5 years and the number of motorcycles aged five years or more to be 256,000 or 36 percent of the fleet. Since 1997, as shown in Table A1.14, the official statistics on the number of motorcycles aged five years or older (and therefore subject to a mandatory safety and emissions test) showed that from around 160,000 to an estimated 220,000 motorcycles were more than five years old. These data from LTD appear somewhat contradictory but there is some additional confirmation of the estimated age distribution.

Table A1.14
Number of Motorcycles Aged Five Years or Older Being Inspected in BMR, 1997–2000

Year	*No. of MCs tested > 5 years in BMA*
2000	220,000
1999	158,230
1998	168,378
1997	197,174

Source: LTD (2001).

A1.21 A summary of the estimated registered in-use motorcycle fleet and its characteristics is shown in Table A1.15.

Table A1.15
Characteristics of the BMR In-Use Motorcycle Fleet, 2000

Characteristic	Statistic or Estimate (million)
No. of registered motorcycles, 1999[28]	1.6
Estimated no. of registered motorcycles, 2000[28]	1.7
Estimated in-use (legal and illegal) motorcycles in Bangkok, 2000	0.8
Estimated in-use (legal and illegal) motorcycles in the adjacent provinces within the BMR	0.1
Estimated legally registered in-use motorcycles in Bangkok, 2000	0.69
Annual growth rate in legally registered in-use fleet in Bangkok, 1995–2000	–5.7% per year
Estimated 4-stroke/ 2-stroke fleet split in Bangkok, 2000	20% / 80%
Estimated % of new motorcycle sales in Bangkok in 2000 that were 4-stroke	About 80%
Estimated % of legally registered in-use motorcycles in Bangkok aged > 5 years in 2000	42% or 293,300 motorcycles

[28] Includes all motorcycles registered and those formally de-registered, but not those whose registration has lapsed.

Sources of Motorcycle Financing

A1.22 The main sources of financing for purchasing a new motorcycle are as follows:

- Financing Companies—hire purchase agreements provided by Thailand's eight main specialist financing companies affiliated with dealers;
- Dealer financing—hire purchase agreements provided by dealers through their own financing companies; and
- Cash.

A1.23 Interviews with two dealers and three financing companies suggest the following distribution of financing alternatives for new motorcycle purchases:

- Cash only—up to 15 percent;
- Trade-in plus financing (with or without cash)—20 percent.[29] Financing is often provided up to the maximum permitted by financing companies (85 to 90 percent of the new motorcycle price); and
- Financing with cash down payment—65 percent. Financing is usually provided up to the maximum permitted by finance companies of (85 to 90 percent of the new motorcycle price).

A1.24 About 75 percent of all transactions are estimated to involve financing to a significant degree. These data suggest that 25 percent of the approximately 109,674 motorcycles sold (new motorcycles registered) or over 25,000 motorcycles in 2000 involved a trade-in. Hence, the MUP scheme that involves a total trade-in target of 20,000 to 30,000 motorcycles over three years will potentially increase the number of trade-ins by at least 30 percent per year.

Financing Companies

A1.25 There has been insignificant bank lending for new motorcycle purchases to date. There are eight main companies that specialize in providing financing for new motorcycle purchases. Information was received from three companies[30] that some 30 to 40 percent of the financing was provided by these companies. (The financing companies have formed an informal club to share information on a common "black list." They plan to formalize the club into an industry association in the near future.) The financing companies are all private firms whose funds come largely from equity investment. The Bank of Thailand does not regulate these companies.

A1.26 These firms are estimated to provide financing in approximately 75 percent of all new motorcycle purchases but none in recent years for the purchase of second-hand motorcycle purchases. Approximately 65 percent of all new motorcycle purchases involve no trade-in. These financing companies are dealing with prospective buyers who have no collateral. The companies do check the following, however, among other things:

- Job history;
- Credit history; and
- Other assets such as the prospective buyer's own home.

A1.27 Financing is provided by Hire Purchase Agreements with terms varying from 6 to 30 months—the average term being 22 months. All motorcycles financed by these firms must

[29] The high ownership rate of motorcycles (0.4 in-use motorcycles per household) tends to suggest that the proportion of new motorcycle purchases involving a trade-in of an old motorcycle is high.

[30] The three companies were Hiway (Khun Yuttapong, Tel: 3191713) which is owned by TISCO (a Bank); Tanabaan (Khun Wisut and Khun Boonsong, Tel: 2824753); and Prime Capital Leasing Co (Khun Niti, Tel: 3080022.

have third-party insurance. Until the outstanding moneys are repaid, ownership of the motorcycle rests with the financing company that keeps the registration book.[31]

A1.28 As a large proportion of the firms' clients are people who have migrated to Bangkok, they are unlikely to have significant assets in Bangkok and probably rent their flat or other form of lodging. Based on the numbers of distribution of their collectors, the financing companies estimate that 30 to 40 percent of their clients actually live in the neighboring provinces of the BMR although the motorcycles are registered in Bangkok.

A1.29 The financing companies have a team of collectors who personally collect repayments that are due. Each collector must report daily to the head office and put down a deposit to minimize potential cheating in his or her own ranks.

A1.30 Interest rates are high—at present, 2.2 to 2.4 percent per month (flat rate on original principal equal to an annual rate of 50 to 60 percent per year). The high cost appears to be partly attributable to credit risk, which is affected by the lack of secure income for purchasers[32]—reflected in repossession rates, motorcycle theft, and accidents. About 25 percent of motorcycles financed are repossessed by financing companies, and a further three percent are written off because of theft or accident. In addition, collection costs are high.

A1.31 Interest rates depend on the amount of down payment (made up of cash plus the value of the trade):

- 2.4 percent per month flat on original principal when the down payment is 3,000 baht; and
- 2.2 percent per month when the down payment is more than 3,000 baht.

A1.32 The 25 percent of financing arrangements that result in the repossession of a motorcycle represent approximately 800 to 1,000 motorcycles per month. These repossessed motorcycles are auctioned every week and sell for approximately five percent less than the market price. The authors obtained data on average prices of motorcycles by model that were repossessed and auctioned by Highway over the last five years. Agents of second-hand dealers and individuals purchase the motorcycles; the older ones are likely to be sold up-country.

Dealer Financing

A1.33 Dealers may provide or arrange financing to motorcyclists wishing to trade-in their old motorcycle for a new one. Larger dealers may have their own financing companies. Most dealers are affiliated with one or two of the eight financing companies mentioned earlier. A motorcycle worth approximately 15,000 baht or more makes the owner a relatively low credit risk in the dealer's and the associated financing company's view. As dealer margins are low (1,500 baht on an average 40,000-baht machine), there is some incentive for dealers that provide

[31] A Registration Book is issued to the owner of a motorcycle when it is first registered, and is transferred to a new owner when the motorcycle is sold.

[32] Discussions with community groups and industry representatives suggest that about half of the motorcycles in Bangkok are used for income-generating activities, for example messenger, courier, and taxi services. Much of this activity is undertaken on an informal basis, linked to the provision of individual services rather than undertaken by salaried staff.

financing from their own companies to make money either by paying a lower price for a trade-in or encouraging would-be buyers to finance through hire purchase even if they have cash. For each arranged transaction with the affiliated (but non-dealer-owned) financing companies, the dealers receive a commission of about 800 baht per transaction.

Cash and Bank-Provided Finance

A1.34 Cash purchases are also important for the second-hand market as may be "loan shark"–provided financing at presumably much higher interest rates than provided by financing companies. These options are in use because there is limited Bank financing available for second-hand motorcycle purchases.

Retailing Structure

A1.35 Super-dealers are defined loosely as those with sales of more than 100 motorcycles per month. Authorized super-dealers must invest in a showroom, take a minimum quota of motorcycles every month, and have a service center. They may have a number of showrooms. Major dealers may achieve significant sales but not be classified as a super-dealer and consequently not have to meet all the requirements imposed by manufacturers. In addition, there are sub-dealers who buy from major dealers or other sub-dealers. A dealer may have a range of relationships with motorcycle manufacturers—for example, a dealer may be a major dealer for one company and a sub-dealer for others.

A1.36 In Thailand there are about 930 major dealers, 99 super-dealers, and 790 sub-dealers (Table A1.16). More data are required on these companies, especially super-dealers. In Bangkok there are 182 major dealers, including 20 super-dealers and 335 sub-dealers. Dealer margins are quite low as discussed above. Dealers purchasing motorcycles from manufacturers are given credit-free terms of 30 to 45 days.

A1.37 Dealers make their profit through the following:

- Margins;
- Provision of financing (hire purchase) directly or through associated companies—prospective buyers with a trade-in are generally regarded as a low credit risk; and
- Reselling the traded-in motorcycle—motorcycles resold are usually only cleaned up and cosmetic improvements are made.

A1.38 It is manufacturers that control dealer profitability by controlling new motorcycle prices and the cost of spare parts—if a motorcycle is to be upgraded, for example.

A1.39 In Bangkok, 14 of the 71 LTD-registered inspection stations that carry out motorcycle inspections are connected to existing motorcycle dealers. (There are a total of 169 inspection stations in the city that do car or car-and-motorcycle inspections and a further 57 in the rest of the BMR).

Table A1.16
Distribution of Dealers and Sub-Dealers, Bangkok and Thailand

Brand / Location	*No. of super dealers/Major dealers*	*No. of sub-dealers*	*Total*
Kawasaki			
Bangkok	3/44	150	197
Rest of Thailand	20+/113	100	233
Kawasaki, Total Thailand	23+/157	250	430
Honda			
Bangkok	6–7/53	150	210
Rest of Thailand	70/170	150	390
Honda, Total Thailand	76/223	300	600
Suzuki			
Bangkok	5/60	15	75
Rest of Thailand	0/290	105	395
Suzuki, Total Thailand	0/350	120	470
Yamaha			
Bangkok	5/25	20	45
Rest of Thailand	0/175	100	275
Yamaha, Total Thailand	0/200	120	320
Total Bangkok dealers	**20/182**	**335**	**527**
Total Thailand dealers	**99/930**	**790**	**1,820**

Source: Estimate provided by participating dealers.

Large Fleets

A1.40 Motorcycle taxis and motorcycle messengers are a common feature of Bangkok's transport system. While some companies may own their own fleet of motorcycles, most do not and instead hire motorcycle drivers with their own motorcycles on a temporary basis. Government agencies—for instance, the BMA and the police—may have their own motorcycle fleets. While the police fleet is not registered with LTD, the fleets of other agencies are. Data on all large fleet owners (those with more than 50 motorcycles) have been requested from LTD.

A1.41 Large fleets are of particular interest because they are intensively used and a few large owners rather than many individual owners make maintenance decisions. The motorcycle taxi fleet of some 40,000 motorcycles that operate in almost every soi (small side street) in Bangkok is a readily identified fleet. These motorcycles are available at roadside corners and

entrances to congested side streets and offer a much faster trip than three or four-wheeled transport. Fares are negotiated and may be 20 baht for trips on main roads and up to 60 baht for a trip of 5 km—and 5–10 baht for short trips on a side street. It is estimated that motorcycle taxis represented about nine percent of all passenger demand in Bangkok in 1995 (Table A1.17).

A1.42 The police regulates the taxi fleet's operations informally. Police sell the right to operate to an investor for between 15,000–60,000 baht depending on passenger demand in the soi in question. In return, a colored, numbered shirt is issued which gives the right to operate in that particular soi. The owner must pay the police another 20–30 baht per day. The investor then rents the shirt to a motorcycle owner for 150–300 baht per day.

A1.43 At present the annual income from motorcycle taxi operations alone to the police is worth over 240 million baht. The value of shirts issued is estimated at about 1.6 billion baht. In a more preferable scenario, LTD control would reduce what amounts to a police-levied tax on the industry that is not used for the public good and put it to work to increase the safety of the industry for the benefit of passengers.

Table A1.17
Transport Task and Role of Motorcycle Taxis

Mode	*Average speed (km/hr)*	*Fleet size in 1995*	*Fares in 1997 (baht)*	*Approx. no. of passengers daily in 1995*
Regular buses (Blue / Red)	12–13	5,400	2.5–3.5	3,654,000
Air-conditioned buses	12–13	1,200	6.0–16	521,000
Minibuses	12–13	2,000	2.5	1,200,000
Micro-buses	12–13	850	30.0	73,000
Tuk-tuks	12–13	7,400	min. 30–60	342,000
Four wheels (Si-lor)	12–13	8,500	30–60 negotiated	360,000
Motorcycle taxis	40	24,000	10 soi, 20+street, negotiated	784,000
Taxis	12–13	49,000	min. 35	980,000
Chao phraya river ferries	13–24	152	min 4–15	360,000
Canal ferries	13–24	151	5.0–15.0	43,000
SRT trains (provincial within BMR)	15–20	—	2–6	100,000
TOTAL	**n.a.**	**98,350**	**n.a.**	**8,417,000**

—. Not available.
n.a. Not applicable.
Source: From notes on fleet data.

Table A1. 18

Domestic Motorcycle Sales, 2000

Maker/Months	*JAN-JUN*	*JUL*	*AUG*	*SEP*	*OCT*	*NOV*	*DEC*	*JUL-DEC*	*TOTAL (1–12)*
TYPE: MOPED									
HONDA	283,888	41,531	45,581	43,283	42,362	45,109	44,006	261,872	545,760
YAMAHA	39,613	3,878	8,413	10,438	10,579	8,249	11,377	52,934	92,547
SUZUKI	58,314	10,017	7,633	6,917	8,017	7,346	8,285	48,215	106,529
KAWASAKI	5,382	356	500	588	521	1,371	933	4,269	9,651
CAGIVA	52	7	-	3	-	-	-	10	62
SUBTOTAL	**387,249**	**55,789**	**62,127**	**61,229**	**61,479**	**62,075**	**64,601**	**367,300**	**754,549**
TYPE: SPORT									
HONDA	11,523	1,539	1,579	1,147	1,192	1,334	1,220	8,011	19,534
YAMAHA	533	143	128	34	35	64	36	440	973
SUZUKI	10	-	1	-	-	1	-	2	12
KAWASAKI	4,462	704	884	785	675	539	561	4,148	8,610
CAGIVA	-	-	-	-	-	-	-	-	-
SUB-TOTAL	**16,528**	**2,386**	**2,592**	**1,966**	**1,902**	**1,938**	**1,817**	**12,601**	**29,129**
TYPE: MOPED AND SPORT									
HONDA	295,411	43,070	47,160	44,430	43,554	46,443	45,226	269,883	565,294
YAMAHA	40,146	4,021	8,541	10,472	10,614	8,313	11,413	53,374	93,520
SUZUKI	58,324	10,017	7,634	6,917	8,017	7,347	8,285	48,217	106,541
KAWASAKI	9,844	1,060	1,384	1,373	1,196	1,910	1,494	8,417	18,261
CAGIVA	52	7	-	3	-	-	-	10	62
TOTAL	**403,777**	**58,175**	**64,719**	**63,195**	**63,381**	**64,013**	**66,418**	**379,901**	**783,678**

Details of In-Use Fleets in Bangkok and Thailand, 1999

A1.44 Data on the in-use fleet for 1999 for Thailand and Bangkok are shown in Table A1.19. This Table shows the actual legally registered in-use fleet for each vehicle type—the figures vary significantly from those published by LTD, which show a fleet of motorcycles of over 1.6 million in 1999.

A1.45 A further check on the in-use motorcycle fleet was made by using data from the extensive home interview survey in the BMR carried out for the Office of the Commission for Land Traffic in 1995. As it appears that population slightly declined from 1995 to 2000, the 1995 estimates of motorcycles in use are assumed to be reasonably accurate for 2000 as well. The survey was conducted for the purpose of developing a transport-forecasting model for the BMR. Only information on motorcycles garaged overnight (assumed to be in-use bikes) at the household was obtained. The data therefore exclude large corporate fleets that are assumed to be relatively small. The numbers of in-use motorcycles estimated from the survey data are as follows:

- 550,000 motorcycles garaged overnight in the BMA; and
- 936,000 motorcycles in total (that is, including the BMA) in the BMR.

A1.46 LTD's official published registration figures (that is, cumulative ones) show that 181,000 motorcycles are registered in the five provinces surrounding the BMA and within the BMR. Assuming that of these 181,000, say, 100,000 motorcycles are actually in use and re-registered annually outside of the BMA, then one can estimate that some 836,000 motorcycles are likely to be re-registered in the BMA but may be used in the BMA as well as the rest of the BMR. That is, the ratio of motorcycles registered in the BMA over the total garaged overnight in the BMA appears to be 550/836 or 66 percent. In other words, 34 percent of those motorcycles registered in the BMA may be used outside of the BMA, in the balance of the BMR. This estimate is consistent with information provided by the finance companies.

Table A1.19 Comparison of Registered and In-Use Motor Vehicle Fleet, Bangkok and Thailand, 1999

Vehicle type	*Bangkok*					*Thailand*				
	Total		*In-use*		*% in-use of total reg.*	*Total*		*In-use*		*% in-use of total reg.*
	Registered[33] *at end-1999*	*New reg., 1999*	*Actual re-registration, 1999*	*Total in use, 1999*	*Bangkok, 1999*	*Registered* [33] *at end-1999*	*New reg., 1999*	*Actual re-registration, 1999*	*Total in use, 1999*	*Thailand, 1999*
Vehicles under MVA										
Sedan and microbus (? 7 passengers)	1,317,062	45,814	800,965	846,779	64.29	2,123,590	67,815	1,348,780	1,416,595	66.71
Microbus/ passenger pick up (> 7 passengers)	289,116	3,808	174,177	177,985	61.56	526,871	5,585	326,540	332,125	63.04
Van and pick-up truck	664,080	40,393	409,811	450,204	67.79	3,097,831	100,673	2,083,366	2,184,039	70.50
Motor-tricycle	885	2	378	380	42.94	2,535	7	568	575	22.68
Interprovincial taxi	249	0	5	5	2.01	334	0	14	14	4.19
Urban taxi (7-person)	61,950	1,979	26,558	28,537	46.06	64,072	1,979	26,744	28,723	44.83
Fixed-route taxi	8,229	0	2,099	2,099	25.51	8,796	45	2,624	2,669	30.34
Tuk-tuk	7,405	0	6,297	6,297	85.04	50,445	29	14,320	14,349	28.44
Hotel taxi	960	35	483	518	53.96	1,117	46	677	723	64.73
Tour taxi	317	1	109	110	34.70	354	1	144	145	40.96
Car for hire	106	0	46	46	43.40	127	0	46	46	36.22
Motorcycle	1,660,119	86,299	630,380	716,679	43.17	13,244,961	465,705	5,565,513	6,031,218	45.54
Tractor	20,167	366	4,320	4,686	23.24	110,971	4,376	39,201	43,577	39.27
Road roller	5,769	159	2,183	2,342	40.60	10,712	592	4,713	5,305	49.52
Farm vehicle	64	0	25	25	39.06	87,442	1,789	39,861	41,650	47.63
Trailer	1,137	37	327	364	32.01	3,558	49	924	973	27.35
Subtotal ve hicles under MVA	**4,037,615**	**178,893**	**2,058,163**	**2,237,056**	**55.41**	**19,333,716**	**648,691**	**9,454,035**	**10,102,726**	**52.25**
Vehicles under LTA										
Fixed-route bus	13,785	455	8,782	9,237	67.01	69,610	1,322	53,388	54,710	78.60
Non-fixed-route bus	7,361	125	5,161	5,286	71.81	18,911	539	14,740	15,279	80.79
Private bus	3,782	54	2,307	2,361	62.43	7,280	181	5,157	5,338	73.32

Vehicle type	*Bangkok*					*Thailand*				
	Total		*In-use*		*% in-use of total reg.*	*Total*		*In-use*		*% in-use of total reg.*
	Registered[33] *at end-1999*	*New reg., 1999*	*Actual re-registration, 1999*	*Total in use, 1999*	*Bangkok, 1999*	*Registered* [33] *at end-1999*	*New reg., 1999*	*Actual re-registration, 1999*	*Total in use, 1999*	*Thailand, 1999*
Small rural bus	0	0	0	0	0.00	22,066	435	17,888	18,323	83.04
Subtotal bus	**24,928**	**634**	**16,250**	**16,884**	**67.73**	**117,867**	**2,477**	**91,173**	**93,650**	**79.45**
Non-fixed-route truck	31,819	1,186	25,206	26,392	82.94	72,609	2,263	56,244	58,507	80.58
Private truck	67,253	1,886	53,517	55,403	82.38	540,734	8,574	399,765	408,339	75.52
Subtotal truck	**99,072**	**3,072**	**78,723**	**81,795**	**82.56**	**613,343**	**10,837**	**456,009**	**466,846**	**76.11**
Subtotal vehicles under LTA	**124,000**	**3,706**	**94,973**	**98,679**	**79.58**	**731,210**	**13,314**	**547,182**	**560,496**	**76.65**
Grand total (excl. NMVs)	**4,161,615**	**182,599**	**2,153,136**	**2,335,735**	**56.13**	**20,064,926**	**662,005**	**10,001,217**	**10,663,222**	**53.14**

Notes:
LTA = Land Transport Act.
MVA = Motor Vehicles Act.
NMV = Nonmotorized vehicles.
[33] Total cumulative registrations at end-1999 since the present system of registration commenced prior to 1970. These cumulative figures do include lapsed registrations which are not advised to LTD but do not include formally advised transfers of registration and de-registrations.

Annex 2

Cost-Benefit Analysis Summary (currency unit US$, March 2001)

Table A2.1 For the Motorcycle Upgrade Program only

	Present value of flows		*Fiscal impact*	
	Economic analysis[34]	*Financial analysis*[35]	*Taxes*	*Subsidies*
Benefits	$29.9 million	n.a	n.a.	n.a.
Costs	$ 9.7 million	$13.0 million	n.a.	$5.3 million
Net Benefits:	$20.2 million	n.a.	n.a.	n.a.
IRR	102%	n.a.	n.a.	n.a.

n.a. Not applicable

[34] The economic analysis does not include bus and truck upgrade pilots.

[35] If the difference between the present value of financial and economic flows is large and cannot be explained by taxes and subsidies, a brief explanation of the difference is warranted, for instance, "The value of financial benefits is less than that of economic benefits because of controls on electricity tariffs."

Table A2.2 Summary of Benefits and Costs

Year	*Total cost ($million)*	*Total benefits ($million)*	*Net benefit ($million)*
1	14.2	6.60	(7.6)
2	8.3	12.81	4.5
3	(1.0)	11.43	12.5
4	(6.3)	7.10	13.4
5	(4.2)	5.88	10.1
6	(2.8)	0.00	2.8
7	(1.8)	0.00	1.8
8	(1.2)	0.00	1.2
9	(0.8)	0.00	0.8
10	(0.5)	0.00	0.5
NPV ($M)=	9.7	29.9	20.2
B/C=	3.1		

Main Assumptions

A2.1 The key assumptions used in calculating costs and benefits in this project are shown below. For estimating health benefits, mortality was valued by means of human capital measure of the value of reduced risk of death rather than the willingness to pay (to reduce the risk of dying). The value of earnings lost when a person dies prematurely will, in general, understate the economic value of reduced risk of death. This approach was adopted because if policies pass the cost-benefit test when benefits are conservatively measured, the results can be presented to policymakers with confidence. U.S. monetary values for mortality (foregone earnings) and morbidity were transferred to the BMR using an income elasticity of 1.0. Aside from these assumptions, the coefficients for estimating mortality and morbidity as well as economic valuation figures were taken from K. Lvovsky, G. Hughes, D. Maddison, B. Ostro, D. Pearce, Environmental Cost of Fossil Fuels: A Rapid Assessment Method with Application to Six Cities, Environment Department Paper No. 78 (2000), The World Bank, Washington. The figure for change in $\mu g/m^3$ per ton of PM reduced was taken from Hagler Bailly, *Health Effects of Particulate Matter Air Pollution in Bangkok*, March 1998 report submitted to the World Bank. The final values reported are in the year 2000 and in U.S. dollars.

Table A2.3 Assumptions for Benefit Cost Calculations

Benefit discount rate%=	15
Cost discount rate%=	15
Baht/$=	42.7
change in ug/m^3 per TPY emissions reduced	0.00205
Annual benefits ($/capita/change in µg/$m^3$)	3.4
Population (million)	10
Population growth rate (%/yr)	0.41%
Number of MCs in use in Bangkok	690,500
MC population growth rate	5%
% MC retirement per year	24%
%Deterioration factor (EF) increase (g/km/yr)	1%
VKT (km/day)	40
Fuel economy (l/km)	0.03
Price of fuel ($/l)	0.2
Fuel savings (remanufactured and scrapped)	40%[a]

[36] This large increase in fuel economy comes about because vehicles replaced have old two-stroke engines, and all new vehicles purchased are assumed to be of four-stroke engine design which has inherently higher fuel economy than two-stroke.

Base emission factor (g/km)	0.3
New MC emission factor (g/km), four-stroke	0.03
General MC population emission factor decrease (%/yr)	5%
Major repair deterioration factor (%/yr)	10%
Total motorcycles for MUP	300,000

Project year	*MCs for MUP*	*No. of MCs*
1	46%	136,940
2	39%	115,680
3	16%	47,380

	Pass	Tune-up	Major repair	Leave	Remanufacture	Scrap	MCs outside project
Number, %	68.6%	17.2%	1.3%	3.0%	5.0%	5.0%	
Emission factor reduction	2.5%	10%	25%	2.5%	90%	90%	1%

Scrappage allowance = 5,000 baht per vehicle scrapped

First year cost of new MC= $1,090

First year salvage value = $ 250

Salvage value reduction/yr 25%

Table A2.4 Sensitivity analysis / Switching values of critical items (in million US$)

	Cost	*Benefits*	*Net benefit*	*Benefit/Cost*	*IRR*
Base case	9.7	29.9	20.2	3.1	102%

Sensitivity analysis examples:

Discount rate	*Cost*	*Benefits*	*NB*	*B/C*	*IRR*
10%	8.6	33.7	25.1	3.9	102%
15%	9.7	29.9	20.2	3.1	102%
20%	10.4	26.8	16.4	2.6	102%

Annual benefits ($/Capita/ change in ug/$m^3$)	*Cost*	*Benefits*	*NB*	*B/C*	*IRR*
1.5	9.7	14.4	4.7	1.5	28%
3.4	9.7	29.9	20.2	3.1	102%
5.0	9.7	43.0	33.3	4.4	251%

Change in ug/m^3 per TPY emissions reduced	*Cost*	*Benefits*	*NB*	*B/C*	*IRR*
0.00103	9.7	16.1	6.4	1.7	34%
0.00205	9.7	29.9	20.2	3.1	102%
0.00308	9.7	43.8	34.1	4.5	266%

Annex 3

Bangkok Motorcycle Fleet Upgrade Program

Trade-in and Additional Upgrade Program

Background

A3.1 The Bangkok Metropolitan Administration (BMA) and the World Bank launched the urban air quality–improving project, the "Bangkok Motorcycle Fleet Upgrade Clinic" in 2000. The project involved the inspection of the motorcycle fleet, data collection, and the motorcycle trade-in program. The first motorcycle inspection (clinic) was arranged in Bangkok during May 15–17, 2000. Approximately 1,400 motorcycles took part; 566 questionnaires were collected and used for further analysis. The second motorcycle clinic was carried out during July 11–13, 2000 in Bangkok. More than 1,500 motorcycles participated in the second clinic. Combined data from the two motorcycle clinics were used for statistical analysis and were compiled in the report.

The Trade-In Program

A3.2 Based on the analysis of all collected data, the number of motorcycles that failed the emissions test was determined. Then the owners of the motorcycles were contacted and informed about the trade-in program. There were 43 owners of highly polluted motorcycles who indicated their interest in the trade-in program. The details of the motorcycles—for example, brand, model, registered number, chassis number, model year, engine size, and estimated motorcycle value—for exchange are illustrated in Table A3.1. Some of the 43 motorcycles were selected for the fuel consumption test and emissions test before and after the reconditioning process. The selection criteria were as follows:

- The motorcycles were used for more than 3 years.
- The engine sizes were in the range of 100–150 cc.
- The accumulated distance for each motorcycle exceeded 30,000 km.
- All of the samples were two-stroke motorcycles since there was only one four-stroke motorcycle participating in the trade-in program.

Table A3.1
Details of 43 Motorcycles Involved in the Trade-In Program

No.	Registered number	Brand[37] / model	Chassis number	Model year	Evaluated value[38], baht	Swept volume, cc
1	8?-0338	S / CRYTAL	BE12A-TH230202	1991	15,400	110
2	1ª-3245	S / ROYAL	BE121-TH110244	1995	23,300	110
3	?¥? 949	S / RC100	BE11-TH591763	1996	21,100	100
4	1¦-6695	S / RGV	XG11A-TH241696	1994	12,000	150
5	5•-0711	S / AKIRA	BE13B-TH110979	1991	12,000	110
6	??? 762	Y / RXZ	3XX-044106	1993	19,000	135
7	??? 114	Y / TZR	3RR-059106	1993	30,900	150
8	1¢-9355	Y / JR-S	4AC-069971	1993	19,000	120
9	9?-3697	Y / BELLE-R	3PP031831	1990	10,000	100
10	1?-3402	Y / TZR	3RR-023149	1981	27,500	150
11	7?-6001	Y / RX100	IVI-K38979	1980	4,000	100
12	?¨? 195	Y / RX	29M-16247K	1984	7,000	135
13	7¦-7341	Y / JR	4MA-009310	1994	23,000	120
14	8 -5068	Y / JR	4AC-044953	1993	21,000	120
15	6?-6838	Y / BELL	3PP-028292	1989	8,500	100
16	9?-6536	K / GTO	GTO-M-62186	1992	14,657	125
17	3•-1910	K / KR125	ARR-12581	1987	5,000	125
18	??¬ 307	K / KR	KR150E A68826	1995	46,800	150
19	¦-2162	H / DASH	NL125N-0014787	1993	32,000	125
20	7¢-8154	H / NSR	NS150P-0007572	1993	35,100	150
21	5®-6625	H / DASH	NZ125N-0181632	1995	37,300	125
22	1®-9757	H / DASH	NZ125N-0181016	1995	38,400	125
23	5¦-5791	H / LS	LS110N-0071088	1994	38,300	125
24	9 -0300	H / NOVA	NZ110L-134312	1993	22,919	105
25	??ª 79	H / WING	TG125E-B1179	1984	8,000	125
26	5¥-4262	H / NSR	NS150-0055661	1994	40,800	150
27	??¡ -35	K / KR	KR150B-A26253	1993	36,000	150
28	?•¬ 599	H / NZ125	NZ125TS-0060967	1997	39,000	125
29	4- -4382	K / KR	KG150A-A21843	1995	36,000	150
30	???-144	H / DASH	NZ125TS-0027126	1996	35,000	125
31	???-333	K / KR150	KR150B-A30476	1994	46,875	150
32	??? 490	K / KR150	KR150C-A54786	1996	39,000	150
33	2ª-2052	H / DASH	NZ125N-0127135	1995	30,000	125
34	7?-9436	H / NSR	NS150-029173	1992	26,000	150
35	9•-9736	H / NOVA	NZ110K-134833	1991	17,000	110
36	??? 953	K / GTO	GTO-M55344	1991	12,000	125
37	8ª-6872	Y / TZM	4AP-016481	1995	35,000	150
38	8¡ -7283	H / DASH	NZ125N-0013365	1993	30,000	125
39	??ª 338	H / NSR	NS150-018642	1991	28,000	150

No.	Registered number	Brand[37] / model	Chassis number	Model year	Evaluated value[38], baht	Swept volume, cc
40	??? 195	S / AKIRA	BE13A-TH196351	1992	14,000	110
41	?? • 91	H / DASH	NZ125TS-0045416	1997	35,000	125
42	??¬ 254	K / NEON	AH110A-A13005	1995	18,000	110
43	9 -3108	K / KR150	KR150B-A22467	1993	37,000	150

[37] Brand of motorcycle.
H = HONDA S = SUZUKI K = KAWASAKI Y = YAMAHA
[38] Evaluated values used information from the Finance Association.

A3.3 The 20 motorcycles selected from the list of the trade-in program were categorized into two groups of 10. The details of the motorcycles in Group 1 and Group 2 are displayed in Tables 2.5 and 2.6, respectively. There were different testing conditions for Group 1 and Group 2. For the motorcycles in Group 1, the testing included emissions test at idle, fuel consumption test, and mass emission using facilities at Thailand Automotive Institute (TAI). For the motorcycles in Group 2, the testing excluded the mass emissions test at TAI. The motorcycles in both groups were tested twice, before and after reconditioning.

The Fuel Consumption Pretest

A3.4 Before the motorcycles selected for trade-in were reconditioned, they were tested to monitor fuel consumption rate (Figure A3.1). This test was carried out at the PDK test site in Samutprakarn. The test procedure was as follows. First the speedometer of each motorcycle was adjusted to work properly. Then the devices to measure fuel consumption were installed on the tested motorcycle. This allowed a driver to turn the fuel switch on at the beginning point and off at the end point. The test site was a straight private track longer than 200 meters (annex Figures 3.2 and 3.3). The tests were set at constant speeds of 30, 50, and 80 km/hr. The motorcycles with engine sizes smaller than 125 cc were tested at 30 and 50 km/hr, while those with engine sizes between 126 and 150 cc were tested at all three speeds. For each speed, the motorcycles were tested twice and the average fuel consumption rate was computed and recorded. The device for measuring the fuel consumption rate is shown in Figure A3.1. The photograph of actual testing environment is shown in Figure A3.2 and the diagram of the testing track is displayed in Figure A3.3. The results of the fuel consumption rates for 20 motorcycles are shown in Tables 2.7 and 2.8. At speeds of 30 and 50 km/hr, the fuel consumption rates of the motorcycles in Group 1 were in the range of 25–74 km/liter and 21-60 km/liter, respectively. For Group 2, the fuel consumption rates were in the range of 32–56 km/liter and 28–51 km/liter for the two speeds of 30 and 50 km/hr, respectively. Generally, at higher speed the fuel consumption rate increased.

Figure A3.1
Device to Measure Fuel Consumption Rate

Source: Project Study Team.

Figure A3.2
The Fuel Consumption Testing Area

Source: Project Study Team.

Figure A3.3
The Fuel Consumption Testing Track Diagram

Source: Project Study Team.

The Emission Pretest at Idle

A3.5 Before the reconditioning, emissions of the 20 motorcycles at idle were measured using the NDIR emission analyzers (Figure A3.4). There were two analyzers to measure carbon monoxide and hydrocarbon. The first one was the Horiba MEXA 554JA and the second was the Hermann. The limits of CO and HC were 4.5 percent and 10,000 ppm, respectively. For white smoke, the measuring device was a full flow opacity type, which has two photo-sensors, a light-emitting sensor and a light-receiving sensor. The white smoke was allowed to flow between these sensors. The amount of light received by the receiving sensor was inversely proportional to the opacity of the white smoke. The opacity limit was set so that it would not be greater than 30 percent on the device scale (annex figures 3.5, 3.6, and 3.7). The results of emissions at idle were shown in Tables 2.9 and 2.10. The results of Group 1 show that CO levels were in the range of 1.1–4.3 percent and HC levels were 3,460–9,310 ppm (except motorcycle number 7). White smoke levels of six motorcycles were in the range of 0–21 percent and another four motorcycles emitted white smoke that exceeded the limit of 30 percent.

Figure A3.4
HERMANN CO and HC Emissions Analyzer

Source: Project Study Team.

Figure A3.5
Emissions Testing at Idle

Source: Project Study Team.

Figure A3.6
Device to Measure White Smoke

Source: Project Study Team.

Figure A3.7
Measuring the White Smoke Level

Source: Project Study Team.

The Mass Emissions Pretest

A3.6 The third test for the motorcycles before reconditioning was the mass emissions test. Only 10 motorcycles in Group 1 were selected to participate in the mass emissions test. The facilities at Thailand Automotive Institute in Samutprakarn were used for this test. The test cycle was an ECE R-40 driving pattern. For the ECE test, two types of testing were conducted. The type 1 test was the mass emissions and the results were in g/km. The type 2 test was the emissions concentration at idle, which was measured following the driving cycle. Figures 3.8 and 3.9 show activities during the mass emissions test. The results of the test are presented in Table 2.11. The results show that CO emissions of three motorcycles were above the limit of 16 g/km and HC emissions of eight motorcycles were above the limit of 7.0 g/km.

Figure A3.8
The Mass Emissions Test Cell at Thailand Automotive Institute

Source: Project Study Team.

Figure A3.9
Testing the Motorcycle Mass Emissions Using the ECE R-40 Driving Cycle

Source: Project Study Team.

The Additional Upgrade Program

A3.7 After conducting testing for emissions and fuel consumption on the 20 trade-in motorcycles, all 43 motorcycles were cleaned, adjusted, and reconditioned. The reconditioning process varied from one motorcycle to another depending on the motorcycle's condition. Engine parts such as cylinder jacket, cylinder head, piston, crankshaft, spark plug, oil pump, carburetor, air filter, and exhaust pipe were cleaned, checked, adjusted, or changed. The details of the reconditioning processes for Group 1, Group 2, and the rest are shown in Tables 2.12 and 2.13, respectively. The cost for reconditioning could be estimated as follows: The oil change cost 82 baht/motorcycle (for 2T-oil change approximately 86 baht/motorcycle) and a spark plug replacement cost 36 baht. The labor cost for cleaning and checking a motorcycle was 100 baht if the engine size was smaller than 125 cc, and 150 baht if it was larger than 126 cc. The costs of other spare parts can be determined by studying market prices.

The Fuel Consumption Post-Test

A3.8 After all the motorcycles were cleaned, checked, adjusted, or changed some parts of them, the reconditioning processes were completed. To investigate the effect of reconditioning motorcycles on the improvement of fuel consumption and emissions, tests similar to those conducted before the reconditioning were done. Tables 2.7 and 2.8 show the results of the fuel consumption test before and after reconditioning for motorcycles in Group 1 and Group 2, respectively. After the reconditioning process, the fuel consumption rates of the motorcycles

seemed to increase moderately. It is noted that in Group 1 the average fuel consumption rates changed from 51.25 km/liter to 36.35 km/liter at the speed of 30 km/hr and 43.92 km/liter to 37.68 km/liter at the speed of 50 km/hr. For Group 2, the average fuel consumption rates changed from 43.37 km/liter to 41.22 km/liter at the speed of 30 km/hr and 39.74 km/liter to 38.93 km/liter at the speed of 50 km/hr.

Table A3.2
Details of Estimated Values, Reconditioning Costs, and Sale Prices of the Remaining 23 Motorcycles

No.	Registered number	Estimated values (baht)	Reconditioning costs (baht)	Sale prices after reconditioning (baht)
1	1ª-3245	23,300.00	3,927	18,500
2	?¥? 949	21,100.00	3,061	20,000
3[39]	1¦-6695	12,000.00	---------	---------
4	1?-3402	27,500.00	2,921	23,000
5[40]	7?-6001	4,000.00	--------	---------
6	7¦-7341	23,000.00	2,898	20,000
7	8 -5068	21,000.00	3,136	19,000
8	6?-6838	8,500.00	6,187	9,000
9[41]	3•-1910	5,000,00	---------	---------
10	??¬ 307	46,800.00	1,123	30,000
11	7¢-8154	35,100.00	1,745	23,500
12	1®-9757	38,400.00	1,885	22,500
13	5¦-5791	38,300.00	11,882	23,000
14	5¥-4262	40,800.00	2,414	27,000
15	??¡ -35	36,000.00	11,224	26,000
16	4- -4382	36,000.00	5,694	23,500
17	???-333	46,875.00	756	27,500
18	??? 490	39,000.00	6,615	19,000
19	2ª-2052	30,000.00	667	21,500
20	7?-9436	26,000.00	2,414	18,500
21	??? 195	14,000.00	643	14,000
22[41]	8ª-6872	35,000.00	2,177	--------
23	??ª 79	8,000.00	1,485	8,000

[39] The motorcycle was stolen while it was kept at the PDK factory.
[40] The reconditioning costs of these two motorcycles were so high that they might not be worth repairing.
[41] This motorcycle is waiting for spare parts.

The Emission Post-Test at Idle

A3.9 Emissions test at idle was also repeated after the reconditioning process. The results before and after the reconditioning are shown in Tables 2.9 and 2.10. It is noteworthy that after the reconditioning process CO and HC levels at idle generally increase while white smoke levels decrease.

The Mass Emission Post-Test

A3.10 For the mass emissions test at Thailand Automotive Institute in Samutprakarn, only 10 motorcycles in Group 1 were used. The results of the mass emissions test (type 1) expressed in g/km and the emissions concentration (type 2) before and after reconditioning are shown in Table 2.11. The Table demonstrates that the reconditioning process can yield a modest reduction in CO mass emissions. After reconditioning, only one motorcycle failed the CO mass emissions test (three had failed before reconditioning). Although the reconditioning process can reduce the HC mass emissions slightly, its amount both before and after reconditioning is still higher than the limit of 7.0 g/km. The results of the type 2 test show that CO and HC concentrations are reduced slightly after the reconditioning process.

Summary of the Study

A3.11 Bangkok Motorcycle Upgrade Project was launched in 2000 by the BMA and the World Bank team. The program started with two motorcycle clinics in May and July 2000, which collected baseline data of motorcycles running in Bangkok to arrive at the number of highly polluting motorcycles. After the data were collected and analyzed, the trade-in program was launched. The details of trade-in program were summarized in this report.

A3.12 There were 43 highly polluting motorcycles that were selected for the trade-in program—16 Hondas, 10 Kawasakis, 6 Suzukis, and 11 Yamahas. The engine sizes ranged from list either in alphabetical order by brand name or numerically by number of motorcycles. 100 to 150 cc and the model years from 1980 to 1997. The exchange values ranged from 4,000 to 46,875 baht.

A3.13 Before the motorcycles were reconditioned, 20 were tested to determine fuel consumption rates and emissions. The reconditioning process included cleaning, adjusting, and changing some engine parts such as spark plugs, air filters, ignition coils, and so on. The costs of reconditioning ranged from 100 to 11,882 baht per unit.

A3.14 The results revealed, surprisingly, that the fuel consumption rates of motorcycles after reconditioning increased modestly; and CO and HC emissions increased slightly as well. (For example, the average fuel consumption at the test speed of 50 km/hr changed from 43.92 km/liter to 37.68 km/liter.) It is believed that the reconditioning process involves adjusting motorcycle carburetors to the manufacturing set point. This set point usually yields good engine performance and produces certain concentrations of CO and HC at idle—hence the increases.

A3.15 However, the results from the mass emissions test show that the reconditioning process can help to reduce the amount of CO moderately and HC slightly. Also, the reconditioning process generally helps reduce white smoke levels.