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Urban Transport Energy Use in the APEC Region
Benefits and Costs

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URBAN TRANSPORT ENERGY USE IN THE APEC REGION

BENEFITS AND COSTS

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FOREWORD

We are pleased to present the report, *Urban Transport Energy Use in the APEC Region – Benefits and Costs*. This is the second part of a two-year study undertaken by the Asia Pacific Energy Research Centre.

Phase I of this study analysed factors affecting urban transport energy demand, particularly with *passenger vehicles*, in both developing and developed economies in APEC. It offered options to control transport energy demand in urban areas within APEC.

By broadening the scope, phase II of the study seeks to analyse the factors affecting both energy and CO_2 intensities of *urban mass transit systems* in APEC. In addition, the study reviews the financial performance of the major urban transport systems in APEC and analyses potential socio-economic benefits that are likely to result from the development of mass transit systems.

The report is published by APERC as an independent study and does not necessarily reflect the views or policies of the APEC Energy Working Group or individual member economies. But, we do hope that it will serve as a useful basis for analytical discussion both within and among APEC member economies for the enhancement of energy security in APEC and sustainable development around the world.

Kenji Kobayashi
President
Asia Pacific Energy Research Centre

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Yonghun Jung, Vice President of APERC, provided overall guidance and valuable insights on the study's direction.

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LIST OF ABBREVIATIONS

ABARE	Australian Bureau of Agriculture and Resource Economics
APEC	Asia Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
ASEAN	Association of Southeast Asian Nations
AUS	Australia
BCM	billion cubic metres
BRT	bus rapid transit
BD	Brunei Darussalam
CDA	Canada
CHL	Chile
CNG	compressed natural gas
CO_2	carbon dioxide
CO	carbon monoxide
CT	Chinese Taipei
DOE	Department of Energy (USA)
EDMC	Energy Data and Modelling Center (Japan)
EIA	Energy Information Administration (USA)
EWG	Energy Working Group (APEC)
GDP	gross domestic product
GHG	greenhouse gases
g/kWh	grams per kilowatt-hour (used to measure the emissions caused by the generation of one unit of electricity)
GNP	gross national product
GRP	gross regional product
GTL	gas to liquids
GW	gigawatt
GWh	gigawatt-hour
HC	(un-combusted) hydrocarbons
HOV	high occupancy vehicle
HKC	Hong Kong, China
IEA	International Energy Agency
IEEJ	Institute of Energy Economics, Japan
INA	Indonesia
IPCC	Intergovernmental Panel on Climate Change

JPN	Japan
kgoe	kilogram of oil equivalent
ktoe	thousand tonnes of oil equivalent
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LRT	light rail transit
MAS	Malaysia
mbd	million barrels per day
MCM	million cubic metres
MEX	Mexico
MMBTU	Million British Thermal Units
MRT	mass rapid transit
Mtoe	million tonnes of oil equivalent
NGV	natural gas vehicle
NRE	new and renewable energy
NOx	unspecified nitrogen oxides
NO_2	nitrogen dioxide
NZ	New Zealand
O_3	(surface) ozone
PE	Peru
PM	particulate matter of unspecified diameter (generally <10 microns)
PNG	Papua New Guinea
PPM	parts per million
PPP	purchasing power parity
PRC	People's Republic of China
R&D	research and development
ROK	Republic of Korea
RP	the Republic of the Philippines
RUS	the Russian Federation
SIN	Singapore
SO_2	sulphur dioxide
toe	tonnes of oil equivalent
TWh	terawatt hours
US or USA	United States of America
USD	United States dollar
WTO	World Trade Organisation
VN	Viet Nam
VOC	volatile organic compounds

GLOSSARY

ON TRANSPORT MODE

Passenger Vehicle

A light, motor-driven, 2-axle vehicle that is used primarily for passenger transport on paved roadways (typically privately owned and operated on demand). Passenger vehicles include both *cars* and light trucks that are operated for passenger transportation.

BRT

A high-passenger-capacity road vehicle, with 2 or more axles, that is propelled by an on-board motor. It is powered by on-board fuel or electricity and operates on exclusive busways or High Occupancy Vehicle (HOV) lanes.

LRT

Intra-city rail, typically with a smaller car weight, less passenger capacity, narrower rail gauge, shorter operating distance, and slower speeds than MRT systems (typically operated above ground at-grade). It carries its own motor, but relies on external electricity for propulsion.

MRT

Intra-city rail, commonly know as heavy rail – including metro systems or subway systems. MRTs operate above and below ground, on a fixed-track, with longer distances between stations, and have a greater passenger capacity than LRT systems.

Local/feeder bus

A high-passenger-capacity road vehicle, with 2 or more axles, that is propelled by an on-board motor. It is powered by on-board fuel or electricity. Local/feeder bus systems operate on roads, with or without exclusive busways.

(Urban) mass transit includes MRT, LRT, BRT, commuter rail, motor bus, trolley bus, and other urban transit modes offering high passenger capacity intra-city travel service. Urban mass transit may be publicly- or privately-owned or operated and is typically run on a set schedule according to a standard fare rather than on-demand. For this study, taxi service and inter-city mass transit (by bus, rail, plane, or ferry) is excluded from urban mass transit.

ON TRANSPORT MEASUREMENT

Passenger-km

An indicator showing one person's travelling for one kilometre.

Person-trip

An indicator showing one person's travelling for one journey segment on a single mode.

Tonne-km

An indicator showing one tonne of freight transport for one kilometre.

EXECUTIVE SUMMARY

Urbanisation, with respect to both migration from rural to urban areas and structural transformation of rural areas into urban ones, is one of the key factors affecting energy demand growth. The higher personal incomes and greater economic potential of urban areas transfer labour and other inputs from rural agricultural regions to the industrial and services sectors of urban areas. Driven by the growth in disposable income, urban dwellers spur the growth of motorised transport as they demand more mobility and switch from non-motorised modes, such as bicycling and walking. This shift causes a strong upward pressure on transport energy demand.

A study of urban transport energy use has been designed to assist APEC policy makers in addressing energy and environmental problems in urban areas, as cities are the centre of economic development and energy demand growth.

URBAN TRANSPORT ENERGY USE IN THE APEC: PHASE I

The initial phase of the urban transport study aimed to analyse methods to reduce vehicle dependence in urban life and to understand both contributing and offsetting factors for urban transport energy use. At the culmination of this first phase, the study developed several indicators on urban transport and laid out various policy and economic instruments.

To comprehensively capture both contributing and offsetting factors to passenger transport energy consumption in urban areas, two urban transport indicators, a road indicator and an offset indicator, were created. Through these indicators, the following findings and implications were obtained.

Accessibility to rail/subway infrastructure is the key component that can reduce passenger vehicle dependence and improve energy intensity of the urban passenger transport sector in Asia. The urban transport indicators show that Seoul and Taipei successfully reduced growth in their passenger vehicle dependence because of increased access to mass transit between 1995 and 2005. By contrast, Bangkok's city dwellers tripled vehicle ownership during the same time period as their access to rail/subway remained limited.

Timely investment in rail/subway infrastructure is necessary both to shift people away from passenger vehicle dependence and to prevent passenger vehicle ownership. Unless access to rail/subway infrastructure is ensured, a steady increase in the income of urban dwellers can drive growth in passenger vehicle stocks. In addition, it is hard to change peoples' lifestyle, away from vehicle dependence, once they acquire a passenger vehicle. Therefore, **city planners, especially at the early stage of development, need to assess their future transport requirements and plan investment towards rail/subway infrastructure at an appropriate time.**

To determine whether rail/subway is the most energy efficient option among various transport modes and, further, to identify contributing factors for transport energy intensity, an in-depth analysis on US transit systems was conducted, focusing on 83 transit systems of 60 metropolitan agencies.

Energy intensity of US mass transit systems, calculated as energy requirements per annual passenger-kilometres served, is inversely correlated with the total annual passenger-kilometres served by each system. However, wide variation among systems is observed, with the energy intensity of systems with small transit demand representing higher variation than that of larger systems. Surprisingly, **some transit modes use more energy per passenger-kilometre than the average-occupancy US passenger vehicle does.**

Despite the difficulties in improving the energy intensity of US urban mass transit systems, **urban mass transit systems are useful tools in controlling the type of fuels used and the way in which those fuels are used.** Fuel switching within mass transit is relatively easy compared to its implementation within an urban area's entire private vehicle fleet.

URBAN TRANSPORT ENERGY USE IN THE APEC REGION: PHASE II OBJECTIVES

The second phase of the study attempts to:

- Analyse energy intensities and CO_2 intensities of mass transit systems (MRT, LRT, and buses) within the major cities of APEC,
- Identify factors affecting ridership of mass transit systems and draw policy implications,
- Review the financial performance of urban mass transit systems in APEC and identify key factors affecting this financial performance,
- Quantify socio-economic benefits and costs of mass transit (in monetary value) , and
- Identify institutional barriers for developing mass transit systems and provide policy options to overcome such barriers.

ENERGY INTENSITY OF URBAN MASS TRANSIT IN APEC

Using data from 12 metropolitan areas in APEC, the study provides a comparison between transport systems' energy/CO_2 intensities within Asian and North American cities and analyses factors affecting them. The study analyses energy/CO_2 intensities of 12 MRT systems (commonly referred to as subway or metro), 8 LRT systems, and 15 city bus systems (standard, express, and BRT networks), stratified by annual passenger-kilometres served.

Though energy intensity of mass transit systems is inversely correlated with the total annual passenger-kilometres served by each system, these intensities vary greatly among the systems considered. Variation is greatest amongst systems that serve a relatively small transit demand. The smallest systems show the highest intensities, but other small systems also show some of the lowest energy intensities. In most cases, **data shows that Asian and Canadian transit systems are less energy intensive than US transit systems.** MRT/LRT systems tend to have similar or slightly lower energy intensities than bus systems.

Even urban areas with low population densities have potential to achieve energy and emissions reductions by developing mass transit systems — be they rail or bus. **Bus systems, however, seem to be a safer choice for those urban areas with the lowest population densities because they perform more in line with passenger vehicles. Urban areas with higher population densities should not neglect bus systems** because buses consistently perform even better as population density rises. However, such areas should consider that they are likely to reap the most energy and emission savings through a high-volume rail system.

A transit system's energy intensity ranking can differ from its CO_2 intensity ranking. In other words, **transit systems can perform poorly in terms of energy intensity, but perform better in terms of CO_2 emissions intensity.** A similar dynamic is true for some bus systems. This is because CO_2 intensity is affected by the power generation or fuel mix. In particular, **those cities that have access to low carbon power generation, such as nuclear or renewables, can realise low CO_2 emissions intensity.** CO_2 emissions intensity for MRT/LRT systems is generally lower than in bus systems.

Bus or rail mass transit systems have great potential to reduce an urban area's overall transport energy use and CO_2 emissions relative to passenger vehicles. To realise this potential, **policy-makers and planners may need to take advantage of an urban area's particular characteristics.**

FACTORS AFFECTING URBAN MASS TRANSIT RIDERSHIP

The study considers five factors that affect mass transit ridership and attempts to draw implications for planners and operators on how to increase ridership. The factors analysed in this chapter are: (1) travel time and its cost, (2) accessibility, (3) population density, (4) system integration, and (5) fare.

Out of the numerous factors, **cost of MRT/LRT system use, including both (1) time cost and (2) monetary cost is identified as the basis for passengers to decide a transit mode.** Travel time cost refers to the time and its associated monetary value that is required for a passenger's travel. Monetary cost refers to the transit fare or operational cost of passenger vehicles.

In an effort to increase ridership, **planners/operators may need to lower the time cost at both the collection and distribution phase through enhancing passengers' accessibility.** However, city-specific characteristics, such as population density, need to be carefully considered in addition to enhancing accessibility.

Transit fare is an important determinant of ridership. However, in order to increase ridership, **the availability of competitive alternative**

transport modes should be factored in when considering fare adjustments.

To maximise the ridership of MRT/LRT systems and fully realise their potential benefits, such as energy savings and CO_2 emissions reduction, **it is important to implement a comprehensive policy approach that covers all aspects of energy and transport.**

Mass transit ridership is affected by numerous demand and supply factors, including the presence of alternative transport modes. As such, before the development of a MRT/LRT system, **ridership forecasts are a valuable planning component, since ridership is a key element in improving energy/CO_2 intensities and the financial performance of MRT/LRT systems.**

FINANCIAL PERFORMANCE OF URBAN MASS TRANSIT

Based on the annual reports of major MRT/LRT systems within APEC, the study reviews their financial performance. The study also analyses the risks that affect the financial viability of these projects and attempts to identify key factors that influence the profitable operation of MRT systems.

Among the systems studied, **five systems (Hong Kong MTR, Singapore SMRT, Taipei TRTC, Tokyo Toei, and Tokyo Metro) reported a higher revenue flow than expenditure in 2006** (Taipei TRTC's analysis uses 2005 data). In contrast, three systems (Bangkok Metro, SF BART, and Seoul SMRT) were not able to cover their expenses through their revenue intake.

To increase the financial viability of mass transit, efforts to increase ridership may be required by policy makers and planners. One option may be to **integrate the MRT system with other mass transit modes,** such as feeder buses. **Introduction of *smartcard* fare systems might encourage multi-modal transfer**, which can lead to an increase in MRT ridership.

Although **fare needs to be maintained at an affordable level for the general public to increase ridership**, it should also cover the high capital investment and interest payments. To satisfy these objectives, **the fare system has to be flexible.** For example, by discriminating customers by time of day or distance travelled, **a flexible fare system can maximise a MRT/LRT's financial output.**

For a mass transit project with low project viability, **government support to provide either funding or other subsidy** (such as low interest rate or land rights) **is necessary.** Also, **in developing economies, strengthening capital markets, especially municipal bond markets, can expand financing opportunities.** At lower interest rates than bank loans, bonds can provide long-term capital for investment in MRT/LRT projects.

In addition, **international lending organisations can play an important role by providing a guarantee to the overall debt of mass transit projects** because their involvement can increase the project's credit worthiness.

ECONOMIC EVALUATION OF URBAN MASS TRANSIT

By evaluating four different urban areas (Bangkok, Hanoi, Jakarta, and Manila), the study tries to analyse the benefits and costs associated with MRT systems and estimate their economic internal rate of returns (EIRRs). The benefits include (1) energy savings, (2) CO_2 savings, (3) time savings, and (4) vehicle ownership cost savings, while the costs include (1) capital investment cost and (2) operational cost.

For Bangkok, mass transit expansion could yield the highest socio-economic benefits among the four cities. In Bangkok's case, **time savings would account for the largest share of total benefits because the city has a (1) relatively high time value among the four cities studied and (2) the highest time savings potential due to heavy traffic congestion.**

Despite the relatively low income level of Manila, about half of that of Bangkok, **MRT systems could be a viable option both financially and economically. This is because of Manila's high population density,** which is almost double the level of Bangkok.

Besides monetary benefits, **MRT systems could substantially reduce energy consumption if appropriate conditions are present.** As a result of expanding mass transit systems, Bangkok could save about 17 percent of its current gasoline consumption by 2030 and Manila could save as much as 19 percent of its current gasoline consumption by 2030. **Similarly, substantial CO_2 emission savings are expected.** By 2030, Bangkok could save approximately 2 percent of the present transport CO_2 emissions in Thailand, while Manila could save approximately 6 percent of the present transport CO_2 emissions in the Philippines.

These socio-economic benefits can only be realised if the assumed MRT project is implemented as planned. However, it should be noted that it often takes at least two decades to realise these potential benefits. This suggests that **the early and timely implementation of a MRT project can help maximise the potential socio-economic benefits.**

To facilitate early implementation, **planning for mass transit systems should be an integral part of the city's energy and environmental policy. Appropriate institutional arrangements to enhance inter-agency coordination should be made** in order to increase the effectiveness of these MRT projects.

INSTITUTIONAL ISSUES IN URBAN MASS TRANSIT: JAKARTA AND MANILA

Jakarta: Jakarta is rapidly adding new BRT corridors and extending corridors into suburban areas. In the process, the city is receiving public criticism that the BRT system is failing to reduce congestion, and moreover, that the development of BRT corridors is actually increasing congestion. To enhance the effectiveness of the BRT system, **Jakarta may need to develop specific policies related to the BRT and feeder bus system.**

Manila: Despite the estimated socio-economic benefits of mass transit, in reality, **cities face institutional problems that prevent them from expanding mass transit systems.** For example, in Manila, various agencies compete for the same project and this keeps mass transit projects from happening. Therefore, **enhancing coordination among transport related agencies is important to achieve results.**

Energy Intensity of Urban Mass Transit in APEC

INTRODUCTION

Urban mass transit has become an attractive option to deal with pressing urban passenger transport difficulties now encountered throughout the APEC region. One subset of these issues—increasing energy use, oil dependence, and CO_2 emissions as a result of rapid motorisation—could be addressed by the development of urban rail and bus networks. Such mass transit systems are largely energy efficient and well-received by the urban populace.

However, energy efficiency from the introduction of mass transit systems, in particular, does not come free and should not be taken for granted. In real-world implementation, not all urban mass transit systems clearly reduce transport energy use. The range of mass transit energy and CO_2 emission intensities in comparison to a passenger vehicle baseline are influenced throughout the APEC region by a number of factors, including mass transit system mode, urban area population density, and an economy's power generation profile. Other factors, such as urban area population size, do not seem to be important in influencing a system's energy and CO_2 emissions intensity.

In its 2007 study, *Urban Transport Energy Use in the APEC Region*, APERC demonstrated that both bus and rail urban mass transit systems in the US provided, on average, only marginal energy savings compared to passenger vehicle-equivalents and that variation among transit systems was wide. Urban mass transit in the US, however, can be quite different from those of other metropolitan areas within APEC. Different transit systems in different areas, serving different populations, and using different technology, operate according to various restraints and priorities. Thus, in this follow-up study, APERC has broadened the geographical scope of its urban mass transit energy intensity analysis to include the experiences of transit systems in both Asia and elsewhere in the Americas. In consideration of the increasing international attention given to the reduction of greenhouse gases (GHG), the study also includes economy-specific CO_2 emissions intensity analyses for the selected systems.

Data is drawn from 12 metropolitan areas, representing a diverse array of urban area characteristics ranging from geography to population, from land use to transit development. The objective of this study is two-fold: first, provide a comparison among transport system energy/CO_2 emission intensities within Asian and North American cities; second, explore the factors that influence or do not influence urban transit energy/CO_2 emission intensities among these systems in the APEC region.

OVERVIEW OF PHASE I: ENERGY INTENSITY OF URBAN MASS TRANSIT IN THE USA (2007)

To identify factors contributing to transport energy intensity, an in-depth analysis of US transit systems was conducted by APERC during Phase I of this study. This investigation of mass transit energy use and energy intensity focused on the relative position of various US systems when compared against various energy intensity-defining factors. The patterns presented by this relationship were intended as a benchmark tool for transport planners to get a sense of their energy intensity reduction options.

The study resulted in several interesting findings. It was observed that the energy intensity of US mass transit systems (calculated as energy requirements per annual passenger-kilometres) were inversely correlated with the total annual passenger-kilometres served by each system. The degree of variation, however, depends on system size, with the energy intensity of systems with small transit demand representing higher variation than that of larger systems.

Factors such as station throughput and passenger utilisation ratio also displayed noticeable correlation with energy intensity in US MRT and LRT systems. As such, greater system ridership came to the forefront as a means to improve systems' energy intensity. In contrast, many factors that are generally thought to affect energy intensity in fact displayed little correlation with transport energy intensity. These factors included service area population, population density, average trip length, and the percentage of a city's commuters who rely on urban mass transit.

By and large, this initial analysis indicated that urban mass transit systems in the United States use a surprisingly high amount of energy to move one passenger one kilometre: compared to the average US passenger vehicle on the road, LRT, MRT, and bus systems used, on average, 0.71, 0.55, and 0.69 times the amount of energy per passenger-kilometre. In fact, some transit systems used twice as much energy per passenger-kilometre as the average-occupancy US passenger vehicle (such as car or light truck).

METHODOLOGY

Phase II of this study uses a similar methodology as Phase I but adapted to account for data variation across the APEC region, as well as economy-specific energy and CO_2 factors. In order to both calculate system-annual-average energy intensity per passenger-kilometre and then analyse this intensity against other system characteristics, such as service area population density or system size, 35 transit systems administered by 23 transit agencies are selected to represent a diverse array of urban area characteristics within the APEC region. This sample includes 12 MRT systems (commonly referred to as subway or metro), 8 LRT systems, and 15 city bus systems (standard, express, and BRT networks), stratified by annual passenger-kilometres served.

System-specific descriptors in this analysis include:

- Total route length
- Total number of unique stations
- Average passenger trip length
- Average segment length
- Average station throughput
- Service land area
- Service area population
- Service area population density

8.1 **Traveller behaviour/ System characteristics**

CITY	SYSTEM NAME
Calgary	Ctrain
	Calgary Transit Bus
Edmonton	Edmonton LRT
	ETS Bus
Hong Kong	Hong Kong MTR
Los Angeles	LACMTA Heavy Rail
	LACMTA Light Rail
	OCTA Bus
	LACMTA Bus
Manila	Manila LRT Line 1
	Bus
New York City	Newark Light Rail
	PATH
	MTA-NYCT (NYC subway)
	MTA Long Island Bus
	NJ TRANSIT Bus
	MTA-NYCT (NYC Bus)
Sapporo	Sapporo Municipal Subway
SF Bay Area	VTA LRT
	MUNI Light Rail
	BART
	VTA Bus
	AC Trans Bus
	MUNI Bus
Taipei	Taipei MRT
	Taipei Bus
Tokyo	Toei Subway
	Tokyo Metro
	Toei Bus
Vancouver	SkyTrain
	TransLink Bus

8.2 **Transit systems surveyed**

Energy intensities are calculated from aggregate annual passenger-kilometres and fuel/electricity vehicle operational use, as reported by each transit agency or metropolitan government. As a result, non-revenue vehicle energy use is included as energy consumption, but non-vehicle energy requirements such as maintenance, station service, and construction are excluded. Data are averaged for years between 2000 and 2006, where data is available, in the final results. Energy use is disaggregated by fuel type (electric propulsion, electricity battery, diesel, biodiesel, gasoline, CNG, and LNG), converted to toe energy equivalents based upon economy-specific average conversion factors for each fuel type and aggregated within each sample.

CO_2 emission intensities are calculated from the fuel/electricity consumption reported by the transit agencies. The energy use, disaggregated by fuel type (electric propulsion, electricity battery, diesel, biodiesel, gasoline, CNG, and LNG), is converted to terajoules based upon economy-specific average conversion factors for each fuel type. The apparent consumption is then multiplied by fuel-specific emission factors to compute carbon content and the actual carbon stored for each fuel and converted to a CO2-equivalent to determine the total carbon dioxide emissions from fuel/electricity consumption. The final value consists of the aggregated results of all fuels consumed. Data are averaged for years between 2000 and 2006, where data is available, in the final results.

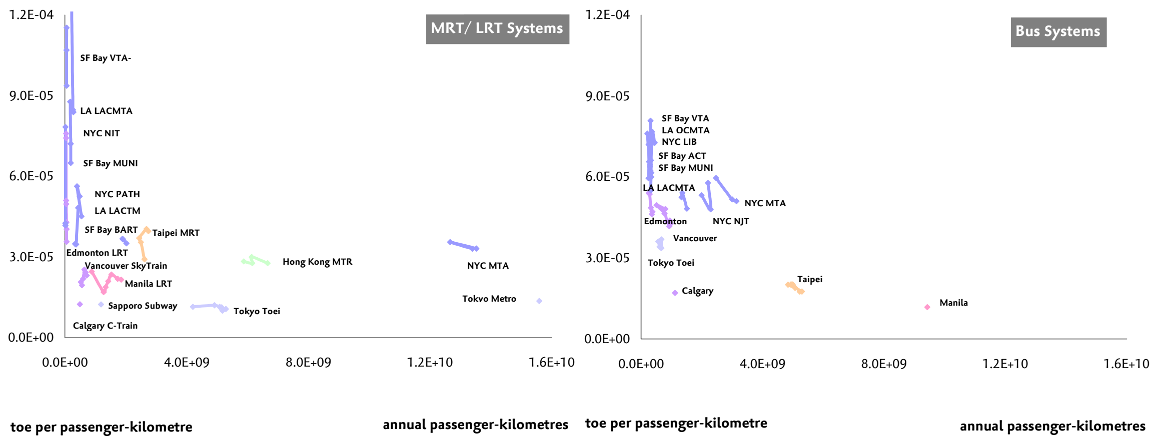
Service area population and population densities are calculated based upon administrative/ political boundaries that correspond to each transit agency's service area. Transit systems located within the same city may have different values for these two variables, since service areas may differ. For perspective, the energy and CO_2 emission intensities calculated for each transit system are compared to a range of energy and CO_2 intensities of passenger vehicles (cars and light trucks) from the US, Japan, and Chinese Taipei to represent the general distribution to be expected across the APEC region.

The uncertainty on each transit system's energy intensity varies with the accuracy of fuel use and passenger-kilometres data. Fuel use data, because it is directly measured by transit agencies or government bureaus, is relatively accurate. Passenger-kilometres data, however, is generally estimated rather than directly measured, and so is subject to different statistical standards by source. In the US, for example, if full counts are not available, the FTA requires annual passenger-kilometres estimates to be certified to a minimum 95 percent confidence with precision +/- 10 percent. Other agencies may have different standards or no published standards at all. The same applies to system characteristic and traveller behaviour variables. When possible, data from multiple sources were compared to validate reported figures and averaged across years. However, the final intensity figures presented in this chapter are only estimates. It is reasonable to expect that reality could fall in a band +/- 20 percent, generally narrower for transit systems in developed economies and wider for those in developing economies.

9.1 **Data uncertainty**

FINDINGS – OVERALL TRENDS

Energy intensity of mass transit systems is inversely correlated with the total annual passenger-kilometres served by each system. As noted in the US-focused Phase I of this study, variation among systems is wide. Variation is greatest amongst systems that serve a relatively small transit demand. The smallest systems show the highest intensities, but other small systems also show the lowest energy intensities. For larger systems that provide more total service (passenger-kilometres served) each year, the maximums seen among the smaller systems begin to drop out, leaving only the less energy intensive systems. Interestingly, for rail systems outside of the US, even the smallest systems generally perform well.



10.1 **Energy intensity per annual passenger-kilometres served**

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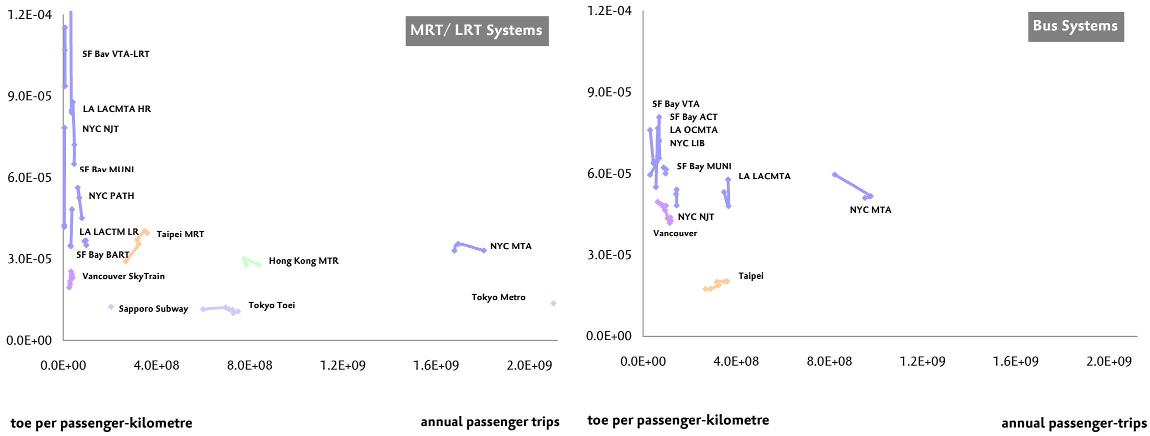

10.2 **Energy intensity per annual passenger-trips served**

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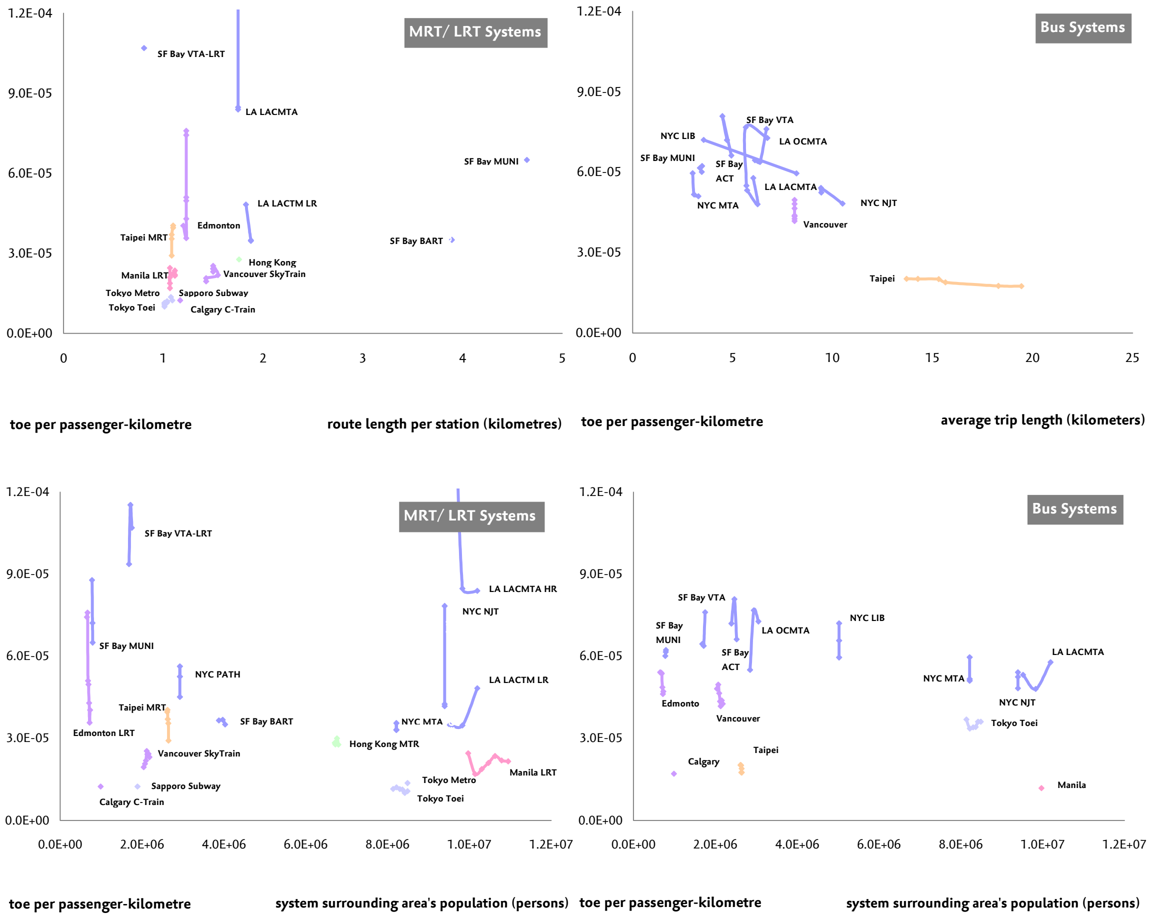
Data shows a similar trend for total annual passenger-trips. Whether evaluated on a passenger-kilometres or passenger-trip basis, similar energy intensities are observed among different transit modes; however buses on average tend to use more energy than rail systems. In terms of ideal transport mode, the statistics are inconclusive. Though slightly more intensive, efficiencies of buses are less variable among different cities, exhibiting lower maximum and higher minimum energy intensities than rail systems. For rail, LRT systems performed similarly to MRT systems. There is little to indicate whether one is better than the other in terms of average energy intensity for any given city over time.

FINDINGS – IMPORTANCE OF SYSTEM AND USAGE CHARACTERISTICS

In this analysis, the link between energy intensity and transit system usage characteristics is explored. Proxies for traveller behaviour and system characteristics [8.1] are investigated to determine discernible trends within the APEC region.

A few urban area or system characteristics simply do not seem to influence energy intensity. These variables include average trip length (bus), route length per station (MRT/LRT), and urban area population (bus and MRT/LRT systems).



11.1,2,3,4 **Rail route length, bus average trip length, and service area population lack trend with energy intensity**

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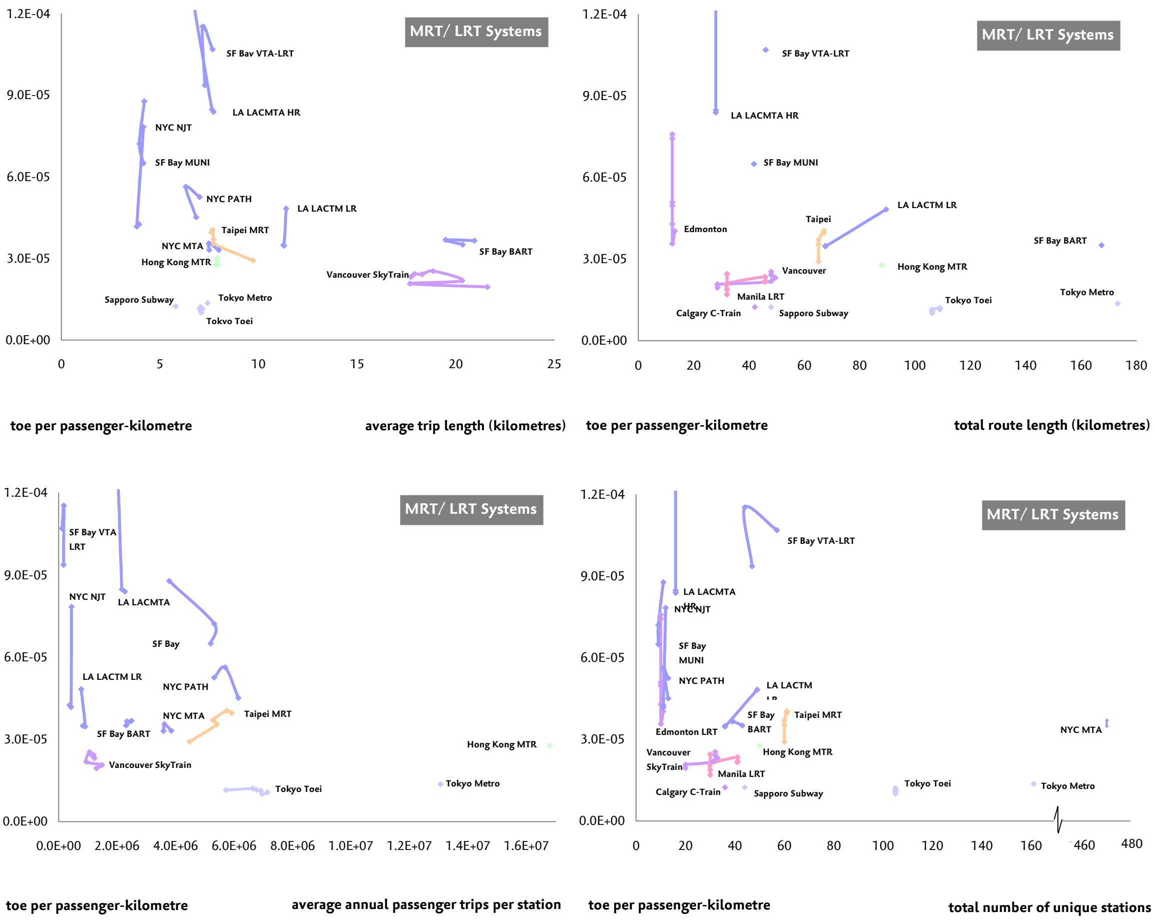
Route length per station, however, shows an interesting trend [11.1]. The statistics reveal that at smaller segment lengths, final energy intensity varies among systems, ranging from 1.12E-05 toe per passenger-kilometre to 1.05E-04 toe per passenger-kilometre. Longer route length is mostly seen in cities where transit systems have been expanded to increase geographic coverage and reach outlying population centres, such as the San Francisco Bay BART system. For these longer route length systems, energy intensity is uniformly high. Thus, as an energy conscious transit planner, the geographic coverage benefits associated with network length expansions, often pursued for political reasons, should be weighed against the likely increase in energy intensity.

For the remaining variables, the data does not reveal significant trends with energy intensity. If US systems are excluded from this investigation, focusing instead on Asian and Canadian systems, most of these variables show no trend. However, if all systems are analyzed, certain urban area/ system characteristics do seem to influence energy intensity to some extent. These variables include average trip length (MRT/LRT), service area population density (bus and MRT/LRT), gross system land area (bus and MRT/LRT), total route length (MRT/LRT), total number of stations (MRT/LRT), and station throughput (MRT/LRT).

Average trip length, station throughput, total route length, and total number of stations show similar trends. At lower values, energy intensity is highly variable. As each of these four variables increase, energy intensity tends to decrease. This trend is similar to that observed between energy intensity and total annual passenger-kilometres of service consumed.



12.1 MRT/LRT system trends- Energy intensity and a number of common descriptive indicators

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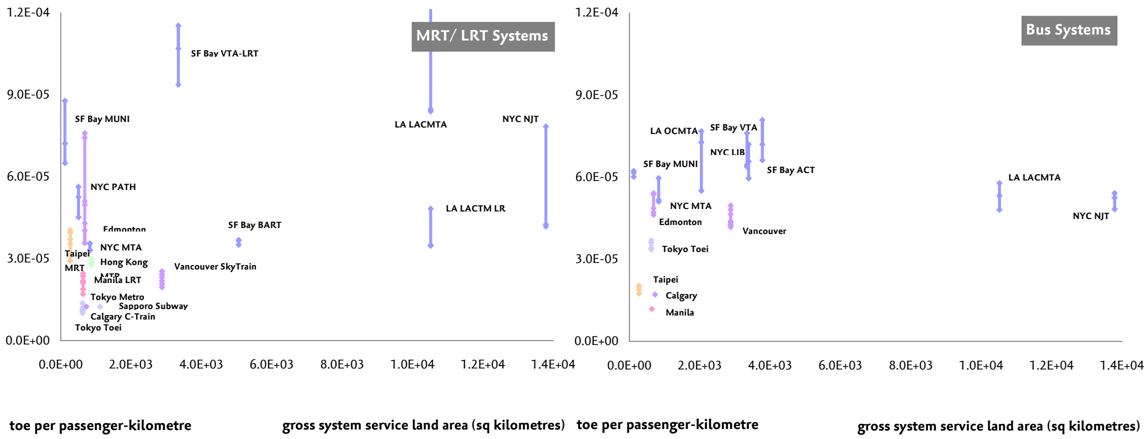
Gross system land area only shows a trend for areas up to 4,000 km^2 [13.1,2]. Although this does not represent the full data set, it is exemplary of a wide range of city specifications, both compact and sprawled. This trend, however, is different for bus and rail systems. For bus systems, energy intensity *increases* as gross system land area increases [13.2]. In contrast, energy intensity *decreases* as system land area increases for MRT/LRT systems [13.1]. This apparent difference can provide some insight into the relationship between land use patterns and traveller behaviour for rail and bus systems. In terms of urban design and transport development, it might intuitively suggest that bus transport is more efficient for compact dense cities, while rail transport may be more effective as a long-distance travel mode.

In general, these findings broadly commiserate with the findings from Phase I. Similar trends are identifiable; however, they are not as robust. As previously mentioned, most of these trends are only evident when US systems are included into the analysis. Asian and Canadian systems, on their own, do not necessarily reveal the same pattern. What this reveals is that the variables investigated in this analysis may not have the same importance across national and regional borders. As such, stronger findings may be detected on an economy-specific basis, similar to the results noted in the US focused phase of this study.



13.1,2 **Different trend between gross system service land area and energy intensity across modes**

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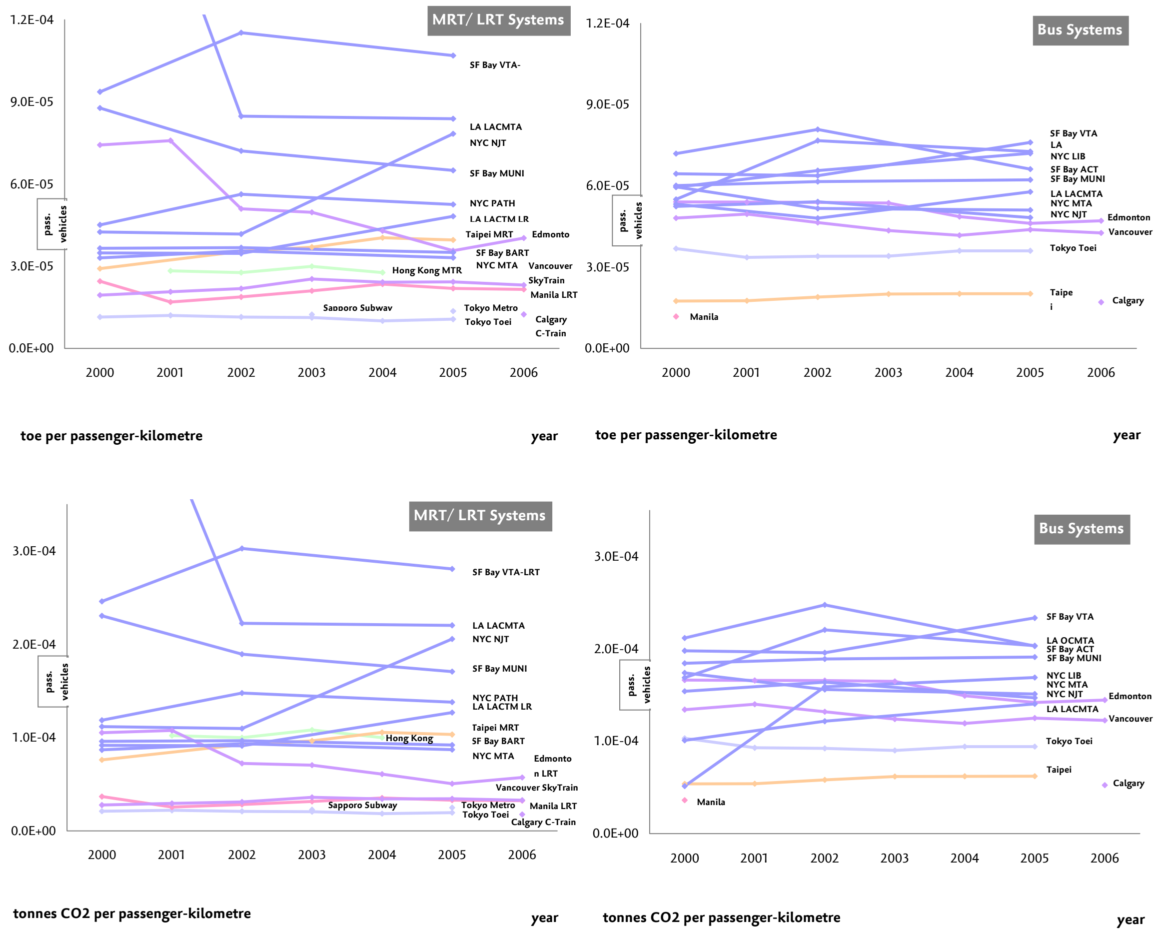
URBAN MASS TRANSIT: ENERGY & CO_2 EMISSION INTENSITIES

Data reveals that a transit system's energy intensity rank could be different from its CO_2 emission rank. For example, transit systems might perform relatively poor in terms of energy intensity, but perform relatively well in terms of CO_2 emissions intensity. This is observed when the original fuel inputs for the final energy used by that transit system include less fossil fuel, and is most evident among MRT/LRT systems. Similarly, CO_2 emissions analysis penalizes buses relatively more than rail, especially in economies where grid-wide electricity generation mix itself is comparatively clean or comprised of a smaller percentage of fossil fuel sources.



14.1 Historical energy and CO_2 emissions intensity across modes

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> It is important to note that different mass transit modes within a city may influence each others energy intensities. Tokyo's rail systems, Toei and Tokyo Metro, are two of the least energy intensive systems in the data set; however this may be at the expense of a less effective bus system, which shows approximately triple the energy intensity.

Conversely, rail systems can exhibit high CO_2 emission intensities (relative to their energy-equivalent intensities) if their respective economy's power generation relies heavily on fossil fuels. For example, Hong Kong's rail system, the Hong Kong MTR, performs less well in terms of emissions intensity due to the high concentration of coal in Hong Kong's electricity generation mix. Canadian systems, on the other hand, outperform certain Asian systems because of the economy's greater use of hydro and other renewables. It must be noted, however, that emissions intensity is based on each economy's average power generation mix—that is, examining the amount of power supply in the economy-wide grid to be "replaced" as a result of transit system operation. Transit systems that do not purchase electricity from the national grid may fare better or worse depending on their local electricity profile.

14.2 Several transit systems in a city— complement or conflict?

ECONOMY	CITY	SYSTEM NAME	FUEL SOURCE	PASS-KM	ENERGY INTENSITY (TOE/ PASS-KM)	CO2 INTENSITY (TONS CO2/PASS-KM)	OPERATOR
Canada	Calgary	Ctrain	E	4.91E+08	1.24E-05	1.76E-05	Calgary Transit
	Vancouver	SkyTrain	E	6.27E+08	2.29E-05	3.24E-05	TransLink
	Edmonton	Edmonton LRT	E	4.77E+07	5.12E-05	7.26E-05	Edmonton Transit System
Chinese Taipei	Taipei	Taipei MRT	E	2.59E+09	3.64E-05	9.49E-05	Taipei Rapid Transit Corp
Hong Kong, China	Hong Kong	Hong Kong MTR	E	6.21E+09	2.84E-05	1.03E-04	MTR Corporation
Japan	Tokyo	Toei Subway	E	4.97E+09	1.12E-05	2.04E-05	Tokyo Metropolitan Bureau of Transportation
		Tokyo Metro	E	1.56E+10	1.36E-05	2.49E-05	Tokyo Metro Co., Ltd.
	Sapporo	Sapporo Municipal Subway	E	1.19E+09	1.24E-05	2.26E-05	Sapporo City Transportation Bureau
Philippines	Manila	Manila LRT Line 1	E	1.43E+09	2.12E-05	3.17E-05	Light Rail Transit Authority (LRTA)
USA	SF Bay Area	VTA LRT	E	5.51E+07	1.05E-04	2.76E-04	Santa Clara Valley Transportation Authority
		MUNI Light Rail	E	1.86E+08	7.45E-05	1.96E-04	San Francisco MTA
		BART	E	1.94E+09	3.61E-05	9.49E-05	San Francisco Bay Area Rapid Transit District
	Los Angeles	LACMTA Heavy Rail	E	2.21E+08	1.10E-04	2.88E-04	Los Angeles County MTA (LACMTA)
		LACMTA Light Rail	E	3.79E+08	3.99E-05	1.05E-04	Los Angeles County MTA (LACMTA)
	New York City	Newark Light Rail	E	1.87E+07	5.64E-05	1.48E-04	NJ Transit
		PATH	E	4.75E+08	5.07E-05	1.33E-04	Port Authority of NY and NJ
		MTA-NYCT (NYC subway)	E	1.32E+10	3.39E-05	8.90E-05	MTA New York City Transit

ECONOMY	CITY	SYSTEM NAME	FUEL SOURCE	PASS-KM	ENERGY INTENSITY (TOE/ PASS-KM)	CO2 INTENSITY (TONS CO2/PASS-KM)	OPERATOR
Canada	Edmonton	ETS Bus	D	3.03E+08	5.06E-05	1.55E-04	Edmonton Transit System
	Vancouver	TransLink Bus	D,C,E	8.25E+08	4.48E-05	1.27E-04	TransLink
	Calgary	Calgary Transit Bus	D	1.12E+09	1.71E-05	5.24E-05	Calgary Transit
Chinese Taipei	Taipei	Taipei Bus	D	5.06E+09	1.91E-05	5.88E-05	DOT, City of Taipei
Japan	Tokyo	Toei Bus	D,C	6.19E+08	3.51E-05	9.45E-05	Tokyo Metropolitan Bureau of Transportation
Philippines	Manila		D	9.43E+09	1.18E-05	3.62E-05	[DOT City-wide Estimate]
USA	SF Bay Area	VTA Bus	D	2.59E+08	6.72E-05	2.06E-04	Santa Clara Valley Transportation Authority
		AC Trans Bus	D,G	3.15E+08	7.29E-05	2.23E-04	AC Transit
		MUNI Bus	D	3.24E+08	6.13E-05	1.88E-04	San Francisco MTA
	Los Angeles	OCTA Bus	D,L,E	3.73E+08	6.90E-05	1.99E-04	Orange County Transportation Authority
		LACMTA Bus	D,G,C	2.16E+09	5.30E-05	1.36E-04	Los Angeles County MTA (LACMTA)
	New York City	MTA Long Island Bus	D,C	2.49E+08	6.58E-05	1.60E-04	Metropolitan Suburban Bus Authority
		NJ TRANSIT Bus	D,C	1.40E+09	5.15E-05	1.56E-04	NJ Transit
		MTA-NYCT (NYC Bus)	D,C	2.87E+09	5.37E-05	1.61E-04	MTA New York City Transit

15.1 **APEC urban mass transit agency operating statistics**

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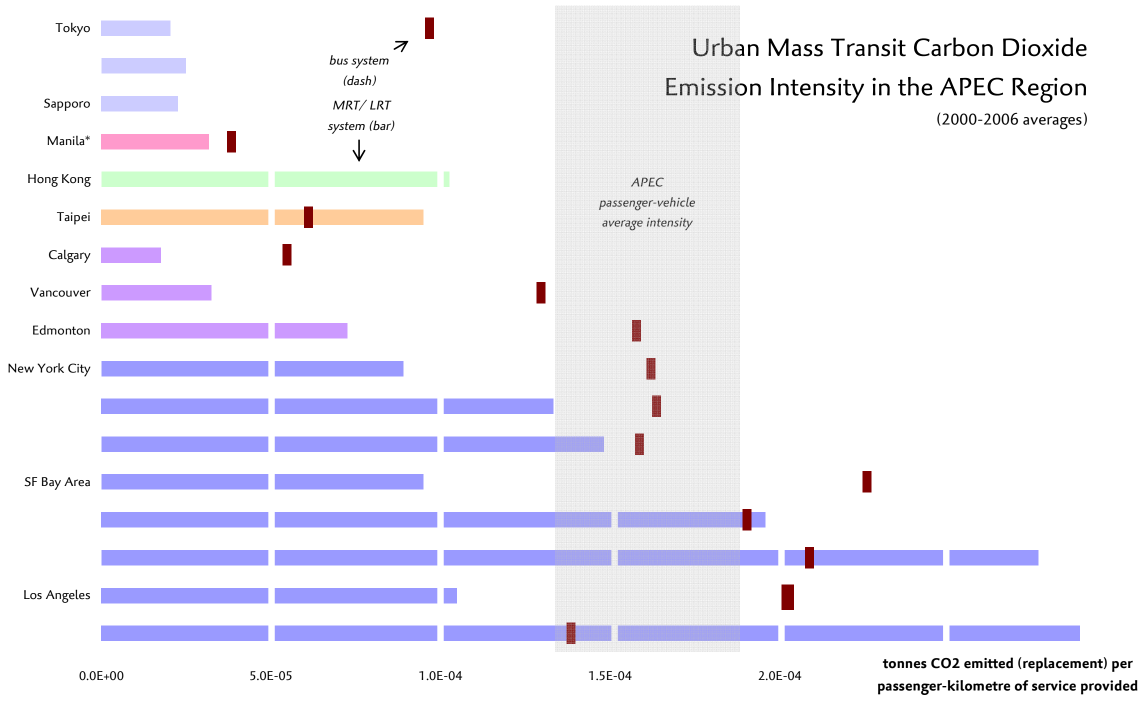
Reducing CO_2 emissions intensity, although important, may not be the single most important objective for transport planners. In cities with limited fuel resources, reducing energy intensity may be a priority. In this case, the variability among urban mass transit energy intensity statistics might seem more informative. These statistics show a wide variation of intensities for bus and rail networks, both on a city and regional level, and across modes within a city. Again, in most cases, data shows that Asian and Canadian mass transit systems are less energy intensive than US mass transit systems.

Ultimately, the discerning efficiency criteria for a mass transit system and its effectiveness differs according to the project's objective and means of measurement, whether it is energy use, global environment, or local environment. Thus, transport planners should take into account these differences when developing mass transit networks.



16.1 Urban mass transit CO_2 emission intensity across modes

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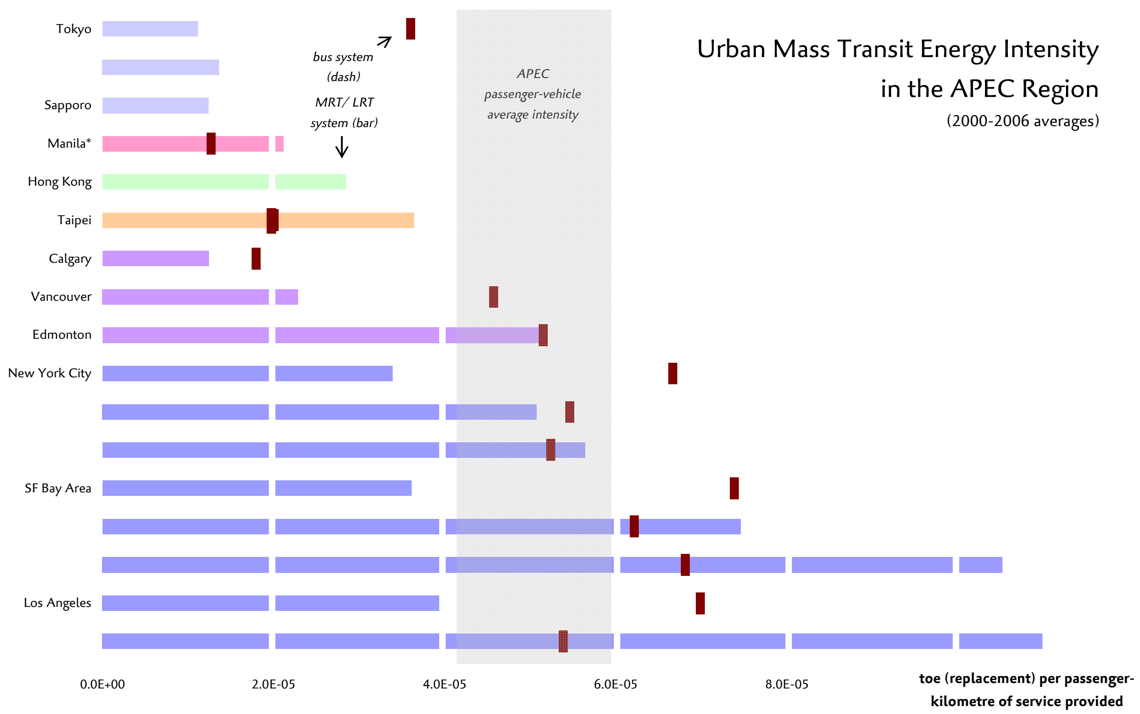

16.2 Urban mass transit energy intensity across modes

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IMPLICATIONS

APEC region policy makers aim for substantial energy and CO_2 emission savings in the future. And while development of urban mass transit has the potential for considerable savings, these are not necessarily achieved in practice. Therefore, to understand, evaluate, and ultimately reduce energy and CO_2 intensities in the field first requires collection, reporting, and analysis of the relevant data. This requires, on a system-by-system basis, knowing both service consumed (on a passenger-kilometre basis), the amount of total energy consumed to provide that service, as well as the carbon profile of that energy.

The transit systems outlined in this study will ultimately be able to improve their intensity performance because they have already taken this first step. Many other urban mass transit systems around APEC were not presented here because their respective operating agencies or overseeing government bureaus do not collect or report these important data; for such systems, energy intensity-related data collection and analysis should be a priority. APEC urban areas developing new mass transit systems today should ensure that extra funding and reporting structures are provided alongside other infrastructure budgets that ensure the collection and propagation of such data. It is likely that the worst performing systems in APEC are the ones that do not even realize it.

ENERGY INTENSITY

Energy intensities of urban mass transit systems throughout APEC vary widely. And it is clear that no single characteristic or usage pattern dictates the potential for an urban area to reduce its transportation energy use or CO_2 emission through mass transit. So while this means that there is no guaranteed way to ensure low energy intensity, it also means that no single urban characteristic should preclude the development of urban mass transit with regard to energy use. Nonetheless, consideration of a few key variables can increase the likelihood of achieving substantial reductions.

Contrary to popular belief, even urban areas with low population densities can achieve energy and emission reductions by developing mass transit systems—be they rail or bus. Bus systems, however, seem to be a safer choice for the most sparsely populated urban areas because buses perform more in line with passenger vehicles. For example, even though non-dense urban rail systems in Calgary and Vancouver perform well, other non-dense urban rail systems in Los Angeles and the San Francisco Bay Area perform appreciably worse than a passenger vehicle. Bus systems, on the other hand, performed in line with passenger vehicles in those same cities with energy intensive rail systems.

Urban areas with higher population densities should not neglect bus systems (buses consistently perform even better as population density rises), however such areas are likely to reap even more energy and emission savings through a high-volume rail system. Fore example, densely-populated Hong Kong, New York City, Tokyo, and Manila all provide high-volume transport services with lower energy intensity than passenger vehicles through the use of MRT and LRT systems.

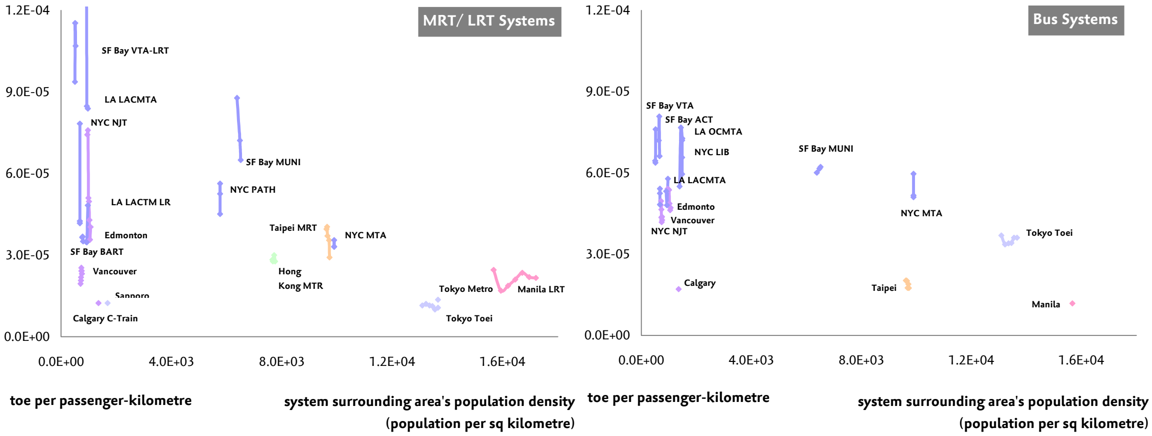
Comparison among transport systems is only the first step to understanding the real-world potential of these systems. To be truly useful, a modal comparison should not exclude passenger vehicles. Data shows that compared to passenger-vehicles, Asian and Canadian transit systems, both bus and rail, are generally less energy intensive than APEC's average passenger vehicle intensity. In Canada, the rail systems investigated predominately fare better than the bus networks. The US statistics reveal that rail systems tend to outperform passenger vehicles; however bus systems are about equal in energy intensity to passenger vehicles.

Similar trends are seen among passenger vehicles and emission intensities. Asian and Canadian systems generally perform better than the average emissions range for APEC passenger vehicles. US systems, however, tend to be comparable or more emission intensive than APEC's average passenger vehicle emissions range.

It is important to reiterate that the passenger vehicle average is derived from data corresponding to the US, Japan, and Chinese Taipei. It is merely intended to represent an expected general distribution for the APEC region and should not be deemed precise and inclusive of all passenger vehicle fleets.

17.1 **Mass transit systems vs. passenger vehicles, a modal comparison**

Despite the fact that urban land area and transit system size are quite different among these densely-populated cities, they all achieve low mass transit energy intensity. Again, sparsely-populated urban areas can perform extremely well with rail systems, but they can also perform extremely poor or have extreme variability in performance between years. Densely-populated urban areas, on the other hand, tend to perform consistently well, year after year, with rail transit systems.



18.1 **Urban mass transit energy intensity and population density, trend across modes**

APERC 2008

So while population density does seem to be important, the gross land area and total urban population served by one transit system are less clearly so. Data is mixed, and what is important for policymakers is that an urban area's size or population, taken alone, does not dictate a mass transit system's energy performance, and so should not be used to argue against the development of mass transit — after all, Calgary's bus and MRT systems outperform Tokyo's bus and MRT systems, despite Calgary having one-ninth the service population.

FUEL SWITCHING

As described in the Phase I study, although the amount of energy savings from deploying urban mass transit systems does vary depending upon factors outside the control of policymakers or planners, the potential for fuel switching through urban mass transit systems is rather straightforward. The more urban dwellers' trips taken by mass transit, the more a planner can influence transportation fuel use for the urban area as a whole. This is particularly valuable if trying to diversify urban transportation fuel sources, improve fuel quality, control local air pollutants, or reduce CO_2 emissions.

CARBON DIOXIDE (CO2) EMISSIONS

CO_2 emissions are determined by both the amount and type of energy consumed. In general, urban mass transit allows for emission reductions in both regards; energy intensity per unit travel consumed can be reduced from passenger vehicle levels for both bus and rail, and CO_2 emission intensity per unit of energy output of the fuels used for both bus and rail systems can be reduced from that of gasoline. Considering this control, policymakers and planners could design more locally optimal transit systems in view of available fuel options and the desired level of CO_2 reduction.

An urban area with ample wind or nuclear power resources may consider development of a rail-based transit system to consume locally produced electricity in order to capture that comparative advantage. Likewise, an urban area that relies on coal power might prefer an extensive diesel or natural gas bus system from a CO_2 emission perspective.

Consider, Edmonton, Canada— a relatively sparsely-populated prairie city with only about 700,000 people. With such characteristics, a bus system might be more desirable than a rail system from an energy and emission perspective. However, Edmonton operates both; the bus system has essentially the same energy intensity as a passenger vehicle, and the small LRT system of only 10 stations is also about the same. However, considering Canada's low carbon power generation mix, Edmonton's LRT is in fact extremely successful at reducing CO_2 emissions on a national power-grid substitution basis— the LRT's emission intensity is actually less than half that of its bus system and passenger vehicles in general, even outperforming more obvious Asian systems in Hong Kong and Taipei.

Such savings are not limited to those areas well-endowed with low carbon power resources. New York City, for example, was able to reduce the carbon footprint of its rather energy-intensive bus system by using CNG in its road fleet. This relatively environmentally-friendly fuel choice shifted its bus system from being worse than passenger vehicles from an energy standpoint, to being essentially equivalent from a CO_2 emission perspective and even more desirable from a local environmental air quality perspective. This is a powerful shift.

Again, urban mass transit should be viewed as an attractive tool for policymakers, planners, and managers to exert extended control over the transport profile of their respective urban areas—including transport energy use. But, it is a tool, and not an ends in itself. Bus or rail mass transit systems have great potential to reduce an urban area's overall transport energy use and CO_2 emissions relative to passenger vehicles, but such reduction should not be taken for granted through planning or operation. Just as outlined through the analysis above, highlighting and taking advantage of an urban area's particular characteristics can have large energy or emission payoffs to complement the other valuable non-energy benefits provided through development of urban mass transit. Put another way, just as development of urban mass transit is a key component of energy management, development of energy management should be recognized as a key component of urban mass transit.

FACTORS AFFECTING URBAN MASS TRANSIT RIDERSHIP

INTRODUCTION

As the previous chapter identified, ridership is a critical factor that can help improve the energy/CO_2 intensities of MRT/LRT systems. In addition, an increase in ridership is essential for the financial sustainability of a mass transit system. Since a MRT/LRT system's fare tends to be kept low for socioeconomic reasons in many APEC economies, an increase in ridership is the only remaining option for improving financial performance. So, how can we increase ridership?

Passengers' choice of transport mode is based on a number of factors, including safety, comfort, reliability, and accessibility. Passengers routinely choose a transport mode by taking into account its time and cost relative to alternative transport modes. Also planners' decisions on system frequency, capacity, and location of MRT/LRT systems can change ridership levels. In other words, ridership results from complex interactions between both demand and supply factors.

Out of these numerous factors, this chapter considers mainly five factors that affect ridership and attempts to draw implications for planners and operators on how to increase ridership. The factors analysed in this chapter are:

- Ridership and travel time cost,
- Ridership and accessibility,
- Ridership and population density,
- Ridership and system integration, and
- Ridership and fare.

RIDERSHIP AND TRAVEL TIME COST

Travel time is an important factor that easily attracts passengers whose time value is relatively high. MRT/LRT systems can transport passengers swiftly, as these are outside of the effect of traffic congestion. During peak hours, the speed of MRT/LRT systems ranges from 30 to 40 kilometres per hour, while that of passenger vehicles (in a congested road) may range from 10 to 20 kilometres per hour.

From the passengers' perspectives, however, mode choice may not solely depend on the travel time of a particular train or passenger vehicle. In the case of commuting, for example, passengers determine their modal choice by calculating the total time required (inclusive of accessing, transiting, and actual riding time).

The total travel time for commuting can be divided into the following three phases: (1) collection phase, (2) travel phase, and (3) distribution phase. For example, the collection phase for MRT/ LRT travel includes travel time from a home to the nearest station (including

Based on a study by O'Sullivan (2000), the following assumptions are used for the hypothetical case:

- Travel time cost per minute in a train/vehicle = USD 0.1.
- Collection/distribution time cost for MRT/LRT = USD 0.3.
- Operating cost of a passenger vehicle = USD 2.
- Parking cost = USD 3.

Based on a review of the average fares for major MRT/LRT systems in APEC, the fares for bus and MRT/LRT are assumed at USD 1.

21.1 **Cost of travel time assumptions**

APERC 2008, O'Sullivan 2000

waiting time in a station). The travel phase entails time in a train and the distribution phase involves the travel time required for a passenger to walk to a work place from the final destination of each transport mode (such as a parking spot, bus stop, or train station).

Monetary cost is also an important criterion for modal choice. Monetary cost refers to a passenger vehicle's operational cost, including parking cost, or the fare of the mass transit mode.

To understand the relative importance of travel time and monetary cost with respect to modal choice, a monetary value is assumed for the time spent for commuting. According to Small (1992), passengers value time spent in a transport mode at about half of their wages, while they value walking time about two to three times higher than the time in a transport mode. Using the formulae presented by Small (1992) and O'Sullivan (2000), a hypothetical case for a passenger to travel about 16 kilometres is constructed to provide a comparison of the total value of travel by various transit modes [22.1]. For MRT/LRT travel time, two cases are set: Case 1 represents a relatively good station accessibility and Case 2 represents a poor station accessibility relative to Case 1.

	PASSENGER VEHICLES	BUS	MRT/LRT (CASE 1)	MRT/LRT (CASE 2)
COLLECTION TIME COST				
COLLECTION TIME (MINUTES)	0	10	4	15
COST PER MINUTE (USD)	0.3	0.3	0.3	0.3
COLLECTION TIME COST (USD)	0	3	1.2	4.5
TRAVEL TIME COST				
TRAVEL TIME (MINUTES)	40	50	30	30
COST PER MINUTE (USD)	0.1	0.1	0.1	0.1
TRAVEL TIME COST (USD)	4	5	3	3
DISTRIBUTION TIME COST				
DISTRIBUTION TIME (MINUTES)	0	5	5	10
COST PER MINUTE (USD)	0.3	0.3	0.3	0.3
DISTRIBUTION TIME COST (USD)	0	1.5	1.5	3
MONETARY COST				
OPERATING COST OR FARE (USD)	2	1	1	1
PARKING COST (USD)	3	0	0	0
TOTAL MONETARY COST (USD)	5	1	1	1
TOTAL TIME COST (USD)	4	9.5	5.7	10.5
TOTAL COST (USD)	9	10.5	6.7	11.5

22.1 **Comparison of travel cost**

APERC 2008, O'Sullivan 2000

This hypothetical case shows that MRT/LRT systems (both Case 1 and Case 2) offer the least cost option in terms of travel time value; however, total cost ranges from USD 6.7 (Case 1 of MRT/LRT) to USD 11.5 (Case 2 of MRT/LRT). Compared with the total travel cost of the MRT/LRT in Case 2, for example, total travel cost of a passenger vehicle and bus is lower at USD 9 and USD 10.5, respectively. The exercise suggests that unless there is good station accessibility, at both the starting point and ending point of travel, passengers may be unlikely to choose MRT/LRT systems as their travel option. Therefore, time spent in the collection and distribution phase may impact passengers' modal shifts more than travel time.

There are other factors that can produce modal shifts. An increase in the operational cost of passenger vehicles, through the provision of additional taxes such as road pricing, increases the overall cost of passenger vehicle use. Also, regulation on parking may add further cost to passenger vehicle operation. Thus, more effective policies could be drawn to increase ridership, if appropriate measures are taken in combination to discourage the use of the alternative transport modes, i.e. passenger vehicles.

RIDERSHIP AND ACCESSIBILITY/SERVICE AREA POPULATION DENSITY

In the previous section, it was shown that accessibility is a factor that may change passengers' decision on transport mode. If a MRT/LRT system is developed in a manner that provides passengers with easy access, possibly within walking distance, ridership can increase significantly.

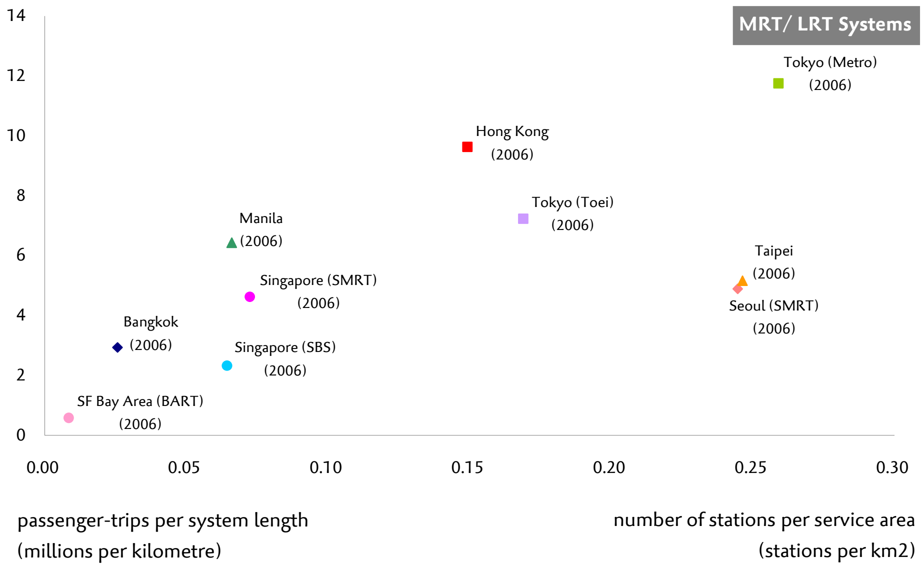
From the planners' point of view, where to locate a MRT/LRT system is an important decision to help maximise ridership and to operate the system in a financially sound manner. Planners of MRT/LRT systems should, if possible, choose the location of stations where they can attract the highest possible passengers, such as in the city centre. Putting the system in a wrong place would easily result in a loss in the number of passengers. Therefore, it is necessary for planners to develop (1) easy access locations for passengers and carefully examine an appropriate location that has a (2) relatively high population density.

A link between accessibility and increased ridership seems logically tenable; however, is there empirical evidence that supports

1. A positive correlation between ridership and accessibility, and

2. A positive correlation between ridership and population density?

To verify the aforementioned respective relationships, data from the annual reports of some MRT/LRT systems within APEC is collected for two correlation analyses. Three indicators are created to allow comparison between different infrastructure levels. First, as a proxy of ridership, the number of passengers is divided by the MRT/LRT system's system length. This indicator, hereafter called *ridership indicator*, shows how intensively the system is utilised. Second, as a measure of accessibility, the number of stations per service area is calculated. This indicator, hereafter called *accessibility indicator*, gauges how easy it is to reach a station within a given service area. Third, service area population density is used, as an indicator, to evaluate the potential passenger demand within an area that MRT/LRT services are offered.



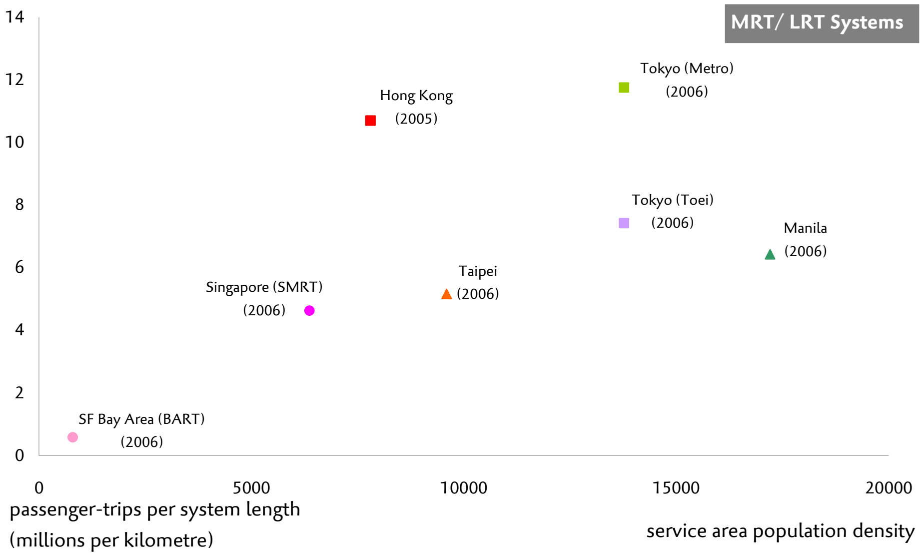
24.1 **Relation between the accessibility and ridership indicator**
APERC 2008

A positive correlation between the *accessibility indicator* and *ridership indicator* is evident, as shown in [24.1]. It should be noted that the presence of supporting systems within the same service territory, whether bus or rail, can impact the ridership indicator. This exercise, nevertheless, does not factor in the availability of supporting transport systems.

Nevertheless, this effect can still be noticed within the data. For example, the *accessibility indicator* of Seoul (SMRT), Taipei, and Tokyo (Metro) are approximately at the same level, however, the *ridership indicator* of Seoul (SMRT) and Taipei is about half of Tokyo (Metro)'s. In addition to good accessibility to infrastructure, Tokyo (Metro)'s high ridership is explained by its direct connections to suburban railways. Such links with suburban railways enable passengers from Tokyo's outskirts to travel to the urban centre, thereby increasing the ridership level.[a]

[a] *APERC 2007.*

A positive correlation is also observed between service area population density and the *ridership indicator* [25.1]. However, the statistical result of this analysis provided a relatively low R^2 of 30 percent, suggesting that there are other factors explaining the ridership level.



25.1 **Relation between service area population density and the ridership indicator**

APERC 2008

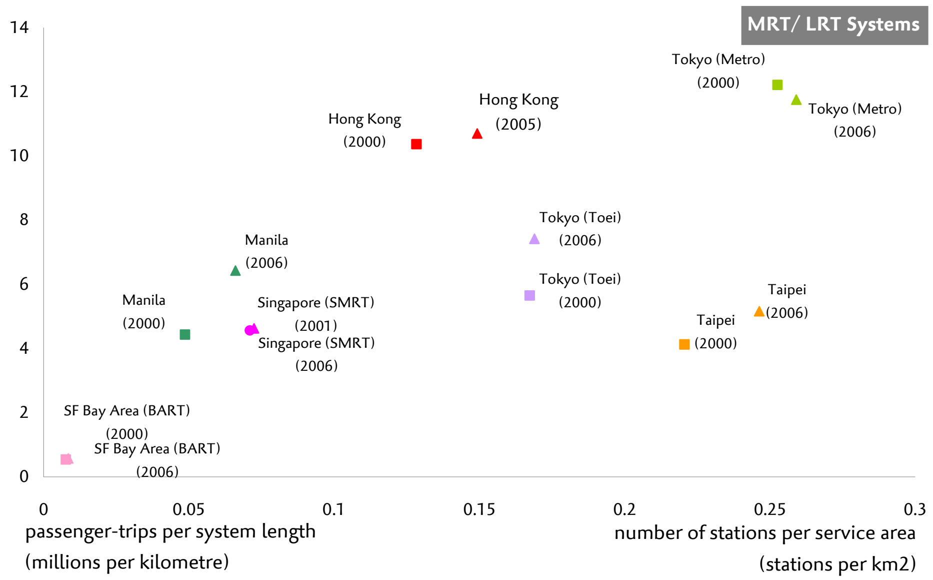
This case study demonstrates that high population density is an important factor, along with accessibility, in determining ridership. The accessibility and ridership indicator analysis [24.1] shows that Manila and Singapore (SBS) have approximately the same value in terms of *accessibility indicator*; however, Manila's *ridership indicator* is almost two times higher than that of Singapore (SBS). This difference in ridership, as shown in [25.1], is attributable to Manila's high service area population density, which is almost three times higher than that of Singapore.

It is important to note that enhancing accessibility to MRT/LRT systems may not necessarily translate into an increase in ridership. For example, in the San Francisco Bay Area, the population is scattered throughout an urban land area of about 15,000 km^2, which is more than two times larger than that of Tokyo and five times larger than that of Hong Kong. As a result, its population density is naturally lower than that of Tokyo or Hong Kong. Therefore, in places with similar geographical characteristics to the San Francisco Bay Area, enhancing accessibility will not necessarily result in an increase in ridership.

HISTORICAL TREND IN RIDERSHIP

How has ridership of MRT/LRT systems within APEC evolved over the years? What are the factors that contributed to this historical trend in ridership? To answer these questions, the recent position of the *ridership indicator* relative to that of *accessibility indicator* is compared with that of previous years [26.1].[b] Comparison between recent data and historical data offers interesting insights into the factors that affect ridership.

[b] *Depending on data availability, time periods are different from case to case.*



26.1 **Evolution of relation between the accessibility and ridership indicator**

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Hong Kong's *ridership indicator* increased from 10.3 million passengers per system length in 2000 to 10.7 million passengers per system length in 2006. Between 2000 and 2006, the magnitude of increase, in terms of the *ridership indicator*, appears rather small at 3 percent. This is because Hong Kong's indicator in 2000 already reached one of the highest levels among the studied systems, surpassing 10 million passengers per system length.[c] Therefore, the addition of 7 stations in the outskirts of Hong Kong during the same time period did not significantly change this indicator.

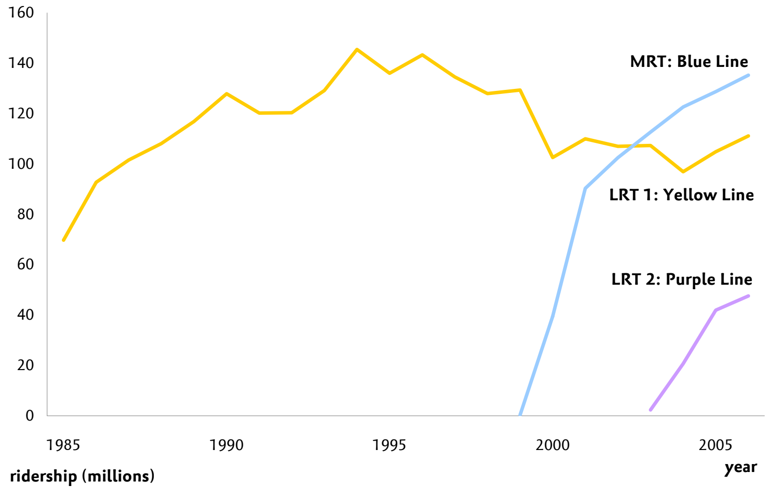
In 2006, the highest level of total passengers, since the opening of Hong Kong's MRT, was recorded at 856 million. This was approximately a 12 percent increase from the 2000 level.

Manila's *ridership indicator* increased nearly 45 percent from 4.4 million passengers per system length in 2000 to 6.4 passengers per system length in 2006. In [26.1], both increases in the *ridership indicator* and *accessibility indicator* are clearly visible.

With the opening of a new LRT line (Purple Line) in 2003, there was an addition of 11 new stations. However, the major increase in ridership came from the MRT line, called the Blue Line. The ridership of the Blue Line in 2006 more than tripled from the level in 2000 and this line's ridership growth accounted for about 60 percent of the total incremental growth in Manila's MRT/LRT ridership (2000-2006) [27.1]. The ridership increase for the Blue Line is attributable to a reduction in fare from Php 34 in 2000 to Php 10 (at minimum) in July 2002.[d]

[c] *In 2000, Hong Kong's ridership indicator was the second highest after Tokyo Metro.*

[d] *The fare of other lines remained constant during the same time period.*



27.1 **Manila MRT/LRT ridership trend**

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Taipei's *ridership indicator* increased from 5.2 million passengers per system length in 2000 to 7.2 million passengers per system length in 2006. This change seems to be linked to an increase in the accessibility level. Between 2000 and 2006, Taipei's MRT added 7 stations that enhanced the links between the residential suburban areas and the urban centre. With the addition of 7 stations, the total system length increased from 65.1 kilometres in 2000 to 74.4 kilometres in 2006, and the MRT's passengers increased to 384 million (a 43 percent growth from the 2000 level).

Tokyo Toei's *accessibility indicator* reached 7.4 million passengers per system length in 2006, a 31 percent increase from the 2000 level. Despite the addition of only one station, the *ridership indicator* improved substantially because the added station serves a newly-built, passenger intensive, business and shopping complex.

From 2000 to 2006, **Tokyo Metro**'s *ridership indicator* dropped by 4 percent, despite an increase in the *accessibility indicator*. Indeed, Tokyo Metro added 4 stations between 2000 and 2006 and the total system length increased from 167 kilometres in 2000 to 183 kilometres in 2006, while the total number of passengers reached 2,150 million in 2006 from 2,042 million in 2000. Similar to the Hong Kong case, Tokyo Metro's *ridership indicator* was one of the highest, at 12.2 million per system length in 2000. Therefore, the addition of stations, particularly at the periphery, did not improve the *ridership indicator* level.

In certain systems, the SF Bay Area (BART) and Singapore (MRT), the *accessibility indicator* did not significantly change over the studied years. Likewise, the ridership level stayed almost the same.

RIDERSHIP AND SYSTEM INTEGRATION

In the previous section, the case of Tokyo showed that integration with other transport modes, such as suburban rails, is an important element that can affect ridership. Suburban rails can transport

In Seoul, when passengers transfer between the MRT system and buses, there is no additional charge (up to five changes) as long as the distance is kept within 10 kilometres to which basic fare applies. Beyond 10 kilometres, the passengers will be charged extra for every additional 5 kilometres travelled. In Singapore, rebates are given to passengers making transfers between different modes (TransitLink). In Taipei, passengers using the *smartcard* automatically receive a free bus ride when transferring from the MRT system to a bus.

28.1 **Ridership and system integration practices in APEC**
APERC 2008

passengers to the nodal MRT/LRT station, and enable passengers a relatively easy transfer to the urban core area.

Aside from rail, the role of bus should not be disregarded in evaluating MRT/LRT system ridership. Bus is assumed to help MRT/LRT system ridership improve if it is effectively managed. In a place where access to MRT/LRT systems is limited, buses can play a complementary role and allow multi-modal transfer (use of both bus and other transport modes within a single journey).

The major ways of integrating MRT/LRT systems with bus systems are through fare integration and connections between MRT/LRT stations and bus route networks.

The most notable method is fare integration of MRT/LRT systems and buses. A *smartcard* transit fare system (a rechargeable stored value card) can facilitate passengers' transfer smoothly by reducing actions such as buying tickets for every ride. Some APEC cities have adopted or will adopt the smartcard system. For example, compared to a cash fare for each trip, smartcard holders in Hong Kong, Seoul, Singapore, and Taipei enjoy discount fares. In addition, the use of these cards brings cost savings to passengers who transfer between MRT/LRT systems and bus in Seoul, Singapore, and Taipei.

A linkage with the bus route network is another critical strategy in the integration of MRT/LRT systems and bus systems. In general, the bus network usually consists of quite a few routes with trunk and feeder services and serves areas isolated from MRT/LRT stations. If the MRT/LRT systems are integrated into the bus route network, passengers will consider taking a bus to a MRT/LRT station. An extension of the bus route network, to connect it to the MRT/LRT stations, is one way to effectively increase MRT/LRT ridership.

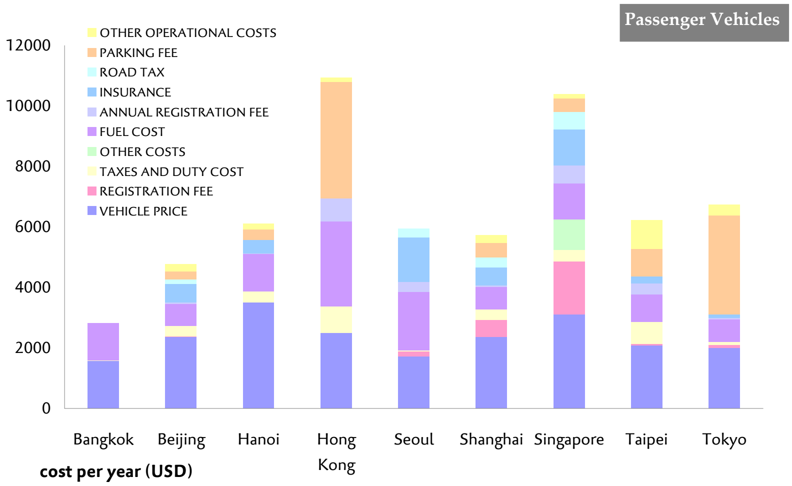
RIDERSHIP AND FARE

A system's fare is supposed to effectively represent the per passenger requirements of (1) capital cost, (2) operational cost, and (3) interest payments. Due to socio-economic concerns, however, fares are maintained low so that a city's MRT can serve the wider general public. Fouracre et al. (1990) showed that MRT operators recognise the need to maintain fares at affordable levels, even if they are financially constrained to achieve the objective of covering their annual costs.[e]

[e] *Fouracre, Allport, and Thompson 1990.*

Empirically there is a significant negative correlation between ridership and fare. According to Beesley and Kemp (1998), estimates of short-run ridership elasticities, with respect to fare, vary within the range of – 0.1 to – 0.7, with most of the estimates concentrating between – 0.2 and – 0.5. What this means is that when fare is increased by 10 percent, ridership may fall by 2 to 5 percent in most cases.

In general, ridership elasticity, with respect to fare, changes with (1) the availability of alternative transport modes, (2) the fare of alternative transport, and (3) the degree of travel necessity. In other words, in locations where alternative transport is limited and the travel purpose is *commuting*, fare elasticity tends to be low. Put another way, ridership is not affected as much by an increase in fare. Similarly, ridership elasticity to fare may be low if the cost of an alternative transport mode, such as a passenger vehicle, is higher than that of the MRT/LRT system.



29.1 **Annual cost of passenger vehicle ownership**

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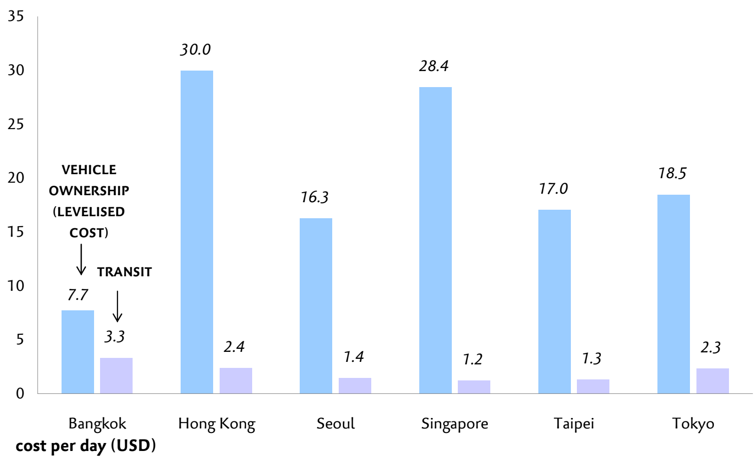
As the cost of alternative transport increases, ridership elasticity, with respect to fare, decreases. In certain cities (Hong Kong, Seoul, and Tokyo) where vehicle operational cost (including fuel price and parking cost) is higher than other less affluent cities, riders' elasticity to fare may remain low [29.1]. In Bangkok, the operational cost of passenger vehicles is lower than other cities due to the absence of parking fees and smaller tax requirements on passenger vehicle ownership. And, the gap between the cost of a passenger vehicle and transit fare is narrower in Bangkok than other cities [29.2]. Therefore, Bangkok's passengers may choose to rely on passenger vehicles rather than mass transit– even if there is a small reduction in fare.



29.2 **Daily cost of passenger vehicle use vs. transit**

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IMPLICATIONS

Among the wide range of factors discussed, cost of MRT/LRT system use, including both monetary and travel time cost, is identified as the basis for passengers to decide a transit mode. Out of these cost elements, in an effort to increase ridership, planners/operators may need to lower the *time cost* at both the collection and distribution phase through enhancing passengers' accessibility.

Accessibility can increase ridership, but not always. City-specific characteristics, such as population density, need to be carefully considered in addition to enhancing accessibility. In areas where population is scattered, enhancing accessibility to MRT/LRT may not necessarily translate into an increase in ridership.

Fare is an important determinant of ridership. However, as another option to increase ridership, the availability of competitive alternative transport should be factored in when considering fare adjustments. This is because, with an increase in fare, passengers' likelihood of changing transport mode, from a MRT/LRT to an alternative mode, tends to be low if the cost of using the alternative mode (such as a passenger vehicle) is higher than that of the MRT/LRT system. This finding provides some insight on the transport policies and measures that can be implemented on passenger vehicles to assist in increasing MRT/LRT ridership. These measures include taxes on passenger vehicle ownership, road pricing, and parking regulations. To maximise the ridership of MRT/LRT systems and fully realise their potential benefits, such as energy savings and CO_2 emissions reduction, it is important to implement a comprehensive policy approach that covers all aspects of energy and transport.

Mass transit ridership is affected by numerous demand and supply factors, including the presence of alternative transport modes. As such, ridership forecasts are a valuable planning component, before the development of a MRT/LRT system, since ridership is a key element to improving energy/CO_2 intensities and the financial performance of MRT/LRT systems. In other words, implementing MRT/LRT projects without a proper assessment of the factors affecting local ridership may predispose a project to failure.

FINANCIAL PERFORMANCE OF URBAN MASS TRANSIT

INTRODUCTION

Urban mass transit, in principle, can serve as a means to transport passengers in an efficient and timely manner. Compared with passenger vehicles, urban mass transit can transport a large number of passengers.

The following urban mass transit systems are included in this analysis:

- Mass Rapid Transit (MRT)
- Light Rail Transit (LRT)
- Bus Rapid Transit (BRT)

31.1 **Types of transit systems analysed**

Urban rapid mass transit systems utilise an exclusive fixed-track. As such, they are essentially outside of the effect of traffic congestion and can swiftly move passengers to a destination on time. They also have the potential to require less energy, compared with passenger vehicles, and fare per passenger tends to be lower than passenger vehicles.

In reality, however, these aforementioned gains are not always obtainable without good economics and an adequate level of ridership. A higher initial capital investment is often necessary to construct rail-based mass transit infrastructure, in contrast to road-based mass transit that utilises existing road infrastructure. Unless fully-fledged infrastructrue is in place to integrate a city's urban centre and suburban residential areas, use of mass transit tends to be low. Therefore, at the early stage of infrastructrue development or in locations with few operating lines, urban mass transit tends to face financial difficulties.

This chapter tries to identify and assess factors with which metropolitan areas can improve the financial performance of urban rapid mass transit systems. In order to address financial issues related to urban mass transit, the chapter presents the costs associated with developing mass transit systems, analyses the risks that affect the financial viability of these projects, and attempts to assess key factors that influence the financial viability of MRT systems.

OPTIONS FOR URBAN MASS TRANSIT

AN OVERVIEW OF URBAN MASS TRANSIT OPTIONS

Rapid mass transit systems operate on a fixed-track and usually have an exclusive right-of-way. Inter-system coordination is essential to maximise benefits, namely to rapidly transport passengers to a destination. In addition, construction and operation of mass transit systems requires coordination among various agencies that are responsible for land use, energy, environment, safety, and general transport issues.

Each rapid mass transit mode has different characteristics with respect to capital costs, operational capacity, speed, and construction time. The characteristics of each mode are summarised in [32.1].

	MRT	LRT	BRT
INITIAL CAPITAL COST (MILLION USD/KM)	15-30 AT GRADE	10-30	1-5
	30-75 ELEVATED		
	60-180 UNDERGROUND		
CAPACITY (PASSENGERS/ HOUR/DIRECTION)	60,000	10-12,000	10-20,000
OPERATING SPEED (KM/HOUR)	30-40	20	17-20
CONSTRUCTION TIME (YEARS)	10 YEARS FOR 19 KM LINE	-	-

32.1 **Cost of travel time assumptions**

Halcrow Fox 2000

MRT systems are defined as high capacity mass transit systems that have their own right of way and generally operate with high service frequency. Among the three mass transit modes analysed, a MRT system's capacity represents the highest, at about 60,000 passengers per hour per direction. Operating speeds range from 30 kilometres per hour to 40 kilometres per hour. The capital investment cost varies widely from a low of USD 15 million per kilometre (at grade) to a high of USD 180 million per kilometre (underground).

LRT systems have a lower passenger capacity than MRT systems. A typical system runs within a shorter operational distance and at slower speeds than a MRT system. It carries about 10-12,000 passengers per hour per direction, at an average operating speed of 20 kilometres per hour. The capital cost ranges from USD 10 million per kilometre to USD 30 million per kilometre.

BRT systems are high-speed bus systems that operate on an exclusive traffic lane. BRT systems combine the flexibility of bus systems and the high-speeds of rail systems. They can transport about 10-20,000 passengers per hour per direction, with a speed of 17-20 kilometres per hour. The capital investment cost is the lowest among the three urban mass transit options, ranging from USD 1 million per kilometre to USD 5 million per kilometre, since they can utilise existing road infrastructure.

There is no single optimal mass transit option for a specific area. The optimality may vary depending on city context —city size, population density, income level, and asset base. For example, cities with a relatively low income level (below USD 10,000) may choose BRT systems as an initial step towards the development of mass transit and build other systems (MRTs, LRTs, and suburban rail systems) as they develop. In the long-run, with inter-system coordination in place, these four rapid mass transit systems, along with a local/feeder bus service, can enable the smooth passage from one place to another.

RISKS AFFECTING THE FINANCIAL VIABILITY OF URBAN MASS TRANSIT PROJECTS

Despite the perceived benefits, urban rapid mass transit projects can often face financial difficulties. As the previous section described, developing rapid mass transit requires substantial initial capital. In addition, there are a series of risks in the construction and operation of these systems that can affect a project's financial viability.

These risks include:

- Cost overrun during construction,
- Low ridership compared to forecasts, and
- Financing and debt repayment.[a]

[a] P R Fouracre, and D A C Maunder 1999.

COST OVERRUN

Cost overrun is common in infrastructure development projects, such as urban rapid mass transit projects. It is caused by various factors including (1) unexpected ground conditions (applied to tunnelling costs), (2) increases in material and equipment costs, (3) disruptions in financial supply, and (4) shortages in labour supply. Often urban rapid mass transit projects require a lengthy pre-feasibility and feasibility period to fully assess a project's cost and risks.

In the case of a MRT system's design, underground conditions are essentially unknown unless construction is started. Cost can increase with changes in global market conditions, which sometimes affect financial and labour markets, leading to increases in material and equipment costs. Generally, urban rapid mass transit projects take more than a decade to be completed, if considered from the beginning of the planning stage, therefore, the final project cost can often be far beyond the initial estimate.

How large are these cost overruns? Are the cost overruns of urban mass transit projects higher than those for other types of transport infrastructure projects?

Flyvbjerg et al.'s (2003) study presents data on the degree of cost escalation for rail systems (high-speed, urban mass transit, and suburban rail), fixed links (tunnels and bridges), and road projects [33.1]. The study surveyed 258 completed projects around the world from 1927 to 1998, and compared the actual and the initially forecasted capital investment. The projects' capital investments were adjusted using constant 1995 prices.

	RAILS	FIXED LINES	ROADS	ALL PROJECTS
NUMBER OF CASES	58	33	167	258
AVERAGE COST ESCALATION (%)	44.7	33.8	20.4	27.6
STANDARD DEVIATION	38.4	62.4	29.9	38.7

33.1 Degree of cost escalation for transport projects

Flyvbjerg et al 2003

According to the survey, rail projects represent the highest degree of cost overrun at 44.7 percent, followed by fixed links at 33.8 percent, and roads at 20.4 percent.[b] It is interesting to observe that rail systems tend to incur higher cost overrun, since they require not only a higher capital investment than the others, but also more complex engineering design.

[b] Due to differences in sample size, a comparison of the three types of projects cannot be solely based on the degree of cost escalation.

LOW RIDERSHIP

Aside from estimating capital investment requirements, accurate ridership assessments also pose a challenge to project planners. Project planners often make an overly optimistic forecast on the number of passengers and this puts a project's financial viability at risk.

Some urban mass transit systems in Asia offer good examples of the potential extent of inaccuracy within ridership forecasts [34.1]. During its first year in operation, the actual ridership of Bangkok's Skytrain, for example, was a mere quarter of the forecasted number, which brought financial troubles to the project.[c] Likewise, Kuala Lumpur's STAR initially expected about 240,000 passengers per day, however in the first year, the number of passengers accounted for only a quarter of the forecast. In 2005, with the completion of the system, ridership almost doubled to reach 110,000 per year, however it is still well below the expected number of passengers. Manila's MRT3 also faced a similar outcome, as it only achieved about a third of its forecasted ridership level.[d]

[c] *Flyvbjerg et al 2005.*

[d] *Halcrow Group Limited 2004.*

	FIRST YEAR RIDERSHIP (PERCENTAGE SHARE OF RIDERSHIP FORECAST)
BANGKOK BTS	25% OF FORECAST
KL- STAR	25% OF FORECAST
MANILA MRT3	33% OF FORECAST

34.1 **Initial year ridership of systems in Asia**
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Cities in the US also find themselves in a similar predicament regarding ridership forecasts. Pickerell's (1989) study shows this overestimation in forecasted ridership, as it compares the forecasts and actual ridership of nine urban mass transit systems in the United States. The nine systems consisted of MRT systems in Washington D.C., Baltimore, and Miami; LRT systems in Buffalo, Pittsburgh, Portland, and Sacramento; and systems defined as the "downtown people-movers" in Miami and Detroit.[e] The study revealed that none of the nine systems transported more passengers than the original forecasted numbers. Washington D.C.'s MRT achieved the closest projection to actual ridership, at 70 percent of the original forecast level, while the other eight systems achieved between 14 to 46 percent of the forecasted values.

[e] *Downtown people movers are fully automated mass transit systems, which are grade-separated, generally serve within a small service area.*

FINANCING AND DEBT REPAYMENT

Several MRT systems have faced financing and debt repayment problems due to low economic viability, coupled with the sheer size of the required capital investment and long payback periods. In some cases, specifically in developing cities, the problems were exacerbated when a major part of the lending relied upon foreign currencies. For example, systems in Bangkok, Kuala Lumpur, and Manila experienced huge debt repayment problems as they faced the devaluation of their currency in 1997.

FINANCIAL PERFORMANCE OF URBAN MASS TRANSIT SYSTEMS

The financial viability of urban mass transit systems is a contested topic. Projections during a project's feasibility stage can vary greatly, ultimately contributing to either the approval or rejection of a project. What is the reality, post construction, when these systems are operational? Can systems be financially sustainable in cities across the APEC region- both developing and developed?

A glance at the financial performance of urban mass transit systems in major cities within the APEC region is presented, primarily focusing on MRT/LRT systems, with the objective to present real life examples of operational systems.

The city selection process, influenced by data availability, gathered examples from North America, Northeast Asia, Southeast Asia, and Oceania. The cities examined are as follows: Bangkok (Thailand), Hong Kong, China, Jakarta (Indonesia), Manila (the Philippines), San Francisco Bay Area (the USA), Seoul (Korea), Singapore, Sydney (Australia), Taipei (Chinese Taipei), and Tokyo (Japan).

	BANGKOK	HONG KONG	JAKARTA	MANILA	SF BAY*	SEOUL**	SINGAPORE	SYDNEY**	TAIPEI	TOKYO**
POPULATION (MILLION)	5.484	6.966	8.461	10.787	7.027	10.277	4.351	4.225	2.616	12.27
URBAN LAND AREA (KM^2) 1	700	0	662	636	17,933	605	699	12,144	134	621
INCOME (US$, PPP)	29,264	34,721	0	14,692	47,464	20,562	30,971	32,471	35,395	52,894

35.1 Selected cities in the APEC region

** 2004 data ** 2003 data [1] Total land area is used for SF Bay Area and Sydney.*
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METHODOLOGY

This analysis principally relies on the annual reports published by urban mass transit operating companies. It must be acknowledged, however, that certain systems were excluded from this financial review. This occurred in cases where operators reported the income statements of multiple modes within one consolidated form. Only operators that have released separate income statements for each mode are included in this review.

	BANGKOK	HONG KONG	MANILA*	SF BAY (BART)	SEOUL (SMRT)	SINGAPORE (SBS)**	SINGAPORE (SMRT)**	TAIPEI***	TOKYO (TOEI)	TOKYO (METRO)
OPERATIONAL INFORMATION										
OPERATOR	Bangkok Metro Public Company Ltd.	Mass Transit Railway Corporation Ltd.	(LRT)Light Rail Transit Authority, (MRT) Metro Rail Transit Corporation	San Francisco Bay Area Rapid Transit	Seoul Metropolitan Rapid Transit Corporation	SBS Transit Ltd.	SMRT Corporation Ltd.	Taipei Rapid Transit Corporation	Tokyo Metropolitan Government	Tokyo Metro Co. Ltd.
SYSTEM LENGTH (KM)	19.7	91	45.7	167.4	152	41	97.2	67	109	183.2
PASSENGERS (MILLIONS)	57.8	876.3	293.8	96.9	743.5	95.2	449.2	360.7	787.9	2153.5
THE NUMBER OF STATIONS	18	53	42	43	148	45	65	61	105	161
PASSENGERS PER KM (MILLIONS)	2.9	9.6	6.4	0.6	4.9	2.3	4.6	5.4	7.2	11.8
PASSENGERS (MILLIONS) PER STATION	3.2	16.5	7.0	2.3	5.0	2.1	6.9	5.9	7.5	13.4
THE NUMBER OF STATIONS PER URBAN LAND AREA	0.03	0.16	0.07	0.00	0.24	0.06	0.09	0.46	0.17	0.26
AVERAGE FARE PER PASSENGER (USD, PPP)	1.67	1.30	1.04	2.64	0.72	0.52	0.61	0.66	1.17	1.04

35.2 Operational information of selected MRT/LRT

** Manila's data comprises the total for MRT and LRT. ** Data for Singapore (SBS and SMRT) comprises the total for MRT and LRT of each company. Segment information is the only data available. *** 2005 exchange rate is used because Purchasing Power Parity for Taiwan is not available.*
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Data gathering revealed that operating companies can have quite different accounting forms. To maintain consistency among diverse accounting forms, total revenues and total expenses are recalculated based on the following:

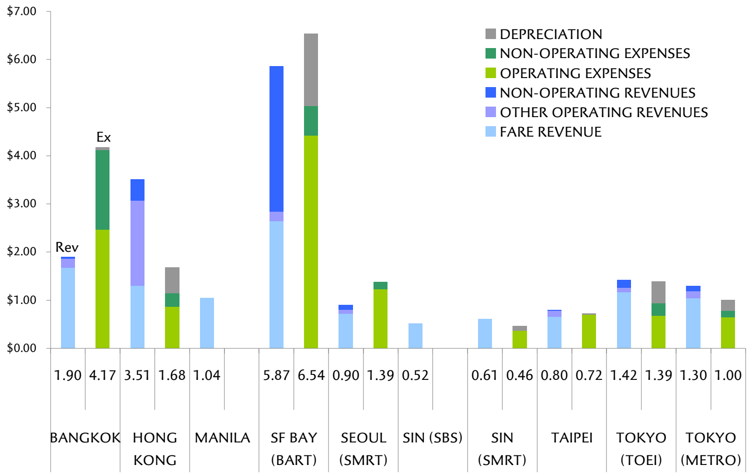
Total revenues = operating revenues (fare revenue + other operating revenues) + non-operating revenues

Total expenses = operating expenses excluding depreciation + non-operating expenses + depreciation

In order to make a reasonable international comparison, values within income statements that are expressed in local currencies are converted into 2005 USD. Currencies in developing economies are frequently undervalued if a market exchange rate is used, therefore, PPP rates are utilised in this financial review.

FINANCIAL PERFORMANCE OF MRT/LRT SYSTEMS

The results from the financial performance review are shown in [36.1 , 36.2]



36.1 Financial performance of MRT /LRT systems (per passenger, USD, PPP)

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	BANGKOK	HONG KONG	MANILA*	SF BAY (BART)	SEOUL (SMRT)	SINGAPORE (SBS)**	SINGAPORE (SMRT)**	TAIPEI***	TOKYO (TOEI)	TOKYO (METRO)
FINANCIAL PERFORMANCE (PER PASSENGER, USD, PPP)										
TOTAL REVENUES	1.90	3.51	1.04	5.87	0.90	0.52	0.61	0.80	1.42	1.30
FARE REVENUE	1.67	1.30	1.04	2.65	0.72	0.52	0.61	0.66	1.17	1.04
OTHER OPERATING REVENUES	0.20	1.76	n.a.	0.19	0.08	n.a.	n.a.	0.12	0.09	0.14
NON-OPERATING REVENUES	0.03	0.44	n.a.	3.03	0.10	n.a.	n.a.	0.02	0.16	0.11
TOTAL EXPENSES	4.17	1.68	n.a.	6.54	1.39	n.a.	0.46	0.72	1.39	1.00
OPERATING EXPENSES	2.47	0.87	n.a.	4.42	1.24	n.a.	0.36	0.70	0.68	0.65
NON-OPERATING EXPENSES	1.65	0.28	n.a.	0.62	0.14	n.a.	n.a.	0.00	0.26	0.13
DEPRECIATION	0.05	0.53	n.a.	1.50	0.00	n.a.	0.09	0.03	0.45	0.22
TOTAL REVENUES/ TOTAL EXPENSES	0.46	2.09	n.a.	0.90	0.65	n.a.	1.33	1.10	1.02	1.29

36.2 Overview of MRT/LRT systems in major cities in APEC

** Farebox revenue is the only data available. ** Data for Singapore (SBS and SMRT) comprises the total for MRT and LRT of each company. *** 2005 exchange rate is used because Purchasing Power Parity for Taiwan is not available.*

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An important caveat to interpreting this study is that the results which follow only represent the financial performance of these systems during the year 2006. There is a possibility that systems with lower revenue than expenditure flow in the studied year may have earned higher revenues than expenditures in other years. It is also important to note that the financial performance of systems at an early stage of infrastructure development tend to be low since asset depreciation is not complete.

A comparative study of these systems, although only for a given year, is nevertheless informative.

In 2006, five of the ten systems in the study group (Hong Kong MTR, Singapore SMRT, Taipei TRTC, Tokyo Toei, and Tokyo Metro) reported a higher revenue inflow than expenditures.[a] In contrast, three systems (Bangkok Metro, SF BART, and Seoul SMRT) were not able to cover their expenses through their revenue intake. Two systems (Metro Manila and Singapore SBS) did not report expenditures data.

Mass transit operators that experienced a higher revenue inflow than expenditures did so primarily through their farebox revenue. Three systems (Hong Kong MTR, Tokyo Toei, and Tokyo Metro) were able to cover their operating expenses solely through their farebox revenue. In the case of Taipei, although the farebox revenue was slightly lower than the operating expenses, other operating revenue contributions helped the total revenue exceed the operating expenses.

Other operating revenue is mainly obtained from an affiliated business. One common practice for operators to do is to diversify their business into property development, advertising, telecommunication services, and rental of retail space. Some MRT/LRT system's own subsidiary companies that engage in such business.

In the case of Hong Kong's MTR, almost half of the total revenue comes from affiliated business.[b] Even for other MRT/LRT operators, the ratio of other operating revenue to the total revenue stream is about 10 percent.

As for non-operating revenue, there are different sources, ranging from interest income to government-related revenue (subsidies and grants). In the case of Tokyo (Toei), approximately 10 percent of its total revenue comes from subsidies.

Understanding how others have achieved high financial performance is useful. However, it is equally if not more important to understand what has influenced low performance. Data shows that mass transit systems with low financial performance are primarily affected by ridership and debt repayment. In the case of Seoul, debt from recent network expansions has significantly contributed to interest payments that account for more than 10 percent of its total 2006 expenses. Similarly, San Francisco's BART system has relatively large expenses associated with the company's need to cover depreciation, maintenance, and administrative expenses. Also, San Francisco's BART system has low ridership – the lowest among the studied systems at 0.58 million passengers per kilometre. Bangkok's Metro, on the other hand, is at the early stage of infrastructure development. Its current coverage has led to low ridership per kilometre; as such it has failed to yield enough revenue to cover costs.

FINANCIAL PERFORMANCE OF BUS SYSTEMS

Similar to the financial review for MRT/LRT systems, farebox revenue is able to cover the operating expenses for profit-making operators, namely, Singapore (SMRT) and Sydney. For Tokyo, the operating expenses are covered by farebox revenue and non-operating revenue. By contrast, Bangkok and Jakarta's expenditures are higher than their revenue inflow. In the case of Bangkok, 91 percent of its operating expenses come from salaries and benefits (40 percent), fuel expenditures (33 percent), and contracted bus maintenance (18 percent). With regard to non-operating expenses, 80 percent is devoted to interest payments.

In many developing economies, a bus system is the most popular mass transit mode. Passengers depend on the bus system because it is less expensive and easier to access. Due to socioeconomic reasons, it is important to keep fares low regardless of the extent of operational expenses so as to provide an affordable transport mode for the lower income brackets of the population. Because of this, metropolitan governments are inevitably obliged to provide financial support to bus operators. It is a challenging issue for governments to reduce the financial burden for bus operations while keeping or improving bus services.

[a] *Taipei TRTC's data is from 2005.*

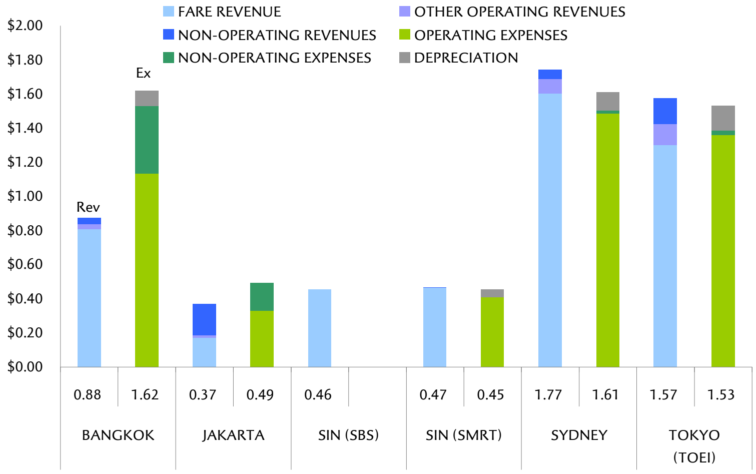
[b] *The share of revenue from affiliated business to the total revenue is broken down as follows: profit on property development(33 percent), station commercial and other revenue (9 percent), and rental and management income (8 percent).*

	BANGKOK*	JAKARTA**	SINGAPORE (SBS)	SINGAPORE (SMRT)	SYDNEY	TOKYO (TOEI)
OPERATIONAL INFORMATION						
OPERATOR	Bangkok Mass Transit Authority	Perum PPD	SBS Transit Ltd.	SMRT Corporation Ltd.	State Transit Authority of New South Wales	Tokyo Metropolitan Government
SYSTEM LENGTH (KM)	n.a.	n.a.	6552	2541.1	n.a.	781.7
PASSENGERS (MILLIONS)	644.7	118.5	748.3	270.3	199.4	206.0
PASSENGERS PER KM (MILLIONS)	n.a.	n.a.	0.1	0.1	n.a.	0.3
THE NUMBER OF ROUTES	214	n.a.	223	76	300	138
FINANCIAL PERFORMANCE (PER PASSENGER, USD, PPP)						
TOTAL REVENUES	0.88	0.37	0.46	0.47	1.77	1.57
FARE REVENUE	0.81	0.17	0.46	0.47	1.60	1.30
OTHER OPERATING REVENUES	0.03	0.01	0.00	0.00	0.08	0.13
NON-OPERATING REVENUES	0.04	0.18	0.00	0.00	0.08	0.15
TOTAL EXPENSES	1.62	0.49	n.a.	0.45	1.61	1.53
OPERATING EXPENSES	1.14	0.33	n.a.	0.41	1.48	1.36
NON-OPERATING EXPENSES	0.39	0.16	n.a.	0.00	0.02	0.02
DEPRECIATION	0.09	0.00	n.a.	0.04	0.11	0.15
TOTAL REVENUES/ TOTAL EXPENSES	0.54	0.75	n.a.	1.03	1.10	1.03

38.1 Overview of buses in major cities in APEC (2006)

**Bangkok's revenue and expenses are estimates based on a monthly profit/loss (March 2007) reported by the Bangkok Mass Transit Authority. The number of routes (214) is comprised of the total for BMTA buses (108) and joint service buses (106). Small buses plying lanes have 108 routes and van buses have 123 routes. ** 2004 data*

APERC 2008



38.2 Financial performance of buses in major APEC cities (per passenger, USD, PPP)

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KEY FACTORS DETERMINING FINANCIAL VIABILITY OF RAPID MASS TRANSIT SYSTEMS

The previous section described a number of risks that affect the financial performance of mass transit systems within the APEC region. To further this analysis, a simulation exercise to evaluate the financial viability of a MRT project is conducted. This simulation helps identify key factors affecting the financial performance of MRT systems.

METHODOLOGY

This simulation exercise is designed to evaluate the thirty-year financial viability of a MRT system in Bangkok. Assuming 19.7 kilometres of subway track, with a total capital investment of USD 1,000 million, the net present value (NPV) associated with 30 years of operation of a hypothetical MRT system in Bangkok is calculated.

For urban mass transit systems, fare revenue is an integral part of MRT systems' overall financial performance. Fare revenue is a product of (1) the fare and (2) the number of passengers. Several sensitivity analyses are conducted in this simulation exercise to evaluate how important these key factors are to the NPV results.

To understand the importance of ridership, two cases are considered: one with high ridership (65 million passengers per year) and the other with low ridership (35 million passengers per year).

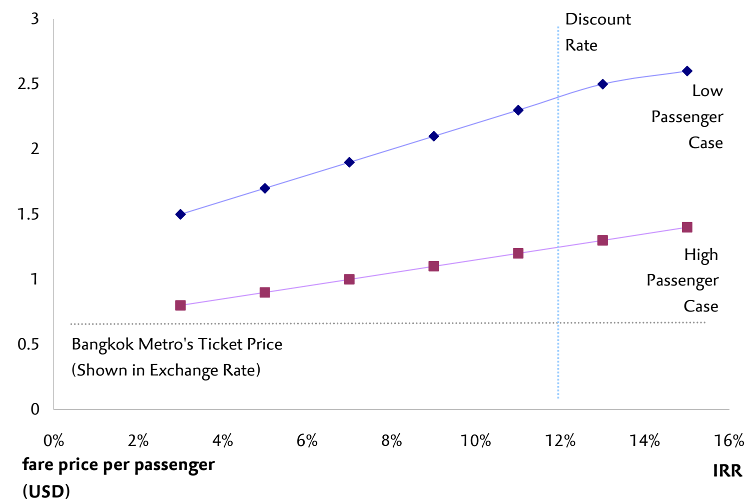
Net Present Value (NPV) is defined as the difference between the present value of total revenue generated over the lifetime of a project and the present value of the project's total lifetime cost.

The internal rate of return (IRR) is the discount rate that makes the NPV zero. In other words, the IRR represents the discount rate that equalises the present value of revenue and the present value of the total expenditures. For example, if the IRR is estimated at 10 percent when the real discount rate is 5 percent, this project is financially viable.

39.1 **NPV and IRR definitions**

FINDINGS

Investment cannot be justified unless the present value of total revenue exceeds that of total costs.



39.2 **NPV analysis: Simulation results**

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The results of the simulation exercise are summarised in [39.2]. The x-axis shows the different IRR, while the y-axis shows the average ticket price per passenger. The simulation aims to find the required fare per passenger that can generate a certain IRR. For example, if the project is to generate a seven percent IRR, the ticket price per passenger for the *high passenger case* should be USD 1, while that for the *low passenger case* would be USD 1.9.

It is important to note that the IRR should be above the lending rate for a project to be financially viable. If Thailand's central bank lending rate is 12 percent, the project's minimum required IRR is 12 percent. To generate an IRR above 12 percent, a ticket price of USD 1.5 (exchange rate, 2005 price) is necessary in the high passenger case and above USD 2.5 (exchange rate, 2005 price) is necessary in the low passenger case. The estimated ticket price, even at the lower range, should be double Bangkok's real ticket price of USD 0.6 (exchange rate, 2005 price), if the project were to be financially viable.

RIDERSHIP

To serve as a viable transportation option for the general public, fare needs to remain at an affordable level. Fouracre, Allport, and Thomson (1990) identified that metro operators recognise the need to maintain fares at affordable levels even if they are financially constrained to cover their annual costs.[f] Because of this tendency, it is essential for a MRT system to increase its ridership, so as to acquire enough financial return to cover a relatively high initial capital investment.

[f] *Fouracre, Allport, and Thomson 1990.*

Increasing ridership is an essential component in successful urban transport policies. One policy option is to integrate the MRT system with other mass transit modes, such as local/feeder buses. Using a *smartcard* transit fare system, as observed in several APEC cities, can facilitate and encourage multi-modal transfer, leading to an increase in MRT ridership. Such system integration, however, requires careful planning and coordination among various government agencies, in terms of the operation and syncing of multiple modes and fare design, since the operation of MRT and bus systems are usually governed by different agencies.

DISCOUNT RATE

The discount rate is another critical factor that affects the financial performance of a MRT system. The central bank's lending rate (or the real discount rate), particularly in rapidly developing economies, tends to be high (usually higher than 10 percent). The high discount rate reflects (1) scarcity of domestic capital and (2) investment risk. As a result of the lessons learned from the Asian Financial Crisis in 1997, developing Asian economies prefer local financing with local currency; however, their lending rates tend to be prohibitively high if the official bank lending rate is applied.

To help lower the financial cost of MRT operation, government support may be necessary, specifically by providing funds at a relatively low rate. Government support may be necessary for economies at a relatively early stage of economic development.

IMPLICATIONS

Sound financial management of urban mass transit, from construction to operation, is critical to its success. Several mass transit systems within APEC economies represent rather poor financial performance. In addition to the high capital investment for designing, land acquisition, and rolling stock, there are additional factors that raise the overall capital investment cost. The cost of developing mass transit can increase because of (1) unexpected ground conditions, (2) an increase in material and equipment costs, (3) disruptions in financial supply, and (4) labour supply shortages.

Excluding a few cases, a number of MRT systems within APEC economies can attract fewer passengers than expected, rendering them financially less viable. Perhaps the absence of infrastructure to facilitate access to passengers has led to a lower number of passengers. Such cases were found in Bangkok, Manila, and Kuala Lumpur. To increase the financial viability of mass transit, efforts to increase ridership are required. Due to the absence of data or the lack of appropriate pre-feasibility studies, planners often fail to project an accurate value for the future number of mass transit passengers. Technical assistance and knowledge transfer, from economies that have already developed mass transit, may be necessary during the planning stage to increase capacity. In addition, physical integration of MRT systems with other mass transit, such as local/feeder buses, is important as it can allow the multi-modal transfer of passengers.

Although fare needs to be maintained at an affordable level for the general public to increase ridership, it should also significantly cover the high capital investment and interest payments. To satisfy these objectives, the *fare system* has to be flexible. For example, by discriminating customers by time of day or distance travelled, a flexible fare system can maximise a system's financial output.[g]

[g] P R Fouracre, and D A C Maunder 2000.

In many economies, government support is also deemed necessary, specifically by providing either funding or other subsidy (such as low interest rates or land rights) for mass transit projects. Developing APEC economies are not always blessed with efficient capital markets. Lack or absence of such markets has been the biggest stumbling block for the development of transport infrastructure. By way of government funding on guaranteed financing, such projects could move on with less cost and delays. Also, in developing economies, strengthening capital markets, especially municipal bond markets, can expand financing opportunities. At lower interest rates than bank loans, bonds can provide long-term capital for investment in MRT/LRT projects.

For large-scale projects, international lending organisations can play an important role by providing a guarantee to the overall debt. An international lending organisation's involvement can increase the project's credit worthiness and enable its actual feasibility.

ECONOMIC EVALUATION OF URBAN MASS TRANSIT

INTRODUCTION

At first glance, urban mass transit systems may not look financially attractive in many cases. In fact a number of systems face financial difficulties because they cannot attract a sufficient number of passengers to cover their initial capital investment, operational expense, and interest payments. Because of socio-economic motivations, system operators cannot increase fare easily and this can put a system's financial profitability at risk. Some critics argue that excluding a few special cases with wealthy, densely populated urban areas, there is little rationale to develop urban mass transit systems, particularly MRT/LRT systems.

A financially-focused evaluation of urban mass transit systems could persuade urban planners and policy-makers to conclude prematurely that mass transit systems are not a viable option, however this neglects the positive non-financial benefits of the systems. These benefits include energy savings, air quality improvements, and CO_2 emissions reduction, in addition to time savings and cost savings from passenger vehicle ownership. Therefore, it is important for policy makers and urban planners to (1) carefully consider what objectives urban mass transit systems may serve, (2) accurately identify what benefits mass transit systems can produce, and (3) quantify how much net benefit, in monetary terms, will be produced by the development of these systems.

This chapter tries to evaluate the economic impact of mass transit systems, specifically MRT systems. By evaluating four different urban areas (Bangkok, Hanoi, Jakarta, and Manila), the chapter analyses the costs and benefits associated with MRT systems and estimates their economic internal rate of returns (EIRRs). Through estimating the EIRRs, the chapter addresses the potential economic benefits of MRT systems, specifically energy security and environmental conservation.

FOUR URBAN AREAS – GENERAL CHARACTERISTICS

The four urban areas chosen for this analysis epitomise areas with different income levels. In 2005, income levels of the four urban areas ranged from a low of USD 6,157 (Hanoi) to a high of USD 27,560 (Bangkok).[a] Despite the wide discrepancy in income levels, the four urban areas all face similar transport problems.

[a] *Both incomes are expressed in purchasing power parity at 2000 prices.*

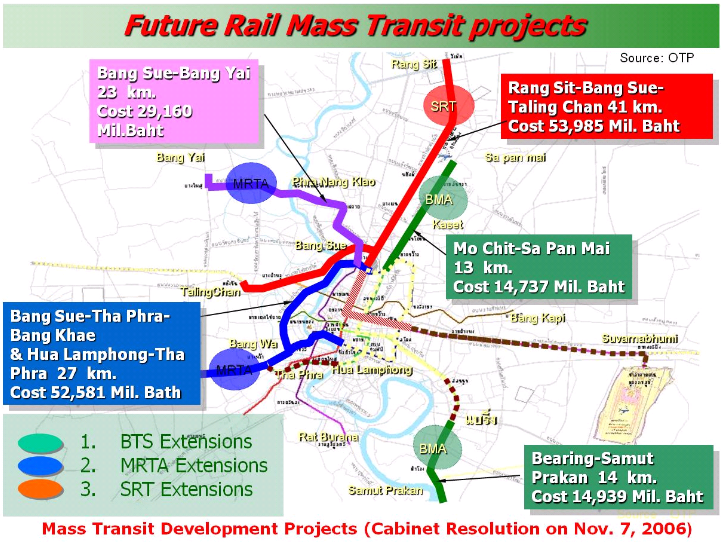
Road congestion in the four urban areas has become severe because road construction has not kept pace with the increase in passenger vehicles and mass transit infrastructure is insufficient - relative to the growing urban transport demand. In the urban core of Jakarta, for example, the average speed of passenger vehicles is about 15 kilometres per hour. Similarly, in the urban core of Bangkok, the average speed of vehicles is about 12 kilometres per hour during peak hours. This heavy congestion has lowered the fuel economy of passenger vehicles and has added to air pollution emissions. In addition, the spatial footprint of these urban areas is expanding, which in turn increases travel distances and drives the growth in energy consumption.

URBAN TRANSPORT PLAN

To alleviate congestion and improve the overall energy efficiency of urban transport, the four urban areas have established plans to expand/introduce mass transit systems or to develop road infrastructure.

In **Bangkok**, currently there are two MRT systems: the Sky Train and the Blue Line. Sky Train has an elevated route of 23 kilometres with 23 stations that transport about 400,000 passengers per day. The Blue Line has an underground route of 20 kilometres with 18 stations that transport around 20,000 passengers daily. To handle passengers more efficiently, the Bangkok Metropolitan Authority is extending the Sky Train. The first phase, a 2.2 kilometre extension, will start operation by the fourth quarter of 2008 and the second phase, a 5.3 kilometre extension, will follow in the fourth quarter of 2010. In addition to rail mass transit, Bangkok is developing a 15-kilometre Bus Rapid Transit system (to open on 12 August 2008) that is expected to carry 50,000 passengers daily. To handle the growing number of passengers more efficiently, Bangkok also plans to extend existing MRT lines, amounting to a total of 118 kilometres by 2020.[b]

[b] *Thailand's cabinet resolution 2006.*



44.1 **Bangkok's future rail mass transit projects**

Kijmanawat 2007.

Hanoi's transport is characterised by a heavy dependence on motorcycles and rapid growth in passenger vehicle ownership. Buses account for a small portion of total person trips, at around 5 percent. Hanoi has released its master plan for 2020. According to the master plan, Hanoi will develop a transport system that can accommodate the increasing number of passengers. With the Plan, Hanoi aims to increase the road occupancy to total urban area ratio from the current 3 percent to about 25 percent of the total urban land area.[c]

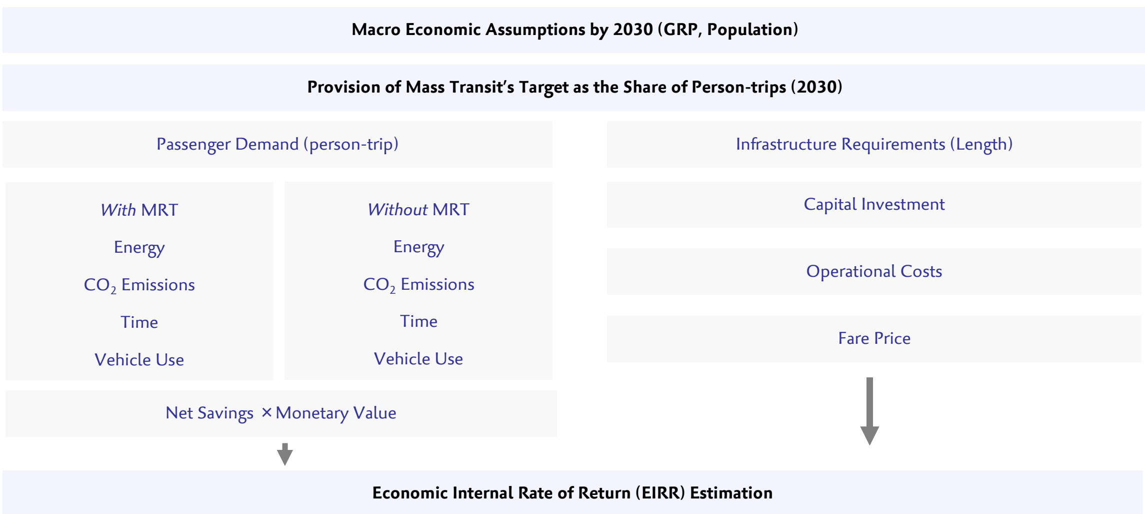
[c] No mass transit introduction is considered in the Plan.

Jakarta depends heavily on road-based transport. Passenger vehicles account for about 11 percent of total person-trips, while buses account for 52 percent of total person-trips. In 2004, the National Development Planning Agency released a transport master plan, known as the *Study on Integrated Transportation Master Plan for JABODETABEK (SITRAMP)*. The plan is designed for the broader Jakarta metropolitan region called JABODETABEK. It aims to deal with Jakarta's congestion problem and reduce energy consumption and CO_2 emissions through investment in road infrastructure and the development of mass transit systems (BRT and MRT systems).

In **Manila,** there are three mass rapid transit systems in operation: one MRT and two LRT systems. The MRT system, the Blue Line, has a total length of 17 kilometres and the two LRT systems, the Yellow Line and the Purple Line, have an operational length of 15 kilometres and 13.8 kilometres respectively. As part of a plan to reduce congestion and handle transport efficiently, Manila plans to expand the existing lines by adding 5.2 kilometres to the Blue Line and developing two LRT systems with a combined total of 33.6 kilometres. Manila also plans to develop two rails that can connect the city centre to suburban areas.

MODELLING FRAMEWORK

The following steps are taken to analyse the costs and benefits associated with MRT systems and estimate their economic internal rate of returns (EIRRs) and financial internal rate of returns (FIRRs).



45.1 **Modelling framework**
APERC 2008

First, a twenty-five year urban passenger transport demand, in terms of person trips (2005-2030), is projected. This projection is based on forecasts of population and Gross Regional Product up to 2030, which are obtained from external sources, such as official projections or the transport master plans released by each city.

The EIRR is different from the FIRR. The FIRR represents the internal rate of return that only takes into account a project's financial flow. The FIRR evaluates the project's financial viability by comparing (1) a project's income with (2) that of its expenditures. In contrast, the EIRR considers the socio-economic benefits and costs of a project, which cannot be measured by financial revenue and cost.

46.1 Difference between EIRR and FIRR
APERC 2008

Second, a city-specific target for MRT systems, in terms of the share of total person trips by 2030, is established. Based on this target, the number of MRT passengers by 2030 is calculated. As summarised in [46.2], different assumptions are given to each city.

Third, the requirements needed to transport the targeted number of passengers, such as system length and investment by 2030, are assessed.

Fourth, the savings in energy, CO_2 emissions, time, and cost of vehicle operation are calculated as the difference between having a MRT system and not having a MRT system. In other words, the savings from a MRT system's expansion/introduction are calculated by comparing against a benchmark case (lack of a MRT system), in which no action is taken to expand/introduce a MRT system and the targeted MRT passengers are handled by passenger vehicles, instead of a MRT system.

Fifth, assuming monetary factors for each variable, an estimate of the monetary value of these socio-economic benefits (savings in energy, CO_2, time, and vehicle ownership cost) is calculated.

Finally, the economic internal rate of return (EIRR) for a twenty-five year MRT project within each city is estimated and compared with the estimated financial internal rate of return (FIRR).

With respect to the benefit and cost of rapid mass transit systems, the variables considered in this study are as follows.

Costs:

- Capital investment for MRT system, and
- Operational cost of MRT system. [d]

Benefits:

- Fare revenue,
- Time savings,
- Energy savings,
- CO_2 emissions savings, and
- Cost savings from non-passenger vehicle use.

[d] *Costs, such as noise during the construction period and a decrease in the employment of taxi and bus drivers, are excluded from this analysis .*

	BANGKOK		HANOI		JAKARTA		MANILA	
	2005	2030	2005	2030	2005	2030	2005	2030
TARGET MRT SHARE IN MODAL SPLIT [%]	4%	20%	0%	10%	1%	15%	2%	15%
MRT LENGTH [KM]	43	197		108		132	46	137
URBAN LAND AREA [KM^2]	700		636		661		636	
INCOME [USD PPP, 2000]	25,896	37,574	1,599	10,215	11,325	26,764	11,196	26,459
URBAN POPULATION [MILLION]	5.5	5.5	3.2	3.2	8.4	8.4	10.9	10.9

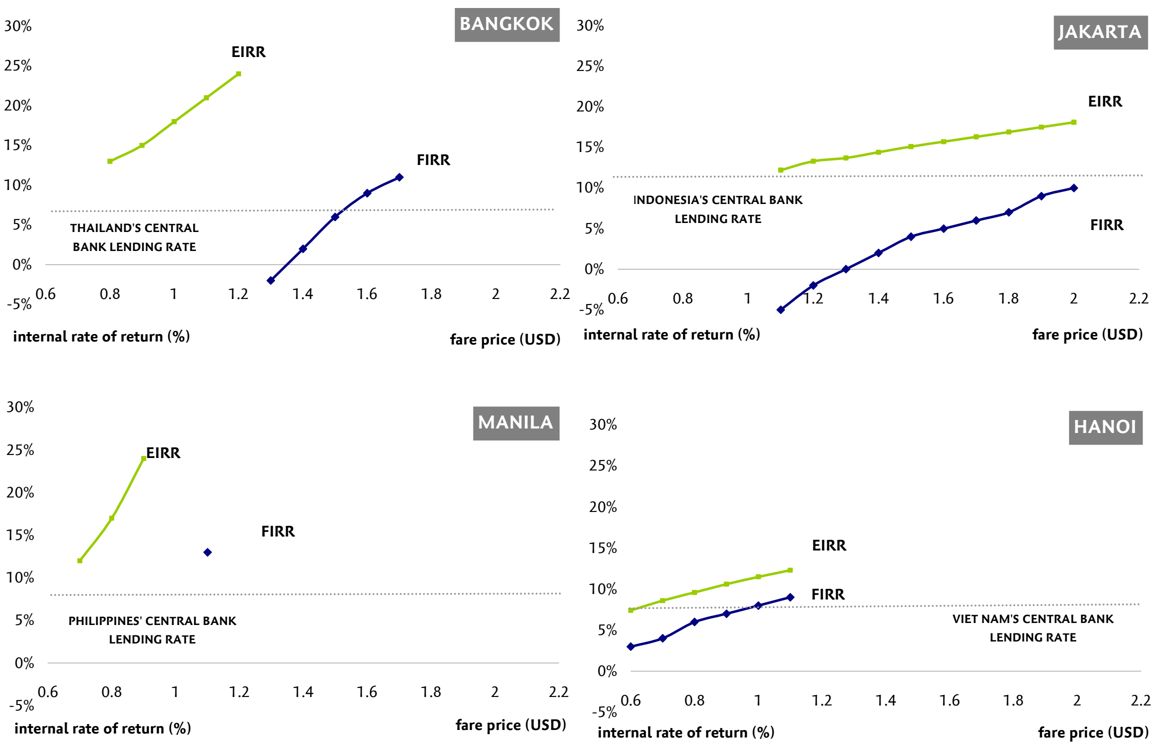
46.2 Basic assumptions
APERC 2008

FINDINGS – EIRR AND FIRR

The results from the simulation exercise for Bangkok, Hanoi, Jakarta, and Manila are shown in [47.1]. In this figure, the various fare assumptions are shown on the x-axis and the corresponding economic internal rate of return (EIRR) and financial internal rate of return (FIRR) results are shown on the y-axis.[e] The horizontal grey line represents the central bank's lending rate for each economy, which is utilised as the discount rate for the MRT expansion project.

[e] *The number of passengers is assumed to remain constant with the change in fare price.*

The analysis shows that the financial viability of MRT projects in the four cities is generally low. Particularly in Jakarta and Hanoi, the estimated FIRR's are below each economy's discount rate. This means that unless a lower interest rate than the central bank official lending rate in the host economy is offered, the MRT system's fare revenue may not be able to cover the cost of the system for the entire project period between 2005 and 2030.



47.1 **EIRR and FIRR in Bangkok, Hanoi, Jakarta, and Manila**
APERC 2008

To compensate for the low financial prospects, the MRT projects can generate additional socio-economic benefits. The gap between the EIRR and FIRR for each city in [47.1] captures the magnitude of the net socio-economic benefits that are expected from each MRT project. A bigger gap between the EIRR and FIRR suggests that the MRT project will have higher socio-economic benefits.

For example, in Bangkok and Manila, the estimated gap between the EIRR and FIRR is greater than 20 percent. By contrast, Jakarta's estimated gap averages around 10 percent and Hanoi's is around 5 percent. This suggests that MRT projects should be more likely to bring in higher socio-economic benefits in Bangkok and Manila than in Jakarta and Hanoi.

It should be noted, however, that the outcomes of this exercise are sensitive to various underlying assumptions. In this analysis, EIRR is defined as the maximum possible rate of return, incorporating both financial and non-financial benefits. Accordingly, the respective savings of energy, CO_2, time, and cost of vehicle ownership are set at their maximum, given the knowledge of current market conditions and future projections in each city. Therefore, in interpreting the simulation exercise results, one should understand that the MRT projects will produce socio-economic benefits that are *within the range* displayed between the estimated EIRR (maximum benefit) and FIRR (minimum benefit).

FACTORS AFFECTING EIRR

The factors included in this analysis affected the estimated EIRR results differently. [48.1] shows the savings assumptions that are considered in the analysis.

48.1 **Savings on energy, CO_2, time and vehicle ownership cost (2015, 2020 and 2030)**
APERC 2008

In **Bangkok**, an expansion of the MRT system could yield the highest socio-economic benefits among the four cities. In Bangkok's case, time savings would account for the largest share of total benefits. This is because the city has a relatively high *time value* [49.1], among the four cities studied, and the highest time savings potential due to the heavy traffic congestion.[e]

[e] *Based on Bangkok's transport master plan, the value of time is assumed as 40 percent of hourly income of each city.*

	2005	2030
BANGKOK	4.0	6
JAKARTA	1.8	4.5
MANILA	1.3	3
HANOI	0.3	1

49.1 **Hourly income (USD, 2000 price, in exchange rate)**
APERC 2008

Despite the relatively low income level (third position among the four cities studied), MRT systems in Manila could be both financially and economically viable because of Manila's high population density, which is almost two times higher than Bangkok's level. The high population density is expected to increase ridership when the MRT network is expanded. In fact, although Manila's target modal share of MRT in 2030 is lower (15 percent) than that of Bangkok (20 percent), Manila's number of MRT passengers could be larger (1,628 million) than that of Bangkok's (1,595 million) in 2030 [49.2].

	MRT PASSENGERS (MILLIONS)	MRT MODAL SHARE (%)	MRT PASSENGERS (MILLIONS)	MRT MODAL SHARE (%)
	2005		2030	
BANGKOK	120	4%	1595	20%
JAKARTA			976	15%
MANILA	169	2%	1628	15%
HANOI			252	10%

49.2 **MRT passengers and modal share (2005 and 2030)**
APERC 2008

The financial viability of a MRT project in **Jakarta** turns out to be low; however, it still has the potential to produce significant socio-economic benefits. In Jakarta, the cost savings for passenger vehicle ownership account for the largest portion of the total benefits. In fact, Jakarta's cost savings potential is the highest, among the four cities, due to the city's taxes, duties, insurance fee, and parking costs.

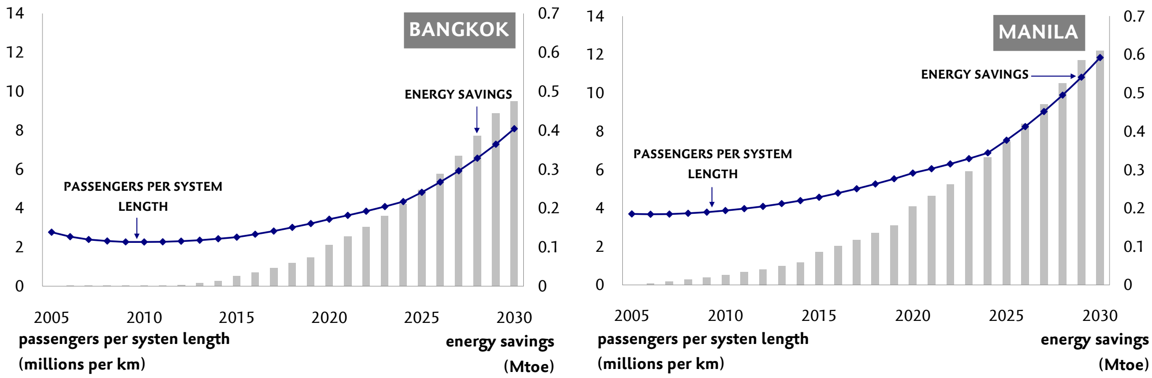
Hanoi's prospects for both the financial and economic viability of a MRT project represent the lowest level among the cities studied. In consideration of its economic development level, the lowest target (10 percent) is assumed, in terms of the MRT share to total person trips in

2030. This modest assumption resulted in smaller socio-economic benefits than the other cities.

FINDINGS- ENERGY AND CO2 SAVINGS

[50.1] shows the energy savings that are expected to take place in Bangkok and Manila between 2005 and 2030. The figure also displays the assumptions used for the number of passengers per system length, a proxy for system utilisation.[f]

[f] Bangkok's number of passengers per system length is assumed to decline from 2005 to 2010. This is because system utilisation does not increase until the system is fully developed to integrate a city centre.

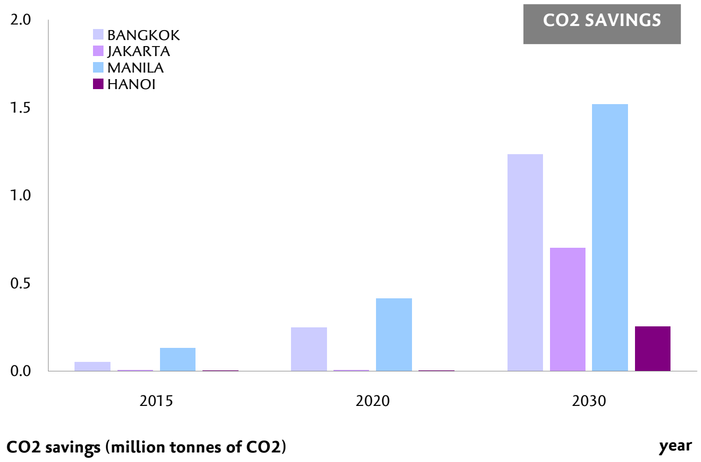


50.1 **Energy savings and passengers per system length (2005-2030)**
APERC 2008

Quite substantial energy consumption savings are expected, especially in Bangkok and Manila.

By 2030, as a result of MRT system expansion, Bangkok could save about 0.5 Mtoe or 17 percent of its current gasoline consumption, while Manila could save about 0.6 Mtoe or 19 percent of its current gasoline consumption. It is interesting to note that Manila could yield higher energy savings than Bangkok despite its lower modal share target for MRT in 2030, 15 percent compared with 20 percent respectively. Again this results from Manila's population density, which is approximately two times higher than that of Bangkok.

Similarly, MRT system expansion could bring about substantial CO_2 savings in Bangkok and Manila. By 2030, Bangkok could save 1.2 million tonnes of CO_2 emissions (approximately 2 percent of the present transport CO_2 emissions in Thailand) and Manila could save 1.5 million tonnes of CO_2 (approximately 6 percent of the present transport CO_2 emissions in the Philippines).



51.1 CO_2 savings (2015, 2020 and 2030)

APERC 2008

In Hanoi and Jakarta, substantial CO_2 emission reductions could be achieved only after 2025. This is because a relatively low ridership per system length is assumed for these cities.

IMPLICATIONS

Despite relatively low financial prospects, MRT systems can, in general, produce substantial socio-economic benefits. The benefits come from savings on energy, CO_2, time, and passenger vehicle ownership.

The simulation revealed that cities with higher income may have bigger socio-economic benefits. Bangkok could enjoy the largest socio-economic benefits from expanding its MRT network. This is mainly attributable to its relatively high value of time.

Cities with higher population density may reap large socio-economic benefits. Although Manila's current income level is relatively low, nearly half of Bangkok's income, the city could enjoy substantial socio-economic benefits by expanding its MRT systems. This is mainly because of its high population density, which almost invariably entails high ridership.

Besides monetary benefits, MRT systems could substantially reduce energy consumption. For example, if an additional 150 kilometres of MRT line are built in Bangkok by 2030 and 20 percent of all the city's passengers utilise the MRT systems, the city could save about 17 percent of its current gasoline consumption by 2030. Likewise, if Manila completes a 90-kilometre expansion by 2030 and 15 percent of all the city's passengers utilise the MRT systems by 2030, the city could save as much as 19 percent of its current gasoline consumption by 2030.

These socio-economic benefits can only be realised if the assumed MRT project is implemented as planned. However, it should be noted that it often takes two decades to realise these potential benefits. This suggests that the early and timely implementation of a project can help maximise the potential socio-economic benefits.

To facilitate early implementation, planning for mass transit systems should be an integral part of the city's energy and environmental policy. Appropriate institutional arrangements to enhance inter-agency coordination should be made in order to increase the effectiveness of these MRT projects in the future.

INSTITUTIONAL ISSUES IN URBAN MASS TRANSIT: JAKARTA

Jakarta has chosen to develop TransJakarta, a Bus Rapid Transit (BRT) system, as a competitive alternative to passenger vehicles. As part of the city's effort to reduce congestion and avoid the economic costs associated with it, the initial plan for the BRT system is to introduce 15 dedicated busway corridors by 2010. Although a notable first step, finding a solution to Jakarta's congestion problem will require implementation of various policy measures and further consideration of several factors. These factors include considering the commuting needs of a broader transportation area and ascertaining the need to construct additional road infrastructure. Specific to the BRT system, understanding the impact that the busway project will have on reducing street lanes and fostering coordination with the development of rail and MRT systems is necessary.

TOTAL POPULATION	LAND AREA	POPULATION DENSITY	GRP *	PCI*	GASOLINE USE	PASSENGER VEHICLES
8.5 MILLION	662 KM2	13,668 P/KM2	115.5 BILLION	13,645	5,059 KTOE	1.8 MILLION

APERC Internal Database (2008), * USD, PPP 2005.

INTRODUCTION

Jakarta, officially called Jakarta - Capital City Special District (DKI Jakarta), is located on the north coast of the western part of the island of Java, Indonesia. Jakarta is the capital city of Indonesia; however, administratively it is a province and is divided into several sub-regions consisting of 5 cities (*kota*) and one regency (*kabupaten*). It covers a land area of 661.52 km², making it the smallest province of Indonesia, and has a population of 8.5 million (2005). Since the separation of the Province of West Java, into two provinces in 2000, Jakarta borders the Province of Banten to its west and the Province of West Java to its east and south.

53.1 **Map of JABODETABEK**

Pacific Consultants International (PCI) 2007

Economic reforms, introduced by the government in the late 1960's to early 1970's, transformed the development of Indonesia and the city of Jakarta. Since the 1970's, Jakarta has experienced several periods of sustained economic growth, however, the Asian Financial Crisis in 1997 abruptly ended this trend.

The city has yet to regain the levels of economic growth that were seen prior to the crisis; however, GRP growth has steadily increased since 2000. The major contributors to Jakarta's GRP, in 2005, were finance and services (42.3 percent); retail, hotel, and restaurants (21.5 percent); manufacturing (17.3 percent); construction (9.9 percent); and other sectors (9.0 percent). [a]

[a] *BPS, Jakarta in Numbers 2006.*

As the city continues to grow, mobility demand within the city increases. To meet this demand, the government has constructed new roads and road infrastructure. As a result, the total road length in Jakarta has increased from 3,510 kilometres in 1985 to 7,645 kilometres in 2005. This road system consists of municipality roads (5,884 kilometres), provincial roads (1,496 kilometres), state roads (170 kilometres), and toll roads (94 kilometres). [b]

[b] BPS, Jakarta in Numbers 2006.

MOBILITY IN JAKARTA: THE BODETABEK EFFECT

In terms of mobility concerns, the city of Jakarta is part of a larger metropolitan region, known as JABODETABEK. The area is comprised of Jakarta, the cities of Bogor and Depok, and the *regencies* of Tangerang and Bekasi. JABODETABEK, a by-product of urban sprawl, has a population of about 22 million and is on a trend of economic growth that could ultimately transform the area into a megalopolis.

	GRP GROWTH (%)
1980-1985	9.34
1985-1990	8.72
1990-1996	8.67
1996-2000	-2.08
2000-2005	5.16

54.1 **Jakarta's average GRP growth**

BPS, Jakarta in Numbers, volumes 1980 to 2005

JABODETABEK's urbanisation trend reveals an underlying suburbanization trend for Jakarta. As JABODETABEK experiences an increase in population, industrial output, and value added services and trade, residents of Jakarta are moving away from the city centre into the surrounding countryside in order to escape escalating land costs and the social and environmental consequences of urban services and amenities.[c]

[c] Ernan Rustiadi 2002.

Due to this trend, population growth is waning in Jakarta. The city's population growth has tumbled from a growth rate of 1.9 percent per year (1980 to 1995) to 0.37 percent per year (2000 to 2005).[d] During the period from 1980 to 1995, the gap between out-migration and in-migration in Jakarta widened. In Jakarta's central district, a measurably large number of residents, about three percent, moved out from 1990 to 2000. Since 1990, the combined population of Bogor, Tangerang, and Bekasi *regencies* (abbreviated as BOTABEK) exceeds the population of Jakarta.

[d] BPS, Jakarta in Numbers 2006.

Cities and *regencies* in JABODETABEK are rapidly developing urban centres, industrial estates, and their own sprawling suburbia. Moreover, new development is concentrated just outside the boundaries of the city. These prolific suburbs are escalating commuting needs, as more people working in Jakarta are residing in this extended suburban area. The freeways and interchanges connecting Jakarta to the outlying cities, while promising easy access to a wider economic region, have encouraged commuting from farther distances to Jakarta. In 2002, there were 700,000 daily commuting trips from the BODETABEK area into Jakarta.[e] This increase is contributing to a serious deterioration of the transport network within the region.

[e] SITRAMP Study 2004.

ENERGY CONSUMPTION FOR ROAD TRANSPORT

Following the peak of the Asian Financial Crisis, the number of new passenger vehicles in Jakarta increased rapidly. In 2003, 333,953 passenger vehicles were added, an increase of 28 percent to the vehicle stock in a single year. By 2006, Jakarta's passenger vehicle stock reached 1,835,653 and the number of motorcycles in Jakarta reached 5,310,068.[f]

[f] *BPS, Jakarta in Numbers 2007.*

	PASS. VEHICLES	CARGO VEHICLES	BUSES	MOTORCYCLES
1995	849,939	320,246	310,128	1,540,825
2006	1,835,653	504,727	317,050	5,310,068

55.1 **Registered vehicles in Jakarta**

BPS, Jakarta in Numbers 2007

HISTORICAL TREND FOR GASOLINE/ DIESEL CONSUMPTION

Between 1985 and 2005, gasoline consumption grew rapidly at an annual rate of 9.95 percent.[g] During the same time period, diesel consumption grew at 4.91 percent – a slower pace than that of gasoline consumption. Diesel in Jakarta is mainly utilized by buses, cargo vehicles, and diesel passenger vehicles.

[g] *BPS, Jakarta in Numbers.*

FACTORS AFFECTING GASOLINE/DIESEL CONSUMPTION

In this section, Jakarta's transport gasoline and diesel consumptions are analysed. A decomposition analysis is used to identify the factors that influence growth in these fuels.

GASOLINE

As expected, the analysis indicates that Jakarta's passenger vehicle stock is the key factor driving the city's estimated gasoline consumption growth. Jakarta's passenger vehicle stock per capita has steadily increased, excluding the Asian Financial Crisis period, and its contribution to gasoline consumption growth has become larger since 2001, even though the city has not fully recovered from the financial crisis.

Vehicle energy intensity (energy requirements per passenger vehicle) displays a different trend depending on the time period examined. It did not significantly contribute to gasoline consumption, in the pre-crisis period, as a result of better vehicle efficiencies within the growing vehicle stock and a lower vehicle utilization rate. During the financial crisis, however, energy intensity does appear as a positive factor affecting gasoline consumption. As the vehicle stock decreased, utilization of the remaining stock increased, as such each vehicle contributed more to the growth of gasoline consumption. This trend changed, from 2003 to 2005, as energy intensity decreased its contribution to the growth in gasoline consumption. In 2005, as a means to ease the burden of the gasoline subsidy on the government's budget, Indonesia's government almost doubled the price of gasoline. This reduced gasoline consumption per passenger vehicle.

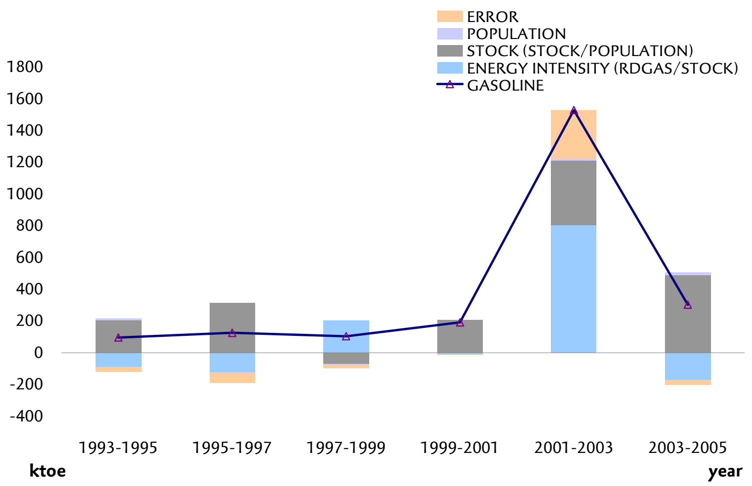
The decomposition analysis used in this section is based on the following calculation:

E = (Rdgas/Stock) * (Stock/ Population) * Population

E: Gasoline consumption,
Stock: Passenger vehicle stock,
Population: Population in Jakarta

E = △(Rdgas/Stock) * (Stock/ Population) * Population + (Rdgas/Stock) * △(Stock/ Population) * Population + (Rdgas/Stock) * (Stock/ Population) * △(Population) + Error

55.2 **Fuel decomposition analysis**



56.1 Decomposition analysis: gasoline consumption in Jakarta

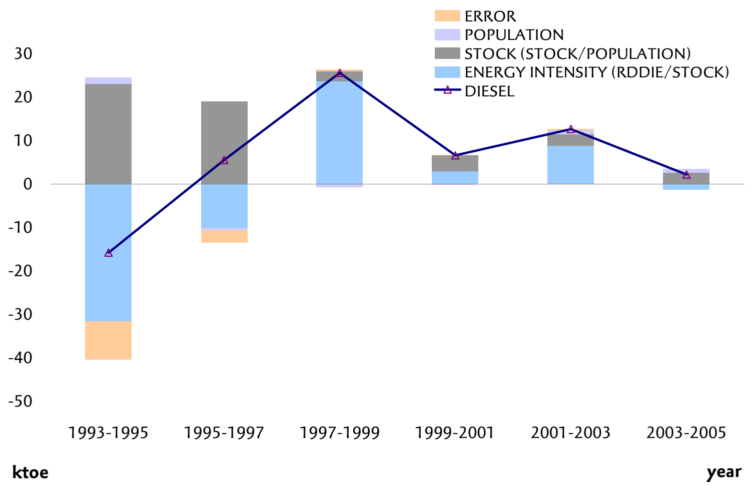
APERC 2008, based on BPS, Jakarta in Numbers

It is also evident from this analysis that population growth did not influence gasoline consumption growth. Excluding the financial crisis period, Jakarta's population stayed relatively the same, at about 8.5 million.

DIESEL

The decomposition analysis shows that post 1997, the estimated growth in diesel fuel consumption by large mass transit buses was mainly influenced by vehicle energy intensity. From 1993 to 1997, however, the data shows that the bus stock increased by 64.7 percent, while the utilisation of these buses remained low.[h] Therefore, during this time, energy intensity contributed less to diesel demand growth for large buses.

[h] *BPS, Jakarta in Numbers 2006.*



56.2 Decomposition analysis: diesel consumption in Jakarta

APERC 2008, based on BPS, Jakarta in Numbers

In the following periods, due to a decline in the bus stock, Jakarta's mass transit operators increased the use of their existing stock. Consequently, energy intensity positively contributed to diesel consumption growth.

ISSUES

CONGESTION PROBLEMS

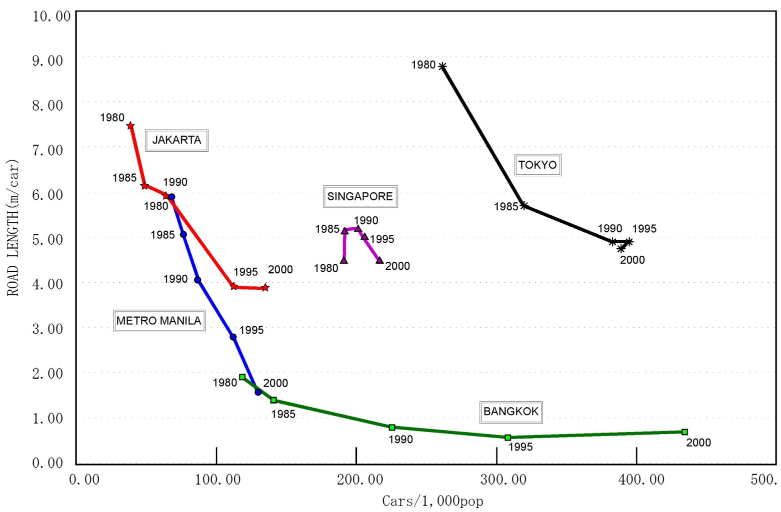
Jakarta's traffic congestion problem has become severe because of an increase in Jakarta's passenger vehicle stock, in-flow traffic from neighbouring provinces, and a lack of additional road infrastructure. In 1980, the ratio of Jakarta's road length to total vehicle stock stood at 8.6 kilometres per vehicle.[i] Due to Jakarta's low automobile ownership per 1000 population, this ratio was comparable to lesser congested cites in Southeast Asia. However, in 2005, this ratio decreased to 2.96 kilometres per vehicle and mobility within the city deteriorated.

[i] *JICA, WB, and ADB Joint Study 2007.*

Congestion in Jakarta has become increasingly worse, particularly during morning and afternoon rush hours. Average traffic speed has been reduced to 10 kilometres per hour or less in many parts of the CBD and in roads and freeways leading to the city.

The annual economic loss due to traffic congestion in JABODETABEK is estimated at about Rp. 3,000 billion for additional vehicle operating costs and Rp. 2,500 billion for wasted travel time.[j]

[j] *SITRAMP 2004.*



57.1 Historical changes in vehicle ownership and road lengths

JICA/ ADB World Bank Joint Study 2007

EFFORTS TO REDUCE CONGESTION

ROAD RESTRICTIONS AND EXPANSION

Jakarta introduced a transportation control measure (TCM), the 3-in-1 system in 2001, to help alleviate congestion. The system restricts certain road sections, during specific times of day, to only passenger

Before the BRT, the local bus system was the only mass transit mode available in Jakarta. It provided most of the city's transport needs. However, since the economic crisis, Jakarta's bus system has been failing. Jakarta's bus system has no clear service quality standard in place; the security, safety, and comfort are far from adequate; there is no fare or route integration, and buses are often over crowded. Moreover, buses in the fleet have been in decline, to approximately half of the pre-crisis fleet size.

58.1 **Condition of Jakarta's regular bus system**
BPS 2006

vehicles with three or more passengers. In 2003, the system was extended to include more road sections and extended the time of day restrictions.

The government has also placed emphasis on the construction of new roads. However, construction of new roads in the CBD area is limited, as land has become expensive or restricted for development. Infrastructure construction is nonetheless still continuing where possible; recent plans include six inner-city toll road sections and the completion of a second outer ring toll road. In spite of these efforts, Jakarta's roads are still severely congested.

MASS TRANSIT DEVELOPMENT: TRANSJAKARTA BUSWAY

Jakarta is developing the TransJakarta Busway system as one option to alleviate congestion. In early 2002, Jakarta's legislative body (Jakarta Regional Parliament) approved a revision to the city's transportation legislation to include regulation specific to the BRT system.

This BRT system is expected to provide an efficient transit option that has a high operational frequency and produces time savings that will appeal to the public. TransJakarta Busway is also expected to provide additional fuel and emission reduction savings.

Trans Jakarta: Demonstration project

Jakarta's first BRT corridor, Corridor 1 (12.9 kilometres), was officially launched in January 2004. In its first year of operation, 15.9 million passengers used the system. The following year, 2005, the number of passengers increased to 20.8 million or 57,000 passengers a day. Ridership increased further in 2006.[k]

Preliminary evaluations show that Corridor 1 has achieved many of its initial targets. It has achieved an operational frequency of 1.6 minutes and influenced a 14 – 20 percent modal shift from passenger vehicles to mass transit.[l, m] In terms of financial performance, during its first 10 months of operation, the government accrued Rp. 35 billion in revenue, the consortium of operators achieved an IRR of 34.3 percent, and the ticketing company achieved an IRR of 20.9 percent. Both the consortium of operators and ticketing company expect to *breakeven* in 7 years.

[k] *Heru Sutomo et al. 2007.*

[l] *Heru Sutomo et al. 2007.*

[m] *ITDP 2007.*

System expansion: Challenges

Jakarta's initial plan was to introduce 15 corridors by 2010. Because of Corridor 1's preliminary performance, Corridors 2 and 3 were approved and became operational in January 2006 and Corridors 4, 5, 6, and 7 became operational in 2007.

With the expansion of the network, several challenges have emerged.

Financing

As Jakarta's first BRT line, Corridor 1 was implemented as a demonstration model and the project was fully funded by the local government. Specifically, the city invested in the construction of the busway, shelters, and pedestrian crossings; the widening of roads; the entire fleet of buses (86 in total); and a ticketing system.

58.2 **Schematic System Map of Jakarta's seven BRT routes**
TRANSJAKARTA 2008

Corridors 2 through 7 have a different financing scheme from Corridor 1. The bus fleet investment for these corridors is assigned to the operator of each BRT line. This has put financial pressure on the other corridors. Due to financing challenges, there has been a lack of investment in the bus fleet. This has led to an insufficient number of buses, particularly in Corridors 4 – 7, resulting in long queues in the ramps leading to the bus shelters.

System integration

A feeder bus network was created to help support the BRT network's operation and bring more passengers from outside of the fixed busway corridors. Thirteen feeder bus routes were introduced for Corridors 1, 2, and 3.

Certain setbacks have hindered the success of this integration. First, the feeder bus operators are contracted out by the Jakarta Transport Office. Since their operation is based on contracts, which are granted to individual buses, institutionalised contractual payment cannot be applied. Second, attempts to introduce a combined fare for feeder buses and the BRT system has failed because feeder bus operators prefer cash payments rather than transfer tickets that require reimbursement.

Way forward: Comprehensive transport system planning

Currently, there is a lack of comprehensive planning in the development of the BRT corridors. Corridors are being developed based on the experience acquired from the development of Corridor 1.

Corridor 1, however, is unique because it runs on the median of a 10-lane street. The other corridors have fewer lanes, as such the conversion of the median to a busway has significantly reduced the passenger vehicle capacity on these streets.

At present, a direct link between congestion relief and the development of the BRT system has not been reported. BRT corridor planning may want to consider replacing lanes that are initially converted to a busway, even though the BRT will help reduce the modal share of passenger vehicles. This expansion may be costly to implement. However, in order to help alleviate congestion within the city, the BRT plan will have to address this problem, particularly since the passenger vehicle stock is still increasing in the city.

IMPLICATIONS

Jakarta is rapidly adding new BRT corridors and extending corridors into suburban areas. In the process, the city is receiving public criticism that the BRT system is failing to reduce congestion, and moreover, that the development of BRT corridors is actually increasing congestion.

To enhance the effectiveness of the BRT system in reducing congestion, Jakarta will need to implement its long-term JABODETABEK transport plan, which incorporates transport, energy, and environmental aspects. Additional policy and institutional development, among transport and energy related agencies, in combination with further integration across modes, may be necessary.

In 2004, the National Development Planning Agency (BAPPENAS) developed a transport master plan, known as *The Study on Integrated Transportation Master Plan for JABODETABEK* (SITRAMP), for the entire JABODETABEK region. The plan aims to deal with Jakarta's congestion problem and provide fuel and emission reduction savings to the region. It requires further investment in road and transit development and the implementation of decisive policies on transport.

The BRT system is a major component of the plan and is envisioned as Jakarta's main mass transit system. It is expected to rapidly increase in passenger capacity. The number of passengers, in the main corridors, is foreseen to increase to about 150,000 passengers per day by 2020.

The master plan recognizes that to compete with passenger vehicles, the BRT system needs to extend its corridors to reduce the travel demand on feeder buses. Feeder bus routes would service the CBD and suburbs to reduce transfer and distribution time. Through the use of a common ticketing system, the transfer between buses and other modes of train (the planned MRT and monorail systems) would be smooth.

59.1 **JABODETABEK Transport Master Plan**

SITRAMP 2004

Jakarta may also need to develop specific policies, related to the BRT and feeder bus system, to help address

1) The setting of adequate fare structures, so as to help maintain a high service quality, while providing reasonable returns to BRT operators;

2) BRT and feeder bus system integration, in terms of route transfers and fares; and

3) The role of government if the development and operation of the BRT and feeder bus system cannot rely solely on fare revenue.

In essence, BRT is a mass transit mode that has the potential to alleviate congestion, lower fuel consumption, and reduce emissions. Nevertheless, to simply adopt and transplant the system on the premise of success in other cities can be ineffective. To be effective, BRT implementation should take into consideration local conditions and reflect these conditions from the planning stage through to the ultimate operating stage of the system.

INSTITUTIONAL ISSUES IN URBAN MASS TRANSIT: MANILA

Proposed transport projects in Metro Manila, including road construction and expansion of the rail network, have either been delayed or not implemented due to a lack of coordination between government agencies and limitations in the scope of specific agency's functions and authority. This has exacerbated the city's traffic congestion problem. As a short-term solution to facilitate the implementation of transport projects, the establishment of an issue-specific "taskforce" on transport, consisting of members from relevant government agencies, may help. As a long-term solution, it is important to strengthen the capacity of Metro Manila's existing 'urban transport manager', the Metropolitan Manila Development Authority, to incorporate all major aspects of urban traffic operations in its scope of functions and authority. This may facilitate project implementation in the future.

TOTAL POPULATION	LAND AREA	POPULATION DENSITY	GRP *	PCI*	GASOLINE USE	PASSENGER VEHICLES
10.8 MILLION	636 KM^2	16,961 P/KM2	108 BILLION	11,196	1,072 KTOE*	1.5 MILLION*

APERC Internal Database (2008), * USD, PPP 2005.

INTRODUCTION

Manila, more commonly known as Metro Manila, is the National Capital Region of the Philippines. With about 10.8 million people living in 636 km^2 of total land area, Metro Manila's population density reached 17,000 people per km^2 in 2005.[a] This makes Metro Manila one of the most populous metropolitan areas in the world and the largest in Southeast Asia.

Comprised of 14 cities and 3 municipalities, Metro Manila is characterised by a wealth of economic, social, and political activities. Metro Manila contributes more than 30 percent to the economy's GDP. In 2005, Metro Manila ranked as the 42nd richest urban agglomeration in the world, with a gross regional product (GRP) of USD 108 billion. Its GRP has an annual growth rate of 5.8 percent (2000-2006), which is greater than the economy's average of 4.8 percent and its GRP per capita in 2005 (Php 186,577) was about 2.9 times the economy's average (Php 63,780). By 2020, Metro Manila is expected to become the 30th richest urban agglomeration in the world, with a GRP of USD 257 billion and an annual growth rate of 5.9 percent.[b]

Aside from being the economy's capital, Metro Manila is also a political, educational, and cultural hub. In the 1950s, there were only 2 million people living in Metro Manila, but by 1980, the number jumped to almost 6 million and continued increasing to about 9.5 million in 1995. This increase is attributed to a continuous migration of people from all over the economy to Metro Manila.

Rural to urban migration, as a factor influencing urbanisation, has been evident in Metro Manila. With continued rapid population growth

61.1 **Map of Metro Manila cities and municipalities**

[a] *2005 estimate by the National Statistics Office.*

[b] *Price Waterhouse Coopers 2007.*

and diminishing agricultural frontiers after the colonial years, rural to urban migration accelerated in the 1970s and picked up further in the 1980s. By 1990, the level of urbanisation rose to nearly 50 percent, the highest in Southeast Asia.[c]

[c] *Executive Conference on Sustainable Metropolitan Development 2006.*

With the growth in population, Metro Manila has been sprawling. A number of residents live in the surrounding provinces (Cavite and Laguna to the south, Rizal to the east, and Bulacan to the north) and commute to Metro Manila. It is apparent that Metro Manila is not a distinct urban area, but rather the core of the expanded metropolitan capital region.[d] In actuality, the population of greater Metro Manila is more than 15 million and the urban area is about 800 km^2.

[d] *Hussein S. Lidasan 2001.*

Driven by both population and economic growth, the number of passenger vehicles within the city has been increasing rapidly. Between 1980 and 1995, the number of registered vehicles increased at an average rate of about 6.0 percent per year. In 2005, the number of registered vehicles reached 1.5 million.[e] Manila's car ownership per 1,000 population, however, is still lower than other rapidly growing Southeast Asian economies. In 1995, there were only 85 cars per 1,000 population in Metro Manila compared to 464 in Kuala Lumpur, 110 in Singapore (1993 data), and 141 in Bangkok (1993 data).[f] This may be explained by the fact that a survey conducted in 1996 showed that most trips, about 78 percent, are taken by buses, jeepneys, and taxis, while only 22 percent are through private vehicles.[g]

[e] *Land Transportation Office 2007.*

[f] *Metro Manila Urban Transport Integration Study 1996.*

[g] *Metro Manila Urban Transport Integration Study (MMUTIS) Person-trip Survey 1996.*

Despite the increase in population and number of vehicles, Metro Manila's road length and quality has not significantly improved over the years. Metro Manila has a total road length of about 4,900 kilometres, consisting of national roads (895 kilometres); city, municipal, and barangay roads (2,366 kilometres); subdivision roads (1,639 kilometres); and privately operated toll expressways (37 kilometres). As a result of land acquisition and funding problems, among others, only about 75 kilometres of new road have been built since 1982. Thus, many roads have reached their capacity limits. Due to traffic congestion, the average travel speed was estimated to be as low as 10 kilometres per hour in 1996.

The present condition of the urban transport system in Metro Manila, as reflected by heavy traffic congestion, poses a big challenge to policy makers. Creating an efficient urban transport system, beginning with the improvement and expansion of infrastructure facilities such as roads, bridges, and railways, plays a critical role in providing decent transport services to the people of Manila.

ENERGY CONSUMPTION FOR ROAD TRANSPORT

HISTORICAL TREND FOR GASOLINE/DIESEL CONSUMPTION

Prior to 1990, gasoline was the fuel of choice for passenger transport in Metro Manila. Gasoline consumption in 1988 was actually more than 10 percent higher than diesel consumption. However, from 1995 onwards, diesel consumption outgrew gasoline consumption. As of 2005, diesel consumption was 32.7 percent higher than gasoline consumption.

Metro Manila's gasoline consumption from 1988 to 2005 grew at an annual rate of 4.2 percent. Coinciding with the region's rapid motorisation trend, gasoline consumption experienced its fastest growth, about 7.5 percent per year, between 1988 and 1995. During this period, the number of gasoline-powered vehicles increased at record levels, from around 412,000 units in 1990 to 728,000 units in 1995.

From 1988 to 2005, diesel consumption grew at an annual rate of 7.4 percent. Since the majority of road-based mass transit vehicles (which are predominately high mileage vehicles) are diesel-powered, diesel consumption outgrew gasoline consumption from 1995 onwards. This growth became more evident following the Asian Financial Crisis, as demand for road-based mass transit increased.

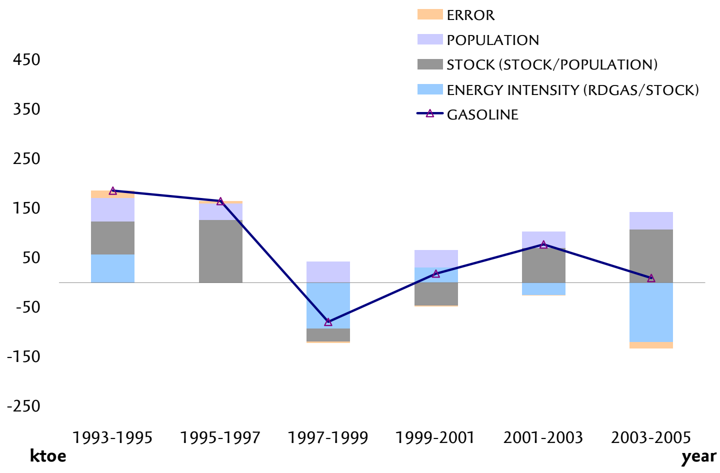
	ABSOLUTE LEVEL (KTOE)					ANNUAL GROWTH RATE (%)				
	1988	1990	1995	2000	2005	1988-1990	1990-1995	1995-2000	2000-2005	1988-2005
GASOLINE	556	648	882	941	1,072	8	6.9	1.5	2.7	4.2
DIESEL	502	641	1,043	1,022	1,592	13	10.4	-0.1	9.7	7.4

63.1 **Gasoline and diesel consumption in Metro Manila**

Philippine Department of Energy 2005, APERC 2008

FACTORS AFFECTING GASOLINE CONSUMPTION

The factors that contribute to Metro Manila's growth in gasoline consumption are examined through a decomposition analysis. From this decomposition analysis, it is evident that population growth has steadily contributed to gasoline consumption growth. Excluding the Asian Financial Crisis period (1997 to 2001), the region's passenger vehicle stock has also substantially contributed to the growth in gasoline consumption.



63.2 **Decomposition analysis: Gasoline consumption in Metro Manila**

APERC 2008 based on Philippine Department of Energy 2005

This analysis also offers interesting results with respect to vehicle energy intensity, since it significantly varied between each period examined. The period from 2001 to 2005 is noteworthy because energy intensity decreased its contribution to the growth of gasoline consumption, even though there was an increase in the registration of gasoline-powered vehicles (about 6 percent per year). This decline in energy intensity is attributed to a number of reasons. First, there was a proliferation of small and fuel-efficient vehicles from 2001 onwards.[h] Second, the price of gasoline became higher than diesel's, which restrained people from utilising gasoline-powered vehicles. On top of this, the government continued to provide discounts (Php1 per liter) to diesel-powered road-based mass transit vehicles. And finally, as a result of higher gasoline prices, there was a modal shift towards road-based mass transit vehicles and the rail transit system.

[h] One of the programmes of the Department of Energy is to promote the efficient utilisation of fuels and technologies. Several fuel-economy tests (fuel-testing of newly built cars of the same specifications from different car manufacturers) were conducted by the DOE to encourage both car manufactures and buyers to use fuel efficient vehicles.

ISSUES

MASS TRANSIT SERVICES

Mass transit services in Metro Manila are currently provided by a network of privately-operated buses, jeepneys, taxis and tricycles. They are supported by three LRT/MRT lines (the Yellow Line, Purple Line, and Blue Line). In 1995, mass transit accounted for 59 percent of total trips. This is remarkably high compared to other megacities in Southeast Asia.

	BANGKOK	KUALA LUMPUR	JAKARTA	MANILA	MANILA (1996 MMUTIS)
PRIVATE TRANSPORT	45.80%	68.80%	28.10%	19.60%	15.80%
PUBLIC TRANSPORT	42.70%	7.20%	25.50%	59.00%	62.30%
NON-MOTORISED TRANSPORT	11.50%	24.00%	46.40%	21.40%	21.90%

64.1 **Modal split of all trips in major cities in Southeast Asia (1995)**

Kenworthy and Laube 2007

Buses operate mainly on EDSA[i] and the major thoroughfares of Metro Manila, including bi-directional expressways to the adjoining provinces. Jeepneys, on the other hand, can be found almost everywhere (except on EDSA). Taxis and tricycles provide feeder services in all areas in Metro Manila. Tricycles operate within sub-divisions (residential villages) and other areas where larger vehicles cannot penetrate. To a certain extent, each vehicle-type causes a disruption to the flow of traffic, especially at pick-up and drop-off locations, where several vehicles might congregate at once.

[i] EDSA is the main circumferential road in Metro Manila, otherwise known as Circumferential Road 4 (C-4). EDSA is the busiest road, as it traverses major cities and business districts in Metro Manila.

The rail transit network in Metro Manila is disconnected from the rest of the region's mass transit network. There are several concerns related to station design, location of stations, and the lack of or poor interchange facilities between rail lines and other mass transit modes.

A recent problem, the delay of an extension that will integrate the Blue Line and Yellow Line, is further hindering the transit network's potential. The extension is projected to increase travel demand and boost a modal shift from road-based mass transit options to the rail transit network. Fortunately, the rail transit network is still gaining popularity among travellers, as noted in the previous discussion about modal shift. The combined ridership of the three rail transit lines has continued to increase, about 13.6 percent per year, from only 142 million in 2000 to 294 million in 2006.

Another mass transit concern is related to provincial buses. Provincial buses cater to the demand of travellers from Metro Manila to outside provinces and vice versa. Over the past few years, there has been an attempt to eliminate provincial buses from Metro Manila's roads. However, the identification of suitable terminal sites, together with the sheer number of buses and passengers, has made this policy difficult to implement.

URBAN TRANSPORT CONGESTION – A WAY OF LIFE

Despite relatively high mass transit use and a modal shift to rail, Metro Manila still suffers from heavy congestion. The average travel speed in Metro Manila was estimated to be as low as 10 kilometres per hour in 1996.

The traffic congestion in Metro Manila is attributed to an insufficient road and rail network. Only three percent of GDP expenditures are spent on transport infrastructure, which is significantly lower than any other country in Southeast Asia.[j] Lack of funding is often exacerbated by the conflicting goals and policies of agencies involved in the transport sector. The Department of Transportation and Communications, in June 1999, quoted traffic costs to the economy at Php 40 billion (USD 1 billion) a year in direct losses and Php100 billion (USD 2.6 billion) in indirect losses.

[j] *Lars Christian Roth 2000.*

	DAILY LOSS (PHP MILLIONS)	DELAY(HOURS)
GOV'T, BUSINESS EXECUTIVES	100.7	0.63
PROFESSIONALS	94.9	0.69
TECHNICIANS	19.5	0.73
CLERICAL WORKERS	20.3	0.72
SERVICE WORKERS	41.8	0.61

65.1 **Money and time lost on road**

Department of Transportation and Communications 1999

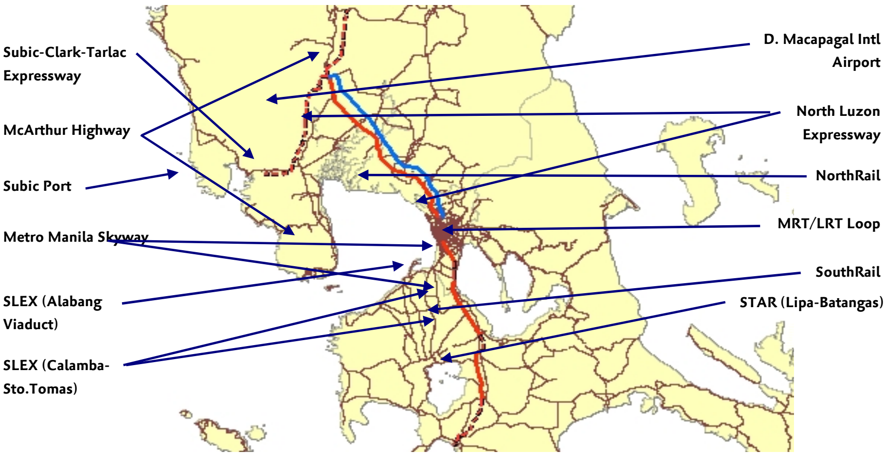
According to the results of the Metro Manila Urban Transport Integration Study (MMUTIS), the Philippine Government needs at least USD 30 billion by 2010 to decongest the choke points in Metro Manila. The projects identified in the MMUTIS aim to reduce traffic congestion in Metro Manila by putting in place a coherent transport infrastructure.

Meanwhile, the Government will continue to pursue various infrastructure projects to minimise traffic congestion in Metro Manila.

PROJECTS TO DECONGEST METRO MANILA

The Philippine Government concedes that urban traffic congestion is a major problem in Metro Manila. In fact, the Government has identified priority projects in its *Medium-Term Philippine Development Plan 2004-2010* to solve this problem. These projects include transport facilities linking Metro Manila to suburban areas, road-based transport rationalisation within the metropolis, and the expansion of the rail transit network to cater to growing transport demand. In view of escalating transport fuel prices and environmental effects from road-based mass transit systems, the government's current policy is to attract passengers to use the rail transit network because it is more efficient in terms of lower energy consumption and CO_2 emissions. The environmental benefits of using the rail transit network in Metro Manila can be significant since the economy is generating about 36 percent of its electricity from renewable energy sources (hydropower, geothermal, biomass and wind power).[k]

[k] *The Renewable Energy Policy Framework (REPF) of the Department of Energy targets a 100 percent increase in renewable based power generation by 2013.*



66.1 **Projects to decongest Metro Manila**

Department of Public Works and Highways (DPWH)

To improve traffic within Metro Manila, a number of projects have been identified. Non-road-based mass transit projects include finishing the linkage between the MRT/LRT commuter loop, the adoption of a unified ticketing system for all three rail transit systems, and the development of other rail transit systems that will connect Metro Manila to outlying provinces. In terms of road-based mass transit, the rationalisation of infrastructure covering the major thoroughfares within Metro Manila will also be prioritised. Additionally, the provision of integrated transfer terminal facilities for provincial buses will be established at the northern and southern edge of Metro Manila to reduce and eventually remove provincial buses from the heavily congested thoroughfares of the metropolis.

Although mass transit infrastructure is a priority, the government has also identified other transport projects to help solve critical infrastructure bottlenecks along national roads and bridges to speed traffic out of Metro Manila. Traffic management schemes, provision of facilities for safe and efficient pedestrian flow, and the construction of privately funded expressways will be strengthened.

LACK OF COORDINATION AMONG GOVERNMENT AGENCIES AND STAKEHOLDERS: A BARRIER TO PROJECT IMPLEMENTATION

At present, the transport sector in the Philippines is regulated by various government agencies that have different and conflicting policy goals and objectives. Overlapping functions, whereby competing government agencies vie for the same project, are the most common cause of bottlenecks in the implementation of projects. In some instances, a government entity competes with the private sector for the same project. This has resulted in the inefficient use of resources, as such further diminishing the limited resource supply in Metro Manila. As a result, most of the projects are either delayed or not implemented at all.

The lack of coordination among government agencies has been exacerbated by implementing policies and programmes that do not conform to a common goal or agenda. National government agencies have sponsored mode-specific plans and policies, with limited regard for developing an integrated, inter-modal transport system. In general, road construction has not taken into account pick-up and drop off sites, transfer points, and waiting areas needed by buses, jeepneys, and tricycle services. This has resulted in chaotic traffic along major corridors and near road junctions, which severely affect the overall traffic flow, cause delays, and increase safety hazards.[l]

The absence of an integrated master plan agreed upon by the cities and municipalities that comprise Metro Manila is apparent. Most major land use projects in Metro Manila do not follow a consistent plan that could be identified with a particular land use or zoning policy. Poor coordination among government agencies that often have overlapping functions and responsibilities has led to institutional gridlock. Although policy making and implementation/enforcement are assigned to specific agencies, organisations usually disregard or bypass one another in the performance of their functions.[m] Unfortunately, the sheer number of agencies intensifies the problem.

One example of this uncoordinated road construction is the Manila-Cavite Coastal Road. The proposed extension of the coastal road up to Noveleta has hindered progress on the Cavite Coastal Plan. This has resulted in a traffic bottleneck within the Talaba/Zapote area that has caused severe traffic jams during peak hours. Similar examples can be found on other major road projects within Metro Manila.[n]

These setbacks are not limited to road infrastructure. Rail transit projects have also been hindered. An example of this is the 5.5 kilometre northern extension of the MRT Blue Line to connect to the Yellow Line. This extension will create the first rail transit integration in Metro Manila. So far, the northern extension of the line has not been built and efforts to bid the extension by the Department of Transportation and Communications have been stalled. The deadline for the start of construction changed from 2004 to 2007, however, the project is yet to commence. Recently, the Light Rail Transit Authority, which operates

The Northrail project, a 100-kilometre double-track rapid rail system, is expected to provide efficient transport service between Metro Manila and Central and Northern Luzon. The Northrail network will go from Ninoy Aquino International Airport and traverse through the busy districts of Metro Manila to Clark, Pampanga in the North. This will help alleviate the traffic problem of going in and out of Metro Manila and reduce congestion in the metropolis. To date, the widening and improvement of the North Luzon Expressway has helped decongest the roads from Metro Manila towards Central Luzon.

Additionally, the government will develop the Southern Luzon corridor all the way to Batangas Port, the industrial belt South of Metro Manila. It will also complete the Southrail project to Bicol and build dormitory suburbs linked to railroad hubs.

67.1 **Road infrastructure expansion projects**

Medium-Term Philippine Development Plan 2004-2010

[l] *World Bank 2007.*

[m] *Dave L Lorito 2002.*

[n] *Hussein S. Lidasan 2001.*

the Yellow Line, has commissioned another study to extend the Yellow Line to link up the two systems. This new proposal is now a national priority, as it will serve the best interest of the riding public.

LIMITATIONS IN SCOPE OF FUNCTIONS AND AUTHORITY

All government agencies are bound by the powers and functions vested to them by law. As illustrated in [68.1], each agency's role and responsibilities in the transport sector are defined. These agency-specific responsibilities, however, limit the agency's ability to resolve particular problems—in this case, urban traffic congestion. Agencies have difficulty developing an integrated solution to traffic congestion as it entails civil works and expansion projects that may not be covered within their mandate.

AGENCY	RESPONSIBILITIES
Department of Transportation and Communications (DOTC)	– Transit planning and implementation – Regulate vehicle ownership and operation for the entire economy
Road Transport Planning Unit	– Plan routes for road-based transit – Review applications for new routes from potential operators
Land Transportation Office	– Driver and vehicle licensing and registration – Ensure that operators abide by the details of their franchise
Land Transportation Franchising and Regulatory Board	– Issue franchises for operation of transit services – Control and set fare levels and structures nationwide
Light Rail Transit Authority	– Construction, operation, maintenance and/or lease of light rail transit systems in the Philippines
Department of Public Works and Highways	– Plan and maintain national roads within Metro Manila – Implement highway projects (government financed and BOT projects) through its main units: the Urban Road Project Office,the BOT Project Management Office, and the Toll Regulatory Board
Metropolitan Manila Development Authority	– Transport planning within Metro Manila – Manage transport and traffic – Rationalise existing transport operations – Institute a system to regulate road users
Local Government Units	– License and regulate tricycles within jurisdiction – Actively manage local roads and prevent encroachment of roadside activities[certain cases] – Provide and regulate transit terminals

68.1 **Agencies with transportation responsibilities in Metro Manila**
Klima Climate Change Centre 2007

As early as the 1960s, efforts have been made to come up with an effective system for metropolitan governance within Metro Manila. The government realised the need to integrate certain aspects of physical development, such as highway networks, transport, sewerage, and flood control across the entire area. These efforts led to the creation of the Metro Manila Commission (MMC) in 1975. The Commission was conceived as a *manager commission body* that would coordinate, integrate, and unify the management of local government services, one of which is traffic management. The agency gained broader powers and became the

Metropolitan Manila Development Authority (MMDA) by virtue of Republic Act 7924. These powers include:

1. The formulation, coordination and monitoring of policies, standards, programmes, and projects to rationalise existing transport operations and infrastructure requirements;

2. Provision of mass transport systems and the institution of a system to regulate road users; and

3. Administration and implementation of all traffic enforcement and traffic engineering services.

The authority over these tasks, however, is undermined by the fact that the responsibility of road construction and maintenance of national roads remains with the Department of Public Works and Highways and with local government entities for local roads. The distinction between infrastructure development and operational issues is most problematic in the area of traffic management, where physical interventions in road layout, geometry, pavement markings and signage, and the use of traffic control systems are often an integral part of the design scheme. This institutional complexity is one of the main sources of inefficiency in the transport sector and often leads to the slow response of traffic and transport issues.[o]

[o] *Rogelio U. Uranza 2001.*

This administrative complexity is a significant reason why traffic congestion in Metro Manila is hard to solve. The extent of this problem is exemplified by the Supreme Court of the Philippines' August 2007 ruling that declared President Arroyo's Executive Order (EO) 179 null and void. EO 179 promoted the decongestion of traffic within the Greater Metro Manila transportation system by eliminating the provincial bus terminals along Metro Manila's thoroughfares. The Court ruled that the Metropolitan Manila Development Authority did not have an explicit mandate to implement the project and that the EO clearly overstepped the authority conferred to the Agency. The Court declared that the MMDA will not be allowed to execute any plan, strategy, or project that it is not authorised to implement through its mandate. As is, although the MMDA has a broader responsibility in the transport sector, in terms of scope and accountability, it cannot go beyond the powers and functions vested by law.

Thus, the provision of transport infrastructure and regulation of transport services within Metro Manila remains a largely inter-agency affair. This seems to be a major cause of bottlenecks within the project implementation process that the government needs to address.

IMPLICATIONS

The travel pattern in Metro Manila is characterised by a high dependence on road-based mass transit, mainly buses and jeepneys. In recent years, there has been a slight shift from road-based transport towards rail transit. Despite this shift, Manila still suffers from heavy traffic congestion problems. This is primarily because government infrastructure projects for the transport sector, such as building roads and expanding rail networks, are either delayed or not implemented.

Overlapping functions among government agencies is the biggest cause of delays in the implementation of infrastructure projects in the transport sector. Instead of working together, various government agencies compete for the same project. This is exacerbated by limited funding resources and limitations in the scope of functions and authority of the relevant agencies.

As a short-term solution, the establishment of an issue-specific *taskforce* as an overarching governing body to the transport sector may facilitate the implementation of delayed transport projects and help alleviate traffic congestion. This may enhance coordination among the relevant government agencies, as it can offer a platform to resolve conflicting policy goals among the different agencies.

As a long-term solution, strengthening the capacity of the Metropolitan Manila Development Authority (MMDA) is an option. If all transport related tasks are assigned or transferred to the MMDA, it will surely enhance coordination. This could make it possible to implement an integrated approach to reduce urban traffic congestion. This process, to a certain extent, is already underway. The Traffic Engineering Center (TEC) [p], which was under the Department of Public Works and Highways (DPWH), is now under the jurisdiction of the MMDA. The responsibilities of TEC were gradually handed over to the MMDA in a move by the government to strengthen the MMDA's role in urban traffic management. This indicates that the government is inclined to strengthen the capacity of the MMDA. However, this shift of authority is only the first step. Other aspects of urban transport planning, development, and implementation need to be incorporated into the MMDA's functions and responsibilities. If this occurs, a holistic, inter-modal approach to address urban transport problems will be much easier to implement.

[p] *The Traffic Engineering Center (TEC) has been responsible for road planning related to traffic engineering and the use of traffic control equipment. It has been responsible for the design and implementation of geometric improvements at intersections within Metro Manila and in upgrading traffic signals to provide a degree of real-time interactive coordination.*

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