ISSN 1880-8468

Technical Report of
International Development Engineering
国際開発工学報告

TRIDE-2012-01 January 4, 2012

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Mitigating Adverse Impacts of Transport in Asian Megacities

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This report is a part of the international collaborative research study, STREAM (Sustainable Transport in East Asian Megacities) organized by Institute for Transport Policy Study (ITPS), and endorsed by the Eastern Asia Society for Transportation Studies (EASTS) as one of its International Research Group (IRG) activities from 2005-2008. The study design and the views expressed are the sole responsibility of the authors.

1. Adverse Impacts on Urban Transport in Asian Megacities

In order to accommodate the fast growing economy as well as to facilitate growing demand of higher quality of life, there has been an upsurge in the urban development in the Asian megacities. More urban areas and economic growth lead to a rising vehicle population, which eventually produces some adverse impacts including the emission of greenhouse gas and local air pollutants, traffic accident, etc.

Vehicles emit carbon dioxide (CO_2) which is a typical greenhouse gas and local air pollution such as carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbons (HC), particulate matters (PM), volatile organic compounds (VOCs) such as benzene, etc. in gaseous and particulate forms. In developing Asians mega-cities, used vehicles are popular for both private cars and buses which are sometimes imported from developed countries. These old used vehicles emit more pollutants than new ones. Motorcycles are popular in some Asian mega-cities e.g. Ho Chi Minh City (HCMC), Taipei and Bangkok. However, this mode has a higher emission load factor per person than four wheel vehicles. Furthermore, worsening traffic congestion exacerbates these problems, and also imposes direct economic and health costs on users and non-users in the form of wasted money, stress, and other illnesses.

The level of CO_2 emissions is related to the amount of energy consumed. In general, the energy intensity per passenger of bus and rail is lower than that of private vehicles. Comparing rail and buses, rail has smaller energy intensity in most cities. In Tokyo, for example, the energy intensities of rail and bus are one-tenth and one-third that of private vehicles (WCTRS and ITPS, 2004). While, in developing Asian cities, the average energy intensity of every mode is below that of developed cities because of high load factors (the number of passengers per vehicle).

Besides pollution, another significant issue of transport sectors is road accidents which cause substantial impact to road, public health as well as economic sectors. In economic terms, the cost of road crash injuries was estimated at roughly 1% of gross domestic product (GDP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries (Jacobs et al, 2000). It is obvious that the urbanization and the magnitude of road accident as a problem are highly correlated.

World Report on Road Traffic Injury (WHO, 2004) showed that fatality rates in high-income countries have been declining, while in the low- and middle-income countries, they are still on an upward trend. Although the magnitude of increase varies by region, it is unfortunate that the highest rise happens to be in Asia (Tanaboriboon and Santiennam, 2005).

As indicated above, this report focuses on air pollution and traffic accidents as the major adverse impacts on urban transport. It attempts to show the current impact and issues of these two problems. Further it looks into recent challenges by pointing out some common and successful practices adopted in Asian megacities. Finally, in the last section, this report suggests some policy recommendation to manage the challenges in mitigating the adverse impacts of urban transport.

2. Current Impact and Issues

2.1 Trends of Global Climate Change in Asian Countries

CO_2 emission data of country level can be obtained from International Energy Agency (IEA) and United Nation Framework Convention on Climate Change (UNFCCC). However, UNFCCC data focuses on only Annex I Parties which are mostly developed countries, thus International Energy Agency (IEA) data was used for analyzing the trends of CO2 Emission in STREAM member Asian countries.

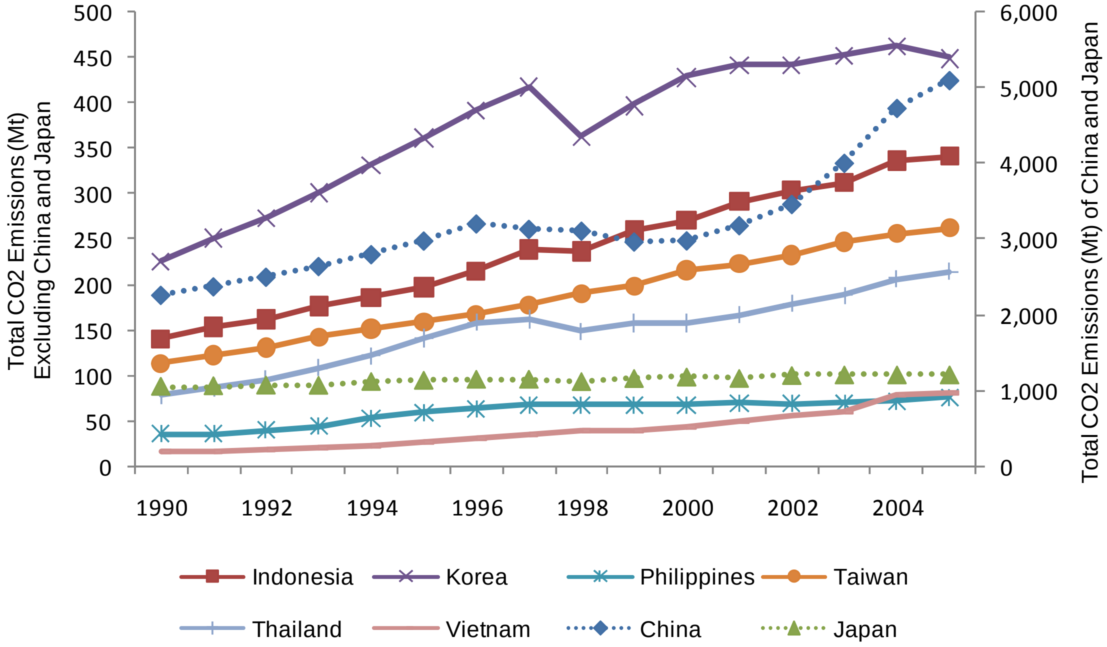


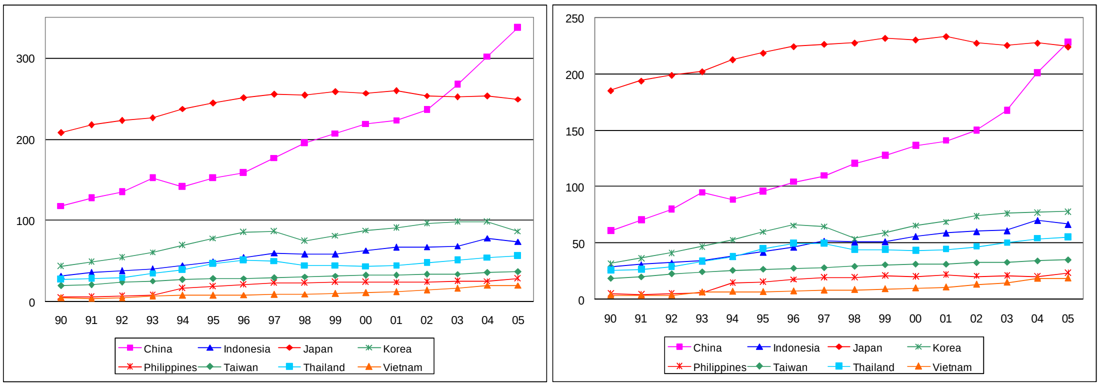
Figure 1 Trends of CO2 Emission in STREAM member countries

Source: International Energy Agency Data Service

Figure 1 shows the trends of total CO_2 emission. CO_2 emissions in China are dramatically increasing after year 2000 by mainly Industrial Sector. In 1998, CO_2 emission of South Korea, Indonesia and Thailand were decreased by the “Asian Financial Crisis in 1997”, but the emissions of these countries were finally “recovered” at most within three years. Emission volume in Japan is stable at around 1200 Mega (Mt) -ton of CO_2 in 2003 – 2005. On the other hand, in South Korea, the emission starts decreasing from 2005.

In Transport Sector as shown in Figure 2, CO_2 emission in China is continuously increasing, however its ratio among all sectors are very low, which is 5 - 7 percent only. In Japan, peak volume was 260 Mt-ton of CO_2 reached in 2001 and since then the emission starts decreasing along with the decrease of emission in road sub-sector. Similar tendency also occurs in South Korea and Indonesia.

In general, road sub-sector is the main contributor of transport sector’s CO_2 emission. All countries except Japan’s emission volume from road sub-sector are increasing, especially China. It should be noted that in China, aviation, rail and domestic navigation sub-sectors also emit high level of CO_2, and thus road sub-sector contributes less than 70 percent.



Note:
Right: trend in transport sector; left: trend in road sub-sector
No data available of Thailand and Taiwan for Domestic Aviation, Indonesia, Philippines and Vietnam for Rail and Vietnam for Domestic Navigation. Source: International Energy Agency Data Service

Figure 2 Trends and Percentage of CO2 Emission in Transport Sector and Road Sub-sector

Source: International Energy Agency Data Service

The trend in regional CO_2 emissions (IEA, 2009) shows that between 1971 and 2007, global emissions doubled in which industrialized countries (Annex II Parties to the UNFCCC including Japan) dominating the historical totals. However, the share of Annex II progressively shrank (61% in 1971, 47% in 1990 and 39% in 2007), as developing countries, led by Asia, increased at a much faster rate. Between 1990 and 2007, CO_2 emissions raised by 108% for non-Annex I countries as a whole and more than doubled for Asia. The growth in Asian emissions reflects a striking rate of economic development, particularly within China and India. In 2007, China, the United States, the Russian Federation, India and Japan, the largest emitters, produced together 55% of the global CO_2 emissions, 50% of the world GDP, and comprised 46% of the total population.

2.2 Trend of Local Air Pollution caused by Transport Sector in Asian Megacities

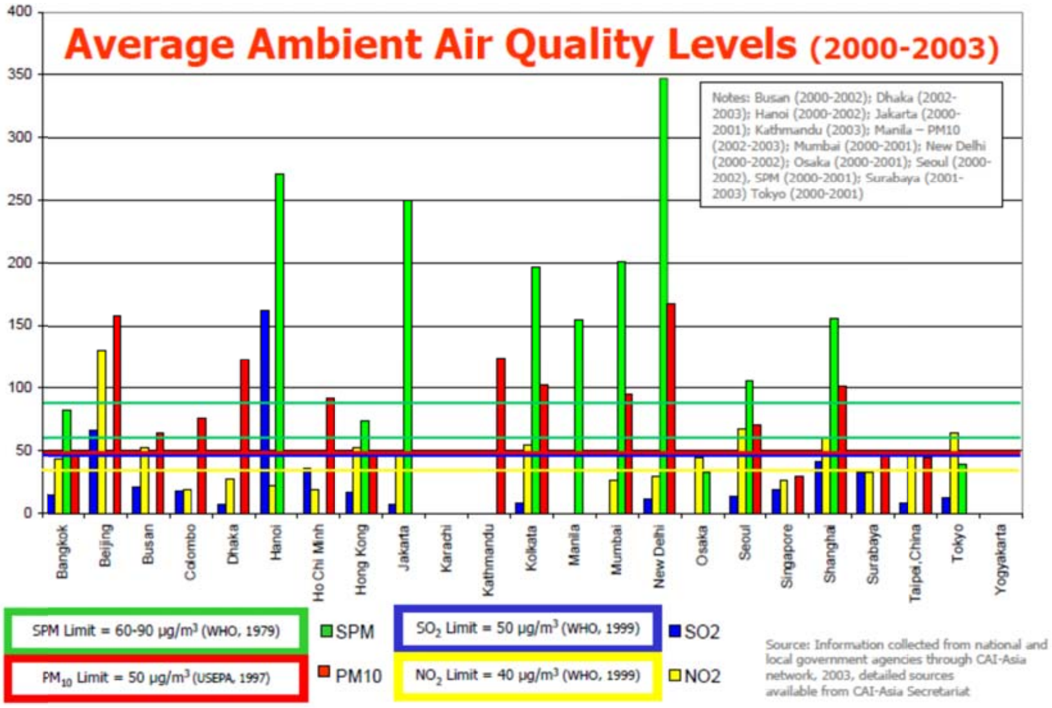


Figure 3 Average Ambient Air Quality Levels

Source: Huizenga, et al., 2004

The air in Asian megacities is amongst the most polluted in the world as shown in Figure 3. In most cities, the level of SO_2 was less than WHO standard[1], however SPM, PM_{10} and NO_2 are over the WHO standard in most cities. Bangkok, HCMC, Jakarta, Manila, Seoul and Shanghai are high levels of SPM/ PM10, while Tokyo is twice levels of NO2 compared to WHO standard.

Referring to ADB study (2006), the data from 20 large cities in Asia show a general situation of slow improvement in air quality, especially for Total Suspended Particulate (TSP) and SO_2. The greatest area of improvement has been reducing levels of TSP and SO_2, while the levels of PM_{10} – by far the most critical air pollutant – have shown a limited decline. PM_{10} average concentrations in many Asian cities still far exceed WHO guidelines, which for PM_{10} is an annual average of 20 $\mu g/m^3$. None of the large Asian cities meets the WHO guideline although Bangkok and Singapore are the closest.

2.3 Trend of Traffic Accident in Asian Countries

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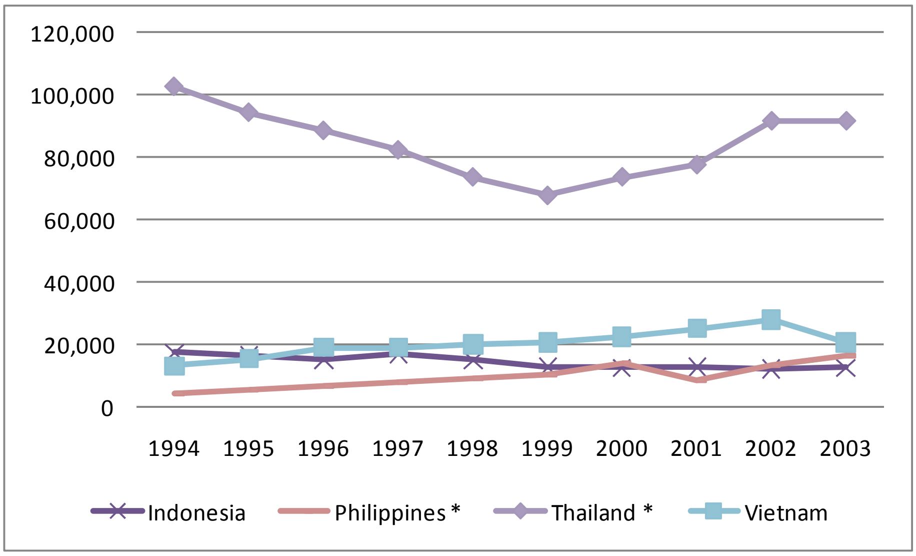
[1] The World Health Organization (WHO) Guidelines for Air Quality (GAQ) are based on epidemiological studies that emerged in the late 1980s and 1990s.

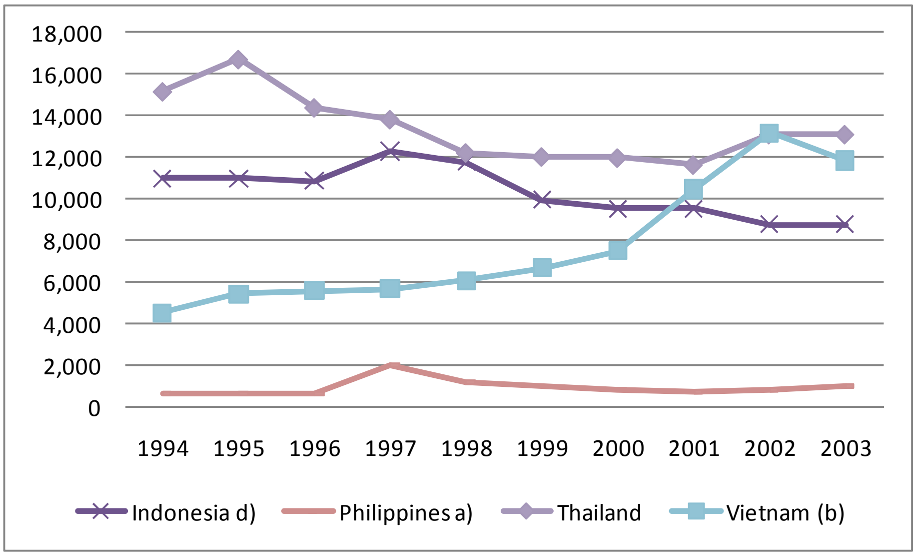
WHO data for 2002 found that road traffic deaths accounted for 23% of all injury deaths worldwide. Around 85% of all global road deaths, 90% of the disability-adjusted life years lost due to crashes and 96% of all children killed worldwide as a result of road traffic injuries occur in low and middle income countries. In these countries – Africa, Asia, the Caribbean and Latin America, the majority of road deaths are among pedestrians, passengers, cyclists, users of motorized two-wheelers, and occupants of buses and minibuses. According to the World Bank's Traffic Fatalities and Economic Growth (TFEC) predictions using transport, population and economic data, between 2000 and 2020, South Asia will record the largest growth in road traffic deaths, with a dramatic increase of 144%.



Note: In Thailand, no. of accidents given for both injury accidents plus accidents with damage only; In Indonesia and Vietnam, number of accidents given resulting in injury or death

Figure 4 Trend of total number of road accidents of STREAM countries in ASEAN
Source: ADB-ASEAN Regional Safety program, country reports

Among STREAM countries in ASEAN, Thailand recorded the highest number of accidents in the past one decade and showing a steady increase year by year, followed by Vietnam, Philippine, and Indonesia. Nonetheless, in Thailand, the number of accidents once decreased during the period of 1994 to 1999. It further increases but remains at lower level compared to the record of 1994. The number of accidents in Indonesia also decreases. In the case of Viet Nam, following a steady increase, a sharp decrease occurred in 2003, so did the number of deaths and injuries (see Figure 4 and 5).

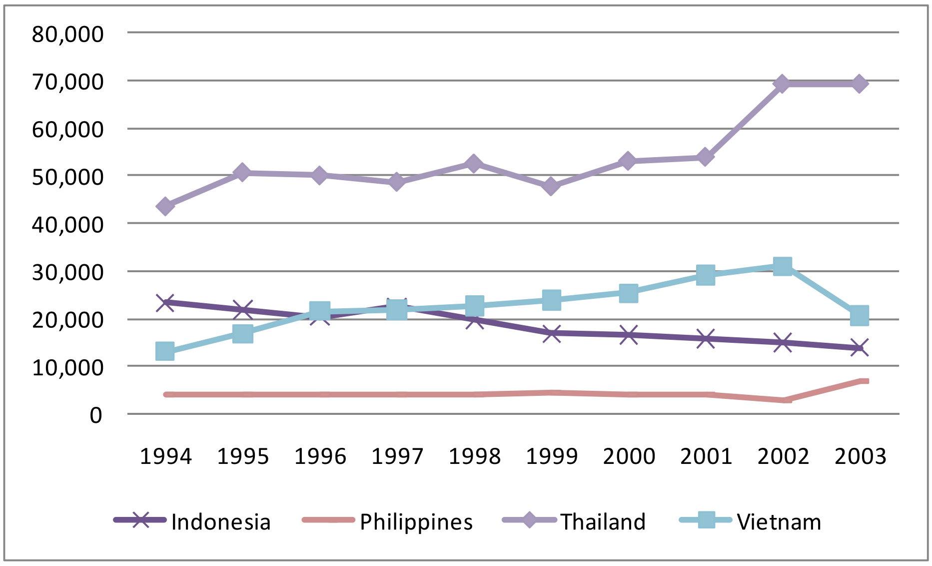


Note: In this data, correction factor of definition of killed is not used. a) on the spot (e.g. Philippines); b) 24 hours (e.g. Viet Nam); c) 7 days; d) 30days (e.g. Indonesia).

Figure 5 Number of Road Accidents' Deaths of STREAM Countries in ASEAN

Source: ADB-ASEAN Regional Safety program, country reports

Fatalities and injuries caused by road accident in Thailand is the highest. Nonetheless, a decreasing trend of number of deaths is found in Thailand's case. It should be noted though that the definition of killed measured by time of death is different among countries.



Note: Including serious and slight injuries; Source: ADB-ASEAN Regional Safety program, country reports

Figure 6 Number of Road Accidents' Injuries of STREAM Countries in ASEAN

Source: ADB-ASEAN Regional Safety program, country reports

3. Challenges: How to Mitigate Adverse Impact

STREAM member mega-cities have put several measures in place to mitigate the two adverse impacts of transport. This section introduces those measures starting from the common ones followed by four measures that are considered successful.

3.1 Common Practices

3.1.1 Mitigating Local Air Pollution

For controlling local air pollution, Asian countries generally have adopted some related standards and carried out some programs to improve the fuel quality of in-use vehicles as follows.

Ambient Air Quality Standards

One of Air Quality Management (AQM) tools is ambient air quality standards in form of National Ambient Air Quality Standards (NAAQS) which have been introduced by most Asian countries since the late 1990s to early 20th century. The standards are not harmonized and vary considerably in terms of the level and the type of pollutants regulated. They also tend to be more lenient than WHO guideline, EU limit or US Environmental Protection Agency (USEPA) standards, except Japan's NAAQS under its Basic Environment Law and Air Pollution Control Law which is to some extent more stringent than USEPA standard.

In Korea, due to differences of regional characteristics, local governments of each province have the authority to enforce their own municipal ordinances for environmental quality standards. Therefore, in March 1998, Seoul implemented stringent standard for SO_2, NO_x and PM. Similar approach is also implemented for Bangkok in Thailand and Jakarta in Indonesia to address more severe environmental problems faced by most capital cities compared to the rest of the countries. Jakarta regulates stricter standard for SO_2, NO_2, O_3 and CO under the 2001 Jakarta's Governor Decree No. 551, two years after the country's NAAQS was established (Government Decree No. 41/1999). In case of China, under the NAAQS which was put into effect in October 1996 and amended in January 2002, the standards are categorized into three Grades whereby different functional zones are expected to comply with specific Grade limits. China has Grade 1 applied for specifically protected areas such as conservation areas, scenic spots and historical sites; Grade 2 for residential areas, mixed commercial/residential areas, cultural and rural areas; and Grade 3 for special industrial areas.

Vehicle Emission Standards

The next AQM tool is vehicle emission standards in which the standards that Asian countries adopted tend to be stricter as shown by Table 1. Japan, Korea and Taiwan are not included in this table but they are more advanced. For many years, Japan has had its own set of emissions standards. These standards are being tightened to address NO_2, O_3 and PM problems in major Japanese cities. Section 8.3.2 describes the details of Tokyo's adequate sophistication and completeness in ensuring the application of such standards. Whilst, in Korea, the current standards for new vehicles powered by gasoline and diesel fuel have met Euro-III and 2002 TLEV standards and further strengthened to Euro-IV and ULEV standards in 2006. Taiwan also began the implementation of Phase I earlier in 1987 for gasoline and diesel engine vehicles and in 1988 for motorcycles. Starting from 1 October 2006, diesel engine vehicles have been required to comply with Phase 4, followed by gasoline engine vehicles starting from January 2008, whereas motorcycles have to pass phase 5 which went into effect on 1 July 2007.

Table 1 Vehicle Emission Standards in Some Asian Cities

Country	**95**	**96**	**97**	**98**	**99**	**0**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**
Bangladesh[a]											▥	▥	▥	▥	▥	▥
Bangladesh[b]											▤	▤	▤	▤	▤	▤
Hong Kong, SAR	▤	▤	▥	▥	▥	▥	▦	▦	▦	▦	▦	▒	▒	▒	▒	▒
India[c]							▤	▤	▤	▤	▥	▥	▥	▥	▥	▦
India[d]					▤	▥	▥	▥	▥	▥	▦	▦	▦	▦	▦	▦
Indonesia											▥	▥	▥	▥	▥	▥
Malaysia			▤	▤	▤	▥	▥	▥	▥	▥	▥	▥	▥	▥	▒ *	▒
Philippines									▤	▤	▤	▤	▥	▥ *	▥	▒ *
PRC[a]							▤	▤	▤	▥	▥	▥	▦	▦	▦	▒
PRC[e]							▤	▤	▥	▥	▦	▦	▒	▒ *	▒	▒
Singapore[a]	▤	▤	▤	▤	▤	▤	▥	▥	▥	▥	▥	▥	▥	▥	▥	▥
Singapore[b]	▤	▤	▤	▤	▤	▤	▥	▥	▥	▥	▥	▒	▒	▒	▒	▒
Sri Lanka									▤	▤	▤	▤	▤	▤	▤	▤
Thailand	▤	▤	▤	▤	▤	▤	▥	▥	▥	▦	▦	▦	▦	▦	▦	▒
Vietnam													▥	▥	▥	▒ *

▤ Euro 1 ▥ Euro 2 ▦ Euro 3 ▒ Euro4

Note:
*Under discussion
[a] gasoline; [b] diesel; [c] Entire country; [d] Delhi and other cities; Euro 2 introduced in Mumbai, Kolkata, and Chennai in 2001; Euro 2 in Bangalore, Hyderabad, Khampur, Pune, and Ahmedabad in 2003, Euro 3 to be introduced; [e] Beijing and Guangzhou (as of 01 September 2006) have adopted Euro 3 standards; Shanghai has requested the approval of the State Council for implementation of Euro 3; [f] Euro 4 for gasoline vehicles and California standards for diesel vehicles

Source: reproduced from Clean Air Initiative for Asian Cities 2006b

As shown in Table 1, most of the countries are currently at the stage of EURO-I (i.e. Philippine by 2003) or II equivalent (i.e. Indonesia by 2005 and Vietnam by 2007). Amongst Asian developing countries, China, India and Thailand are moving faster. China adopted a road map for new vehicle standards, laying out a schedule to introduce vehicle emission standards equivalent to the Euro emissions standards for light duty vehicles. Beijing implemented Phase III in 2005 and Phase IV in 2007 for light-duty and heavy-duty vehicles, while in Guangzhou, Phase III started in September 2006. Shanghai which currently adopts Euro-II equivalent emission standards for vehicles since 2003, is also considering the adoption of Euro 3 standards. Shanghai is also implementing strict measures to limit the circulation of non Euro-II compliant vehicles in some major road arteries. In Thailand, the control of CO and NO_x levels in gasoline vehicles are performed using catalytic converters which are required to be installed by all cars with engine size greater than 1600 cc starting from 1 January 1993 and by lesser than 1600 cc after 1 June 1993.

However, targets are not always implemented as scheduled because of the lack of pre-conditions such as required fuel quality or an effective vehicle inspection system. The following section will further describe the progresses made in this matter.

Vehicle Inspection and Maintenance Program

Japan is on the lead in vehicle inspection and maintenance (I&M) program and by 1967 it has added an exhaust gas test to the vehicle inspection program, followed by a noise test in 1970. The Japanese standards which will be explained further in the next section highlighting successful practices (WTCRS & ITPS, 2004) are notably rigorous, and thus lead to a real rise in the rate of compliance with the regulation.

Korea, Taiwan and Thailand have included routine spots check both for cars and motorcycles for enforcing the program (ADB, 2006; Haq et al., 2002). In Korea, vehicles undergo inspections at least every two years and are subject to mandatory maintenance orders with the possibility of fines if any pollutants are exceeded (Schwela et al., 2006). Random roadside checks are also conducted with over 200 inspection teams based around Korea. Additionally, in Taiwan, dynamometer testing facilities have been installed at 31 inspection lanes in 22 cities and counties nationwide (Feng et al., 2007). Furthermore, automobiles over 5 years old are required to undertake a smog check once every year and those over 10 years are required to be checked twice a year.

Compared to other developing countries in Asia, Thailand does make a considerable progress in I&M program, although the current decentralized I&M program for in-use vehicles is being criticized for its effectiveness because authorized private inspection centers or garages are also allowed to repair, making the procedure becomes questionable and requires further evaluation and improvement (ADB, 2006, Haq et al., 2002). One concrete achievement is that roadside inspection for smoky vehicles in Bangkok is carried out every day by four related authorities. Drivers violating emission standards for in-use-vehicles are fined and the vehicles are not allowed to be used unless they have been repaired and passed the re-inspection. For such inspections, Bangkok Metropolitan Authority (BMA) set up black smoke inspection points, six mobile black smoke inspection units in six areas and motorcycle white smoke (along with noise level inspection) units in inner areas of Bangkok. Moreover, several supporting measures have also been implemented by BMA in 1999 to increase public supports including providing free car engine tune-up service stations for public, publishing car engine maintenance manuals for public distributions, reporting about air pollution in critical areas through display boards, air quality reports accompanied by campaign boards, designating pollution-free roads which prohibited single occupant-vehicles and also car-free streets.

Whilst the three countries above have proceed routine inspections, Viet Nam undergoes periodic inspection starting from 1995 consisting of 55 inspection items before being granted appropriate inspection certificates and allowed to operate on the road again. On the other hand, Indonesia, especially Jakarta, adopted the program much later than the other Asian countries starting from 2000 and it was voluntary instead of mandatory. Since 2005, under Local Regulation No.5, Jakarta makes it mandatory for all vehicles including public transports to meet the national vehicle emission standards and take vehicle emissions test at least every 6 (six) months. Vehicles that passed the test will be given stickers, while those that failed will be subjects to detention or fine. The result of the test is part of the requirements for paying vehicle tax. The sticker has been a requirement for getting strategic parking spaces also. To increase public awareness, the government of Jakarta holds periodic emissions test for free. After July's operation, the most recent operation was on October 2009 resulting hundreds of buses being banned from the street and many vehicles getting warning letters to fix and maintain the vehicles. In 2008 operations, according to Environment Protection Agency of Jakarta, from 30,000 vehicles being tested, 67% failed (Warta Kota, March, 2009).

To address motorcycle booming in Taiwan, The Environmental Protection Agency (EPA of Taiwan, 2009) recently revised the regulations governing the types of motorbikes that need to undergo exhaust emission tests, the frequency of testing and the length of time allowed before retesting. The revisions came into effect on 19 December 2008. The motorbikes in question are those that are registered in Taiwan and are over three years old. Such motorbikes have to be tested once annually for exhaust emission pollutants; if they do not meet the standards laid out in Article 34 of the Air Pollution Control Act the owners have one month in which to make repairs and have the motorbike retested. If the vehicle is not tested within the stated time periods, or fails to meet the required standards on retesting, registration of the vehicle will not be renewed.

Unleaded Gasoline: Phasing out the Use of Leaded Gasoline

Japan is one of the first countries that phased out the use of leaded gasoline (in 1970) responding to concerns about widespread lead contamination of the atmosphere in Tokyo in 1970. As a result of rapid phase-out of lead from gasoline and early introduction of catalytic converters that required increasing of unleaded fuel, only 1-2 percent of gasoline containing lead by early 1980s and free-lead gasoline has been produced and used since 1986 (Lovei, 1998). It is followed by Korea (since early 1993), China (starting from Beijing in 1997 and then in Shanghai, Guangzhou, Tianjin and other big cities), Thailand and Philippine both in late 1990s. Taiwan carried out a gradual phase-out in Taiwan starting in 1993 and since 2000 gasoline in Taipei has been leaded free.

Compared to other countries especially developing ones, Thailand completed the lead phase-out in a quite short term. Strong leadership and coordination are believed to be the key factors. Since 1991, the Excide Department has imposed a lower tax on unleaded gasoline for marker penetration. Leaded regular gasoline RON 83 and leaded premium RON 95 were available until early 1991 and since then the unleaded premium was introduced for the first time, followed by the unleaded regular in 1993. In 1994, leaded regular gasoline was completely phased out. Two years later, from 1 January 1996, both kinds of leaded gasoline were prohibited from use. Furthermore, the benzene content of gasoline is limited to less than 3.5% by volume and the aromatic contest is set to be lower than 35% by volume, while for diesel fuel, sulfur content is reduced from 1.0 to 0.5% by weight.

Stringent standards of benzene and sulfur content are also adopted in Taiwan and Philippine besides phasing out the use of leaded gasoline. In Taiwan, the allowable sulfur content of diesel fuel was gradually reduced from 5,000 ppmw in 1989 to 50 ppmw in 2005. A 50 ppmw cap was out on gasoline fuel, effective 1 January 2007. Philippine also reduced aromatic and benzene content in gasoline to 35% and 2% by volume respectively in 2003 and sulfur content of automotive diesel fuel to 0.05% by weight in 2004. Despite the fact that Viet Nam has only made unleaded petrol available in the market since July 2001 but not phased it out, a new directive issued in 2006 similarly provided standards to limit sulfur content in unleaded transport fuels to be cut to 0.05% and 0.25% for industrial use diesel. Nonetheless, there is no further information on the monitoring of the implementation of these standards.

Indonesia, on the other hand, is lagged behind, although the 1999 Ministry of Energy and Mineral Resources Decree (No. 1585/K/32/MPE) required phase out of lead in gasoline for the whole country by 1 January 2003 (ADB, 2006). From July 2001, unleaded gasoline has been available to residents of greater Jakarta, followed by some other cities. In 1 July 2006, PERTAMINA, the state-owned oil company, stopped the production of leaded gasoline in the country and the phase-out has not been realized.

Phasing out of Two-stroke Engines for Motorcycles

Due to their high mobility and convenience not to mention affordable, motorcycles become extremely popular in both urban and rural areas of Asian countries. There are two types of motorcycle engines: two-stroke and four-stroke. Emissions from two-stroke engines that run on a mixture of gasoline and lubricating oil generates 40% more pollution than four-stroke engines at the same size, especially for PM, HC, CO_2, but lower NO_x emissions. Besides the advantage of 'green label product' for both local and global pollution, four-stroke vehicles also better in terms of: (i) much improved fuel economy; (ii) much less noise; (iiii) not much higher in price than comparable two-stroke version (around 15%); and (iv) established technology (Iyer and Shah, 2004).

Considering the political difficulty and huge social impacts it may cause, no country has completely phased-out those two-stroke engine vehicles. However, in 2005, all gasoline two-wheelers are phased out in Shanghai although few are still operating in suburban areas (Schwela et al., 2006), while Taiwan (since 2004) and Thailand (since 2001) have made the share of four-stroke engines for motorcycles higher by tightening vehicle emission standards. Such approach indirectly forced phasing out of two-stroke motorcycles which have higher emissions.

In Taiwan, the burden is not limited only to the owners but also the manufacturer. If the motorcycles have been properly maintained yet fail to meet the standards, manufacturers are obliged to recall and repair them. Fines will be imposed for failing the roadside inspections and of periodic idle tests. For the case of Thailand, emissions standards for motorcycles have been tightened for eleven years (1993-2004), and by 2001, the standards have been strict enough to preclude the manufacturer of two-stroke motorcycles. Some countries like India, Taiwan (China) and Thailand have adopted strong measures to mitigate emissions from two-stroke engines including the use of low-smoke lubricant, installation of oxidation catalysts, and mechanical metering of lubricant (Iyer and Shah, 2004).

Instead of phasing out two-stroke engines for motorcycles, in 2003, Viet Nam capped the number of motorcycles to be registered to one million down by more than one-third on the previous year (WCTRS & ITPS, 2004). While in Indonesia, under the Blue Sky Program or *PRODASIH* developed by BAPEDAL (The Indonesian Environmental Impact Management Agency), phasing out two-stroke engines for motorcycles is under consideration since approximately 60% of motorcycles in Indonesia have two-stroke engines and these engines contribute about 20% of the SPM, NO_2 and lead pollutants in the air.

From the production side, Honda, the world's largest motorcycle manufacturer, has established a near-term goal of 100 percent four-stroke production. The four-stroke share of annual motorcycle output in China, the largest national producer and consumer of small motorcycles, was 90% in 2002 (Meszler, 2007).

Restricting Para-transit Vehicle Registration

Informal transport services or para-transit varying from minibuses, three-wheelers to motorcycle-taxis play important roles in third-world cities including Asians. On the one hand, these small vehicle modes provide convenient access to residential areas that are mostly connected with narrow streets which cannot be penetrated by formal larger transport services. This particular sector also provides significant employment opportunities to low-skilled worker and became one of the safety-nets during the monetary crisis back in 1998. Yet, they contribute to traffic congestions, accidents, air and noise pollution since informal transport vehicles are often low-performing and old.

Thailand and China have made some efforts to restrict para-transit operations. In Thailand, Land Traffic Department imposed ban for the new *tuk-tuk* registration in 1984 and limit the number of *tuk-tuk* operating up to 7,400 units (Hanaoka, 2007). In 1995, the official passenger van transit system was launched by BMTA and also sets the van routes, and adopts law-enforcement for any violations (Leopairojna and Hanaoka, 2005). In May 2003, Bangkok further required motorcycle taxis to register themselves and being granted a vest as authorization proof (Hanaoka, 2007), whereas in China including Shanghai, most jitney services were banned from major urban areas (Liu and Guan, 2005).

3.1.2 Controlling Greenhouse Gas Emissions

Greenhouse Gas (GHG) emissions are far more difficult to control than conventional air pollutant emissions, especially in transport sector. IPCC (2007) identified key mitigation technologies and practices of transport systems and road traffic management that are currently commercially available and could be adopted, including: (i) promoting cleaner fuel vehicles; (ii) promoting modal shift from road transport to rail and public transport systems, non-motorized transport (cycling, walking); and (iii) integration of land use and transport planning to restraint vehicle demand and use. This report focuses on the first category.

The first category takes into account all technology-based strategies and options to restrain GHG emissions. Sperling and Salon (2002) consider three waves of technological innovations that are sweeping through the international automotive industry. The first wave which is underway in most developing countries in response to stringent emissions standards discussed previously includes improvement of combustion processes, treatment of exhaust gases (e.g. with catalytic converters) and use of cleaner burning fuels. A second wave of innovation is aimed at increasing the energy efficiency of conventional engines. The third wave is more radical involving a transition away from internal combustion engines to electric-drive propulsion technology. These innovations have the potential for the greatest reductions in GHG emissions which would improve energy efficiencies by 50% or more with the potential for much less pollution. The first two waves are underway in most Asian countries to some extent. The most common practice pointed out here is promoting the use of clean fuel as explained in the following.

Promoting Alternative Fuels (LNG, LPG, CNG) for Buses and Taxis

Buses and taxis are the most dominant public transport system in developing countries including Asians. The fact that the majority of the vehicles are old and not roadworthy has prompted the countries to promote clean fuel particularly for them.

In Korea, the share of LPG rose from 3.5% of the energy mix in 1980 to over 14% in 2005 and is used mainly in taxis, buses and trucks (Liu et al., 1997). LPG fuel vehicle was firstly used in 1973 and all taxis were converted into LPG cars in 1982. In fact, 10% of all registered vehicles in Korea are LPG-fueled due to the rapid growth brought about by a large excise tax advantage over gasoline and diesel. Besides LPG, 50% of Korea’s intra-city buses are CNG fueled.

While in Japan, LPG is primarily used by taxis which to date, 260,000 taxis (94%) are LPG-fueled. The government offers grants for conversion or purchase of LPG vehicles and installation of refueling stations. In larger picture, besides the use of LPG, Japan actually features a good example for combining the regulatory, fiscal, and technology instruments altogether to promote the use of fuel efficient and clean fuel vehicles (see subsection 8.3.2.1 for details).

In the case of other Asian countries, although they exhibit a far modest increase of LPG and natural gas use for vehicle fuel compared to Korea and Japan (Timilsina and Shrestha, 2009), some attempts to promote these clean fuels are progressing, especially in China where the Government has played a major role in promoting LPG and CNG fuels in public transport buses through various R&D programs, direct investments, incentive programs, and targets (Yeh, 2007). Starting in November 1997, Hong Kong's government launched a trial program, involving 30 LPG taxis (20 new and 10 old) and aimed to encourage all taxis (18,138 taxis at that time) to switch to LPG. To increase the incentive for using LPG, government arranged a concession to reduce the price of LPG over diesel with LPG refueling station operations through waiving land premium and further offered a one-time grant of HK$40,000 for each replacement of a diesel taxi which would last only within three years. Such incentives were expected to reduce hesitation over having to drive longer distances to refuel at few refueling station in town. By early 2002, more than 75% of taxis had switched to LPG (Hung, 2006).

In April 1999, twelve Chinese cities, including Beijing and Shanghai, participated in the "National Clean Vehicle Action" program that introduced alternative fuels, particularly CNG and LPG. CNG and LPG vehicles and stations increased rapidly in some demonstration cities. In China, local governments, especially Shanghai and Beijing that have led the promotion of CNG and LPG vehicles in the country, played a major role through developing infrastructure (e.g. refueling stations), designing policies (e.g. stringent environmental standards in Beijing) and providing financial support (e.g. subsidy for retrofitting taxis to use LPG and R&D on CNG/LPG vehicle technologies adopted in Shanghai) (Zhao and Melaina, 2006).

As a result, by 2003, CNG and LPG vehicles account for a large amount of urban buses and taxis in some regions, for example, more than 74% of taxis in Shanghai and 85% of buses in Sichuan province, while Beijing has one of the largest bus and taxi in the world implementing LPG and CNG, with around 5,500 buses (of 11,000 buses in Beijing) and 37,000 taxis (Zhao and Melaina, 2006). However, the majority of China's LPG/CNG vehicles are retrofitted, with about 16% being newly manufactured. Initially, most retrofitted LPG vehicles used technology that could improve emission levels compared to the same technology in traditional gasoline vehicles, but the vehicles still could not meet the Euro I standard.

In smaller scale, other countries have also started to convert buses to LPG/CNGs. Indonesia particularly Jakarta through the establishment of TransJakarta Busway has employed 70% of the fleets with CNG fuelled buses, while the rest is Euro II-compliant diesel buses. Thailand has guaranteed in the recent past to hold the CNG price at THB 12/kg for the period 2005-2010 for application in Bangkok's urban bus fleet (103 buses). The Philippines has just started to apply the use of CNG for its current 25 buses plying strategic routes of Southern Luzon to Metro Manila. Furthermore, not only for public transports, the country encourages public to use LPG for other vehicles as an alternative fuel by providing subsidy of NT$3 per liter LPG on 1 October 2001. It further change into NT$2 per liter between 1 January 2007 and 31 December 2008 (EPA, 2009).

Besides buses, some Asian countries have also replaced the majority of taxis and para-transit fleets with LPG/CNG fueled vehicles, including Bangkok (1,500 LPG taxi and 7,400 LPG *tuk tuk*) and Taiwan (LPG taxis). Whereas Indonesia has started to introduce a new Euro-II compliant four stroke CNG *bajaj* model (three-wheelers para-transit) in cooperation with *Bajaj Auto* which expects to replace about 15,000 two-stroke *bajaj* in the coming years (APEC, 2008; USAID, 2006).

Promoting Low Emission Vehicles (LEVs) Use

One emerging LEVs is electric vehicles. Japan through Japanese Electric Vehicle Association (JEVA) has conducted various leasing and purchasing incentive programs since 1978 to promote the use of electric vehicles, supplementary to R&D program and infrastructure supports (Ahman, 2006). In 1996, electric vehicle purchasing incentive program subsidizing 50% of the extra incremental vehicle price was introduced to replace the previous incentive program. Since 1995, under the Environment Conservation Program, the Government gradually took initiatives to replace some public vehicles and government fleets with LEVs. The plans included a total number of almost 100,000 electric vehicles and 170,000 LPG-vehicles in the year 2000, although higher penetration rates were not even remotely being met.

The use of electric-fuel for vehicles in China began with the introduction of electric bikes and was quite successful. Annual electric bike sales grew from 40,000 in 1998 to 10 million in 2005 (ADB, 2006) and largely brought about by legislations banning gasoline-fueled scooters and bikes introduced from 1996 onwards in several major Chinese cities, including Beijing and Shanghai. In cities such as Chengdu and Suzhou, electric bikes have reportedly surpassed the share of regular bicycles. It is estimated that there are 40-50 million electric bikes on China's roadways today (Jamerson and Benjamin, 2007).

Nonetheless, electric bikes have been criticized on a number of grounds, including environmental performance compared to bus or bicycle, contribution to congestion and safety. By far, the biggest environmental reservation associated with electric bikes is Pb pollution, not from tailpipe emissions but rather from production, recycling and disposal processes of batteries, spread over the life cycle of the vehicle. On the other hand, the use of electric bikes may create advantages to the extent that they displace car and conventional motorcycle. Such concerns have forced policy makers to act rapidly to develop national and local policy to promote, discourage or regulate electric bikes (Cherry et al., 2009). In 2006, Beijing followed by Guangzhou banned the use of electric bike. Whilst Beijing quickly retracted the ban, Guangzhou continues it until today. In case of Chengdu, the city has announced a licensing scheme that will restrict the use of electric bikes in the city center based on size and speed characteristics.

Furthermore, the Chinese government updated excise tax rates, cutting rates by 5-2% on small-engine (1.0-1.5 l) vehicles, while raising rates by 8-20% on vehicles with larger engines (more than 4 l), to further encourage the manufacture of smaller-engine vehicles (An et al., 2007). This was supplemented by the elimination of the preferential 5% tax rate on sport-utility vehicles (SUVs). In 2009, more intensive policies and initiative have been initiated, including the implementation of a demonstration project introducing 1,000 electric vehicles (EVs) in 10 cities and providing financial subsidies for energy-saving vehicles and AFVs buyers (Ou et al., 2010).

Similarly, on 27 July 2004, the Thai Cabinet approved a new car excise tax package resulting in the abolition of the off-road purpose vehicle (OPVs) class used for SUVs with four-wheel-drive systems. The tax rate for OPVs was increased from a fixed 29% to ranging between 30% and 50% based on four different levels of engine size. This policy reduced the number of cars with engines larger than 2500 cc up to 2%. The excise tax for pickups was set to 20%, fuel cell and hybrid vehicles 10%, and those using natural gas 20% (Goedecke et al., 2007). Afterwards, in 2007, Thai authorities approved a range of incentives for the production of eco-cars. Eco-car manufacturers were granted a maximum eight-year exemption from corporate income tax payment and machinery import duties, and excise rates for eco-cars were set at 17%, compared with a rate of 30-50% for other type of cars in Thailand (Economist Intelligence Unit, 2008).

3.1.3 Traffic Safety

Haddon (1968) defined three phases of time sequence of a crash event – pre-crash, crash, and post-crash. In each phase, there are three possible factors causing a traffic accident, be it human factor, vehicles and equipment factor and/or road and environment factor. It results in nine-cell Haddon Matrix models with each cell allowing opportunities for intervention to reduce road traffic agency. It led to substantial advances in the understanding of the behavioral, road-related and vehicle-related factors that affect the number and severity of casualties in road traffic (WHO, 2004).

Road Safety Measures in Developed Countries

In addition to seat belt and helmet regulation since 1992, in January 2001, the Korean police began a special control including stiff fines, license suspension and more frequent monitoring for traffic violations in relation to seven risky driving behaviors including drunken driving, driving without license, speeding, violation of traffic signals, intrusion on median strip, wild driving by motorcyclists, etc. As a result, there was a significant drop in the number of fatalities in four categories of risky behavior: drunk driving, driving without license, speeding and violation of traffic signals (Yang and Kim, 2003). Similar approaches have also been implemented in Japan through the Initiative for Stricter Drunk Driving Penalties and Other Measures against Dangerous Driving (IATSS, 2006).

From February to May 1994, enforcement of helmet use for motorcyclists was also implemented in Taipei City. The initiatives showed positive impact in reducing motorcycle fatalities. After intense lobbying and discussion, a motorcycle helmet use law was enacted and implemented in the whole country on June 1, 1997. Under this law, unhelmet motorcyclists caught by the police were fined the equivalent of US$15. Chiu et al. (2000) found that the law is quite effective shown by a 33% decrease in motorcycle-related injuries and decreases in severity of injuries. Data provided by the Department of Health showed that after the implementation of the law, the number of motorcycle related injuries decreased by 14%.

Besides helmet regulation, Taipei City also amended drunk-and-driving regulation to heighten awareness and institute more severe penalties, carried out night-time on-street inspection of passing drivers, and installed speed monitoring at a total of 335 intersections or mid-block sections.

Starting from 1997 to 1999, Korean authority placed monitoring camera systems to check speeding in more spots. The policy successfully reduced 28% number of crashes and 60% number of fatalities within a diameter of 1 km from the camera spots. Moreover, Japan, since

1996, has been developing its Universal Traffic Management System (UTMS) aiming to ensure traffic safety and comfort through a network of advanced traffic control centers. The system is to monitor the traffic, manage vehicular operations, give priority to public vehicles, support safe driving, and ensure pedestrian safety by installing facilities for near-infrared beacons. The work also continued on cruise-assist systems which aim to support safe and secure highway cruising. The system communicates possible hazards to drivers instantaneously using telecommunication systems which connect the car with the highway.

In April 2001, the government of Korea introduced a reward system for citizens reporting traffic violations with graphic evidences. Police agencies also initiated several education-related programs for improved road traffic safety (RTS) from pre-school to high school students and for the elderly in nursing homes. In the second half of 2002, a new education program was to be enforced for people who apply for driver’s license test, making it mandatory for every applicant to take seven hours of RTS education before taking the test.

To further mitigate traffic accidents, synthesizing from Haddon’s work, it is also necessary to focus on the road and environmental factor, including road design and layout, speed limit regulation, and provision of pedestrian and cycling facilities. In Japan, “people first” philosophy acknowledging that, in a civilized society, consideration and sympathy must exist for those who are weaker than others becomes the basis of all traffic safety policies. Hence, Japanese cities are pursuing improvement of sidewalks along school routes, residential roads, and major thoroughfares in urban districts. Despite the scarcity of lands particularly in its major megacities, the nation further continued to provide a safe and comfortable transit environment for pedestrians and bicycle riders through road reconstruction projects. Responding to the aging society, Japanese cities also implemented projects to develop broad, level sidewalks and to install barrier-free signals in areas around train stations and other public facilities. Since 2001, in Korea, the road safety inspection system has been applied to all newly constructed roads starting from their planning stage to their completion.

Road Safety Measures in Developing Countries

In developing countries, road design and road traffic condition are major contributing factor to traffic accidents. According to World Health Organization (2004), most of the victims killed in road accidents in developing Asian cities are pedestrians and motorcyclists. These road users increasingly have to share the road with four-wheeled modes including cars, buses and trucks. Road design and traffic management are generally poor and fail to provide adequate safety in such mix traffic. Lack of pedestrian facilities typically runs a gauntlet of challenges that directly contribute to the high injury and fatality rates witnessed in these countries. The challenges include (Lloyd and Hook, 2007):

- Complete lack of or poor quality of pedestrian pavements;
- No physical separation from high levels of traffic and from high-speed traffic;
- Intersection designs aimed at facilitating high vehicular speeds at the expense of safe pedestrian crossing; and
- Obstructed pavements due to parked cars (illegal or legal), poor design, utility poles and signs, uncollected rubbish, vendors, etc.

One example of practices to intervene this issue is the adoption of Road Safety Audit (RSA)[2] in Thailand. The country took the initiatives to institutionalize it and set up a new committee known as the National Road Safety Management Center composing of high-ranking government officials representing various concerned agencies as well as respected academics. The committee implemented several measures under the 5-E strategy (Engineering, Education, Enforcement, EMS or Emergency Medical Services, and Evaluation), including the RSA (see details in section 8.3.2.4), the setting up of the Thailand Accident Research Center for R&D activities on road safety and the most controversial measure of banning alcoholic drink advertisements on TV and radio.

Another major issue is how to mitigate motorcycle accidents anticipating the growth of motorcycle's users in many Asian cities. In Thailand, one contributing factor to high casualties of motorcycle accidents may be the lack of proper driving skill. According to Kasantikul's research (2001 in Tanaboriboon and Santiennam, 2005) among motorcycle accident victims, the majority of them did not have driver licenses. Moreover, the number of license holders is much lower in the provinces apart from Bangkok which reflects the fact that a substantial number of motorcyclists still ride illegally and perhaps improperly. Therefore, Bangkok enforces motorcycle users to turn on the headlight all the time and builds motorcycle lanes (Tangpaisalkit, 2007). Bangkok also throws safe-driving campaigns by using protection devices especially helmet although it is a pity that may of motorcyclists still choose to take risk by not wearing one. In fact, only 78% wore helmet while riding and this rate dropped dramatically during night time. Among those who whore helmet, only around 30% used helmet with the quality complies with Thai Industrial Standard.

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[2] As defined by AUSTROADS (2002), RSA is a formal examination of a future road or traffic project or an existing road, in which an independent, qualified team reports on the project's crash potential and safety performance.

Figure 7 Three Types of Motorcycle Lanes in Thailand [COPYRIGHT]

Source: Tangpaisalkit (2007)

In 2001, wearing helmet became mandatory in Viet Nam for all motorcycle drivers and passengers on specific roadways (Pervin et.al, 2009). Unfortunately, there was limited enforcement of this legislation and hence, its effectiveness was low resulting approximately 30% motorcyclists using helmet on average. On 29 June 2007, the Vietnamese Government released Resolution 32, a decree that made its mandatory in Viet Nam for all motorcycle drivers and passengers to wear a helmet on all roads from 15 December 2007.

Whereas in Shanghai, since not only that motorcycle has the lowest safety factor of all type of vehicles but also that air pollution induced by motorcycle is serious, the Shanghai government determined to prohibit the operation of motorcycles on main roads inside the circle line, five vehicle roads, and some other regions. Meanwhile, the government enlarged the areas where motorcycles with out-of-city licenses are prohibited and set stringent penalties for motorcycles without licenses operating illegally (APEIS RISPO, 2003).

Traffic accidents can be more effectively reduced if the drivers are aware of any risks that may happen if they are driving recklessly. Therefore, trainings and campaigns both adults and children for nurturing appropriate driving behaviors in the future are not less important. Thailand has initiated the program under its 5E's strategy as briefly mentioned above, including driver training and testing, road safety education for children, and other forms of road safety publicity and campaigns.

In terms of post-crash measures, ensuring the access to medics and rescue facilities is considered critical. Technically is to provide easy access to emergency services, like emergency assistance to road accidents victims in Thailand. Unfortunately, severe congestions may be one barrier to immediate service. Financially is by insuring vehicle which usually covers indemnity for death, medical expenses for injuries including third parties, and costs for rehabilitation. Most countries have introduced laws that require drivers to insure their vehicles including China and Thailand which have established two-tier vehicle insurance system: the compulsory and the additional one.

In Thailand, the Protection for Motor Vehicle Accident Victims Act (1992) stipulates that the owner of a motor vehicle takes out insurance with an authorized insurance company. Failure to do this is liable to a fine between 10,000 and 50,000B. Upon taking out insurance, the owner will receive an insurance policy and an insurance sticker. The law requires the owner to adhere the insurance sticker on the motor vehicle or liable to a fine not exceeding 2,000B. On the basis of the provisions of Article 76 of the "Road Traffic Safety Law of PRC", Shanghai adopted similar regulation to institute a mandatory third party liability insurance system on motor vehicles and apply the determination of compensation liabilities for road accidents of motor vehicles in the administrative area of concurrent municipalities.

3.2 Successful Case Studies in Asian Megacities

3.2.1 Japan's Regulation and Economic Instruments for Reducing GHG Emissions from Transport Sector

Japan's Automotive NO_x and PM Law

In 1992, to cope with the NO_x pollution problems from existing vehicle fleets in highly populated areas, the Ministry of Environment (MoE) adopted the "Motor Vehicle NO_x" law. The regulation is designated for a total of 196 communities in the Tokyo, Saitama, Kanagawa, Osaka, and Hyogo Prefectures. It was amended in June 2001 to tighten the existing NO_x requirements and to add PM control provisions and called as "Automotive NO_x and PM" law which became effective starting in October 2002.

This law introduces emission standards for specified categories of in-use highway vehicles including commercial goods (cargo) vehicles such as trucks and vans, buses, and special purpose motor vehicles, irrespective of the fuel type. This regulation also applies to diesel powered passenger cars, but not to gasoline cars. To meet the 1997/98 emission standards, vehicle owners must either replace old vehicles with newer and cleaner models or retrofit their old vehicles with the approved NO_x and PM control devices. Vehicles have a grace period between 9 and 12 years from the initial registration classified upon type of vehicles. Furthermore, the regulation allows postponing its requirement by an additional 0.5-2.5 years depending on the age of the vehicle. This delay was introduced in part to harmonize this law with the Tokyo diesel retrofit program explained in the following.

Tokyo's Diesel Retrofit Program

In December 2000, the Tokyo Metropolitan Government (TMG) adopted a new "Ordinance on Environmental Preservation", which includes an array of regulatory measures to control air, water, soil, as well as noise pollution. One of the program components is diesel emission control regulation (retrofit program). This new ordinance took effect on April 1, 2001, with several provisions related to vehicle emissions (including the diesel retrofit program) effective by October 1, 2003.

According to the diesel emission regulations, PM emissions from in-use diesel vehicles must be reduced by retrofitting with emission control devices. The retrofit requirements apply to buses, trucks, and special category vehicles based on buses and trucks, such as campers, garbage collection trucks, and refrigerator/freezer vehicles. Passenger cars are not subject to retrofit requirements. The PM emission reductions requirements depend on the vehicle emission level at the time of its manufacture. Older vehicles have higher PM reduction requires and vice versa. The retrofit program has a two-tier structure: the Tier 1 requirements become effective in October 2003 and somewhat more stringent Tier 2 PM emission reduction requirements come to power in 2005.

Table 2 Diesel PM Reduction Requirements and Categories

Vehicle Descriptions	**Tier 1 (2003.10)**		**Tier 2 (2005)**	
	PM Reduction	**Category**	**PM Reduction**	**Category**
Meets 1989/1990 standards, or Fails to meet 1998/1990 standards	>60%	1	>70%	3
Meets 1993/1994 standards	>30%	2	>40%	4
Meets 1997/1998/1999 standards	N/A		>30%	5
OEM-fitted with PM after treatment	Meet PM standards		Meet PM standards	

Note:

*All vehicles receive 7 years of grace period from the date of their first registration. In effect, vehicles must be retrofitted with PM controls either on the Tier 1/2 dates, or in 7 years after first registration, whichever occurs latter.

**All vehicles must comply with the national "Automotive NO_x and PM Law".

Source: Bureau of Environment, TMG, 2006.

Once retrofitted, vehicles are affixed with stickers bearing the approval number of a given PM control device. Owners of non-complying vehicles may receive injunction on operating the vehicles until retrofitted. If the injunction is not obeyed, the vehicle owner's name is made public and a fine up to 500,000 yen is imposed. Within the period of March, 2003 to December, 2004, the compliance ration increased from 33% to 97% (Bureau of Environment, TMG, 2006).

Green Tax System in Japan

In Japan, the so-called green tax system was launched in April 2002, in order to reduce automotive tax on LEVs and to increase the rate for old diesel vehicles. Since implementation, its effect has been so significant that the tax revenue in fiscal year 2002 fell out much lower than expected because the share of LEVs qualifying for tax relief increased to twice the level estimated. In the face of such customer behavior, automobile makers began to compete fiercely in the development of LEVs, recognizing that makers without an LEV range will not be able to survive.

The tax scheme consists of reduction on automobile tax applied to low-emission and fuel-efficient vehicles (introduced in 2001) and reductions on the acquisition tax (introduced in 1999) for purchasers of low-emission and fuel-efficient vehicles. It should be noted that 10% surcharges on the tax are mandated for diesel vehicles on the road 11 years or longer, and for gasoline vehicles on the road 13 years or longer, since first registration.

Table 3 Tax Incentives for Low-Emission and Fuel-Efficient Vehicles in Japan

	Emissions Performance	**Fuel Efficiency**	**Incentives**	
			Automobile Tax	**Acquisition Tax**
Passenger Cars	Emissions down by 75% from 2005 standards	Compliant +25% to 2010 standards	50% reduction	Amount deducted: ¥300,000
		Compliant +15% to 2010 standards	25% reduction	Amount deducted: ¥150,000
Heavy-duty Vehicles	Compliant with 2009 standards	Compliant with 2015 standards	-	2% reduction

Note: Eligible vehicles are those newly registered in 2008 and 2009
Source: Ministry of Land, Infrastructure, Transport and Tourism (Japan).

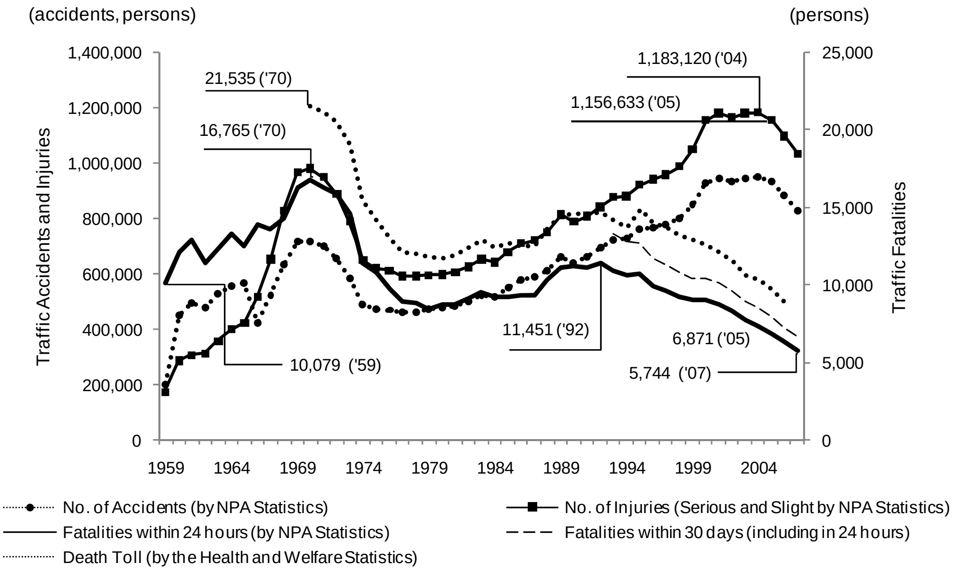
CO_2 emissions in Japan’s transport sector peaked in 2001 and have been on a downward trend ever since, as projected. Japan has often referred as one of the most energy-efficient country worldwide. The positive trend is attributable to efforts in Japan’s road transport sector to: (i) increase vehicle fuel efficiency; (ii) upgrade roads and road infrastructure; (iii) implement other traffic flow-related measures e.g., transport demand management; (iv) use motor vehicles more efficiently, through eco-driving among other measures (JAMA, 2008).

3.2.2 Road Safety Measures in Japan

The annual number of fatalities from road traffic accidents in Japan peaked at 16,765 in 1970. In the same year, the Diet enacted the Traffic Safety Policies Law. In accordance with this law, expert panels have developed plans known as Fundamental Traffic Safety Programs (FTSP) every five years since FY1971. These programs have provided the framework for comprehensive and systematic measures aimed at improving traffic safety. Since 1971, traffic fatalities began to decline and continued a steady downward trend until reaching 8,466 in 1979. Thereafter, however, fatalities turned upward again and continued to rise until 1992, when a new downward trend began. However, in terms of the number of accidents and casualties were increasing and the year 2004 recorded the worst levels in history, which rose to 952,191 and 1,190,478, respectively.

Nevertheless, in 2005, the condition is improving. Traffic fatalities decreased to 6,871 for the first time in 49 years (since 1956) that the death toll fell below 7,000. Moreover, accident and casualties declined to 933,828 and 1,163,504, respectively, marking the first year-on-year-decrease in three years and continue to decrease to date. It should be noted that vehicle kilometers travelled has also been decreasing since 2005. Hence, if we look into the number of accidents per 100 million vehicle-km, it can be found that since 1990s accident rate is relatively steady as shown in Figure 9.

The decline in fatalities compared to 1970's peak until recent years can be attributed largely to efforts to carry out a comprehensive set of measures based on the FTSP, including measures aimed at improving the road traffic environment, at disseminating and reinforcing messages on traffic safety, and at ensuring safe driving practices, and, in addition, measures aimed at advancing vehicle safety, preserving order on roads, and improving rescue and emergency medical systems. Certain quantitatively measurable improvements also contributed to this decline, including (1) increased seat belt usage; (2) lower pre-accident speeds; and (3) the effects of the Initiative for Stricter Drunk Driving Penalties and Other Measures against Dangerous Driving.



Note:

1) Since 1960, figures include minor accidents such as injury requiring less than eight days to be cured or property damage under ¥20,000. Since 1966, figures exclude property damage. Since 1972, figures include those of Okinawa Prefecture.
2) The definition of fatality used by National Police Agency since 1976 is a person who dies within 24 hours of its occurrences. While by Health and Welfare Statistics, the number of fatalities where the original cause of death was a traffic accident. Since 1995, it excluded those who were not clearly involved in a road traffic accident, such as railroad workers from those involved in some kind of transport accident on land.
3) Serious injury is an injury resulting from a traffic accident and requiring medical treatment for a month (30 days) or more, while slight injury requires less than a month. The figure of injury is the total amount of both types of injuries.
4) The figures for the leap year are calculated on 366-day basis.
5) Fatality within 30 days data is provided by NPA since 1993.

Figure 8 Changes in Road Traffic Accidents, Injuries and Fatalities in Japan

Source: Statistics by the Traffic Bureau, National Police Agency (NPA)

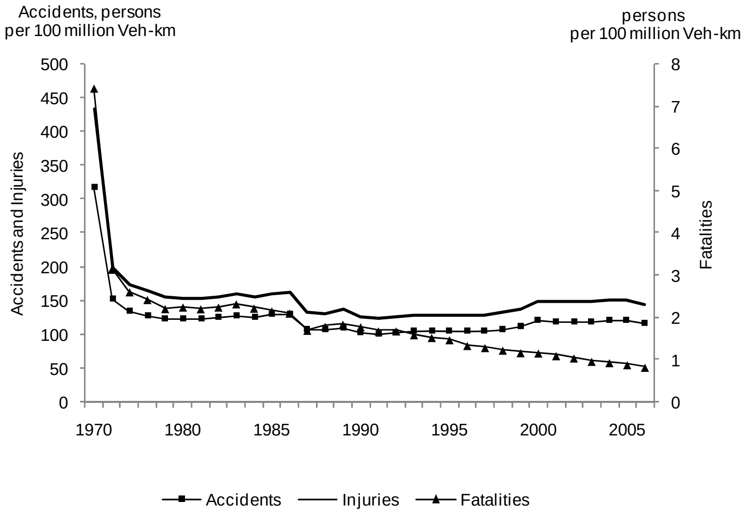


Figure 9 Changes in Road Traffic Accidents, Injuries and Fatalities per 100 million Vehicle-Kilometers Travelled in Japan

Source: Statistics by the Traffic Bureau, National Police Agency and Ministry of Land, Infrastructure, and Transport

Within the fiscal year (FY) of 2004, the government aggressively pursued the following projects for enhancing the traffic safety infrastructure, in line with the "Priority Plan for Social Infrastructure Development":

1. Intensive accident prevention measures were implemented at intersections and road sections that were designated as "black spots" in 2003 for having a high incidence of casualty-inflicting accidents. In addition, the project team created a "Road Safety Manual for Hazardous Spots" and "Compilation of Accident Prevention Measures", implemented scientific measures against accidents in black spots and other dangerous areas, and developed an accident countermeasure database.
2.

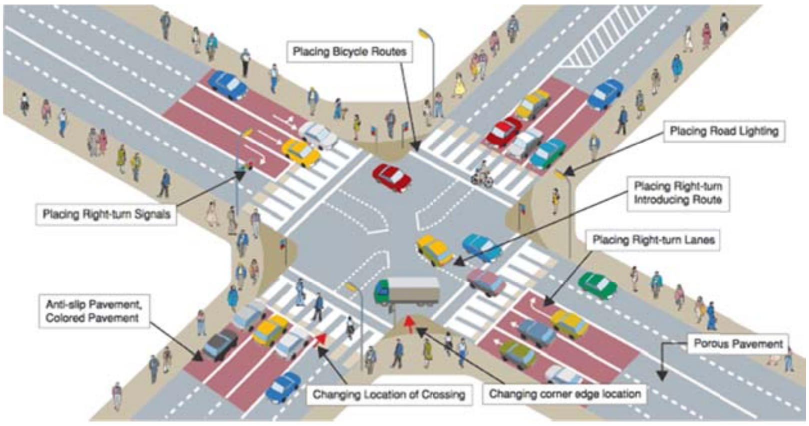


Figure 10 Measures for High Accident-risk Locations [COPYRIGHT]

Source: Road Bureau, Ministry of Land, Infrastructure and Transport, Japan

To date, urgent measures for black spots have been implemented in at least 3,200 locations through placement of right-turn introducing route, lane and signals; improvement of intersections (placing road lighting, bicycle lane at crossings, colored and anti-slip pavement, changing corner edge locations), securing parking space, regulation of illegal parking, widening road, burying electricity cables in underground trenches, elimination of grades and slopes, improvement of alignment, additional vehicular lane, etc.

3. Under the Safe Pedestrian Area project, the coordinators, with the cooperation of prefectural public safety commissions and road management agencies, continued to implemented comprehensive, wide-area accident prevention measures in residential and commercial districts that were designated as target areas in 2003 for having high accident casualty rates. It includes safety measures for pedestrians (sidewalks, shared pedestrian and bicycle tracks, pedestrian overpasses and underpasses) and accident prevention measures for vehicles (median strips, protective fencing for vehicles).
4. In order to help seniors and disabled people lead independent, socially active lives,

> projects were implemented to develop broad, level walkways and install barrier free signals in areas around train stations and other public facilities. Other efforts included the elimination of utility poles, conversion of traffic signals to LED lighting, and enhancements to road signs and markings to make them more visible to elderly motorists.

Japan has also developed an advanced intelligent transport system (ITS) in accordance with the Comprehensive ITS Initiative formulated in 1996 which is used to integrate people, roads and vehicles into a unified system to improve safety, transport efficiency, and other aspects of road traffic. Some of the outputs are the deployment of VICS (Vehicle Information and Communication System) which provides real-time information on traffic congestion and other travel conditions to automobile navigational systems and the UTMS (Universal Traffic Management Systems) which is aimed at preserving road safety and convenience through active, comprehensive management of traffic flow and volume.

In accordance with the UTMS project and other initiatives, efforts were made to accelerate rescue and cleanup responses to traffic accident and other road emergencies by further expanding HELP (Help systems for Emergency Life saving and Public safety), a GPS-based system designed to improve the rescue success rate by allowing accurate accident information (location, etc.) to be instantly sent via mobile phones and other communicators. In order to reduce the response time and collision risk of ambulances en route to accident sites, work was continued on the development of FAST (Fast Emergency Vehicle Preemption Systems) for assisting emergency vehicle drivers, including automatic control of traffic signals to give them immediate right-of-way.

To improve vehicle safety, the government strengthened its efforts to monitor vehicle safety by bolstering its system for collecting vehicle defect information from users via a hotline service and accident information from the police, Japan Automobile Federation (JAF), and other relevant organizations, and by conducting focused audits of suspect manufacturers. In January 2003, the Ministry of Land, Infrastructure and Transport established a recall order system, additional penal measures, and larger fines as part of an effort to ensure proper recall of defective vehicles. Furthermore, promulgated on June 9, 2004, the Law to Partially Revise the Road Traffic Law (Law No. 90 of 2004) which took effect on November 1, 2004 includes among its changes a new set of penalties for mobile use while driving, tougher measures against motorcycle gangs, and stricter penalties against drivers who refuse to tale sobriety tests.

Within the period of FY2006 to FY2010, under the Eighth FTSP, Japan continues to improve current measures and practices particularly in response to aging population and declining birthrates, such as by adopting stronger “people first” measures to provide safe and secure walking spaces for children and the elderly.

3.2.3 Motorization Control and Road Safety Measures in Shanghai

Besides banning motorcycles in some areas within the city, Shanghai also put forward more rigorous parking policy to relieve the parking and traffic pressure in the urban center by adopting parking control area, high limit of public parking area (garage) charging, and keeping on generalizing centralized “parking meter” (Pan, 2007). Moreover, since 1994, the license tag of private car in Shanghai has exercised auction by tender with reverse price. From 2000, for cars, it has changed into public auction without bottom price. The license tag auction has restrained the speed of motorized vehicles in Shanghai, decreased the demand of low-quality vehicles, increased car purchase cost, and, consequently suppressed the residents’ desire to own cars.

Road Traffic Safety Law of the People's Republic of China which was passed on October 28, 2003, is the People's Republic of China's first-ever law on road traffic safety, and was intended to address an alarmingly high traffic fatality rate, which is four or five times greater than other nations. The new law has a number of focus points:

1. Under the new law, when accidents occur between pedestrians or non-motorized vehicles and motor vehicles, except for the case where the pedestrian or the non-motorized vehicle deliberately causes the incident, the motorist must always bear responsibility. Responsibility for the motorist is reduced if the pedestrian or non-motorized side violated traffic laws.
2. The new law enforces a vehicle insurance system. Insurance on motor vehicles is now compulsory instead of voluntary.
3. It abolished a previous regulation which banned holders of driver's licenses of the PRC driving rights on expressways until one year after they had held the license.
4. Expressway speed limits were increased from 110 km/h to 120 km/h.
5. Even harsher penalties were put in place for drunk driving and driving by people who did not hold a valid driver's license, or drove a vehicle without license plates.
6. Cases where drivers were speeding 50% in excess of the applicable speed limit will result in the revocation of the driver's license.
7. The penalty for hit-and-run accidents is permanent revocation of one's driver's license.
8. The pre-existing point system for penalties was integrated into the new law.
9. Penalties are now higher, from the former RMB 200 up to RMB 2000. Also, provinces,

municipalities and autonomous regions can only enact specific penalties within the given range. Previously, the nationwide maximum penalty was RMB 200, but areas like Beijing and Kunming had enacted laws mandating penalties in the thousands of RMB.

3.2.4 Road Safety Audit in Bangkok

As described in the previous section, Thailand implemented several measures under its 5E's strategies for mitigating traffic accidents. One of which is the implementation of Road Safety Audit. It is a new approach with proactive principles to help minimize road safety problems. So far, The Toyota Motor Thailand Co., Ltd. Commission with the Thailand Accident Research Center and the Department of Highways performed a road safety on six national highways as shown in Figure 10. Some benefits obtained from RSA are: (i) the severity of crash is reduced; (ii) the safety performance of road network is improved; (iii) cost of the consequence of road accident can be reduced; and (iv) safety awareness for road users can be raised.

4. Comparison between Developed and Developing Countries Measures in Asia

This report discussed about two adverse impacts of transport sector, greenhouse gas emissions, air pollution and traffic accidents. Globally, the contribution of these two impacts in Asian countries shows an increasing trend and, thus, requires serious mitigation efforts. Despite the concerns about the negative impacts, it cannot be overlooked that there are many positive features of transport. The challenges are how to manage the benefits of transport so that the broad set of environmental and other impacts is reduced while ensuring acceptable outcomes in terms economic performance and equity which become the main concerns of most mega cities in developing countries. Developing megacities should have more options to avoid the more damaging path some developed cities have taken.

Referring to an analysis of over 400 climate change policies implemented in European and American cities (Short et al., 2009), most measures fall into the fuel efficiency (31%) through tax differentiation and regulation. Asian countries especially Japan are no exception. In this study, Japan is regarded as one of the best examples in combining regulation and technology instruments to improve the quality of vehicle running on the road through the implementation of the national law of automotive NO_x and PM altogether with diesel retrofit program in Tokyo and its green tax system. It also complemented those instruments by involving cooperation instruments with private sectors particularly in developing lower emission vehicles.

Most STREAM developing countries have also made considerable progress in developing some forms of AQM by setting up ambient air quality and vehicle emission standards; adopting vehicle inspection and maintenance program; and also making efforts in phasing out leaded gasoline ranging from a complete ban to at least having made unleaded gasoline available in the market like in Indonesia and Viet Nam. Though the standards and other related regulations have been enacted, the degree of implementation varies and most cases indicate weakness in law enforcement. Although the standards have been established, they are not necessarily well implemented in all cities as part of an integrated AQM system due to financial or institutional constraints.

In terms of GHG emission control, most Asian countries have attempted to replace buses, taxis, and three-wheelers to LPG/CNG-fueled vehicles through various R&D programs, direct investment, incentive programs, etc. Although some countries still have to establish more refueling stations to overcome market's hesitation from using LPG/CNG-fueled vehicles due to operational inefficiencies.

Table 4 Comparison of Measures between Developed and Developing Countries and Future Challenges

ADVERSE IMPACTS	CATEGORIES OF MEASURES		DEVELOPED COUNTRIES	DEVELOPING COUNTRIES	FUTURE CHALLENGES
Local Air Pollution	1)	Improve vehicle fuel combustion performance	(i) Stringent NAAQS and vehicle emissions standards; (ii) Mandatory I&M program with harsher penalty; (iii) Mandatory retrofit program (e.g. Tokyo's diesel retrofit program)	(i) Adopted NAAQS and emission standards but varied in the degree of enforcement including the vehicle I&M program; (ii) Phasing out leaded gasoline; (iii) Limiting the use of two-stroke engines for motorcycle	(i) Efficient and effective Air Quality governance (ii) Mandatory and routine vehicle I&M inspections;; (iii) Phasing out the use of two-stroke engines for motorcycles
	2)	Improve road network: traffic management and control	Taking into consideration air quality information in the planning of new roads[1]	(i) Banning motorcycles and/or para-transit from major streets; (ii) Providing motorcycles and pedestrian/bicycle lanes	(i) Smart growth-oriented road/highway development; (ii) Stricter rules for motorcycles; (iii) Improvement of segregated non-motorized modes lanes
GHG Emissions	3)	Promote clean fuel (LPG, CNG) for buses and taxis	(i) Excise tax advantage for LPG/CNG over gasoline and diesel; (ii) Establish sufficient number of refueling station	(i) Providing direct investments, subsidies, or incentives to replace buses, taxis and para-transits (e.g. three-wheelers) with LPG/CNG-fueled; (ii) establishing refueling stations; (iii) R&D on CNG/LPG vehicles technology (China)	(i) Meeting the demand of refueling stations to reduce the time required to refuel; (ii) Adopting more effective fiscal instruments to promote the use of LPG/CNG not only for public transports but also for other vehicles

ADVERSE IMPACTS	**CATEGORIES OF MEASURES**		**DEVELOPED COUNTRIES**	**DEVELOPING COUNTRIES**	**FUTURE CHALLENGES**
	4)	Promote the use of low emission vehicles (LEVs)	(i) Tax differentiation to promote LEVs; (ii) Vehicle efficiency regulations; (iii) Involving cooperation instruments with private sectors for LEVs	(i) Promote the use of electric bikes and scooters (in China); (ii) excise tax rate (China, Thailand); (iii) Some incentives including tax exemptions for eco-car manufacturer (Thailand)	(i) Involvement of business/private sectors in promoting LEVs and efficient fuels through incentives, tax exemptions, etc.; (ii) Fiscal scheme to take into account a broad range of GHG emissions
Traffic Accidents	5)	Pre-crash: crash prevention	Establish monitoring system (ITS), training and campaign for reducing risky driving behavior	(i) Training and campaign have been promoted in various degree; (ii) Stringent regulations have been adopted; (iii) Insufficient monitoring system	(i) Stringent regulations and harsher penalties should be adopted; (ii) Strengthening the licensing system for well-trained driver; (ii) The law enforcement authorities should be sufficiently equipped and funded; (iii) Technological barriers to improve monitoring system (ITS)
			Improving road facilities particularly at black spots, traffic signs, speed limits, etc. to protect vulnerable parties: pedestrians, bicyclists, elderly people, children through road safety audit and road reconstructions	(i) Motorcycle and bicycle lanes are being provided in some countries; (ii) Inadequate pedestrian facilities ; (iii) Road Safety Audit	(i) Providing adequate and safer facilities for non-motorized modes and motorcycles; (ii) Put emphasis on "smart growth" road planning focusing on reducing motorization
	6)	Crash: injury prevention during the crash	Adopted stringent regulations on the usage of vehicle safety measures such as seat belt, helmet, child restraint, etc.	Similar approaches also implemented in developing countries but more emphases are put on motorcyclists	(i) More aggressive approach in promoting people's awareness and enforcing the law; (ii) Economic instruments may be one approach to be considered

ADVERSE IMPACTS	CATEGORIES OF MEASURES	DEVELOPED COUNTRIES	DEVELOPING COUNTRIES	FUTURE CHALLENGES
	7) Post-crash: life sustaining	(i) Two-tier motor vehicle insurance system consists of mandatory and compulsory insurance system; (ii) Improving access to emergency service		Severe congestion may become the barrier to immediate access to emergency service

Note: [1] such as Hong Kong, Singapore, Taipei and Tokyo (Short et al., 2009)

In future to come, it is still necessary to supplement the regulations with fiscal schemes taking into account a broad range of GHG emissions as Japan and other developed countries adopted, especially to promote the use of LEVs. Not until recently, countries like China and Thailand started to implement excise tax rates with some financial subsidies for energy-saving vehicles. Thailand also provides incentives for eco-car manufacturer. Needless to say, such measures are quite challenging for many developing cities due to limited funds and planning expertise, and inexperienced local institutions to enforce them.

Another major concern for developing cities pointed out by this study is the rapid growth of motorcycles. Limiting the use of two-stroke engine for motorcycle and replacing it with four-stroke engine has become one of the approaches to reduce the emissions. Iyer and Shah (2004) suggested Asian countries to carry out more selective bans instead of phasing them out completely, such as through banning only older (and typically more polluting) two-stroke engine vehicles from urban areas, banning new two-stroke engine vehicles, banning or applying high tax for imported two-stroke vehicles. Economic instruments may also be useful to encourage people to change their vehicle such as through trade-in subsidy or ensuring adequate credit is available. As for reducing the use of motorcycle itself, in some cities, motorcycles are restricted from some major streets. Thailand has also provided motorcycle lanes in some road segments. The measures are not only for reducing emissions but also relevant for reducing the number of traffic accidents since motorcycles have lowest safety factor.

When it comes to reducing the number of traffic accidents, an aggressive set of measures updated every five years have been demonstrated by Japan in the last four decades since 1970 which marked its peak of traffic fatalities rate. The first outstanding achievement is the improvement of safer road designs particularly at black spots. Second, the country made a significant improvement in road traffic environment to make travelling a lot safer for all users including children and the elderly. Japan also invested considerable resources in developing ITS system in order to integrate people, roads and vehicles to prevent accidents, reduce the fatality of the accidents and enable immediate rescue to accidents.

Japan’s measures have been partially adopted by developing countries but, needless to say, in relatively modest approaches, such as embedding awareness into people’s behaviors regarding the dangerous of reckless driving. In this case, Shanghai, Thailand and some of Asian countries have adopted stringent regulations, harsher penalties, and continuous traffic safety training and campaigns. As motorcycle accidents are increasing while anticipating its expected growth in the future, most Asian cities, have made using helmet a mandatory. Similar to Japan, attentions have also been paid on safer public facilities for vulnerable parties including pedestrians, bicyclists, children, elderly people, and motorcyclist in the case of developing countries. Road safety audits and road reconstructions for allowing adoptions of more safety measures are being carried out to reduce fatalities.

5. Conclusion

Conclusively, rapid acceleration of motorization is the root of worsening GHG emissions, local air pollution and increasing traffic accidents. Therefore, it may be more effective if developing megacities tackle the issues almost simultaneously by controlling the growth of motorization. Most Asian cities have established the necessary regulation and schematic procedure to reduce local air pollution. Moreover, to some extent, direct investments have been made to promote the use of clean fuel (CNG/LPG) for buses, taxis and para-transits.

Nonetheless, unlike developed countries, it remains uncommon to introduce fiscal scheme for accelerating the use of LEVs in developing countries. There have been some examples of tax policies and incentives helping to lower the overall cost to society of meeting regulations by encouraging companies with the greatest capacities to take the lead, but these tax policies are nonetheless complemented with regulations, public outreach and other tools, which are quite challenging for most developing Asian countries.

In terms of improving road safety, most Asian cities have adopted more stringent regulations and penalties and further exercised more aggressive training and campaigns as preventive measures to reduce fatalities of traffic accidents, especially in Thailand and Shanghai. Although road traffic environment has been recognized as significant factor causing accidents, measures as thorough as Japan’s have not been implemented in other Asian countries possibly due to the financial constraint since Japan’s measures are relatively expensive. Generally speaking, safety issues remain to be a significant tackles for Asian megacities to be at the core while discussing policy options for both private and public modes. More aggressive approaches are required to avoid drastic increase of fatalities.

References

An, F., Gordon, D., He, H., Kodjak, D., and Rutherford, D. (2007) Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update, The International Council on Clean Transportation (ICCT).

APEC (2008) Survey of Policies and Programs that Promote Fuel-Efficient Transport in APEC Economies. http://ase.org/uploaded_files/APEC_Transportation_Survey.pdf

Asia-Pacific Environmental Innovation Strategy Project APEIS-RISPO (2003) Emissions Control Measures in Shanghai, Good Practices Inventory, Institute for Global Environmental Strategies (IGES). http://www.iges.or.jp/APEIS/RISPO/inventory/db/pdf/0031.pdf

Asian Development Bank (ADB) (2006) Country Synthesis Report on Urban Air Quality Management.

Cherry, C.R., Weinert, J.X., and Xinmiao, Y. (2009) Comparative Environmental Impacts of Electric Bikes in China, Transportation Research Part D, Vol. 14, pp. 281-290.

Chiu W.T., Kuo C.Y., Hung C.C, Chen M. (2000) The Effect of the Taiwan Motorcycle Helmet Use Law on Head Injuries. American Journal of Public Health, Vol. 90, No. 5, 793-796.

Department of Energy of Philippine (2009) Promoting Low Carbon in Developing Countries of Asia and the Pacific: The Philippine Experience. Expert Group Meeting on "Towards a Low Carbon Development Path for Asia and the Pacific: Challenges and Opportunities to the Energy Sector", UNESCAP, Beijing, June 17-18. http://www.unescap.org/esd/energy/lowcarbon/2009/forum/LCDP-EGM/S2-MsCarmencitaBariso.pdf

Environmental Protection Agency (EPA) of Taiwan (2009) Control of Mobile Sources of Air Pollution. http://www.epa.gov.tw/en/epashow.aspx?list=99&path=128&guid=8d668c67-e27f-4a96-ac41-323149899ff2&lang=en-us

Feng, C.M., Sun, Y.J. and Luo S.S. (2007) Case Study of Sustainable Transport for East Asian Megacities (STREAM) – Urban Transport in Taipei, Proceedings of the Eastern Asia Society for Transportation Studies, Vol. 6.

Goedecke, M., Therdthianwong, S., and Gheewala, S.H. (2007) Life-cycle cost analysis of alternative vehicles and fuels in Thailand, Energy Policy, Vol. 35, Issue 6, pp. 3236-3246.

Gwilliam, K., Kojima, M. and Johnson T. (2004) Reducing Air Pollution from Urban Transport, the World Bank. http://www.cleanairnet.org/cai/1403/articles-56396_entire_handbook.pdf

Haq, G., Han, W-J., Kim, C. and Vallack, H. (2002) Benchmarking urban air quality management and practice in major and mega cities of Asia, Air Pollution in the Megacities of Asia (APMA), Korean Environmental Institute (KEI).

Huizenga, C., Ajero, M., Fabian, H. and Haq, G. (2004) Benchmarking urban air quality management in Asian cities, 13th World Clean Air and Environmental Protection Congress and Exhibition, London.

Hung, W.T. (2006) Taxation on Vehicle Fuels: Its Impacts on Switching to Cleaner Fuels, Energy Policy, Vol. 34, Issue 16, pp. 2566-2571.

Intergovernmental Panel on Climate Change (IPCC) (2007) Climate Change 2007: Synthesis Report, an Assessment of the IPCC, Adopted Section by Section at IPCC Plenary XXVII, Valencia, Spain, 12-17 November.

International Association of Traffic and Safety Sciences (IATSS) (2006) White Paper on Traffic Safety in Japan 2006, under supervision of Directorate General for Policies on Cohesive Society, Cabinet Office, Government of Japan. http://www8.cao.go.jp/koutu/taisaku/h18kou_haku/english/wp2006-1.pdf.

International Association of Traffic and Safety Sciences (IATSS) (2008) Statistics 2007 Road Accidents Japan, Traffic Bureau, National Police Agency, Government of Japan. http://www.iatss.or.jp/pdf/st/st2007.pdf

Iyer, N.V. and Shah, J. (2004) Module 4c: Two- and Three-Wheelers, Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities, Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ).

Jacobs G, Aeron-Thomas A and Astrop A. (2000) Estimating global road fatalities. Transport Research Laboratory, TRL Report, No. 445.

Japan Automobile Manufacturers Association, Inc. (JAMA) (2008) Reducing CO_2 Emissions in the Global Road Transport Sector. http://www.jama-english.jp/publications/2008_CO2_RoadTransport.pdf

Kim, K.H. (2007) Airborne Lead Concentration Levels on the Korean Peninsula between 1991 and 2004, Atmospheric Environment, Vo. 41, pp. 809-824.

Kim, K.S. and Hwang, K. (2005) An Application of road pricing schemes to urban expressways in Seoul, *Cities*, Vol. 22, No. 1, pp. 43-53.

Kwon Y.I, Kim S.J. and Jun Ma P.G. (2007) Bus Integration in Seoul: Evaluation of the Effect, A Presentation at Center for Sustainable Urban Regeneration International Workshop: Next Step to Sustainable Urban Regeneration, September 3-5, Takeda Hall, the University of Tokyo.

Leopairojna, S. K. and Hanaoka, S. (2005) Market Structure of Passenger Vans in Bangkok. Journal of the Eastern Asia Society for Transportation Studies, Vol. 6, pp. 4192-4207.

Liu, E., Yue, S.Y. and Lee, J. (1997) A Study on LPG as a Fuel for Vehicles, Research and Library Services Division, Legislative Council Secretariat, Hong Kong.

Liu, R. and Guan, C.Q. (2005) Mode Biases of Urban Transportation Policies in China and Their Implications, Journal of Urban Planning and Development, Vol. 131, Issue 2, pp. 68-70.

Lloyd, W. and Hook, W. (2007) Bus Rapid Transit Planning Guide, Institute for Transportation and Development Policy, 3rd Edition, New York, USA.

Lovei, M. (1998) Phasing Out Lead from Gasoline: Worldwide Experiences and Policy Implication, Pollution Management Series, World Bank Technical Paper No. 397, Washington, U.S.A.

Meszler, D. (2007) Air Emissions Issues Related to Two and Three-Wheeled Motor Vehicles: An Initial Assessment of Current Conditions and Options for Control. A Report prepared for International Council on Clean Transportation. www.theicct.org/documents/Meszler_2&3Wheelers_2007_v3.pdf.

Ministry of Economic Affairs (MoEA) of Taiwan (2008) Framework of Taiwan's Sustainable Energy Policy. http://www.moeaboe.gov.tw/English/files/Framework%20of%20Taiwan's%20Sustainable%20Energy%20Policy.pdf

Ministry of Environment (MoE) of Korea (2008) ECOREA: Environmental Review of 2008. http://eng.me.go.kr/docs/publication/publication_detail.html?idx=42&mcode=A&topmenu=E&cat=310

Ou, X., Zhang, X., and Chang, S. (2010) Alternative Fuel Buses Currently in Use in China: Life-cycle Fossil Energy Use, GHG Emissions and Policy Recommendations, Energy Policy, Vol. 38, Issue 1, pp. 406-418.

Pan, H. (2007) Promoting Reduction in Travel Demand in Transport Sector of Asian Cities: Case of Shanghai, China, Air Pollution Control in the Transportation Sector: Third Phase Research Report of the Urban Environmental Management Project, Institute for Global Environmental Strategies (IGES), Japan.

Pervin A., Passmore J., Sidik M., McKinley T., Thi Hong Tu N., and Phuong Nam N (2009) Viet Nam's mandatory motorcycle helmet law and its impact on children, Bull World Health Organ, Vol. 87, 369-373.

Pew Center on Global Climate Change (PewClimate) (2008) Climate Change Mitigation Measures in India, International Brief 2. http://www.pewclimate.org/docUploads/India-FactSheet-09-08.pdf

Schwela, D. et al. (2006) Urban Air Pollution in Asian Cities: Status, Challenges and Management, Stockholm Environment Institute and the Clean Air Initiative for

Asian Cities.

Short, J., van Dender, K. and Crist, P. (2009) Transport Policy and Climate Change, Reducing Climate Impacts in the Transportation Sector (Daniel Sperling and James S. Cannon, eds.), Springer Science+Business Media B.V.

Sperling, D. and Salon, D. (2002) Transportation in Developing Countries: An Overview of Greenhouse Gas Reduction Strategies, Prepared for the Pew Center on Global Climate Change, University of California, Davis. http://www.pewclimate.org/docUploads/transportation_overview.pdf

Sun, Y. et al. (2006) Characteristics and Sources of Lead Pollution after Phasing Out Leaded Gasoline in Beijing, Atmospheric Environment, Vol. 40, pp. 2973-2985.

Tanaboriboon, Y. and Santiennam, T. (2005) Traffic accidents in Thailand. IATSS Research, Vol. 29, No.1, 88-100.

Tangpaisalkit, C. (2007) The Situation of Road Safety in Thailand: A Country Report presented by Director of Transport Safety Bureau, Ministry of Transport, Government of Thailand. http://www.vti.se/epibrowser/RS4C_MR_Chamroon_Bangkok.pdf.

Timilsina, G.R. and Shrestha, A. (2009) Transport Sector CO_2 Emissions Growth in Asia: Underlying Factors and Policy Options, Energy Policy, Vol. 37, pp. 4523-4539.

UNESCAP (2005) Review of Developments in Transport in Asia and the Pacific. www.unescap.org/ttdw/Publications/TPTS_pubs/pub_2392/pub_2392_ch11.pdf.

World Health Organization (WHO) (2004) World Report on Road Traffic Injury Prevention, WHO Report, http://www.who.int/violence_injury_prevention.htm

Wirahadikusumah, K. (2002) Jakarta Air Quality Management: Trends and Policies. Presented at the Regional Workshops on Better Air Quality in Asian and Pacific Rim Cities, Hong Kong, December 16.

World Conference on Transport Research Society (WCTRS) and Institute for Transport Policy Studies (ITPS) (eds.) (2004) Urban transport and the environment - An international perspective-, Elsevier.

Yang, B.M. and Kim, J. (2003) Road Traffic Accidents and Policy Intervention in Korea, Injury Control and Safety Promotion, Vol. 10, No. 1-2, pp. 89-94, Swets & Zeitlinger.

Yeh, S. (2007) An Empirical Analysis on the Adoption of Alternative Fuel Vehicles: the Case of Natural Gas Vehicles, Energy Policy, Vol. 35, Issue 11, pp. 5865-5875.

Zhao, J. and Melaina, M.W. (2006) Transition to hydrogen-based transportation in China: Lesson-learned from Alternative Fuel Vehicle Programs in United States and China, Energy Policy, Vol. 34, Issue 11, pp. 1299-1309.

Appendix 1

Local Air Pollution and GHG Emissions Reduction Measures in STREAM Member Countries

Common Practices	Country							
	Japan	Korea	Taiwan	China	Thailand	Philippine	Indonesia	Viet Nam
Local Air Pollution								
1. Ambient Air Quality Standards								
Legal Basis Enactment	1973	1980, amended several times	1975, revised in 2002	Oct 1996, amended in Jan 2000	1981, revised in 1995 under NEQA 1992	1999	1999 Government Decree No. 41 (national)	1995, updated in 2005
Coverage of Pollutants	SO2. CO, SPM, NO2. Photochemical Oxidants	SO2, CO, NOx, O3, Pb, PM10 and total SPM	PM10, SO2, NO2, CO, O3	SO2, TSO, PM10, NO2, CO, O3	TSP, PM10, NO2, CO, O3, Pb, SO	SO2, TSP, PM10, NO2, CO, O3, Pb (short and long term PM10 and SO2)	SO2, PM10, NO2, CO, O3, SPM, Pb	SO2, TSP, NO2, O3, Pb,
Level of Standards								
National scale	Stricter than USEPA	Municipal ordinances are encouraged to address different characteristics of regions	Local government agencies may draft stringent standards with central authority's approval	Apply specific Grades limit for different functional zones (three grades)	More lenient than WHO values	Short and long-term PM10 and SO2 more lenient than WHO values, relatively similar to USEPA values	SO2 and NO2 more lenient than WHO values	More lenient than WHO values
		SO2, NO2, lead more stringent than USEPA	Equal to USEPA; PM10 and NO2 lenient than EU limit values	Grade 2 standards for SO2, NO2 and O3 are lenient than WHO values				
City scale	None	In 1998, Seoul adopted stricter standards for SO2, NOx, PM	None	None	None	None	In 2001, Jakarta adopted stricter standards for SO2, NO2, O3, CO	None

Common Practices	Country							
	Japan	Korea	Taiwan	China	Thailand	Philippine	Indonesia	Viet Nam
2. Vehicle Emission Standards								
National scale	Set its own emissions standards: Japan's automotive NOx and PM law	Euro IV and ULEV in 2006	Euro-IV (2006)	Euro II - III	Euro III (2004); Control CO and NOx level in gasoline through catalytic converters since 1993	Euro II (2007)	Euro II (2005)	Euro II (2007)
City scale	Since 1992, being tightened to address NO2, O3 and PM problems in major cities	None	None	Beijing (Euro IV for light-duty and heaby-duty vehicles)	None	None	None	None
3. Vehicle Inspection and Maintenance Program	Exhaust gas test was added to the program in 1967 and a noise test in 1970	Mandatory at least every two years; random roadside checks	routine inspections; spot checks	Has recently been tightened and became mandatory for gasoline vehicles since 1 July 2005 under two-speed idle conditions	I&M program adopted but subject to review; roadside checks, public campaign	Under 1999 Clean Air Act, annual inspection is required prior to registration; random check for smoke emission testing	Became mandatory in Jakarta since 2005, the government holds periodic emissions test for free	Since 1995, periodic inspection began
4. Leaded Gasoline Phase-out	1986	Early 1993	Gradual phase out since 1993, and since 2000 Taipei has been leaded-free	In Beijing from 1997, followed by other cities	1996	December 2000	Unleaded gasoline has been available in the market since 2001 for Jakarta, followed by other cities	Unleaded gasoline has been available in the market since July 2001

Common Practices	Country							
	Japan	Korea	Taiwan	China	Thailand	Philippine	Indonesia	Viet Nam
5. Phasing Out Two-stroke Engines for Motorcycle			Tightening vehicle emission standards incl. motorcycle (2004)	All gasoline two-wheelers are phased out in Shanghai	Tightening vehicle emission standards incl. motorcycle (2001)		Under consideration	Capped the no. of motorcycles
6. Para-transit Restrictions				Most jitneys are banned from urban areas	Imposed ban for new taxi *tuk-tuk* registration; BMTA launched licensing system for passenger van in 1995			
GHG Emissions								
1. Promote Clean Fuel for Buses and Taxis	Subsidies for CNG, hybrid and electric buses and taxis	Large excise tax advantage on LPG over gasoline and diesel (LPG taxis and CNG buses)	LPG taxis	Subsidy for retrofitting taxis , refueling stations, R&D programs (LPG/CNG buses and taxis)	LPG-powered taxi and *tuk-tuk*	Started to apply the use of CNG for some strategic routes of buses in Metro Manila	Subsidy for CNG and Euro-II compliant diesel buses for BRT (Jakarta); CNG four stroke *bajaj* (three-wheeler)	
2. Promote LEVs Use	Incentive programs for purchasing LEVs, replacing buses and government fleets with LEVs		Subsidy of NT$2 per liter of LPG	Banning the use of gasoline fueled bicycles and scooters → increase in electric scooters and bikes use; excise tax rates and subsidies	New car excise tax; lower tax for fuel cell, hybrid, and natural gas vehicles; incentive for eco-car manufacturers			