ERIA Research Project Report 2012, No.29

STUDY ON ENERGY EFFICIENCY IMPROVEMENT IN THE TRANSPORT SECTOR THROUGH TRANSPORT IMPROVEMENT AND SMART COMMUNITY DEVELOPMENT IN THE URBAN AREA

Edited by
ICHIRO KUTANI

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DISCLAIMER

This report was prepared by the Working Group for the "Study on energy efficiency improvement in the transport sector through transport improvement and smart community development in the urban area" under the Economic Research Institute for ASEAN and East Asia (ERIA) Energy Project. Members of the Working Group, who represent the participating EAS region countries, discussed and agreed to utilize certain data and methodologies to assess the efficiency improvement in transport sector. These data and methodologies may differ from those normally used in each country. Therefore, the calculated result presented here should not be viewed as official national analyses of the participating countries.

FOREWORD

To cope with increasing oil demand is being regarded as one of a top policy agenda in East Asia Summit (EAS) countries since it rendering variety of concern for the country, such as deteriorate security of oil supply, exacerbates fiscal balances and worsened the air quality. This study is aims to support policy planner in EAS countries by suggesting a way how to improve efficiency of the transport sector oil demand for mitigating such concerns.

I hope this study could bring new insight for those who are involved in this issue.

Ichiro Kutani

Leader of the Working Group

June 2013

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June 2013

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List of Abbreviations and Acronyms

CNG = Compressed natural gas

CO_2 = Carbon dioxide

COE = Certificate of entitlement

EAS = East Asia Summit

ERIA = Economic Research Institute for ASEAN and East Asia

ERP = Electronic road pricing

GDP = Gross domestic product

GRP = Gross regional product

IEA = International Energy Agency

IEEJ = The Institute for Energy Economics, Japan

JICA = Japan International Cooperation Agency

IDR = Indonesian Rupiah

LTA = Land and Transport Authority

MRT = Mass Rapid Transit

MRV = Measurement, Reporting and Verification

N.A. = Not Available

NAMA = Nationally Appropriate Mitigation Actions

OECD = Organization for Economic Cooperation and Development

PPP = Purchasing Power Parity

TDM = Traffic Demand Management

WG = Working Group

EXECUTIVE SUMMARY

Energy demand of East Asia Summit (EAS) countries has been growing substantially, led mostly by energy for the power sector and transport sector. Energy for the transport sector in EAS countries is dominated by oil, of which imports have been increasing rapidly as the domestic production slows, rendering energy supply security concerns. Meanwhile, some EAS countries subsidize oil products to ensure affordable price levels for social considerations, and this exacerbates fiscal balances. In addition, motorization in the urban areas of some EAS countries has worsened the air quality because of increased combustion of low quality oil products. As these incidents prove, increases in transport oil demand have great socio-economic impacts, and the improvement in efficiency for the transport sector oil demand would be the important policy agenda across the EAS countries.

Under this background, the study was conducted to deliver the following outcomes.

1. This study analyzed the options that could control the passenger transport energy demand building on the ASIF framework. As a result, the study identified various policies and measures, including (1) avoid the use of passenger vehicles, (2) shift toward the mass rapid transits, (3) upgrades the overall efficiency of urban transport, and (4) provision of financial support.
2. The identified policies and measures could be effective when each of them is implemented individually, while more effects could be obtainable when a packaged of the identified measures is being implemented.

Policy options

Avoid	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.	・Vehicle registration fees/tax ・License plate fee ・Mandatory vehicle insurance ・Road pricing ・Parking fee
Shift	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.	・Mass rapid transit systems ・Bus rapid transit systems ・Improving feeder bus service ・Improving multi-modal transfer through comprehensive tariff structure
Improve	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.	・Fuel economy improvement, ・Alternative vehicles (electric, CNG, and fuel cell vehicles) ・Intelligent transport systems ・Incentives or regulation.
Finance	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.	・Fuel tax ・Congestion pricing ・Environmental tax ・Vehicle registration tax ・Licence plate bidding ・Parking fee

3. Other than the above listed measures, infrastructure investment, particularly on road is important to control the transport sector oil demand growth. In fact, the investment in road infrastructure could provide the short-term means that can cope with the traffic congestions, and save the oil demand. In contrast, the infrastructure investment in the alternative transport mode, such as rails and buses, could provide with the long-term measures to cope with the congestion and oil demand growth. This study has conducted a simulation exercise on the impacts of road infrastructure investment, which could be implemented within a relatively short time period, and small monetary amounts. The result shows that

the analyzed area in Kuningan of Jakarta could save about 15% of oil demand with the investment amounting to US$ 4,000.

4. Nevertheless, the simulation exercise has found that the small-scale investment for road infrastructure improvement could provide a solution only for one or two years in view of the fast increases in the number of passenger vehicles.

5. The study has found that step-by-step approach for implementing the policy measures and infrastructure improvement is necessary to cope with the urban transport issues, such as congestion, ultimately to manage the growth in oil demand.

Step 1 Immediately	Implementation of small-scale investment options as soon as possible.
Step 2 within 1-2 yr	Implementation of relatively large-scale investment options before the effect of small-scale investment is being felt.
Step 3	Implementation of fundamental ASIF measures to control traffic demand and to mitigate oil demand increase before the effect of large-scale investment is being felt.

6. How to implement the policies, measures and plans would continue to pose the important agenda. A number of cases in rapidly growing Asia show that the urban transport related infrastructure development plans were not implemented as planned due to variety of reasons. These would include, lack of governance, lack of ministerial coordination at the central government level, and lack of coordination between central and local governments. The case study on Jakarta pointed out that a number of policy recommendations have been made, while the implementation did not follow as expected. It is important to clearly identify the barriers for implementation and measures need to follow.

CHAPTER 1

Introduction

Energy demand of East Asia Summit (EAS) countries has been growing substantially, led mostly by energy for the power sector and transport sector. Energy for the transport sector in EAS countries is dominated by oil, of which imports have been increasing rapidly as the domestic production slows, rendering energy supply security concerns. Meanwhile, some EAS countries subsidize oil products to ensure affordable price levels for social considerations, and this exacerbates fiscal balances. In addition, motorization in the urban areas of some EAS countries has worsened the air quality because of increased combustion of low quality oil products. As these incidents prove, increases in transport oil demand have great socio-economic impacts, and the improvement in efficiency for the transport sector oil demand would be the important policy agenda across the EAS countries.

The growth in transport sector oil demand has been led by motorization in some EAS countries of which income level is growing rapidly. Particularly, the urban area of rapidly growing Asia represent higher income level than the country average, and their soaring passenger vehicle ownership has been causing a number of socio-economic issues, including chronic traffic congestion. In fact, the average travel speed of some urban areas of Asia represents low level, Jakarta at 15 km/hour, and Bangkok at 12 km/hour; and this in turn means the energy waste, time losses in economic activities, and worsening the air quality.

At the early stage of urbanization, developed countries experienced those issues arising from the rapid motorization, such as oil demand growth, congestion, and health impacts arising from air quality problems. It is deemed necessary for EAS countries to take on a growth pattern different from those of developed countries since the emerging Asian countries increase the presence in the global energy market. For sustainable socio-economic development, the emerging Asian countries are required to meet three objectives: enhancing energy security, improving environmental quality, and stable economic growth; and creation of "smart community" would be able to satisfy these objectives, which at conventional economic development path tend to conflict with each other.

With respect to the transport sector, smart community aims to simultaneously achieve the efficiency improvement in the transport sector and lowering environmental burden through the optimization of transport infrastructure – such as road and rail, introduction of the next generation vehicles (hybrid, PHV, and EV), and transport demand management. In other words, smart community for the transport sector could cope with various transport issues in the urban areas of Asia.

A number of studies have been implemented to consider the energy saving potential in the transport sector of Asia through the shifts towards fuel efficient vehicle units. Meanwhile, this study will utilize a simulation model which would be able to analyze the impacts of infrastructure development on the traffic flow and subsequent impacts of the overall transport sector energy efficiency improvement within the rapidly developing Asian cities. The outcomes from the study would provide new insights that would contribute to the sustainable development for the cities of EAS countries with the urban transport improvement.

1. Rationale

The rationale of this study is derived from the 17th ECTF[1] meeting held in Phnom Penh of Cambodia on 5 July 2012. In this meeting, the ERIA explained and proposed new ideas and initiatives for EAS energy cooperation, including the following:

- Strategic Usage of Coal
- Optimum Electric Power Infrastructure
- Nuclear Power Safety management, and
- Smart Urban Traffic

The participants of the ECTF Meeting exchanged views on the above proposals and agreed that it was time to consider new areas in addition to the current work streams to reflect the dynamics of energy demand and supply in the East Asian region. As such, the ECTF Meeting endorsed the proposed new areas and initiatives.

As a result, The Economic Research Institute for ASEAN and East Asia (ERIA) has formulated the Working Group for the "Study on energy efficiency improvement in the transport sector through transport improvement and smart community development in the urban area". Members from Indonesia, Japan, Philippines and Vietnam are represented in the WG with Mr. Ichiro Kutani of the Institute of Energy Economics, Japan (IEEJ) as the leader of the group.

[1] Energy Cooperation Task Force under the Energy Minister Meeting of EAS countries.

2. Objective

This study is aims to draw out policy recommendation for improving energy efficiency of transport sector in EAS countries. Firstly, the study will gather and marshal existing policy or initiatives for improving energy efficiency in a transport sector. In addition to this policy survey, the study will quantify the effect of load investment and traffic management on oil demand by using simulation model for specific city area.

3. Work Stream

The study consisted of three work streams for fiscal year 2012.

(A) Selection of Model Cities

The study will select one city among those Asian cities with large room for improvement of energy efficiency in transport sector through traffic management. As the below listed factors and availability of data for a simulation analysis being considered, Jakarta is proposed as an initial candidate of a model city for the purpose of this study.

- Population size and population density
- Income level
- The number of passenger vehicle stocks
- Traffic congestion level
- Level of infrastructure development
- Potential for cooperation from the relevant government agencies
- Potential for data collection to conduct the analysis listed in (C)

(B) Data/Information Gathering for Traffic Demand Management

Data/Information will be gathered to analyze the selected city's potential for traffic demand management. The below includes the example of data list.

- Map of the selected city representing the locations for road, rail, and buildings
- Trends in traffic demand by passenger vehicles, motor cycles, and trucks
- Plans for road and public transport infrastructure (for rails and buses) development
- Policies for traffic demand management/improvement

(C) Analysis of possibility to improve road traffic

A model will be developed to simulate traffic demand at certain area of a model city using the data/information listed in (B). Given the certain budgetary constraints, the model will be able to simulate the impacts of infrastructure development (for road, and public transport) on traffic demand (in terms of improvement in travel time improvement), savings on oil demand, and CO2 emissions reduction. Building on the simulation results, benefits/costs analysis will be conducted to understand the socio-economic impacts of traffic demand management within the selected model city.

Aside from the simulation analysis of infrastructure development on traffic demand, an analysis will be made to estimate the impacts of passenger vehicle ownership arising from various transport related tax imposition.

The study will focus to the impacts of road infrastructure development on the traffic demand, not including simulation analysis of next generation vehicle and public transport infrastructure.

4. Working Group Activities in 2012

The study has form a working group with the experts from those emerging countries of Asia that have great needs for the transport sector improvement. Experts from Indonesia were given higher contribution in terms of data/information provision, to the working group since Jakarta was selected as the model city for the study.

In 2012, the WG was held for 2 times in October 2012 and February 2013 both in Jakarta, Indonesia. In the first working group meeting, current traffic related problems / difficulties in the region. And also, methodology and conditions for simulation analysis was provided. In the second working group meeting, concentrated discussion was made on policy measure in efficiency improvement of transport sector and result of simulation analysis.

CHAPTER 2
An Overview of Urban Transport Situation in Asia

1. Introduction

Passenger vehicle ownership is soaring in Asia. Passenger vehicles can offer convenient means that can fulfil rising transport needs. Passenger vehicles can offer secure transport means, and for some people its ownership can be a status symbol too. As income of Asian increases, the cost of passenger vehicles decreases at some Asian countries and these two factors primarily assist spurring the growth in the passenger vehicle ownership in Asia. For example, China's accession to World Trade Organization (WTO) in 2001 contributed to decrease the price of imported vehicles, and Thailand's aspiration toward becoming "Detroit of Asia" has promoted to establish domestic vehicle manufacturing industry which can provide opportunities to own vehicles at lower cost. In both countries, the number of passenger vehicles expanded during the time period between 2000 and 2009. China's passenger vehicle stocks quadrupled from 7.9 million units in 2000 to 31.5 million units in 2009. Thailand's passenger vehicle stocks more than doubled from 2.0 million units in 2000 to 4.5 million units in 2009. Asia – as a whole, the number of passenger vehicle stocks increased from 90 million units in 2000 to 140 million units in 2009 constituting about 34% of incremental growth of passenger vehicle stocks in the world during this time period.[1]

What are the drivers for passenger vehicle ownership in the cities of Asia? How does passenger vehicle ownership interact with passengers' urban mass transit usage? What are the barriers and facilitators for shifting people away from passenger vehicle dependence toward less-energy intensive mode of mass transit systems? Understanding these key questions will serve as the basis for the rapidly developing cities in Asia to consider city-specific policy options that can accommodate people's desire for mobility, while the policy options can ensure energy security and sustainable development.

At the *national level*, it is widely accepted that income is a primary driver for car ownership. In fact, a study by Dargay, Gately and Sommer (2006) demonstrates that the relationship between the growth of vehicle ownership and per-capita income is highly correlated, but the level of income needs to be understood as the vehicle ownership follows a

[1] Japan Automobile Manufacture's Association. (2011). *World automobile statistics*. Tokyo.

curb similar to the S-shaped Gompertz function.[2] In other words, at the lowest income level, vehicle ownership increases relatively slowly. Then at middle-income levels (from $3,000 to $10,000), the speed of growth in vehicle ownership becomes twice as fast as that of low income level, and this rate of growth continues until passenger vehicle ownership level reaches saturation at the highest income level.

The broad relationships between income, passenger vehicle ownership and demand for public transport, including mass transit systems, are analyzed by a number of papers. Paullery and et al., (2006) outline these relationships as follows. First, an increase in income will lead to an increase in passenger vehicle ownership, depending on the level of income. Second, an increase in vehicle ownership/availability will lead to a reduction in the demand for public transport modes. Third, the sign and magnitude of demand elasticities for public transport with respect to the income will vary depending upon the income levels. Fourth, income growth is expected to increase average trip length.[3]

Nevertheless, the above discussions over the relationship between income, passenger vehicle ownership and mass transit use need to be carefully interpreted since they may not be the case in Asian cities. Other factors may interplay more important roles. Barter et al., (2003) points out that besides income level, such factors as land use characteristics, transport related policies and infrastructure development can also affect city dwellers decision on passenger vehicle ownership as well as choice of transport mode.[4]

This chapter tries to present the historical trends of the motorization, and resulting growth in the gasoline/diesel consumption of the major urban areas of Asia. The chapter also identifies the critical issues that affect the worsening congestion levels in the major cities of Asia.

2. Motorization in Asia: General Trends

To capture different growth trends in passenger vehicle ownership by city, this section provides the 7 major cities in Asia, including Bangkok, Beijing, Jakarta, Seoul, Shanghai,

[2] Dargay, J., Gately, D., and Sommer, M. (2007). Vehicle Ownership and Income Growth, Worldwide: 1960-2030. A paper presented at the USAEE North American Conference. 25 September, 2006. http://www.econ.nyu.edu/dept/courses/gately/DGS_Vehicle%20Ownership_2007.pdf

[3] Paulley, N, Balcombe, R., Mackett, R., Titheridge, H., Preston, J., Wardman, M., Shires, J., and White, P. (2006). The demand for public transport: the effects of fares, quality of service, income and car ownership. *Transport Policy.* 13, (2006) pp.295-306.

[4] Barter, P., Kenworthy, J., and Laube, F. (2003). Lessons from Asia on Sustainable Urban transport, in Low, N.P. and Gleeson, B.J. (eds.) *Making Urban Transport Sustainable* (Basingstoke UK: Palgrave-Macmillan).

Singapore and Tokyo. These cities involve diverse economic development levels, population and population density.

Table 2-1 compares population, urban land area, population density, gross regional product and per capita gross regional product of the analyzed cities. As the comparison show, the analyzed cities involve diverse group in terms of economic development, and population size. Tokyo's per capita gross regional product in 2009 represented the highest at $53,201.5 (purchasing power parity in 2005 price level), which is more than 3.8 times bigger than that of Jakarta at $ 16,738.2 in the same year. Likewise, the analyzed cities involve diverse level of population ranging from Singapore's 5.0 million at the lowest to Shanghai's 19.2 million at the highest in the same year. Somewhat the size of urban land area represents the similar level at around 600-700 km^2, excluding Beijing of which urban land area stands at the highest of 12,187.8 km^2.

Table 2-1: Comparison of Key Statistics for the 7 Analyzed Cities

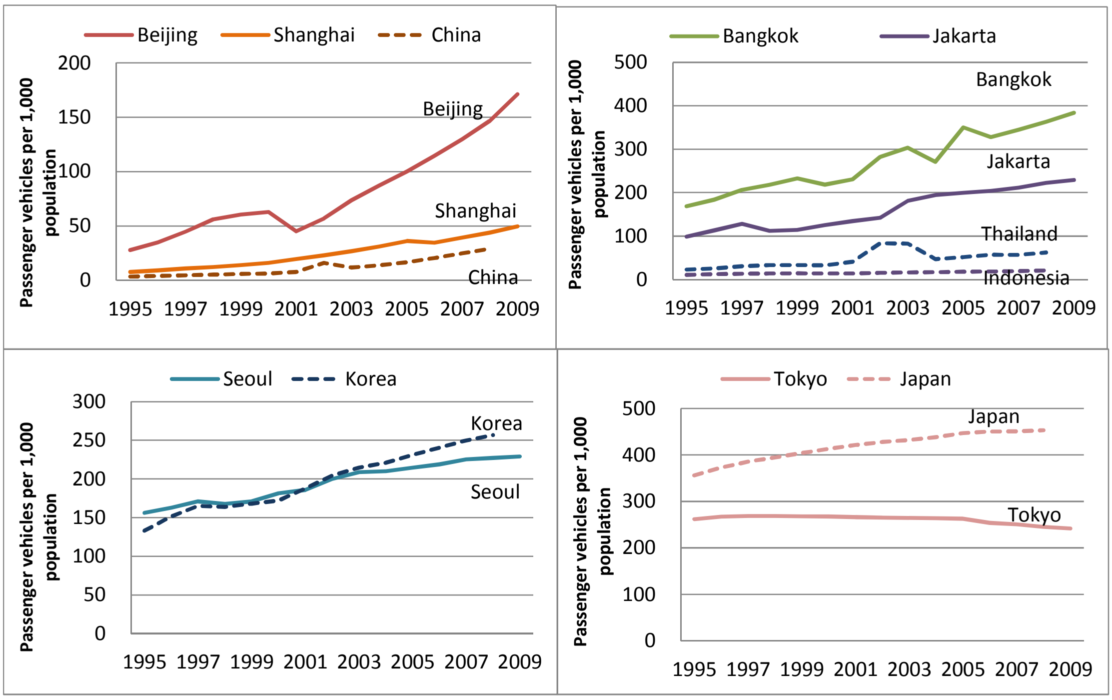
		Bangkok	Beijing	Jakarta	Seoul	Shanghai	Singapore	Tokyo
Population	millions	5.7	17.6	9.2	10.5	19.2	5.0	13.0
Urban Land Area	km^2	700.0	12,187.8	661.5	605.0	660.0	710.0	621.5
Population Density	person/km^2	8,146.6	1,440.0	13,942.6	17,296.0	29,110.9	7,024.8	20,901.4
Growth Regional Product	million US $ 2005 PPP	127,207.9	293,755.9	128,278.7	310,776.0	363,694.9	226,821.9	691,088.1
Per Capita GRP	US $ 2005 PPP	22,307.0	16,738.2	13,908.6	29,699.4	18,929.4	45,477.2	53,201.5

Source: Author's analysis from the following sources. **Bangkok**: National Statistical Office (2008). *Quarterly bulletin of statistics*. Bangkok. **Beijing**: Beijing Municipal Statistics Bureau (2010) and China Statistics Press (2011). **Jakarta**: BSP Statistics of DKI Jakarta Province (2010). **Seoul**: Seoul Metropolitan Government and National Statistical Office of Korea (2010). **Shanghai**: Shanghai Statistics (2011) and China Statistics Press (2011). **Singapore**: Department of Statistics, Singapore (2010) and Japan Automobile Manufactures Association, Inc. (2011).

Tokyo: Cabinet Office, Government of Japan (2010) and Tokyo Metropolitan Government (2009).

Among the analyzed cities, the vehicle ownership level offers different levels. Figure 2-1 compares passenger vehicle stocks per 1,000 population of the Asian cities with that of country average (Singapore is excluded from this). As the figure shows, differences can be observed between the city's per 1,000 population passenger vehicle stocks and that of country average.[5]

Figure 2-1: Passenger vehicles per 1,000 populations – comparison between cities



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5 For cities, time periods covered in this figure are between 1995 and 2009, while those of countries are between 1995 and 2008 because of data availability.

For example, China's average passenger vehicle stocks per 1,000 population reached 29 in 2008, while that of Beijing was 147 in the same year – five times bigger than the country average level. The Beijing's substantial difference from the country average results from the high income level. In 2008, Beijing's per capita Gross Regional Product (GRP), expressed in purchasing power parity (PPP), at 2005 price) was $15,800, nearly four times bigger than country's per capita GDP at $4,129.[6] By contrast, Shanghai's per capita GRP represented even higher level than that of Beijing at $15,800 in 2008, while its passenger vehicle stocks per 1,000 population was 44 in the same year, accounting for about 50% larger than China's average. The relatively low vehicle ownership level of Shanghai results from the city's policy to implement license plate bidding. Those private car owners would have to bid for license plate as an official requirement, and in 2008 the cost of number plate was nearly $10,000 (in PPP or $6,300 in exchange rate). The additional cost of vehicle ownership results in relatively low vehicle ownership in Shanghai compared with its high income level.

Similar to Beijing, passenger vehicle stocks per 1,000 population for Bangkok and Jakarta represented substantially higher level than that of country's average. Bangkok's this indicator in 2008 was 363, compared with the country's average at 62 – more than five times bigger than the country's average. Also, Jakarta's per 1,000 population passenger vehicle stocks was 222 in 2008, representing more than 10 times bigger than the Indonesia's average at 21 in the same year. Again, the higher income level (in terms of per capita GRP) of cities resulted in higher passenger vehicle stocks per 1,000 population. Bangkok's per capita GRP in 2008 was $22,238, which represents nearly four times bigger than Thailand's per capita GDP in the same year. Jakarta's per capita GRP in 2008 was $12,513, more than five times bigger than that of country's average at $2,191 in the same year.

Income of Seoul and Korea represented similar level respectively at $28,704, and $22,361 in 2008. About a quarter of total population in Korea lives in Seoul metropolitan area, and as a result of this, the income of Seoul offers the similar levels with that of Korea's country average. As a result, per 1,000 population passenger vehicle stocks in Seoul had been at a similar level to that of country's average from 1995 to 2000, but it has been surpassed by country's average from 2001 onwards. In 2008, Seoul's passenger vehicle stocks per 1,000 population was 227, compared with that of country's average at 257. Higher cost of passenger vehicle ownership in Seoul along with the recent improvement in the access to the public transport in Seoul (including buses and subways) explain the changing trends.

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[6] Prices shown in this paper were calculated with purchasing power parity basis at 2005 prices.

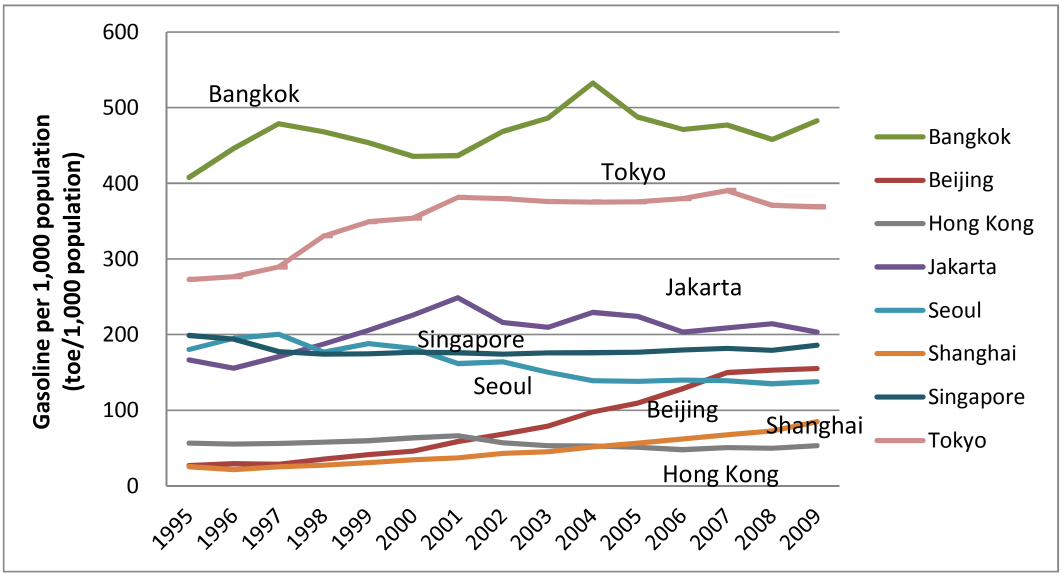
The case of Tokyo offers different trend from the rapidly developing cities. Tokyo's passenger vehicle stocks per 1,000 population has been representing lower level than that of country average for the entire analyzed period from 1995 to 2008. Per capita GRP of Tokyo in 2008 was nearly double the level of Japan's average at $55,032 (Japan's average was $28,661 in the same year). Apart from Tokyo's good access to public transport systems (including rails and subways), high cost of vehicle ownership (resulting mainly from parking and fuel costs) have resulted in lower passenger vehicle ownership per 1,000 population. By contrast, it is observed that Japan's number of passenger vehicle stocks per 1,000 population has been moderately increasing since 2000 onwards reflecting the increased numbers of small-sized vehicles.

3. General Trends in Gasoline Consumption

To allow inter-city comparisons, gasoline consumption per 1,000 population of eight cities is presented in Figure 2-1. The figure shows wide variations in terms of both levels and trends of per capita gasoline consumption. In terms of the levels, gasoline consumption per 1,000 population ranged from Hong Kong's 50 tons of oil equivalent (toe) at the lowest to Bangkok's 458 toe at the highest in 2008. In terms of trends, Beijing and Shanghai's gasoline consumption per 1,000 population has been on rising trends driven by robust economic development. Meanwhile, that of Seoul has been on a declining trend due to rising fuel prices. Other cities' gasoline consumption per capita represented similar level from 2005 onwards although differences can be observed by city.

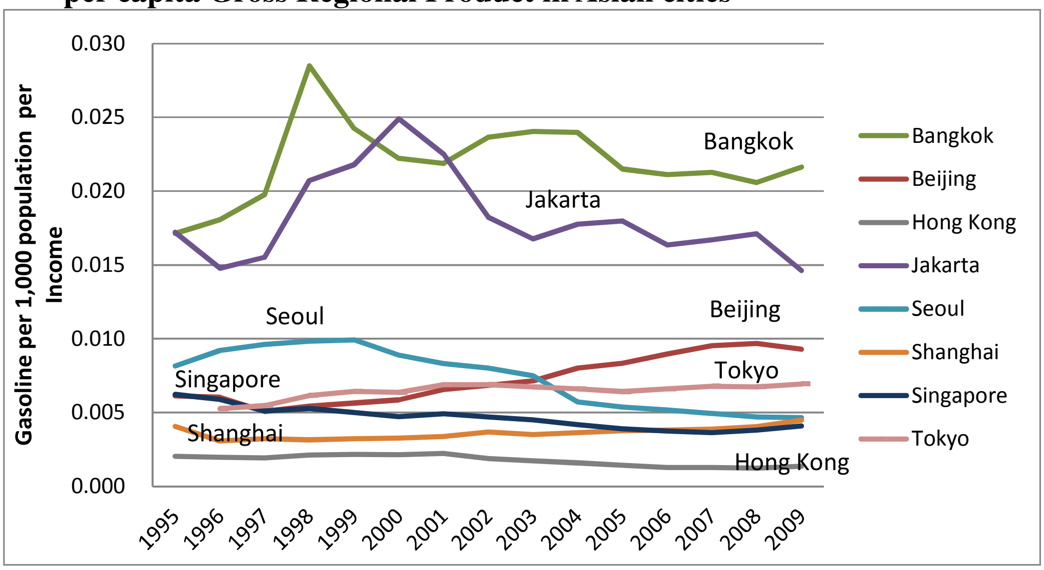
In order to further reflect differences in income level among the analyzed cities, gasoline consumption per 1,000 population was normalized by each city's income (Figure 2-2). This indicator can offer proportional size of per capita gasoline consumption relative to the size of income level. As the figure shows, wide variations exist in the historical trends of income normalized per capita gasoline consumption among eight cities. Bangkok and Jakarta represented the highest levels of this indicator although it declined from the respective peak levels in 1998 and 2000, which suggests these cities' high dependence on passenger vehicles for mobility – relative to the size of income. By contrast, Hong Kong's this indicator was the lowest level over the analyzed periods from 1995 to 2008, which suggests least dependence on passenger vehicles for meeting the mobility needs – relative to the income level. The case of Seoul offers an interesting trend that income normalized per capita gasoline consumption has been continuously declining since 1995, and the trend is accelerating in recent years from 2004. Beijing's this indicator shows an increasing trend since 2001 onwards, which coincides with the timing of China's WTO accession.

Figure 2-2: Comparisons of gasoline consumption per 1,000 populations in Asian cities



Source: Author's analysis from the following sources. **Bangkok**: Alpha Research Co., Ltd. (2010) and National Statistical Office (2008). **Beijing**: Beijing Municipal Statistics Bureau (2010) and China Statistics Press (2011). **Hong Kong**: International Energy Agency (2011) and World Bank (2010). **Jakarta**: BSP Statistics of DKI Jakarta Province (2010). **Seoul**: Korea National Oil Corporation (2011) and National Statistical Office of Korea (2010). **Shanghai**: Shanghai Statistics (2011) and China Statistics Press (2011). **Singapore**: International Energy Agency (2011) and World Bank (2010). **Tokyo**: Tokyo Metropolitan Government (2009).

Figure 2-3: Comparisons of gasoline consumption per 1,000 populations normalized by per capita Gross Regional Product in Asian cities



Source: Author's analysis from the following sources. **Bangkok**: Alpha Research Co., Ltd. (2010) and National Statistical Office (2008). **Beijing**: Beijing Municipal Statistics Bureau (2010) and

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4. Common Issues/Challenges Arising from the Motorization in Asia and Options for Overcoming the Issues/Challenges

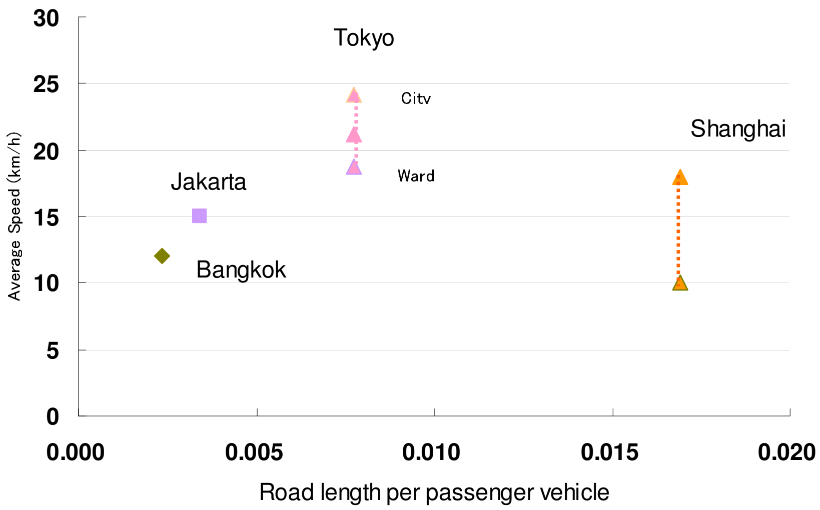
Nevertheless, increases in passenger vehicle stocks pose numerous socio-economic costs. For example, the rising vehicle ownership in turn would mean soaring demand for oil, increasing part of which supply should be secured by imports in Asia. This will pose a great burden on the economy at a time when international crude oil prices record historically high level and the high levels of international crude oil prices are likely to be maintained in future. Asia Pacific Energy Research Centre (APERC) (2009) projects that the major *net oil exporter* in Asia will become *net oil importer* through 2030 as a result of the dwindling oil production and continued increase in oil demand – driven mostly by the increase in the transport sector.[7] For example, Malaysia and Viet Nam are respectively expected to become the net oil importer sometime around 2025 and 2015. Indonesia became the net importer of oil in 2003, and the amount of oil imports will increase in future.

Also, road transport is responsible for significant share of the world CO_2 emissions. In 2008, CO_2 emissions from the road sector accounted for 20% of the world CO_2 emissions. In terms of growth trends of Asia, CO_2 emissions from the road sector grew at a faster pace (2.3% per year) than that of total world CO_2 emissions (1.8% per year) during the time period between 1990 and 2008. Asian Development Bank (2009) shows that the transport sector CO_2 emissions in Asia is projected to increase at the fastest annual rate of 2.8%, followed by the power sector at 2.6%, the residential/commercial sectors at 2.4%, and the industry sector at 1.5% between 2005 and 2030.[8]

[7] Asia Pacific Energy Research Centre – APERC. (2009). *APEC energy demand and supply outlook – the 4th edition.* Tokyo.

[8] Asian Development Bank – ADB. (2009). *Energy outlook for Asia and the Pacific.* Manila.

Figure 2-4: Average speed and road length per passenger vehicle



Source: Various sources.

Aside from the above mentioned issues on energy security and CO_2 emissions growth that rapidly developing Asian countries are facing, the major cities of Asia generally suffer chronic congestion problems caused by rapid motorization and relatively low infrastructure development for roads, and insufficient level of public transport infrastructure (for buses, urban rails and subways). The congestion problems in turn deteriorate the passenger vehicles' fuel economy as well as economic efficiency of urban areas. For example, average vehicle's travel speed in the urban core area of Jakarta is about 15 km per hour, and that of Bangkok is about 12 km per hour. The average speed travelled on major road in the city center of Shanghai during peak hours, ranged from 10 to 18 km per hour.[9] Asian Development Bank (ADB) estimates that the costs of congestion account for as much as 2-5% of GDP annually in developing Asia because of lost time and increased transport costs.[10]

[9] Shanghai Metropolitan Multi-Transport Planning Research Center. (2004). *Shanghai metropolitan transport development report.* Shanghai.

[10] Asian Development Bank – ADB. (2011). *Sustainable transport initiative, operational plan.* Asian Development Bank. Manila.

Table 2-2: Road length per passenger vehicle

	1995	2009
Bangkok	0.004	0.002
Beijing	0.034	0.007
Hong Kong	0.005	0.005
Jakarta	0.007	0.003
Seoul	0.004	0.003
Shanghai	0.060	0.017
Singapore	0.009	0.006
Tokyo	0.008	0.008

Source: Author's analysis from the following sources. **Bangkok**: Alpha Research Co., Ltd. (2010) and National Statistical Office (2008). **Beijing**: Beijing Municipal Statistics Bureau (2010) and China Statistics Press (2011). **Jakarta**: BSP Statistics of DKI Jakarta Province (2010). **Seoul**: Seoul Metropolitan Government and National Statistical Office of Korea (2010). **Shanghai**: Shanghai Statistics (2011) and China Statistics Press (2011). **Singapore**: Department of Statistics, Singapore (2010) and Japan Automobile Manufactures Association, Inc. (2011). **Tokyo**: Cabinet Office, Government of Japan (2010) and Tokyo Metropolitan Government (2009).

Not only this, air pollution arising from passenger vehicles' fuel combustion and road congestion problems affect urban dwellers' health conditions in Asia. The region's cities suffer from the highest air pollution levels in the world, and the transport sector is responsible for as much as 80% of cities' air pollutions. According to the analysis by the World Health Organization (2009), the costs of health – including respiratory ailments and other diseases from local air pollution, and resulting premature death – would cost up to 2-4% of GDP in Asia.[11]

[11] World Health Organization (2009). *Global status report on road safety. Time for action.* Geneva.

CHAPTER 3
Methods for Urban Transport Energy Efficiency Improvement in Asia

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.

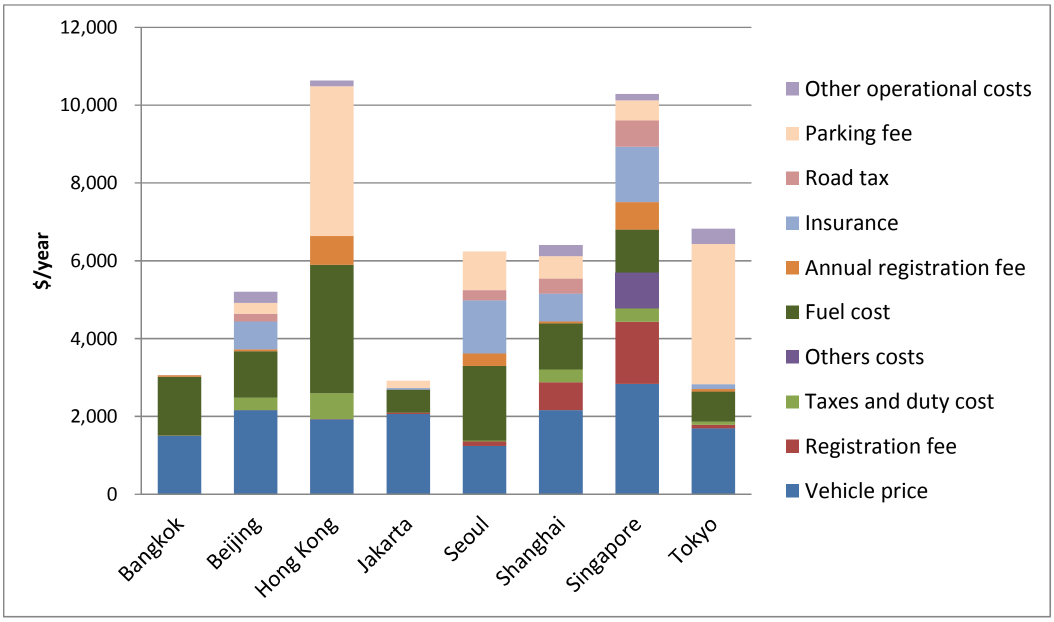
The comparison between the city's passenger vehicle stocks per 1,000 population with that of country average in the previous chapter offers that higher income level – than the country's average – is the key determinant affecting the higher vehicle ownership per 1,000 population in cities, however; it 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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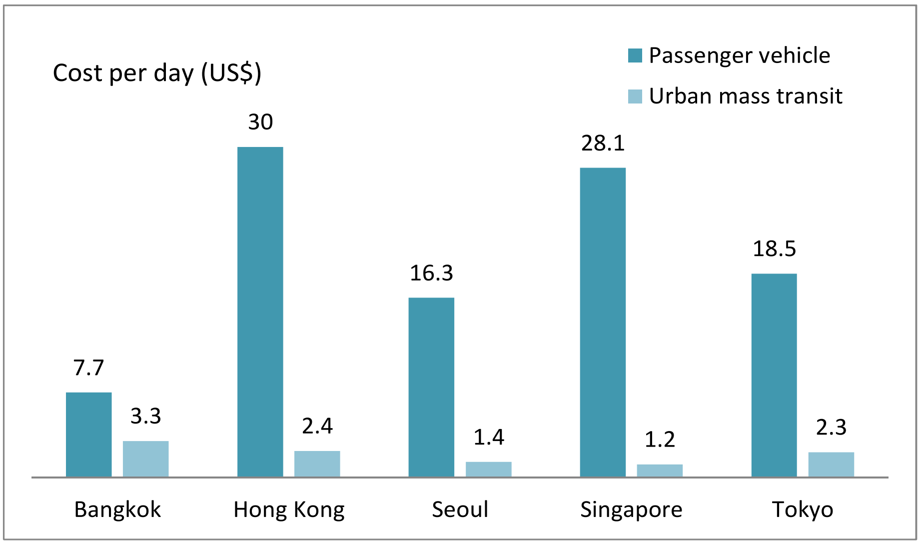
[5] Thailand's cabinet resolution 2006.

[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

CHAPTER 4

Transport Situation in Jakarta

1. Introduction

This Chapter will conduct micro approach analysis of the energy efficiency related issues in a transport sector by selecting Jakarta of Indonesia as a model city. In addition, the Chapter will select target area and provide information on traffic conditions of the area which will be utilized in a simulation analysis in the next Chapter.

The reason for selecting Jakarta of Indonesia as a model city will be explained as follows.

- Jakarta is one of a large city in the region where facing chronic traffic congestion and corresponding problems.
- Necessary date set for simulation analysis (Origin-Destination data of traffic) can be easily obtained by a support of JICA Indonesia.

For conducting such simulation, the model specification should be designed to correspond with socio-economic setting of the location, the direction of on-going policy, priority for implementing the policy and the financing capacity for potential implementing agency to test the simulation results on the ground.

To serve the information for modelling work of simulation analysis, we observed current socio-economic and urban transportation in DKI Jakarta, including the review of on-going policy initiatives in Jakarta. An exercise for setting up the priority for implementing policies in transport sector conducted by Coordinating Ministry of Economic Affair is also reported as one of consideration to specify the simulation model. Moreover, a specific observation on financial capacity for the potential implementing agency is conducted to estimate the scale of infrastructure improvement to be simulated. Then, a recommendation for the site of simulation model is provided with the description of current situation and future development plan of the influencing area.

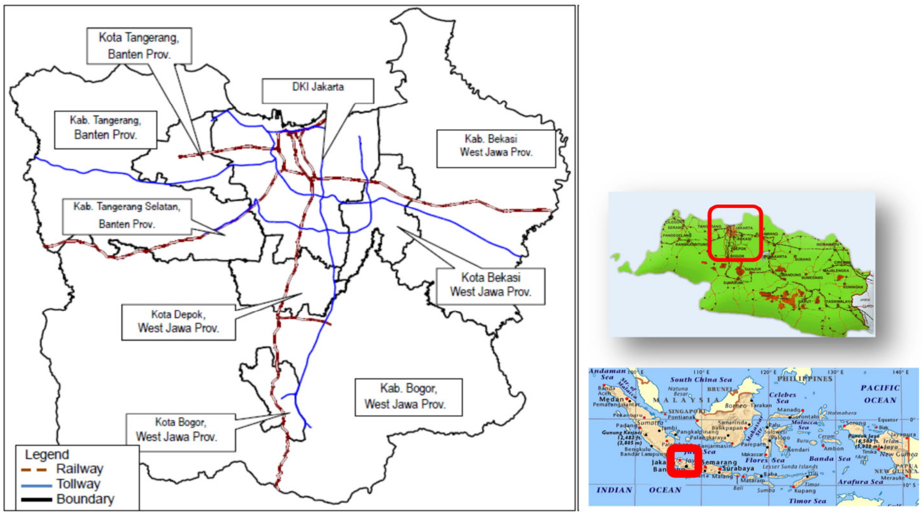
2. Socio-Economic Setting of DKI Jakarta

2.1 Land Use System

Spatial development in the Jakarta City is strongly influenced by the presence of other cities around it, namely Bogor, Depok, Tangerang, and Bekasi as the satellite cities of

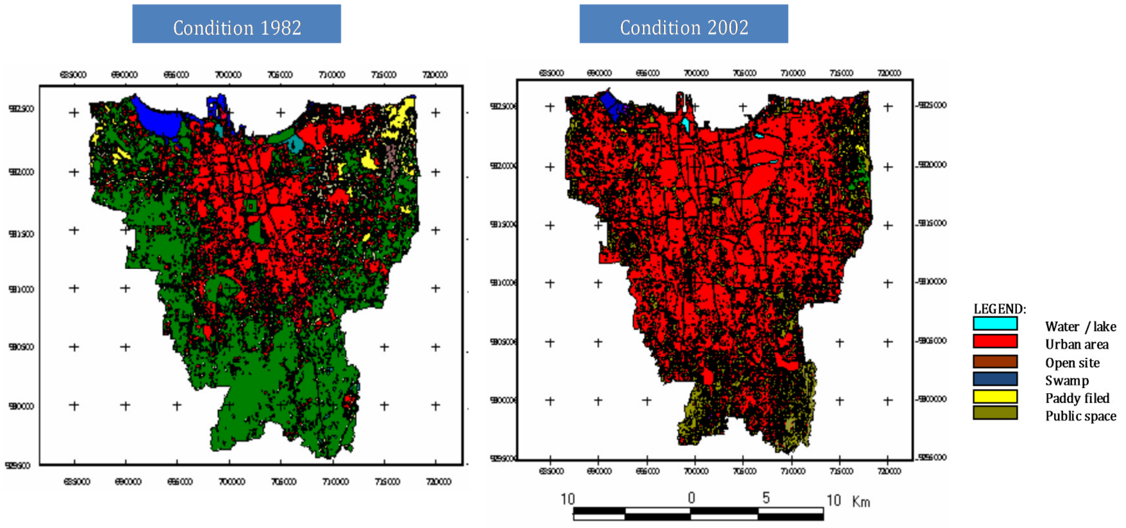
Jakarta. Social and economic interaction between the City of Jakarta and surrounding cities has created an agglomeration of Greater Jakarta region so called JABODETABEK (Jakarta, Bogor, Depok, Tangerang, Bekasi) with the complexity of social and economic issues.

Figure 4-1: Map of JABODETABEK region



The development of land use in Jakarta City shows that the urban physical development has experienced to spread wider from the center to the sub-urban areas as illustrated in the Figure 4-2. During 1983 to 2002, the housing development has been moving from the center area to the east, west, and south areas.

Figure 4-2: The Image of urban sprawl development in Jakarta region



Source: Landsat Image (2002).

From the trend of the spatial development of JABODETABEK, the location of "work force" area does not have much change where the tendency of the increased intensity remains at the center of Jakarta City. The pattern of people movement creates a commuter travel and this has given an impact on the road traffic and capacity.

The disharmonic situation of development situation between the land use development and the development of road infrastructure within the JABODETABEK has been triggered by inconsistency in the spatial development implementation. In addition, the spatial development of JABODETABEK did not experience the process of synchronization, and the inconsistency of spatial development amongst the cities surroundings the Jakarta City, especially in the suburban areas.

The above situation is reflected in the randomized people movement pattern which leads to inefficient utilization of existing transportation infrastructure. This situation has been more aggravated by the condition of the rapid growth of land use. This also happens in other cities in Indonesia in general, as shown in Table 4-1 which shows that Indonesia has rapid growth rate of urbanization and the highest level of urbanization amongst the cities within the East Asia region. [1]

[1] Cities in Transition: Urban Sector Review in an Era of Decentralization in Indonesia, East Asia Working Paper Series, Dissemination Paper No. 7, The World Bank. 2003.

Table 4-1: The growth and level of urbanization in the East Asia Region

		Urbanization Level		
		Low (<20%)	Medium (20-40%)	High (>40%)
Urbanization Rate	Rapid (>4%)	Cambodia Lao PDR		**Indonesia** Philippines
	Moderate (2-4%)		China Myanmar Vietnam	
	Slow (<2%)	Thailand		Mongolia

Source: the World Bank, 2003

The current trends, the role of the private sector in the spatial development is dominant where the growth of new activity centers does not consider the carrying capacity of existing transport networks. Based on the trend of development process seems that the development intensity is running scattered in various locations and not concentrated in the certain areas. This condition finally has formed the phenomenon of urban sprawl.

This situation creates an irregular travel patterns and with a growing motorcyle it tends to generate the motorized short trips pattern which makes less of advantageous from the aspect of mass public transportation service provision. This is possible because the existing paradigm is that the provision of transport infrastructure and service is an obligation of government but the strategic action to make it into realization is not in place. Furthermore, the government is likely to encourage the private sector to play their role without being aware of its ability to prepare and provide the sufficient transportation infrastructure in terms of both time and cost. This condition is also exacerbated by the inconsistency in the planning and implementation of policies in the border areas (sub-urban). This situation is reflected in the transportation problems such as traffic congestion.[2]

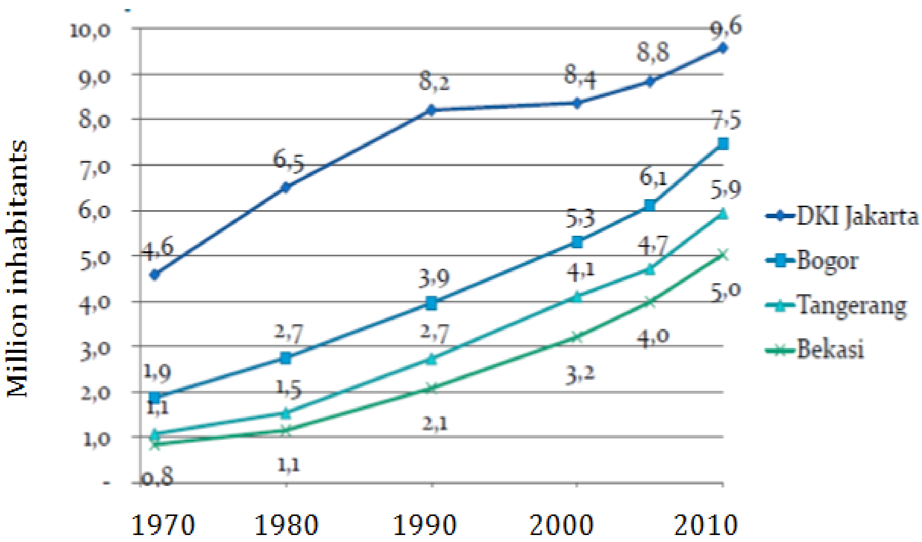
2.2 Population Growth

The growth of population in Jakarta City and its surrounding cities during the last five decades (1970-2010) can be seen in the Figure 4-3. In 2010, the number of population of DKI Jakarta Province is approximately 9.6 million. During 1970 to 2000, the population growth in DKI Jakarta Province tends to decrease from 3.5% per year (1970-1980) to 0.2% per year

[2] The Macro Transportation Concept of Jakarta, Local Transportation Agency of DKI Jakarta, 2010

(1990-2000). This figure experienced to increase again during 2000 to 2010 with the number of population growth 1.3% annually.

Figure 4-3: The population growth of JABODETABEK (1970-2010)

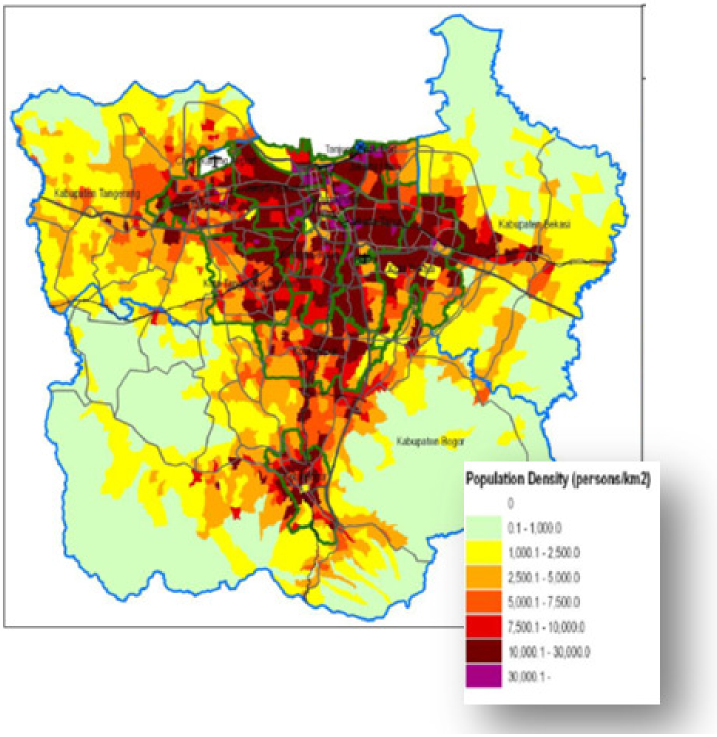


Source: Statistics Indonesia.

In the context of JABODETABEK region, number of population living in this region has reached 26.6 million inhabitants[3] or approximately 10% of the total population of Indonesia in 2010 (amounting to 237.6 million inhabitants).[4] The highest density of population in Jakarta City reaches 30 thousand people per kilometer square where generally is located in the core of Jakarta City (central and northern side).

[3] The physical mobility at Metropolitan Jakarta: Urban Spatial, Marco Kusumawijaya, 2011
[4] Trends of the Selected Socio-Economic Indicators of Indonesia, BPS, February 2012

Figure 4-4: The population density of JABODETABEK (2010)



Source: Kusumawijaya (2011).

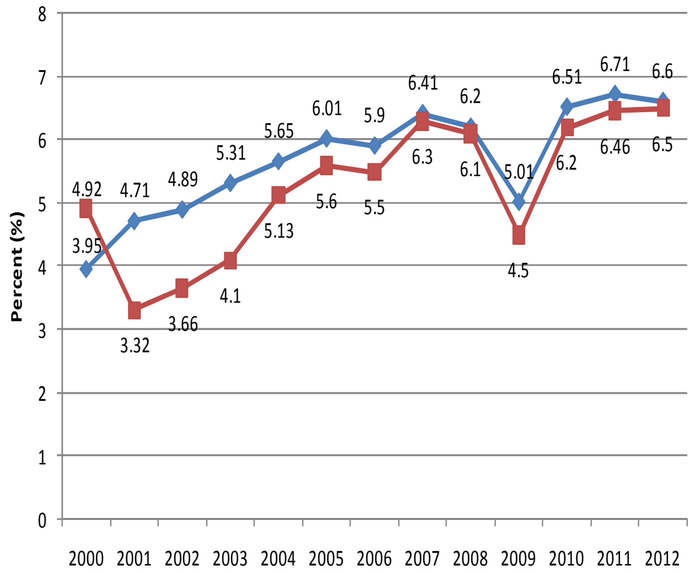
The existence of strong interaction between the City of Jakarta and its surrounding cities has created a roundtrip journey population which was estimated at 20.7 million trips per day trip[5]. The population of cities around the Jakarta City continues to increase with the similar pattern of growth during that period. The urban sprawl effect of DKI Jakarta has increased the number of population and the people mobility in the surroundings cities of Jakarta. This condition has stimulated the increase of transportation demand or needs in Jakarta.

2.3 Macro Economy Condition

The economics of DKI Jakarta Province during 2000-2012 tends to increase from year to year (see Figure 4-4). The highest increase was in 2011 with a growth rate of 6.71 %. Meanwhile, the lowest growth occurred in 2000 with a rate of 3.95 %. In the latest year, the province's economy grew by 6.6 % per year or experienced to decrease when compared to the previous year.

[5] The Macro Transportation Concept of Jakarta, Local Transportation Agency of DKI Jakarta, 2010

Figure 4-5: The economics growth of DKI Jakarta during 2000-2012 (%)



Source: Statistic Agency of DKI Jakarta Province.

In 2010, the regional GDP of DKI Jakarta Province by market price reached approximately 862 trillion IDR while by 2000 constant price which was recorded by local government statistic agency has reached around 396 trillion IDR. The condition of macro economics of DKI Jakarta Province during 2000-2010 can be seen in Table 4-2.

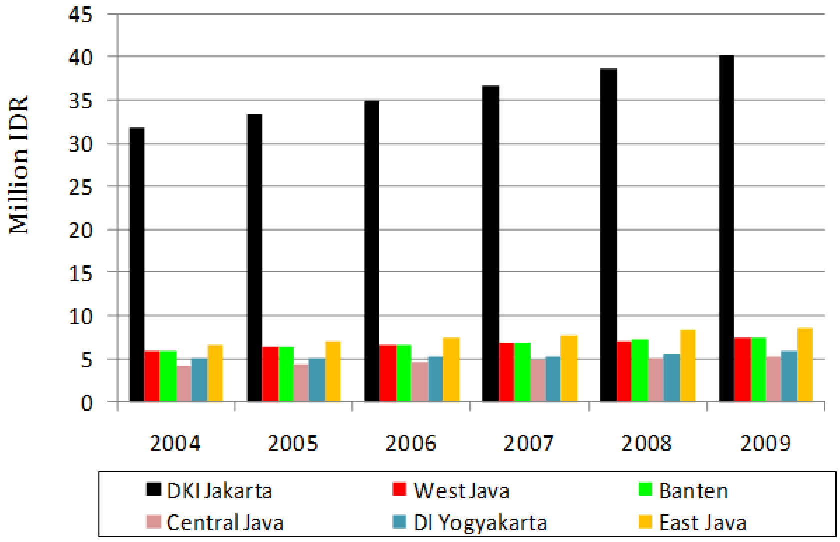
Table 4-2: The macro economics of DKI Jakarta Province during 2000-2010

Ekonomi Makro	2000	2005	2010
Regional GDP by 2000 Constant Price (trillion IDR)	228	295	396
Annual growth of Regional GDP (%)	3.95	6.01	6.51
Regional GDP by Market Price (trillion IDR)	228	436	862
Regional GDP per capita by market price (million IDR)	27	49	89
Regional GDP per capita by 2000 constant price (million IDR)	28	33	41

Source: Statistic Agency of DKI Jakarta Province.

When viewed from the level of welfare of population, the Province of DKI Jakarta has a higher level of welfare relatively compared with other provinces in Java Island. Figure 4-6 shows the level of income per capita population of Jakarta (during the period 2004-2007) was higher than the other provinces in Java Island such as West Java, Banten, Central Java, Yogyakarta and East Java Provinces. Level of welfare of the population in Jakarta City when viewed from the province's GDP per capita is in the range of 31.83 to 36.73 million IDR in the same period.

Figure 4-6: The progress of regional GDP/capita of DKI Jakarta amongst other Provincesin Java Island during 2004-2009



Source: Central Bureau of Statistics of Indonesia.

The rapid growth of transport and communication sector development in Jakarta City could not be separated from the income growth. This sector has become the main sector of Jakarta City with the most rapid growth from year to year (see Table 4-3). One of the impacts of the development of Jakarta's people income is the private vehicle ownership growth which has been growing rapidly in the last decade.

Table 4-3: The growth of regional GDP of DKI Jakarta from the real sectors during 2001-2010 (in %)

No.	Sectors	2001	2005	2010
1	Agriculture	-2.79	0.98	1.27
2	Mining and quarrying	-1.01	-7.24	-1.73
3	Manufacturing industry	3.91	5.07	3.38
4	Electricity, gas and water supply	7.1	6.95	4.44
5	Construction	2.29	5.89	7.09
6	Trade, hotel and restaurant	5.44	7.89	6.95
7	**Transport and Communication**	**14.16**	**13.26**	**14.80**
8	Finance dwelling and business service	4.19	4.1	4.12
9	Services	4.09	5.06	6.68

Source: Regional statistics of DKI Jakarta Province (2010)

Jakarta regional income structure consists of two main components i.e. revenue from local tax and balance fund from the Central Government. The amount of revenue from local tax of Jakarta City was about 81.72 % of total revenue. In the last three years (2008-2010), the acquisition tax of Jakarta City reached an average of 9.2 trillion IDR, with an increase of 6.7 % annually.[6]

3. Current Situation of Public Transportation

3.1 Trend of private vehicle ownerships and people mobility

Transportation system in Jakarta is supported by land, sea, and air transportation. As the capital of Indonesia, the development of transportation in Jakarta City is the densest among other provinces. According to the DKI Jakarta Police Office recorded that the number of motor vehicles in Jakarta is consistently increasing each year. It can be seen from the number of vehicles registered from annually. In 2011, total vehicle in Jakarta is recorded more than 13 million. Motorcycle is still dominant by number more than 9 million, followed by passenger cars (2.5 million), and the rests are trucks and buses (0.9 million).

Table 4-4: Number of motorized vehicles in DKI Jakarta Province (in unit)

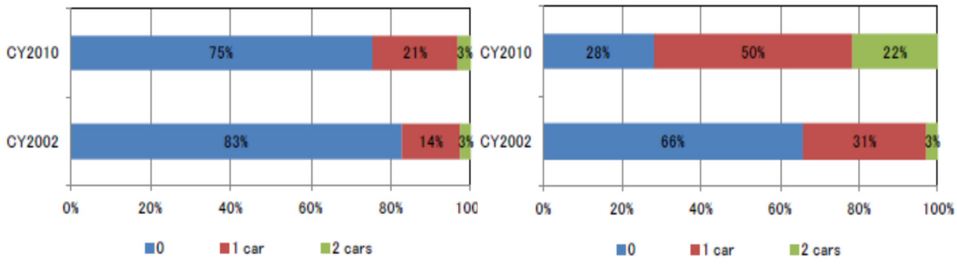
Year	Motorcycle	Passenger Cars	Trucks	Buses	Total
2001	1,813,136	1,130,496	347,433	253,648	3,544,713
2002	2,257,194	1,195,871	366,221	254,849	4,074,135
2003	3,316,900	1,529,824	464,748	315,652	5,627,124
2003	3,940,700	1,645,306	488,517	316,396	6,390,919
2005	4,647,435	1,766,801	499,581	316,502	7,230,319
2006	5,310,068	1,835,653	504,727	317,050	7,967,498
2007	5,974,173	1,916,469	518,991	318,332	8,727,965
2008	6,765,723	2,034,943	538,731	308,528	9,647,925
2009	7,518,098	2,116,282	550,924	309,385	10,494,689
2010	8,764,130	2,334,883	565,727	332,779	11,997,519
2011	9,861,451	2,541,351	581,290	363,710	13,347,802

Source: Regional statistics of DKI Jakarta Province (2012).

JUTPI (Jabodetabek Urban Transportation Policy Integration, 2010) has indicated that the rate of car ownerships around 17 % in 2002 and this figure has increased to 25 % in 2010 (see Figure 4-7). The number of motorcycle owners has been increasing rapidly. The share of motorcycle owners of all households was one third in 2002. However, it was more than 70 % in 2010. Furthermore, the number of households that have two or more motorcycles has been increasing rapidly (see Figure 4-8).

[6] Quoted from Revenue and Expenditure of DKI Jakarta Province during 2008-2010

Figure 4-7: The change of number of private cars owned by households (2002 and 2010)

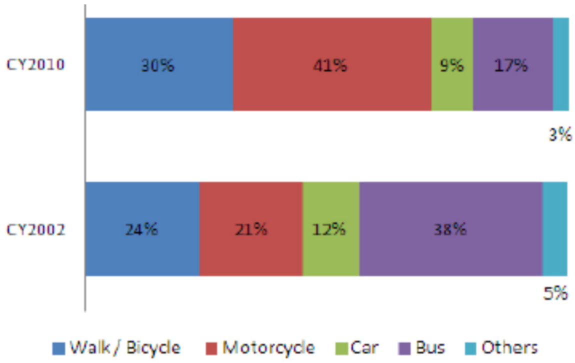


Passenger Cars Motorcycles

Source: SITRAMP, JUTPI Commuter Survey Report (2012).

According to JUTPI project (2010), based on the strong economic growth, the number of low income households has been reducing. The share of middle income households, those with a monthly household income of more than 1.5 million Rupiah and less than 6 million Rupiah, has been growing rapidly and is now more than 50 %. It seems that this condition has influenced the way people to own their private motorized vehicle.

Figure 4-8: The change of transportation mode commuting in Jakarta (2002 and 2010)



Source: SITRAMP, JUTPI Commuter Survey Report (2012).

The area and population of DKI Jakarta is almost the same as the specified districts in Tokyo Metropolitan area. The number of commuters to Jakarta has been increasing dramatically and is now 1.5 times as many as of 2002 (see Figure 4-9).

Figure 4-9: The change in number of Commuters to DKI Jakarta

Source: SITRAMP, JUTPI Commuter Survey Report (2012).

3.2 Existing condition of Road Infrastructure

According to the DKI Jakarta Province Transportation Agency, the growth of motorized vehicles over the last five years is approximately 10 % annually in average, with the growth in passenger car type vehicles per day around 240 vehicles, while for the type of motorcycle as much as 890 vehicles. Meanwhile, the growth of road development in DKI Jakarta Province is very low at 0.01 % per year. In other words we can say that the growth rate of motor vehicles in Jakarta cannot be balanced with the available space for motorized vehicles movement. The length of road in DKI Jakarta Province is amounted 6,543,997.43 meter with the status of road as follows.

Table 4-5: The length and areas of road by status in DKI Jakarta Province (2008)

Road Type	Length (m)	Areas (m2)	Road Status
Toll roads	112,960.00	2,472,680.00	National
Primary Arteri roads	112,149.00	2,140,090.00	National
Primary Collector roads	51,630.75	671,384.50	National
Secondary Arteri roads	506,415.00	8,406,014.00	Province
Secondary Collector roads	823,913.91	6,970,938.77	Province
Urban roads	4,936,928.77	20,988,103.81	Municipality
Total	**6,543,997.43**	**41,649,211.08**	

Source: Public Works Agency of DKI Jakarta Province

3.3 Congestion and Transport Energy Consumption

Traffic demand in the JABODETABEK area will be rapidly increasing from 66 million trips in 2010 to 74 million trips in 2020[7]. If there is no action taken (do-nothing), the share of public transport will be declining and the traffic situation becomes worse. Below is the illustration of Volume – Capacity ratio of daily traffic in JABODETABEK area in two scenarios: (1) do-nothing and (2) do-something/Masterplan.

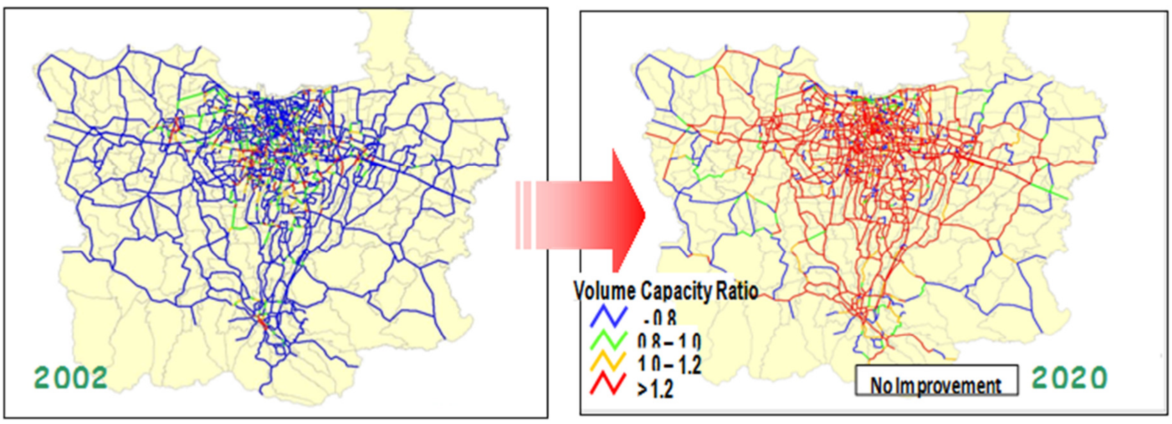
Table 4-6: The road based transportation performance in DKI Jakarta Province

Indicators		2010 (Existing)	2020 (do-nothing)	2020 (master plan /do-something)
Total travel demand (trips)		66 mio	74 mio	74 mio
Share mode	Cars	20%	28%	24%
	Motorcycles	53%	50%	42%
	Public transp	27%	22%	34%
Traffic Load	PCU-km	150 mio	210 mio	179 mio
	PCU-hours	10 mio	27 mio	15 mio
Traffic performance	V/C (daily)	0.85	1.15	0.87
	Travel speed	23.6 km/hour	15.2 km/hour	24.3 km/hour
Public transportation	Pax-km/trip	9.3 km	9.2 km	9.2 km
	Pax-hour/trip	0.41 hour	0.45 hour	0.4 hour

Source: JAPTraPis Report (2012); not included the non-motorized public transport.

The result of SITRAMP project indicates that if there is no action taken, the number of V/C ratio in JABODETABEK area is increasing becomes more that 1.2 in 2020. In this situation, the road traffic will be congested in everywhere.

Figure 4-10: The predicted V/C ratio in JABODETABEK area in 2020 (do-nothing situation)

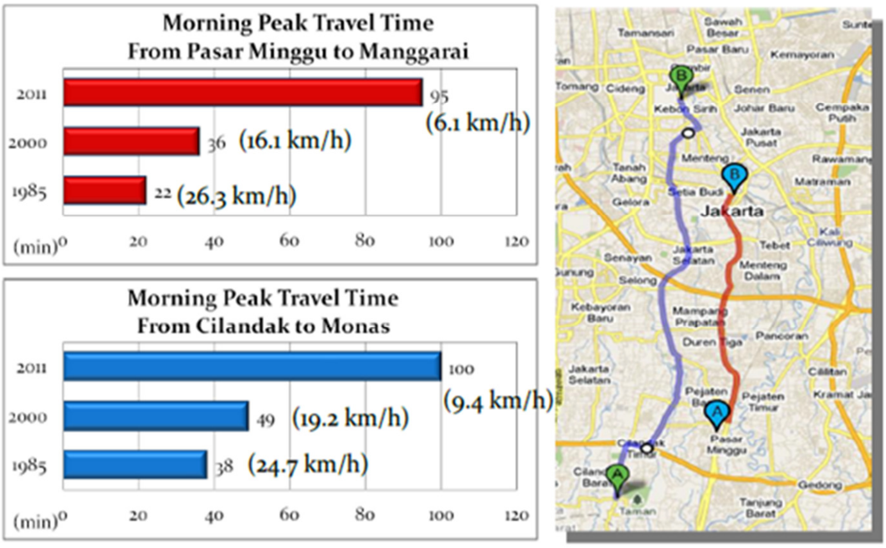


Source: SITRAMP Report.

[7] JAPTraPIS report, 2012

According to the travel speed survey conducted during the SITRAMP and JUTPI projects has indicated that in some road segments in Jakarta City area, such as Pasar Minggu – Manggarai segment showed to decrease from 16.1 km/hour (in 2000) to 6.1 km/hour (in 2011). This situation has also been experienced within Cilandak - Monas segment with the travel speed decrease from 19.2 km/hour to 9.4 km/hour (see Figure 4-11).

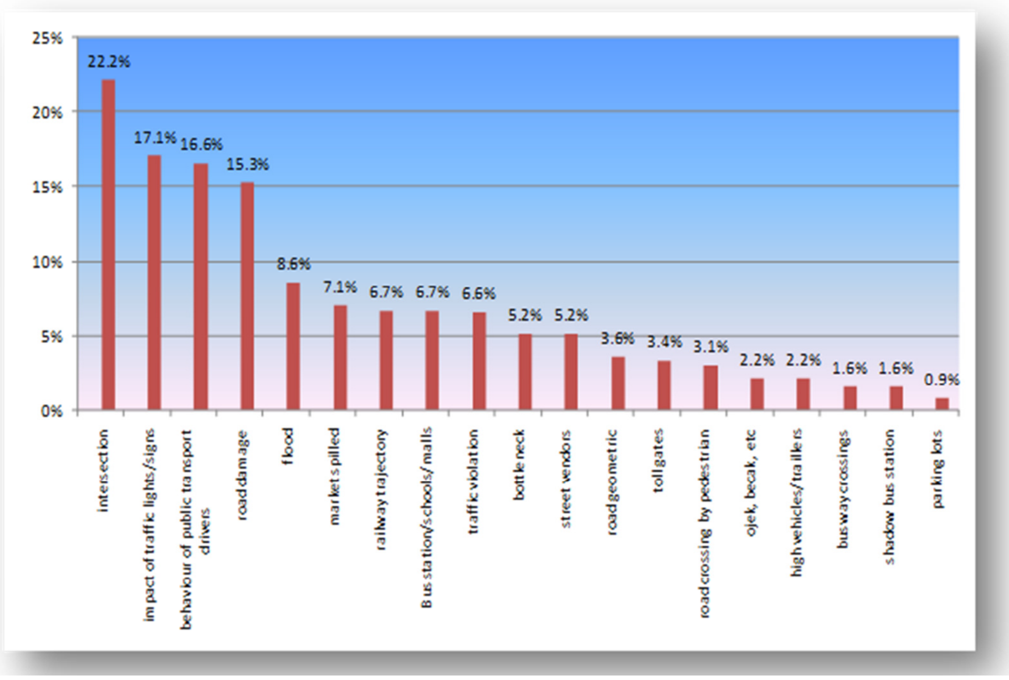
Figure 4-11: The morning peak travel time and speed in Pasar Minggu-Manggarai segment and Cilandak-Monas segment



Source: SITRAMP-travel speed survey (2000), JUTPI –travel speed survey (2011).

Currently, there are approximately 771 locations of road traffic congestion which are spread across the JABODETABEK region. According to the inventory survey conducted by National Development Planning Agency (BAPPENAS), showed that there are 20 factors cause of the congestion, among others i.e.: bottle neck, narrow roads, markets spilled, intersections/junctions, traffic lights/signs/ markers, flood, ramp toll booth, the trajectory of the railway, and the damage of roads infrastructure. The dominant factor causes the congestion is intersection/junctions.

Figure 4-12: Factors causing the congestion in JABODETABEK area



Source: BAPPENAS (2011).

As a result of road traffic congestion especially in Jakarta City, according to economic experts, it has created an inefficient transportation. Each year, the economic loss due to transportation congestion in Jakarta City was estimated approximately 46 trillion IDR, and the inefficient of fuel use was estimated at 10 trillion IDR[8].

4. Existing Policy Measures and Its Challenges

To provide a brief infomation on existing policy measure, two set of policy initiative for urban transport improvement in Jakarta is presented. First is based on the TRL report on the Case study of a transport MRV NAMA: TDM Measures in Jakarta, Indonesia. Second, a policy exercise to generate altenatives of policy option and its priority for program implementation is reported. These set of policies determine the possible consideration for directing the simulation model.

4.1 Case study of a transport MRV NAMA: TDM Measures in Jakarta, Indonesia

The Asian Development Bank (ADB) in 2012 has conducted a study that has been reported by Holger Dalkmann entitled "Applicability of Post 2012 Climate Instruments to the

[8] Online report of Local Transportation Agency of DKI Jakarta Province, 2010.

Transport Sector (CITS)" as a first step to help ensure that the transport sector can benefit from the revised/new climate change mitigation instruments under a post-2012 Climate Change Agreement. This study was conducted in order to ensure that developing cities are placed on a low-carbon growth path, and to realize the full benefits of a sustainable transport system including lower air pollution and less congestion, it is imperative that actions at the local level are fully supported by the Post-2012 climate framework centering upon the notion of Nationally Appropriate Mitigation Actions (NAMAs).

The development of NAMAs has three specific areas thought to be of central concern to the development of NAMAs, namely: (1) Measurable-reportable-verifiable/MRV methodology, (2) institutional structure, and (3) the financial framework. This case study examines all three types of NAMAs and their potential application for TDM in Jakarta through technology and infrastructure intervention as described by the following table.

Table 4-7: Potential transport NAMAs (adapted from Bongardt & Sakamoto, 2009)

	Technology	Infrastructure/Behaviour
National level	Energy efficiency policy package	Long distance Avoid and Shift policy package (freight/passenger)
Local level	Vehicle and fuel standards/requirements specific to a city/region	Support programs for local Avoid and Shift policies, e.g. urban transport plants.

In the case of DKI Jakarta, the rapid growth in transport activity is seen most prominently in the urban areas of Indonesia. It is known that the number of motorized vehicles has grown at a pace of roughly 9.5% per annum for the last 5 years, to reach roughly 5.5.million vehicles. This consists of 98% private vehicles serving 44% of all trips, and 2% of public transport vehicles serving 56% of all trips. The consequences of this rapid motorization include for example;

- Chronic congestion, particularly in the peak periods where the total cost of traffic congestion is estimated at Rp12.8 trillion per annum (approximately USD 1.4 billion) (Based on time value, fuel consumption and health costs);
- Degradation of local air quality, with air quality hotspots throughout the city;
- Large levels of noise and vibration;
- Reductions in road safety, particularly for vulnerable street users such as pedestrians and cyclists.

In an attempt to address these issues, stakeholders in the Jakarta capital region have initiated a number of measures under a so-called "Transportation Masterplan", including the three core aspects of: (i) **public transport development**; (ii) **traffic restraint**; and (iii) **network capacity improvement.**

As noted in above that Jakarta experiences severe traffic-related problems associated with the exponential growth in traffic activity. There is growing recognition by policy makers, academics and civil society alike, of the importance of TDM measures to stem these problems. This is shown by the fact that TDM has already been implemented to some extent in Jakarta, for example: (i) **the development of a network of Bus Rapid Transit/BRT** and (ii) **limiting access to a part of the central business district** (during peak hours).

In this context, a number of additional and/or improved TDM measures are gaining acceptance by local policy makers as options for implementation in the near future. These include; (i) **Electronic road pricing (ERP);** (ii) **parking restraint;** and (iii) **BRT provision.** By reducing the number of trips/distances travelled by private modes, the above three collectively contribute to the reduction of transport emissions.

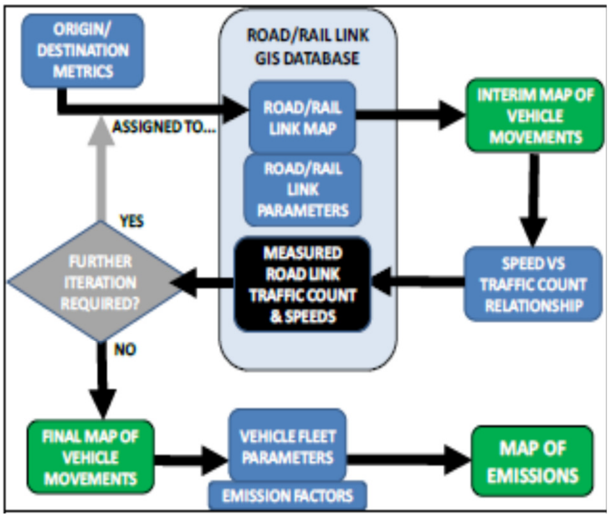
The MRV as a TDM model for Jakarta has been exercised by the University of Bandung in order to assess the impact of TDM measures in the city of Jakarta. The approach utilizes an "equilibrium flow" model which assesses the demand for travel by collating origin and destination information, and then distributing these journeys across the existing network.

The model operates with passenger kms (and tonne kms), rather than vehicle kms. Therefore, parameters such as occupancy levels, or vehicle fleet parameters (which determine fuel consumption, and therefore carbon emissions) are extremely important in subsequently calculating accurate emissions to air. The model incorporates the road transport network (with a mode resolution of cars, motorbikes, buses, and lorries). Inclusion of trams or monorail types systems are considered under the different scenarios, but may be achieved by simply adding links to the network with the appropriate properties (such as flows across the relevant network links).

Whilst the model is best suited to transport management and assessing congestion, it can also be used for estimating vehicle kilometers and emissions of both carbon and air quality pollutants (such as CO and NOx). The output of the model is provided by road link, giving a very high spatial resolution.

An overview of the model and its inputs/outputs are shown in the Figure 4-13.

Figure 4-13: A schematic Diagram of Jakarta Transport Model



Source: ADB (2012).

The key messages of MRV for Jakarta are the followings.

- MRV is crucial in ensuring the transparency of mitigation actions, to allow an accurate estimation of mitigation efforts in meeting domestic (voluntary) targets, as well as to ensure accountability of the impacts of international support received.
- The TDM NAMA could be seen as an element of a city-wide approach to measuring mitigation actions, which would enable the contribution of TDM to the meeting of mitigation targets at the city level to be explicitly made (in the case of Jakarta, 30% below BAU by 2030).
- The challenge of creating robust MRV methodology, which was seen as a barrier for transport CDM projects, remains for the design of a transport NAMA.
- The measurement of CO2 mitigation and associated co-benefits would be made possible by utilizing a bottom up methodology that combines a transport demand model (equilibrium flow model) with data on the vehicle fleet (e.g. emission factors).
- The measurement of carbon could be cross-checked using top-down methods utilizing (regional) fuel sales data, to improve the robustness.
- The lack of and poor quality of data is a major constraint in the accurate measurement of the mitigation potential (and co-benefits) of the TDM NAMA. For example, assigning traffic flows to the entire road network in Jakarta requires very extensive and detailed traffic count information, supplemented by origin and destination data.
- Capacity building in the area of data collection, database development and management is seen as a key priority in ensuring MRV of mitigation actions in the future, particularly in allowing TDM to be implemented as a tradable NAMA. Such capacity building efforts could be conducted as part of a supported NAMA, or through other means of (international) support such as Official Development Assistance.

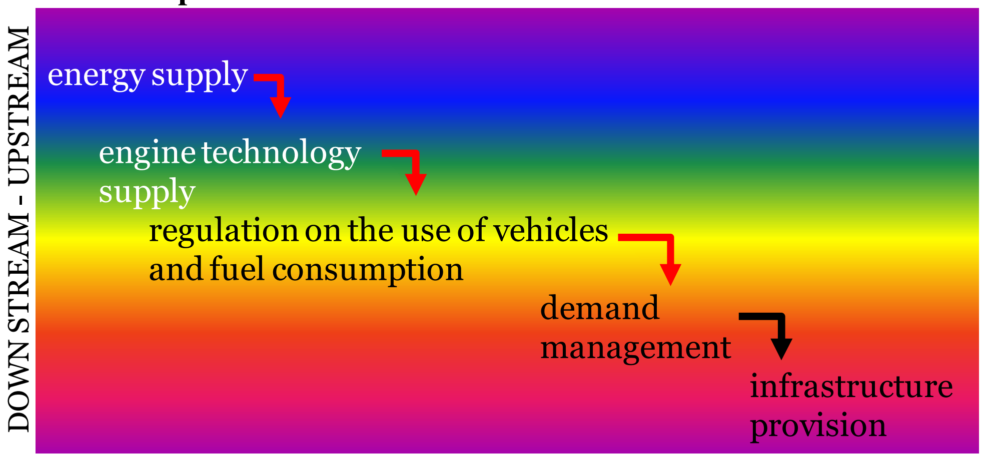
4.2. Policy exercise for transport sectors efficiency

This exercise consist of two sections, first is the introduced new framework based on a supply chain of energy to generate policy alternatives. Second the priority setting for policy and program implementation.

4.2.1. Policy framework with supply chain of energy and its relationship with transport development

One big issue on energy sectors is how transport sector respond to the changes in fuel consumption. One option to look at a variety of possible responses is to define the supply chain of energy use for transport. By knowing the supply chain, the energy efficiency efforts can be pursued. The following scheme is supply chain of energy related to the transport sector development.

Figure 4-14: The supply chain of energy and its relationship with transport development



Source: modified from Monitoring and Evaluation Team on National Transportation Policy, Coordinating Ministry of Economic Affairs (2008)

Knowledge of the each part within the supply chain of energy is used to see the cost effectiveness or value for money from a variety of policy and program interventions as described in the Table 4-8.

Table 4-8: Policy options and related programs

	Policy options	Programs
UPSTREAM	Energy supply	• Fuel security • Fuel technology
	Engine technology supply	• Fuel efficiency • Engine technology
	Regulation on the use of vehicles and fuel consumption	• Driving behaviour • Mode change • Private vehicle use
DOWNSTREAM	Demand management	• Travel needs • Rational pricing • Land and space use
	Infrastructure provision	• Infrastructure improvement • New construction

The Coordinating Ministry of Economic Affairs has formulated the policy, strategy and program for energy efficiency on transport sector that needs to further exercise based on policy option formulation as indicated in Table 4-9.

Table 4-9: Policy, Strategy and Program for Energy Efficiency on Transport Sector

OBJECTIVE	POLICY	STRATEGY	PROGRAM	TARGET
The provision of national transport that will be enabling the energy efficiency	1. Energy supply	1. Domestic energy security	1. to identify/explore new oil resources 2. to increase the strategic reservation of crude oil and its product processing 3. to increase oil production 4. to improve the access to energy 5. to improve the refinery technical capacity on oil and gas fuel supply	Short-term Mid-term Long-term Short-term Mid-term
		2. Improving the unconventional fuel technology	1. renewable energy infrastructure development 2. renewable energy use prioritizing 3. to improve the supporting renewable energy business 4. encouraging the national energy conservation and diversification 5. to formulate the priority for renewable energy development based on potential and technology, financial and social feasibility 6. to develop the alternative fuel technology (such as bio diesel, bio ethanol, gas fuel, LPG, liquid coal, hydrogen, electricity, etc.)	Mid-term Mid-term Mid-term Short-term Short-term Long-term
	2. Engine technology supply	1. Improving technology which can support engine and emission efficiency	1. to develop the motorized vehicle technology supported by alternative fuel use 2. to develop the lower capacity engine on motorized vehicle	Long-term Mid-term
		2. Environmentally-friendly engine technology supply	1. to develop the environmentally-friendly engine technology 2. to encourage the catalytic converter use	Mid-term Short-term
	3. Travel demand and fuel consumption management	1. Encouraging the driving behavior to support energy efficiency	1. to train the public transport drivers to support the energy efficiency program 2. to improve the motorized vehicle driving license	Short-term Short-term

OBJECTIVE	POLICY	STRATEGY	PROGRAM	TARGET
			standard	
		2. Providing the environmentally-friendly modal	1. to realize the emission standard for EURO 4; EURO 5 2. to encourage the Clean Development Mechanism implementation 3. to improve the motorized vehicle evaluator competency 4. to implement the private motorized vehicle test 5. to improve the number of certified and accredited public motorized service stations 6. to develop the emission test facility 7. to encourage non-motorized vehicle use	Long-term Long-term Mid-term Mid-term Short-term Mid-term Long-term
		3. Private vehicle use restriction	1. to implement the progressif tax for private vehicle 2. to implement the parking progressif charge 3. to decrease the fuel subsidy for private vehicle	Mid-term Short-tem Mid-term
		4. Motorized vehicle operational life-time restriction	1. Progressive tax for based on vehicle age	Mid-term
	4. Travel demand management	1. Encouraging the efficient travel management	1. Travel Demand Management implementation 2. public transport route integration 3. to develop integrated ticketing of urban public transport	Short-term Short-term Mid-term
		2. Encouraging rational vehicle use (rational pricing)	1. road pricing implementation 2. bus priority lane development 3. mass public transport development 4. to increase modal share of the public transport	Mid-term Mid-term Mid-term Short-term
		3. Land and space use management to create the finest build environment and to improve transport	1. Transit oriented development in big cities. 2. to create the compact and effective urban space	Long-term Long-term

OBJECTIVE	POLICY	STRATEGY	PROGRAM	TARGET
		accessibility and mobility		
	5. Infrastructure management	1. Transport infrastructure quality improvement	1. road infrastructure quality improvement	Mid-term
		2. developing new infrastructure	1. railway infrastructure development	Long-term
	6. Sustainable financing scheme for national energy efficiency program on transport sector	1. Improving the tax and retribution structure and calculation	1. to allocate the revenue from taxes for alternative fuel development and incentives for efficient fuel technology development; 2. road congestion reduction funding through retribution;	Long-term Short-term
		2. Improving the sectoral and special budget allocation	1. to increase budget allocation for research activities in the field of engine technology and alternative energy development; 2. to increase the special budget allocation for regional investment in term of transport sector development to support the energy efficiency program	Short-term Mid-term

Source: Monitoring and Evaluation Team on National Transportation Policy, Coordinating Ministry of Economic Affairs (2008)

4.2.2. Policy exercise on the implementation priority

Referring to the above scheme, the exercise to set-up priority for policy intervention of energy use in transport sector has been conducted to assess the relative important of each program to the IMPACT and CAPACITY for implementation. By this approach, the Government of Indonesia represented by Coordinating Ministry of Economic Affairs together with the other related stakeholders, has formulated the priorities and strategy to implement based on impact on fuel reduction and capacity implementation as can be seen in the following table.

Table 4-10: Priorities and strategy to implement

No	Based on **IMPACT ON Fuel Reduction**	No	Based on **CAPACITY IMPLEMENTATION**
1	Mass public transport utilization	1	Fiscal disincentive on motorized vehicle ownership
2	Shifting from fossil based fuel to CNG for public transportation vehicles	2	Mass public transport utilization
3	Vehicle retirement strategy	3	Vehicle Retirement Strategy
4	Fiscal dis-incentive on motorized vehicle ownership	4	Shifting from fossil based fuel to CNG for public transportation vehicles
5	Road pricing	5	Traffic management to improve the road capacity performance
6	The use of "greener" automotive technology and other alternative energy for motorized vehicles	6	Road pricing
7	Traffic management to improve the road capacity performance	7	The use of "greener" automotive technology and other alternative energy for motorized vehicles
8	Eco-driving implementation	8	Eco-driving implementation

The excercise is successfully generate a priority for the implementation (Table 4-10). Surprisingly, there is no policy intervention for energy supply (BLUE color) and infrastructure provision (RED color) listed. The overlooked policy options indicate that the current initiatives on those option insufficiently result in impacts on fuel reduction. On the other side, the intitutional capacity is also insufficient to implement those policies. Therefore, we learnt that it is important to pay more attention to support research activities related to the energy security issues and to enchance the capacity for investing in infrastructure program. In addition, the necessity for infrastructure improvement can be indicated from the prioritize policy option of energy technology supply (GREEN color) that actually requires the auxiliary service infrastructure networks (RED color).

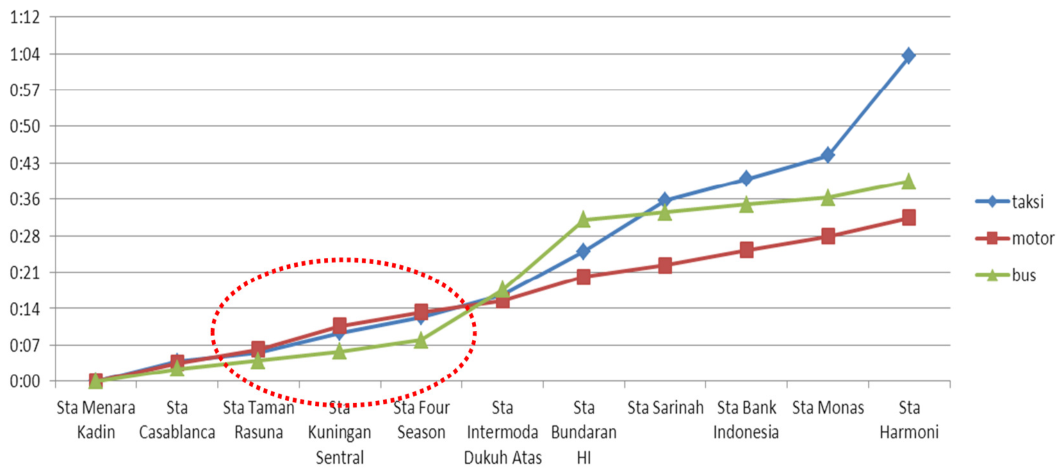
From this policy exercise, we learnt that the result of exercise is in accordance to the case study of a transport MRV NAMA which prioritize TDM program. With similar concern on infrastructure improvement, we can expect that the TDM program would significantly influence the new pattern of traffic flow, hence it needs to be supported by infrastructure improvement programs.

5. Case for simulation

5.1 Finding a critical spot of urban traffic congestion

To find the proper case study for simulation an observation on one of the main commuter corridor to the city center of Jakarta (Monas and Harmoni) has been conducted. The observation involve travel time of three types of transport mode (bus, taxi and motorcycle). The comparison of travel time, in particular motorcycle, indicate the most congested segment. At the segment where motorcyle travel time is the highest indicates that the congestion is very high and even the motorcycle that commonly easy to navigate in a dense traffic could not move. Figure 4-15 shows that the most congested segment where motorcycle as the highest travel time in comparison to taxi and bus (BRT). Hence a location in Kuningan Area is proposed for conducted simulation.

Figure 4-15: Travel speed mode comparison to find the congestion spot in a commuter corridor



Source: field survey (traffic counting), PUSTRAL-UGM (2012).

Figure 4-16 illustrates a situation in Kuningan Area where the congestion spot will be selected for simulation model. A detailed observation on road traffic situation in Kuningan Area is provided in next section to describe the condition of daily traffic situation and vehicle occupancy level on Central Kuningan, Casablanca Street, Rasuna Park, and West Kuningan .

Figure 4-16: Kuningan area, Jakarta

5.2. Traffic informatin in Kuningan Area, Jakarta

From the daily traffic data, the road traffic situation in Kuningan area can be indicated by volume of motorized vehicle as shown in Table 4-11. The highest volume of road traffic in Kuningan area is separately occurred in Rasuna Park segment with number of vehicle more than 42,500 units for each direction dominated by private motorized vehicles such as motorcycle and passenger cars. In the peak time, the number of vehicle is around 3,800 units for each direction.

Table 4-11: Volume of motorized vehicle in Kuningan area

Segment	Average Daily Traffic		Peak time	
	South-North	North-South	South-North	North-South
Central Kuningan	35,597	30,656	3,204	2,759
Rasuna Park	43,299	42,726	3,897	3,845
Casablanca street	25,332	41,137	2,280	3,702
West Kuningan	7,011	6,545	631	589

Source: field survey (traffic counting), PUSTRAL-UGM (2012).

Based on the field survey (2012), the level of vehicle occupancy that illustrates the amount of movement of passengers that pass through the Kuningan area based on occupancy rate per vehicle mode can be seen in Table 4-12.

Table 4-12: Vehicle occupancy level in Kuningan area

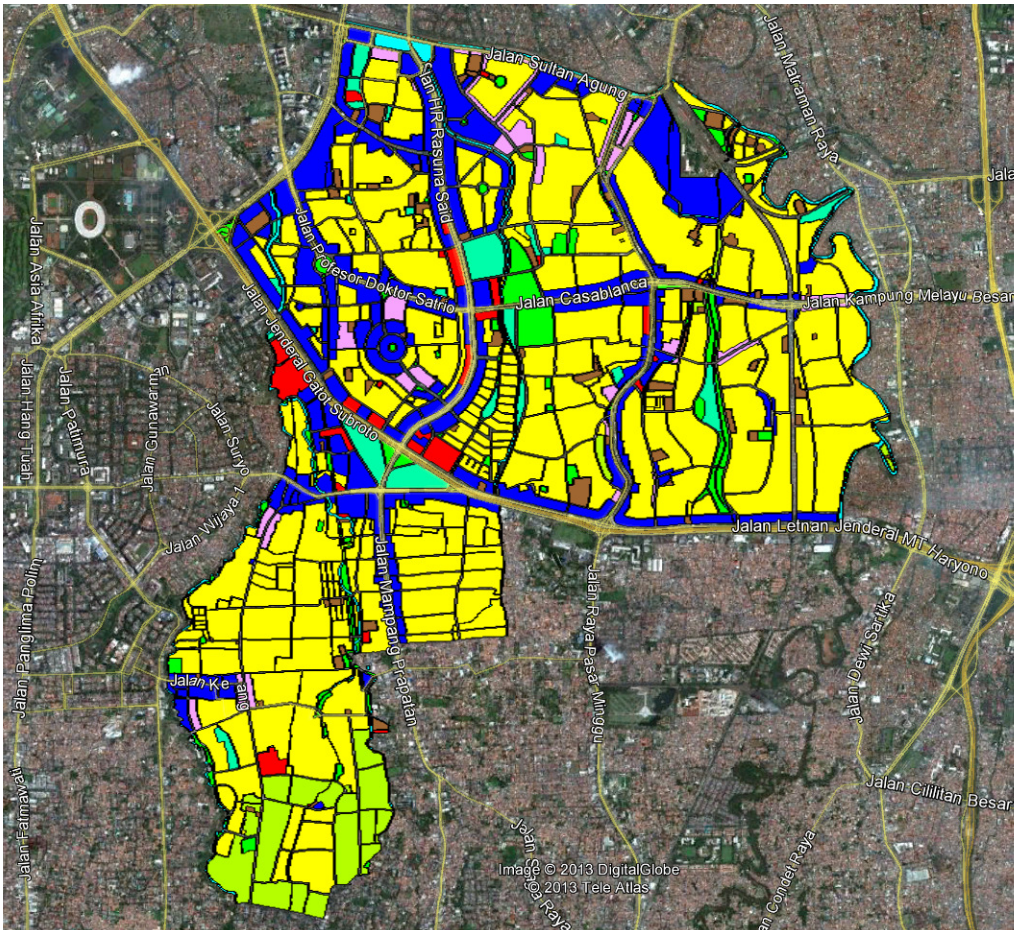
Segment	Occupancy level	
	South to North	North to South
Sta Kuningan Sentral	2,07	2,43
Sta Taman Rasuna	1,17	1,17
Sta Casablanca	1,53	1,47
Sta Kuningan Barat	1,60	1,73
Sta Mega Kuningan	1,13	1,20

Source: field survey (traffic counting), PUSTRAL-UGM (2012).

5.3. Landuse pattern and traffic flow problem in Kuningan Area

The high traffic volume in Kuningan area is caused by the condition of existing land-use system. As it is known that the Kuningan area is a dense region in central Jakarta were filled with commercial, administration, and socio-economic facilities and activities. The future Kuningan area (Figure 4-17) will be developed to establish the current pattern of high density business district development (blue, purple and red colours).

Figure 4-17: Development Plan for Kuningan area 2030 (Draft), Jakarta



Source: The Government of DKI Jakarta Province.

Kuningan as a strategic bussiness district with a highly developed activities on the both sides of the road also worstening traffic situation when the traffic from other side of the road would across the road to access the building or sites on the other side. It create a U-turn conflicted traffic that slowdown the through traffic on the main street. It is important therefore in the simulation to take into account this traffic situation.

5.4. Estimating scale of investment for the simulation

To set the case of simulation model it is important to assess the system boundary of the model. The determining factor is not only the area but also the scale of investment. For the micro-simulation traffic model, the impementation should consider the available budget of potential implementing agency (i.e Public Work and Transportation Agency). If the implementation will be considered as a pilot project for smart community development as proposed in this study, a reasonable amount of budget should be estimated to ease the introduction of new approach for finding traffic congestion solution. Hence, to get a reasonable amount of investment for piloting, the estimate will not at the level of new road infrastructure, instead for a maintainance level. Learning from the budget allocation for maintain and rehabilation of several road di DKI Jakarta in 2012, the estimate of average cost/km is Mio IDR 9,151 (~ USD 1000,000).

Table 4-13: The estimate for road maintenance cost for Jakarta (2012)

Road Segments	Cost (Mio IDR)	Length (Km)	Average Cost/Km (Mio IDR)	Average Cost/100m (Mio IDR)
S Parman, Gatot Subroto, MT Haryono	30,000	5.400	5,555	555
Cakung Cilincing, DI Panjaitan	24,500	2.439	10,045	1,004
RE Martadinata	42,800	1.930	22,176	2,217
TB Simatupang, Mayjen Sutoyo	7,028	2.618	2,684	268
Jl Link Barat	1,152	0.225	5,120	512
		Average	9,116	911

Source: Directorate General of Highway, Ministry of Public Works (2012).

The micro simulation is intended to provide a solution for certain spot i.e junction, U-turn, hence the estimate of 100 meter lenght is quite reasonable volume for piloting. Therefore, we recommend that USD 100.000 would be the maximum threshold for designing engineering solution in the simulation. With this level of investment, a quick yielding can be obtained and the new approach for addressing traffic congestion and efficient transport sector could be bought-in by the implementing agency.

CHAPTER 5
Simulation Analysis

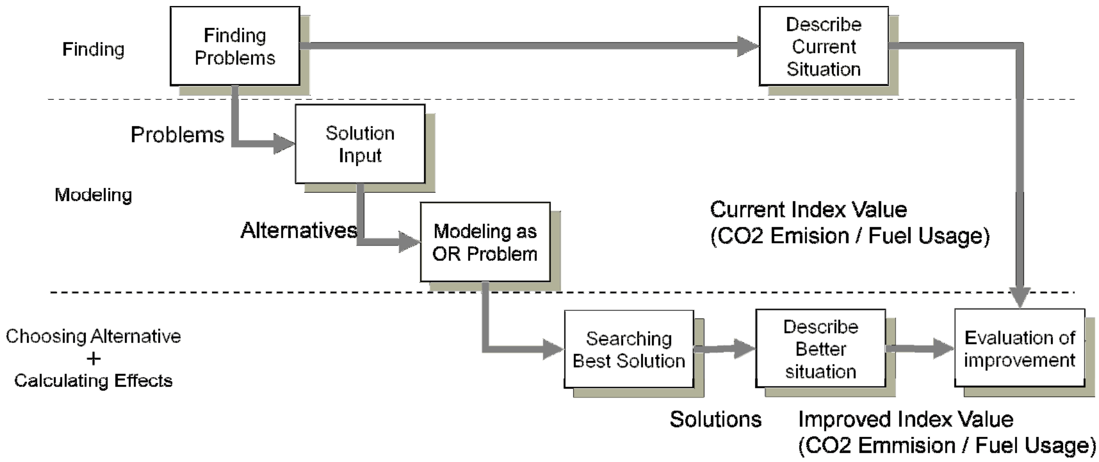
1. The Purpose of this Chapter

A number of options are available to cope with the congestion problems, which would have different impacts with different costs. Given budget limitation, city planners or national/municipal policy-makers would have to choose the options that can generate maximum impacts given the budget limitations. In other words, it is important for city planners or national/municipal policy-makers to know the impacts of each available option prior to their decision making.

This chapter tries to analyze the impacts of available infrastructure development options that can cope with traffic congestion problems, taking the Kuningan area in Jakarta of Indonesia as a model city. While caution needs to be paid in interpreting the analysis results, nevertheless, these would provide a useful basis for the other cities that share the similar road transport related problems. It is important to note that the similar analysis methods could be applied to the other cities in consideration for the location specific transport related factors.

Figure 5-1 shows the analysis method. Firstly, the traffic problems are investigated to identify the factors behind the issues. Secondly, several options to cope with the traffic problems are listed. Thirdly, the analyzed area's traffic situation is modeled as the basis and the optimal combination of solutions is calculated given certain budget limitation with the use of mathematical programming. Lastly, the effects of the selected options on the fuel consumption are estimated with the traffic simulation.

Figure 5-1: Flow of the simulation analysis



2. Target of Simulation

2.1 Traffic problem and Ideas for Improving Road Infrastructure

The analysis in this chapter focuses on the area located 2 km north from the Kuningan intersection in Jakarta city, which is shown in the blue line (Figure 5-2).

Figure 5-2: Target area for simulation analysis

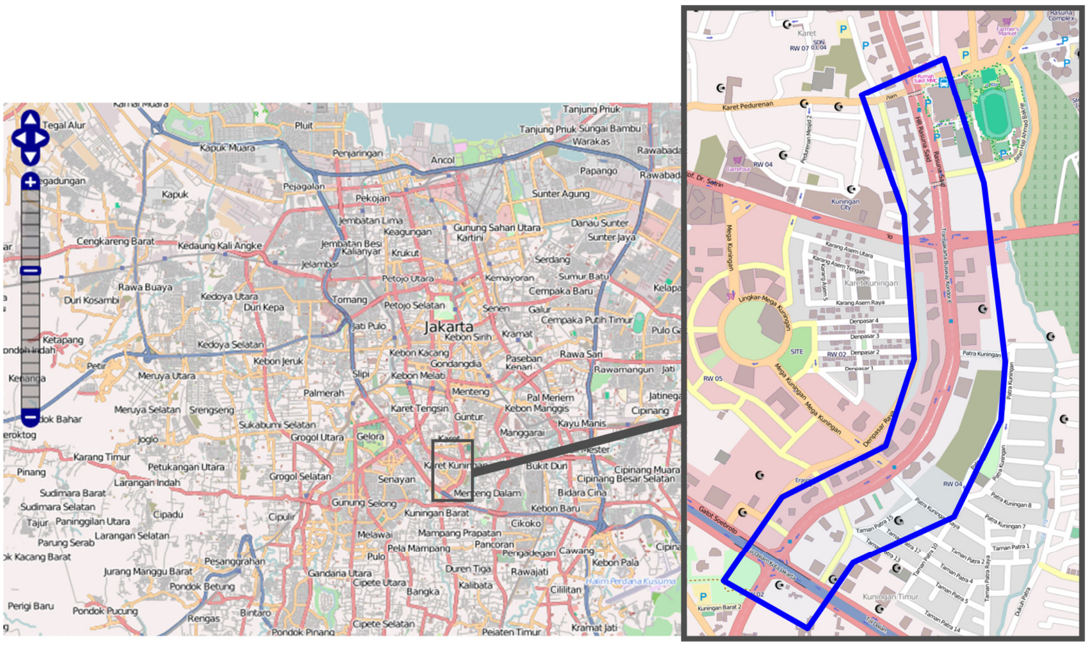
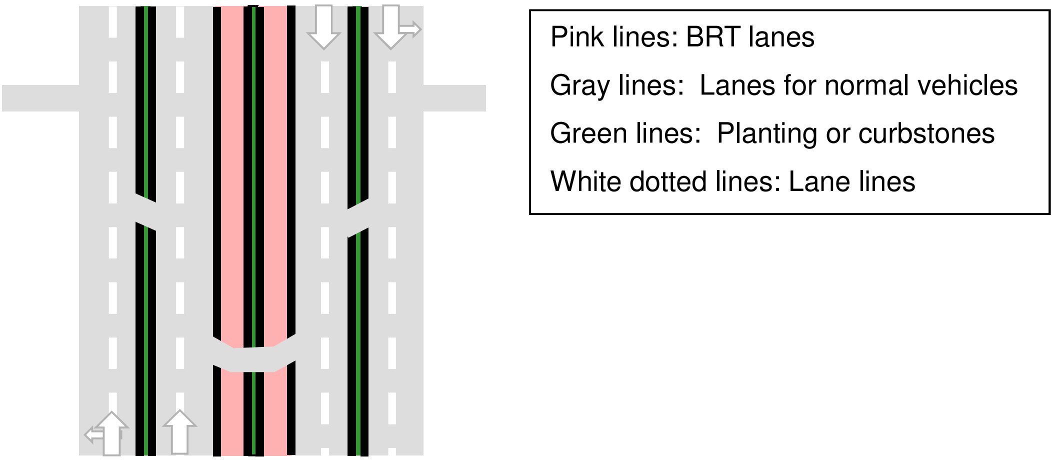


Figure 5-3 shows the road structure. Each side has the four lanes for vehicles and one BRT lane. BRT lanes are separated by planting or curbstone at the center. Basically, there is little intersection to turn right in this area. Instead, some points for making U-turn are available, where drivers can intersect with BRT through a gap of the curbstone. Also four lanes of each side are separated into two lanes by curbstones; it is possible to change lanes from inner/outer to outer/inner at the gap of curbstones. This described structure of the arterial road represents a typical one in Jakarta.

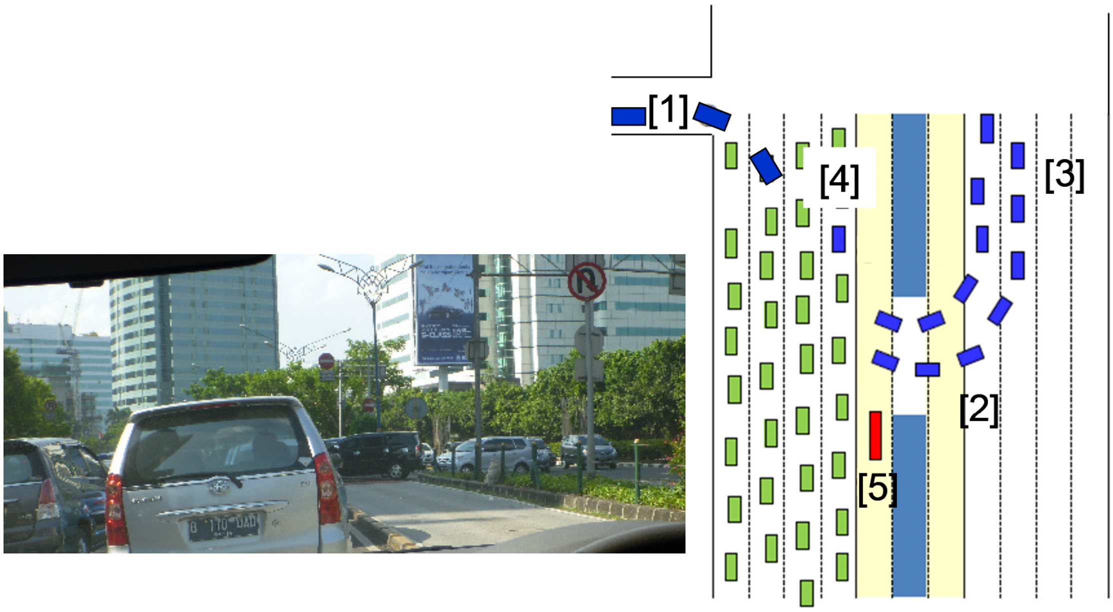
Figure 5-3: Illustration of the road structure



Traffic volume is very large in this area especially in the morning and evening rush hours. Traffic congestions are mostly attributed to the road structure. Factors affecting the road congestion can be summarized as follows (Figure 5-4):

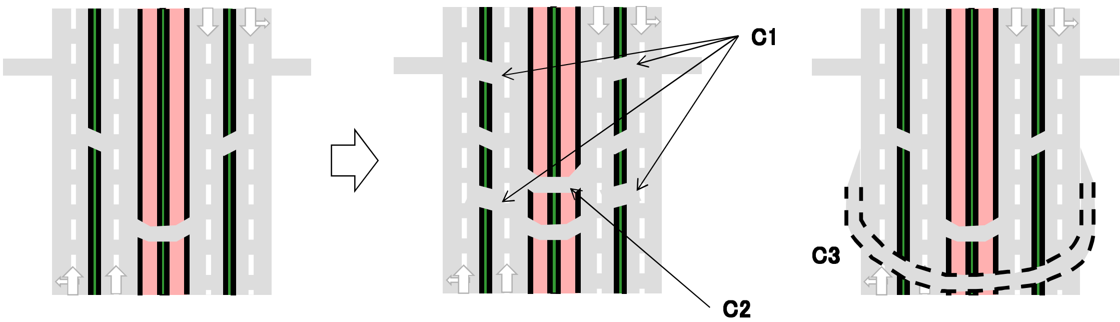
Vehicles on the way to point [1] make U-turn at point [2]. These vehicles block following vehicles around [3] and disturb the bus way at [5]. After making a U-turn, they change lanes from inner lanes to outer lanes at the point [4], which interferes with the passing vehicles.

Figure 5-4: Understanding of traffic congestion



To remove or alleviate these traffic congestions, two types of improvement options could be proposed. One is to build additional U-turn and/or lane-change points (C1 and C2 in Figure 5-5). Since traffic volume that passes through the point of U-turn and lane-change are limited, additional U-turn and lane-change points have the potential to reduce the burden of each point. The other is to construct an under/overpass (C3 in Figure 5-5). If U-turn point is altered to underpass or overpass, the interferences between vehicles making a U-turn and going straight can be reduced.

Figure 5-5. Types of improvement of road infrastructure



Construction costs of each improvement options are shown in Table 5-1, whose value is roughly estimated by PUSTRAL-UGM.

Table 5-1. Construction cost

Type of construction	Unit Cost (thousand IDR / m)	Quantity in one point	Cost per one improvement point (IDR)	Cost in Optimization Analyses / Simulation (IDR)
C1: Lane change	1,500 – 2,000	1 lane x 24m	36 – 48 million	40 million (4120 USD)
C2: U-turn	1,500 – 2,000	3 lanes x 16m	72 – 96 million	80 million (8240 USD)
C3: Under/Overpass	250,000 – 350,000	125 m	31.25 - 43.75 billion	40 billion (4.12 B USD)

10 thousand IDR = 1.03 USD
Source: PUSTRAL-UGM

2.2 Simulation Strategy

Measures for the traffic problems improvement can be classified into two types. One measure can be implemented in small scale, low cost, and short implementation period, and the other is large scale, high cost, and long period with fundamental transformations. The cost of options under/overpass (C3) is estimated to represent three thousand times larger than the cost of lane-change (C1) and U-turn (C2). Other options in even larger scale are traffic demand management such as modal shifts mass rapid transits discussed in Chapter 3.

Table 5-2 shows the combination of options to ease the traffic problems in Jakarta. Case A represents the small-scale investment options that combines the lane-changes (C1) and U-turns (C2). In this case, the best improvement plans are selected from several lane-cahnges and U-turns by mathematical programming and the effect of the plans are simulated. The budget varies from 40 million IDR to 720 million IDR. Case B is a relatively large-scale investment option on under/overpass (C3), which is combined with the lane-changes (C1). In this case, construction of one under/overpass is simulated to examine its effect, since it is difficult to construct several under/overpasses. The budget is 40 billion IDR. Lastly, combination of Case A, B and large traffic volume options of traffic management such as modal shift is discussed.

Table 5-2: Case setting

	Budget	Available Options		
		Lane change	U-turn	Under/overpass
Case A (small scale)	40 -720 million IDR	Yes	Yes	No
Case B (relatively large scale)	40 billion IDR	Yes	No	Yes

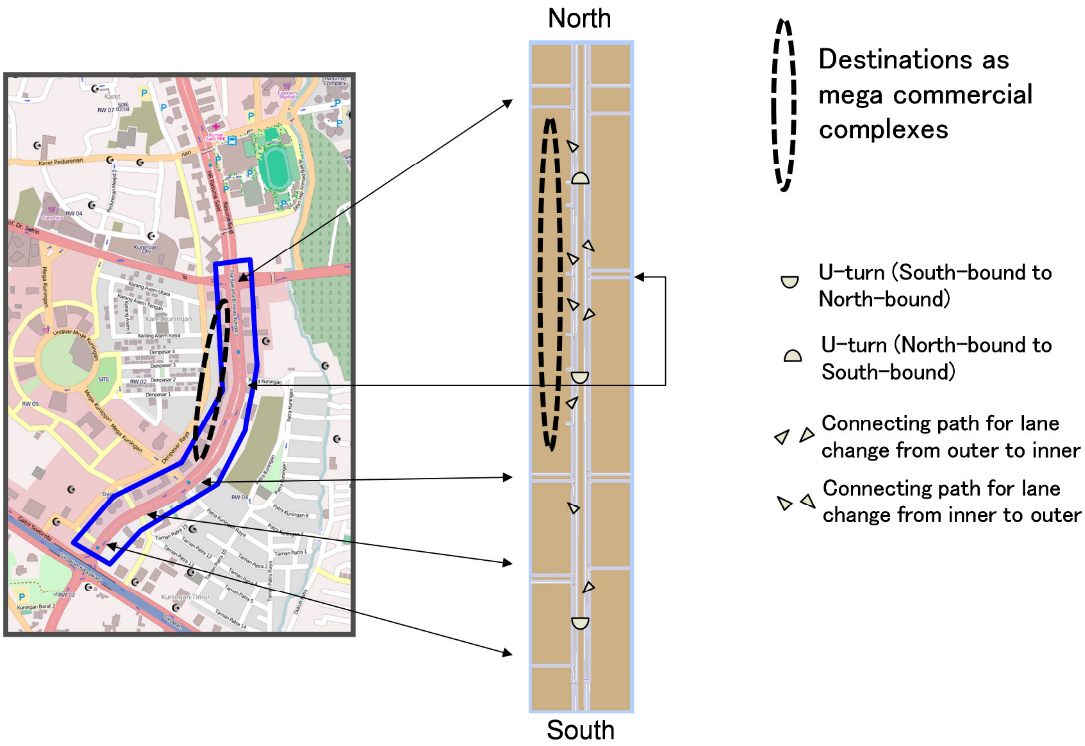
3. Traffic Simulation of Current Situation

Before simulation analysis of Case A and B, the ability to simulate current traffic situation is verified by comparing the simulated results with observed data. If the simulation results duplicate the observed data, the effect of improvement can also be estimated with accuracy.

The simulator used for this chapter is a microscopic traffic simulator, MATES (Fujii and Yoshimura 2010). Since microscopic simulator calculates the detailed action of each vehicle, the amount of gasoline consumption can be calculated accurately.

The road network in the area is modelled as shown in Figure 5-6. On the left side of the straight arterial road, some commercial mega complexes are located. Some vehicles utilize this road as they go to these mega complexes.

Figure 5-6. Model of road network



The traffic volume, which goes straight, is estimated roughly as 3,600 vehicles/h in both directions from Table 5-3. This is referred in the Sec 3.1.2-4 and 3.4.2 of "Preparatory Survey for Metropolitan Arterial Road Improvement Project, March 2012". Hereinafter traffic flow going straight is referred as the background traffic flow.

Table 5-3: Observed traffic volume at Kuningan intersection

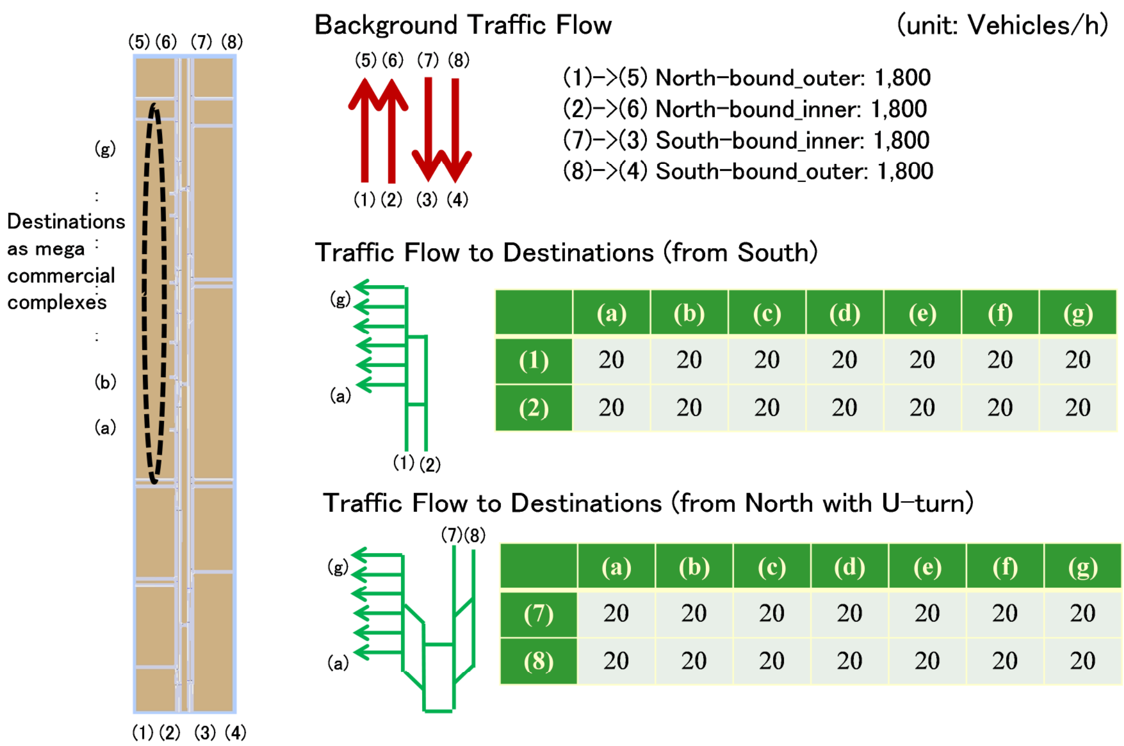
	Traffic volume for 16 hours in cross-section [vehicle number]	Averaged travel speed (evening) [km/h]	Length of traffic jam (evening) [m]	Signal cycle (evening) [sec]
north ⇒south	37,545	9.0	380	219 (We observed that signal shows "go" sign to north-south flow for 1/3 of the total period and to east-west flow for 2/3 of the total)
South ⇒north	57,873	12.5	240	

Average:
2,300 num/hour
3,600 num/hour

Source: Preparatory Survey for Metropolitan Arterial Road Improvement Project, March 2012.

Because no traffic volume for going to the mega commercial complexes was obtained, it is estimated that 40 vehicles/h going to seven entrance gates each from south and north. The summary of Origin-Destination input data are shown in Figure 5-7.

Figure 5-7: Input of OD data



	(a)	(b)	(c)	(d)	(e)	(f)	(g)
(1)	20	20	20	20	20	20	20
(2)	20	20	20	20	20	20	20

	(a)	(b)	(c)	(d)	(e)	(f)	(g)
(7)	20	20	20	20	20	20	20
(8)	20	20	20	20	20	20	20

Simulation results on the above condition are shown in Table 5-4. The traffic volumes in the cross section are about 3000 vehicles/h. These are lower than the observed traffic volume, but are considered to be acceptable. Average travel time in this area is consistent with the observed data.

The simulated traffic situation is consistent with the above stated observed situation. Thus, it is confirmed that developed traffic model can be utilized for the real traffic situation although traffic volume going to the mega commercial complexes remains unknown.

Table 5-4: Simulation result and observed data

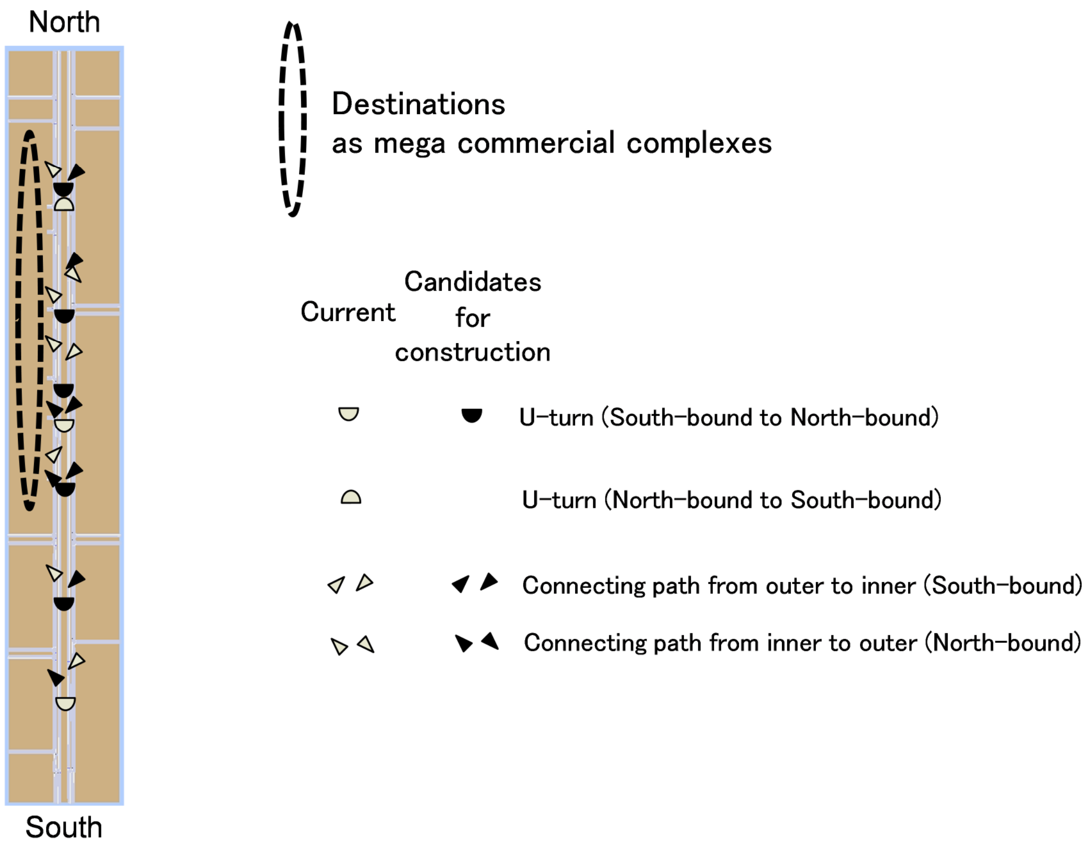
	Simulated value	Measured / Target value	Evaluation
Outgoing Flow: North-bound at north end	2,950 /h	3,600 /h	Acceptable
Outgoing Flow: South-bound at Kuningan	2,713 /h	3,000 /h	OK
Length of South-bound Traffic Jam	300-500 m	380 m	OK
Traveling Time from north end to Kuningan (South-bound, inner lane)	5-10 min	10min	OK

4. Case A: Small-scale Improvements (U-turn and Lane-Change)

4.1 Modelling

Locations of the candidate U-turns and lane-changes are decided as follows. Vehicles making a U-turn in the current traffic situation are the vehicles travelling to commercial mega complexes from north end, therefore, five new U-turn points from southward to northward are listed as candidates. New U-turn points are placed not to overlap the BRT stations. Then, for the vehicles on the way to the U-turn points, five new points of lane-change from outer lanes to inner lanes are listed at southward road. For the vehicles after making a U-turn, three new points of lane-change from inner lanes to outer lanes are listed on the northward road, which enables vehicles to enter the gate of mega commercial complexes (Figure 5-8).

Figure 5-8. Candidates for construction



Calculation flow to select optimal combination of candidate of U-turns and lane-changes under the limit of budget is shown in Figure 5-9. If road network, traffic demand, construction cost, and budget of the current traffic are input to a solver (GUROBI OPTIMIZER are used in this chapter), then optimal solution, that is, optimal combination of U-turn and lane change points could be derived as the outputs. The meaning of "optimal" is defined as the minimized total travel time. The purpose of this chapter is to reduce fuel consumption, therefore, optimal solution should be defined as to minimize the total gasoline consumption. However it is difficult to formulate total gasoline consumption compared to total travel time. This is because that travel time depends only on the vehicle speed, but gasoline consumption depends not only on speed but also acceleration and deceleration. Thus, after solving the problem of minimizing total travel time, gasoline consumption is simulated by microscopic traffic simulation.

To calculate travel time, it is necessary to develop an interference model between vehicles going straight and vehicles making a lane-change at a lane change point. An interference model is formulated by simulation changing traffic volume little by little (Figure 5-10).

Budget is set to be changed little by little from 40,000 thousand IDR which equals to the construction cost of a lane change point, to 720,000 thousand IDR, which equals to the construction cost of all candidates of U-turn and lane change points.

Figure 5-9: Calculation flow to select optimal improvement plan

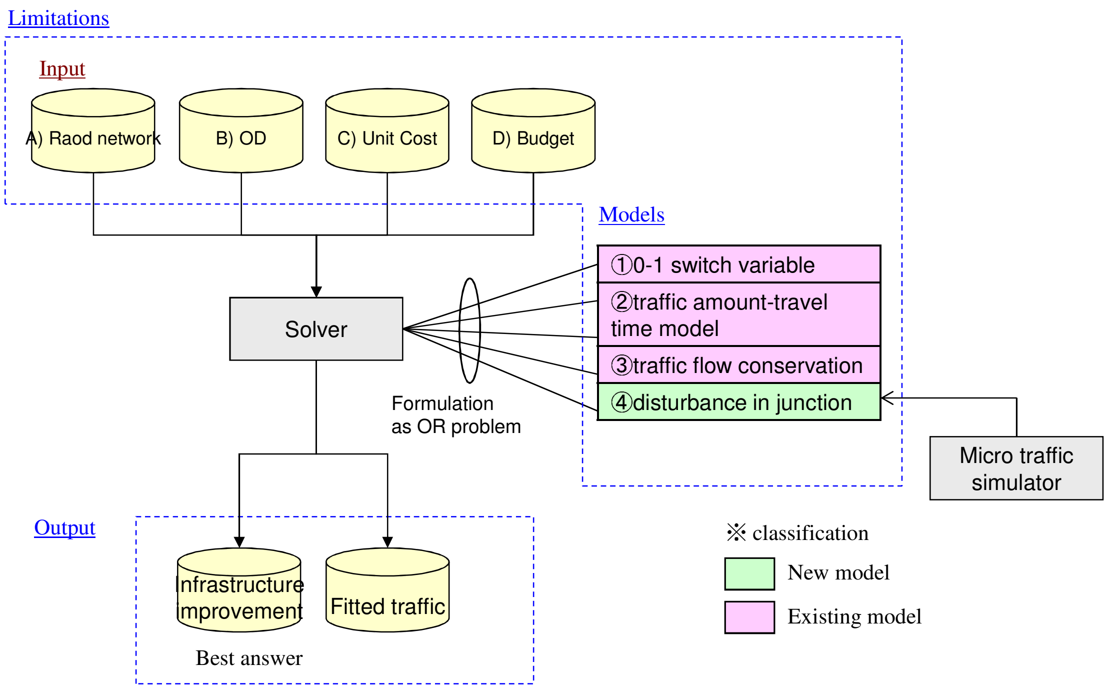
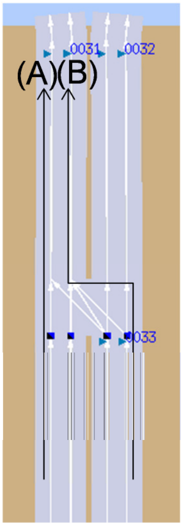
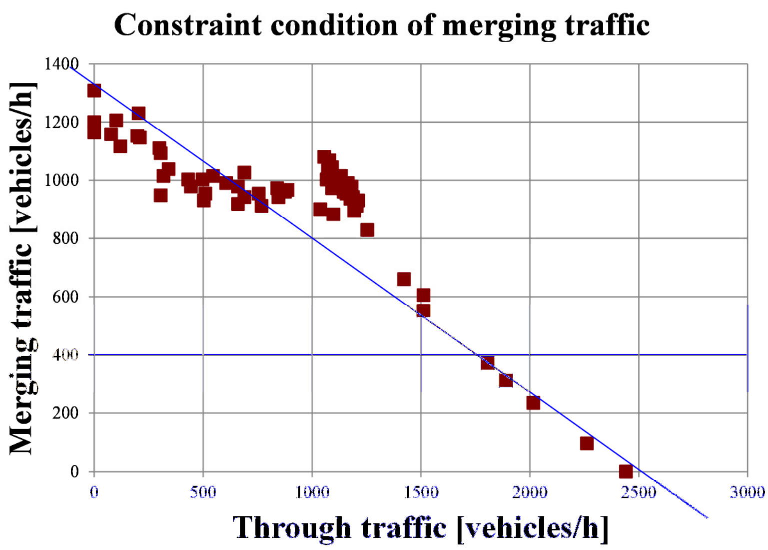


Figure 5-10: Interference model at lane change point

Flow volume of merging vehicles(B)
+ 0.56 Flow volume of through vehicles(A) ≦ 1350





4.2 Result: Reduction of total trip time

The optimization results are shown in both total travel time (Figure 5-11) and selected combination of U-turn and lane change points (Figure 5-12). As shown in Figure 5-11, the budget increases, the total travel time is shortened. This means that adding U-turns and lane-change make the traffic flow smooth and reduce travel time of vehicles passing through the area. The total travel time is shortened by up to 2% of the original travel time. Figure 5-12 shows that most effective U-turn candidates are the southernmost one, and the most effective lane-change candidate is the second southern one.

It is important to note that the length of travel time decreases in proportion to the amount of budget for improvement. Nevertheless, the improvement effect is not expected even though additional investments – above 400 million IDR – are made. That is, improvement with budget over 400 million IDR is not worthy of investment from cost-effectiveness. This shows that the minimum investment is adding 4 U-turns and 2 lane-changes (=400 million IDR) to distribute the current traffic load. This is why it is important to assess cost-effectiveness of infrastructure improvement. For the assessment, quantitative simulation analysis in this study is useful.

Figure 5-11: Reduction of total trip time

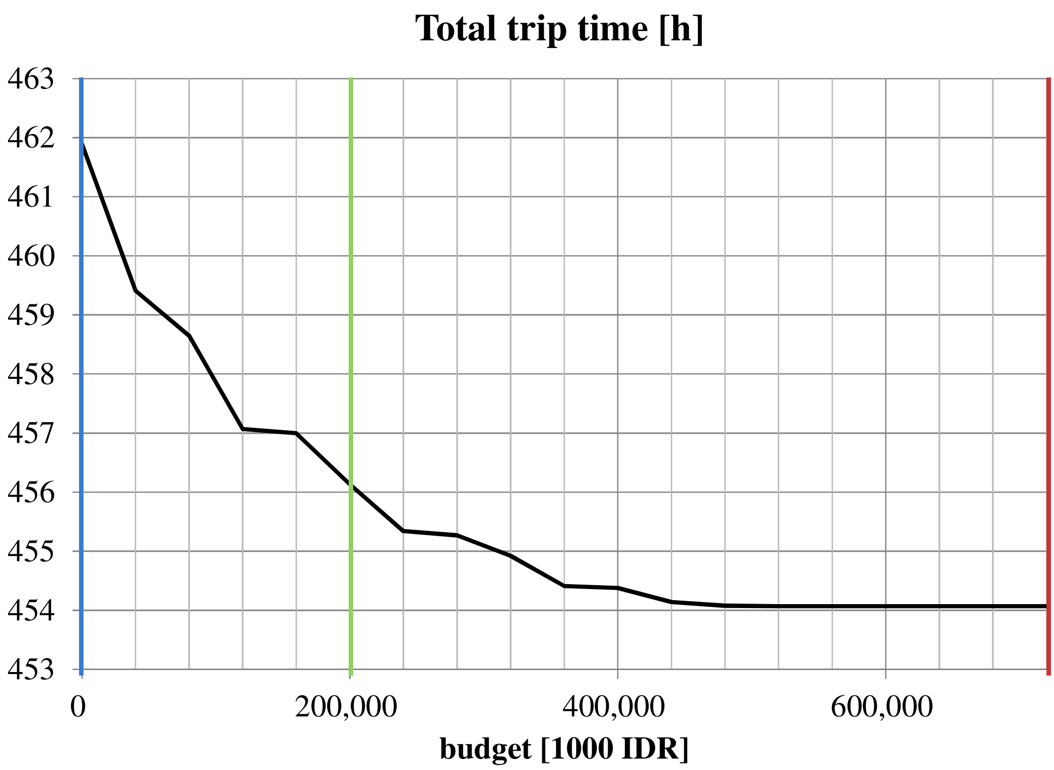
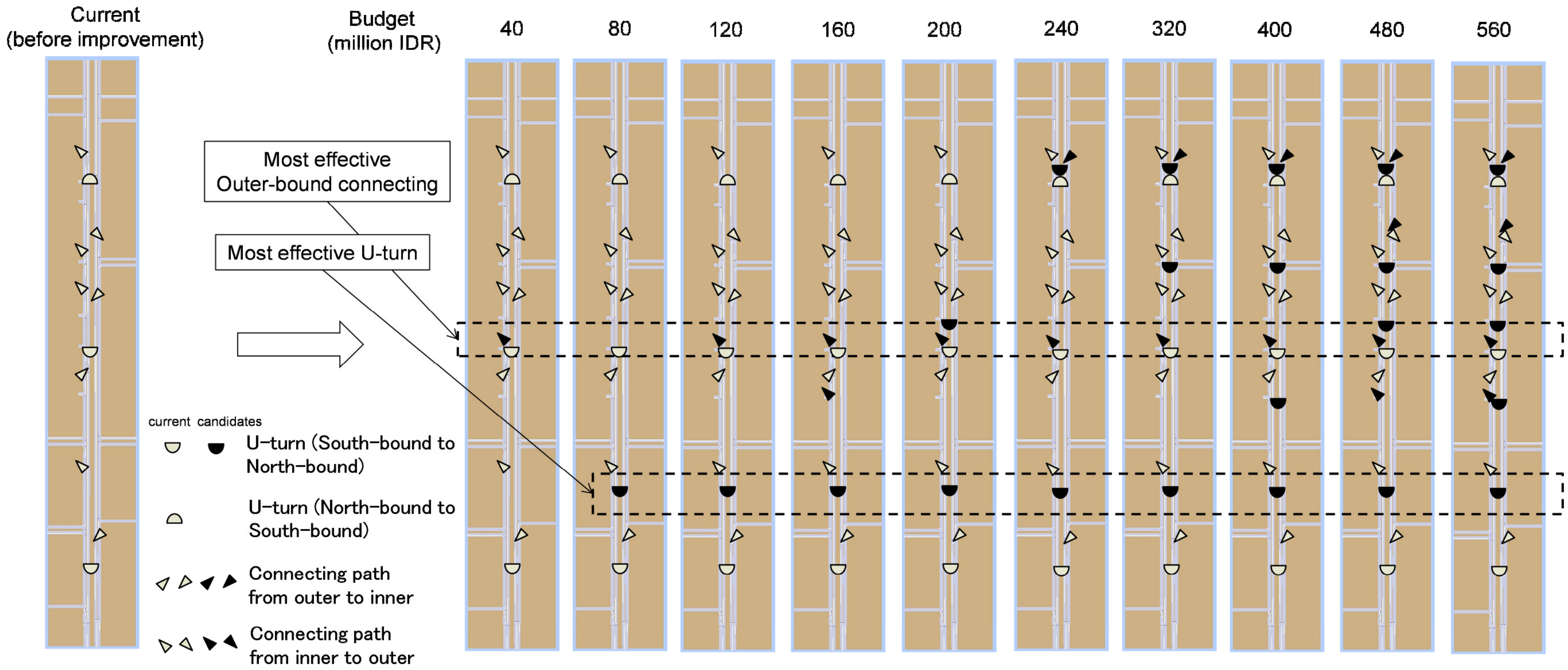


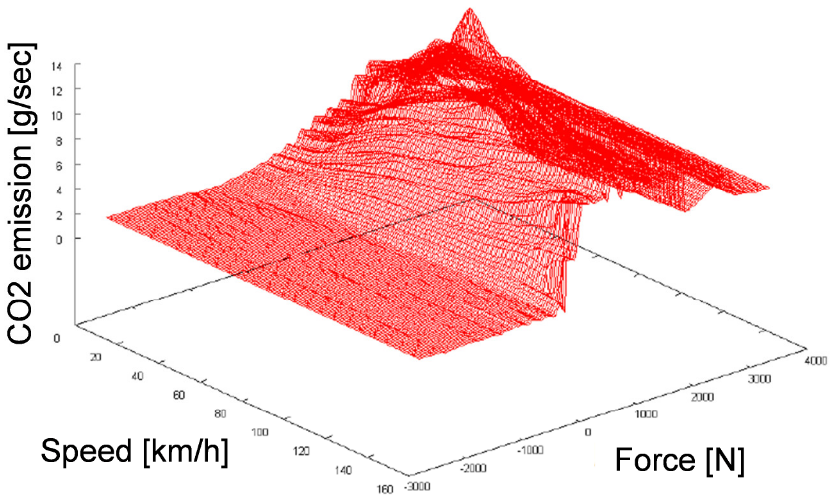
Figure 5-12: Optimization results



4.3 Result: Savings of gasoline consumption

Optimization results are evaluated in terms of gasoline consumption, building on the calculation method as follows. Firstly, traffic flow with optimized road network is simulated by MATES. It generates the speed and acceleration of each vehicle in each time step. Secondly, the data are converted to CO_2 emissions with reference to an emission table of a specific car model. The study referred the JCAPII, which is the open information by Japan Petroleum Energy Center. Thirdly, total CO_2 emissions of all vehicles in the simulation area are calculated. Lastly, CO_2 emissions are converted to gasoline consumption: one kl of gasoline equals to 2.32 tons of CO_2 emissions.

Figure 5-13: Example of emission table



The simulated traffic flow is shown in Figure 5-15, where red dots show those vehicles traveling at slow speed and green dots shows the vehicles with fast traveling speed. Comparing to the traffic situation with the current road network, the traffic flow with the budget 400 million IDR reduce traffic congestion and improves the flow smoothly. Especially in the area marked as (a) in Figure 5-15, traffic congestion waiting for lane-change (a line of red dots) disappears after the improvement. Similarly, in the area marked (b), long intermittent traffic congestion caused by U-turn nearly disappears. Improvement of the traffic jam is expected to raise the average speed of traffic flow and to reduce the frequency of stop and go, which leads to reduce waste of gasoline.

In fact, the simulated gasoline consumption in Figure 5-15 shows that the amount of gasoline consumption with the budget 200 million IDR is about 10% reduction of current traffic. The case with budget 720 million IDR saves about 15% of fuel consumption.

Figure 5-14. Microscopic traffic simulation

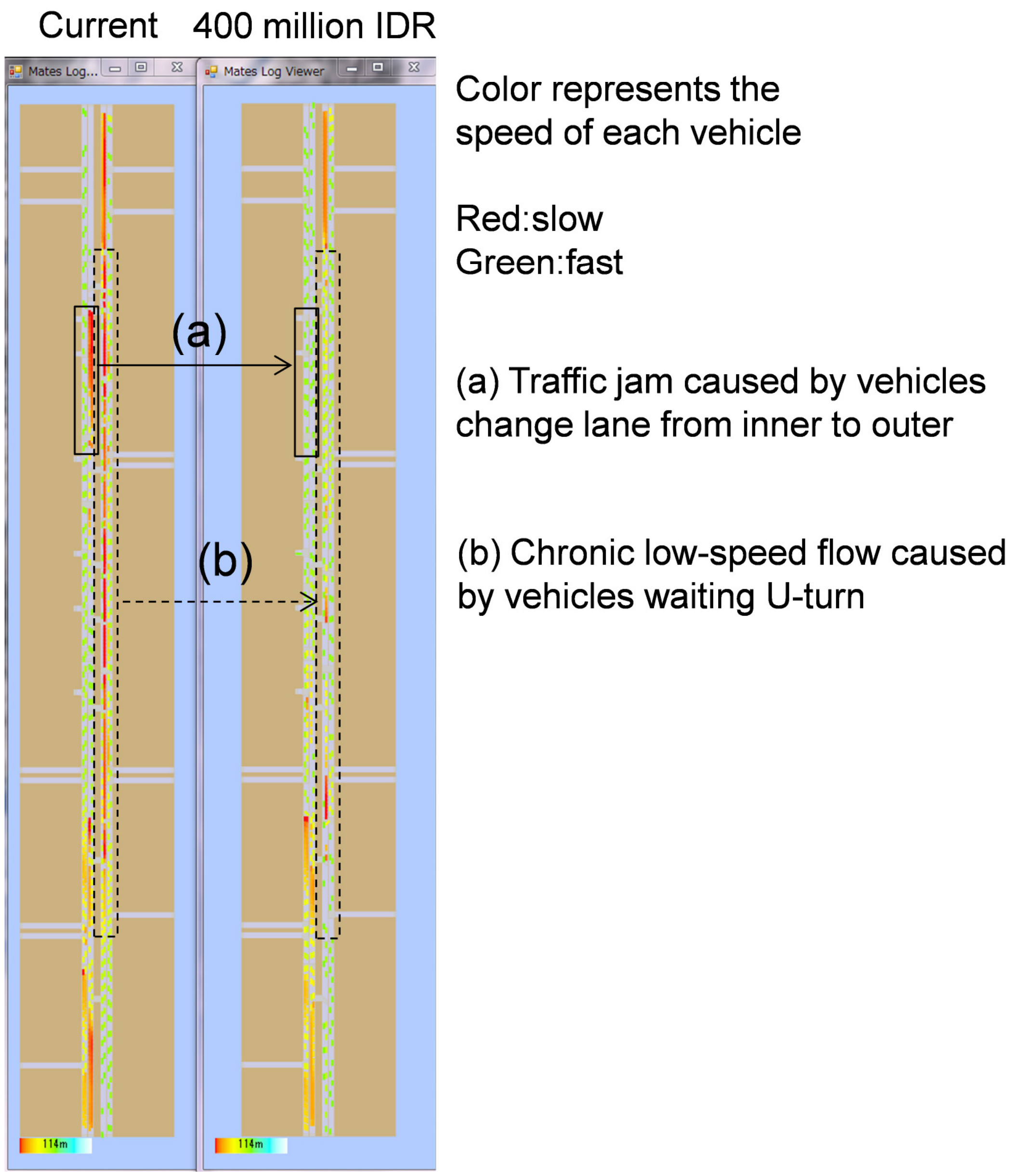
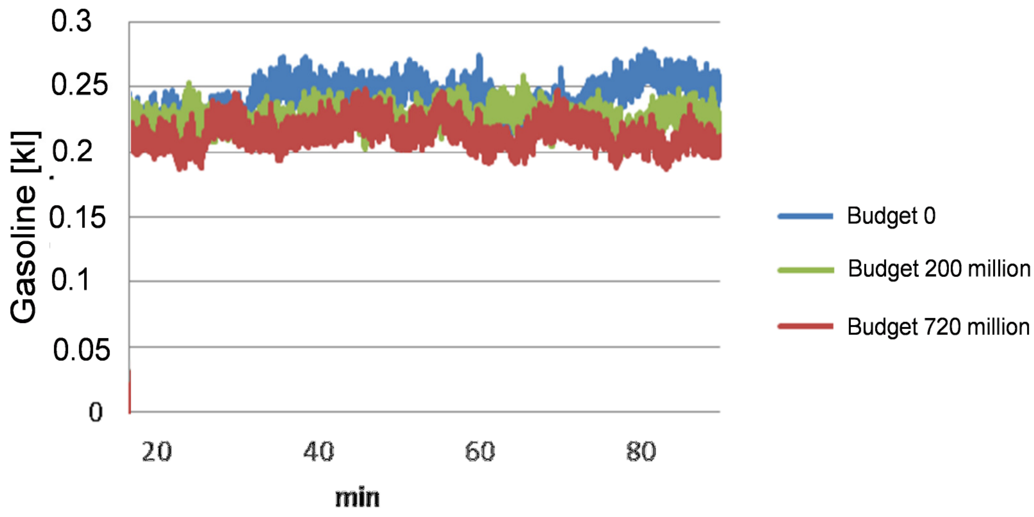


Figure 5-15. Time variation of gasoline consumption



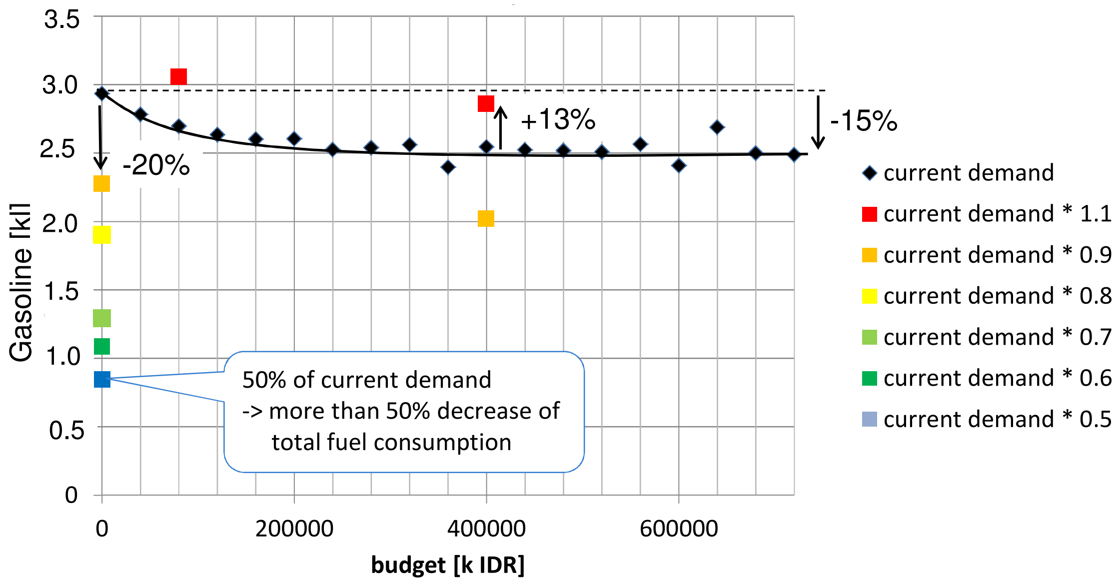
4.4 Result: Effect of traffic flow amount

In the above discussion, improvement plans for the current traffic demand are examined. However, the variation of traffic demand should be taken into consideration. This is because the traffic demand in Jakarta may continue increasing in line with the income growth, and more fundamental solutions such as traffic demand management would be necessary. In fact, several measures for traffic demand management are studied and implemented: 3 in 1, odd-even license plate number regulation, road pricing, etc. Thus, optimal improvement plans and fuel consumption were calculated by varying the amount of traffic demand

The traffic situation is examined by varying traffic demand from 50% of current traffic demand to 120% with 10% increments, while the case of 120% is not shown in Figure 5-16. It is because under the assumption for 120% traffic demand, the solution cannot be obtained mathematically as the traffic demand exceeds traffic capacity of the road network. In order to absorb traffic demand over 120% of current demand, the road network needs further capacity expansion.

Simulated results are shown in Figure 5-16 where total gasoline consumption in Kuningan area during two hours of rush hour is plotted. Black dots are gasoline consumption to the current traffic demand, and other colour dots show the changes in the traffic demand. In the case of current traffic demand, investment up to 200 million IDR is cost-effective and can save 15% of gasoline consumption. If traffic demand is reduced by 10 %, gasoline consumption decreases by 20%. Considering the fact that the number of vehicles increased by 8% per year over the past years (source: BSP Statistics of DKI Jakarta Province, 2010), the improvement effect by adding U-turns and lane-changes are almost the same as the ability to absorb traffic increase for one year. For getting further improvement effect, larger-scale solutions are required.

Figure 5-16: Gasoline consumption



5. Case B: Relatively large-scale improvements (Under/Overpass)

From the simulation analysis of Case A, it became evident that improvement by adding U-turns and lane-changes can cope with the only one year increase of traffic demand, and that the road network needs further capacity in order to absorb traffic demand of above 120% of current demand. Thus, under/overpass, which may cost high but has relatively large capacity, is examined in this section.

In simulation analysis, only one underpass is examined because of the high cost of constructing an underpass. As shown in Figure 5-17, all the current points for making a U-turn from southward lanes to northward lanes are deleted. This is because vehicles making U-turn and vehicles going straight interfere with each other at a U-turn point, which makes a negative influence to the traffic flow in the whole area. Instead, an underpass is set for vehicles on the way to the mega commercial complexes from the north. Because the underpass connects with the outer southward lanes to the outer northward lanes (Figure 5-18), a point for lane-change is also set from inner southward lanes to outer southward lanes.

Figure 5-17. Road network with an under/overpass

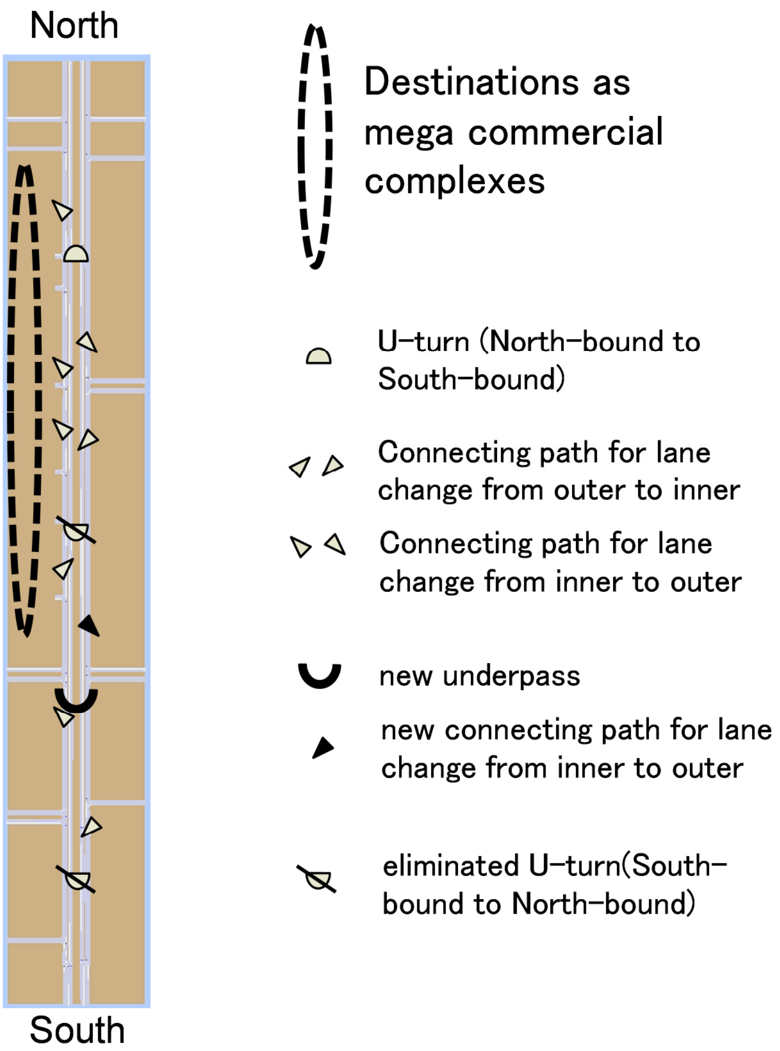
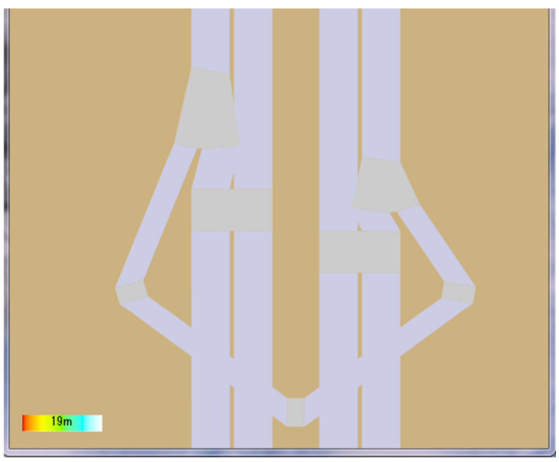


Figure 5-18. Design of under/overpass



This placement of an underpass is simulated by traffic simulator and examined by varying traffic demand from 50% to 150% of current demand with 10% increments.

In the case of current traffic demand, the simulated traffic situation shows that entire flow makes improvements by the decrease of interaction between vehicles making U-turn and vehicles going straight (Figure 5-19). Long intermittent traffic jam caused by vehicles making U-turn disappears after deleting current U-turn points. Traffic flows smoothly on the under/overpass instead.

Figure 5-19: Traffic flows before and after improvement

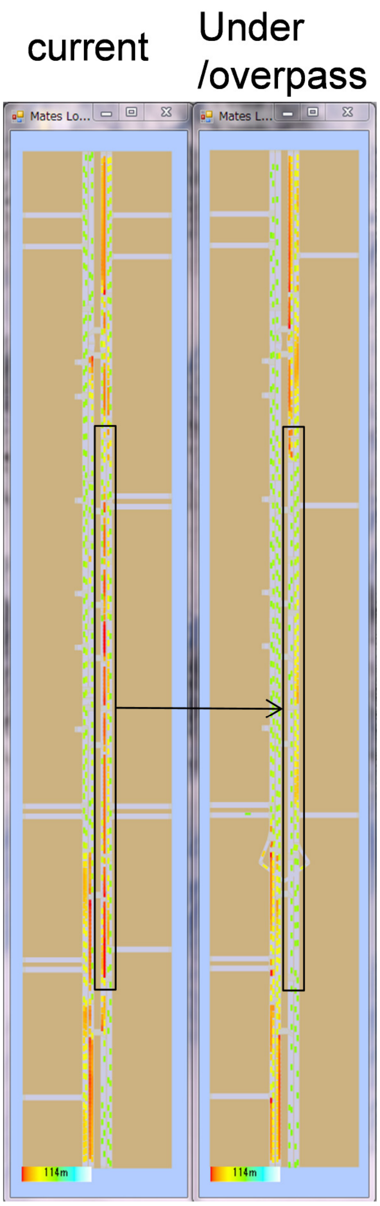
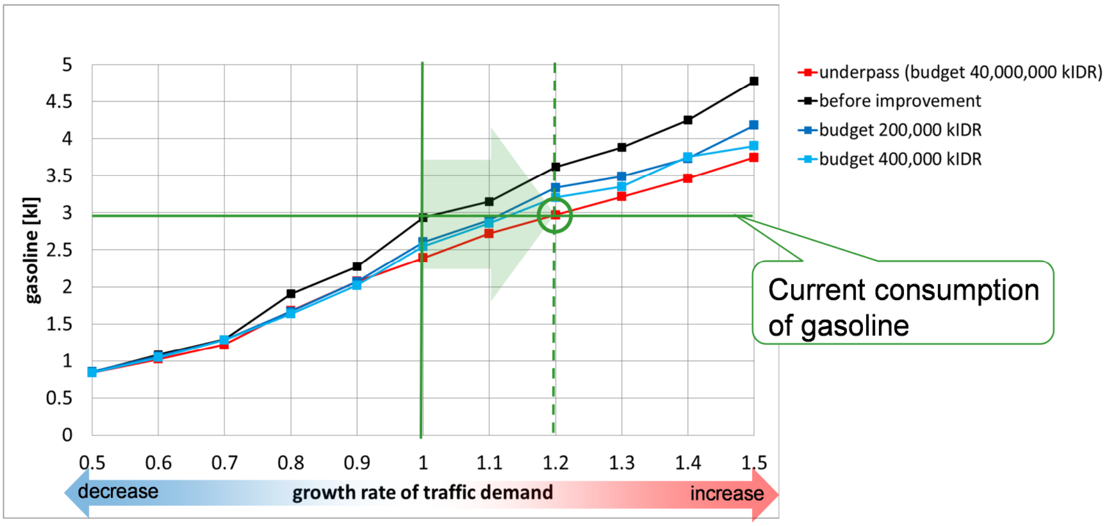


Figure 5-20 shows the change of gasoline consumption with respect to growth rate of traffic demand. Here, the black line shows the gasoline consumption before improvement, and the red line shows that of after construction of an under/overpass. When the traffic demand is 50-70% of current demand, the difference of gasoline consumption between before and after under/overpass construction is very small. When the traffic demand increases more than the present level, an under/overpass construction would reduce gasoline consumption obviously. Construction of an under/overpass keeps the gasoline consumption at the current level even if traffic demand increase 20% from now (light green arrow in Figure 5-20). It means that an additional under/overpass has the ability to manage traffic demand increase for 2.5 years (converted by traffic increase rate 8%/year).

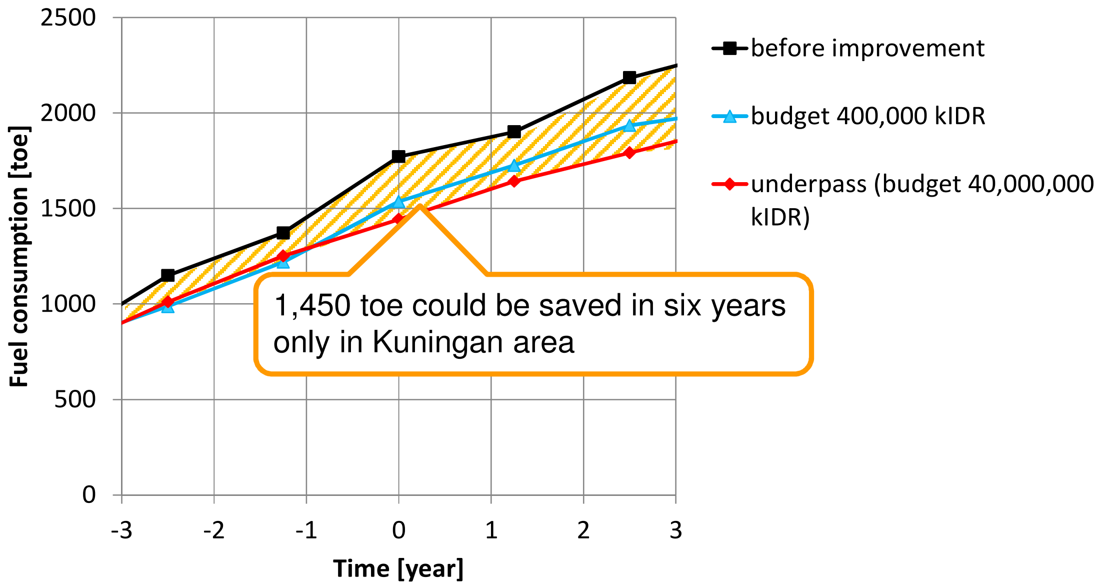
Figure 5-20: Gasoline consumption



Then, how much fuel consumption can be saved by the construction of a under/overpass? Figure 5-21 shows the estimated annual fuel consumption, where it is assumed that the traffic demand in Kuningan area increases by 8% per year and annual consumption equals to multiplying gasoline consumption during 2 hours of rush hour by 2 x 365 (2 means morning and evening rush hour). The shaded area in Figure 5-21 indicates the difference of gasoline consumption between current road infrastructure and an additional under/overpasses construction. As it stands now, it is estimated that 400 tons of oil equivalent (toe) per year is wasted.

Now, the case that construction of under/overpasses is analyzed to all the main road in Jakarta is discussed. The total length of primary arterial roads and primary collector roads is 164 km (See Chapter 4), which is 82 times longer than 2 km of the road length in Kuningan area. Thus, it is estimated that fuel consumption 400 toe multiplied by 82 is about 30 thousand toe can be saved by the construction of under/overpass in whole Jakarta. Annual fuel consumption in the transport sector of Jakarta is about 600 toe, calculated by the multiplication of gasoline consumption for the 2009 in Jakarta: 200 toe/1,000 population), population in 2010 in Jakarta: 9.6 million (see Chapter 4), and the share of Jakarta's transport sector fuel was 30% in 2010. Thus, implementation of under/overpasses in the whole Jakarta would save the amount equivalent to 5% of fuel consumption in the transport sector of Indonesia. Considering further increase of traffic demand in the future, early construction of under/overpasses will prevent waste of fuel from being accumulated.

Figure 5-21. Estimated annual fuel consumption



6. Key Findings

Case A: Selection of lane-changing points and U-turn points has been optimized under the limitation of budget (40 – 720 million IDR). Gasoline consumption decreases about 15% by additional U-turn and lane-changing points. Gasoline consumption decreases more effectively by raising the budget until 400 million IDR. Further investment is not so effective for the decrease of consumption. It is important to assess cost-effectiveness of infrastructure improvement. For the assessment, quantitative simulation analysis like this chapter is useful.

Case B: The construction of an underpass is evaluated (budget 40 billion IDR). Entire flow would improve by deleting the existing U-turn points and placing an underpass. Construction of an underpass keeps the gasoline consumption at the current level even if the traffic demand increases by 20% from the current demand. Oil savings is estimated to reach 400 toe per year only in the Kuningan area with the construction of an under/overpass. If plans for construction exist, it is necessary to act as soon as possible to minimize the congestion as well as wasteful use of fuel.

Comparing these results to the fact that the number of vehicles increase by 8% per year, proposed plans in case A and B can be considered as measures that can handle the traffic increase for 1 year and 2.5 years, respectively. As stated in section 2.2, large-scale investment measures take longer time to implement. Thus, the followings are suggested:

1. Implementation of small-scale investment options as discussed in Case A as soon as possible,
2. Implementation of relatively large-scale investment options as shown in Case B when the effect of Case A investment is being felt, and
3. Implementation of fundamental measures to assist passengers shifts toward the other transport mode when the effect of Case B investment is being felt.

In view of the long-term increases in the transport demand and resulting energy demand, it is important to implement the available options from the ones that can achieve the maximum impacts for easing congestion and saving fuels with least cost. Step-wise approach is deemed necessary for Jakarta to cope with the congestion problems and resulting wasteful use of fuels as highlighted above. The city could start from the least cost option, and moves to higher cost options when the effects of lower cost options are being felt. Earlier implementation of the entire approach is necessary before the transport system in the city faces gridlock.

It is important to note that the implementation of the comprehensive package of policies and measures, aside from the infrastructure investment, including the economic measures and financial measures, is required. Ultimately, the city dwellers and public entities can greatly enjoy the benefits from the alleviation of the congestion problems and resulting wasteful energy use as efficient transport system would be the fundamental element for the socio-economic activities of city dwellers.

CHAPTER 6

Major Findings and Next Step

1. Key Findings

The study delivered the following outcomes.

1. This study analyzed the options that could control the passenger transport energy demand building on the ASIF framework. As a result, the study identified various policies and measures, including (1) avoid the use of passenger vehicles, (2) shift toward the mass rapid transits, (3) upgrades the overall efficiency of urban transport, and (4) provision of financial support.
2. The identified policies and measures could be effective when each of them is implemented individually, while more effects could be obtainable when a packaged of the identified measures is being implemented.

Table 6-1. Policy options

Avoid	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.	• Vehicle registration fees/tax • License plate fee • Mandatory vehicle insurance • Road pricing • Parking fee
Shift	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.	• Mass rapid transit systems • Bus rapid transit systems • Improving feeder bus service • Improving multi-modal transfer through comprehensive tariff structure
Improve	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.	• Fuel economy improvement, • Alternative vehicles (electric, CNG, and fuel cell vehicles) • Intelligent transport systems • Incentives or regulation.
Finance	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.	• Fuel tax • Congestion pricing • Environmental tax • Vehicle registration tax • Licence plate bidding • Parking fee

3. Other than the above listed measures, infrastructure investment, particularly on road is important to control the transport sector oil demand growth. In fact, the investment in road infrastructure could provide the short-term means that can cope with the traffic congestions, and save the oil demand. In contrast, the infrastructure investment in the alternative transport mode, such as rails and buses, could provide with the long-term measures to cope with the congestion and oil demand growth. This study has conducted a simulation exercise on the impacts of road infrastructure investment, which could be implemented within a relatively short time period, and small monetary amounts. The result shows that the analyzed area in Kuningan of Jakarta could save about 15% of oil demand with the investment amounting to US$ 4,000.

4. Nevertheless, the simulation exercise has found that the small-scale investment for road infrastructure improvement could provide a solution only for one or two years in view of the fast increases in the number of passenger vehicles.

5. The study has found that step-by-step approach for implementing the policy measures and infrastructure improvement is necessary to cope with the urban transport issues, such as congestion, ultimately to manage the growth in oil demand.

Step 1 Immediately	Implementation of small-scale investment options as soon as possible
Step 2 within 1-2 yr	Implementation of relatively large-scale investment options before the effect of small-scale investment is being felt.
Step 3	Implementation of fundamental ASIF measures to control traffic demand and to mitigate oil demand increase before the effect of large-scale investment is being felt.

6. How to implement the policies, measures and plans would continue to pose the important agenda. A number of cases in rapidly growing Asia show that the urban transport related infrastructure development plans were not implemented as planned due to variety of reasons. These would include, lack of governance, lack of ministerial coordination at the central government level, and lack of coordination between central and local governments. The case study on Jakarta pointed out that a number of policy recommendations have been made, while the implementation did not follow as expected. It is important to clearly identify the barriers for implementation and measures need to follow.

2. Next Step

Building on the analysis and key findings in this phase study, following two issues could be analyzed in depth as the next phase of study.

- **Identification of barriers for policies implementation and study on overcoming the barriers**

  The next phase of the study will focus on the analysis of how to implement the policies and measures that could cope with the transport related issues. Through case study for some members in East Asia, the study will identify the barriers for implementing policies and plans. The study will also analyze the cases outside of East Asia, to highlight the successful cases in implementing the urban transport policies and plans, and to learn lessons.

- **Quantitative analysis of the impacts of rails, subways, and buses as the alternative to passenger vehicles**

  As the extension of the impacts from road infrastructure investment, the next phase of study will quantitatively analyze the impacts from the introduction of alternative transport mode (rails, subways and buses) on the energy savings. The cost effectiveness of rails, subways and buses will be analyzed to draw policy implications that can provide the useful basis for policy-makers and urban planners.