

# Energy Efficient Cities Initiative

## **GOOD PRACTICES IN CITY ENERGY EFFICIENCY**

### **Bogota, Colombia – Bus Rapid Transit for Urban Transport**

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Project title	TransMilenio BRT in Bogota
Sector	Urban Transport
Type of project	Bus Rapid Transit (BRT)
City and country	Bogota, Colombia
City population	8.2 million (Bogota Metropolitan area)
Initial investment	Phase 1 - \$240 million Phase 2 - \$545 million Phase 3 - \$1.3 billion
Annual % energy reduction	47%
Project status	Phase I - completed December 2000 Phase II- completed in 2006 Phase III - ongoing; due for completion 2015/16 Phase IV-VIII - Planned

## Project Summary

The TransMilenio Bus Rapid Transit (BRT) system in Bogota, Columbia, provides the city with an efficient and safe mass transit system that encourages high ridership. About 1.5 million passengers now travel on the system every day following completion of the first two phases. The BRT system, through a combination of advanced Euro II and III technology buses and improved operational efficiencies, has clearly played a major role in reducing traffic congestion throughout the city. Residents and visitors of Bogota now enjoy reduced travel time, cleaner air, and fewer accidents. With the system's implementation, there has been a 32% reduction in overall travel time; a 40% reduction in air emissions from the scrapping of more than 2,100 old public service buses; and a 92% reduction in accident rates in corridors where the TransMilenio system operates. Post-BRT Bogota has recorded significant fuel savings of 47%, while increasing throughput by 60%.

With registration of the BRT system's Phase II-VIII with UNFCCC in 2006<sup>1</sup>, the city expects US\$25 million in Clean Development Mechanism (CDM) carbon credits by 2012. The program was a success due to many factors: strong leadership from the City Mayor; careful design and planning; use of state-of-the-art technology; the establishment of a well-managed company; sound investment in infrastructure; and an efficient single-fare pricing system.

<sup>1</sup> United Nations Framework Convention for Climate Change (UNFCCC).  
<http://cdm.unfccc.int/Projects/DB/DNV-CUK1159192623.07/view>

## 1. Introduction

Bogota, Colombia's capital, is located near the geographic center of the country, 2,640 meters (8,661 ft) above sea level. It is the largest and most populous city in the nation, with an estimated population of 8.2 million in the metropolitan area in 2007 and a population density of 3,912 inhabitants per square kilometer. Its economy generates 25% of Colombia's total gross domestic product (GDP).

Over the past two decades, the city's roads had become highly congested following significant growth in private car ownership and use. While private cars occupied 64% of road space, their occupants represented just 19% of the population, with a daily average commute of 70 minutes each way. Other issues included a high rate of accidents and extremely severe air pollution during peak travel hours.

By the end of the 1990s, Bogota's public bus transportation system suffered from underuse, with poor quality service and efficiency. The average speed of public transportation was 10 km/hour, reduced to 5 km/hour during peak hours due to heavy traffic. Passengers became increasingly frustrated by consistently long wait times for buses. To reduce waiting time, riders had to use the first bus available rather than wait for a less expensive bus to arrive. Without price regulation, private bus operators were free to hike up prices and charge far more than public bus operators.<sup>2</sup>

In 1998, Mayor Peñalosa launched a long-term urban mobility plan, as part of an urban renewal strategy. It consisted of measures that would restrict private automobiles, promote non-motorized transportation, and improve public transit by partly financing infrastructure improvements. In 1999, after the new National Government rejected plans for a subway system, Bogota's Mayor presented his plan for a Bus Rapid Transit (BRT) system, built on a successful experience in Curitiba, Brazil. Transitioning to a BRT system would help realize the Mayor's four main goals by: (i) improving the public transport system with respect to efficiency, safety, speed, convenience, and comfort, ensuring high ridership; (ii) restricting private automobile use; (iii) expanding and improving bicycle paths; and (iv) increasing availability of public space.

## 2. Project Description and Design

The original proposal for a public transit system featured both heavy rail (Metro) and a network of buses. It was abandoned because it cost four times more than the proposed BRT system, which required only US\$1-10 million/km to implement. The Mayor envisioned the BRT as the centerpiece of an integrated mobility strategy requiring that institutional problems that led to price hikes by small private bus operators were addressed. The small bus owners and drivers fought the proposal by coordinating worker strikes to try and block its ratification.

The TransMilenio BRT integrates four elements to ensure operational efficiency:

**Infrastructure:** The system consists of 22 central trunk corridors, feeder zones, terminal stations, pedestrian overpasses, plazas and sidewalks. Dedicated bus lanes,

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<sup>2</sup> Lozano, 2003; Chaparro, 2002; Lieras, 2003. Adapted from, 'The Economics of TransMilenio: A Mass Transit of Bogota.' CEDE. August 2004.

including new bus stations and integration stations at the end of the lanes, ensure a smooth transfer to feeder lines. Traditional buses are banned from operating in trunk corridors.

**Fare System:** Ticket booth stations allow passengers to pre-pay for Smart Cards (fare cards) that use a magnetic device, streamlining the ticketing and boarding processes. Passengers can change from a local to an express bus, as well as one route to another, using the same electronic fare card that is automatically debited at turnstiles used to direct passengers. Revenue from card sales is deposited in a trust fund, from which operators are paid, according to rules in concession contracts.

**Bus Technology:** The new buses use Euro II & III technology and operate on dedicated lanes 18 hours a day. Each bus has a capacity of 160 persons with platform level access, including room for disabled persons. There are new feeder buses that run on local streets and have a capacity of 70-90 persons. Trunk buses use the central lanes of existing streets, longitudinally segregated from the general traffic.

**Transit Management:** The operations fleet center manages bus dispatch, notifies passengers of schedule changes and other updates, produces reports, and maintains records. All buses are equipped with GPS (global positioning system) devices linked to the operations center. Under a centralized system of coordination, monitoring is done via eight substations (80 buses per station) and communication is established to schedule services and provide real-time responses to contingencies.

The BRT system uses various design features to accommodate high passenger volume. These include the use of high-capacity buses, exclusive running ways, level boarding, off-board fare payment, and frequent bus service permitting headways as low as 13 seconds on busy sections of the system. Of the 388 km (241 miles) comprising eight phases of the TransMilenio BRT Masterplan, construction of the first two have been completed. The second phase saw 84 km completed in 2006. The system is now designed to transport 5 million people per day and divert 80% of city travel to the system. Stations are located every 500 meters, with pedestrian access via overpasses, tunnels or intersections with traffic signals.

The combination of express and local buses allows the system to carry up to 45,000 passengers per hour in each direction. The model's multi-faceted approach incorporates advanced technologies for ticketing and operations and a sustainable private participation scheme. Both the transit management scheme and fare system were operating prior to the start of the project's second phase. The BRT system was also designed to be flexible and may be expanded over time to meet the needs of the growing city.

The municipality created TransMilenio S.A.<sup>3</sup>, a public-private partnership (PPP), to plan, organize, and build the transportation infrastructure, and oversee operation of the system. The corporation also manages concession contracts, awarded through an open bidding process, with private firms and a consortium for operations and ticketing. The consortium includes existing bus operators and runs both trunk and feeder buses. Four different firms, formed by the traditional bus service operators, won contracts to provide

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<sup>3</sup> website: [http://www.transmilenio.gov.co/WebSite/English\\_Default.aspx](http://www.transmilenio.gov.co/WebSite/English_Default.aspx)

service on the trunk corridors. Feeder buses are operated by three companies (Sidauto S.A., Codatermil, and Uribe & Uribe Consortium). Buses (including drivers) are contracted through private firms. TransMilenio oversees all finances and pays each operator according to each specific contract. Proceeds from operations are deposited into the trust fund, which are distributed as follows: (i) Trunkline Operators (65.5%); (ii) Feeder Service Operators (20%); Fare Collectors (11%); TransMilenio Company (3%); and Trust Fund Administrator (0.5%).

### 3. Cost, Financing, Benefits, and Effects

TransMilenio is unique and represents one of the world's premier BRT systems. By leveraging much of the city's existing infrastructure, it shows how cost-effectiveness can be leveraged in building and operating a public municipal transportation system. The stations were built to be low-cost and highly functional; the main investment has come in the form of the city's new rolling stock (buses); and the responsibility for the city's vehicle and fare collection costs was transferred to the private sector. The capital cost of the infrastructure for Phase I was US\$297 million<sup>4</sup>, or \$9.4 million per mile (\$5.4 million per km), excluding the cost of land acquisition. The cost for Phase II rose to \$545 million, or \$21.3 million per mile (\$13.3 million per km). The higher cost was due primarily to increased investment in public space (bridges, interchanges, etc.) and associated transportation infrastructure improvements. TransMilenio's BRT Masterplan for the full 241 miles is estimated to cost US\$3.3 billion.<sup>5</sup>

Phase I was financed through local fuel taxes (46%), national government grants (20%), a World Bank loan (6%) and other local funds (28%). Funding sources for Phase II were significantly different than Phase I, coming from the national government (66%) and local fuel surcharges (34%). The local government mobilized resources by raising gasoline taxes, launching a campaign against tax evasion, increasing its property tax base, and reducing capital investments in the City's Telecommunication Company.

TransMilenio is designed to recover 100% of its costs through passenger fares in order to be financially sustainable. Since it is privately operated, any revenue increase from expanded ridership goes directly to operators. Likewise, if costs increase while demand decreases, private operators are required to cover risks and losses. The national and city governments only cover capital costs.

#### Benefits

**Financial & Fiscal Gains:** The TransMilenio BRT system improves on Brazil's Curitiba system by operating without subsidies from public authorities. Fares were established at US\$0.40 in 2000 and were raised to US\$0.61 to ensure all operational costs provided by private operators were covered. This was achieved through a concession-based contract aimed at regulating service operations and eliminating rents, to avoid fare-hikes. The private operator can earn profits when demand for ridership increases and

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<sup>4</sup> Clinton Climate Initiative, C-40 Cities: Bogota, Colombia.  
[http://www.c40cities.org/bestpractices/transport/bogota\\_bus.jsp](http://www.c40cities.org/bestpractices/transport/bogota_bus.jsp)

<sup>5</sup> Applicability of Bogota's TransMilenio BRT System to the United States, (2006). Federal Transit Administration, USA.

incur costs if demand for ridership declines. The BRT provided incentives for private operators to compete for specific route in terms of per-kilometer basis, as opposed to a per-passenger basis. This has spurred healthy competition “for the market,” as opposed to unhealthy competition “in the market” characterizing the previous traditional system. This policy has enhanced operating efficiency, while reducing fiscal risk imposed on Bogotá’s city government. The reduction in operating costs has been significant; in 1999, the municipal budget’s allocation for operating costs fell from 50% to 20% of its total budget.

**Better Air Quality and Fuel Efficiency:** The TransMilenio BRT appears to have improved air quality (40% reduction in air emissions) by transporting more passengers in less time and employing the use of energy-efficient vehicles while scrapping more than 2,100 old public service buses. The following reductions have been reported: SO<sub>2</sub> decline by 43%; NO<sub>x</sub> by 18%; particulate matter by 12%. Fuel savings of 47% have also been reported,<sup>6</sup> with a cumulative savings estimate for 7 years (2006-2012) of more than 1 million tons of oil equivalent, with a 60% increase in throughput.<sup>7</sup> Estimated CO<sub>2</sub> reductions and equivalent emissions are projected to be 15-25 million metric tons for the first 30 years of operation.

**CDM Model:** By earning the distinction of being the world’s first mass transport project registered with UNFCCC for CDM credits in 2006, TransMilenio’s BRT has become a model for similar transport-related CDM initiatives being developed worldwide. The project is expected to earn US\$25 million in carbon credits by 2012.

**Faster Trips:** Average trip times have fallen by 32% while TransMilenio users’ travelling speed has risen from 12-18 km/hour to 26.7 km/hour. Reduced traffic congestion has also resulted in increased travel speed for other vehicles.

**Better Safety:** City traffic fatalities have fallen by 92%, injuries by 75%, collisions by 79%. The number of robberies has also fallen, by 47%.

**Increased Public Demand:** At present, more than 1.5 million passengers use the TransMilenio system. This exponential growth in the use of mass transit since start-up in December 2000 clearly shows that BRT is seen as efficient and affordable. Once completed, the system is expected to carry an estimated 5 million passengers, or 80% of the city’s total commuters.

**Efficient Regulation:** Higher gasoline taxes mostly affect private vehicle owners who form less than one-fifth of the city’s population. This resulted in redistribution of resources favoring poorer city residents who comprise the majority of the city’s public transportation users.

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<sup>6</sup> Sylvia Klatka, *Fuelling Bus Rapid Transit for Europe*, April 2008, Transport Research Arena, Europe, 2008.

<sup>7</sup> CDM Executive Board.



Bogota Before      versus      After TransMillenio



#### 4. Lessons Learned

BRT projects are complex and require technical, financial, and legal studies to ensure successful implementation. Demand forecasting studies are important and require a large amount of data and time to improve model calibration and determine appropriate fleet size and required services. This underscores the importance of adequate funds for upstream project analyses. Mayor Penalosa mobilized a team to make municipal reforms for effective service delivery by promoting cost-efficient schemes.

One of the great achievements of the TransMilenio BRT system has been the concession contract-based system for regulating service operations. The project encouraged participation of small operators and provided them incentives to play an important role in the public-private partnership (PPP) for bus operations and fare collection, with rights and responsibilities defined by the concession contracts. Previously, bus owners and operators, often affiliated with trade unions and cooperatives, made profits by reducing or eliminating vehicle maintenance and forcing bus drivers to work long hours. They did not have incentives to improve quality as they earned additional profits as demand increased. TransMilenio BRT's policy framework allows it to oversee bidding, contracting, and operations of the system while enforcing checks and balances. The contract-system demonstrates solid financial management, allowing bus operators to assume demand risk associated with running a public transit system.

Of course, during implementation of the new system, some unexpected and adverse effects on the city's existing public transportation system did arise. Reductions in travel times were limited mainly to TransMilenio users, while average travel time for traditional public transportation systems actually increased by about 10%. The slow pace of scrapping buses from the traditional system appears also to be causing additional congestion in corridors not served by the TransMilenio system (Lleras, 2003).

## **5. Project Innovation**

The system has used an innovative PPP approach that does not require subsidies for operation. Under the PPP, the new public sector agency, TransMilenio S.A., plans the system, takes responsibility for funding its infrastructure, and supervises daily operations. Private sector participation has been promoted and existing bus operators who have won competitive contracts are responsible for fare collection and operations (including vehicle costs). This PPP has been hailed as a great success for the Bogota BRT system.

Through a competitive bidding process requiring bidders to have minimum working capital, private bus operators were encouraged to form formal companies. Points were awarded to companies based on factors such as experience, bus quality, and emission levels, to encourage operation of efficient and non-polluting vehicles. Each bidder was provided with equity to finance replacement of a portion of old fleets with new and efficient buses. Contracts require that private operators maintain their fleet as well as high-quality service standards. When an operator is not in compliance, their market share is reduced.

## **6. Financial Sustainability, Transferability, and Scalability**

The project has shown solid financial management by promoting innovative implementation at the design phase. For the TransMilenio BRT project to be successful, it was imperative that fares fully cover operations costs. The project required the fare to be raised US\$0.10 (ten cents) (from 30¢ to 40¢) to cover these costs. Wary of possible public resistance to a bus fare hike, the city of Bogota approved the new rate a year before the system opened. Following the rate hike, there was considerable public outcry, not against the city itself, but against private bus operators. Thus, when TransMilenio opened a year later with the new fare price, customers were accustomed to the new rate. Only a few who considered the fare increase part of TransMilenio's planning process protested. With higher quality offered, the system has continued to attract passengers from the traditional system and encouraged a shift away from use of private vehicles. Complementary policies like car restrictions have further strengthened demand for BRT ridership. The private sector earns about a 33% profit margin under the contract with an obligation to maintain a high standard of service. At the current fare of US\$0.61, the rising number of passengers reflects that the system is meeting public expectations. A recent survey shows 88% customer satisfaction.

The TransMilenio BRT project design is flexible and could scale up operations by adding more buses, once necessary infrastructure is in place. Buses are adaptable to traffic changes and demographic patterns and provide door-to-door service. However, the Rail System (First Metro Line) is still part of the City Plan, but currently has no budget commitments. It is projected that current capacity of 45,000 pphd (passengers per hour per direction) will not be exhausted for decades once the system is completed. Encouraged by the project's success, the Government of Colombia is now embarking on a major program to replicate similar systems in the Colombian cities of Medellín, Pereira, Bucaramanga, Barranquilla, and Cartagena.

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## ANNEX: CITY AND PROJECT PROFILE

### CITY PROFILE

<b>1. Name of the City</b>	<b>Bogota</b>
<b>2. Area</b>	<b>Colombia</b>
<b>3. Population</b>	<b>8.2 million</b>
<b>4. Population Growth Rate</b>	<b>7,185,889 (2005); 6,276,428 (1999); In 5 years, Bogota population grew by 14.5%</b>
<b>5. GDP of the City</b>	<b>US\$386 billion</b>
<b>6. GDP Growth Rate</b>	<b>3.5%</b>
<b>7. GDP per Capita</b>	<b>US\$8,900</b>

### PROJECT PROFILE

<b>1. Project Title</b>	<b>TransMilenio BRT in Bogota</b>
<b>2. Sector</b>	<b>Urban Transport</b>
<b>3. Project Type</b>	<b>Bus Rapid Transit</b>
<b>4. Total Project Capital Cost</b>	<b>Phase 1 - \$240 million Phase 2 - \$545 million Phase 3 - \$1.3 billion</b>
<b>5. Energy/Cost Savings</b>	<b>47%</b>
<b>6. Internal Rate of Return</b>	<b>N/A</b>
<b>7. Project Start Date</b>	<b>2000</b>
<b>8. Project End Date</b>	<b>2016</b>
<b>9. % of Project Completed</b>	<b>2 stages</b>

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