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Review

Comparative Studies on Vehicle Related Policies for Air Pollution Reduction in Ten Asian Countries

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Abstract: Asian countries are facing major air pollution problems due to rapid economic growth, urbanization and motorization. Mortality and respiratory diseases caused by air pollution are believed to be endemic in major cities of these countries. Regulations and standards are the first requirement for reducing emissions from both fixed and mobile sources. This paper emphasizes monitoring problems such as vehicle registration systems, inspection and maintenance (I/M) systems and fuel quality monitoring systems for vehicles in use. Monitoring problems in developing countries share similar characteristics such as a weakness in government initiatives and inadequate operation of government agencies, which results from a lack of human resources and availability of adequate facilities. Finally, this paper proposes a method to assure air quality improvements under the different shares of emission regulations in these Asian countries and introduces an example of an evaluation method based on a policy survey to improve air quality.

Keywords: Asia; air pollution; environment and development; transportation; regulatory policies

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1. Introduction

Asian countries are facing major air pollution problems due to rapid economic growth, urbanization and motorization. Mortality and respiratory diseases caused by air pollution are believed to be endemic in major cities of these countries. Regulations and standards are the first requirement for reducing emissions from both fixed and mobile sources. In order to reduce vehicle emissions, the respective governments of Asian countries are making efforts to introduce vehicle emission regulations for new vehicles. This paper attempts to compare the implemented policies for air pollution reduction. It emphasizes monitoring problems such as vehicle registration systems, inspection and maintenance (I/M) systems and fuel quality monitoring systems for vehicles in use. Monitoring problems in developing countries share similar characteristics such as a weakness in government initiatives and inadequate operation of government agencies, which results from a lack of human resources and availability of adequate facilities.

Finally, this paper proposes a method to assure air quality improvement under the different shares of emission regulations in these Asian countries and introduces an example of an evaluation method based on a policy survey to improve air quality. For the proposal, the database needs to improve data quality and quantity.

2. Background of Air Pollution

Asian countries have been facing increased motorization due to rapid economic growth. Figure 1 shows GDP per capita [1] and number of vehicles (passenger and commercial vehicles) per 1,000 people over the period 1985–2002 for Bangkok [2,3], Kuala Lumpur [4], Jakarta [5], Manila [6], and Japan [7-10]. As a first observation, compared to Japan (1975), Bangkok (2002) and Kuala Lumpur (2002) are already beyond it in terms of vehicle numbers per 1,000 people even if GDP of the two cities in 2002 were lower than in Japan (1975). These Asian cities have a faster process of motorization in terms of GDP per capita [11-14]. As the second observation, the national average level [10,15] follows the city level in accordance with economic growth. In the future, there is a high probability of achieving the Japanese level, 427 units per 1,000 people (2002), at the national level in Asian countries.

Figure 1. GDP per capita and number of vehicle per 1,000 people. Data sources: JETRO [1], Alfa Research Co. Ltd. [2], National Statistical Office [3], Statistical Bureau of Malaysia [4], Land Transport Office [6], JARI [10], BPS [16,17], Hirota [18], UITP [19], NSCB [20]. ●: City level, ▲: National Level.

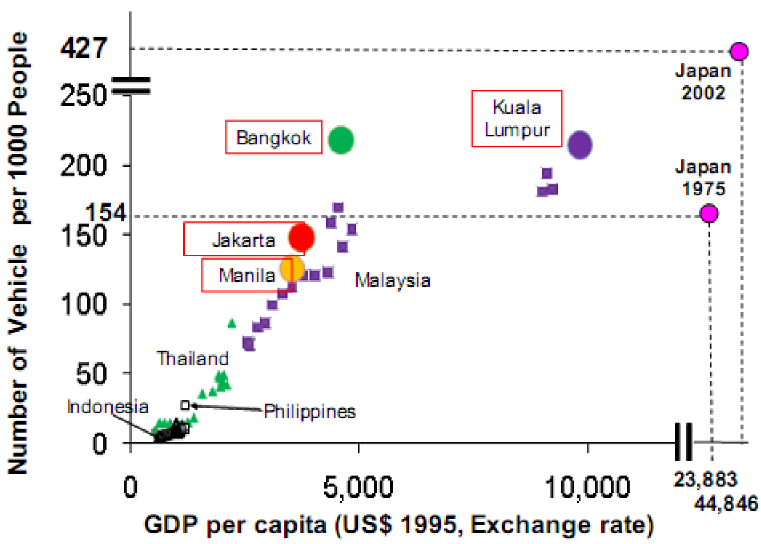


Table 1 shows air quality monitoring in large Asian cities using the criteria of WHO guidelines [21,22] as of 1990 and the most recent years of 2002–2005 [3,4,23-30]. Rapid motorization may negate the efforts of air pollution reduction policies.

CO is produced primarily due to the incomplete combustion of vehicle fuel. In Indonesian large cities, mobile sources accounted for around 70% [24,28] of total emissions in 1991 and 1998. In Manila, mobile sources accounted for 99.2% [30] (1999)–71% [26] (2005) of total CO emissions. In Malaysia, 98% [4,31] of total CO emissions were discharged from mobile sources in 2004. Department of Environment (DOE) Malaysia estimates contribution by vehicle type: passenger vehicles 42%, vans and lorries (trucks) 39.4% and motorcycle 14.7% account for CO emissions of mobile sources in 2004 [31]. In Jakarta, 70% of CO emissions were estimated to be emitted from motorcycles, 16% from cars, 9% from trucks and 4% from buses in 2001 [28]. In Bangkok, 75.42% [27,29] of total CO emissions were estimated to come from mobile sources in 1997. Eighty nine percent of new motorcycles were two-stroke in Manila in 2002, while the number was 64% [27] in Bangkok in 2002. In mobile sources, proper maintenance and use of catalytic converters will reduce CO emissions. Two stroke motorcycles are by far a dominant source of CO emissions. A switch to 4 stroke motorcycles could be an effective policy for CO emissions reduction.

The air pollutants PM10 and NO_2 have become serious concerns from 1990 to the most recent years. In Jakarta, 71% [28] of the total PM emissions in 1998 were discharged from mobile sources. In Malaysia, mobile sources accounted for about 31% [25,31] of total PM emissions in 2004. Malaysia estimates contribution by vehicle type: vans and lorries 62.4%, buses 33.4%, and taxis 3.9% accounted for PM10 emissions of mobile sources in 2004 [31]. In Manila, source apportionment analyses indicate that mobile sources contributed 31% [30] of PM10 emissions in 2001. The Thai Pollution Control Department (PCD) estimated that mobile source accounted for 54% [29] of total PM in Bangkok in 1997. A survey in Bangkok estimated contribution of PM emissions by vehicle type: light duty trucks 31%, city buses 30%, city trucks 23% and motorcycles 10% account for total mobile sources [29]. One of the most important PM control measures to mobile sources must be regular inspection and maintenance of vehicles.

The main causes of NO_2 pollution are vehicles and industry. In Jakarta, 71% [24] of the total NOx emissions were discharged from mobile sources in 1998. In Malaysia, mobile sources accounted for 59% [25,31] of total NOx emissions in 2004. The Malaysian DOE estimates contributions by vehicle type: vans and lorries (55.9%), buses (21.1%) and passenger vehicles (19.5%) accounted for NO_2 emissions of mobile sources in 2004 [31]. The emission inventory for Manila in 2001 indicated that mobile sources contributed 58% [30], while industrial sources contributed 41% [30] of the total NOx emissions. The PCD identified 80.4% [29] of total NOx emissions as coming from mobile sources in 1997.

SO_2 is formed when fuel that contains sulfur (coal and oil) is burned in energy production and other industrial processes. In Jakarta, 21% [24] of total SO_2 emissions were discharged from mobile sources in 1998. In Malaysia, mobile sources accounted for 7% [25,31] of total SO_2 emissions in 2004. The Malaysian DOE estimated the contribution by vehicle type: vans and lorries, buses and passenger vehicles accounted for 53.7%, 20% and 19.6% of the SO_2 emissions from mobile sources, respectively. In Manila, mobile sources contributed 9% [30] of total SO_2 emissions in 2001. PCD estimated 4.12% [29] of SO_2 emissions came from mobile sources in Bangkok in 1997. One of the most important SO_2 control measures for mobile sources is sulfur content reduction in automobile fuels.

Ozone is not emitted directly into the air but it is formed by the reaction of VOC (Volatile Organic Compounds) and NOx in the presence of heat and sunlight. Data on source apportionment survey on ozone was hardly found.

Lead concentration in air has been reduced due to lead phase out policies. Lead from gasoline was phased out at the end of 1995 in Bangkok, in April 2000 in Manila and in 1998 in Kuala Lumpur. In Table 1, lead in air concentration was reduced in Bangkok from 1990 to 2005 [27,29], in Manila from 1990 to 2002 [26] and in Kuala Lumpur from 1990 to 2004 [23] because lead had been phased out from automobile fuel in these cities [31]. Lead concentrations in air increased in Jakarta from 1990 to 2004 [32-34] even though lead was phased out from automobile fuel in July 2001 [35,36].

When in the future car stocks at the national level in Asian countries reach the Japanese level, 427 units per 1,000 people (2002), the air quality should be improved by air pollution reduction policy.

Table 1. Air quality monitoring in four Asian large cities. Data sources: BPS [17], Hirota [18,37], WHO [22], Alam Sekitar Malaysia Sdn. [23], ADB [24-27], WB [28-31], ACFA [34].

Latest Year (2002-2005)

City		CO	NO_2	PM_{10}	O_3	SO_2	Lead
Jakarta	2004	E	C	E	C	D	D
Kuala Lumpur	2004	C	D	D	C	B	A
Manila	2002	C	E	E	D	C	B
Bangkok	2005	A	D	D	B	C	B

1990

City		CO	NO2	PM10	O3	SOx	Lead
Jakarta	1990	C	B	D	C	C	C
Kuala Lumpur	1990	C	C	B	C	B	C
Manila	1990	D	D	D	D	B	C
Bangkok	1990	B	B	E	B	B	C

A	50 % below from WHO guideline
B	Within WHO guideline
C	Within 200 % from WHO guideline
D	Within 300 % from WHO guideline
E	300 % over from WHO guideline

According to the World Health Organization (WHO) [22], worldwide mortality caused by air pollution in large cities in 2002 was estimated to be approximately 800,000 people [21]. Two-thirds of these deaths were concentrated in Asian cities. With these concerns about mortality and respiratory disease caused by air pollution in large cities, it is an urgent matter to reduce air pollution in Asian cities. According to the literature from HEI surveys on changes in mortality and respiratory disease caused by increases of PM10 in Asia, a PM10 increase by 10 μg/m^3 results in a mortality change increase of 0.3% to 1.5% [21] compared to natural mortality during 1990–2006, and the respiratory disease rate increases at a rate of 1.1% to 4.5% from the normal probability of respiratory disease.

Figure 2 shows the relationship between AQI (Air Quality Index; http://www.airnow.gov/index.cfm?action=aqibasics.aqi (X axis) and 53 literature results on mortality (diseases of respiratory system and diseases of circulatory system: pneumonia, COPD, cardiovascular, cerebrovascular, ischemic stroke, respiratory disease, CE, CI, MI, ICB, IHD) in Asian cities (Hong Kong, Seoul, Inchon, Taipei, Bangkok, Gaoshiung, Shanghai, Beijing, Delhi, 13 cities in Japan, Tokyo) from 1999 to 2006. The annual average values of the air pollutants PM10, TSP, SPM, NO_2 and SO_2 of these cities in the literature are converted to AQI following the US EPA style. The Y axis represents the percentage of mortality change of the disease occurrence per 10 μm/m^3 increase of the five types of pollutants. Standard deviation of each value (red dot in the Figure) shows the lower and upper limits of confidence intervals. The Figure shows a linear co-relation between AQI and the change of mortality in these 53 literature results. The linear indicates that the higher the AQI, the higher the probability of mortality.

Figure 2. AQI and mortality (literature survey).

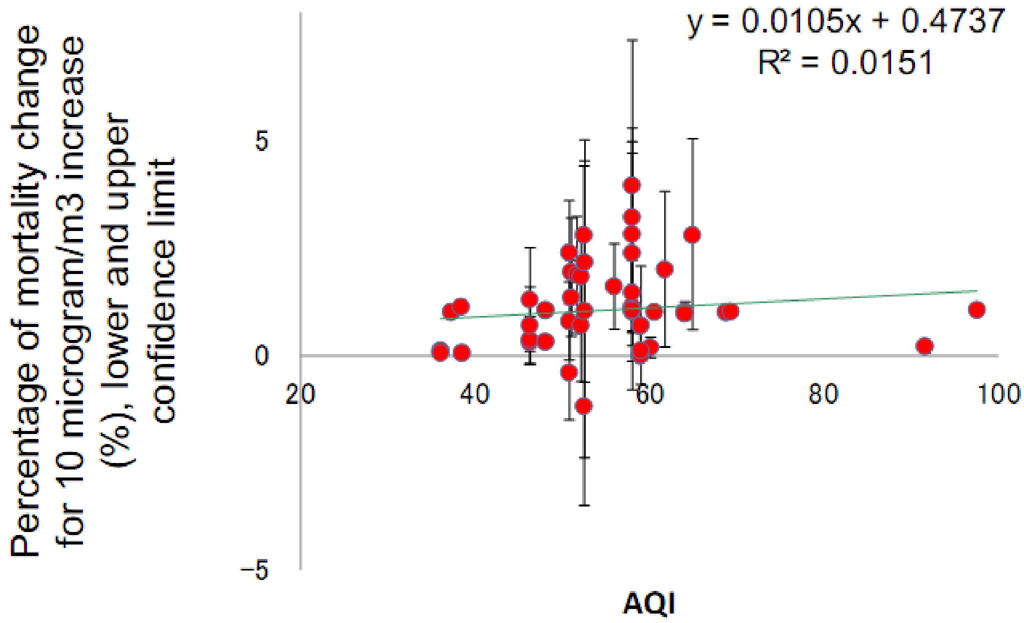
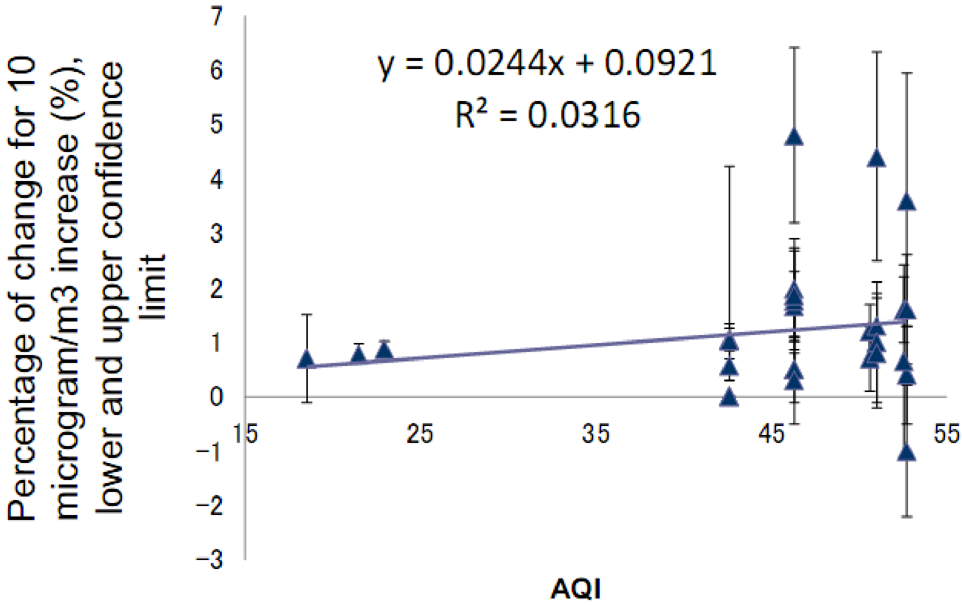


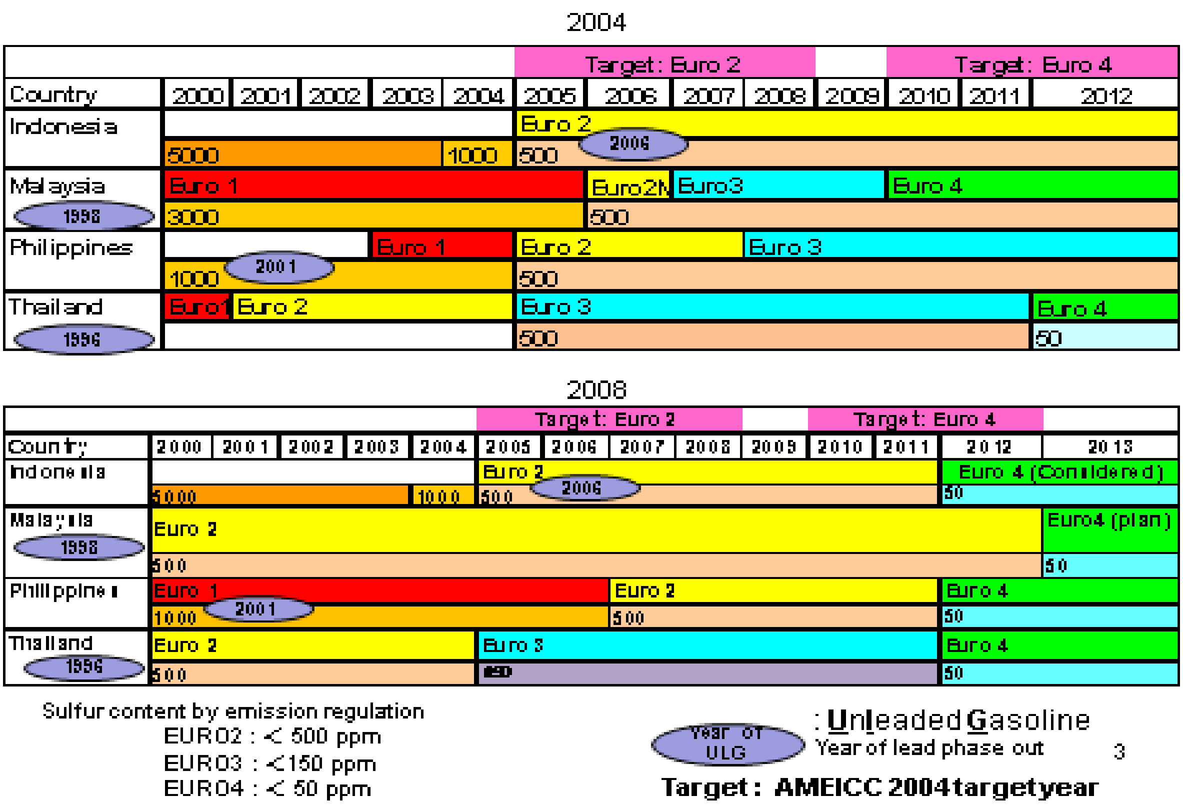
Figure 3 shows the relationship between AQI (Air Quality Index; http://www.airnow.gov/index.cfm?action=aqibasics.aqi) (X axis) and 29 literature results on hospital admission (respiratory system and circulatory system diseases: pneumonia, cardiac, cerebrovascular, ischemic stroke, respiratory disease, heart failure, heart stroke, asthma, IHD, CB) in Asian cities (Hong Kong, Seoul, Tokyo, Kushiro) from 1998 to 2004. The annual average values of the air pollutants PM10, TSP, SPM, NO_2 and SO_2 of these cities in the literature are also converted to AQI following the US EPA style. The Y axis represents the percentage of hospital admission change of the disease occurrence per 10 μm/m^3 increase of the five types of pollutants. Standard deviation of each value (red dot in the figure) shows lower and upper limit of confidence intervals. The figure shows a linear co-relation between AQI and the change of hospital admissions in the 29 literature results. The linear relationship indicates that the higher the AQI, the higher the probability of hospital admission.

Figure 3. AQI and hospital admissions.



Taking into consideration the future health costs [38], policy implementation of emission regulations for new vehicles in early motorization can reduce the cost of air pollution reduction. If the cost of air pollution is reduced at present, the cost of health care is reduced in the future.

Table 2. Time schedule for emission regulations (upper line) and fuel quality (lower line) gasoline passenger vehicle. Data Source: Hirota [18,42,43], AMEICC 2007 [39], AMEICC 2004 [40], AAF [41].



3. Introduction of Vehicle Emission Regulations and Fuel Quality

The introduction of emission and fuel regulations are merely the first step toward political implementation of air pollution reduction policies. In recent years, the governments in Asian countries have been introducing vehicle emission regulations for new vehicles [41]. Table 2 shows the time schedule of the vehicle emission regulations and sulfur content for new gasoline-driven passenger vehicles in Asian countries. The common target is the introduction of EURO 2 by 2008 and EURO4 by 2012 [18,42]. In fact, the time schedule of 2007 is delayed compared to the time schedule of 2004 [43,44]. In order to meet the EURO 2 standard level, it is important to install catalytic converters to meet the emission regulation levels (CO, HC, NOx etc). Since lead in gasoline causes the catalytic converter to malfunction, leaded gasoline in Asian countries has already been phased out [43]. As the next step, lowering the sulfur content (below 500 ppm) is the focus for introducing stricter emission regulations [43].

4. Availability of Clean Fuel Vehicle and VKT in Asian Countries

In order to evaluate impact of air pollution policy in Asian automobile sector, it is necessary to understand the actual situation of vehicle usage and implemented policies. For policy analysis, the actual situation of vehicle usage such as car stocks, vehicle speeds and vehicle kilometers traveled (VKT) should be measured as quantitative data. These quantitative data can be also referred to as preparation of emission inventory, which often also involves estimates using fuel consumption and emission volumes.

The Japan Automobile Research Institute (JARI) played the role of ERIA working group (WG) secretariat for the WG “Sustainable Automobile Society in East Asia (SASEA)" in 2008. The ERIA WG secretariat sent questionnaires to 10 member countries on vehicle category, VKT, method of VKT estimation, clean vehicle availability, inspection interval of vehicle and related tax system from December 2008 to January 2009. The answers from the 10 member countries are integrated as a database [37]. The the database results are shown in this section.

Table 3 shows the availability of clean vehicles on the market of the surveyed Asian countries. Clean vehicle availability in turn depends on the availability of clean fuel supplies. Most of the Asian countries have only introduced a limited volume of bio fuel vehicles at present (2009). Currently (2009) the only E5 available countries are Indonesia and India. In Vietnam E5 has been available from 2008 to 2010. E10 available countries are China and Thailand. B5 available countries are Vietnam and Malaysia. In Indonesia, B2.5 became available in 2009. Natural gas vehicles are available in all the member countries. LPG vehicles are available in all except Singapore. Hybrid vehicles and electric vehicles are available through pilot projects. DME has been introduced only in Japan and Vietnam as pilot projects.

Table 3. Availability of clean vehicles in market of Asian countries. Source: Hirota [37]. CN: China, IDN: Indonesia, PH: Philippines, SG: Singapore, TH: Thailand, IN: India, JPN: Japan, KR: Korea, VN: Vietnam, ML: Malaysia.

	IDN	CN	SG	TH	PH	IN	JPN	KR	VN	ML
Bio-fuel vehicle	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No (On trial run)	Yes (pilot)	Yes
Natural gas	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes (pilot)	Yes
DME	No	No	No	No	No	No	Yes	No	Yes (pilot)	No
Hybrid vehicle	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes (On trial run)	Yes (pilot)	Yes (imported car)
Electric vehicle	No	Yes	Yes	Yes (but not yet available)	Yes	Yes	Yes	No (On private roads)	Yes	No
LPG	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes (For Taxi, Rental Car, Cars for the disabled)	Yes	Yes

Table 4 represents vehicle kilometers traveled (VKT) per vehicle. The annual passenger vehicle kilometers traveled (VKT) is higher by 1.5–2.6 times in other Asian countries than that of Japan. The VKT measurement methodology is diverse among the various Asian countries. In China and in India, VKT is estimated from investigation by questionnaires. In Singapore and in Korea, VKT data is accumulated at the time of periodic inspections. In Thailand and Vietnam, VKT can be calculated from secondary data. In Indonesia, Philippines and Malaysia, the members reported no data availability.

Table 4. VKT in Asian countries. Source: Hirota [37].

Questionnaire		IDN	CN	SG	TH	PH	IN	JPN	KR	VN	ML
VKT: Annual travel distance per vehicle (km/year)	Passenger vehicle	No data	26,000	20,000	14,853	No data	No data	10,000	18,225 km (avg. of all reg veh.), 64,321 km (avg. of commercial only)	15,000–20,000	No data
	Bus		45,000	85,000	39,268			55,000	29,950 km (avg. of all reg. bus), 86,674 km (avg. of commercial only)	15,000	
	Truck		65,000	35,000	45,744			70,000	20,892 km (avg. of all reg veh.) , 53,399 km (avg. of commercial only)	50,000	
	Motorcycle		7,500	13,000	5,627			3,000	N/A(not collected)	5,000–9,000	

Table 4. *Cont.*

Have you heard how to measure driving distance (km/vehicle) in your country?	Data collection from the drivers, vehicle owners, based on the odometer readings	No data	•			No data	•				No data
	The average kilometres travelled per vehicle are estimated based on mileage survey of in-use vehicles conducted at mandatory periodic vehicle inspections.			•					•		
	Calculation from secondary data				•					•	

5. Monitoring System (I&M, FQM)

Not only implementation of emission standards for new vehicles, but also regular inspection and maintenance of vehicles with uncontrolled emissions are effective for emission reductions. Asian countries have legislation regarding registration, I/M (inspection and maintenance) and Fuel Quality Monitoring (FQM) systems. However, operation of the registration, I/M (inspection and maintenance) and fuel quality monitoring systems used in developing countries are observed to share similar characteristics, such as a weakness of government initiative and inadequate operation by government bodies, which results from shortages of human resources and analysis facilities [35]. These present issues may affect emission volumes from mobile sources.

With respect to vehicle category, when the more popular vehicle types were used, more detailed categories existed. In general vehicle type is categorized by emission displacement, vehicle model and use purpose. With respect to I&M, commercial vehicle were inspected with top priority. In some countries, inspection for private vehicles is applied after the vehicle reaches a certain age.

A better operation of an I&M system enables used vehicles to be regularly checked for defects in vehicle parts and improve them by replacing them with better parts and also by tuning the engine, *etc.* [45,46]. A better operation of inspection systems can definitely phase out high-emission vehicles [47-49]. According to a GTZ report [50], vehicles which did not pass an inspection test emitted 1.7–7 times higher CO levels than vehicles which did pass. As a successful example, in 2000 a voluntary I/M bus project in Jakarta called the "Blue Sky project" reduced HC by 49%, CO by 53%, soot by 61%, and increased fuel saving by 5% [51,52].

Table 5 shows the type of vehicle inspections, intervals and deregistration processes. Due to less-efficient operation of registration systems, the number of inspected vehicles is very limited, so that the system is unable to reflect the overall emission quality situation in the real world. Less-efficient operation of registration system can hardly protect consumer rights from recalls and stolen vehicles. The lack of deregistration is another problem [53-56] in registration system. Deregistration process can clarify the track record of discarded vehicles by number and year.

Table 5. Inspection and maintenance guidelines for different categories of vehicles Asian countries. * Valid period until next inspection. Number shows "First inspection year-Second inspection year Third inspection year-". Ex) 1-1-1-: Annual inspection. Data sources: Hirota [18,37]. Data reference: Ministry of Industry, Indonesia [53] Aminuddin [54], Hirota[55], Ovasith [56], AIT [57], JASIC [58,59], UN ESCAP-JARI [60].

	Inspection interval			
	Passenger	Bus	Truck	Motorcycle
CN	Vehicle age (VA) ≤ 6 0.5-0.5-0.5- 6 < VA ≤ 15 1-1-1- VA > 15 2-2-2-	VA ≤ 5 1-1-1- VA > 5 2-2-2-	VA ≤ 8 1-1-1- VA > 8 2-2-2-	VA ≤ 4 0.5-0.5-0.5- VA > 4 1-1-1-
IDN	No	0.5-0.5-0.5-	0.5-0.5-0.5-	No
TH	VA ≤ 7 not required VA > 7 1-1-1- Taxi:0.3-0.3-0.3-	≤20 seats: 3-3-3- Others: 0.5-0.5-0.5-	Unloaded vehicle ≤3.5 t: 3-3-3- Others: 0.5-0.5-0.5-	VA ≤ 5 not required VA > 5 1-1-1-
SG	VA ≤ 3 not required 3 ≤ VA ≤ 10 2-2-2- VA > 10 1-1-1-	0.5-0.5-0.5-	VA ≤ 10 1-1-1- VA > 10 0.5-0.5-0.5-	VA ≤ 3 not required VA > 3 1-1-1-
PH	1-1-1-	1-1-1-	1-1-1-	1-1-1-
IN	Fitness: Commercial vehicle: 2-1-1- Private vehicle VA > 15 years: 2-1-1- PUC:0.5-0.5-0.5- (Commercial Vehicle only)	Fitness: Commercial vehicle: 2-1-1- Private vehicle VA > 15 years: 2-1-1- PUC:0.5-0.5-0.5- (Commercial vehicle only)	Fitness: Commercial vehicle: 2-1-1- Private vehicle VA > 15 years: 2-1-1- PUC: 0.5-0.5-0.5- (Commercial vehicle only)	Fitness: Commercial vehicle: 2-1-1- Private vehicle VA > 15 years: 2-1-1- PUC: 0.5-0.5-0.5- (Commercial vehicle only)
JPN	3-2-2-	1-1-1-	1-1-1-	2-2-2-
KR	Private : 4-2-2- Commercial : 2-1-1-	VA ≤ 5 1-1-1- VA > 5 0.5-0.5-0.5-	Middle scale : 1-1-1-commercial large scale : VA ≤ 2 1-1-1- VA > 2 0.5-0.5-0.5	NA
VN	VA ≤ 7 1-1-1- 7< VA ≤20 0.5-0.5-0.5- No usage after 20years			NA
ML	VA> 10 years old 5-5-5-	1-1-1-	1-1-1-	No inspection

In order to support an I/M system, it is necessary to identify the technology level by a nationwide certification system for engineers, inspectors and mechanics. Asian countries do not have a nationwide certification for mechanics, while some local private maintenance shops do not have adequate skills for tuning EURO 2 vehicles. If technical skill are identical, vehicle users can send vehicles to any dealer or maintenance workshop. Another problem is regional differences in technology levels between auto dealers and local repair shops. While car dealers usually have the knowledge and technology to tune EURO 2 level or higher vehicles, local repair shops sometimes do not have either the knowledge or the technology to tune these vehicles. A nationwide certification system can smoothly guarantee and monitor more stringent emission standards in the future. With the nationwide certification system, more stringent emission regulation than EURO 2 can also be introduced with better effectiveness. This certification system can create new business opportunities for maintenance shop, thereby creating job opportunities.

For policy recommendation, operations of registration and deregistration should be improved similar to that of developed countries. In the future, the better operation of registration system will be essential for monitoring the vehicle recycle process. It enables proper collection of tax revenues. It can also differentiate vehicle tax levels by technical performance.

A better operation of an I/M system is based on a better operation of the registration system. A better operation of the registration process confirms the track record of vehicle registration by year, model, and vehicle age, which assures tax revenue from the vehicles. Less-efficient operation of a registration system allows these four Asian countries to keep old vehicles on the road for longer.

One of the problems is related to vehicle tax systems (Table 6). If vehicle related taxes are differentiated by vehicle performance related to emissions or energy savings, air pollution, including CO_2 can be reduced by the system. Many Asian countries have introduced vehicle related taxes. Some countries have also introduced environmental taxes.

Table 6. Vehicle related tax system in Asian countries Source: Hirota [37].

	Acquisition			Ownership		Motoring	Other incentives for environmentally friendly attitude
	Acquisition (registration fee)	Excise tax, VAT	Import tax	Local tax	Ownership (Annual tax)	Fuel	
IDN	Yes	Yes	Yes	Yes		Subsidy for fuel	
CN	Smaller engine capacity	Yes	Yes	Yes	Heavier tax for leaded gasoline		Early scrappage
SG	COE, Additional Registration Fee (ARF)	Exercise duty, Goods & Services Tax (GST = 7%)			Road tax, Road tax surcharge (for vehicles over 10 years), Special tax for diesel-driven vehicles	Tax on gasoline	Partial additional registration fee (PARF) Rebate, green vehicle rebate (GVR)
TH		HEV (<3,000 cc), EV, FCV = 10% Eco-Car =17% E20 & E85 ≤ 2,000 cc =25%, E20 & E85 2,001–2,500 cc = 30%, NGV =20% Otherwise, <2,000 cc = 30% 2,001–2,500 cc = 35%	Yes	Yes		Cheaper bio fuel tax	Clean energy vehicle

Table 6. *Cont.*

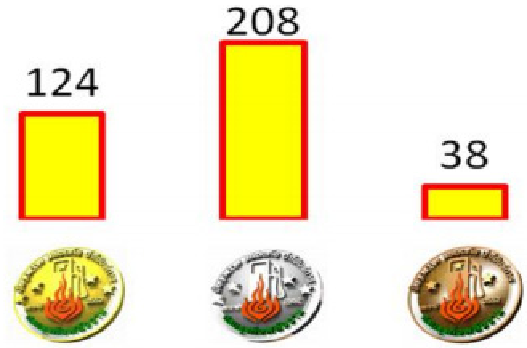
PH		Yes	Income tax holiday, Duty-free		Yes		
IN		Yes	Yes	Yes			
JPN	Tax reduction for eco-car	Yes			Green tax	Yes	Low emission better fuel economy
KR	City compact car (under 1,000 cc) : 50% acquisition/ registration tax cut, Hybrid car (by 2009 July) : acquisition/registration tax cut up to $1,000 Bus: $1,000 tax cut	Yes		Yes	Compact car: fuel tax refund up to $80 per year Taxi : fuel tax refund; Fuel subsidy for compact car, truck, tax; Fuel subsidy for compact car, truck, taxi		Compact car: Parking fee 50% cut, toll 50% cut Subsidy for NGV
VN	Registration tax: 12% Registration fee: 2–3 mil VND/case	VAT: 5%			Road and Bridge fee (separated /included in Fuel price)		
ML							Incentives for public transport companies

The delay in introduction of more stringent emission regulations is caused by a short supply of appropriate fuel quality of gasoline, diesel and bio fuels [43,44]. The more stringent fuel quality (EURO2, 3 and 4), less fuel quantity in general. In Asian countries, FQM law and monitoring system do exist, however, the pace of implementation needs to be matching with the proposed implementation of progressive emission norms. All member countries had FQM, but the problem is operation. There was still lack of information from each country. It was necessary to improve the quality and quantity of database. Following operation problem, a seminar of FQM needed to organize to share information.

The following two examples show the results of fuel quality monitoring. First, the fuel monitoring results for lead content, obtained by the Ministry of Environment in Indonesia and an Indonesian environmental NGO called KPBB [35] have observed an increase in off-specification fuel after the introduction of EURO 2 in 2005 [33]. In 2003 and 2004, prior to its introduction, all samples (number of samples = 31 per year) were observed to meet the lead standard at a national level. In 2005, after the introduction of EURO 2, 12 out of 31 samples were noted to have exceeded the lead content as compared to the designated standards.

In Thailand, the Ministry of Energy Business has an initiative of a campaign for fuel quality and safety service at petro stations. The Ministry of Energy Business evaluates fuel quality and safety from 1 to 5 points (Figure 4). If a petro station is rated at full points, it receives a gold sticker. If it is rated at 4 points, it receives a silver medal. If it is rated at 3 points, it receives a bronze medal. One thousand two petro stations participated out of 18,902 petro station in 2008. One hundred and twenty four petro stations received a gold medal sticker. Two hundred and eight received a silver medal sticker. Thirty eight petro stations received a bronze medal. In total, 370 out of 1,002 gas stations, which is 40% of participated petro stations, were certified. This campaign promotes awareness of fuel quality and safety issues at petro stations. By showing these stickers at petro stations, it promotes consumer awareness.

Figure 4. Fuel quality and safety gas station campaign in Thailand. Data Source: http://www.doeb.go.th/bfbs/index.html. Source: Hirota [37].

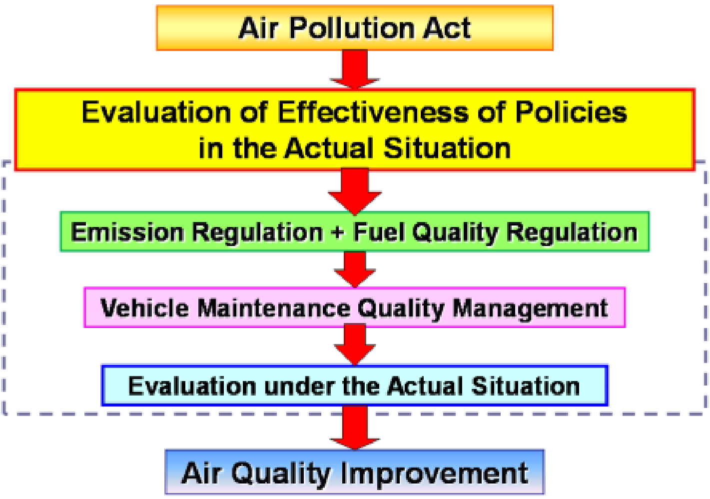


How to assure air quality improvement under the different shares of vehicle types in Asian countries? After an air pollution act, vehicle emission and fuel quality regulations are introduced, and monitoring policies such as better operation of monitoring systems like registration, inspection, fuel quality monitoring and air quality monitoring should be introduced [18]. Based on a simulation of emission volume from these policies [43], it is necessary to evaluate if the total emission volume can be ultimately below the prescribed standards.

Figure 5 shows an example of an evaluation method of policy implementation. First, real vehicle usage such as car stock by vehicle age, vehicle speed and emission factors on-road should be measured as quantitative data. By use of modeling, driving cycle and proper methodology, with quantitative data, the total emission volume is estimated by simulations. This is usually referred to as preparation of emission inventory, which often also involved estimates using fuel consumption, VKT travelled and even through actual monitoring of VKT. These data can be validated by air monitoring studies, followed by source apportionment, which can reliably make conclusions about the contributions from different sources, including mobile sources. After the problem estimation, a list of countermeasures can be worked out as potential options and their techno-economic feasibility can be worked out. From the list of control options, the potential policies/options need to be revised at the activities level and prioritized from the point of cost performance, health impact and other criteria. Finally, proper implementation of control options and policies remains the last important issue, which will ultimately determine the benefits of health effects.

Under the progress of motorization, Asian countries share similar problems related to automobiles. Common issues are I&M and FQM policies. They have not been implemented in an effective and feasible way. With respect to I&M (Inspection and Maintenance), commercial vehicles are inspected with top priority. In some countries, inspection for private vehicles is applied after a certain vehicle age. All member countries have FQM (Fuel Quality Management), but sometimes the problem is operation and implementation. When motorization enters into its full-scale stage, energy and urban environments should be improved with effective I&M and FQM policies.

Figure 5. How to assure air quality improvement? Source: Hirota [43].



6. Conclusions toward Political Recommendations

This paper proposes an evaluation method based on a policy survey to improve air quality. In order to reduce automobile emissions, the governments of Asian countries have been making efforts to introduce stringent vehicle emission regulations. It is also necessary to match the fuel quality to which is necessary for the application of suitable technology for emission control. Vehicle emissions have detrimental effects on air quality, and consumers/users should cover the costs related to emission control. The present results show that early implementation of emission regulations for new vehicles are important. Besides emission regulation implementation, fuel quality monitoring systems, registration systems and I/M systems should support vehicle emission regulations and fuel quality standards.

Finally this paper suggest that these Asian countries to some extent have different challenges of vehicular emission problems with different vehicle type shares, different emission regulation levels, fuel quality, enforcement issues, environmental awareness, economic considerations, *etc.*

The suggestion includes an integrated policy to establish environmentally sustainable development and to improve upon both air pollution and economies. This paper concludes the integrated policy needs improvements of I&M system, FQM system, emission regulation, AQM (Air Quality Management) system and PCE (Public Campaign and Education).

Fortunately, Japan has a long experience dealing with air pollution, especially related to automobile usage. Japan also has state-of-art technologies related to automobiles as well as emission control. This experience, knowledge and technology should be exploited by Asian countries to ensure improved air quality, leading to a "Sustainable Automobile Society".

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