PROMOTING GREEN TRANSPORTATION IN CITIES OF DEVELOPING COUNTRIES THROUGH IMPLEMENTING BUS RAPID TRANSIT (COMPARATIVE STUDY: JAKARTA AND HANG ZHOU)

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Abstract

As the transportation sector is one of the most significant contributors of air pollution in major cities, it is a requirement for cities with high population density and high growth of vehicles to promote green transportation in order to reduce CO_2 emissions as obligated by Kyoto Protocol. The operation of Bus Rapid Transit (BRT) in Jakarta and Hangzhou are selected and analyzed using SWOT analysis to review the strengths, weaknesses, opportunities and threats of the system. The analysis found

that BRT is effective and efficient in promoting green transportation. A further analysis is conducted through transportation policy instruments that consist of planning, regulatory, economic, information and technological instruments in order to apply BRT system to other cities of developing countries.
Keywords: Green Transportation, Bus Rapid Transit, SWOT Analysis, Policy Instruments

1. Introduction

The continued growth of urban centers throughout the world results in higher demand in transportation services. It is no wonder that a growing motorization trend has been observed in most countries in Asia and that the number of vehicles is forecast to continue to grow in years to come. This has led to traffic congestion, increasing energy consumption, air pollution, GHG emissions and other negative environmental consequences. The transportation sector is seen as the most significant contributor of air pollution in the major cities of Asia, especially for particulate matters (PM), carbon monoxide (CO) and nitrogen oxides (NOx). It is also one of the major contributors to GHG emissions. In 1994, the transportation sector in Asia accounted for 20% of carbon dioxide (CO_2) emissions in Japan, 25% in Indonesia, 28% in Thailand, 27% in the Philippines, and 15% in Singapore, respectively (UNFCCC, 2004). The share of world carbon emissions from Asia shows a growing trend mainly due to growing economies and the extensive development in the developing countries of the region, especially China. To solve these issues, innovations in terms of modern transportations systems are therefore necessary.

While the authors of this paper believe that the most appropriate transportation system to address the above issues could be rail-based public transportation systems due to their larger passenger capacity, higher speed and smaller emission of air pollutants (Litman, 2006), the high cost of investment for such systems is seen as a major obstacle for their adaptation and implementation in the developing countries of Asia. Even in the cities with rail-based systems already, many of them are still finding it difficul to raise their operating costs and only operate by receiving subsidies from the government (Matsumoto, 2004). The Bus Rapid Transit (BRT) system is therefore viewed as the best alternative to rail-based transportation systems.

Like rail-based transportation systems, BRT is a rapid mode of mass transportation that can provide the quality of rail transit and the flexibility of buses. In many respects, the BRT is a rubber-tired Light Rail Transit (LRT), but with greater operating flexibility and potentially lower costs. Oftentimes, a relatively small investment in dedicated guide ways can provide regional rapid transit.

2. Objectives

The main objective of this paper is to promote BRT as an alternative transportation system for rail-based transportation systems in the developing countries of Asia. In order to access the applicability of this system as an alternative transportation system in developing countries of Asia, the following specific objectives are undertaken:

a. Review of the existing BRT systems and operations in Jakarta, Indonesia and Hangzhou, China.
b. Review of their success/failure stories and impact of the BRT systems in the respective cities.
c. Determine the strengths, weaknesses, opportunities and threats of the BRT system and identify possible solutions to circumvent the said weaknesses and threats.

3. Review of BRT System

3.1. BRT System in Jakarta

(1) General Background

Jakarta, the capital of Indonesia, occupies an area of 650 square kilometers and is inhabited by 9.6 million people in 2011 and during the day, this increases by around 2 million commuters from surrounding Jakarta, BODETABEK (BOgor, DEpok, TAngerang and BEKasi). It is estimated that this population will grow to up to 17.3 million by 2015 (BPS, 2011). Jakarta, as the most populous city in Indonesia, is strained by transportation problems because of a lack of urban public transportation. The development of transportation is mainly focused on road networks. Although railway public transportation is present, it only contributes to 1.5 percent of all trips using public transportation (SITRAMP, 2004). Jakarta is experiencing rapid growth of motorized trips and for the time being, growth in number of vehicles has exceeded the development of road networks. The growth in number of vehicles is 9 percent and the growth of road networks is less than 1 percent. Based on data collected from the Directorate of Traffic Polda Metro Jaya, in 2008 the number of vehicles in Jakarta is as many as 11,362,396, of which 8,244,346 units are motorcycles and 3,118,050 units are cars. According to the Traffic Management Centre (TMC) Polda

Metro Jaya, it was predicted in 2011 that the number of motor vehicles in Jakarta will be as many as 12,062,396 vehicles.

As seen in the other metropolitan areas around the region, heavy traffic jams and low air quality have also become serious problems in Jakarta. As a part of the traffic management scenario, a high-occupancy vehicle scheme has been applied to private cars in recent years in selected areas at selected times, and will be extended to some other areas. Under this scheme, only private cars with more than three passengers are allowed to flow into the restricted areas. These conditions led to Jakarta becoming the city with the fifth highest level of pollution in the world after Beijing, New Delhi, Mexico City and Bangkok. In fact, there is a calculation that estimates losses from traffic congestion have reached 43 trillion IDR (about 4.8 billion US$ per year). Vehicles emissions in Jakarta during 1998 were approximately 71% NOx, 21% PM10 and 21% SO2 to total emission load based on the vehicle population that comprised of 29% passenger cars, 10% trucks, 8% buses and 54% motorcycles (Shanti Syahril et al, 2002 in Sutomo et al in 2007).

To cope with the problem mentioned, through the Governor's Decree No. 84 year 2004, the development of the transportation system in Jakarta mainly focused on mass public transportation such as promoting the use of trains and buses. After conducting comparative studies, the BRT system was launched on January 15, 2004.

(2) BRT System

1) History

The BRT system in Jakarta is called the Transjakarta and it will serve as the backbone of the public transportation system and act as connection to the other systems i.e. urban rail and the planned MRT and monorail system. The MRT has launched the system to attract middle-class citizens to shift from cars to public transportation and to reduce traffic congestion. The concept was first initiated in early 2002 by the metropolitan authority and the operation started on January 15, 2004. The project was postponed for 2 years because it was recognized that the concepts of implementation were premature, many parties including the Ministry of Transportation and non-governmental organizations urged the metropolitan authority to postpone the implementation until a substantial improvement was made. At that time, it was seen that regulations and operational concepts, such as ticketing and the marketing system, as well as the strategy to handle the impact of decreasing the number of lanes due to bus lane assignment were not well prepared.

The Transjakarta was the first BRT system in South and Southeast Asia. As of March 2011, there were 10 corridors (or lines) in operation, with five more to be built. The Transjakarta was designed to provide Jakarta citizens with a fast public transportation system to help reduce rush hour traffic. It is used by approximately 280,000 people every day. The buses run in special lanes or exclusive lanes. Currently, The Transjakarta has routes with a length of 172 km and has more than 524 buses in operation. Table 1 below shows the Transjakarta routes already implemented or still planned.

Table 1: The Transjakarta Routes

No	Name	Route	Established
1	Corridor 1	Blok M-Kota	February 1, 2004
2	Corridor 2	Pulo Gadung-Harmoni	January 15, 2006
3	Corridor 3	Kalideres-Pasar Baru	January 15, 2006
4	Corridor 4	Pulo Gadung-Dukuh Atas 2	January 27, 2007
5	Corridor 5	Kp. Melayu-Ancol	January 27, 2007
6	Corridor 6	Halimun-Ragunan	January 27, 2007
7	Corridor 7	Kp. Rambutan-Kp. Melayu	January 27, 2007
8	Corridor 8	Lebak Bulus-Harmoni	February 21, 2009
9	Corridor 9	Pluit-Pinang Ranti	December 31, 2010
10	Corridor 10	PGC Cililitan-Tanjung Priok	December 31, 2010
Planned corridors are:			
11	Corridor 11	Kampung Melayu - Pulo Gebang	
12	Corridor 12	Pluit - Tanjung Priok	
13	Corridor 13	Blok M - Pondok Kelapa	
14	Corridor 14	Manggarai - University of Indonesia	
15	Corridor 15	Ciledug - Blok M	

Source: www.transjakarta.co.id, access: August 2011.

Due to demand, the operation time of the Transjakarta was extended from 10 pm to 11 pm for almost all corridors except corridor 8.

2) Institutional Arrangement

To support the operation of the Transjakarta, the local government, that is the Governor of Jakarta, established a new local regulation in 2004. This regulation supports some privileges of the Transjakarta, namely the use of a special lane in the center of the road (exclusive lane), the passengers boarding through the right door, having special stops or shelters, the ticketing system, and other features to improve public transport services. This regulation also established coordination among several public offices, namely the local transportation agency that has responsibility for implementing the new system of the Transjakarta, the public works office that is responsible for preparing the Transjakarta infrastructure, and the landscaping office that is responsible for median strips, street furniture, open space and plants.

Using well-managed BRT and with the government's guarantee, the public transportation business attracts private investors. This was demonstrated when the government planned to put corridors 4, 5, 6 and 7 on tender. Some private companies were interested in offering proposals. However, the implementation of this system still faces challenges from the public transportation operators who are still preserving old paradigms. This is caused by the reform process for public transportation systems that take place relatively quickly, which means that the recent business opportunity in public transportation operation is enjoyed only by some big public transportation operators, such as PT. Jakarta Exspress Trans, PT. Trans Batavi, PT. Jakarta Trans Metropolitan, PT. Jakarta Mega Trans, PT. Prima Jasa Perdana Raya Utama dan PT. Eka Sari Lorena Transport.

By using the Buy the Service system, in which is there is no direct contact in transactions or service payments between passengers and operator, the financial and fare problems can be easily handled and the government has guaranteed that the income of the bus operators will be worth the service given. In addition, to attract more passengers, the local government of Jakarta supports the operation of the Transjakarta by subsidy so that the ticket price is affordable.

3) Operation

There are two types of buses operating in the Transjakarta: single buses and articulated buses. The passenger doors of the Transjakarta buses are higher than on normal buses so that passengers can only board from designated shelters. The doors use automated folding mechanisms that can be controlled manually by the driver. On corridor 2 and 3, buses use sliding doors in order to accommodate the surge of passengers during rush hours so that it can open and close properly. To optimize passengers' movement during rush hours, seats in all buses face the aisle.

Each bus is equipped with an electronic board and speakers that announce the name of shelters in two languages, Indonesian and English. Each bus is also equipped with a bi-directional radio transceiver to allow the driver to provide and to receive updated information regarding traffic jams, road accidents or lost items. To keep the air fresh, especially during rush hours, each bus is equipped with automatic air freshener dispensers that periodically spray a fragrance throughout the bus.

The Transjakarta shelters, located in the middle of the road and reached by elevated bridges, are also different from ordinary bus stops. The connecting elevated bridge ramps have gentle slopes (with some exceptions) to accommodate the disabled although the disadvantage of the ramps is that passengers need to walk a relatively long way up the ramps, and then double back, to reach the boarding shelters. The floors of the bridge are mostly tread plates, although some are made from concrete. There is air ventilation at the shelters and it works through fins on the aluminum part of the shelter. The doors of the shelters will open automatically when a bus arrives. One problem with the tread plate is that considerable noise is generated by the movement of passengers across the tread plate surfaces. The other problem is there are no sanitary facilities in most of the shelters.

The Transjakarta operates from 5 am to 11 pm except corridor 8, which is to 10 pm (the Transjakarta website, 2011), although opening hours can be extended if there are passengers still waiting at closing time. Shelters often become extremely overcrowded because of long intervals between buses. The large Harmoni Central Busway (HCB) shelter on Jalan Gadjah Mada, Central Jakarta, is built over the Ciliwung River. It is a transit point between Corridors 1, 2, and 3. However, in a plan, the average headway of the Transjakarta should be about 3 minutes and the average travel time for each route is less than an hour (about 45 minutes).

The tariff of the Transjakarta (March, 2011) is 3,500 IDR (about 39 cents USD) per trip, or 2,000 IDR (about 22 cents USD) in the early morning, from 5 a.m. to 7 a.m. Passengers who change direction or move to another corridor do not need to pay again if they do not exit the shelter. The tariff is quite cheap because is is subsidized by the local government of Jakarta. The Transjakarta tariff is more expensive than other ordinary buses, where the tariff is 2,000 IDR (about 22 cents USD) for

almost in the same distance on average.

Passengers first buy a single trip ticket in the form of a smart card or paper ticket. To enter a shelter, passengers insert the ticket into the slot on one of the ticket barriers or show it to an attendant.

In terms of the energy used, there are 2 types of buses operating for the Transjakarta: the first type is buses using diesel fuel and the second type is buses using gas as their energy source. However, there is a problem for buses using gas as their energy source because only certain fuel stations provide gas.

(3) The Impact of Implementing BRT

For the corridor 1, the BRT was implemented in the same area of 3 in 1, which is only a car with minimum 3 passengers can through this area, and one lane was dedicated as a BRT lane. Some congestion was predicted to increase due to the smaller space occupied by the same number of vehicles. In this situation, the 3 in 1 scheme on the BRT lines resulted in users, particularly commuters, leaving their cars and using BRT as the alternative transportation to enter the area. In the future, the Government of DKI Jakarta is planning to upgrade the 3 in 1 scheme to a road pricing scheme. Based on ITDP's presentation document in 2004, there was around **a 20% shift from private vehicle users.** However, the impact on traffic congestion may be insignificant considering the very high growth of vehicle ownership occurring recently. Another measure to reduce congestion is to eliminate street parking. Although this measure may not reduce the number of trips, it can at least create an obstacle for private cars users.

The other impact of implementing BRT is **to reduce pollution.** According to a survey conducted by the ITDP, in Jakarta the level of NOx had been reduced from 0.271 to 0.076 metric tonnes/day or 16 metric tonnes 7 months after BRT operation. Meanwhile, the level of PM10 had fallen from 0.029 to 0.002 metric tonnes/day or 2.3 metric tonnes. As for global emissions of GHG, the reduction is quite amazing. It declined up to 1,710 metric tonnes.

The other advantage of the BRT operation is the indirect change in the attitude of bus crews and the community. The bus crews who used to be reckless when driving, race with other public transportation system, halt and take passengers anywhere, halt too long and wait for passengers are now gradually changing their habits. The community indirectly learns and changes their attitude when using public transportation. **Queuing practices and discipline are improved, such as getting on and off the bus only at the available bus stops and paying with tickets bought at certain places.**

From the institutional point of view, this new system can also resolve existing problems. Due to the implementation of the kilometer-based payment system instead of vehicles, there will **no longer be fat and skinny routes.** Operators are appointed through a tender system using the service standard issued by the government. Consequently, the government can control the service during operation, sanctioning the operators who violate the contract.

Those are the positive effects, but there are also **some negative results.** To implement the BRT system, it is necessary to provide feeders, but the number of feeders is still limited and tickets are not integrated. Previously, integrated tickets between the Transjakarta and feeders was implemented but there was a problem regarding sharing of revenue. The other issue is CNG provision: as mentioned previously, only certain stations provide CNG. To achieve affordability for passengers, the tariff of the Transjakarta is lower than the operational cost, so the local government of Jakarta needs toprovide a subsidy. On the other hand, during peak hours the number of passengers is very high so the capacity of some shelters is inadequate. Attention to fleet maintenance is still low. There is still limited knowledge of the new system; in other words changes of how to adapt and adopt the operational, financial and institutional aspects. d.

3.2. BRT System in Hangzhou

(1) General Background

Hangzhou, the capital city of Zhejiang province in China, occupies an area of 3,068 square kilometers and has a population of 1.27 million with a stable growth rate of around one percent since 2001 (figures are for the central area, not the whole administrative area). Hangzhou also suffers from heavy traffic jams like many large cities in China, partly caused by the increasing demand from local citizens, but also due to excessive private car ownership, relatively scarce public transportation supply as well as an inappropriate public transportation structure. According to the latest data announced by the Hangzhou government (2010), the total number of vehicles in Hangzhou is 1.17 million, of which private cars account for 0.84 million while public transportation accounts for the rest. As for the structure of public transportation, 8496 taxies form the largest part and 5,603 buses follow. Public bicycle is a subordinate means of transportation, whose number is rapidly increasing and now reaches 25 thousand. Additionally, the subway is still under construction and will not been completed until 2012. As Hangzhou is a world-famous tourist destination, it attracts more than 53.24 million tourists both from China and abroad every year, placing a greater burden on traffic conditions.

Given the relatively poor traffic conditions in Hangzhou and the advantage of BRT itself (such as a relatively short construction period, small investment, large passenger capacity as well as high speed and punctuality rates), BRT is the appropriate choice for improving traffic conditions. Besides, all the buses in Hangzhou are run solely by Hangzhou Public Transportation Group Co. Ltd and its branches, resulting in more convenience for the BRT introduction to and operation in Hangzhou.

(2) BRT System

1) History

The Hangzhou government has realized that it is necessary to take some measures to optimize the public traffic system in Hangzhou and make it more convenient for citizens. After the technical visit to Curitiba in Brazil in 2004, the plan to build the BRT system was put on the agenda. Two rapid lines, named line K188 and K186, were built as pilots. The local government also carried out a project to make plans for the building of the BRT system. Many experts in the traffic field participated in the project and finally developed a plan for establishing 11 BRT lines to be running by 2020, with an average speed that could reach 30-35 km/hour. Under these circumstances, citizens could reach any destination from downtown in one hour. After two years' preparation on technology and policies, the first BRT line began to operate on April 26th, 2006, and Hangzhou became the second city with BRT in China since then.

In order to make the whole bus system more convenient and reasonable, the Hangzhou Government Transportation Sector adjusted some existing normal bus routes to adapt to the BRT (i.e. stop some routes, reduce buses at the same route with BRT). To date, there are 6 trunk lines and 13 branch lines in the Hangzhou BRT system, with two more trunk lines under construction. Among the branch lines, some are actually normal buses that can transfer with BRT while some can run on the exclusive bus lane. Table 2 shows the bus routes.

Table 2: Hangzhou BRT Routes

No	Name	Route	Established
Trunk Lines			
1	B1	Huanglong -Xiasha higher education east zone	27.3km
2	B2	Gold cross road north bus station-Civil Center	22.7km
3	B3	Dingqiao-Wushan	16.1km
4	B4	Xianlin-East Railway Station	12.7km
5	Part Line B2	Jiangcun Bus Center-Chengzhan Railway Station	14km
6	Part Line B1-1	Huanglong-Xiash	22.3km
	Part Line B1-2	Huanglong-Residential area of Xiaosha	22km
Branch Lines			
1	B-1	Jindubeilu-Guanyintang	25.2km
2	Part Line B-1	North Bus Station-Zhaokounongxincun	17km
3	B-2	Jianqiao-Liuhelu beikou	22.7km
4	Part Line B-2	Jianqiao-West Bus Station	17km
5	B-3	Gaotangcun-Binwen Center	22.6km
6	B-4	Era electronic market- Xiasha higher education east zone	30km
7	Part Line B-4	West Bus Station- Car passenger transportation center	19km
8	B-6	Qingchun square-Qiantangwan Park	21.4km
9	K96	Hangzhou Jiebai-Jingdu lu binkanglukou (connect with B2 at Civil Center)	17.4km
10	323	Jiaojiacun-Xiaoshangaojiaoyuan (connect with B1 at Zhaokounongxincun, with B2 at Xiachelukou)	22km
11	K508	Car passenger transportation center-Chengzhan Railway Station (connect with B1 at Yaochang)	13.6km
12	K509	Genshan Liushuiyuan-Linpin North Station (connect withB1 at Yaochang)	13.6km
13	K900	Sandun- Chengzhan Railway Station (connect with B1 and B2 at Baziqiao)	17.2km
Under Construction Routes			
22	B5	Fuyanlu-East Railway Station	
23	B7	Shaoxinglu Jiaojiacun-Tangxi Passenger North Station	

Source: Hangzhou Government Transportation Sector Website, 2011

2) Institutional Arrangement

Different from Jakarta, public transportation in Hangzhou (including normal buses and BRT) is operated solely by a company named Hangzhou Public Transportation Group Co. Ltd. This company belongs to the local government and is responsible for public transportation in different districts through a number of branches. Since BRT has many advantages over normal buses, it will be a substitute for normal buses to a certain extent. However, since normal buses and BRT in Hangzhou are owned by the same company, it will effectively remove the obstacles in the process of BRT introduction and operation, including easing the conflict of interest between normal buses and BRT, integrating BRT lines to normal bus lines and facilitating transfer, etc.

In the construction of the BRT system, Hangzhou Public Transportation Group Co., Ltd also needs to cooperate with related manufacturers. Before construction, Hangzhou Public Transportation Group Co., Ltd will conduct a bidding process to select the most qualified domestic manufacturer to produce certain products and build the system, including the fare collection system, platform door system, LED passenger information display and control system, etc. Bidding will introduce more competition and effectively reduce the investment and cost.

After the start of BRT operations, operation and maintenance is still in the charge of Hangzhou Public Transportation Group Co., Ltd. As we mentioned above, branches of Hangzhou Public Transportation Group are responsible for the public transportation management in different districts respectively. Moreover, BRT in Hangzhou always covers a long distance, from one district to another; therefore it is necessary for different branches to work together.

3) Operation

The total length of the BRT routes in Hangzhou is about 395.8 km including the feeders. Taking line B1 as an example, the average daily passenger flow is about 55000 people. At peak hour the departure interval is about 2-3 minutes, while it is about 3-4 minutes during ordinary times. The BRT bus runs on the open exclusive bus lane, which is about 3.5-4 meters wide, with average speeds reaching 22-26 km/hour. The punctuality rate of BRT in Hangzhou is very high, approaching 89.7 percent. It is much higher than that of normal buses, which is just under 30 percent. The average distance between stations is 1.1 km. There are 50 stations in total, 18 of B1, 23 of B2 and 9 of B3; including 5 of B3 under construction not yet open (data current as of April 2010). Moreover, there do exist public bicycles near the BRT station, which provides much more convenience for those who are riding to transfer to BRT.

There are 104 BRT buses in operation (with 48 in corridor 1, 56 in corridor 2) (data current as of April 2010). Most of the buses are articulated vehicles produced by German Neoplan based in Zhejiang, with a length of 18 meters, and each bus has a capacity of 160 persons. Because of the low and flat floor vehicle, passengers can easily board the car horizontally. There are also some 12-meter-long ordinary buses with less capacity used in BRT. All the BRT buses use diesel oil as energy fuel, which is environmentally friendly to some extent. Inside the bus, there is an automatic announcement system to tell passengers about station information and the running schedule clearly, both in Chinese and English.

At the BRT stations, there are also electronic boards with bus information and schedules, which are updated in real time. BRT passengers can buy tickets or use an IC card at the station but not on the bus, saving time especially during peak hours. The median ticket price is 4 RMB (about US 62 cent) and there is a discount when an IC card is used. The passengers are free to transfer to another BRT route at the same station.

(3) Results of Implementing BRT

According to a recent questionnaire carried out by a Hangzhou local newspaper, the satisfaction rate of citizens who have used BRT is 96%, resulting from the positive impact BRT brings to traffic, environment and people's behavior. BRT won the Best Habitat Award of Hangzhou in 2006, delivering the concept of "people-oriented" and making Hangzhou a more livable city. However, BRT also inevitably leads to certain negative consequences.

Positive impact on traffic. Since the introduction of BRT in 2006, Hangzhou's traffic conditions have significantly improved due to BRT's large capacity and high speed, especially during peak hours. According to the survey, the efficiency of BRT for unit of per capita is about 4-5 times that of the city's main roads. Since the subway in Hangzhou will be under construction until 2012, BRT is the favorable alternative for track traffic with its advantages of a shorter construction period, smaller investment, and lower daily operation and maintenance costs as well as less strict requirements concerning geographic conditions.

Positive impact on the environment. Given BRT's high efficiency and large capacity, energy consumption per capita and per kilometer decrease dramatically. Furthermore, as BRT services improve, more and more people will shift from private cars to BRT for the sake of the environment, which will further contribute to energy saving. Although the existing BRT in

Hangzhou still uses diesel as energy, not adequate to limit carbon dioxide emissions, the BRT being planned could employ more environmental friendly energy.

Positive impact on people's behavior. In addition to the positive impact on traffic and the environment, the benefits BRT brings to people's lives cannot be ignored. Firstly, with the features of high speed and a high punctuality rate, BRT enhances people's confidence in buses. Secondly, BRT in Hangzhou has a dedicated waiting station with an accurate information system and is always less crowded than normal buses, both providing a more comfortable experience for waiting and traveling. Moreover, BRT is significantly cheaper than taxis especially for long-distance travel. Consequently, BRT will gradually become the substitute for normal buses, taxis and even private cars in the future.

Negative consequences and potential challenges. Every coin has two sides, and BRT is no exception, In the short term, the dedicated lanes for BRT will reduce the area for existing vehicles and cause even more serious traffic congestion. However, efficiency should be measured by the number of people rather than that of cars moving in unit time. The advantages and advancement of rapid transit will reduce the number of private cars in the long-term, and ultimately improve road conditions significantly. As for the design of the exclusive lane, since it is set on the sides of the road rather than in the middle, when other vehicles need to turn right into the main road on both sides, they must cross the dedicated lane, which partly limits BRT's speed.

BRT in Hangzhou is also confronted with certain potential challenges due to existing and potential competitors. The first line of subway in Hangzhou will go into service in 2012 as planned, and is a major threat to BRT for specific lines. Compared with normal buses, the ticket price of BRT is also 1/3-1/2 higher regardless of different destinations. Further, public bicycles are widely used in Hangzhou among citizens for simple short-distance travel. This problem is merely temporary; as time goes on, people's concept changes and technology advances, conditions will be improved and the problem will be solved.

4. Results and Discussion

BRT Systems that are already implemented in Jakarta and Hangzhou are better examples for promoting green transportation. With many positive results for promoting green transportation, we can evaluate the BRT system that is already under way in Jakarta and Hangzhou through SWOT (Strength, Weakness, Opportunity and Threaten) analysis. From the SWOT analysis, we can obtain some findings to make the BRT system more successful not only in Jakarta and Hangzhou but also for implementation in other cities especially in Asian Developing Countries. Table 3 explains the result of SWOT analysis of the BRT system in Jakarta and Hangzhou and the analysis is based on Levinson et al. (2003) and Wright (2005).

Table 3: SWOT Analysis for Jakarta BRT system

STRENGTHS	**WEAKNESSES**
1. The infrastructure cost of BRT systems is far less than rail-based systems 2. Larger passenger capacity (2 million people) 3. Institutional setup (a public managing company is in charge of running and planning the BRT) 4. Energy consumption and emissions from public transportation are lower for each passenger per kilometer than private vehicles 5. BRT was found to be a cost-effective measure to reduce CO_2 in the transportation sector (after 7 months operation, GHG declined to 1,710 metric tons) 6. Use advanced digital technologies that improve customer convenience, speed, reliability and operational safety 7. Simple fare collection systems make it fast and easy to pay, and allow multiple door boarding and reduced time in stations	1. Success of BRT depends on the presence of complementary transportation options, such as promotion of non-motorized transportation and integrated feeder services
OPPORTUNITIES	**THREATS**
1. Supported by the government (Governor Sutiyoso of DKI pushed through the BRT project through implementation using his budget and staff (Ernst 2005)) 2. Better policies to reduce emissions without reducing accessibility to goods and services 3. Funding from international organizations (For the Transjakarta project, the Institute for Transportation and Development Policy (ITDP) provided technical assistance based on a grant from the United States Agency for International Development (USAID) (Institute for Transportation and Development Policy 2003d))	1. Pressures by automobile interests

Source: Author's analysis, 2011

Table 4: SWOT Analysis for Hangzhou BRT System

STRENGTHS	WEAKNESSES
1. The infrastructure cost of BRT systems is far less than rail-based systems. 2. Securing segregated bus ways. 3. Larger passenger capacity (2 million people) 4. Higher speed (22-26 km/hour). 5. Energy consumption and emissions from public transportation are lower for each passenger per kilometer than private vehicles. 6. The service is all-day meaningless waiting and no need to consult schedules. 7. The integration of local and express services can reduce long-distance travel times (45 minutes to all destinations). 8. Use advanced digital technologies that improve customer convenience, speed, reliability, and operational safety. 9. Clear route maps, signage, and real-time information displays. Automatic vehicle location technology to manage vehicle movements 10.Simple fare collection systems make it fast and easy to pay, and allow multiple door boarding and reduced time in stations. 11.Improving the services such as integrated feeder services, punctuality (89.7%), and satisfaction of citizens is 96%. 12.All the buses in Hangzhou are run by a company and its branches, making it easier to introduce and operate BRT.	1. Police enforcement is not strict. 2. Passengers who change direction or move to another type of bus could not use the same ticket. 3. Success of BRT depends on the presence of complementary transportation options, such as promotion of non-motorized transportation and integrated feeder services. 4. The exclusive lane is set on the sides of the road rather than the middle. 5. In the short term, the exclusive lanes of BRT reduce the area for existing vehicles and cause even more traffic congestion. 6. BRT in Hangzhou do not use renewable energy, using diesel. 7. The ticket is 1/3-1/2 more expensive than normal buses. 8. Difficult to transfer to normal buses since stations of normal buses and BRT are sometimes far away.
OPPORTUNITIES	**THREATS**
1. Better policies to reduce emissions without reducing accessibility to goods and services 2. More and more people live in suburbs and prefer BRT.	1. Pressures by automobile interests 2. Competition from subway: The first line of subway in Hangzhou will go into service in 2012 as planned 3. Public bicycles are widely used in Hangzhou for citizens for simple short-distance travel.

Source: Author's analysis, 2011

Existing BRT systems can be improved and made more responsive to the domestic conditions of each country by employing appropriate policy instruments (Lee Backjin, 2011). The following are some examples of recommended policies to enable smooth and unobstructed operation of BRT systems in developing countries as an alternative to rail-based mass transportation systems.

Table 5: Policy Instruments to Improve BRT Systems

Planning Instruments	1. Strategic assignments of BRT routes to service the optimum number of passengers 2. Dedicated bus lanes to ensure unobstructed flow of buses along non-major highways 3. Transit-oriented development to reduce traveling and promote walking and bicycle use instead of motorized vehicles 4. Provide sidewalks and bicycle lanes as much as practicable 5. Provide permanent parking facilities at stations 6. Undertake regular review and evaluation of the system's operation and plan out regular system upgrading and expansion of covered area 7. Ensure connectivity of major ports, commercial areas, and other points of public and tourism interests
Regulatory Instruments	1. Regulate entry of private vehicles into the CBD to encourage utilization of the BRT system instead of own vehicles. 2. Strictly implement vehicle efficiency standards and low carbon fuel standards 3. Regulate operations of regular buses by private operators to complement the BRT system instead of competing with it 4. Strict enforcement of traffic regulations 5. Stricter qualifications for approval of driver's licenses

Economic Instruments	1. Deregulate fuel prices and impose fuel taxes 2. Vehicle registration tax 3. Impose road user's tax 4. Provide subsidies/incentives for mass transit mode users 5. Parking tax outside the BRT stations' parking facilities
Information Instruments	1.Public awareness campaigns 2.Improve driver behavior (eco-driving schemes) 3.BRT service marketing 4.Synchronization of trip schedules of major transportation facilities 5.Provision of free flyers of transportation facilities schedules to encourage public to make planned travels
Technological Instruments	1. Continuous R&D to further improve better BRT services and fuel efficiency 2. Utilization of ITS 3. Utilization of PV to supply power to onboard and in-station devices

Source: Author's analysis, 2011

5. Concluding Remarks

Along with the increasing urbanization rate in the capital cities of the developing countries in Asia, the number of vehicles is also increasing, resulting in traffic congestion, air pollution, increasing energy consumption and CO_2 emissions. In support of environmentally friendly programs that can reduce pollution resulting from the transportation sector, BRT is promoted as a green transportation system. Based on the experience of the implementation of BRT in Jakarta and Hangzhou, by using SWOT analysis strengths, weaknesses, opportunities and threats are identified. Based on the SWOT analysis, the implementation of BRT in Jakarta and Hangzhou is quite successful in promoting green transportation because it can reduce emissions and the system is more effective and efficient than other systems.

From the success stories of BRT in Jakarta and Hangzhou, it is concluded that the BRT can be a cost-effective alternative to rail-based mass transportation systems in developing countries owing to its cheaper operation costs with similar efficiency in terms of passenger capacity.

The foreseen weaknesses and threats of the BRT system may easily be avoided or circumvented by applying appropriate policy instruments. Application of innovative strategies and green technology can make the BRT system in developing countries more attractive to the riding public and in a way help reduce energy consumption and CO_2 emissions in the transportation sector.

However, to improve the BRT system in Jakarta and Hangzhou, and this can be the lesson learned for other cities in developing countries, transportation policy instruments including planning, regulatory, economic, information and technological instruments, should be adopted.

References

Asian Development Bank Report, address: http://www.adb.org/Documents/Brochures/Low-Carbon-Transport/ Low-Carbon-Transport.pdf, access: August, 2011

Badan Pusat Statistik Provinsi DKI Jakarta, (2011), *Hasil Sensus Penduduk 2010, Data Agregat Per Kabupaten/Kota Provinsi DKI Jakarta,* Badan Pusat Statistik, Jakarta.

Backjin, L. (2011), *Green Transportation Policies & Strategies in Korea,* Lecture Note in Summer Course: Development Within a Low Carbon World 2011 in Beijing.

Bus Rapid System in Hangzhou, address: http://baike.baidu.com/view/70241.htm, access: August 2011

Bus Rapid System in Hangzhou, address: http://www.chinabrt.org/en/cities/hangzhou.aspx, access: August 2011

Guo K. et al. (2008), *Bus Rapid Transit: 'Integrated' Business Model Analysis - Case Studying of B1 Line in Hangzhou,* Urban Transport, Vol.6, No.3.

Levinson, et al. (2003), *TCRP Report 90, Bus Rapid Transit, Volume 1: Case Studies in Bus Rapid Transit,* Transportation Research Board, Washington, D.C.

Litman, T. (2006), *Evaluating Public Transit Benefits and Costs,* Best Practices Guidebook, Victoria Transport Policy Institute, 2011

Matsumoto, N. (2004), *Environmentally Friendly Public Transport Planning,* Policy Dialogue on Environment and Transport in the Asian Region, January 16-17, Manila

Matsumoto, N. (2006), *Analysis of policy processes to introduce Bus Rapid Transit systems in Asian cities from the perspective of lesson-drawing: cases of Jakarta, Seoul, and Beijing.* Better Air Quality Workshop, Yogyakarta, Indonesia, 20p.

Research report of the Urban Environmental Management Project (2007), *Air Pollution Control in the Transportation Sector,* Institute for Global Environmental Strategies (IGES), Japan.

Shihua, Cao, et. al. (2009), *An RFID signal capturing and controlling system for BRT priority system,* 1st International Conference on Information Science and Engineering, ICISE 2009, p.4725-4729.

Sutomo, H. et al. (2007), *Bus Rapid Transit in Jakarta: Evaluating the Factors that Impede or Facilitate,* Institute for Global Environmental Strategies (IGES), Japan.

Technical Report of the *Study on Integrated Transportation Master Plan (SITRAMP) for Jabodetabek* (2004), undertaken by Pacific Consultants International and ALMEC Corporation on behalf of the Indonesian National Development Planning Agency (BAPPENAS) and the Japan International Cooperation Agency (JICA).

UNFCCC (2004), *Greenhouse Gas, United Nations Framework Convention on Climate Change*

Wright, L. (2001), *Bus Rapid Transit, Sustainable Transport: A Sourcebook for Policy-Makers in Developing Cities,* Eschborn: Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), Germany.

Wright, et al. (2005), *Climate Change Mitigation and Transport in Developing Nations.* Transport Reviews 25 (6): p.691-717.

Yuan Huaming, (2006), *Good Luck for You! The BRT in Hangzhou. Observation and Thinking,* No.15, page 20-24.

Zhang B. et al. (2009), *Economic Evaluation of Bus Rapid Transit operating in Hangzhou, Modern City,* Vol.4, No.3.