

Benefits and Costs of Urban Mass Transit in Asia - Cases for Bangkok, Hanoi, Jakarta and Manila

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Abstract: This paper tries to evaluate the economic impact of mass transit systems, such as subways or railways. On evaluating four different urban areas (Bangkok, Hanoi, Jakarta, and Manila), the paper analyses the benefits and costs associated with urban mass transits and estimate their economic internal rate of returns (EIRRs). Through estimating the EIRRs, this paper addresses the potential economic benefits of urban mass transit systems, specifically energy security and environmental conservation.

The paper found that urban mass transit systems can, in general, produce substantial socio-economic benefits. The benefits come from savings on energy, CO₂, time and passenger vehicle ownership. Also the simulation exercise revealed that cities with higher income may have bigger socio-economic benefits. Bangkok could enjoy the largest socio-economic benefits from expanding its urban mass transit network. Additionally, the analysis found that cities with higher population density may yield large socio-economic benefits. An outstanding example includes the case of Manila, which income level is nearly half of Bangkok, however, the city's high population density will result in substantial socio-economic benefits through expanding its mass transit systems. It should be noted that more than two decades is required to realize the potential socio-economic benefits from the urban mass transit systems. And this suggests that the early and timely implementation of a project could maximize the potential benefits. To facilitate early implementation, planning for mass transit systems should be an integral part of the city's energy and environmental policy.

Keywords: Urban transport, mass transit, cost and benefit assessment, energy security, and sustainable development.

1. Introductions

A motorization trend has been taking place in the urban areas of some rapidly developing countries in Asia. With growing income and lack of sufficient urban mass transit infrastructure, urban population of Asia increase vehicle ownership to fulfill their mobility needs. Traffic congestion has been prevalent, and this creates air quality problems in such cities. By contrast, some wealthy cities in Asia such as Seoul, and Taipei have successfully reduced growth trends in vehicle ownership, and mitigated the traffic congestion as well as resulting air quality issues as a result of the development of efficient mass transit systems.¹

Despite the benefits, developing mass transit systems are not financially viable options 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 considerations, system operators cannot increase fare easily and this can put a system's financial profitability at difficult situation. Therefore, it is often pointed out that excluding a few special cases with wealthy, densely populated urban areas, there is little rationale to develop urban mass transit systems, such as rails or subways.

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 viable, but this neglects the positive non-financial benefits of these systems. These benefits include energy savings, air quality improvements, and CO₂ emissions reduction, in addition to time savings and cost savings of 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.

By evaluating four different urban areas (Bangkok, Hanoi, Jakarta, and Manila), the paper analyses the costs and benefits associated with urban mass transit systems and estimates their economic internal rate of returns (EIRRs). Through estimating the EIRRs, the paper tries to draw policy implications from the introduction of urban mass transit systems, for the purpose of enhancing energy security and environmental conservation.

2. Four urban areas – general characteristics

The four urban areas chosen for this analysis include areas at different economic development levels. Taking per capita Gross Regional Product (GRP) of each urban area as a proxy for economic development, it could be understood that in 2005, the four urban areas have wide disparity, ranging from a low of USD 6,157 (Hanoi) to a high of USD 27,560 (Bangkok).² Despite the wide variations in per capita GRP levels, the four urban areas all face similar transport problems.

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. For example, in the urban core of Jakarta, the average speed of passenger vehicles is about 15 kilometers per hour. Similarly, in the urban core of Bangkok, the average speed of vehicles is about 12 kilometers 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.

¹Between 1995 and 2005, Seoul and Taipei made substantial investment to increase the accessibility to subway/rail systems. During this time period, the number of subway/rail stations in Seoul increased from 66 to 263, and that of Taipei increased from 0 to 63. As a result, the growth trends in vehicle ownership per 1,000 population for these two cities slowed respectively at an annual rate of 2.9 percent (from 156 in 1995 to 206 in 2005) and 1.5 percent (from 228 in 1995 to 264 in 2005). By contrast, the number of vehicle stock per 1,000 population in Bangkok increased substantially at 6.7 percent per year (from 169 in 1995 to 323 in 2005) when the access to the subway/rail stations in Bangkok did not improve as much as the other two cities from 0 to 18 during the same time period.

²Both incomes are expressed in purchasing power parity at 2000 prices.

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, there are currently two mass transit systems: the BTS Sky Train and the Blue Line in the Mass Rapid Transit (MRT) network [1].³ Sky Train has an elevated route of 23 kilometres with 23 stations that transport about 400,000 passengers per day. The Blue Line in MRT 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 [2-3]. The first phase, a 2.2 kilometer extension, started operation in 2009, and the second phase, a 5.3 kilometer extension, is scheduled to be operational in 2011. In addition to rail mass transit, Bangkok is developing a 15-kilometer Bus Rapid Transit system (opened May 2010) that is expected to carry 50,000 passengers daily. To handle the growing number of passengers more efficiently, Bangkok also plans to extend the existing MRT line, and add new lines, amounting to a total of 118 kilometers by 2020.⁴

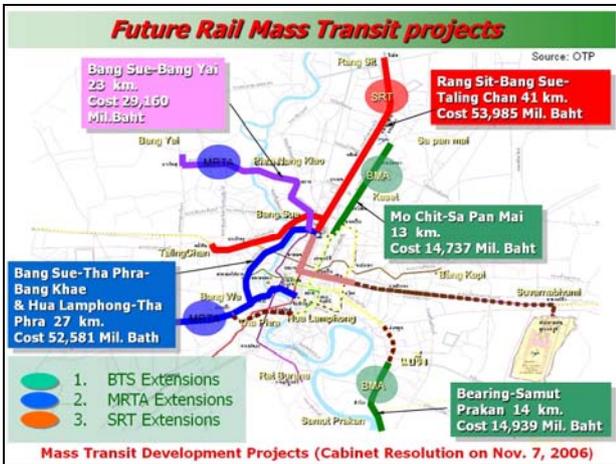


Figure 1. Bangkok’s future rail mass transit projects.

Hanoi’s transport is characterized 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 [4]. 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.⁵

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 [5]. In 2004, the National Development Planning Agency released a transport master plan, known as the Study on Integrated Transportation Master Plan for JABODETABEK (SITRAMP) [6-7]. 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 CO₂ 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 kilometers and the two LRT

systems, the Yellow Line and the Purple Line, have an operational length of 15 kilometers and 13.8 kilometers respectively. As part of a plan to reduce congestion and handle transport efficiently, Manila plans to expand the existing lines by adding 5.2 kilometers to the Blue Line and developing two LRT systems with a combined total of 33.6 kilometers. Manila also plans to develop two railways that can connect the city centre to suburban areas.

3. Model 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).

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.

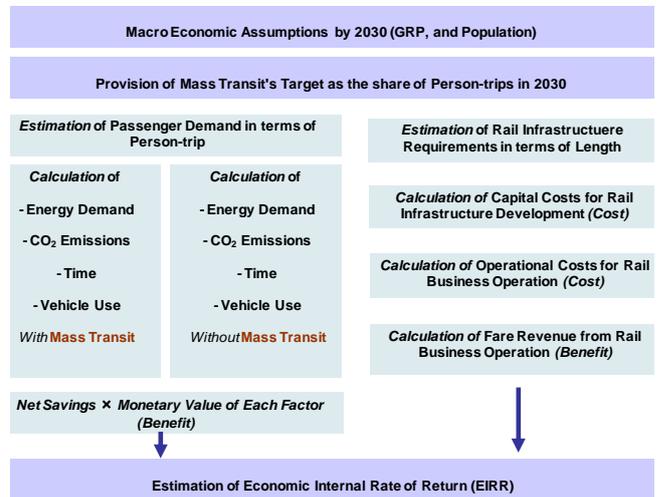


Figure 2. IRRs: Model framework.

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. In case the official sources do not cover the time period up to 2030, author’s estimate is utilized through extending the trend.

Second, a city-specific target for MRT systems, in terms of the share of total person trips by 2030, is determined. Based on this target, the number of MRT passengers by 2030 is calculated. As summarized in (Table 1), 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, CO₂ emissions, time, and cost of vehicle operation are calculated as the difference between having a mass transit system and not having a mass transit system. In other words, the savings from a mass transit system’s expansion/introduction are calculated by comparing against a benchmark case (lack of a mass transit system), in which no action is taken to expand/introduce a mass transit system and the targeted

³Other than the Sky Train, and Mass Rapid Transit, the Suvarnabhumi Airport Link opened on 23 August, 2010, which is linked to both the Sky Train and Mass Rapid Transit networks.

⁴Thailand’s cabinet resolution 2006.

⁵No mass transit introduction is under consideration in the Plan.

passengers are handled by passenger vehicles, instead of a mass transit system.

Fifth, assuming monetary factors for each variable, an estimate of the monetary value of these socio-economic benefits (savings in energy, CO₂, time, and vehicle ownership cost) is calculated.

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

With respect to the benefits and costs of rapid mass transit systems, the variables considered in this study are as follows:

Costs:

- Capital investment for mass transit system, and
- Operational cost of mass transit system.

Benefits:

- Fare revenue,
- Time savings,
- Energy savings,
- CO₂ emissions savings, and
- Cost savings from non-passenger vehicle use.

The data were basically obtained from the following sources:

Bangkok: Office of Transport and Traffic Policy and Planning, Thailand (2005). Bangkok mass transit implementation plan, Bangkok, Thailand

Hanoi: Institute of Energy Economics, Japan and Institute of Energy, Viet Nam (2008). The collaboration study on energy

efficiency and conservation in Vietnam – Transportation in Hanoi. Tokyo, Japan.

Jakarta: Japan International Cooperation Agency, and National Development Planning Agency Indonesia (2004). The study on integrated transportation master plan for JOBODETABEK (Phase II), Tokyo, Japan.

Manila: The National Statistics Office, the Philippines and personal communication with Herminio Ayala Ariola, the Department of Energy, the Philippines.

4. Findings – EIRR and FIRR

The results from the simulation exercise for Bangkok, Hanoi, Jakarta, and Manila are shown in (Fig. 3). 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. The horizontal grey line represents the central bank’s lending rate for each country, which is utilised as the discount rate for the mass transit expansion project.

The analysis shows that the financial viability of mass transit 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 mass transit system’s fare revenue may not be able to cover the cost of the system for the entire project period between 2005 and 2030.

Table 1. Basic assumptions.

	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

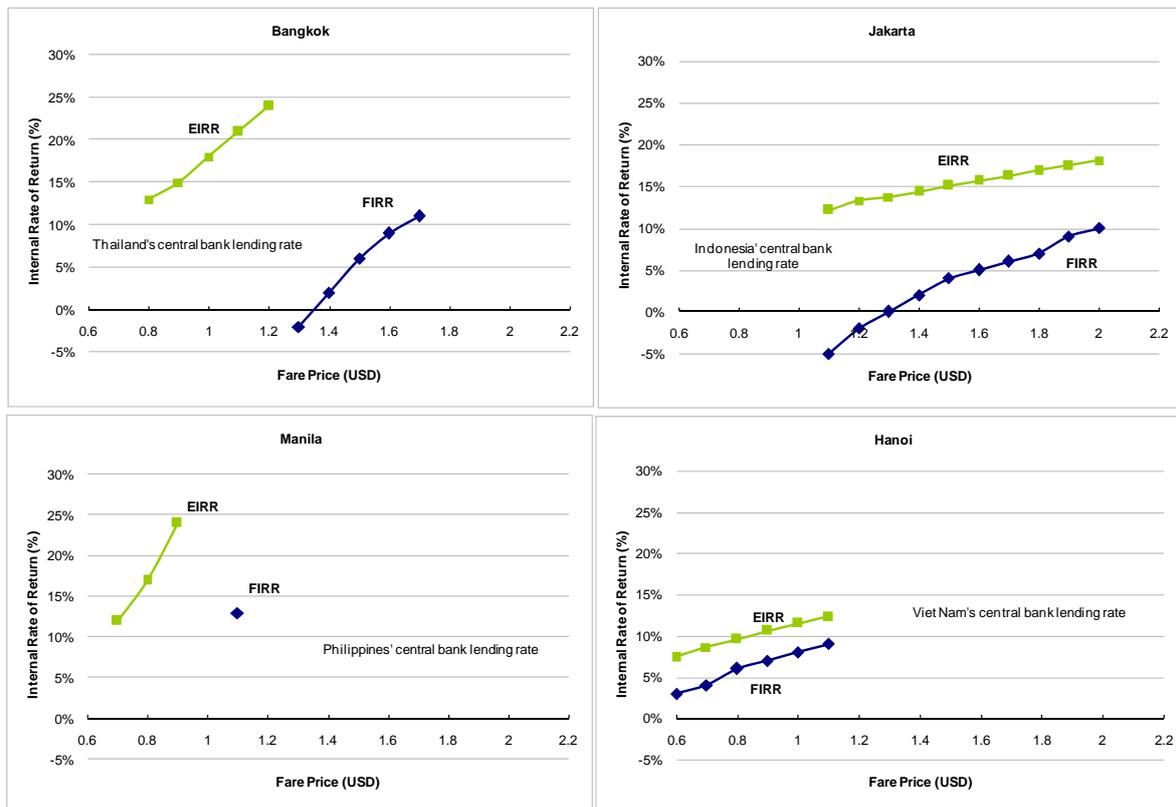


Figure 3. EIRR and FIRR in Bangkok, Hanoi, Jakarta, and Manila.

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 (Figure 3) captures the magnitude of the net socio-economic benefits that are expected from each mass transit project. A bigger gap between the EIRR and FIRR suggests that the mass transit project would 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 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, CO₂, 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 mass transit 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

Each factor included in this analysis affected the estimated

Table 3. Mass transit passengers and model share (2005 and 2030).

	Mass Transit Passengers [Millions]	Mass Transit Modal Share [%]	Mass Transit Passengers [Millions]	Mass Transit Modal Share [%]
	2005		2030	
Bangkok	120	4%	1595	20%
Jakarta			976	15%
Manila	169	2%	1628	15%
Hanoi			252	10%

EIRR results differently. Figure 4 shows the savings assumptions that were considered in the analysis.

In Bangkok, an expansion of the mass transit 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 (Table 2), among the four cities studied, and the highest time savings potential due to the heavy traffic congestion.⁶

Table 2. Hourly income (USD, 2000 price, in exchange rate).

	2005	2030
Bangkok	4.0	6.0
Jakarta	1.8	4.5
Manila	1.3	3.0
Hanoi	0.3	1.0

Despite the relatively low income level (third position among the four cities studied), mass transit 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 mass transit network is expanded. In fact, although Manila's target modal share of mass transit in 2030 is lower (15 percent) than that of Bangkok (20 percent), Manila's number of passengers could be larger (1,628 million) than that of Bangkok's (1,595 million) in 2030 (Table 3).

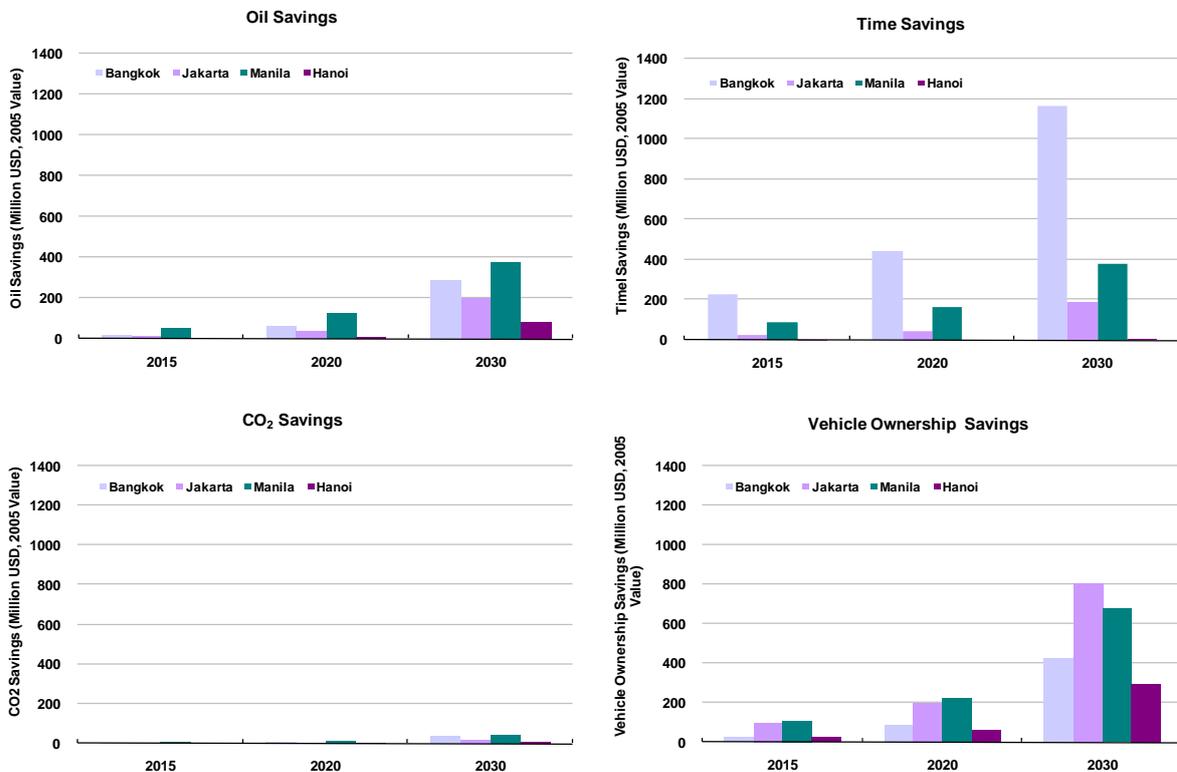


Figure 4. Savings on energy, CO₂, time, and vehicle ownership cost (2015, 2020, and 2030).

⁶ Based on Bangkok's transport master plan, the value of time is assumed as 40 percent of hourly income of each city.

The financial viability of a mass transit project in Jakarta turns out to be low, but 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 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 mass transit project represent the lowest level of all the cities studied. Considering of its level of economic development, the lowest target (10 percent) is assumed, in terms of the mass transit share to total person trips in 2030. This modest assumption resulted in smaller socio-economic benefits than the other cities.

5. Findings – Energy and CO₂ Savings

Figure 5 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.⁷

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

By 2030, as a result of mass transit 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 mass transit system 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, mass transit system expansion could bring about substantial CO₂ savings in Bangkok and Manila. By 2030, Bangkok could save 1.2 million tonnes of CO₂ emissions (approximately 2 percent of the present transport CO₂ emissions in Thailand) and Manila could save 1.5 million tonnes of CO₂ (approximately 6 percent of the present transport CO₂ emissions in the Philippines).

In Hanoi and Jakarta, substantial CO₂ emission reductions could be achieved only after 2025 due to a relatively low ridership per system length being assumed for these cities.

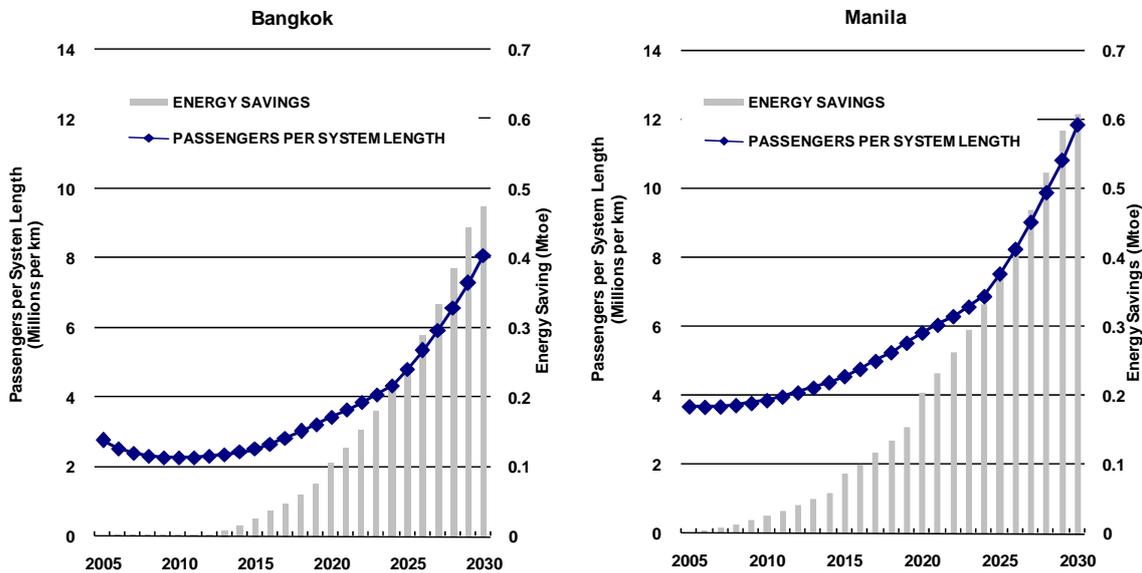


Figure 5. Energy savings and passengers per system length (2005-2030).

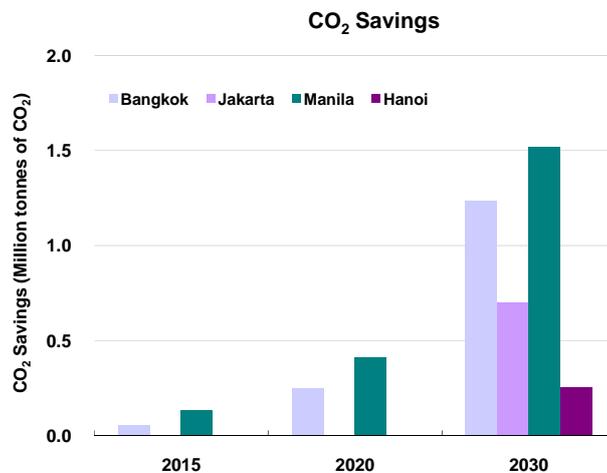


Figure 6. CO₂ savings (2015, 2020 and 2030).

⁷ Bangkok's number of passengers per system length is assumed to decline from 2005 to 2010 this is because system utilization does not increase until the system is fully developed to integrate a city center.

Table 4. Sensitivity analysis with different model share target for Bangkok and Manila

	Bangkok				Manila				
	10% target	15% target	20% target [Base Case]	25% target		10% target	15% target [Base Case]	20% target	25% target
Fare price: 0.8 USD	9.62%	11.59%	12.70%	13.45%	Fare price: 0.6 USD	5.85%	8.06%	9.38%	10.30%
0.9 USD	12.39%	14.09%	15.04%	15.67%	0.7 USD	10.39%	12.38%	13.56%	14.37%
1.0 USD	15.55%	16.88%	17.60%	18.07%	0.8 USD	15.68%	17.34%	18.27%	18.90%
1.1 USD	19.54%	20.19%	20.53%	20.76%	0.9 USD	23.54%	24.18%	24.49%	24.67%

6. Sensitivity Analysis

To consider the impact of the number of passengers on EIRRs, a sensitivity analysis was conducted for Bangkok and Manila. The mass transit's different modal share targets in 2030 were provided to understand the impacts on EIRRs. As Table 4 shows, a higher mass transit's modal share would mean bigger size of passengers in 2030; therefore, a larger benefit in terms of EIRR can be derived at a same fare price level. Naturally, mass transit's higher modal share in combination with a higher fare price level can result in the highest EIRRs among the cases analysed. It is important to note that a wider discrepancy for EIRRs is observed at the lowest fare price levels for both Bangkok (0.8 USD) and Manila (0.6 USD). This finding suggests the importance of the increasing number of passengers in rapidly developing cities in Asia since the fare price cannot be easily increased for social considerations.

7. Conclusion

Urban mass transit systems can produce substantial socio-economic benefits. The benefits come from savings on energy, CO₂, time, and passenger vehicle ownership.

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

Cities with higher population density may yield large socio-economic benefits as well. Although Manila's current income level is relatively low, being nearly half of Bangkok's income, the city could still enjoy substantial socio-economic benefits by expanding its urban mass transit systems. Its high population density would almost invariably entail high mass transit ridership.

Increasing the number of passengers would be important for those rapidly developing cities in Asia to fully enjoy the socio-economic benefits of mass transit systems. For social considerations, in such rapidly developing cities, fare prices cannot be easily increased and affordable levels would have to be maintained. As the sensitivity analysis for Bangkok and Manila offers, above a quarter of total passengers would have to utilize mass transit systems in 2030 to ensure economic viability of mass transit operations, at a time when relatively low fare price levels would need to be maintained.

Besides monetary benefits, urban mass transit systems could substantially reduce energy consumption. For example, if an additional 150 kilometres of mass transit network is extended in Bangkok by 2030 and 20 percent of all the city's passengers utilize the urban mass transit 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 urban mass transit 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 realized if the assumed urban mass transit 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 urban mass transit projects in the future.

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