Chapter 3

Methods for Urban Transport Energy Efficiency Improvement in Asia

Study on energy efficiency improvement in the transport sector through transport improvement and smart community development in the urban area Working Group

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CHAPTER 3
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1. Introduction

To overcome the difficult challenges arising from passenger vehicle ownership increases in the urban areas of Asia, and to make sustainable urban transport systems within Asia, the ASIF framework is proposed by Lee (2011).[1] The framework is to consider sustainable transport options through (1) Avoid, (2) Shift, (3) Improve, and (4) Finance. The four items are defined as follows, which are interdependent each other.

- **Avoid** means to reduce travel demand by integrating the land use planning and transport planning to create city clusters that require less mobility, or reduce travel demand.
- **Shift** means to utilize the alternative mode of transport, such as mass rapid transit systems, away from passenger vehicles. Mass transit systems would include buses, rails and subways, of which energy/CO_2 intensities per passenger kilometer would theoretically be lower than that of passenger vehicles.
- **Improve** means to upgrade the overall efficiency of urban transport on vehicle efficiency through technological innovations, or policy measures to manage road traffic or use of information technology.
- **Finance** means to offer monetary basis for developing and improving transport related systems. Various taxes are available as the options, and the revenues could be reallocated to road improvement or public transport enhancement.

The ASIF framework offers the need for a comprehensive package of developing sustainable urban transport systems that can overcome the difficult challenges for the rapidly developing countries/cities in Asian. The critical element in this framework would be to consider measures to shift people of urban areas away from passenger vehicle dependence. One option would be to promote the use of buses, urban rails, and

[1] Schipper, L. (2011). Fuel economy trends in the IEA countries: Lessons and lemons in the race to de-carve. A Presentation Made at the IEEJ Conference. Tokyo. 22 February, 2011.

subways as the number of urban cities plan to implement the infrastructure development. Regardless of the aspirations by city planners, however, such a shift in the choice of transport mode toward mass transits does not take place easily. Cities of developing Asia often lack financial basis to develop infrastructure for mass transit systems. Besides, once urban dwellers acquire passenger vehicles, it is difficult to change their modal choice unless good access to mass transit systems is ensured.

Using the ASIF as the framework, this chapter presents the efforts made among the Asia to handle the transport demand, and to improve the overall efficiency of transport systems.

2. Measures for Avoid

Policies to promote the "avoid" would involve compact urban development, infrastructure development for urban mass rapid transit systems or buses, and policies that require additional costs at the purchase or usage of passenger vehicles. Such policies include:

- Vehicle registration fees/tax,
- License plate fee,
- Mandatory vehicle insurance,
- Road pricing, and
- Parking fee.

In fact, passengers choose transport mode by taking into account of various factors, including reliability, frequency, safety and comfort. Besides, passengers consider the entire cost of urban mass transit relative to its alternative modes. In other words, "avoiding" usage of passenger vehicles can be promoted when the relative cost of alternative transport mode is lower.

The entire cost of urban mass transit involves both payment of fare and time required for travel. In terms of commuting, O'Sullivan (2000) classifies the time of travel into three phases: (1) collection phase, (2) travel phase, and (3) distribution phase.[2] The collection phase for urban mass transit systems entail time required for moving from home to the nearest station. The travel phase refers to the time in a train or

[2] O'Sullivan, A. (2000). *Mass transit.* Urban Economics. The McGraw-Hill Companies, Inc.

in a vehicle, and distribution phase involves time required to the final destination (such as school or work place) from the final train station or parking.

To consider the entire cost of commuting – both including travel time cost and monetary cost, a hypothetical case (of travelling about 16 km) is established using the framework by O'Sullivan (2000). The time cost refers to Small (1992), which evaluates that passengers value travel time in a transport mode about half of their wages, while passengers value time for walking and waiting about two to three times higher than the time in a transport mode.[3] Monetary cost of passenger vehicles involve operational cost (such as cost of gasoline, and insurance), as well as parking cost, and those of passengers for buses and urban mass transits refer to the fare payment.

Table 3-1: Comparison of Commuting Cost by Mode

	Passenger vehicle	Bus	MRT (Case 1)	MRT (Case 2)
Collection Time Cost				
Collection time (minutes)	0	10	4	15
Cost per minute (US$)	0.3	0.3	0.3	0.3
Collection time cost (US$)	*0*	*3*	*1.2*	*4.5*
Travel Time Cost				
Travel time (minutes)	40	50	30	30
Cost per minute (US$)	0.1	0.1	0.1	0.1
Travel time cost (US$)	*4*	*5*	*3*	*3*
Distribution Time Cost				
Distribution time (minutes)	0	5	5	10
Cost per minute (US$)	0.3	0.3	0.3	0.3
Distribution time cost (US$)	*0*	*1.5*	*1.5*	*3*
Monetary Cost				
Operating cost or fare (US$)	*2*	*1*	*1*	*1*
Parking cost (US$)	*3*	*0*	*0*	*0*
Total Monetary Cost (US$)	*5*	*1*	*1*	*1*
Total Time Cost (US$)	*4*	*9.5*	*5.7*	*10.5*
Total Cost (US$)	*9*	*10.5*	*6.7*	*11.5*

Source: O'Sullivan. 2000.

[3] Small, K.A. (1992). *Urban transportation economics.* Fundamentals of pure and applied economics series, vol. 51. Harwood Academic Publishers, New York, USA.

The comparison of commuting cost by mode offers that bus and mass rapid transit are not necessarily the least cost option if the collection time and distribution time are longer. In other words accessibility – both at the origin and destination to/from a bus stop or mass rapid transit station can determine the time for collection and distribution phases, and these are the critical elements to avoid heavy dependence on passenger vehicles.

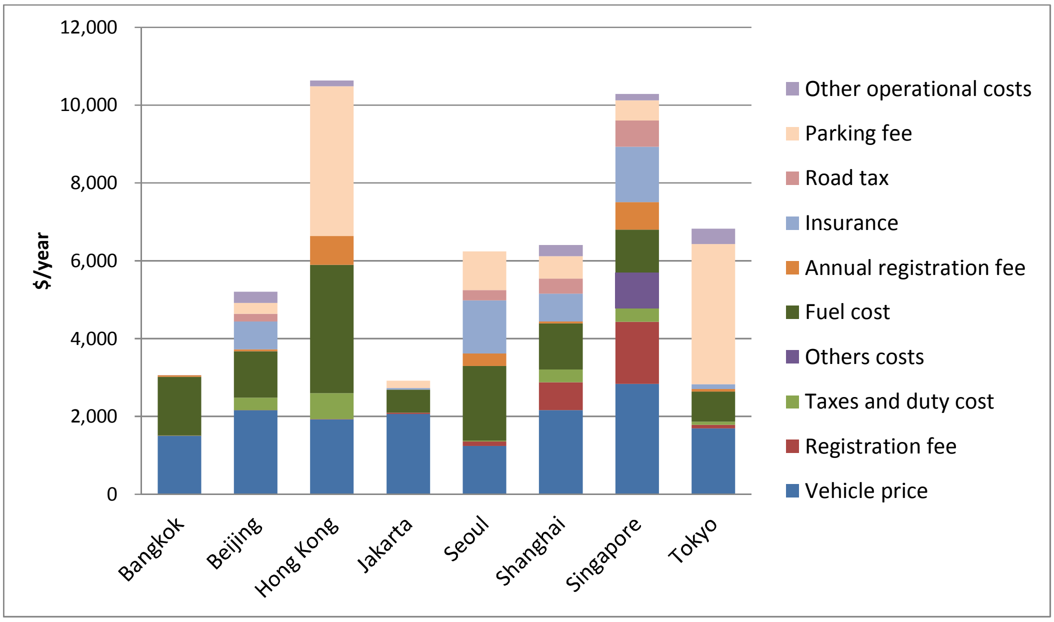
The comparison between the city's passenger vehicle stocks per 1,000 population with that of country average in the previous chapter offers that higher income level – than the country's average – is the key determinant affecting the higher vehicle ownership per 1,000 population in cities, however; it is important to note that there are exceptions. Also, the previous chapter identifies relatively weak correlation between income and passenger vehicle ownership among the analyzed cities.

To clarify the factors behind those key findings, an investigation into "cost of vehicle ownership" is necessary. Here, the cost of vehicle ownership is defined as those costs that are incurred to a vehicle owner from the time of purchase to utilization.[4] This involves vehicle sales price, taxes for vehicle registration and usage, fuel price, parking costs and insurance. Different transport policies/measures, energy pricing and city-specific land use characteristics affect differences in overall cost of vehicle ownership. Understanding the size of these cost elements by city, and the comparisons among the studied cities would provide better perspectives on what are the drivers/constrainers for passenger vehicle ownership.

Figure 3-1 shows the annualized vehicle ownership cost for the 8 cities in Asia. Assuming a ten-year ownership of a popular car with the engine size of 1,600cc – such as Toyota Corolla or Hundai Avante – city-specific annual cost of vehicle ownership is calculated to account for both capital cost and operational cost. The capital cost involves vehicle price, registration fee and other taxes and duties. Apart from this, operational cost involves fuel cost, annual registration fee, insurance, road tax, parking fee and other operational cost.

[4] The cost of vehicle ownership here does not include the social costs, such as health impacts from the emissions of air pollutants as a result of petroleum products combustion, noise, or potential threat to climate change resulting from vehicles' CO_2 emissions.

Figure 3-1: Annualized vehicle ownership cost by city



Source: Author's analysis from various official sources of each city/country. In addition, personal communication with the following persons supported the estimates: Intharak, N. (Energy Policy & Planning Office, Thailand); Li, J. (Energy Research Institute, China); and (Sidemen, G., Ministry of Energy and Mineral Resources, Indonesia).

Different factors differently affect the cost of vehicle ownership. Hong Kong and Singapore represent the highest level of annual vehicle ownership cost among the studied cities at $10,638 and $10,296; nevertheless, the factors affecting to this high vehicle ownership cost for the two cities are quite different. For Hong Kong, the major contributing factors for this high level of cost are fuel and parking cost. The gasoline price of Hong Kong represented the highest level at $1.95 per liter among the studied cities (compared with that of Jakarta at $0.5 per liter – the lowest level among the studied cities). Along with the high price level, relatively long average travel distance at 50 km per day resulted in the high cost of vehicle ownership. Apart from this, monthly parking cost represents high level at above $320 – as a result of the high land price caused by small land area and high population density.

Meanwhile, in Singapore, to control the number of vehicles, the Land and Transport Authority (LTA) introduces a number of measures, which increase cost of vehicle at the time of both purchase and operation. To control the number of vehicles, the LTA determines the number of new vehicles allowed for registration, and the city dwellers would have to bid a permit of owing a car called Certificate of Entitlement (COE), which costs as high as $8,500. Registration fee increases the overall cost of vehicle ownership as above 100% of average market price of certain type of car – is imposed at the time of purchase. Additionally, several measures are introduced to control the traffic, including Electronic Road Pricing (ERP), and parking regulation.

Even within a country, the annualized vehicle ownership cost for Beijing and Shanghai offers different levels. Shanghai's annual cost of vehicle ownership is calculated to reach $6,408, compared with that of Beijing at $5,210. One main factor for Shanghai's high vehicle ownership cost results from the cost of license plate. Similar to Singapore, Shanghai's motorists would have to bid for license plate, which costs above $7,000. Additionally, congestion pricing is implemented in Shanghai at the central business district in order to control passenger vehicle traffic.

Tokyo and Seoul are calculated to represent similar level of annual vehicle ownership cost respectively at $6,827 and $6,246. It is interesting to observe that different factors contribute to the calculated result. For Tokyo, reflecting the high land value, more than half of ownership cost results from parking cost. By contrast, the cost of fuel represents a lower level at $771 per year compared with that of Seoul at $1,918. Assumed gasoline prices for Tokyo and Seoul are respectively at $1.4 per liter, and $1.5 per liter. Meanwhile, the longer daily average trip in Seoul has resulted in a more fuel requirement than that of Tokyo, contributing to an increase the vehicle ownership cost.

Interestingly, the calculated costs of vehicle ownership in Bangkok and Jakarta are the lowest among the analyzed cities respectively at $3,062 and $2,926. Bangkok's low vehicle ownership cost reflects the Thailand's policy to promote vehicle manufacturing industry. Thailand seeks to become "Detroit of Asia", and domestically manufactured vehicles can enjoy lower excise tax rate at 17% compared with 30-50% of imported ones. In addition, Bangkok and Jakarta have not established transport policies to control the number of vehicles and traffic volume; such that there is literally neither parking regulation, nor mandatory insurance requirement.

Comparisons of vehicle ownership cost by city can clearly highlight that toward achieving sustainable transport city, comprehensive transport policies and measures are necessary to be implemented to control vehicle ownership at the time of purchase, as well as at the time of usage. Hong Kong and Singapore, of which annual average vehicle ownership cost are the highest, represent relatively low number of vehicle stocks per 1,000 population at 56 and 116. By contrast, Bangkok and Jakarta, whose annual average vehicle ownership cost, are the lowest, account for large number of vehicle stocks per 1,000 population at 384 and 229. Of course these cost elements are not the only factors affecting the vehicle ownership, however, those cities at the early stage of development tend to account for high level of vehicle ownership as its income level is rising, while the relative size of vehicle ownership cost gets lower.

3. Measures for Shift

Measures for shifting away from passenger vehicles include infrastructure development for mass rapid transit systems for rails, subways and buses. Additionally, bus rapid transits can also become effective alternative transport option if appropriate operational aspects (such as frequency, punctuality and travel comfort) are ensured. The options for facilitating "shift" would include:

- Mass rapid transit systems,
- Bus rapid transit systems,
- Improving feeder bus service, and
- Improving multi-modal transfer through comprehensive tariff structure.

Table 3-2 compares the length of rails and subways in the major urban areas of Asia and their respective accessibility is calculated as length of rails and subways divided by urban land area. The comparison shows diversity in terms of infrastructure development for rails and subways, and ease of access to such mass rapid transit systems. In terms of the accessibility to the rails/subways, it ranges from Tokyo's 1.599 km/km^2 at the highest to Bangkok's 0.103 km/km^2 at the lowest.

Of the analysed cities, **Tokyo** represents the best in terms of infrastructure development for mass rapid transit systems per urban land area, of which indicator representing 1.599 km per km^2. Tokyo is a special case in the analysed cities as the city developed along with the rail/subway infrastructure development. And the city's subway systems are connected to suburban rails; thereby making it possible to allow commuters from the cities outside of Tokyo to the core business area. Meanwhile, **Seoul** represents the second level in terms of access to the subway/rail systems representing 0.701 km per km^2. The city has a good urban transport network, which connects bus systems with the subway systems through smart card. In case passengers utilize the public transport (buses, rails and subways), those smart card users will be charged by the distance travelled which facilitates multi-modal transfer from one mode to the other.

Table 3-2: Length of Urban Mass Rapid Transits in Asia

	Length of Mass Rapid Transits (Rails and Subways): km	Urban Land Area: km^2	Access/Land Area: km/km^2
Bangkok	71.8	700.0	0.1026
Beijing	228.0	735.0	0.3102
Hong Kong	204.2	335.0	0.6096
Jakarta	114.0	528.0	0.2159
Seoul	425.0	606.0	0.7013
Shanghai	355.1	660.0	0.5380
Singapore	147.7	699.4	0.2112
Tokyo	994.0	621.5	1.5994

Singapore is often quoted as a good example of urban transport policies implementation, due to its strong enforcement of certificate of entitlement (that regulates the number of vehicles sold in the market), and electronic road pricing (that controls the vehicle usage). Meanwhile, it is important to note that the city's access to subway systems ranks the second from the lowest one in Bangkok as the public transport in Singapore heavily relies on buses.

Bangkok shows the least developed in terms of rails/subways that handle the city's mobility needs. The city has three mass rapid transit systems; the BTS Sky Train, the Blue Line in the Mass Rapid Transit (MRT) network, and the Suvarnabhumi Airport Link. Sky Train has an elevated route of 23 km with 23 stations, transporting about 400,000 passengers per day. The Blue Line in MRT has an underground route of 20 km with 18 stations that transport around 20,000 passengers daily. The Suvarnabhumi Airport Link opened on 23 August, 2010, which is linked to both the Sky Train and Mass Rapid Transit networks. Meanwhile, as the mass rapid transit systems are concentrated on the urban core area, and they do not help ease the city's chronic congestion problems. To better handle the mobility needs, the city is planning to expand the mass rapid transit systems building additional lines, amounting to a total of 118 km by 2020.[5]

3.1 How to facilitate shift toward mass rapid transits

The previous section described that passengers consider both time cost and monetary cost required to move from one destination to another. Then how do passengers respond to change in fare? The urban mass transit's fares are maintained at low level to make it affordable to wider general public. Through survey of major urban mass transit systems in the world, Fouracre, Allport, and Thompson (1990) pointed out that financial performance of urban mass transit systems generally provides poor outcomes, as both capital and operating costs exceeded revenues by a large margin.[6]

Empirical evidence shows that ridership has negative correlation with fare. According to Beesley and Kemp (1987), short-run ridership elasticities with respect to fare, vary within the range of –0.1 to –0.7, which most of the estimates concentrating between –0.2 and –0.5. This means that 10% increase in fare would result in 2%-5% reduction in ridership.[7] It is important to note that short-run elasticities exhibit low level when alternative means of travel are unavailable or available at high price. Thus, fare elasticities tend to be low for commuting purposes if urban mass transit is the only available means of transport at affordable level.

As the cost of alternative transport increases, ridership elasticity with respect to fare decreases. Figure 3-2 shows the levelized cost of passenger vehicle use and fare to urban mass transit systems for six cities in Asia. The comparison clearly shows that the gap between the levelized cost of passenger vehicle use and fare to urban mass transit systems represents the smallest in Bangkok. The Bangkok's low cost of passenger vehicle use reflects the absence of parking fees and smaller tax requirements on passenger vehicle ownership. City dwellers in Bangkok tend to choose passenger vehicles rather than urban mass transit even if there were decreases in fare.

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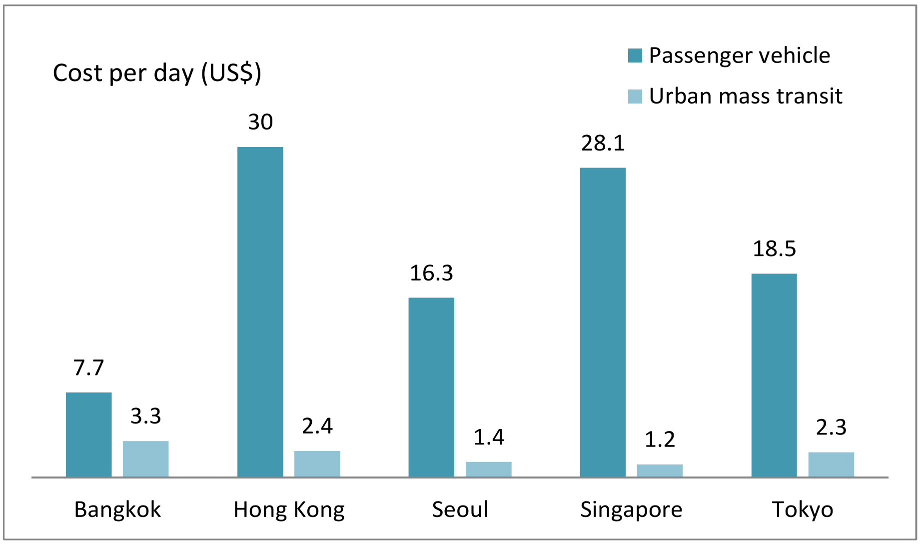
[5] Thailand's cabinet resolution 2006.

[6] Fouracre, P. R., Allport, R. J., and Thomson, J. M. (1990) *The performance and impact of rail mass transit in developing countries.* Transport and Road Research Laboratory. Research Report 278. Berkshire, U.K.

[7] Beesley, E. M., and Kemp, A. M. (1987). *Urban transportation. Handbook of regional and Urban Economics.* Vol.2. Elsevier Science B.V. Amsterdam, the Netherlands.

Figure 3-2: Daily cost of passenger vehicle use and urban mass transits in US dollars.



Source: Author's analysis. Daily cost of vehicle use was calculated based on the data on Figure 2-3, and daily cost of urban mass transit systems was calculated from the following sources: Bangkok Mass Transit Authority; Bangkok Metro Public Company Limited; Hong Kong MTR Corporation Limited; Seoul Metropolitan Rapid Transit Corporation; SMRT Corporation Limited; Tokyo Metro Corporation Limited; and Tokyo Metropolitan Subway.

4. Measures for Improve

Measures for "improve" include the provisions of incentives for deploying efficient vehicles or regulation on fuel economy. Policy measures to road traffic management through the information technology can also assist the urban transport efficiency improvement. Measures for improve can be listed as below:

- Fuel economy improvement,
- Alternative vehicles (electric, CNG, and fuel cell vehicles),
- Intelligent transport systems, and
- Incentives or regulation.

In Asia, various plans are formulated to improve the fuel economy and to deploy the alternative vehicles. Motivations behind these are diverse among the Asian countries, revolving around energy security enhancement, environmental improvement and assisting manufacturing industry development through new technology innovation and their commercialization.

The below includes the undertakings by China, Indonesia and Thailand that try to improve the overall efficiency of the transport sector.

China

During the 12th five-year planning period (2011-2015), Chinese government tries to structurally reform the transport sector, and deploy efficient technologies. Targets are set at both passenger and freight transport to improve the respective energy intensity (energy consumption per passenger, and energy consumption per freight goods) by 6% and 12% by 2015 (2005 as the base year). Chinese government also sets targets for the wider deployment of efficient vehicles, with the goal of selling 5 million units of electric and plug-in-hybrid vehicles by 2020, increasing from a target of 500,000 units of sales in 2015. Additionally, targets are set to improve the fuel economy of conventional internal combustion engine vehicles (reaching 14.5 km/liter in 2015 and 20 km/liter).

Higher targets are placed on fuel economy improvement of efficient vehicles (such as hybrid vehicles), reaching 16.9 km/liter in 2015, and 22.2 km/liter in 2020. These targets are indented to strengthen the international competitiveness of domestic vehicle manufactures, concentrating on the fuel efficient vehicles, such as electric, plug-in-hybrid, and hybrid vehicles.

Indonesia

National energy efficiency and conservation policy already introduced in Indonesia since few years ago to overcome some problem related to energy supply and demand. The Government already set target in 2025 to reduce energy intensity in all sectors around 1%/year, energy elasticity to be less than 1 and energy consumption around 15.6% in 2025. Energy efficiency potential is quite high in all sectors. It's around 15-30%. Some programs to achieve those targets already run, however the progress in quite low.

On 29 May, 2012, the Government of Indonesia again announced the campaign program on Energy Saving to ease the fiscal deficit caused by the provision of fuel subsidies. In relation to the transport sector, the program aims to ban the sales of subsidized gasoline to the vehicles operated by government entity and regulates the sales of subsidized gasoline/diesel to the mining/agricultural sectors. To monitor the use of oil subsidy, the Government also installs gasoline/diesel monitoring system at each fuel filling station in order to prevent illegal sales of subsidiez oil.

In transportation sector, the Government of Indonesia also has program to convert gasoline engine vehicles to natural gas engine. This program has been launched since few years ago, however the infrastructure to support the shifting from oil to gas engine for vehicle is still limited. This program not only to support effort on reducing oil consumption but also to encourage the utilization of clean energy which can reduce CO_2 emission.

In addition, the Government of Indonesia also would like to expand the program by introducing fuel efficient vehicles such as hybrid and electric vehicles with the long-term aim for enhancing domestic manufacturing capacities as well as increasing the utilization of clean energy.

Thailand

Thailand government considers automobile manufacturing as the basis for industry growth. Meanwhile, to cope with the environmental implications caused by the motorization, the Thai government has promoted the manufactures to produce "eco cars", of which size should be below 1,300 cc, and manufactures are required to guarantee to invest more than 5 billion baht in the eco car production and produce more than 10,000 vehicles per year.[8] Those eco cars should be fuel efficient, and do not consume over 5 liters per 100 km, and should have a minimum pollution standard of EURO4 or higher. And these eco cars should emit no more than 120 grams of carbon dioxide per km.[9] Additionally, excise tax incentives are offered by the Ministry of Finance, lowering the tax rate on eco-cars to 17% from that of standard cars between 30-50%. Aside from the measures for promoting the eco cars, recently the Thai government has introduced incentives for hybrid and electric vehicles by lowering excise tax to 10%. Besides, import duties for batteries and transmission for hybrid vehicles are waved as a means to promote their domestic production.

5. Measures for Finance

How to finance the road infrastructure, technologies for efficient vehicles deployment or to develop efficient urban transport network would be the critical element toward establishing the sustainable transport system. Although various plans

[8] Thailand, Board of Investment. BOI drives the ecocar forward. Available: http://www.boi.go.th/tir/issue_content.php?issueid=30;page=0

[9] Ibid.

and goals are formulated by the number of governments in Asia, while its implementation does not often follow due to financial difficulties.

Congestion problems are endemic in the most urban cities of Asia. Underinvestment in road infrastructure in contrast to the rapid rise in the passenger vehicle ownership and lack of alternative public transport mode is the major cause of congestion (as previously indicated). Drivers mostly can utilize roads (excluding highways) without direct charge. Meanwhile, indirectly drivers are charged for the amount of their road usage in the form of taxes on gasoline and diesel. Nevertheless, in most of the Asian countries, the implementation of gasoline tax or diesel tax face strong public opposition, and lead to provide gasoline/diesel at the affordable level to the general public, which in turn raises vehicle usage and deteriorates congestion problems.

Cost arising from the road usage involves various socio-economic elements, including congestion, maintenance, and environment. Comprehensively covering the cost of road usage through taxation may not be easily implemented, particularly in the rapidly growing countries. Meanwhile, it is important for the city planners to consider various available taxes or fees, which are listed under Avoid, including fuel tax, congestion pricing, environmental tax, vehicle registration tax, licence plate bidding and parking fee, to charge for road usage, and in turn utilized for the purpose of road construction or reallocated them to invest in developing and enhancing public transport infrastructure.

Aside from the fuel taxation, congestion pricing (or road pricing) would be the effective methods that can control the vehicle utilization as well as to raise necessary funds to be reallocated to the public transport enhancement. Singapore is a known case that has successfully been implementing the Electronic Road Pricing (ERP). Implementation of the ERP over the ears since 1998 has increased the drivers' elasticies to price changes. In other words, drivers become conscious on the change in ERP prices and change their travel pattern according to the change in ERP.[10] It is important to note that the ERP revenues are not reallocated to transport related areas. It is channelled to the government's consolidated fund. Meanwhile, cities such as Jakarta that has plan for

[10] Yap, J. 2005. *Implementing Road and Congestion Pricing Lessons from Singapore.* A paper presented at a Workshop on Implementing Sustainable Urban Travel Policies in Japan and Other Asia-Pacific Countries. Tokyo. 2-3 March, 2005.

the ERP implementation could utilize the revenues to the transport related development and maintenance.

Shanghai's implementation on the license plate bidding offers a good example that has helped lower the congestion problems and increased the city's revenues. Vehicle owners in Shanghai would have to bid for license plate at the time of registration, of which price could reach as high as 90,000 yuan ($14,480) in March, 2013. Although it is pointed out that the system is pointed out to involve inequity issue for it does not differentiate the bidders' income level. Regardless of the income level, bidders would have to pay the same price. Meanwhile, the revenues from the licence plate bidding are reallocated to the public transport improvement, which can benefit those who have no financial capacity to purchase a vehicle and need to rely on public transport.[11]

6. Implications

Policy makers and urban planners of rapidly developing Asia have the important role to handle the rising transport demand through controlling the excessive vehicle dependence. Heavy congestion results from lack of road and other public transport infrastructure to manage the rising transport demand. ASIF framework can provide a comprehensive package of measures to cope with the transport related issues, as it reinforces the measures for reducing vehicle dependence, improving vehicle efficiency and developing the public transport systems. Meanwhile, the measures listed in the ASIF framework often face public opposition. Policy makers and urban planners of rapidly developing Asia could implement the measures from the ones that can generate maximum impacts with minimum costs. Aside from such a short-term policy implementation, long-term planning for the policy implementations – which can evolve with time – is necessary. Ultimately such transport related policies and measures can benefit the urban residents greatly.

[11] Institute for Global Environmental Strategies. *Development of Environmentally Sustainable Transport Systems in Urban Areas.* Available: http://enviroscope.iges.or.jp/contents/APEIS/RISPO/spo/pdf/sp4206.pdf