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C40 CITIES IN ACTION: HOW BIKE-SHARE AND BRT ARE ACCELERATING ACROSS THE WORLD

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FOREWORD

Overwhelming evidence suggests that accelerating effects of climate change can be devastating to our cities and standard of living. Without decisive action, we will be unprepared for short and long term developments.

Since 2005, C40 has been educating its members on emissions reductions strategies, with mayors around the world implementing and sharing the results of their initiatives. C40 has further invited their partners, the Clinton Climate Initiative, and The World Bank, to leverage these findings to better promote innovation globally.

C40 has asked Columbia University graduate students in Sustainability Management to consider two transportation initiatives, Bike Share programs and Bus Rapid Transit. The charge is to identify key success factors and features that make these initiatives successful and attractive to cities, while offering emission reductions opportunities.

This report is an overview of a 12-week effort, stemming from literature research, interviews, evaluation of trends and forecasts, and identification of key indicators. Where feasible, best practice literature and recent publications are referenced for trends on these very new and growing initiatives.

The team would like to thank the Seth Schultz and the C40 organization for their participation in, and support of this research. We would also like to thank our advisor Thomas Abdallah for his guidance and encouragement.

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INTRODUCTION

Bike Share and Bus Rapid Transit are sustainable transportation initiatives gaining popularity around the globe. They offer convenient, safe, and cost effective alternatives to cars, while helping to relieve congestion, reduce pollution, and provide for a healthier lifestyle and more livable community. These are the motivations for municipal and regional governments to promote interest and encourage investment in these systems. Supportive leadership, stakeholder involvement, financial commitment, and adherence to specific design and performance criteria are critical in determining their ultimate success.

Bike Share and Bus Rapid Transit can play a critical role in reducing greenhouse gas emissions - a key mission of the C40. A consistent global tracking methodology is needed to measure the success of each program and will help C40 cities determine the ultimate value of Bike Share or Bus Rapid Transit within the spectrum of emissions reductions strategies.

The focus of this study is to determine the key characteristics, benefits, and success factors for Bus Rapid Transit and Bike Share programs so as to understand what is driving their rapid uptake in cities across the globe and postulate future trends.

KEY FINDINGS

C40 City Population Growth & World Shift

The urbanization and rapid growth of global cities into megacities sets them on pace to represent nearly 75% of global population by 2050.[1] As the world's largest centers of commerce, cities will contribute significantly to global greenhouse gas emissions. This also positions cities to be key responders to climate change through implementing innovative programming to reduce emissions.

C40 cities now account for nearly 300 million people, 3 billion annual tonnes of CO_2e, and a collective GNP of over $10 trillion US.[2] C40 City Mayors can use their influence to activate programs emission reduction strategies. This is evidenced by the over 4,700 collective actions taken by C40 cities to date combating climate change.

The C40 cities are also part of growing urban agglomerations. C40 cities are part of agglomerations that will total over 1.6 billion people by 2025.[3] Three quarters of the growth, and three quarters of all 2025 C40 cities agglomeration will be in C40's Asia and Oceana region. Transportation strategies such as BRT should be considered to capture large and concentrated growing populations in this region, especially before private cars become more predominant.

Developing countries are outpacing the population growth of developed countries, especially among working-age population.[4] Developed countries are experiencing slower growth and a growing share of aging population over the age of 65. Developing countries are witnessing a growing percentage of working-age population[5], those predominantly in need of urban transportation.

In a trend reversal of many decades, younger generations in both American and European countries are electing to drive less.[6] Fewer own automobiles and instead favor using mass transit. This provides an incentive for cities to focus on transportation strategies that target these non-driver populations.

Populations in developing countries desire to achieve a higher standard of living. This creates tension between rising affluent populations wanting car ownership, and those who look to reduce global emissions.

In summary, developing countries are growing fast and have a greater potential for GHG emissions growth. Therefore cities in developing countries may be the best targets for low emission strategies such as efficient mass transit.

The C40 Transportation Sector

The transportation sector for C40 Cities is where global greenhouse gas emissions are rising most rapidly.[7] A major contributor to this growth is the demand for oil, which will rise sharply through 2030 as the number of road vehicles rises. To address this, the C40 Transportation Initiative is working with cities in three key ways:

- **Reducing the need for journeys** through mixed-use and transit-oriented developments;
- **Moving journeys to more efficient modes of transport** such as public transit and non-motorized transportation
- **Improving the efficiency** of public and private fleets

Bus Rapid Transit and Bike Share strategies are well positioned to assist in each of these key focus areas:

- **Both are well suited to integrate into transit-oriented developments, and appeal to citizens by improving their lifestyle and daily commutes.** In tandem, they help to make urban areas more livable and relieve congestion.
- **BRT can transport large portions of a population effectively and relatively efficiently**. A single bus can displace dozens of cars and move passengers quickly, while freeing up street space that can be reclaimed for pedestrian use.
- **BRT service fleet can be selected specifically** for the geography, speeds and distances required in order to maximize efficiency.
- **Bike Share programs can attract specific segments of the population.** This creates a user group that can travel practically emissions free.

Reducing Greenhouse Gas Emissions

Transportation projects are initially justified for their local benefit, but city planners are beginning to have a growing appreciation for the greenhouse gas reduction potential of these projects. For instance, Changwon has identified Climate Change as biggest problem facing the world and in 2008 instituted it's "Nearby Useful Bike, Interesting Joyful Attraction" (NUBIJA) bike-sharing program as a practical response to climate adaptation and mitigation. NUBIJA has been designed to be a leading model of urban sustainability in the world and the extensive use of technology is one of the program's hallmark features.

The TransMilenio BRT in Bogotá was the first transportation project to qualify under the United Nations program to reduce carbon emissions known as the Clean Development Mechanism. TransMilenio takes nearly a quarter million metric tonnes of carbon out of the atmosphere each year and has received payments in the millions of dollars for the sale of its credits.

Global stakeholders have an interest in climate change, greenhouse gas emission reduction and shifting the current paradigm to a sustainable world for all. In the transportation sector, funding procured at the global level is starting to include GHG emissions inventory as part of the grant applications. A growing number of global stakeholders have shown an interest in GHG emission inventories and reduction:

- United Nations Environmental Program
- UN Convention to Combat Desertification
- UN Framework Convention on Climate Change
- UN Industrial Development Organization
- UN Development Program
- Institute for Transportation & Development Policy
- The World Bank
- Inter-American Development Bank
- African Development Bank Group
- Stockholm Environmental Institute
- Global Environmental Facility

Developing a consistent method for measuring and tracking GHG emission reduction for both Bike Share and BRT programs will improve C40's ability to promote these programs. Having a validated quantification of GHG reduction is in line with C40's mission and will help encourage city mayors to implement these programs. Additionally, it will aid C40 and partners to better understand the value and performance of programs as effective emissions reductions mechanisms.

A new emissions model tool may help cities calculate transportation project GHG education potentials, faster, with less data and at a lower cost. Recently stakeholders have developed an excel-based, free-of-charge spreadsheet models collectively called as "Transport Emissions Evaluation Models for Projects" (TEEMP) available here (http://goo.gl/W9rFnw) along with guidelines.

BRT & Bike Share: Growth & Characteristics

BRT and Bike Share have been rapidly growing across the world. Since 2000, BRT has grown eight-fold. There are currently over 170 BRT systems in the world. Within the last decade, one in three C40 Cities has developed a BRT program. Bike Share has a similar story. Since 2007, Bike Share programs have increased over 700%, with currently more than 500 programs globally. One in two C40 cities has a Bike Share program.

There are a few critical reasons why Bike Share and BRT programs have seen rapid implementation by cities over the past few years:

- They are easy to implement
- They can be more cost effective than other mass transit options
- They help improve the quality of life for residents
- They improve city image.

Easy to Implement

BRT and Bike Share are easier to implement than other mass transit options. Instead of spending decades digging an underground tunnel for a subway, BRT can be deployed along existing roadways or by adding dedicated bus lanes in as little as five years or less. Bike docks and bikes can be relatively easily placed on existing roads in as little as a few months to just a few years.

Lagos launched Africa's BRT in March 2008, less than 20 months after beginning a feasibility study, and carried nearly 10 million passengers in its first 100 days of operation. By using the median on the main carriageway, planners were able to add service without compromising existing travel lanes.

London's Bike Share system was announced in August 2007. The system was designed in February 2008 and commenced operation just two years later in July 2010. Depending on the size of the system, other bike share programs have gone operational in as little as 3 months.

Cost Effective

BRT and Bike Share are more cost effective than other transit programs and offer affordable initiatives for C40 mayors. For instance, Istanbul's subway cost US $1.6 billion; while the BRT system cost about US $400 million and bike share only US $1 million. Bike share programs range from $ US 2-3 million (e.g. Toronto or Portland) to over US $40 million (New York) and US $140 million (Paris). BRT and Bike Share costs are at a scale that a major city could afford, especially with support from private partners.

Improved Quality of Life

BRT and Bike Share improve quality of life by making streets safer, reducing pollution and congestion, and improving access. Bike Share programs have also been shown to improve overall health by reducing stress, osteoporosis, and obesity through extra physical activity.

Roadway safety is measurably improved by BRT. In the first two years of TransMilenio operations, traffic collisions, pedestrian accidents and related fatalities along Bogotá's main corridor decreased by 94 percent.

Both BRT and Bike Share also decrease air and noise pollution. Noise levels in the main corridors of Bogotá's TransMilenio are 3 to 10 dB lower than pre-BRT levels. In Seoul, carbon monoxide emissions decreased 34.8% and particulate emissions decreased 39.5% in the year following the implementation of a BRT system.

Improved City Image

Congestion relief and reduced travel times from BRT also improve the city image. As car ownership grows and city populations increase, cities are increasingly facing more traffic and congestion. In a world of mass urban migration, a BRT program can radically improve transportation, making travel more efficient for city dwellers and commuters.

There is a positive transit benefit as well. For instance, Bike Share can serve to support the "last mile" in a commute, filling a gap within existing public transit, or by simply helping commuters move from point A to point B within the city. This brings a convenience factor, and although not critical to transportation, is a "nice to have" for residents and visitors alike.

Success Drivers

The successful implementation of either a BRT or Bike Share program can be driven by a few critical factors:

- A strong public champion
- Stakeholder engagement
- Effective funding
- The right technology
- Providing quality service.

Strong Public Champion

Successful BRT and Bike Share programs usually have a visible and committed political ally. This could be the mayor, head of transport or another member of the municipal government, or community.

For instance, London Mayor Boris Johnson is a strong advocate of Bike Share. In fact, they call the London system 'Boris's Bikes.' Chicago's Transportation Commissioner Gabe Klein, also an avid cyclist, was charged with implementing 100 miles of bike lanes as well as BRT. Prior to that, Klein helped launch Capital Bikeshare in DC.

In 2009, the Executive Mayor of Johannesburg, Councilor Amos Masondo, made the Rea Vaya BRT project a centerpiece of the city's effort to establish itself as a World Class African City in preparation for hosting the 2010 FIFA World Cup. When Enrique Peñalosa took office as the Mayor of Bogotá in 1998, he promoted BRT as a way to build a more equal society by improving quality of life for all income levels.

Stakeholder Engagement

BRT and Bike Share need engaged stakeholders. These include local government, existing private transit operators, local business, and citizens. Without the buy-in of critical stakeholders, a BRT or Bike Share program won't succeed.

The municipality must be supportive of BRT and Bike Share programs. If they do not deem it necessary or choose to favor other transit options, it may be difficult for these programs to get off the ground. When existing transport interests are effectively engaged and given an opportunity to participate in BRT systems with a vested interest, the projects have a high rate of success.

Private transit operators must also be won over to ensure success for BRT programs. This is especially true for BRT in cities that have developed extensive private transit options, such as private buses and taxis. In these cases, the free market economy rules the roads, which can result in multiple options, but also chaotic conditions.

An example of a creative stakeholder engagement is Bogotá's TransMilenio. In the period leading up to the development of this system, as many as 30,000 private bus operators would drive aggressively, swerving in and out of lanes to compete for ridership. This resulted in unsafe, chaotic conditions, and poor air quality, making BRT an obvious solution. In order to implement the program Bogota had to engage existing bus drivers by offering them an equity stake. Bus operators had to also scrap the older/higher polluting buses and replace them with new clean tech buses.

Citi Bike is a good example of a Bike Share program that optimized stakeholder partnerships. The Mayor and Department of Transportation were strong Bike Share champions. Citibank provided $41M for funding. Alta, the largest US bike operator, runs the program, while Bixi from Montreal supplies the latest and best technology.

Both BRT and Bike Share need support from local business owners. There can be winners and losers among local businesses, depending where their storefronts are situated along BRT routes and where Bike Share docking stations are placed. Some business owners near BRT stops may see an increase in business traffic whereas others may be more cut off from consumers once a BRT line becomes operational. Business owners near bike docks may be aggravated by loss of parking spots or sidewalk congestion, or they may benefit from increased foot traffic. Either way, the majority of business owners along BRT routes or near bike docks have to be in favor of the program or it may delay or halt implementation.

Ultimately, citizen participation in BRT and Bike Share ensures lasting success. Both BRT and Bike share programs are only successful if they are used. Los Angeles is the American city most identified with a love of automobiles. When the Metro Orange Line was being considered as the city's first BRT, organizers reached out to tens of thousands of local citizens and engaged people in programs like Metro Art and safety seminars in order to encourage use of the system. The results have been impressive, with ridership growth exceeding the expectations of transportation planners.

On the other hand, cities with a popular private biking community may not adopt Bike Share because there may be less of a need. For instance, Copenhagen's Bike Share program faltered because there was already a significant private biking population. As a result, the city program had to be scrapped and is now being reengineered to emphasize "last mile" and integrated transit.

Funding Schemes

Developing an effective funding scheme is critical. Lagos, Nigeria employed a creative structure of international, domestic and local resources to finance the LAMATA BRT system. The World Bank provided $100 million in credit financing to fund the infrastructure, while the government of Lagos contributed $35 million and Ecobank Nigeria underwrote loans to help purchase the first 100 buses. A number of bike share programs have recently been funded through advertising companies. The Paris bike share system was financed by the advertising company JCDecaux SA, which paid the start-up costs of $140 million in return for street advertising.

Technology

Technology and innovation play a critical role in the success of BRT and Bike Share.

A modern BRT program requires more advanced technological features than a standard bus system. Such enhancements include level platform boarding, pre-payment of tickets, quality stations, and dedicated lanes. All of these help make the BRT system more efficient, speedy, and comfortable.

Selecting the right options for bus fleet improves emissions performance and air quality. This includes selecting technologies such as new hybrid, electric, and biodiesel buses. Keying specific bus types to geography, frequency of stopping, and average travel speeds will be important to maximize efficiency. A hybrid bus may be more effective in stop and go conditions, while diesels may perform better over long distance and changing topography.

Most high-tech buses can control traffic lights through infrared sensors. This allows them to quickly move through intersections and improve transit times, making BRT use more attractive to citizens and more successful overall.

A new Bike Share program must also include higher technological advances. This includes specialized bikes, a network of docking stations, and smart card payment systems. Bikes are now designed for easy riding and heavy usage. Some bikes are even equipped with GPS systems and LED lights. Stations can be solar powered with wireless technology for communication. Bike docks are built with smart locks to help with theft and vandalism.

Technological improvements may also bridge existing barriers to Bike Share for some people. A kinetic rear wheel marketed in both Denmark and the United States can offset the energy required for riding uphill by storing energy generated in downhill and braking situations. Beyond that, credit programs can provide incentives for riders to bring their bikes back to an uphill docking station, which helps supports effective redistribution of bikes. E bikes can help with uphill topography as well, which may encourage use.

Innovation also includes the integration of BRT and Bike Share with all other forms of transit. This could make connecting travel seamless and more convenient throughout a region. The use of digital and hand-held services for information and payment can accelerate this advancement. BRT and Bike Share can be creatively integrated with other forms of transit where the user can move from one system to another seamlessly. Some cities are already instituting a unified ticketing option that enables a passenger to rent a bike as part of a BRT fare purchase to complete the final leg of a journey. Others are providing bike storage at bus stations. Another example is a city that institutes measures to discourage private vehicle use to alleviate traffic, such as congestion pricing, even/odd day license driving, or prohibited private driving days. For instance, Beijing's even/odd license plate policy effectively reduced automobile congestion by as much as 40%.

Quality Service

In order to be successful, BRT and Bike Share must provide quality service. Buses and bikes must be operable, comfortable, and reliable, and both systems must be affordable and reduce travel times.

Complaints rose in Lagos in the years following the opening of the BRT system when replacement parts were hard to come by and buses fell into disrepair. The reputation of the system and ridership noticeably suffered throughout the ordeal, however the issues have since been addressed and repairs are underway.

Feasibility studies on optimal placement of bike docks and BRT bus stations help determine the best areas for stations, and are critical to ensuring the system is convenient for users, and ultimately to the success of a program. For example, in Bangkok one BRT line was placed on a corridor with no public transport demand, the line eventually failed. Effective bike distribution is also an issue for bike ridership. Bikes must be available at docks, otherwise the system will not be utilized. The Bike Share operator must therefore institute an effective bike redistribution system to meet demand. Dedicated bike lanes are also important to make the experience safer and more convenient.

Observations and Trends

BRT and Bike Share programs are evolving rapidly. It is important to keep an eye on developing trends that may shape their future.

Bike Share

The availability of peer reviews, research papers, and program guides have helped accelerate the strategic implementation of bike share programs globally. Such information allows cities with newer programs to learn from the mistakes and triumphs of previous programs and plan for more successful launches. Some observations include:

- **Evidence indicates that Bike Share program users are typically more affluent, better educated, and male.** In fact, this learning has driven newer programs such as Philadelphia's to target this demographic in the rollout of their initial selected neighborhoods in order to achieve immediate success and anchor the system.
- **Both technology and cost may be barriers to lower income populations.** Portions of the population do not have the credit available, nor the ways or means to access the technology interface which is becoming more attractive to Bike Share users.
- **Outlying neighborhoods have not been successful in establishing programs.** Factors may include longer travel distances required, program availability, integration with other forms of public transport, cost, the needs for transportation (carrying bags to and from store, or taking children to school). These will be barriers to transit systems seeking to provide a "last-mile" alternative.
- **Physical Barriers.** While not a focal point of this study, topography, climate extremes, and seasonal patterns may alter the success of the program in particular cities.
- **Age Barriers.** Safety concerns in traffic areas and health factors increase with older populations, potentially making them less likely to use bike share.
- **Bike share success could signal the beginning of an innovation curve towards human powered transportation.** Already a company in Denmark is introducing a new cargo bike that is environmentally friendly. The firm is marketing the bike as fun and sexy, appealing to the new urban audience. While it is too early to understand if this is a trend, it will be interesting to see what the course of development may be.
- **Although Bike Share programs are exploding globally, growing pains are becoming evident.** In an apparent setback to the London system, Barclays has just withdrawn its sponsorship, effective in 2015, citing bicyclist safety and vehicular-caused deaths as their main concern. It is forecasted that only half of its original pledge of £50m is to be provided by 2015. Meanwhile, costs to participants have risen, and ridership is markedly off as compared with calendar points in the previous year. These new developments will raise concern over the long-term feasibility of the program.

Bus Rapid Transit

BRT largely evolved from Latin America and developing countries, and over the past three decades has improved in technology and programming. Some observations about BRT include:

- **The most successful programs share key success factors.** These include critical leadership, stakeholder involvement, focus on specific operational and design criteria, and quality service through critical locations, scheduling and capacity.
- **In developing countries, BRT offers safe, affordable and convenient transportation.** BRT is often the only practical choice for lower income families and working class**.**
- **Cities such as Mexico City and Bogotá are beginning to have thriving BRT systems enjoyed by commuters in the business community as well.** Its appeal to this segment is convenience, cost, and freedom from traffic congestion.
- **In developed countries it may be more difficult to make BRT appealing to the new urban generation.** This may require a crossover of what attracts them to Bike Share. Features such as digital connectivity, freedom, ease of use and integration of transit modes, will draw users away from perception about bus systems.
- **For mature drivers, it may be key to reach them through targeted and ongoing programming**, to change perceptions on travel time, cost and congestion.

Behavioral Change - Getting travelers out of the car

An interesting area of focus is the behavior of how travelers make decisions on the mode of their journey. Often decisions towards using a personal car are not rational when faced with convenient and cost effective mass transit alternatives. Some recent findings indicate the impact of conformation bias on otherwise rational decision-making.

- **A recent study out of Sweden[8] indicates that basic levels of quality mass transit service and occasional incentive programs aren't enough to convert habitual drivers into habitual riders.** The results suggested it may be more beneficial to understand the specific attributes of the auto experience and how those qualities may be applied to mass transit systems in order to convert drivers to riders. The study specifically cites three drivers[9]:

  First, pay more attention to rider perceptions and the "critical incidents" they have experienced that may be causing confirmation bias.
  Second, target a car traveler's motivations to drive, including comfort, travel time, and the programming and technology that could be appealing to them.
  Third, that "context matters", in the sense that not all drivers will respond similarly in a given market, so targeting sub-sets of the population for specific programming may be required.

- **A study by researchers in Italy[10] confirms a strong preference towards car travel, even when costs become prohibitive**, citing experience biases leading travelers from making rational decisions on mass transit.

DATA ANALYSIS

Tableau, an online graphing tool, along with statistical graphing software were used to illustrate the available data in the hope of developing a better understanding of Bike Share and BRT program characteristics within the C40 Cities. Although a number of charts were tested in order trying to elicit trends, information inconsistencies and low confidence levels in the data, limited the scope of the analysis. Nonetheless, we felt the power of some of the resulting images are worth sharing.

Bus Rapid Transit Programs

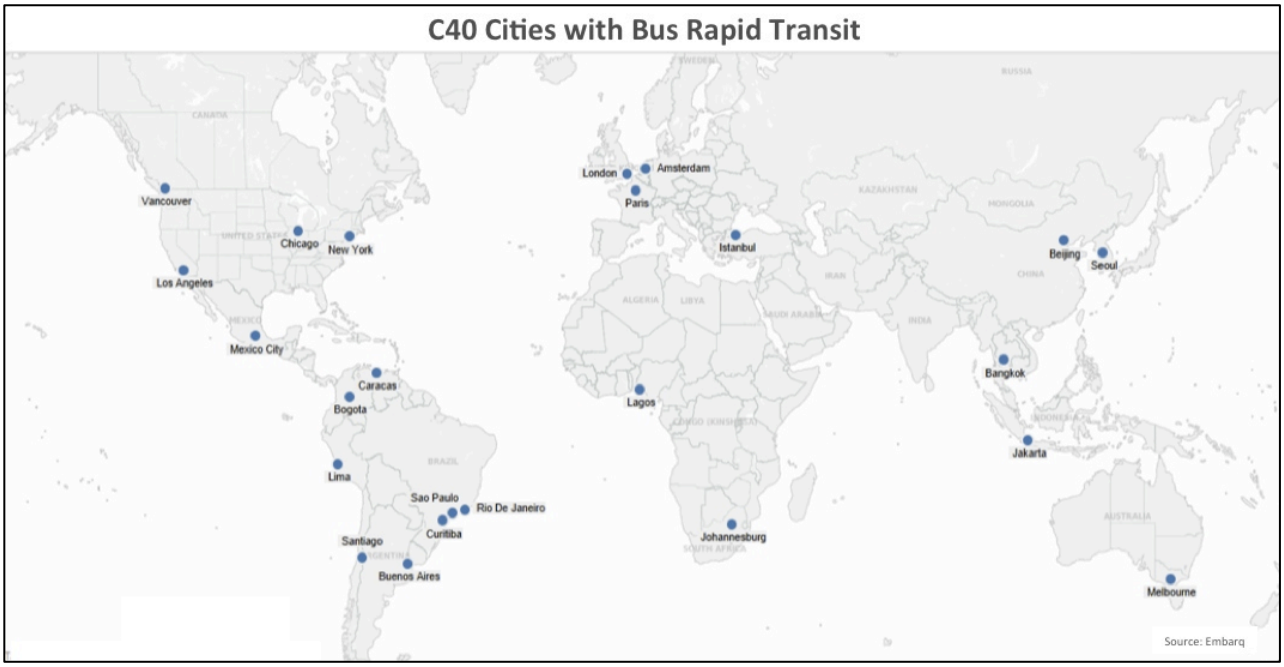

Exhibit 1. Bus Rapid Transit program schemes in the C40 cities around the globe. Latin American cities seem to dominate.

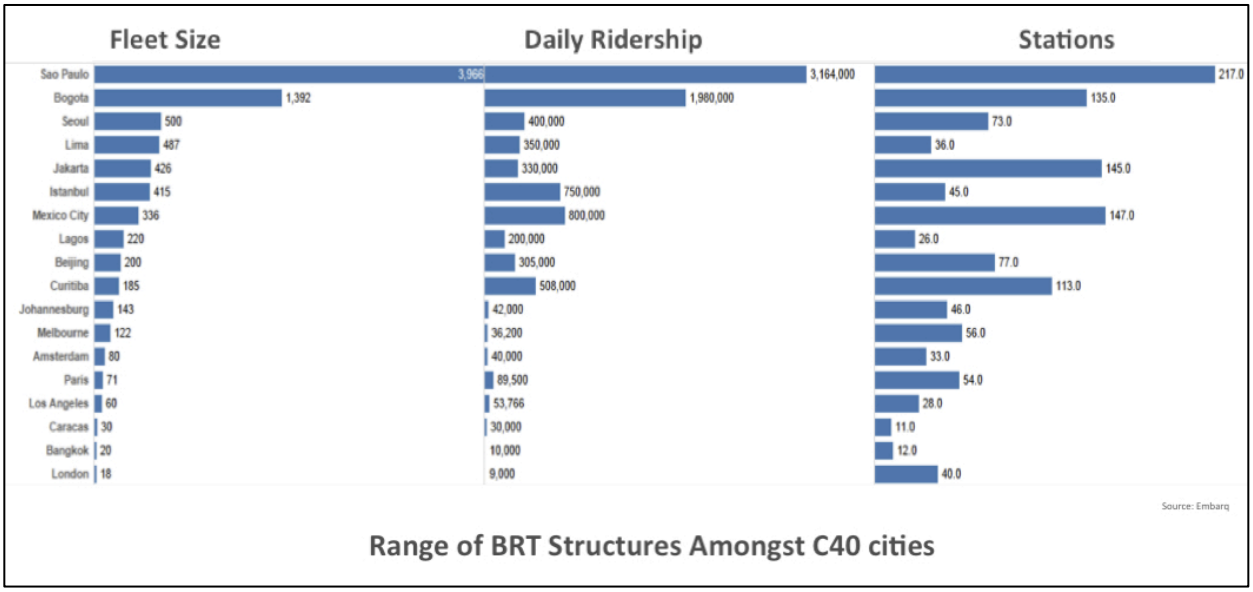

Exhibit 2. Range of structures in C40 Cities that have BRT comparing fleet size and number of stations with daily ridership. A higher daily ridership seems to correspond to a larger fleet and more stations, but some cities still have quite a few stations with minimal ridership - see London, Paris, and Melbourne.

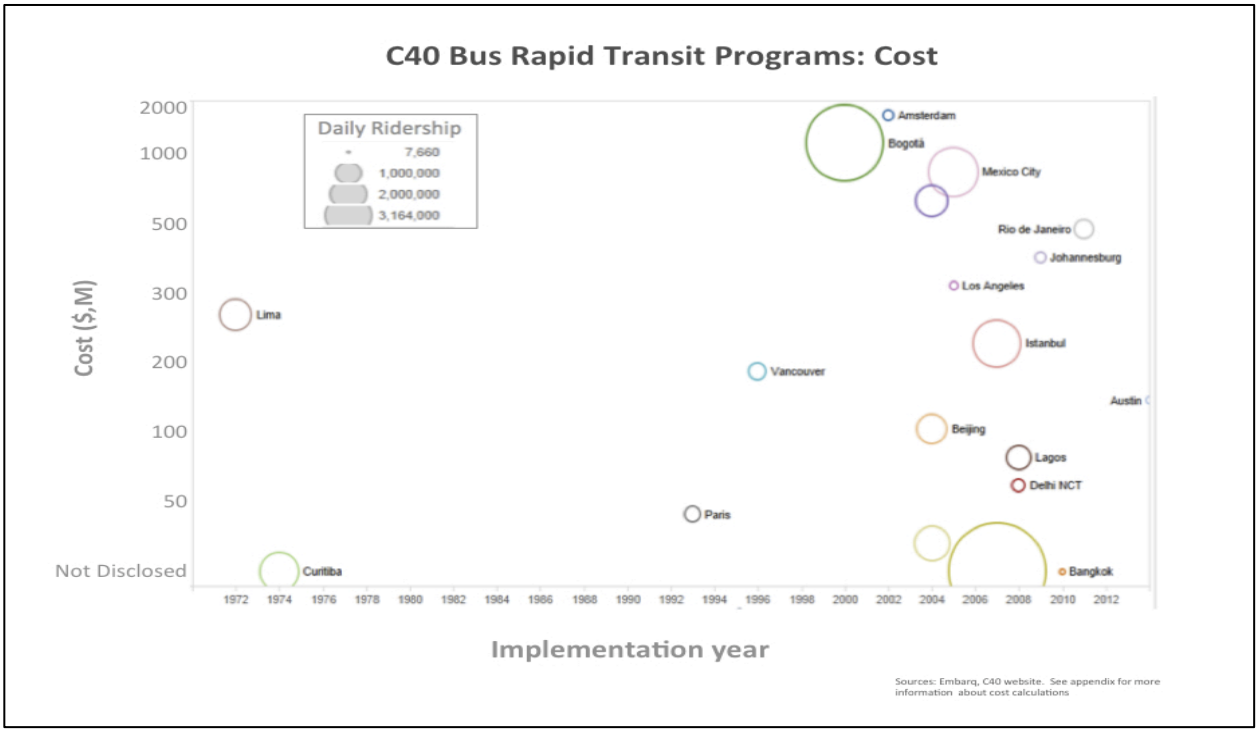

Exhibit 3. This graph represents the implementation date and the initial cost of the BRT system in each of the C40 cities. The size of each circle represents daily ridership. From this observation, there is no direct correlation between implementation date and initial cost. The majority of the BRT programs within C40 cities have been implemented within the last decade, but the initial cost of each program varies significantly across the cities and among the continents. While this observation does not indicate any specific contributing factors, some drivers of cost could be the size of the initial BRT programs and the type or fleet size of the buses.

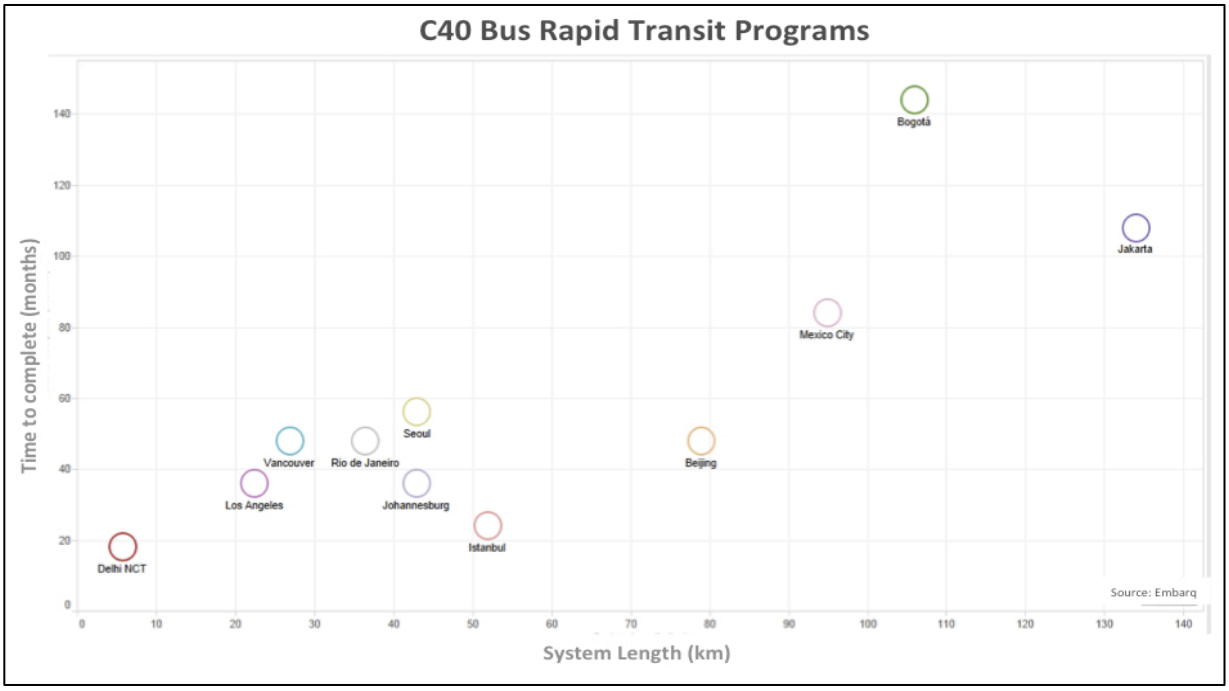

Exhibit 4. Time periods required to complete the initial phase of BRT systems were compared with the length of each system among the C40 cities. The obeservation shows that the length of BRT systems corresponds to the amount of time required to complete initial phase. Longer systems tend to take more time to build.

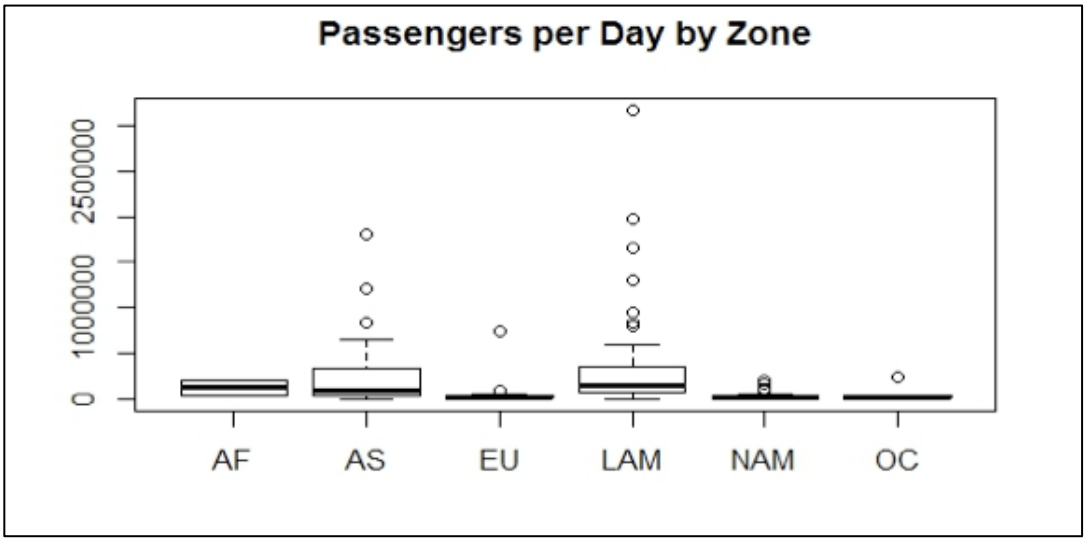

Exhibit 5. A box-plot to compare number of passengers using BRT service per day across different regions: Africa (AF), Asia (AS), Europe (EU), Latin America (LAM), North America (NAM), and Oceania (OC). Latin American and Asian cities serve more passengers per day than North American, Oceania (Australia), and European cities. Latin America on average has a higher number of passengers per day than other regions.

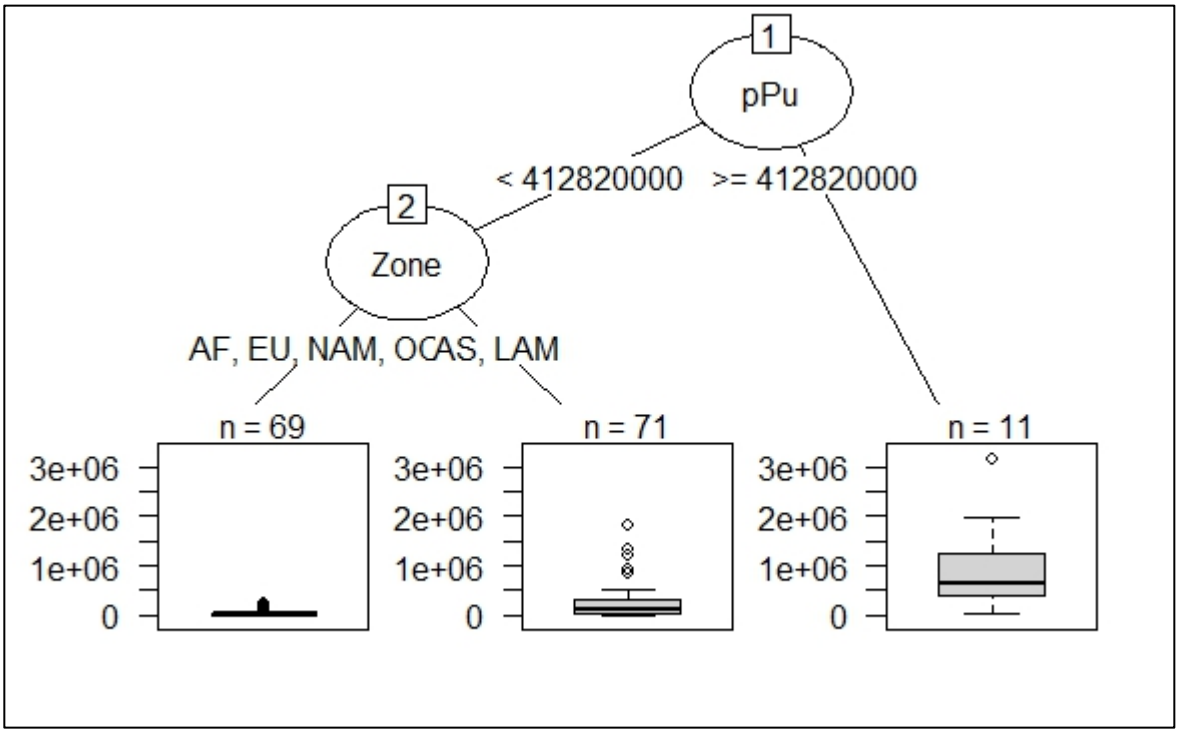

Exhibit 6. A clustering tree for Number of Passengers per day (PPD) served by BRT services. The number of passengers per day (ppd) served by BRT is mostly dependent on the number of people using public transit (pPu). Employing a model-based recursive partitioning method, ppd was clustered using the following variables: zone, population, number of people using public transit, number of people using private vehicles, commercial corridor speed, and population density. The cities with population using public transit of more than 4.1 million have significantly higher ppd. Then, among cities with population using public transit less than 4.1 million, those in Latin America and Asia have higher daily ridership (ppd) as compared to cities in EU, NAM, OC, and AF.

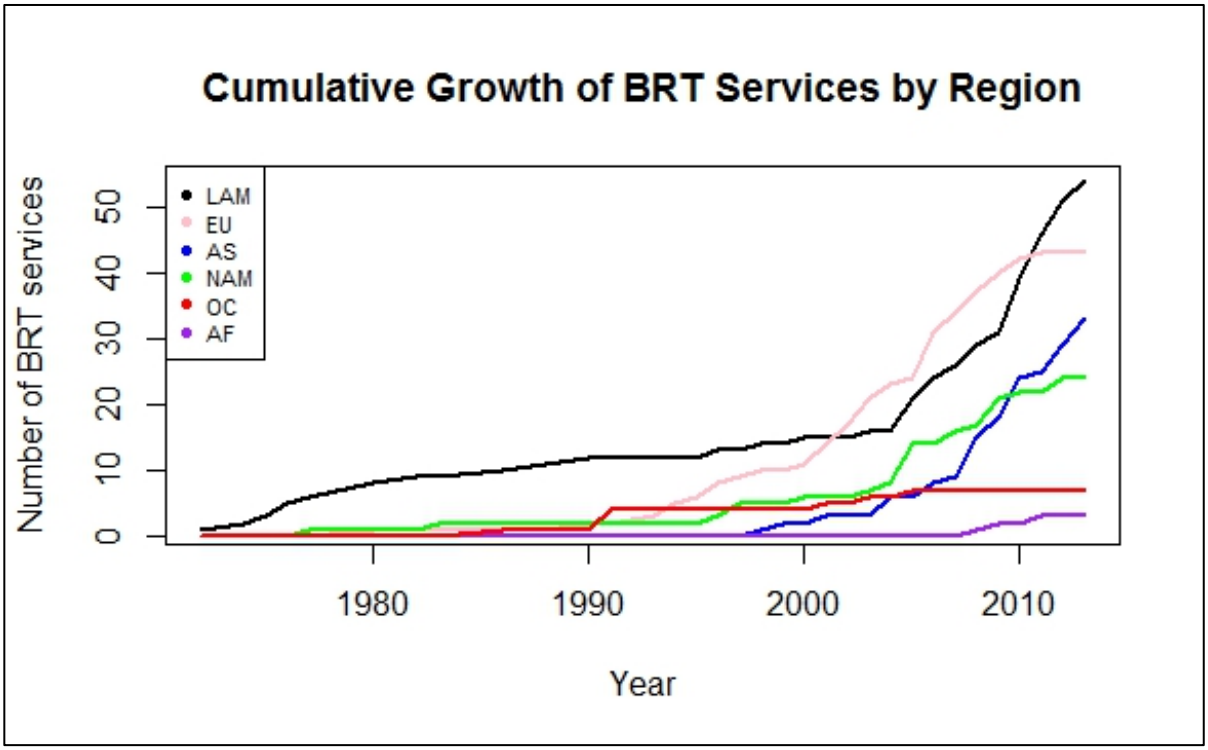

Exhibit 7. Cumulative growth of global BRT services by Region. The data set includes all BRT programs, not only those within C40. The growth of BRT in Latin America has been significant.

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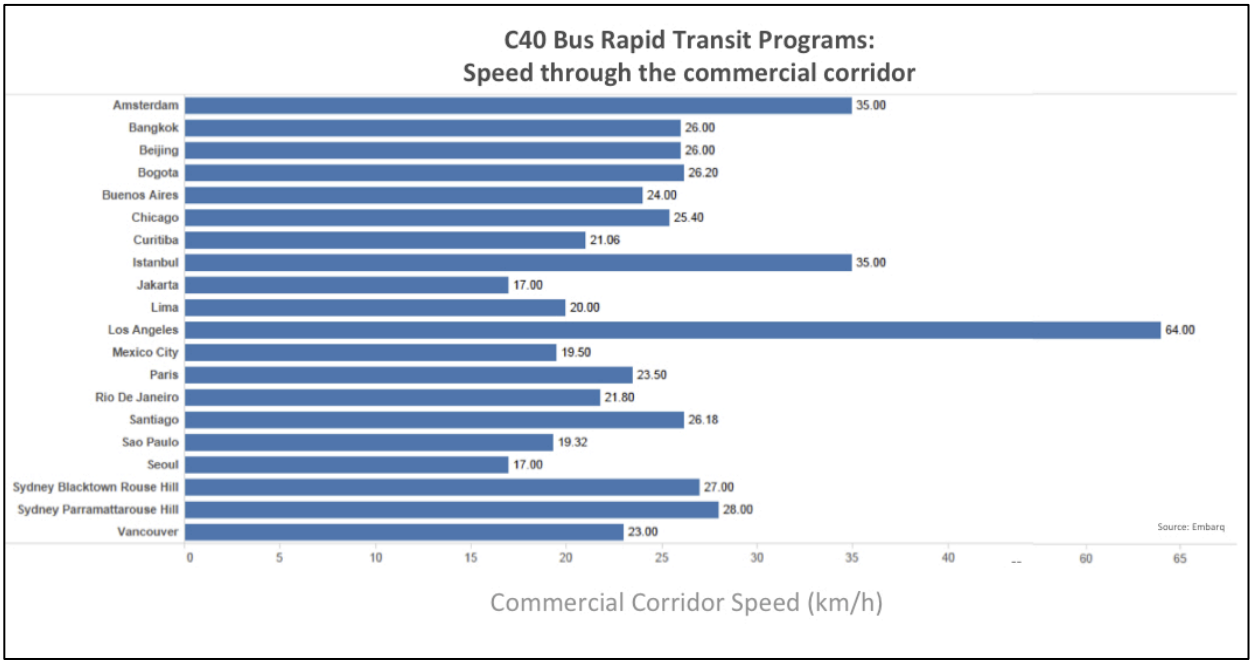


Exhibit 8. Average speed of buses through the commerical corridor. Los Angeles has the fastest fleet speed.

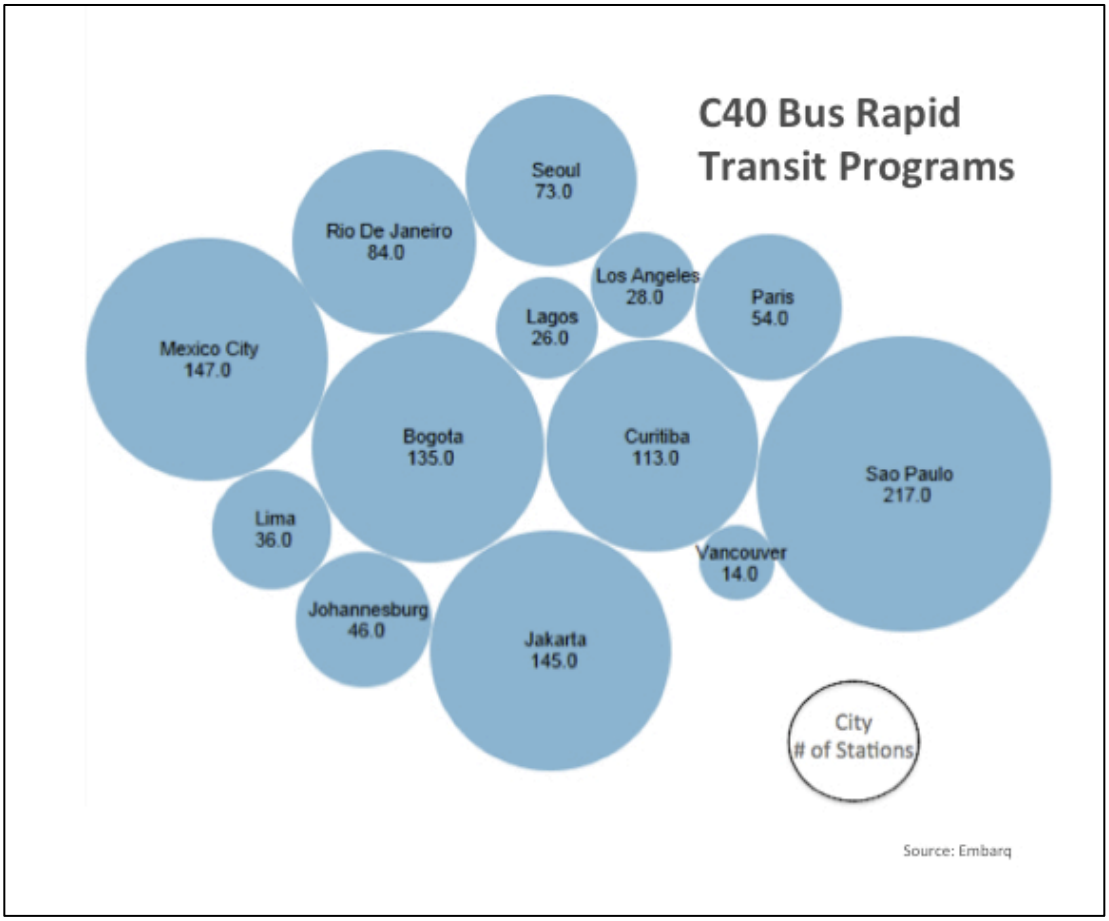


Exhibit 9. Bubble graph showing the number of stations each city has for its BRT program. São Paolo quickly stands out as the largest program followed by Mexico City, Jakarta and Bogotá.

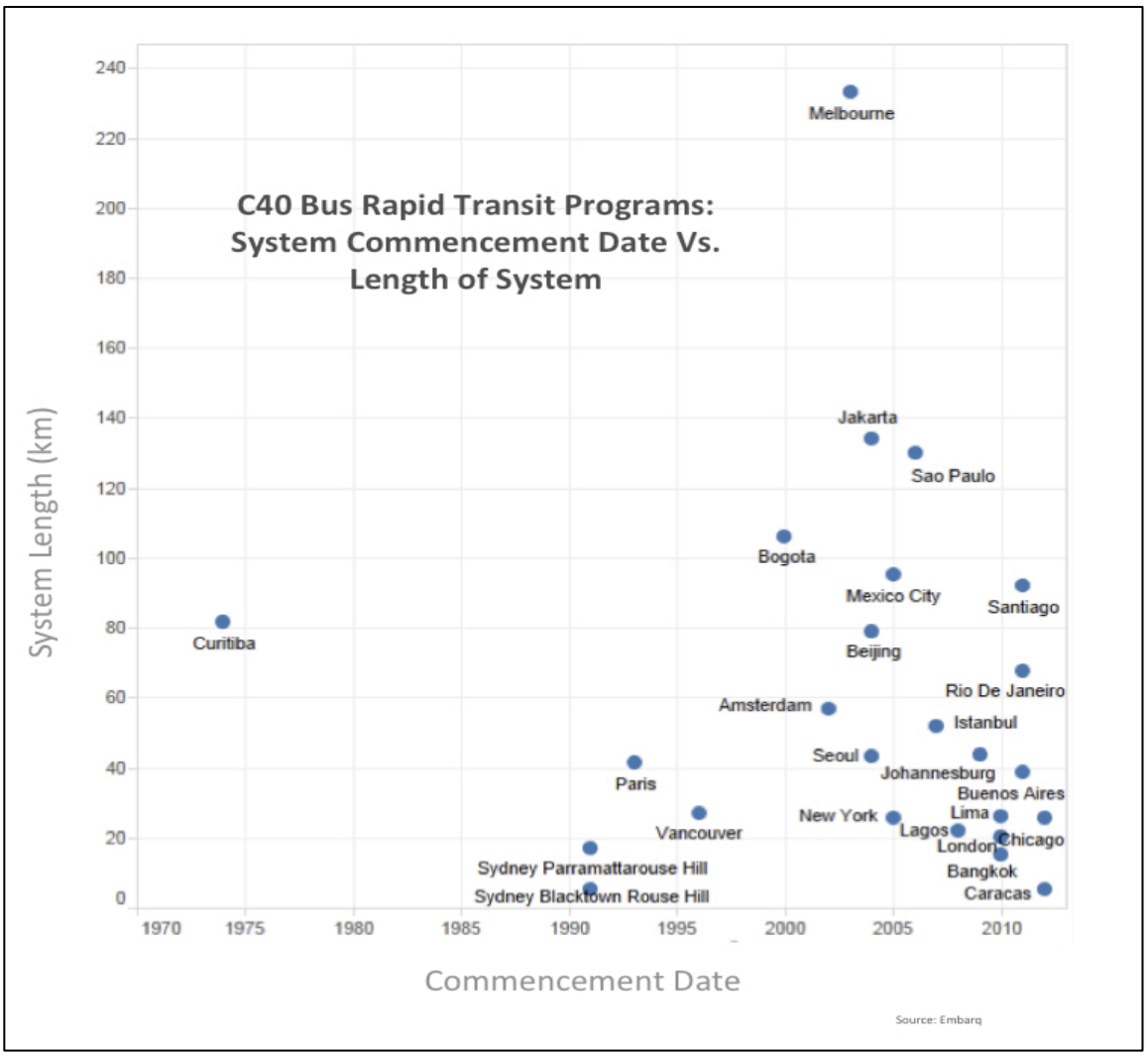


Exhibit 10. Chart showing the year a program started with the system length. Both the number of programs and the length/size of the systems seem to be increasing in C40 cities over time.

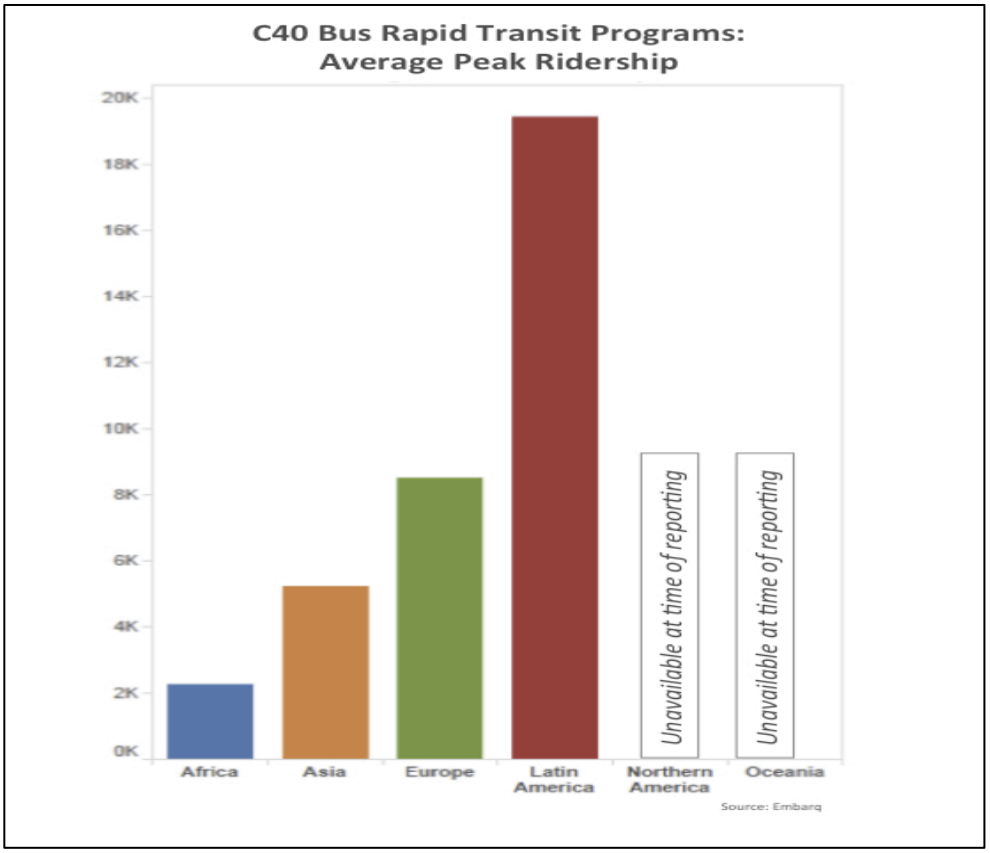


Exhibit 11. Average peak ridership by region. Latin America clearly overshadows other regions.

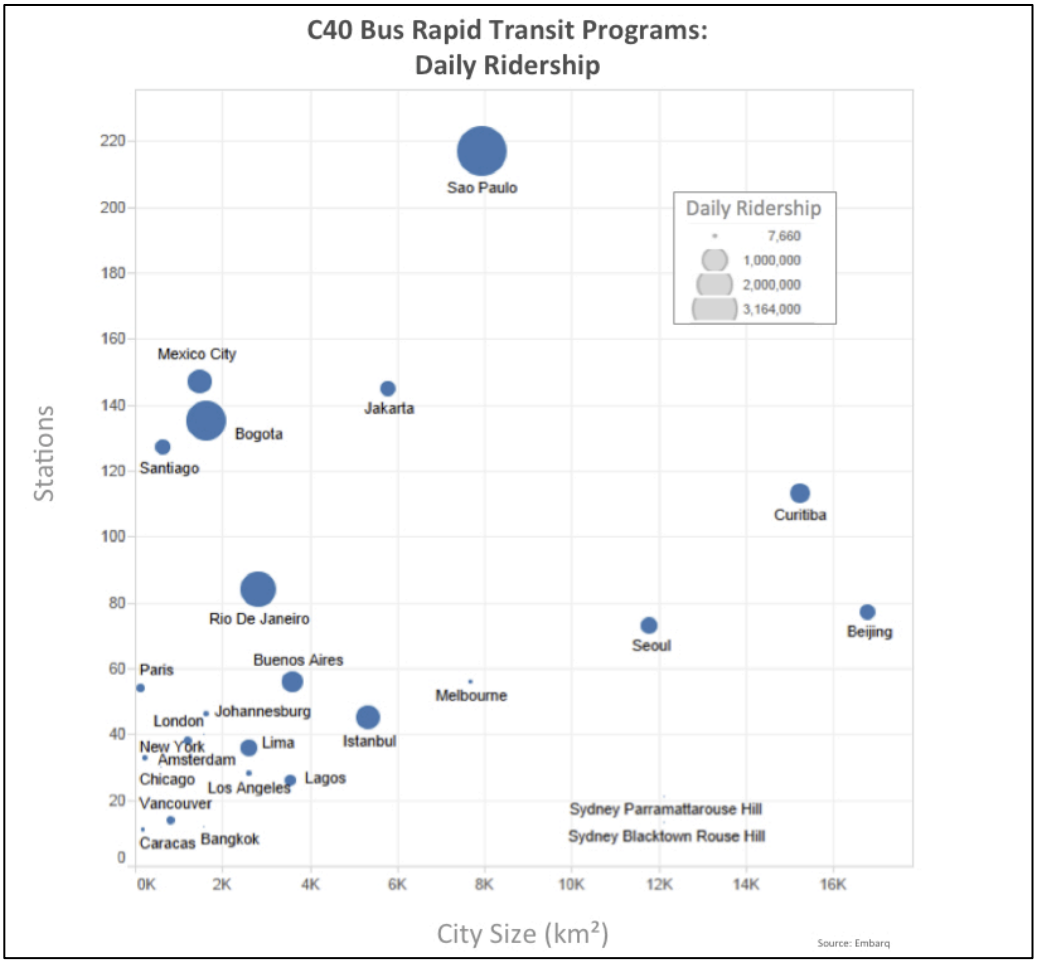


Exhibit 12. The daily ridership of a system plotted against the number of stations and city size (km^2). Size of the bubble indicates the daily ridership. Some interesting outliers include Bogotá, São Paolo and Beijing.

Bike Sharing Programs

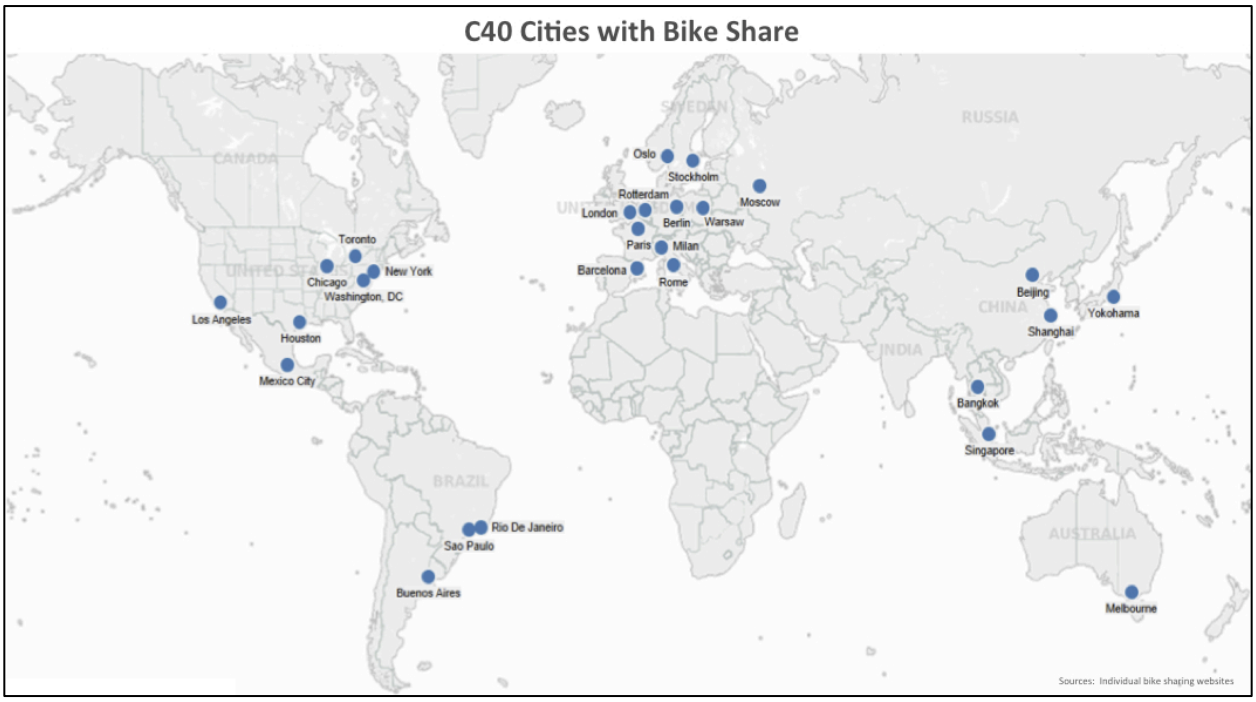


Exhibit 1. Bike sharing program schemes in the C40 cities around the globe. European and the North American cities dominate.

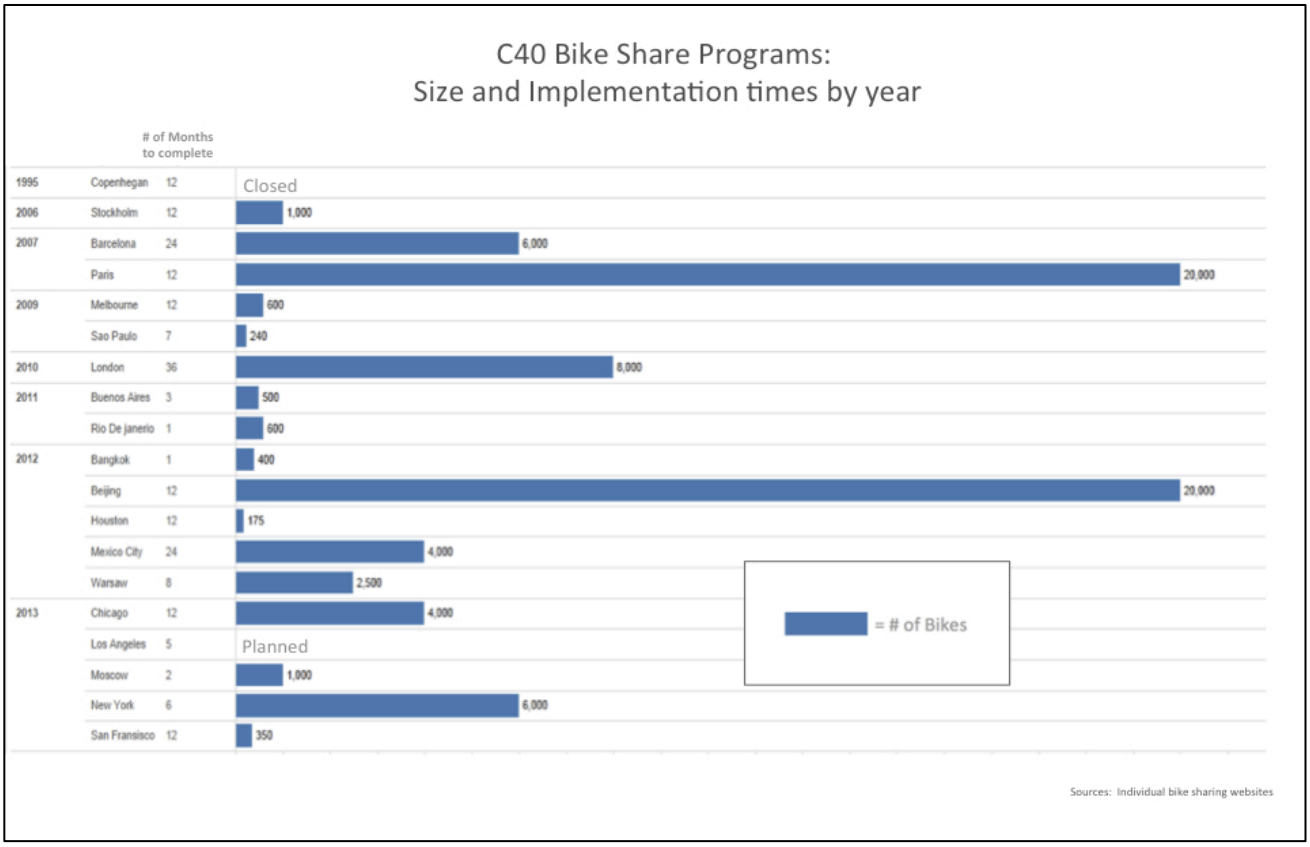


Exhibit 2. Time required for C40 cities to implement a program and the number of bikes in the program plotted against launch date. Program sizes vary over the time period, as does implementation time with no specific trend.

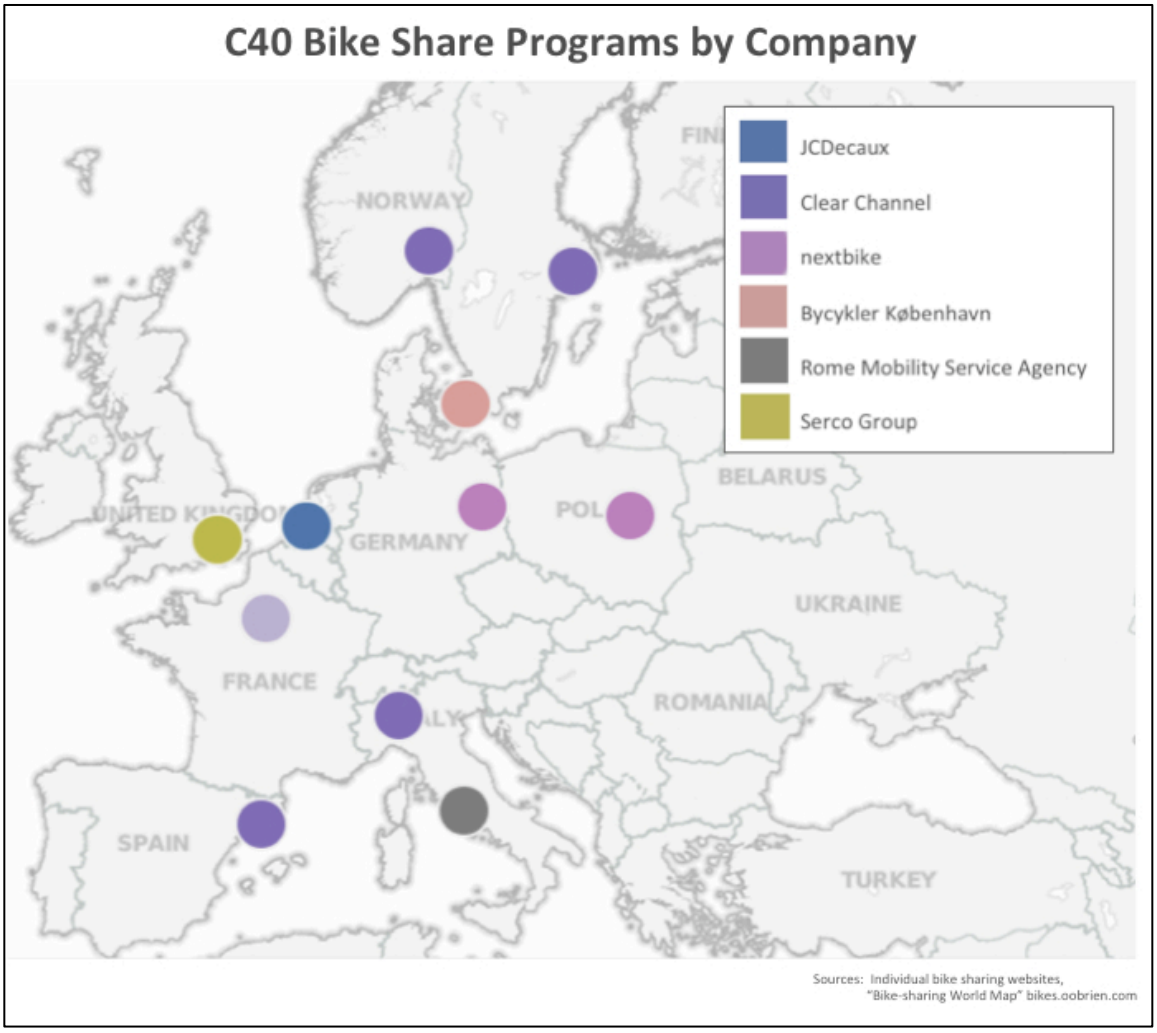


Exhibit 3. A close look at bike sharing program schemes in Europe where Clear Channel dominates as an operating partner.

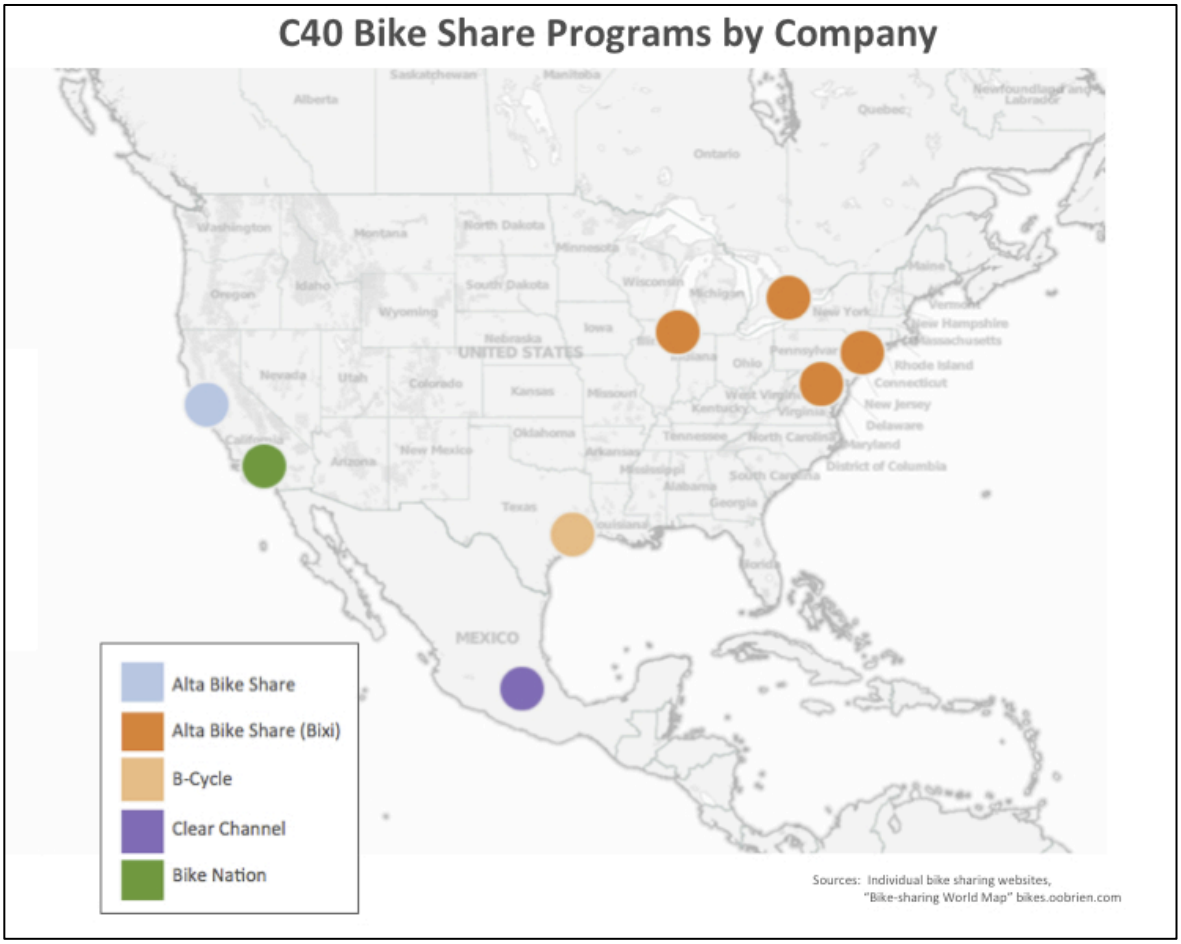


Exhibit 4. A close look at bike sharing program schemes in North America where Alta dominates as an operations partner.

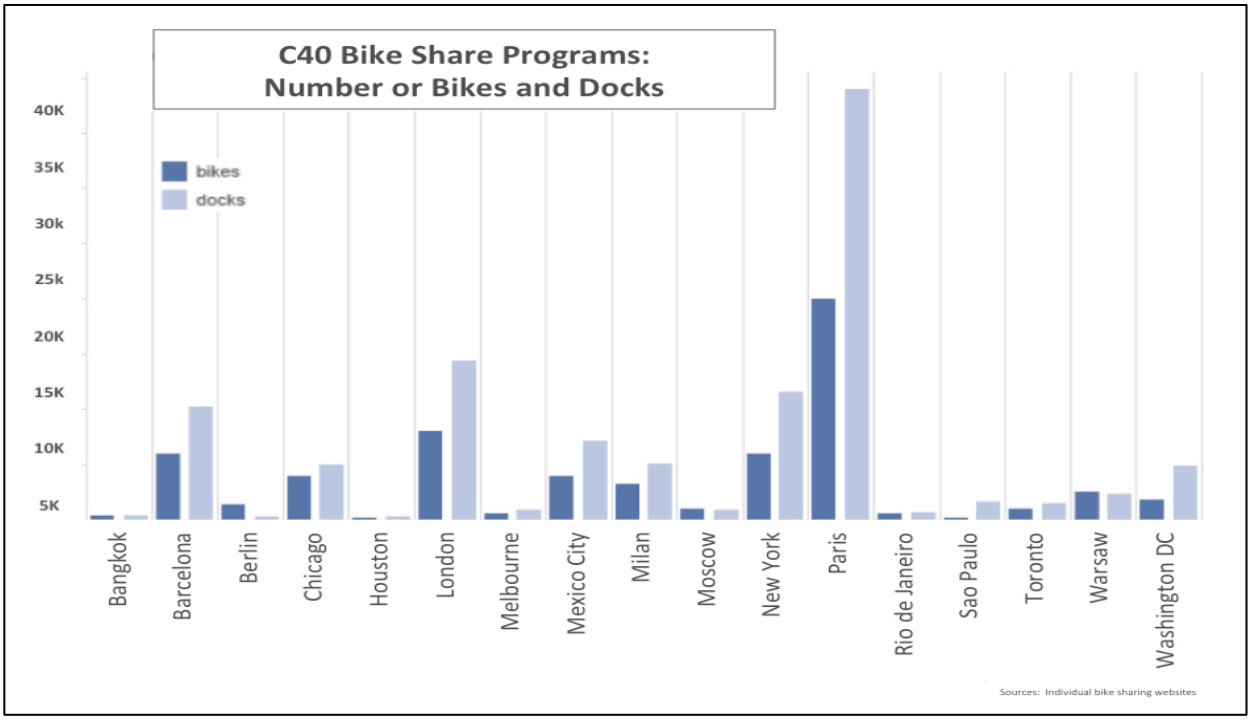


Exhibit 5. The total number of bikes is compared to the total number of available bicycle docks among the Bike Share programs from 17 different cities. Based on the data, the bike sharing programs in cities such as Paris, London, and Barcelona, New York, Washington D.C., Mexico City, and São Paulo have a high ratio of docks to bikes. Paris, London and Barcelona's Bike Share programs have been around the longest and are highly successful. The Bike Share programs in New York, Washington D.C. and Mexico City have been relatively new in comparison but they are currently growing at a rapid rate. This observation supports the notion that a successful, sustainable Bike Share program should aim to meet a docks-to-bikes ratio close to 2:1.

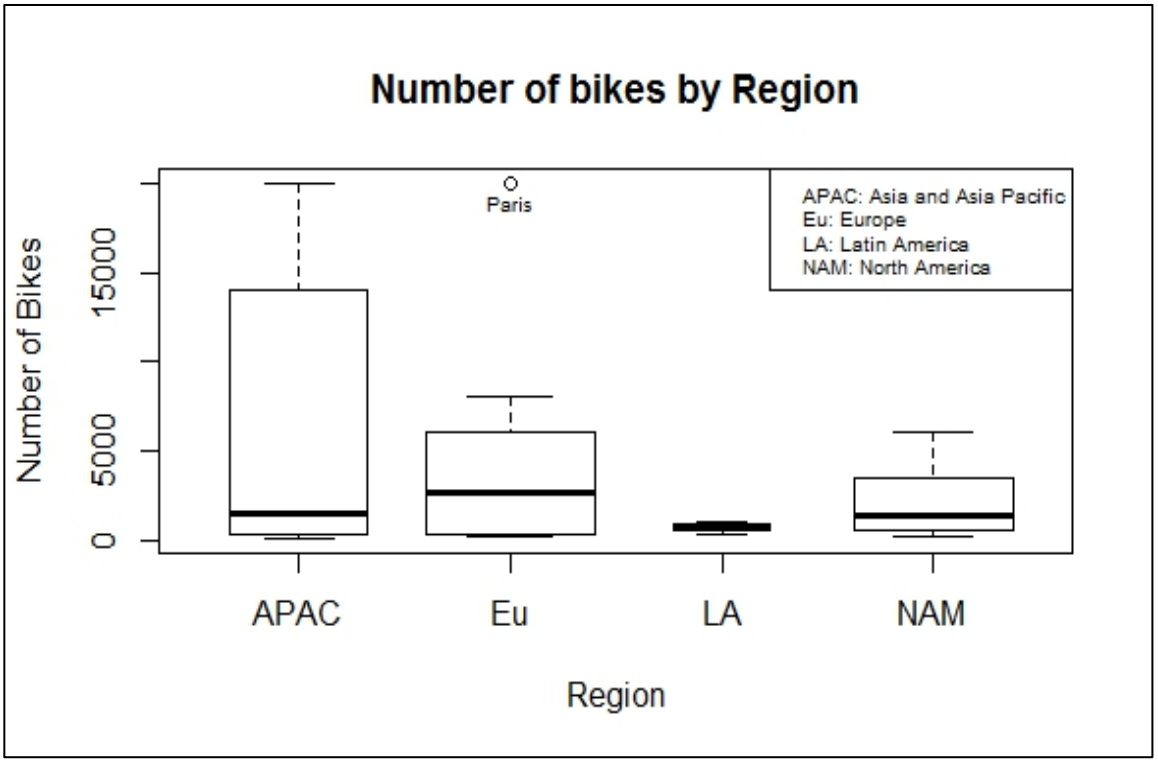


Exhibit 6. A box-plot to compare number of bikes across different regions: Asia and Asia Pacific (APAC); Europe (Eu); Latin America (LA); North America (NAM). Based on the median number of bikes for each region, we could see the sizes of projects (# of bikes) are similar for APAC and LA. European projects tend to be larger. Notable outliers are Paris and Shanghai with 20,000 bikes.

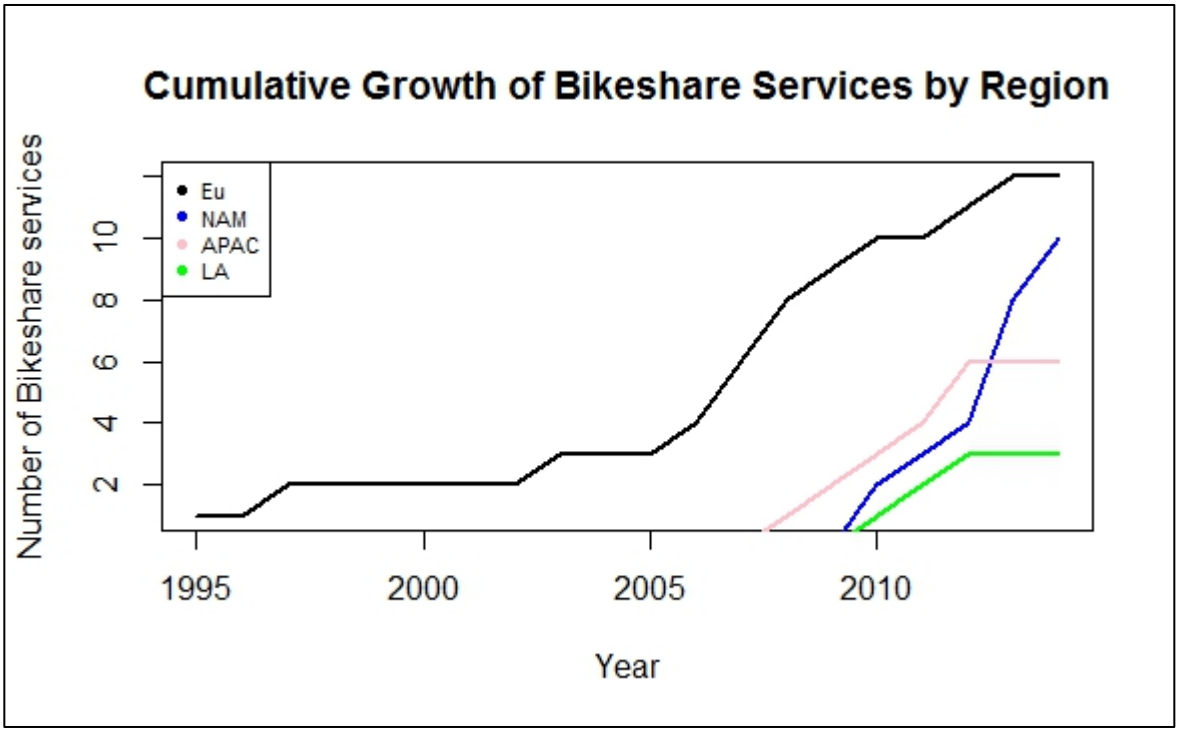


Exhibit 7. Cumulative growth of bike share programs in C40 cities across different regions: Asia and Asia Pacific (APAC); Europe (Eu); Latin America (LA); North America (NAM). European cities were forerunners in adopting Bike Share programs. Copenhagen was the first among C40 cities to adopt Bike Share in 1995, followed by Rotterdam in 1997. However, both programs were closed later on. A big surge in number of programs came in after 2005. In other regions, Bike Share systems start appearing after 2007, which reinforces the hypothesis that Paris's Velib (started in 2007) was instrumental in making Bike Share a trend among rest of the world.

BUS RAPID TRANSIT (BRT)

INTRODUCTION

Bus Rapid Transit (BRT) has become a popular choice for city planners that demand increased mobility for their residents without the sticker shock of a light or heavy rail project. These systems have several defining characteristics that include dedicated lanes, pre-board ticketing and traffic signal priority controls that shorten commuting times by decongesting major corridors. According to Embarq, BRT systems are now the chosen mode of transportation internationally for 27 million passengers a day. The benefits for a city, beyond saving tens of millions of dollars on implementation costs, extend to the realms of social, environmental and economic progress.

The pioneer BRT system, Rede Integrada de Transporte, was implemented in the C40 city of Curitiba, Brazil as a mitigation strategy for the city when it started experiencing problems surrounding the growth of the personal car in the early 1970s. The success of Curitiba's program inspired other Latin America cities to steer residents away from dependence on the car for mobility and into public transportation by making BRT both the cheaper and faster option. Currently, over 60% of all BRT systems are in Latin America.

Beyond Latin America, BRT has continued to grow in popularity at an increasing rate as best practice techniques and proven value have been transferred across regional borders. There are now over 160 cities worldwide with BRT systems in place, with countless more that have developed hybrid models of BRT to fit specific needs like infrastructure constraints and budget. While cities with the biggest opportunities to implement systems tend to be medium–sized developing cities, some of the larger, more developed cities are experimenting with BRT in recent years as well. For example, according to Embarq, the world's longest BRT route is Jakarta, Indonesia's TransJakarta BRT at 134km, while Los Angeles, California's Orange Line, at just 22km, was a simple variation built over a pre-existing bus route.

This section examines both the constraints that cities face and the benefits offered by BRT that have led to the growth of BRT in C40 cities by examining trends and highlighting case studies amongst the C40. To date, just 22 of the world's 160 BRT systems are in C40 cities. Some cities in the C40 have implemented true BRT systems, while others have created hybrids. This is in part due to the sharing of such technological and logistical elements as video surveillance of routes with non-separated lanes. Information exchange occurs most commonly on the regional level, although developing cities around the world have looked to the early adopters in Latin America as they sought to launch their own BRT.

BRT: ENVIRONMENTAL & SOCIAL IMPACTS

The section aims to present analysis on environmental and social opportunities and risks of Bus Rapid Transit (BRT) systems throughout the world with special emphasis on chosen C40 cities including Bogotá, Mexico City, Seoul, Jakarta, Istanbul, Johannesburg, and Vancouver. While Bogotá's TransMilenio provides irrefutable evidence of what BRT can do, there is still the issue of whether these achievements can be replicated in other urban environments.

The Bus Rapid Transit Planning Guide[11] by ITDP, UNEP, GTZ and GEF constitutes a framework for the following analysis.

Environmental Impacts of BRT

BRT as a means of transportation has powerful impacts on human health. Well-designed policies and infrastructure investment priorities can lead to far-reaching reductions in traffic-related health risks from air and noise pollution and injuries. Cycling and walking, on their own or as part of a rapid transit journey, can greatly enhance levels of physical activity, and help prevent a range of chronic diseases including heart disease, some cancers, and even diabetes. BRT as a part of the transport sector is a source of greenhouse gas emissions, yet presents cities with an opportunity for major emissions reductions, and thus is an important focus of climate change mitigation efforts. To optimize the social and environmental benefits that can be derived from BRT, they need to be examined in light of their expected health impacts and potential risks.[12]

City Transport Planning and Travel Behavior Change

Evidence shows that in order to obtain greater health co-benefits, BRT should place greater emphasis on transport and land use planning that makes cities more accessible.[13] BRT systems that provide a high level of service can consequently be expected to have a positive impact on travel behavior change.[14] A study by Institute of Transport and Logistics Studies[15] suggested that increased frequency and reliability have an important influence on BRT ridership growth, since these performance measures can be indicators of reduced waiting time and in-vehicle time. According to an IPCC study,[16] a shift to active transport (walking and cycling) and BRT transport, combined with improved land use, can yield much greater immediate health co-benefits than improving vehicle fuel efficiency.

Reduced Levels of Local Air Pollutants

In city centers, motorized vehicle emissions account for 95% of ambient carbon monoxide (CO) and 70% of nitrogen oxides (NOx).[17] The vehicle fleet in cities is also frequently responsible for a majority of the particulate matter (PM) emissions and some of the sulphur oxides (SOx), which have particularly severe health impacts. The poor air quality in most developing cities limits economic growth and dramatically lessens quality of life.

To date, overwhelming evidence suggests that BRT can markedly improve the state of urban environments by reducing emissions across the life of the BRT project. An established air quality monitoring system can facilitate before and after comparisons of air quality. Air sampling at BRT projects shows that while cleaner engine technologies have somewhat mitigated these emissions in developed nations, the age and maintenance requirements of developing-nation vehicles means that even relatively low vehicle numbers can create health

and air quality problems. It is worth noting that the construction process itself can be disruptive and lead temporarily to some increases in emissions. The table below summarizes the improvements in ambient air quality in Bogotá after the first year of TransMilenio's implementation[18] and the key pollutants that BRT systems in Istanbul,[19] Mexico City[20] and Vancouver[21] remove from the air each year.

Bogota: Pollutant	Daily average concentration before system, year 2000 (ppb)	Daily average concentration after system, year 2001 (ppb)	% reduction in pollutant
Sulphur dioxide (SO_2)	6.8	3.8	44%
Nitrogen dioxide ($N0_2$)	24	22.4	7%
Particulate matter (PM10)	50.8	38.6	24%

Key pollutants saved per year (ton)	PM10	CO	THC	NOx
Istanbul	7.3	78	25	282
Mexico city	2.8	N/A	144	690
Vancouver	0.01	59	5	5

Reduced Emissions of Greenhouse Gases

Fossil fuel use in the transport sector contributes 39% of global greenhouse gas emissions.[22] Greenhouse gas emissions from motorized vehicles are predominantly carbon dioxide (CO_2) but also include some emissions of methane (CH_4) and nitrous oxide (N_2O).

When comparing costs per ton for various CO_2 reduction methods, fuel technology options were found to be significantly more costly than mode shifting options - those that move travellers from higher to lower polluting modes of transport. The finding implies that even shifting relatively small percentages of travellers to more sustainable transport options can be worthwhile. In the study, a 1% reduction in mode share of private automobiles represents over 1 million tonnes of CO_2 reduction over a 20-year project period. Actual reductions can vary greatly depending on local circumstances and a range of factors, including baseline mode shares, local infrastructure costs, and cultural preferences for particular modes of transport.[23]

Regardless of whether a bus is 'clean' or 'dirty', if it is reasonably full it can displace anywhere from 5 to 50 other motorized vehicles.[24] Certainly, a cleaner bus will yield lower emissions, but

dramatic reductions in road space, fuel use, and most emissions can be achieved through displacing other vehicles with any bus.[25]

Seoul's BRT system succeeded in lowering GHGs emissions by 35%.[26] Vancouver and Mexico City BRT systems reduce GHGs emissions by 35,000[27] and 1,200[28] tons per year, respectively.

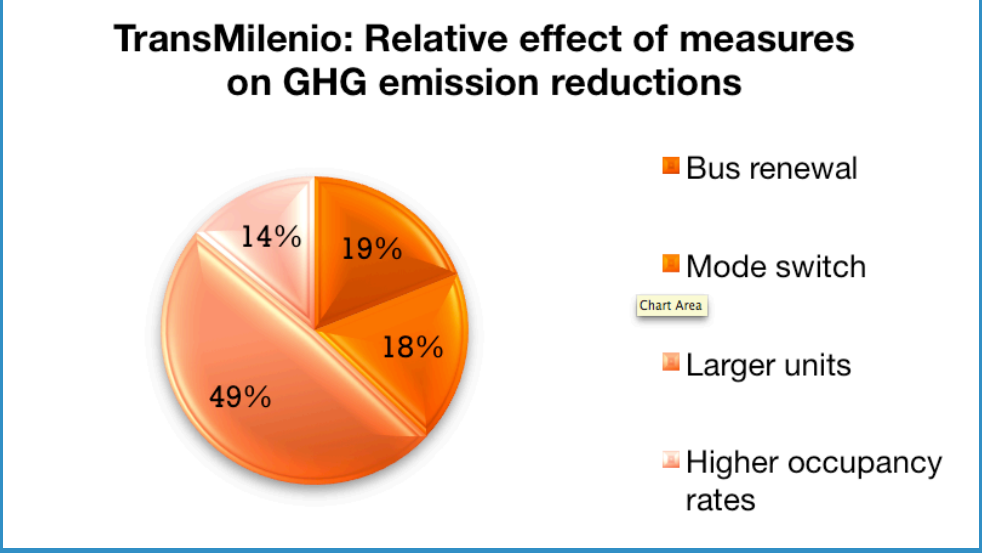
Other city examples in Colombia are interesting because they differ in terms of population or demand characteristics. Pereira is a small city of around 500,000 inhabitants. Expected emissions reductions from the BRT are around 40,000 tons of CO_2 annually. Pereira demonstrates the viability of a BRT for smaller cities, as well as the viability of realizing a Clean Development Mechanism (CDM) transport project of limited size. Cali is a city of around 4 million inhabitants in Colombia. The special feature of its BRT is that it covers 90% of all trips. Expected annual emission reductions of this project are around 140,000 tons of CO_2.[29]

TransMilenio GHG Reductions

TransMilenio earned the distinction of becoming the world's first mass transit project registered with the UNFCCC for Clean Development Mechanisms (CDM) credits in 2006. The project generated 277,044 Certified Emission Reduction credits under the Kyoto Protocol's CDM for 2006-2009, which were sold to provide additional funding for bus purchases. The expected additional income from the sale of CER credits is US $25 million by 2012 (assuming a total estimated reductions of 1,725,940 tCO_2 is achieved in the first crediting period 2006-2012 and) price of US $14.5/$tCO_2$).[30]

TransMilenio[31] is achieving emission reductions through the following mechanisms:

- Increasing the share of public transport ridership by dramatically improving the quality of service (in terms of travel time, comfort, security, cleanliness, etc.)
- Replacing 4 to 5 smaller buses with a larger articulated vehicle
- Requiring the destruction of 4 to 8 older buses for every new articulated vehicle introduced into the system. Other cities have since been influenced by Bogotá's vehicle scrapping program.
- GPS controlled management of the fleet allowing the optimization of demand and supply during peak and non-peak periods
- Encouraging transit-oriented development around stations and along corridors
- Emission standards requiring a minimum of Euro II emission levels with a future schedule requiring eventual Euro III and Euro IV compliance
- The drivers and maintenance personnel receive annual training in processes such as economical and ecological driving, and in maintenance aspects to reduce emissions32



Reduced Noise Levels

Inefficient engine technologies create noise levels in cities that can exceed safe levels. Large quantities of mini-buses are among the biggest contributors to excessive noise generation.

Bogotá Reduced Noise Levels

Bogotá's TransMilenio helps reduce noise levels in corridors from 3-10 decibels[33] through:[34]

- Replacing 4 to 5 mini-buses with a larger public transport
- Using quieter engine technologies
- Managing the system to produce "smoother" vehicle operations
- Employing noise dampening devices
- Encouraging mode shifting from private vehicles to public transport

Liquid and Solid Wastes

BRT operations will also generate a variety of liquid and solid waste, including waste oil, other lubricants, and industrial solvents, as well as solid waste such as worn tires and failed components. BRT systems can help to reduce and control these pollutants by providing standard procedures and a more controlled environment. While informal operators may dispose of waste products in an uncontrolled fashion, BRT operators must follow procedures in the contractual concession agreements.[35] For example, the TransMilenio[36] depots in Bogotá include infrastructure to facilitate the recycling and proper disposal of wastes. By 2010 Bogotá's BRT system successfully reduced solid waste generation by 31%.[37]

Social Impacts of BRT

The social impacts of a BRT system will depend mostly on how the system is designed, so project specific appraisal is generally necessary. However, based on evidence to date, we have observed the following areas of BRT social impacts.

Property Expropriation and Involuntary Resettlement

BRT systems are designed in such a way as to minimize involuntary resettlement, and in fact BRT systems frequently make it possible for municipalities to put off or altogether stop new road projects that would have much higher levels of involuntary resettlement. Moreover, failure to handle the property purchases in a fair manner can result in the loss of international financing.

A Path to Equitable Resettlement to Make Way for BRT

Some characteristics of a well-designed property purchase program include[38]

- Clarity in the procedures
- Transparency and openness of the process
- Timeliness in processing and timeliness in resolving conflicts
- An over-riding sense of fairness in the process

Bogotá has developed a similar process to fairly deal with property purchases required by the expanding TransMilenio system. The following steps outline the Bogotá process[39]:

1. Map the area plots in relation to the planned BRT system in a way to minimize land acquisition
2. Determine the property ownership history
3. Survey the actual activities and socio-economic conditions of existing occupants
4. Assess the property value through independent appraisers to compensate the commercial value of the plot
5. Offer assistance in searching for relocation options
6. Offer an arbitration process

Displacement of Paratransit (Community Transit) Workers

In most BRT systems, negotiations with existing bus operators (minibuses, taxis, jitneys) have been tense as the new system often displaces the existing operators. In the best cases, like in Bogotá, Guayaquil, and Jakarta, major social upheaval was avoided by negotiation and compromise which ensured that at least some existing operators enjoy the benefits of the new system, while at the same time not holding the public interest hostage to the demands of these private interests. In the worst case, like in Quito, a general strike by the former bus syndicates shut down the transit system for five days and the military had to be called in to avoid further disputes. For this reason, most BRT systems do not completely turn private bus operations over to international competitive bidding, but rather structure the terms of the competitive bid to ensure that a significant number of the existing bus operators in the corridor affected are reincorporated into the new system. How this is done specifically will vary depend on the structure of the existing paratransit industry.[40]

Incorporating Existing Bus Operators into BRT

In Bogotá, for example, the companies bidding on becoming the operators of the new BRT system got extra points for "experience operating buses in the corridor." Also, each bidder had to destroy several of the old paratransit buses for each new vehicle that they procured. This requirement forced the bus enterprises to buy the old buses from small individual bus owners, so that these parties would be able to recoup the value of their only capital asset. Some accepted cash and others accepted shares in the new company.[41]

Poverty alleviation and Social Equality

Lower operating costs allow BRT systems to be self-financing at much lower fare levels, making it possible to keep the bus operations in private hands (principally in the developing world) while providing services affordable to the poor. Also, many new systems have focused initial corridors on the lowest-income neighborhoods. This emphasis helps ensure that the BRT will play a role in improving access to jobs and public services.[42]

Furthermore, the locations of the urban poor will tend to make different fare structures more or less equitable. For a system to be viewed as successful in terms of poverty reduction, the fare structures should be adjusted to reflect and accommodate the settlement patterns of low-income neighborhoods.

In most developing country mega-cities, the poor tend to live at the periphery of the city. In such circumstances, a flat fare structure such as that utilized in Bogotá, Guayaquil, and Quito will tend to cross subsidize long distance low-income trips. On the other hand, there are some exceptions, where the poor are more randomly distributed throughout the greater metropolitan area, or where the poor occupy the central city. In these rare instances, a distance-based fare structure may be more equitable.[43]

The World Bank has been a proponent of BRT in developing nations. Whereas roadway infrastructure projects mainly benefit motorists in the form of commuting timesaving, the working poor in the developing world typically neither own nor drive a car. Yet that is the demographic that the World Bank attempts to support through urban transport projects. The values of time that the poorer classes hold might also be substantially less than those of the middle and professional classes. For the poor, enhanced access opportunities might be a more worthwhile benefit – and contribute to the World Bank's over-arching objective of poverty alleviation — than reduced travel-time expenditures.[44]

BRT Supporting Low Income Populations

A recent passenger survey on the Beijing BRT[45] found that the majority of passengers (78.7%) were from low income and lower middle groups; company staff (37.3%) and self-employed (16.4%) were the main divisions of occupation for sampled passengers.

Similar data has been collected for the TransJakarta system.[46] From a sample of 350 system users, a study found that approximately 40 percent of passengers were defined as “low income.” In terms of travel cost, 47 percent said their travel cost was slightly lower, 29 percent said it was the same, and 21 percent said their travel cost was higher than before.

Johannesburg, South Africa - Segregated Transit for Segregated Communities- An Apartheid Legacy

The story of transit in Johannesburg is tied to the socioeconomic legacy of apartheid. The greater metropolitan area is home to more than seven million people and is spread out into distinct racially divided territories.[47] Official policy in that era forced the poor to live far from their workplace, yet public investment in a transport network for that part of society was negligible. Blacks came to Johannesburg's predominantly white Central Business District with passes to work and then returned to their townships in the evenings via minibus taxis and on buses operated by the privately owned Public Utility Transport Corporation, or PUTCO.

In the post-apartheid era, gated white suburban districts proliferated. The municipally owned Metrobus principally served these areas, even as private vehicle use expanded there.

Two-thirds of Johannesburg residents did not own private cars and were dependent upon other means of transit to get around. At the time, half of the 3.5 million trips made each day were made by some means of transport other than private vehicle and three-quarters of those were by commercially operated minibus taxis. Less than one in ten residents used the public Metrobus.[48]

Facing limited resources and a relatively high cost of minibus taxi service, residents of the poorer townships were not opting to patronize the Central Business District outside of working hours. As the townships and the suburbs grew, this downtown area lost its social and economic vibrancy.[49] In effect, Johannesburg's pervasive difficulties - distinctly separate public and private transportation groups, costly fares, and increasingly congested roadways leading to long commutes - resulted in a kind of de facto reinforcement of social segregation, even in the post-apartheid era.

Rea Vaya – BRT as a Social Engineering Tool

In the mid 2000s, city government, led by then Mayor Amos Masondo, needed to find a sustainable transit solution for Johannesburg's nearly four million inhabitants and the nearby townships and suburbs that made up the greater metropolitan area.

The impetus for change emerged when the FIFA World Cup came to South Africa in 2010 and Johannesburg built three new venues to host the games and ceremonies. It was imperative that visitors be able to get to and from the events safely and efficiently. Johannesburg took advantage of this opportunity to address the socioeconomic legacy of apartheid and to showcase itself on the world stage when it introduced Africa's first full BRT system.[50]

The system, named Rea Vaya meaning 'We Are Going,' had a goal of integrating the greater metropolitan region and boosting its economy by making transit rapid, accessible, safe and affordable for all. The government anticipates the system will play a major role in revitalizing the Central Business District. The initial phase, completed in 2009, created 3,300 new jobs and the full system is expected to generate more than 29,000 jobs.[51] To date, 22,287 jobs have been created.[52]

Crime reduction

Some evidence suggests that public transport upgrades can also reduce crime. Improvements in station lighting and nearby footpaths as well as the presence of security cameras and security personnel can do much to create a safer and more secure urban environment.[53] According to statistics from the Center for Criminal Investigations of the Bogotá Metropolitan Police, aggregate crime in the area around Avenida Caracas dropped 85% between the period prior to (1999–2000) and following (2001–2002) the implementation of TransMilenio.[54]

Safety

BRT features like the separation of public transport vehicles from mixed traffic and the improvements to pedestrian crossings and traffic signalization tend to produce significant safety benefits. Thus, reductions in vehicle accidents and pedestrian accidents often accompany the implementation of a new system.[55]

However, even though barriers physically separate the BRT from general traffic, the exclusive busway may encounter some unexpected use by other transport modes.

BRT Improves Safety in Beijing and Seoul

In the case of Beijing,[56] occasionally some cars or even tricycles intrude onto the busway corridor, due to driver carelessness. In addition, a few passengers climb over the barrier to find a shortcut to the BRT station. All of these have resulted in hidden trouble for safe BRT operation.

In Seoul, the number of traffic accidents has decreased by 25 percent, and number of deaths by 31.7 percent.[57]

Bus related traffic accidents and causalities					
Year	Number of accidents	Number of the injured	Heavily injured	Death	Total
2003	654	916	49	6	971
2004	478	704	36	0	740
Change	26.90%	23.10%	26.50%	100%	23.80%

Zoning Policies

The relationship between BRT and land use can have long-lasting impacts on the form of the city. Busways can play an important role in concentrating new development in strategic locations that minimize the long-term cost of providing transit and other urban services to these households and businesses.[58]

BRT Helps Creates a More Livable City in Vancouver

Vancouver BRT lines are part of the Greater Vancouver Regional District's Livable Region Strategic Plan - a blueprint for future development in the region, which is "compact urban development and/or complete communities, anchored by regional and municipal town centers and supported by a network of high quality transit links." Vancouver's officials see this transportation investment as a method to encourage desired land use patterns.[59]

The impacts described herein demonstrate the environmental and social change that is taking place alongside the physical reordering of infrastructure, as well as through the associated urban development. Examining the benefits and costs of a project can also answer the question of what is the dollar value of the improvements that it creates in people's lives.

The Political Economy of BRT

There are a variety of social and economic factors that come into play in the development and operation of Bus Rapid Transit. The existing reality of a local political economy is the first of these many considerations. Even as cities across the globe race to introduce Bus Rapid Transit for all the right reasons, mayors and civic leaders face disparate challenges of a political and cultural nature that can have a profound effect on the economic success of the program. This is especially evident in the developing world where recognition of the interests of stakeholders and the roles they play is every bit as essential to the successful implementation of BRT as are the economics of the system.

The Importance of the Existing Paradigm

The historical context of transport within a given city can be both the biggest incentive and challenge in developing a BRT system. While BRT offers an opportunity to create a new economic paradigm for transit - one that can create jobs, reduce time lost commuting, reduce commuting costs, relieve congestion and reduce emissions related costs – existing social, economic and political realities are part of the calculus to be addressed in seeking to bring change to entrenched ways of conducting business.

Cities have historically either operated their own public transit systems or have enabled private systems to develop with varying degrees of oversight.

Public Sector Mass Transit

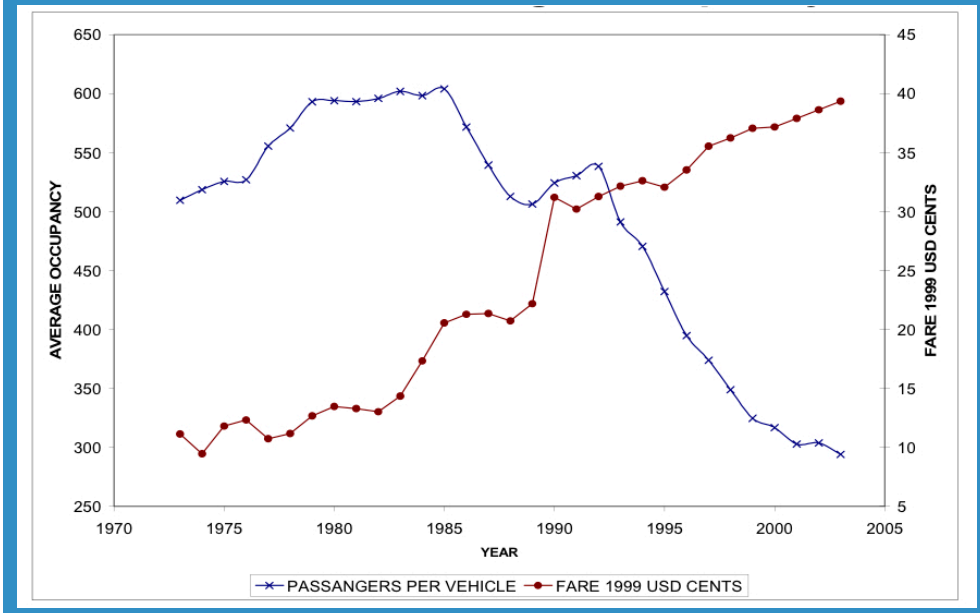
In the developed cities of North America, Europe and Asia, mass transit systems are commonly owned and operated by local government authorities. While there are certain benefits to this, including good transparent governance and oversight, there is no profit motive under this structure. Public transport systems can operate somewhat inefficiently and at a higher cost to public coffers than is warranted. Unlike the private sector that responds when it sees a market need by profitably providing new services, public transport is constrained by budgets and the limits of its authority. The nature of public works is such that constraints on system administrators make it difficult to provide new resources where there is pent up demand. When new projects are authorized, public bureaucracy can often be a burden on system costs. Still, mature transport systems in the public domain are proving to be an effective framework for managing well-organized BRT in cities accustomed to fully public transport.

Private Sector Mass Transit

In developing cities in Africa and South America, private vehicle ownership has historically been relatively low and the populace is therefore far more dependent upon transit. While that is desirable to the extent that the widespread use of quality mass transit has the potential to keep traffic congestion and emissions levels down, the existing reality is oftentimes markedly different. In many of these cities there is a legacy of myriad private operators that compete for ridership, often in a free-for-all, actually causing increased congestion, safety issues and inefficient multi-tiered business models. This is a market failure that results because the operators in these mass transit systems do not have exclusive property rights, or in the case of buses, curb rights.[60] Interloping privateers take advantage of the considerable market potential for passengers, resulting in negative economic consequences, not the least of which are higher prices in places where individuals with low incomes can spend nearly a fifth of their income on transportation.[61] When these conditions occur, BRT can present a way out of this downward spiral.

Bogotá, Colombia – The Penny Wars: Misguided Policies Led to Market Failures

A series of economic policy shifts over the course of the preceding decades led to the conditions that made BRT a viable solution to the transit situation in Bogotá. Years of fare subsidy increases, followed by subsidy retractions led to market distortion. Compensation for both the bus companies and the drivers was based upon the number of passenger fares. As the population increased in the twenty-year period prior to the opening of the TransMilenio BRT, the number of privately operated buses on the road doubled in response to the opportunity to gain revenue share. Outsized bargaining strength of the private bus companies operating under local government authority led to a four-fold increase in fares over the course of three decades leading up to the implementation of BRT.[62]



Bus fare and average occupancy, 1970-2003 in Bogotá, Colombia[63]

Yet as fares increased, ridership decreased and private vehicle use increased. Bus operating companies, and in many cases, the drivers to whom the older buses were sold, kept their vehicles on the road long past their design life. This added to traffic congestion, longer commuting times and increased emissions. Prior to rolling out the TransMilenio BRT, there were 21,000 registered private buses and an estimated 9,000 other unregistered vehicles[64] vying for riders.

In that system, bus operators generated income solely from fares. The payment structure and the lack of any organized mass transit laid the foundation for the intense competition that begat the "penny wars," where drivers often drove aggressively, deviating from assigned routes, making unscheduled stops, often arbitrarily raising fares for passengers unwilling to wait for another bus and at other times lowering fares in order to entice greater ridership.[65]

In total, unsafe conditions, increased traffic gridlock, slowed commuting times, unprecedented increases in private vehicle ownership and the resulting air quality issues, all created the conditions that made the TransMilenio BRT an obvious solution.

Transitioning to BRT

Transportation in major cities is a large and complex issue that mayors address daily. As importantly, it is the lifeblood of a city's economy, an organism in constant motion comprised of many different players, each with a unique vested interest. Residents and visitors have a vested interest in getting to and from work, home, shopping and leisure activities in a timely and affordable manner. Service providers have a vested interest in getting the people to where they want to go.

Occasionally, existing transport systems are well planned and effectively organized. Oftentimes, they are a disjointed outgrowth of existing conditions that become increasingly confounding as city populations expand. Changing patterns of urban density present a challenge for providing mobility for residents and commuters alike, many of which may not have access to fully networked public transit systems. This can be a source of economic hardship and emissions when the prevailing system no longer serves effectively and people turn to private vehicles for transport.

Stakeholders

As mayors and transportation authorities grapple with the challenges of getting people swiftly from place to place, they must also attend to the needs of those whose jobs and businesses it is to move people around the city, and to those whose lives and businesses are affected by the transportation network. As a city expands, its transportation infrastructure gets stretched and can quickly become overburdened. Officials and transportation experts may well be aware of the options available and the merits of introducing new systems into the fabric of the city, but the measures are not likely to be viewed as successful unless all the stakeholders are engaged.

BRT planning works most effectively when cities convene groups that have an interest in the status quo and are affected by the new paradigm to be created. To best identify the stakeholders, several questions must be addressed:

- Which communities will the BRT systems serve?

- What basic demography information will be useful in understanding overall ridership trends?
- Can the governing stakeholders bridge the gap in meeting the needs of the average commuter through implementing a BRT system?
- Which transport services providers would be displaced?
- How will the BRT system be funded and implemented?

Stakeholder groups that can understand and evaluate the economic, environmental and societal impacts and benefits of transportation networks will be able to identify the barriers to success earlier in the process. The stakeholders commonly influencing decisions in BRT projects include[66]

- Government
    - Elected Leaders & Politicians
    - Municipal Agencies
    - Special interest groups
- Transport Industry
    - Bus operators, owners, managers, drivers
    - Taxi Owners & Operators
    - Vehicle Maintenance Operators & Mechanics
    - Trade Unions
- Business
    - Real Estate Interests
    - Trade Associations
    - Commercial, Industrial and Retail Businesses
- Technical Experts
    - Transportation Planners
    - Engineers, Architects and Constructors
    - Equipment and Technology Manufacturers
    - Fare collection System Manufacturers and Integrators
    - Network Administrators
- Investors
    - Financial institutions
    - Development banks
    - Public/semi-public and non-governmental institutions
    - Bondholders

Lagos, Nigeria – The "Go Slow"

Less than forty years after Nigeria had gained independence, transportation in its largest city was literally at a standstill. The average commuting time in Lagos took two hours and stories abounded of people sitting in traffic for twice as long. The typical journey along the main arteries had become known as the "go slow."[67]

Transit in Lagos was comprised of 75,000 minibuses known as danfos, plus 25,000 mini-buses called molues, shared taxis or kabu-kabu, and motorcycle taxis, called okadas. Three quarters of the six million daily passenger trips were conducted in the buses.[68] Private vehicles, commonly secondhand discards from other nations, were becoming plentiful. With a city population of eight million and more than twice that in the greater metropolitan area, Lagos was in danger of choking its economy with productivity lost in traffic.

The state and federal governments moved to find a solution in 1999 and established the Lagos Urban Transportation Project. Three years later, the Lagos Metropolitan Area Transport Authority (LAMATA) was created under law to plan and coordinate the existing public transport. Over the course of the next four years, LAMATA explored ideas for improving efficiency and reducing congestion, including larger buses, traffic management systems, and new terminals. In 2006, LAMATA began a feasibility study for a Bus Rapid Transit corridor. Later that year, LAMATA was empowered as the sponsor for all mass transit within the city and throughout the surrounding region, including what would come to be known as BRT-Lite.[69]

LAMATA convened representatives from the labor sector – the National Union of Road Transport Workers (NURTW) and from management – the Road Transport Employers Association of Nigeria (RTEAN) to develop consensus in the design of the operating framework for a BRT system in Lagos. Joint delegations visited the Curitiba Research and Urban Planning Consultancy in Brazil, the TransMilenio BRT in Bogotá, Colombia and the Transantiago BRT in Santiago, Chile in order to learn about best practices.[70]

Lagos soon launched its BRT-Lite successfully in great part because officials had taken strides to reach out to the stakeholders and to engage them in a participatory process. Now riders of the BRT can speed right past the 'go slow.'

Operating Models

Cities around the world have BRT systems that are financially structured using several different operating models. These include public sector operated systems and hybridized public-private partnerships. Fully privatized BRT networks are generally not found due to the public nature of roadway infrastructure and ancillary spaces.

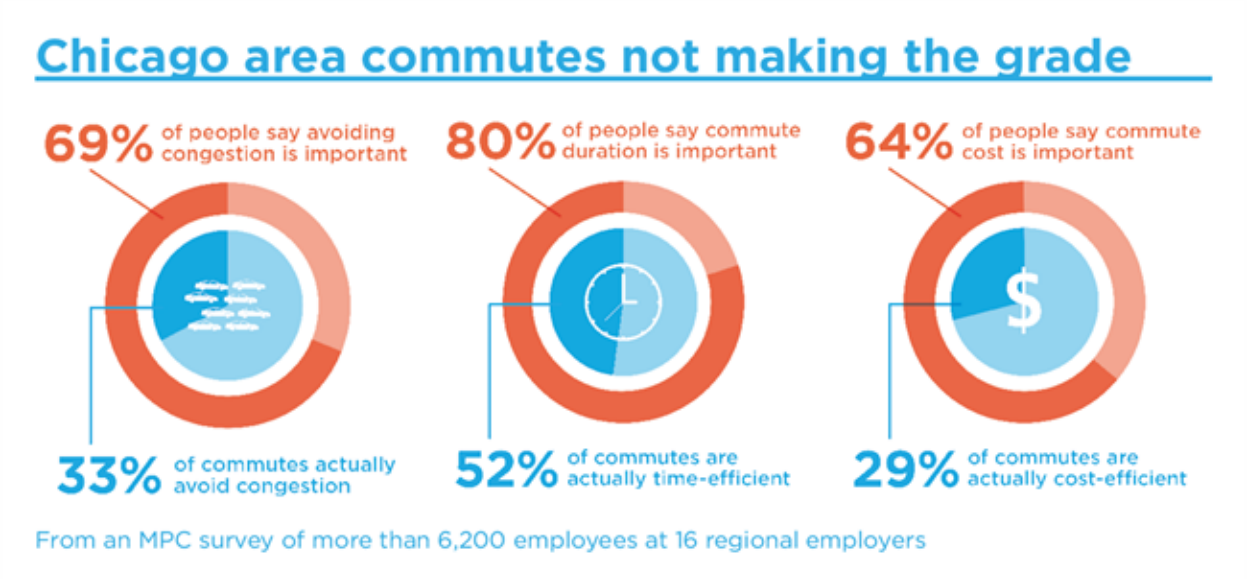
Public Government Operated Model

In the public model, a government authority owns, operates and maintains the infrastructure, fare collection system and vehicles. This is most common in many of the developed nations of Europe, Asia and North America. For example, in the United States, government empowered transit authorities commonly own and operate bus and rail systems. This was not always the case however. In the three largest metropolises of New York, Chicago and Los Angeles – all C40 member cities - private companies built and operated mass transit on the streets and rails until the mid-twentieth century, when the systems were gradually given over to the public domain. These public authorities, along with others throughout the United States, have moved to introduce some form of Bus Rapid Transit to alleviate congestion and speed commutes along some of the busiest corridors.

In Los Angeles, CA, the Los Angeles County Metropolitan Transit Authority developed one of the first BRT systems to open in the United States. LAMTA, as it is known, opened the Orange Line in 2005, eight years after visiting Curitiba, Brazil to study that system. The very public review process even included a court-ordered injunction that temporarily stopped construction for a half-year period in response to a plea by a citizens group to evaluate the cost effectiveness of the project against another strategy. A Revised Final Environmental Impact Report determined that the Orange line, despite its price tag of $304 million, was actually the most cost effective option, provided the most benefit to the public, including faster and more consistent travel times, higher ridership, lower operating cost and more transit oriented development.[71] LAMTA then built upon that success and opened the Wiltshire Boulevard BRT in 2013 at one-tenth the cost of the first project.

In New York City where land costs are at a premium, transportation planners have less leeway to commandeer roadways to create fully dedicated lanes. The Metropolitan Transportation Authority has initiated several routes that have many of the benefits, but not all of the design standards of full BRT systems. New York's Select Bus Service dedicates lanes to bus travel during high traffic commuting hours, but allows regular traffic during other hours, thus minimizing the impact on local commerce.[72]

Chicago is the nation's second largest city and has experienced significant regional congestion and longer commutes as its population has grown. A survey by the non-profit Metropolitan Planning Council revealed that Chicagoans believe that their commutes are unsatisfactory when it comes to congestion, time and cost.



Source: Metropolitan Planning Council[73]

The Chicago Transit Authority's existing rail lines are well run and well utilized by American standards, but there are gaps in the system that are the source of bottlenecks and aggravation. BRT seemed to be the most effective means to filling in those gaps, but limited roadway widths presented challenges. Chicago looked to such cities as New York and Mexico City for examples of how to implement BRT in narrower streetscapes with densely populated urban environments.[74] The CTA then examined the region under the lens of the federal government's six Livability Principles to identify the most opportune locations to implement BRT.[75] Chicago's first full-scale BRT, the Jeffery Jump, opened in 2013. The Central Loop line is under construction and will be operational in 2014. The CTA is now planning the Ashland Corridor, which is expected to be the first Gold Standard BRT in the United States.[76]

The cost of building and operating a BRT system is one of the most important aspects of planning that a city must address. Success can often be viewed through the lens of what it costs the stakeholders, particularly how that cost affects transit fares. Transportation infrastructure costs are usually seeded from government subsidies as a means of keeping costs in line with affordability for the riding public. Often national or regional development banks are willing to provide incentivized loans. These sources of funds are also options for procuring rolling stock.

Jakarta, Indonesia – Public Fare Subsidies

TransJakarta was the first BRT system implemented in Asia and at 184.31 km it is the longest BRT system route in the world. The TransJakarta Busway Management Unit (TBMU) is the Indonesian governing agency that serves the country's public transit needs and operates TransJakarta. TBMU was created to improve outmoded transportation services and provide safe, affordable, and accessible modes of transit for its communities.

TransJakarta is currently funded by a combination of commuter fares and government subsidies. At inception, TBMU had considered subsidizing the full cost of commuter fares by the year 2014. The rapidly growing system usage has added significant maintenance and operational needs to the BRT system and TMBU has determined that a full fare subsidy is not viable at this time.

Public-Private Partnership Model

In the public-private partnership model, a government authority builds and maintains the infrastructure, while private companies own, operate and maintain the bus fleet. Either a third party private company or the governing authority may handle fare collection. Public-private partnerships are more prevalent in developing cities of Africa and South America.

Africa Mayors Climate Change Declaration – The Power of Regional Planning

Regional planning in Africa has been used to successfully expand BRT programs with public-private operating models. African mayors signed the Africa Mayors Climate Change Declaration in 2011 as part of a commitment to sustainable growth. The mayors agreed to share long-term growth strategies to manage climate change risk through replicable projects, including BRT systems. The successful implementation of the LAMATA BRT-Lite system in Lagos and subsequently the Rea Vaya BRT system in Johannesburg provided models for three other BRT networks in South Africa and Tanzania.

One reason for this is that existing transit in developing cities is commonly the private model. As these cities have grown, settlements have sprouted and expanded where land costs are cheaper. These areas were historically ill served by any public transport. Hence private operators stepped into the void, offering transport to the growing masses, often in a disorganized manner. Over the course of time, these operators become entrenched in the local economy. When BRT systems are planned, they invariably displace these operators, which can have a deleterious effect on the transport sector of the economy.

Private sector transit operators can view BRT negatively and raise objections to the new system. These operators have protested, sometimes violently, against what they perceive as a threat to their livelihood, providing an object lesson into the need for effective stakeholder engagement. Yet when existing transport interests are offered an opportunity to participate financially with a vested interest in a BRT operating entity, they have a chance to become partners in the project's success.

Bogotá, Colombia – Stakeholder Partners in Transition

In Bogotá, Colombia, the government recognized that it was necessary to recast much of the existing private bus system as a partner in operating the new TransMilenio BRT. The expertise and skills lay with the private operators. A public-private partnership would preserve jobs and reduce emissions while raising the quality and consistency of service. The government convinced the cartel of private bus operators to support the new TransMilenio BRT by encouraging them to join the new system as operators while permitting them to continue to offer services in areas not served by the new system. In exchange for the opportunity to participate as shareowners in the new entity, the operators would need to scrap their older polluting buses and purchase new cleaner equipment meeting government standards.[77]

New criteria were established for compensating bus operators in the TransMilenio corridors based upon kilometers traveled, rather than ridership. Hence drivers are incentivized to operate as efficiently as possible. In fact, this compensation structure provides a disincentive for making unscheduled stops to pick up extra passengers.

Contracts in the new TransMilenio corridor and feeder routes are publicly bid and are awarded based upon lowest fare offered. Fares are collected by a separately contracted concessionaire prior to boarding, rather than by the driver. Operators on non-corridor feeder routes are compensated based upon a combination of distance traveled and ridership, but the compensation structure developed for these include maximum limits that ensure the drivers will collect passengers and stick to their routes.[78]

The bus companies are responsible for the maintenance of the rolling stock of vehicles and since operators are paid by the distance traveled each day under the new system, they now have a vested interest in keeping their vehicles well maintained and on schedule.

Johannesburg, South Africa – Steering Minibus Taxis toward BRT

The mayor and the city council took heed of the experiences that other developing cities gained in building their BRT systems, including those in Bogotá, Quito and Jakarta. The need to engage stakeholders throughout the planning and development process was among the most relevant object lessons. It was clear that in Johannesburg, the minibus taxi operators and the private bus company, PUTCO, would stand to lose business, and their employees would lose their jobs, as riders would migrate to the new system. Hence, Rea Vaya established an "employment-neutral" goal to ensure that all jobs lost in the existing public transport concerns would be replaced with new jobs in the BRT system.[79]

One of the first priorities was to replace the older, polluting, ill-maintained and oftentimes recklessly driven minibus taxis with the new cleaner burning BRT vehicles. Johannesburg city government made a concerted effort to involve the taxi drivers in the process, with the mayor even leading a delegation of the minibus taxi associations to Bogotá to see how similar concerns had been addressed there. The city then helped the operators create a new bus operating company, now known as PioTrans, with the capability of owning and operating the new buses, negotiating the contracts and even resolving conflicts with other minibus taxi operators not participating in the new system.[80]

In the first phase, 585 of the older vehicles were removed and replaced with 143 cleaner burning low-sulfur diesel buses. Operators bought shares in PioTrans from the proceeds of their scrapped vehicles. The result is a true public-private partnership, with PioTrans owning two-thirds of Rea Vaya and the city and other shareholders owning the rest. As is the case in most such partnership structures, the city develops, owns and maintains the physical infrastructure, and promotes the new public transport system, while the bus operating company owns, operates and maintains the rolling stock. The city sets the fare structure. PioTrans is paid by the kilometer, rather than by the number of fares collected as had been the case under the old system, and must keep to a schedule.[81]

As a result of Johannesburg's careful approach in Rea Vaya's initial phase, the city's polluting, costly and notoriously unsafe taxi industry is being transformed into a sustainable enterprise with a vested interest in the success of low cost, safe and reliable public transport. It has not been an easy process, even with the efforts made to engage taxi industry leaders in the planning phases. Strikes and occasional violence have dogged the new BRT. In the second phase, which opened in October 2013, Rea Vaya brought the private bus company, PUTCO, into partnership with PioTrans, as the operator. To date, Rea Vaya has opened 43 km of the planned 330 km system.[82]

Financing BRT

Studies of major cities in the developing world reveal that the cost to build, operate and maintain public transport systems run between 1% and 2% of Gross Domestic Product, or GDP. As they consider how best to leverage that money, many cities are looking toward Bus Rapid Transit as a prudent investment of public and private funds.[83]

Bogotá, Colombia – An Investment in a City that Pays Dividends

The TransMilenio BRT system in Bogotá established a new governance and contracting structure for the local bus system that is generally considered to be a successful example of a public-private partnership. Of the nearly $2 billion price tag for the first two phases, two-fifths are funded by private entities.

TransMilenio costs, Phases I and II (present value 1998–2018, with a 12% discount rate).

	COP billion (2008)	USD million (2008)
Public costs	**$2189.30**	**$1216.3**
Studies and project preparation costs	$24.39	$13.55
Real estate purchase and resettlement	$281.57	$156.43
Infrastructure construction and/or rehabilitation	$1705.70	$947.61
Infrastructure maintenance	$87.06	$48.36
Implementation of control center	$28.96	$16.09
Control center operation	$6.38	$3.54
Costs of the public project management agency	$55.23	$30.68
Private costs	**$1401.42**	**$778.57**
Bus fleet acquisition	$431.52	$239.73
Bus fleet operation	$743.85	$413.25
Implementation of collection system	$19.55	$10.86
Collection system operation	$206.51	$114.72
Total	**$3590.72**	**$1994.84**

Source: EMBARQ (2009) based on data provided by TRANSMILENIO S.A.

TransMilenio became operational in 2000 and, according to a study commissioned four years later, was a boon to commuters using the new line, reducing transit times by 32%, boosting traffic safety with a 90% reduction in the accident rate, and improving air quality with a 9% reduction in airborne particulate matter. Over a four-year period, from 2007 to 2010, the average annual reduction in carbon emissions in the BRT corridor was 59%. The system has expanded to 84 km at a cost of $18.6 million per kilometer, and with nearly 2 million riders daily, it is the world's second largest by volume.[84]

Present value of benefits, TransMilenio, Phase I and II (using a 12% discount rate).

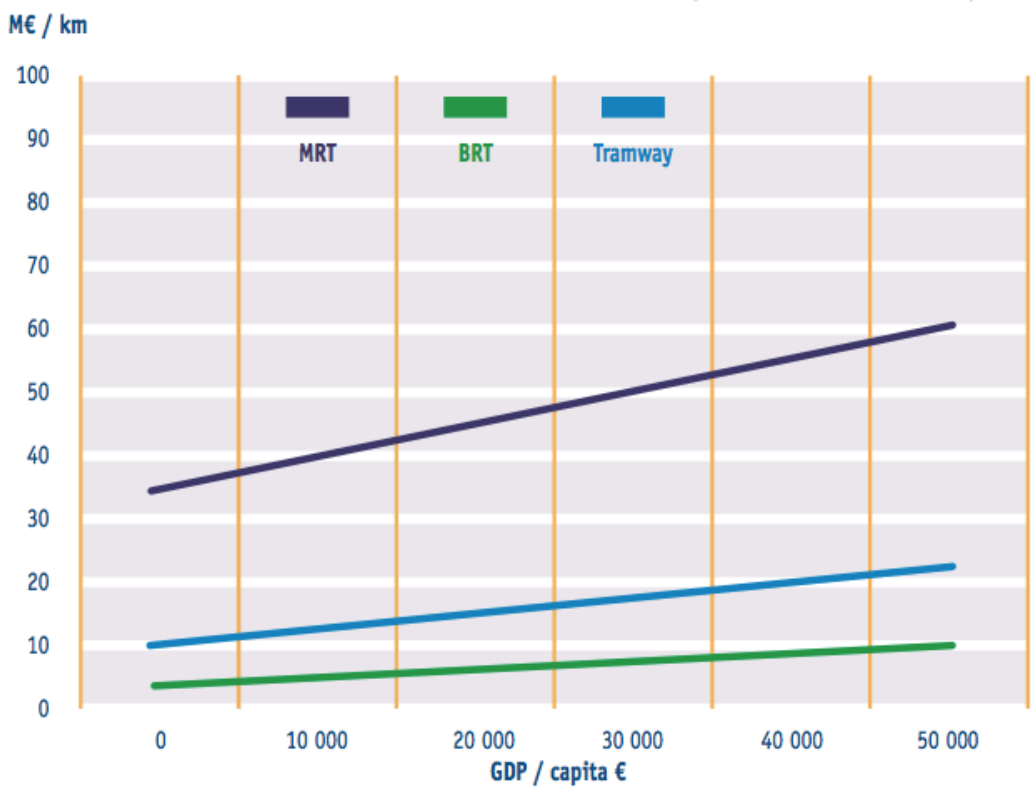
Benefits	COP billion (2008)	USD million (2008)
Reduced travel time in public transport	$3066.28	$1703.49
Time lost during construction	($173.84)	($96.58)
Reduced operating cost of public transport vehicles	$2230.58	$1239.21
Reduced injuries, deaths and losses due to road crashes	$301.49	$167.49
Positive impact on health due to reduced emissions of air pollutants	$206.01	$114.45
Total	**$5630.52**	**$3128.07**

Source: EMBARQ (2009), data provided by TRANSMILENIO S.A.

Financing Infrastructure

BRT is a major investment for a city. Dedicated roadways, properly designed and located stations and traffic signal priority are essential to making the system operate optimally. Of course, these physical and technological changes significantly impact the urban fabric. A new BRT system affects roadways, utilities, parking, businesses, homes and many other elements of the cityscape. The planning choices that are made must consider the public interest, even as they disturb or dislocate private interests. The Institute for Transportation and Development Policy (ITDP) has found that the type of infrastructure that is constructed can determine its success.[85] Hence the onus to develop the needed BRT infrastructure invariably falls upon city governments, rather than the private sector.

Of course, cities should carefully study the full spectrum of transit options and weigh them appropriately. Still, the initial investment required for a city to develop a BRT system is significantly lower when compared to other modes of mass transit.



©Systra. Source: Stratégie de mobilité durable dans les villes des pays en développement. (Sustainable mobility strategy in cities in developing countries.) MEEDDAT. CERTU. (2008)

Average investment costs based on transport modes and GDP per capita

Cities generally seek capital for BRT infrastructure development from a variety of sources including municipal bonds, government grants, bilateral aid, loans from such institutions as the World Bank, roadway tolls, parking fees and fuel taxes. Tolls, parking fees and fuel taxes are a particularly appropriate approach in that they provide a disincentive known as a Pigouvian tax on the use of private vehicles to compensate for the negative externalities and social costs of emissions. Such an approach sometimes referred to as the 'polluter pays principle,' drives up the cost of operating a private vehicle, discouraging its use and inducing BRT ridership.

Bogotá, Colombia – Fuel Taxes Funding an Environmental Benefit: BRT

Private vehicles, taxis and private buses had become so prevalent in Bogotá that poor air quality had become an unavoidable environmental health problem. The government needed to address air pollution at the same time that it dealt with the paralyzing traffic congestion situation in the city. They developed a fiscal plan to fund the TransMilenio BRT that would get people to think twice about using private vehicles when there would be another mass transit option available in BRT. Forty-six percent (46%) of the US$240M Phase I infrastructure costs were paid for through the imposition of local fuel taxes. The remainder was financed through national government grants (20%), a World Bank loan (6%) and other local funds (28%). Funding for the US$545M Phase II infrastructure also includes a local fuel surcharge of thirty-four percent (34%) with the balance coming from the Colombian government.[86] The strategy was successful, as TransMilenio quickly became the model for BRT systems the world over. Travel times along the main corridors have dropped, as has traffic congestion, air pollution, noise levels and frequency of traffic incidents.

Fast Tracked Solutions

Full BRT systems can take years in planning and development. Cities also often do not have the available resources to build out BRT systems to the highest standards from the outset. As such, civic leaders often consider faster and lower cost solutions to alleviate pressing problems. New York City, for example, elected to implement its Select Bus Service rather than undertake the expense of building out fully dedicated lanes and elevated stations. This enabled New York to launch a version of Bus Rapid Transit with less infrastructure investment and disruption. Other cities in the developing world that have even greater challenges accessing needed capital have taken similar approaches. Lagos, Nigeria, one of the fastest growing megacities in the world, reorganized its existing infrastructure rather than lose time and incur the expense to build out a new road network.

Lagos, Nigeria – A Fast Response to an Urgent Need

Government officials in Lagos, recognizing that an immediate solution to alleviate congestion was of paramount importance, moved quickly to implement BRT-Lite. As a result of that pragmatic approach, the Lagos Metropolitan Area Transport Authority (LAMATA) had the system operational in early 2008, only 15 months after launching the formal planning process. The process was accomplished swiftly, principally because road construction was kept to a minimum. Roadway medians were narrowed to make way for the dedicated lanes that comprise 85 percent of the 22 km route. As such, the total cost at US$1.7 million per km was also significantly less when compared to an average price tag of US$6 million per km for BRT systems elsewhere. LAMATA does have plans for a more sophisticated BRT Classic system expected to open by the end of 2014 that will commence with a 13.5 km extension to the first phase. That project is anticipated to generate 2,000 direct and 5,000 indirect jobs.[87]

Among the lessons learned from other C40 cities in South America was that Lagos would do well to create an organizational structure that integrated the various stakeholders into an economically effective public-private partnership. After exploring several possibilities, LAMATA crafted arrangements with NURTW and financial institutions through which the Lagos BRT-Lite system could operate. LAMATA is developed the roadway, station and depot infrastructure. NURTW created the Lagos NURTW 1st BRT Cooperative Society Limited to purchase and operate the buses.

LAMATA received $100 million in credit financing from the World Bank, while the government of Lagos contributed $35 million as counterparty to the project. This arrangement enabled the infrastructure to get built.[88]

The new operating corporation comprised of approximately fifty members lacked needed business experience and resources, however. This along with concerns about potential mismanagement and corruption made it difficult to secure adequate funding for the rolling stock. The end result was that the selected vehicle manufacturer from India accepted deferred payment terms for a two-year period, provided that a local financial institution would underwrite the risk. Ecobank Nigeria Plc stepped in and provided funding for 100 buses under the condition that senior officers in the NURTW cooperative submit to collateral personal guarantees against embezzlement and excessive maintenance issues. Meanwhile, the lender was given first lien rights on fare collections to further ensure repayment.[89]

Financing Operations

The financial construct for operating a BRT system is dependent upon the objectives that the city may have for the program and its operational structure.

A publicly operated BRT system can readily address social goals without the need to derive a profit. Working within budgetary guidelines, a city can run a system – drive and maintain buses, purchase fuel, pay salaries and benefits, administer fare collections and keep up the infrastructure – without the need to earn a profit. Fares can be structured to match costs of operations, debt service and future needs, or they may be subsidized if there is an objective to assist a certain segment of the population as a public benefit. While there is inevitably a need to keep the budget balanced, sources of operating capital can sometimes be supplemented by public funds.

In a public-private partnership, the bus operations are generally the purview of the private sector. There is an inherent profitability component to this arrangement. In some systems, other roles are also in the domain of private companies, including the fare collection systems, terminal operations, and information technology. Good governance requires that there be a separation of fare collection and the rest of system operations, hence there is often a trustee role responsible for administering distribution of revenues.

The most substantial portion of BRT operating costs is attributable to the bus operating companies. The experience of cities in developing economies has been that BRT systems operate most effectively when private bus operating companies are paid by the kilometer for trunk routes and in many cases for feeder routes, too. Payments to bus operating companies are based on an equation that factors the travel distance times the cost of operations per kilometer plus a required return on investment:

Payments = (Bus Kilometers) X (Operating Cost per Km X Return-on-Investment)[90]

This incentivizes the private sector company to run its buses efficiently in order to remain profitable while maintaining the standards specified by the city under the operating agreement.

Bogotá, Colombia – Running Without Subsidies

The operating costs of the TransMilenio system in Bogotá are entirely funded by fare collections, which now operate without direct subsidies. Two thirds of the revenues go to the TransMilenio operators, while one fifth goes to the feeder bus operators. In Bogotá, the fare is a flat fixed cost, regardless of the distance travelled. In effect, the riders who come from outlying areas are generally of lesser means than those who live closer to the city center or near the trunk lines. Those passengers who use a through ticket to pay for the feeder bus and the trunk line rides, do not pay an additional fare for that leg of their journey. For them, the feeder bus ride is therefore effectively free. That is to say that since the fare is the same as for those riding just the trunk lines, that latter group is essentially subsidizing the full cost of the feeder bus ride.[91] This fare structure eliminates the privateering and reckless driving that used to occur before the opening of the TransMilenio BRT and makes it more cost effective for those who can least afford the cost of the ticket.

Proper maintenance of newly acquired buses and operating systems is essential to the long-term success of BRT. Cities must ensure that there are adequate funds and resources built into public or private operating budgets in order to ensure that the substantial investment made in infrastructure and depreciable assets such as buses is not compromised. Costs for

hiring and training maintenance staff, parts inventory, roadway repairs, station upkeep, cleaning, etc., must be evaluated and included in financial models.

Lagos, Nigeria – A Cautionary Tale

Maintenance problems are the most common concern with the BRT-Lite system in Lagos, Nigeria. Inadequate training for mechanics on the specialty systems, including bus hydraulics, is part of the problem. Scant staffing for repairs has also been a concern from the outset. Reports of leaky buses and missing windows appear in local newspapers.[92] Roadways are in poor condition and many of the buses are in need of replacement after only four years, rather than the 10 to 12 years of projected useful life.[93] The National Union of Road Transport Workers (NURTW), the private cooperative that operates the system, has ordered 50 new buses for delivery before the end of 2013 and has also begun refurbishing another 100 of the total bus fleet of 220 vehicles.[94]

Sustainability Awareness Can Drive BRT Funding

Many funding agencies involved in financing BRT systems are doing so particularly because of environmental benefits. An effective Environmental Impact Assessment can greatly aid the BRT development process by highlighting possible areas of concern and by suggesting design alternatives that will mitigate environmental impacts. The Global Environment Facility (GEF) is amongst the world's largest grant-making facilities to fund projects alleviating global environmental problems using systems-based approaches to transport initiatives. The World Bank-led GEF has financed BRT projects in Lima, Mexico City, Santiago, and Hanoi with additional projects being planned for cities in China, Colombia, Mexico, Brazil, and Argentina.[95]

For certain sources of international financing, including all World Bank financing, the project must demonstrate some sort of poverty alleviation impact, while others (US AID Housing Guarantee Loans, for example) require that the principal project beneficiaries are below median income levels. In the past, some members of the World Bank sta have questioned the viability of urban mass transit investments for lack of clear evidence that they benefit the poor.[96]

Carbon Markets

A number of transport projects, BRT in particular, have applied for registration in the UNFCCC's Clean Development Mechanism known as CDM. Admittance into the program is especially vigorous, yet projects can earn revenue through the sale of carbon credits. To date, 13 BRT projects have been registered with the CDM.[97]

In Johannesburg, if only 15 percent of local car users switch to the BRT, Rea Vaya has the potential to reduce regional greenhouse gas emissions by 1.6 million metric tons by 2020.[98] Rea Vaya is the fourth BRT project to have been registered with the Clean Development

Mechanism (CDM) of the Kyoto Protocol. The City of Johannesburg hopes to be able to earn additional revenues to fund the system over the coming years.

Perhaps the most notable of all these statistics is that the second phase of Bogotá's TransMilenio BRT is the first transportation project to be approved by the United Nations to sell carbon credits under the Clean Development Mechanism (CDM) of the Kyoto Protocol. It is estimated that this portion of the system generates 300,000 fewer metric tonnes per year in carbon emissions, or approximately 2,000,000 $MtCO_2e$ since it registered with the CDM in 2006. Those carbon offsets are anticipated to be worth as much as $350 million to Bogotá.[99]

Item	GHG reductions until 2012 (tCO_2eq)	Expected income from sale of emission reductions until 2012 (US$)	GHG reductions until 2026 (tCO_2eq)	Expected Income from sale of emission reductions until 2026 (US$)
CERs	1,700,000	20,000,000	8,500,000	100–300,000,000
VERs	2,100,000	10,000,000	5,000,000	30–50,000,000
Total	3,800,000	30,000,000	13,500,000	130–350,000,000

Source: calculation by Grütter based on expansion projections of TransMilenio and calculated GHG offsets; price range from 2012 onwards based on constant prices as currently (low level and price increase based on increasing world market price due to increased marginal cost of offsets)

Financial Benefits of CDM for TransMilenio

Transit Oriented Development

An Environmentally Responsible Strategy for Social & Economic Growth

The ITDP, in its September 2013 report titled "More Development for Your Transit Dollar: An Analysis of 21 North American Transit Corridors," determined that when supported by the right policy framework, investment in transit systems yields even greater returns through investment in transit-oriented development, or TOD. The cities that recorded the most significant growth in TOD were those buttressed by the most effective local government policies specifically designed to promote such development.[100]

Cities are most able to leverage public investment in transit systems to improve the economic health and vibrancy of transit corridors when they implement supporting initiatives, such as those that promote rezoning, develop and implement a comprehensive plan with a specific focus on the corridor, undertake pro-active outreach to developers to encourage environmental cleanup, land assembly, extensive marketing of the corridor, and a range of financial incentives. The following table illustrates the correlation between the level of support that governments have provided through pro-development policies targeted to transit corridors and the amount of private TOD investment along those corridors.

CORRIDOR	GOVERNMENT TOD SUPPORT	TOD INVESTMENT (MILLIONS)
LRT Portland MAX Blue Line	Strong	$6,600
BRT Cleveland HealthLine	Strong	$5,800
BUS Kansas City Main Street Metro Area Express (MAX)	Strong	$5,200
SC Portland Streetcar	Strong	$4,500
SC Seattle South Lake Union (SLU) Streetcar	Strong	$3,000
LRT Phoenix Metro	Moderate	$2,821
LRT Denver Central Corridor	Moderate	$2,550
BRT Las Vegas Strip & Downtown Express (SDX)	Moderate	$2,000
BUS Boston Waterfront Silver Line	Moderate	$1,000
BRT Ottawa Transitway	Moderate	$1,000
BRT Pittsburgh Martin Luther King, Jr. East Busway	Moderate	$903
LRT Charlotte Lynx	Moderate	$810
BUS Boston Washington Street Silver Line	Moderate	$650
BRT Los Angeles Orange Line	Moderate	$300
LRT Denver Southwest Corridor	Moderate	$160
BRT Eugene Emerald Express Green Line (EmX)	Moderate	$100
BUS Las Vegas Metropolitan Area Express (MAX)	Moderate	nominal
LRT Ottawa O-Train	Weak	nominal
LRT Pittsburgh "The T"	Weak	nominal
BRT Pittsburgh South Busway	Weak	nominal
BRT Pittsburgh West Busway	Weak	nominal

BRT Bus Rapid Transit BUS Bus SC Streetcar LRT Light Rail Transit

Government interventions are essential to leveraging land development in a range of citywide land markets.[101]

The study concluded that BRT corridors leverage transit oriented development investment more cost effectively than other mass transit options. Walter Hook, ITDP's Chief Executive Officer, noted that BRT "can move an urban economy forward quickly and efficiently" and provide "the best bang for the buck."[102] The study determined that the capital construction cost for BRT was less than half of that for Light Rail Transit (LRT) and for streetcar systems. Moreover, when maintenance and depreciation is counted, the overall operating cost of BRT also proves to be lower than other transit systems.[103]

Johannesburg, South Africa – TOD as a Two-Way Street toward Prosperity

In 2003 the City of Johannesburg began its focus on an Integrated Transport Plan as part of the Spatial Development Framework with a goal of integrating society in the city. Five years later, the city formally adopted a Transit Oriented Development policy to concentrate mixed-use development in the main transit corridors, particularly those precincts along the BRT trunk lines.

In the City's Johannesburg 2040 Growth and Development Strategy, Mayor Mpho Parks Tau outlines an approach to societal integration that at the same time improves the economic wellbeing of city residents by encouraging the creation of housing, workplaces, commerce and social activities situated around affordable mass transit nodes. Under this strategy, mobility opportunities for residents would increase, as would the number of desirable destinations.[104] This is essential for a city that has seen its population grow by more than a third over the course of the past decade and expects it to as much as double over the next three decades.

Johannesburg 2040 creates the framework to encourage urban growth and economic vitality in areas that people can access by way of the Rea Vaya BRT. This in turn makes Rea Vaya more cost effective. By creating more destinations that are both geographically and affordably within reach, ridership increases, as does ridership turnover and hence the number of fares per trip. This makes for higher ridership per kilometer and improved revenue-to-cost ratios for Rea Vaya.

BRT and Property Values

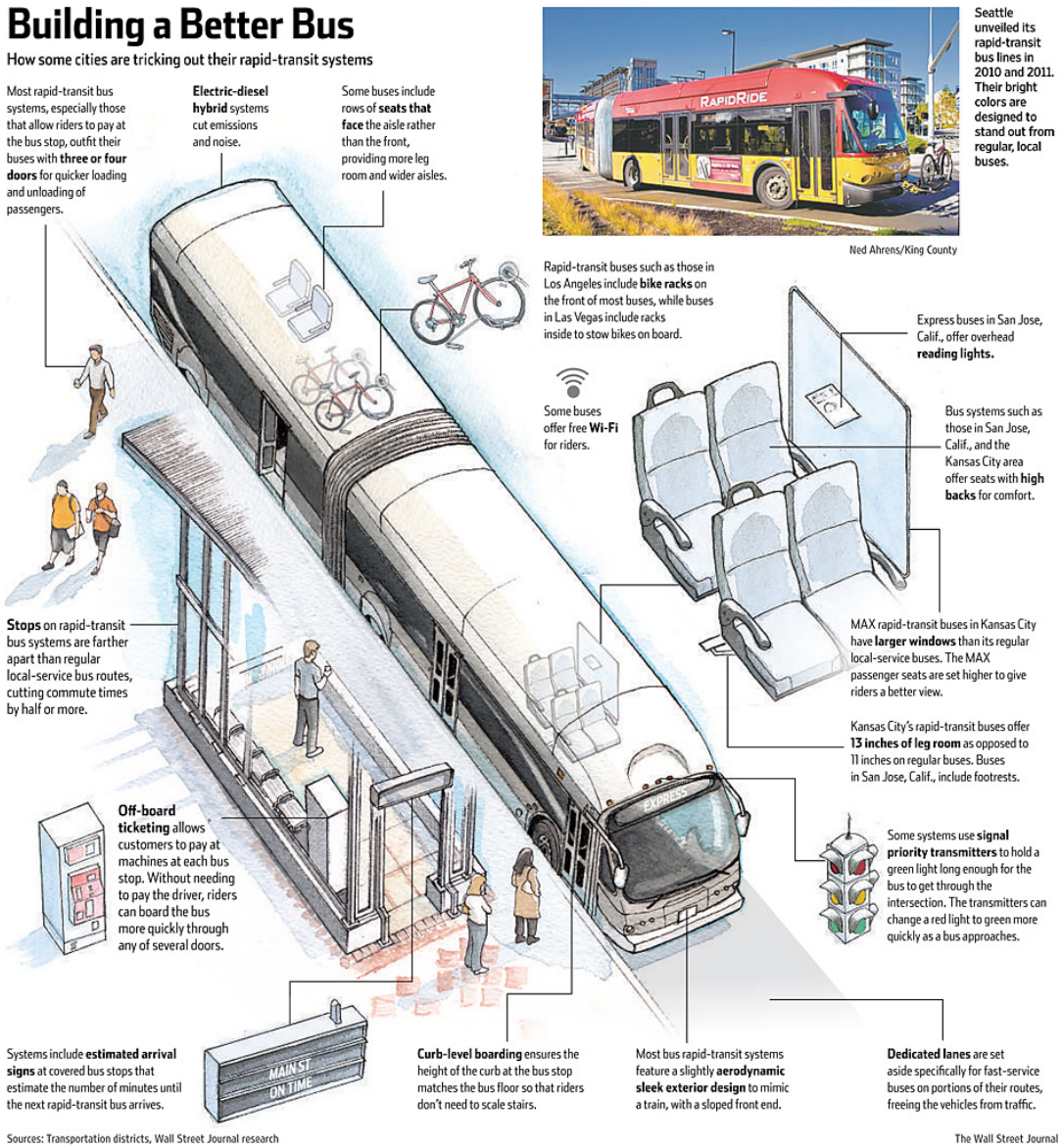
A tangible measure of the benefit of BRT as a central element of a Transit Oriented Development strategy is the effect that it can have on the value of real estate in the vicinity of stations. A study of land prices in Seoul, Korea showed 5% to 10% price premiums for residential property situated within 300 meters of BRT stops. Retail shops and other non-residential properties saw price premiums from 3% to 26% over a radius of 150 meters from the nearest BRT stop.[105]

Bogotá, Colombia – A Look at Property Values

Economic benefits have been manifested within the Bogotá real estate market as a result of the TransMilenio project. Several studies indicate that property values have risen for those within walking distance of a TM station by as much as 15% to 20%, even during periods when the rest of Bogotá was experiencing reduced valuations. That said, there has been some evidence of lower housing prices in the immediate station vicinities indicating some trepidation about perceived noise and safety.[106]

BRT Technology

This section gives an overview of some of the different technologies available for BRT. There are many key technological Bogotá advances that are being implemented into systems all around the world. Many of these technologies help to make the systems affordable, efficient, and safer. Cities all over the world are experimenting with these new technologies to help better move people. Many of these new, fast and efficient technologies are found in the ticket stations, traffic control signals, phone applications and even in the buses themselves. Some cities are even using new technologies to help integrate their bus rapid transit systems and bicycle programs.



Hudson K. The Commute of the Future. Wall Street Journal September 28, 2012
http://online.wsj.com/news/articles/SB10000872396390444358804578016191463503384

Technology for BRT is such an important aspect of a successful BRT system that many of the technological features were included in the 2013 BRT Standard report. Features such as off-board fare collection, transit signal priority, and platform level boarding are all included and can weigh heavily on a particular systems rating. An off-board fare collection system, for example, can provide a maximum of 7 points to a systems rating.[107]

London, United Kingdom – Smartphones Come to BRT

Smartphone applications are being created to get live information on when the next bus will arrive at your stop. Transport of London in the United Kingdom has created a system where you can text your bus stop code to a set number and it will tell you when the bus is due to arrive. A passenger no longer has to wait long in bad weather. The days of running to catch an approaching bus are over.[108]

Ticket Stations

Ticket stations are one of the most important parts of implementing a bus rapid transit line. If people are unable to get tickets fast and easily it will discourage the use of the system. Fare collection is one way a BRT system can help speed up the system. There are two major forms of collecting fare, one is on-board collection and the other is off-board collection. On-board collection usually requires the use of one door (although some systems may allow two) and payment as your board the bus. Off-board collection is done at the station where the passenger pays before the bus arrives. When the bus arrives everyone can then quickly board the bus. Studies have shown that off-board collection saves a great deal of time loading passengers onto the bus. In addition, a bus will more likely be able to load using two doors versus just one. Where longer articulated buses are in use, three doors may be used for loading.

A good example of off-board loading is Bogotá's TransMilenio system. Before TransMilenio in 1998, buses were able to move people 30 kilometers in approximately 2 hours. With the advent of Bogotá's BRT system, the same trip can be done in about 50 minutes.[109] Off-board loading allows three different doors to open at once and for people to load rather quickly.

Bogotá TransMilenio System, the off board loading helps to speed up loading of the buses.
http://www.streetfilms.org/bus-rapid-transit-Bogotá/

Smart Cards

Smart card technology is a state of the art system that can help speed on-board payment in a BRT system. With smart card technology, a rider simply taps their card on a device and quickly boards. This eliminates having to take the card out of a purse or wallet and can help speed up passengers who otherwise have their hands full. In systems where off-board loading may not be as easy to implement, the smart card can be a useful solution.

Smart Card technology installed in Los Angeles
Photo from: http://www.govtech.com/transportation/Los-Angeles-Buses-Smart-Card-Fares.html

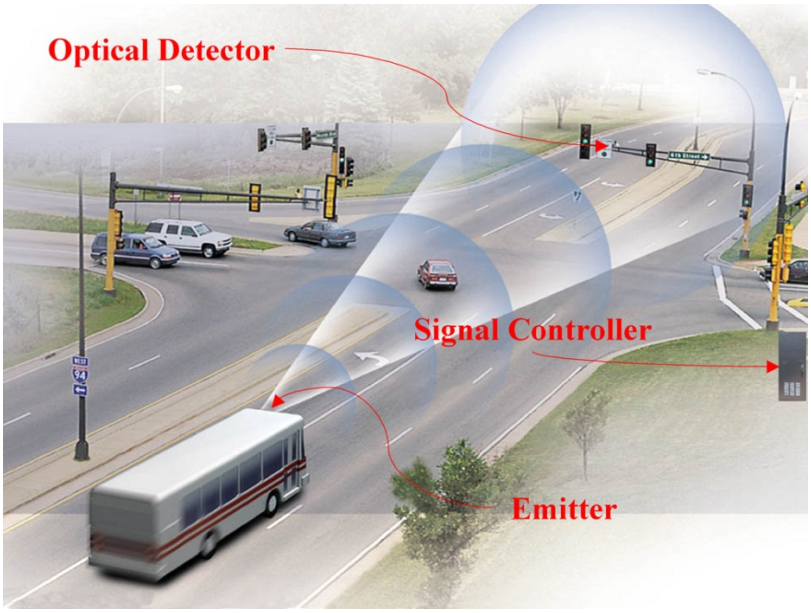
Next Bus Arrival Displays

Next Bus Arrival Displays at bus stations are an essential technology that can help build passenger ease and confidence in the BRT system. These displays let the passengers know how long the wait time is until the next bus is going to arrive. Letting a passenger to know how

long he or she has to wait builds trust and encourages them to use the system. London, UK is a successful example, having installed these displays at select stops across the city in June 2012.[110]

Transit Signal Priority

Transit signal priority is one of the most essential technological advancements to increase the efficiency and timeliness of a BRT system. A bus spends almost 25% of its run time waiting for red lights.[111] This technology is mounted on the bus and allows the bus to hold lights which are turning red to remain green long enough for the bus to make it through. It will also speed up the light change to green if a bus is waiting at an intersection. One form of the system includes a transmitter that emits a signal as the bus approaches the light. An optical detector perched on the top of the light then sends a signal to a controller on the ground near the light. Based on the current state of the light, the controller will make the determination of whether it needs to hold the green or change to green quickly. According to the American Public Transportation Association this system has a total time saving of about 2% to 18% depending on the route, traffic and bus operations.[112]



Transit Signal Technology
http://sustainabletransportationholland.org/transit/transit-signal-priority/

Passenger Counting System

An Automatic Passenger Counting system is a technology used to count the number of passengers as they enter the bus. The technology has a sensor (usually infrared) by the door that monitors passenger movements entering and exiting the bus. The system has the ability

to monitor how many passengers are on the bus in real time, a task that can otherwise be labor intensive.

Bus Design

New technology is also very important in the design of the bus. Low floor vehicles have been around in Europe for some time now, however they are just starting to get recognition in North America and other parts of the world. These low floor vehicles allow people with disabilities to enter the bus quickly.[113] In older buses, disabled passengers are forced to walk up a number of stairs, which can slow the loading process. Buses with new designs with wider doors are also helpful in loading and unloading quickly and efficiently. Some buses have even implemented buses with doors on both sides, as different stops require entrance and exits from different sides.

A BRT ridership analysis completed by the United States Department of Transportation found that the style and look of a bus influences the level of ridership on a BRT system. Many people found that a sleek looking bus that looks similar to a train more appealing and attracted more riders.[114]

Control Rooms

When all of these technologies are applied, the result is a clean, fast and efficient BRT system that benefits all parties. Together they form a smart web of Intelligent Transportation Systems that can all be managed from a centralized control room. This room employs screens that can track all of a city's buses so that system managers can monitor in real time through the use of GPS technology. Mayor Eduardo Paes of Rio de Janeiro, Brazil shows in his Ted Talk, "The 4 Commandments of Cities," that he can run his city using his iPad. He demonstrates maps in real time that show the exact locations of buses within his city.

The use of this technology captures data in real time that used to take many days to compile. As these systems are implemented in cities around the world, the aggregated data will allow mayors to make modifications to their systems. Through the use of new bus technology and adjustments to the BRT systems, they will gradually become faster and more efficient.

Bogotá, Colombia – TransMilenio HQ

The Bogotá TransMilenio system has a control room that resembles an air traffic control room. System managers are able to control approximately 1,000 buses during peak hour from the centralized control room. The hub dispatches the buses and tracks their locations around the city in real time. This becomes quite useful during peak hours and at other times if buses begin to bunch together.[115]

BRT & Bike Share Integration

There is real potential to not only use technology to improve BRT around the world, but also to integrate a city's Bike Share program into a unified transit system. GuangZhou, China is one city that has adopted a Bike Share program and a bike parking system at BRT stations. As of June 2010, GuangZhou had 5,000 bikes and 113 Bike Share stations.[116] Bogotá's TransMilenio also provides bike storage facilities in some of its Bus Rapid Transit stations. Bogotá's mayor is encouraging people to ride bikes to TransMilenio stations in order to save costs and reduce emissions. TransMilenio operators believe that if they can get BRT passengers to ride bikes to stations they will be able to reduce the feeder bus service outside the BRT main corridors.[117] Bike storage systems at BRT stops will allow for people to ride to the stop and then get onto the bus. With the advent of new Bike Share technology, this may be a common trend sometime in the future.

Summary

Given that there are different political systems, geographic topologies and urban infrastructures around the world, only a certain combination of these technologies may prove to be effective for a BRT system within any particular city. A chart created by a research study in the United States called the Hierarchy of BRT-ITS Technologies attempts to model which technologies may be best suited for a particular city and hence which ones would be most effective.[118] The model separates BRT into four levels or stages of technology implementation, with such factors as whether buses have their own dedicated lane or are in mixed traffic. The different technology types are then rated and paired with the different stages based on their effectiveness. "Every BRT system is different in many ways depending on the city," says Matthew Hardy one of the researchers who developed the chart. "Designing a BRT system and applying specific technology to help make it successful is an art".[119]

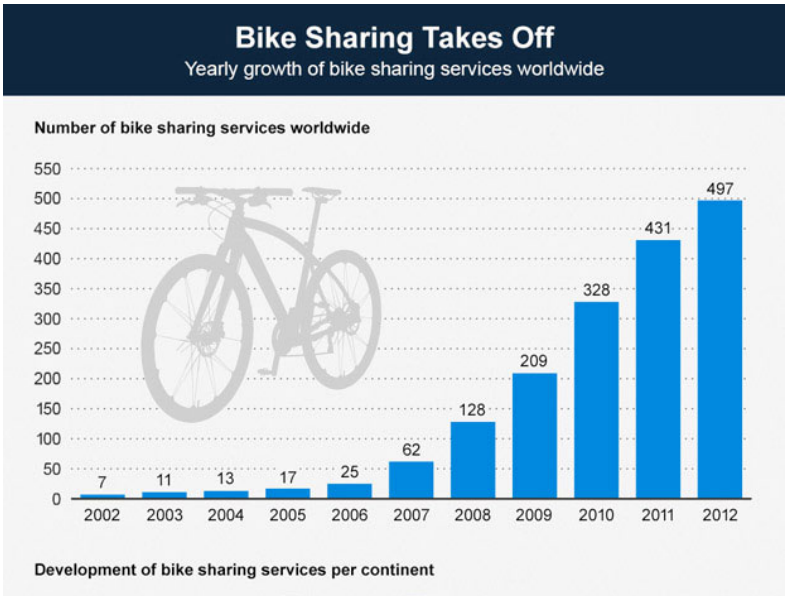
Chicago, IL – An Early Adopter of BRT in the USA

The Chicago BRT operation started a pilot project in 2000 on the #49 route of the Neighborhood Express Bus Route System, with other routes targeted in the future. The #49 Bus runs on a corridor that shares use with other private vehicles for 18 miles with 31 stops. Actual savings of 25% in the travel time has been recorded. Low floor buses are used. As an early pilot project, the #49 Bus was a below average user of Intelligent Transportation Systems, or ITS. Signal Priority provides vehicle Prioritization. Operations Management is augmented by use of Vehicle Tracking. Vehicle-based Electronic Fare Payment and Traveler Information are used at bus stops.[120]

BIKE SHARE

BIKE SHARE RAPID GROWTH

Bike sharing is on a tear across the planet. Cities large and small and in every part of the world have started or are planning bike share programs. According to MetroBike, bike share programs have exploded worldwide from 62 in 2007 to almost 500 in 2012 – a 700 percent growth rate over a five-year period.[121]



Bike Share Growth 2002-2012 (Source: metrobike.net from US News Online)[122]

As of April 2013 there were 535 bike-sharing programs globally, with an estimated fleet of 517,000 bicycles.[123] Bike sharing is found in cities in across the globe, such as New York, London, Paris, and Beijing. For the most part, bike-share programs are more prominent in North America, Europe, and Asia, although Latin America is beginning to build. Today, bike-sharing is no longer just about convenience and efficiency, it can be an effective tool for boosting city transportation, improving the health of city inhabitants, reducing traffic congestion, and helping minimize city GHG emissions.[124]. As the Mayor of Lyon, France says, "There are two types of mayors in the world: those who have bike-sharing and those who want bike-sharing." [125]

A bike-sharing system provides bicycles to individuals for a short-term basis that can be picked up and dropped off at different locations or the same location through a network of bicycle docking stations. Instead of using a personally owned bike, participants share bikes with fellow community members. Bike rentals are either for rent or for free, depending upon the city system and are usually in short-term time increments, such as 30 minutes, or for day use. Bike sharing is a convenient way for local city residents, suburbanites and tourists to use a bike in a city or suburb for a brief trip, such as going from the subway system to work or for touring the city on a recreational basis.

THE PATH TO MODERN BIKE SHARE SYSTEMS

In the past 45 years there have been three generations of bike-sharing systems, and now there's a fourth.

The 1st generation began in 1965 in Amsterdam, with the "White Bikes". Ordinary bikes were painted white and left throughout the city. Ridership was free and riders could leave the bikes wherever they wanted. This system failed within days because the bikes were poorly distributed, stolen, or thrown in to the canals.[126]

A 2nd generation of bike-sharing programs began in 1991 in Demark followed by a larger launch in Copenhagen in 1995. This program was more formalized with bikes and docks designed specifically for bike sharing. Payment was made by coins in meters. However, the system faltered due to vandalism and thefts.

The advent of smart card technology in the 1990's led the way to the 3rd generation of bike-sharing and acceleration in the popularity of bike sharing programs. A smart card is a plastic card used for electronic processes such as financial transactions. The "Vélo à la Carte" system in Rennes, France was the most notable bike-sharing scheme to use smart cards. 3rd generation technology also included the use of cell phones for access and payment and electronic locking docks. Global Positioning Systems (GPS) and Radio Frequency Identification (RFID) were also introduced to track and monitor bicycle locations, which improved bike distribution and helped with theft and vandalism. [127] [128] [129] By 2009 there were 120 3rd generation programs in operation.

Cities are now moving into the 4th generation of bike share featuring higher tech bikes and docks with wireless technology, solar powered stations, improved tracking and distribution, station-less systems, and integrated transportation between bikes and other means of public transportations such as trains and buses. With these improvements, bike docks can be implemented even faster, re-distribution of bikes between stations is more efficient, and new electric bikes with pedal assistance make transport easier.[130]

BIKE SHARE SOCIAL & ENVIRONMENTAL BENEFITS

With the entrance of 4th generation bike share technology, even more cities are realizing the benefits of bike-share programs including:

- **Better Public Transportation**: In the right market, bike share programs are a legitimate source of relief to the urban reliance on mechanized transportation.[131] Bike share programs can offset overcrowded bus and subway lines, reduce traffic congestion, and fill gaps in existing public transit.
- **Improved Access**: Bike share programs provide affordable transportation for trips that are normally too long for walking, thus improving access to areas of the city for residents, tourists and underserved populations.
- **Greater Public Health**: Increased aerobic activity and better air quality improves health in a number of areas.
- **Reduced Emissions**: Bike share programs also benefit the environment by decreasing particulate matter and GHG emissions from motorized vehicles

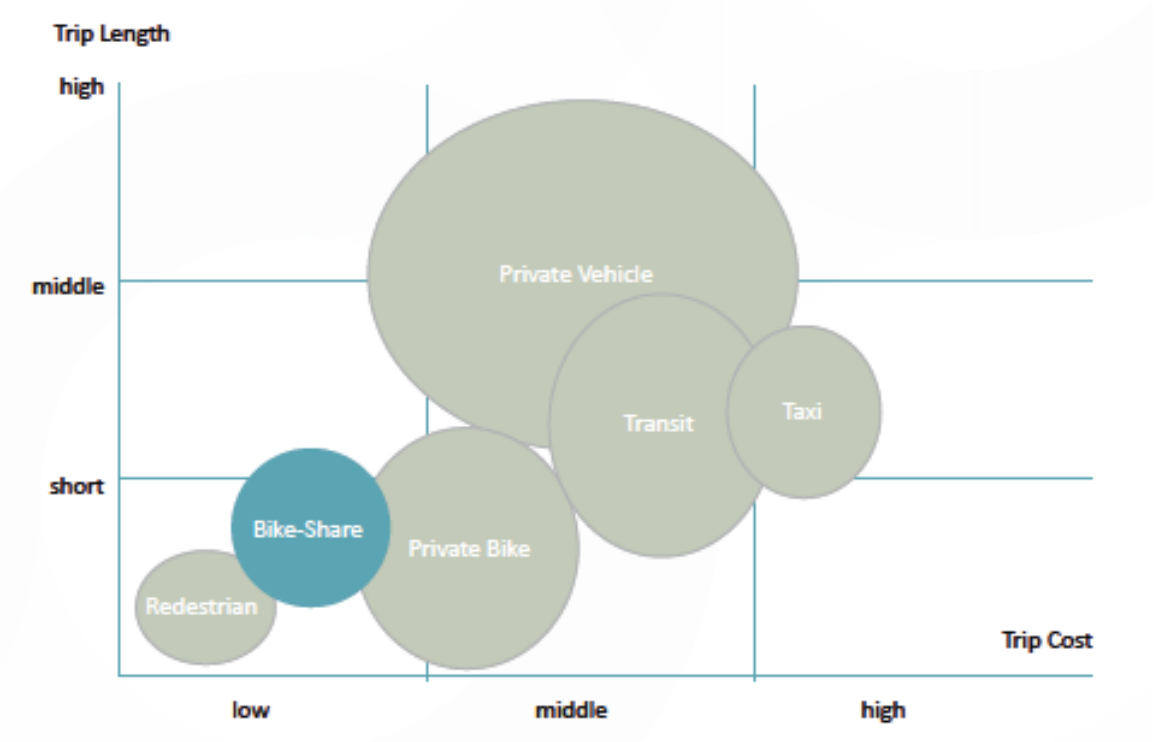
Better Public Transportation

Bike share programs serve as an integral addition to public transportation because they complement existing forms of transport such as buses, subways, and trains. Many public transit systems are overcrowded, making for unpleasant commuting. For example, the strain on New York City (NYC) subway trains is so severe during rush hour that the Metropolitan Transportation Authority (MTA) has recommended removing seats to help alleviate passenger congestion.[132] By offering a complementary mode of transport, bike share can improve train and bus conditions by disbursing riders. Bike share programs also allow commuters to bike from a crowded bus or subway stop to a less populated line, further reducing congestion. Since bike share programs are available 24 hours, they also extend travel operations beyond transit system closing times. For example, the Paris Metro stops running at 1 AM, but with the bike share system people working atypical hours can still bike home.

In the UK, 25% of auto trips are less than 3.2 kilometers (2 miles) in length[133], an appropriate distance for alternative active transportation. Current UK infrastructure supports public and active transport for approximately 40% of travel, but with minor improvements can accommodate 80% of domestic trips.[134]

Improved Access

Bike share implementation can also provide an active and affordable means of transportation for trip lengths longer than walking distances. Residents have access to a greater variety of amenities, tourists can see more, and underserved populations may have easier access to the things they need. This is especially relevant in vehicle-dependent societies where services and amenities are unreachable by city inhabitants living in poorer neighborhoods.[135] Depending on the pricing structure of the bike share program, the system may increase access for vulnerable populations with restricted access to fresh healthy food, subpar healthcare and limited access to park and recreational spaces.



Bike share within urban transport[136]

Greater Public Health

Bike share programs can also improve public health directly and indirectly. Bike riding directly impacts health by increasing aerobic activity, which can decrease the incidence of serious health issues like obesity, coronary and vascular disease, cancers, mental illness and diabetes.[137] Various international studies state that up to 14% of certain cancers are the result of inactivity while others say regular exercise is actually protective against cancer.[138] Improving public health also decreases the burden on national health services. For example, the National

Health Service (NHS) of the United Kingdom spends roughly US $5,000 per minute treating diseases preventable by routine physical activities. The UK's NHS estimates that by 2050 the annual financial burden of obesity will double its healthcare costs to £10 billion and cause socioeconomic costs of £50 billion.[139]

Bike share can also indirectly improve health by improving air quality. Replacing Vehicle Miles Traveled or VMT's with bike riding reduces car emissions like nitrogen oxides (NOx), toxic chemicals and small particulate matter (PM_{10} and $PM_{2.5}$) - known to be harmful to human health. Approximately 3 million premature deaths a year occur worldwide from toxic anthropogenic air quality; with two-thirds attributed to $PM_{2.5}$ levels and the remainder due to ozone exposure.[140] Carbon dioxide, ozone and $PM_{2.5}$ can all be reduced by offsetting emissions and VMTs with organized active transport like bike share programs. Reducing VMT's and thus vehicle pollution provides immediate benefits to local populations, including decreases in pulmonary disease, asthma and allergies.[141]

With urban air pollution on track to becoming the lead environmental cause of death globally by 2050,[142] it is even more critical for cities to find new ways to reduce car emissions. While bike share programs can't fully replace vehicle transportation in cities, they can help.

Houston Texas Bike Share Sees Emissions Reductions

In May 2012, the city of Houston, Texas rolled out a bike-share program as part of a three-pronged approach to directly reduce particulates, VOCs and GHGs. Success was immediately measured with even further improvements expected over time.[143]

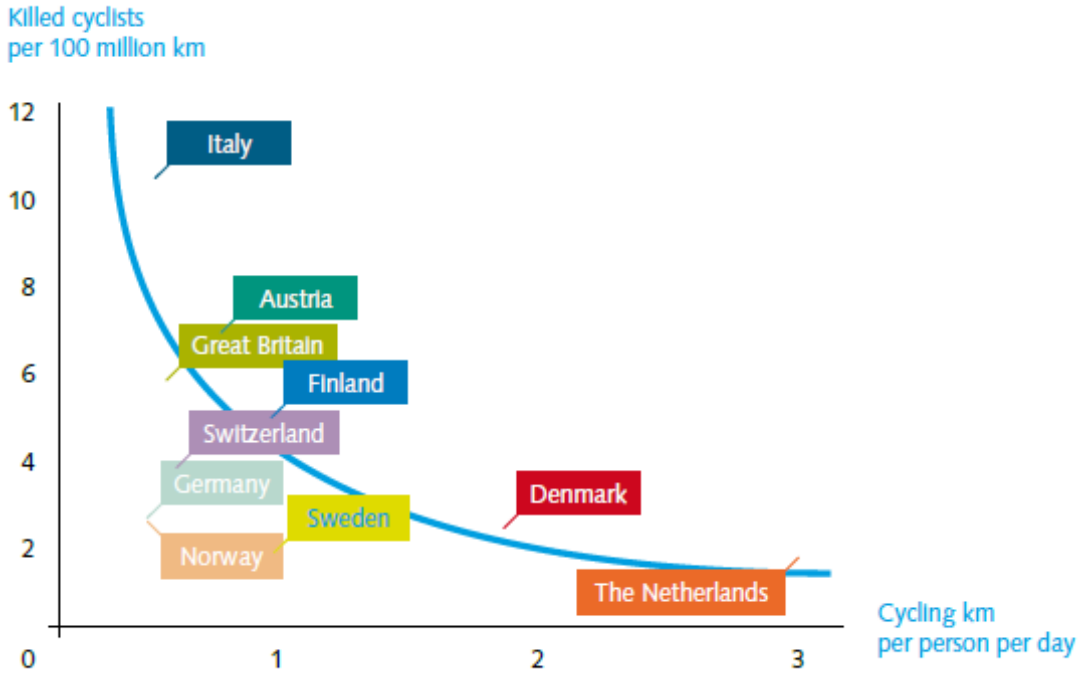
	Reported Results (as of September 2012)	Projected Cumulative Results
Annual GHG Reductions	2.1 mt CO_2e	24 mt CO_2e
Electric Vehicles Purchased	7	5
Charging Stations Built	4	4
Bike Share Stations Built	3	1

Houston, Texas program results[144]

Replacing car transport with bike transport also reduces noise pollution. For all of Europe, the number of coronary disease deaths attributed solely to noise pollution is estimated to be 210,000 annually, or 3% of all coronary heart disease deaths.[145]

Furthermore, an urban assessment shows that lowering transport system carbon levels by incorporating bike share programs will help in preventing 7,400 disability adjusted life-years (DALYS) in London, UK and 13,000 in Delhi, India.[146] DALYS are a common metric that accounts for the aggregate years of life lost (YLL) and years of living with disability (YLD). Governments worldwide can help by enforcing strict regulations, which can provide improved health protection. The US Environmental Protection Agency (EPA) estimates that the Region 7 Air Program will annually save approximately 15,000 lives among four Midwest states (Iowa, Kansas, Missouri and Nebraska).[147] These will mostly be among vulnerable populations such as the elderly and existing heart and lung disease patients.

There are some hazards, however, with increased bike use. Because bike riders have greater exposure to existing $PM_{2.5}$ there can be an elevated risk of contracting pulmonary disease. However, if outdoor air quality improves, the amount of $PM_{2.5}$ will dissipate and be less of an issue. There is also a concern for increase mortality from bike accidents, but numerous studies show that as bike use increases in a city, accidents actually decrease. In London, bike use has doubled from 2000-2008, yet rider morbidity reduced by 12%. In Berlin bike ridership quadrupled from 1975-2001, yet accidents decreased 38% decrease from 1992-2006. A survey of numerous case studies throughout Europe also consistently shows this trend of fewer bike accidents as bike use increases.[148]. This occurs partly because an increase in the number of bikers usually results in fewer vehicles, but also because as bike share programs become more popular, biking infrastructure, maintenance and policies improve accordingly, making conditions safer for both drivers and cyclists.[149]



Accidents and bicycle use[150]

Reduced GHG Emissions

A 2013 San Francisco, USA survey emphatically concludes that in addition to dramatic health improvements, median daily bike riding of 22 minutes will decrease GHG emissions by 14%.[151] The transportation sector is the fastest growing source of GHGs, comprising 26% of global carbon dioxide (CO_2) emissions.[152] Besides increasing building energy efficiency, the best way for cities to reduce their carbon footprint is to improve public transportation. Cars are the second largest GHG emissions contributor within the transportation sector.[153] Whereas bikes produce almost net zero carbon emissions.[154]

For instance, in the first two years of Vélib', the bike share program in Paris, there has been a 70% rise in biking and a 5% decrease in VMTs and congestion.[155] This is notable because in 2001, six years before the program launched, the mayor's office announced the *Espaces Civilisés* plan to increase green spaces and livability throughout the city. Bike share is part of adaptable public transportation planning[156] and contributes to the overarching goal for a sustainable city.

Life Cycle Assessment (LCA) of a Bike vs. a Car

The life cycle assessment (LCA) of bicycle production, maintenance and use emits 21 grams of CO_2 emissions per kilometer traveled (gCO_2e/km), and the corresponding LCA of a car yields 271 gCO_2e/km.

Summary

Cities around the world are realizing that social justice, human behavior, public health, environmental integrity, urban planning, and commerce are interrelated matters. When properly integrated, public policies have the potential to mitigate climate change and improve public health.[157] Bike share programs lead to immediate and direct benefits. Furthermore, tracking behavior patterns such as bike use is helpful for to decision making while the sharing of data assists with success.[158]

Case Study: Vélo'v, Lyon, France

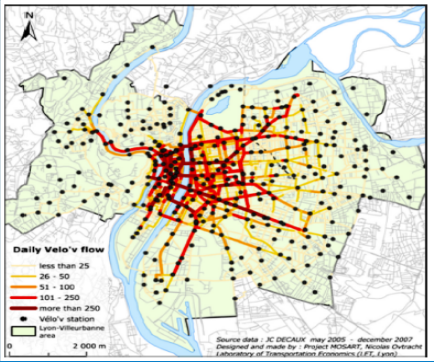


Figure 13: Vélo'v stations and daily flow[159] Figure 12: A Vélo'v bicycle in Lyon, France[160]

In 2005, the City of Lyon became the first in France to implement a bike sharing system, called Vélo'v, an amalgamation of the French word *"vélo" (bike)* and the English word *"love".* Lyon is relatively small at 18.51 square miles and less than 500,000 residents[161] but it boasts a GDP of 62 billion euro[162] and a thorough public transportation system of buses, trams and metro. Lyon is an economic center for chemical, pharmaceutical, and biotech industries, as well as for banking and local start-up sectors.[163] Commerce operates around the clock, but because the metro closes at 12:30 AM, there is a societal need for an alternative mode of transport. For those driving cars in Lyon, the roads are choked and parking is scarce.[164] Bike share was implemented to relieve vehicle traffic and the associated air pollution while promoting a healthy active lifestyle.

Within six months of being launched Vélo'v was awarded by the *Congrés de villes cyclables* for a revolutionary contribution to transport. Available every hour of every day, the flexibility of Vélo'v has altered the commuting habits of area residents.[165] Peak use is during commuting hours and over lunchtime, a provision of extending the mobility reach of public transit from home to office. The program boasts 340 docking stations with over 4,000 bikes.[166]

Vélo'v was used as the national test market for developing density standards used for proper siting of docking stations, both in frequency and location.[167] In essence, it summarizes urban dynamical movements.[168] Tracking Vélo'v bike trips since the inaugural year have yielded valuable data useful to urban master planning including infrastructure updates. The information garnered was then applied to the development of Vélib', the scaled-up bike share model in Paris, which has since become an example of excellence and the largest system worldwide. Both are run by the French company JCDecaux. This success shows the importance of integrating urban design and ridership patterns into the design of a bike share program. Furthermore, these programs need to be incorporated into the city's master plan. Interestingly, JCDecaux has documented that urbanites care more about the environment and are therefore more willing to adapt travel methods.[169]

BIKE SHARE IMPLEMENTATION

Because of the numerous benefits associated with bike share programs, more cities are seeking to implement them. While new funding schemes and models are making it easier for cities to have a bike share program, there are costs involved. It is important for cities to remember that the bike share programs are usually not large profit centers. On the other hand, having a bike share program does improve city image and makes cities more attractive to tourists.

Successful bike-sharing programs should aim to be self-sufficient, but achieving that goal can be difficult. Private stakeholders can play a significant part in providing the technology know-how, as well as financial resources, to get programs started and keep them going. In addition, private stakeholders can offer management and administrative support to the local municipalities when necessary. Some of the better programs have been those managed through public private partnerships. But in general, the commitment of all stakeholders, and ridership from the public is a requirement for success.

Stakeholders

Stakeholders can be municipalities, private institutions, non-profit organizations as well as government entities such as national banks or transportation authorities.

Municipalities

It is important to have city support in order for a bike-sharing program to be successful. A bike share program must be considered into overall city planning, design, and operational policies. The local municipality drives the initial planning and implementation stage of the program as well as the infrastructure development. Furthermore, bike paths, biking laws and bike dock space, all elements managed and controlled by the city, are required for successful bike share implementation, convenience and safety. Studies have shown that the most often cited reasons for not riding are fear of traffic, no access to a bike or a place to ride, lack of secure parking, the weather, and distance.[170] Local municipalities can help riders overcome some of these obstacles through infrastructure improvement, policy change, and education. Municipalities can conduct promotional and awareness activities to increase bicycle ridership, promote bicycle safety, and develop public or public-private partnerships as needed.

The Importance of Public Support

Bike-sharing programs will not be sustainable without the public support. While participants do not have control over the development, the financing, and the implementation of a bike-sharing program, the public does decide whether or not to use the system, which ultimately decides the program's fate. For example, there are more than 20 million people living in Beijing. The system has about 14,000 bicycles for rent yet they bikes have only been used 700,000 times. Cars often use bike lanes, which makes cycling a dangerous option. As a result, public rental bikes sit idle as not enough riders use the service, and some people

actually use the rental areas to park their own bicycles or electric vehicles.[171] Beijing's failed attempt could be a valuable lesson for others.

While a bike-sharing program could have many advantages, it can be a nuisance if the bike share program conflicts with the public's routine, convenience, or customs. Without public support or use of the bike share program, it will likely be terminated despite strong advocacy by the local municipality and deep financial pockets from the stakeholders.

Interestingly, Bogotá has one of the finest bike infrastructure systems in South America, yet the city is experiencing difficulty with bike share popularity. In the case of Bogotá, the daily workforce has not been enthusiastic about biking to work. The advocate group "Mejor en bici" or "Better on bike" is currently working with employers to encourage cycling among their employees and get people who may be new to cycling on bikes to participate.[172]

Bike Share Costs and Profitability

The costs related to bike sharing can be categorized into two major categories: capital and operating costs**.** Direct capital costs include bicycle purchase, station equipment, membership system, maintenance and distribution vehicles and installations. Associated capital costs include infrastructure improvement and construction.[173] According to the New York City Department of City Planning, capital costs can range between $3,000 and $4,500 per bicycle.[174]

Operating direct costs include maintenance, insurance, staff, office space, storage facilities, and electricity charges for the docking stations. Associated operating costs include insurance costs and maintenance of the docking infrastructure and existing bike lanes. Operating costs range between $1,200 and $1,700 per bicycle.

Barclays Cycle Hire – London

London introduced its newest mode of transportation, Barclays Cycle Hire on 30th July 2010. The program was designed, built and implemented by Serco in conjunction with Transport for London (TfL). The total cost of implementation of cycle hire scheme was $124.9 for the phase 1, and $56.4M for phase 2[175]. Barclays sponsored the scheme, with the sponsorship worth up to $81.3M to 2018; TfL contributed the remaining cost. The project was initially thought to be financially sustainable; however the sponsorship and user fee was consistently falling short of its operating cost. In the financial year 2012/13 the operating cost was $39M, while the income from user fee and sponsorship was $12.2M and $8.8M respectively, leading to a deficit of approximately $18M, which was borne by TfL[176]. In an attempt to salvage the cost of the scheme, TfL has imposed extra charges on stakeholders. Boroughs hosting cycle hire docking stations are

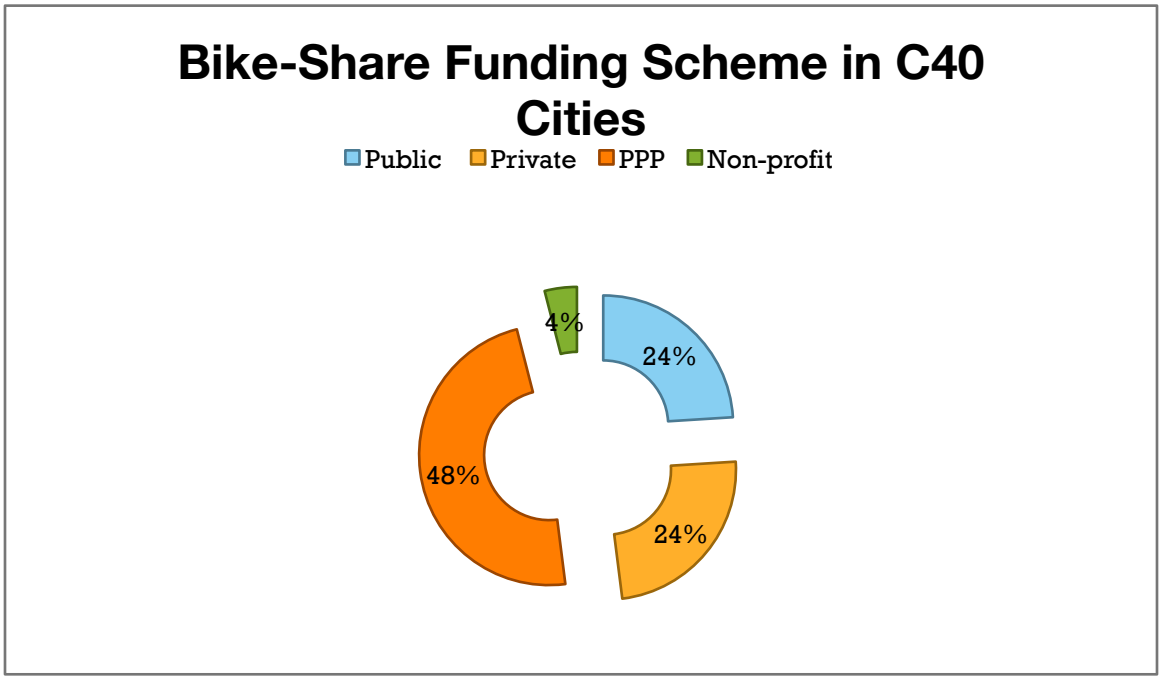
required to pay TfL $3.25M, while the user fee has been increased from $1.63 to $3.25 for 24 hour access, from $8.13 to $16.3 for weekly pass, and the annual memberships have increased from $73.2 to $146.3[177]. (*Pounds converted to USD*)

Membership and usage fees are the primary revenue source for bike sharing programs. In addition, advertising is considered a major revenue stream for several bike sharing programs worldwide. Several private companies choose to advertise on bike stations or the bicycles as a marketing strategy. This revenue stream can be lucrative, but generally more so when the bike share program is privately owned and operated, which is not the most common model.[178]

In most cases, the social and environmental benefits often overshadow financial incentives of bike sharing programs. The majority of public/private bike sharing programs are designed to maximize public ridership rather than to maximize revenue collection. User fees are usually kept low so as to incentivize more people to use bike sharing. With minimal profit margins, the main benefit to the city comes from improved transportation options, citizen health, environmental and air conditions and city image.

Implementation Models

There are currently four types of bike-sharing implementation models: Public-Private Partnerships (PPP), Private, Public, and Non-Profit. Out of 25 C40 cities with bike share, 64% are implemented by Public-Private Partnerships (PPP). PPP is a cooperative initiative between local municipalities and private enterprises. The second most popular funding scheme is public (28%), in which the programs are funded and operated 100 percent by public organizations. The remaining programs are funded by non-profit organizations (8%). Within the C40 cities, there were no private-only programs. A private program is owned and operated by private enterprise.



Regional Trends

In Europe the third-generation public bike-share programs tend to be large scale, and operated through public-private partnerships and advertising models. It has become common for external operators, notably advertising firms (with JCDecaux and Clear Channel being the most prevalent) to work alongside city authorities in the implementation of a bike-sharing system. These operators have developed bike share models that they then sell to the city to setup and maintain the system. In contrast, North American programs focus more on sponsorships to support program costs rather than advertising agencies as program funders and operators. Outside of Europe and North America, no particular business model seems to be dominating.

One of the largest bike sharing programs in the world is the "Hangzhou Public Bicycle." The Hangzhou government established the program. It is operated by China's Public Transport Agency, and has allowed advertisements on the bikes and docks to bring in revenue[179].

Public Private Partnerships (PPP)

Public Private Partnerships are contractual agreements between public and private partners. Typically, the city government is responsible for the system's infrastructure while the private organizations oversee the operation and maintenance of the bicycles and stations. The agreement establishes an allocation of responsibilities and investments risks in order to provide mutual benefits that promote the achievement of results for both parties. Under the PPP system, both the local government and private institutions work together to operate and maintain the program. Typically, the city government is responsible for the system's infrastructure while the private organizations oversee the operation and maintenance of the bicycles and stations.

There are two major categories of the private involvement in PPP schemes. The first category is based on the financial sponsorships of bike-share programs by the private sector. London, New York, and Moscow are examples of the PPP model with a private financial sponsor. Large companies and banks (such as City Bank in New York, and Barclays in London) are taking advantage of advertising their brands on the bikes, stations and websites. Such involvement may help improve the image of the private partner as an environmentally responsible company, and also helps the city by providing needed funding. The second category is based on advertising. In this model, private companies offer bike-sharing programs in exchange for the right to use public space to display revenue-generating advertisement. The advertising company usually does not benefit from revenues generated by the system. To date, this model has been most popular in Europe.[180]

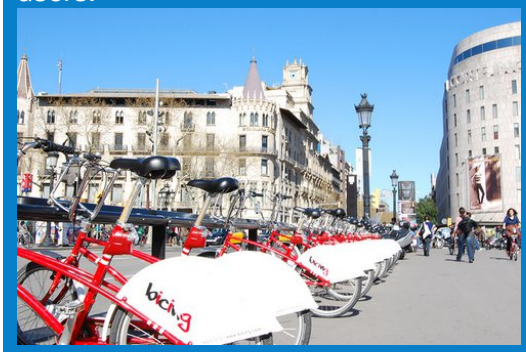
Pros: The PPP business model can be very advantageous in cities where governmental funding for projects such as bike share is very limited. PPP broadens the pubic financial capacity to carry out such infrastructural projects in a shorter time period. In addition, PPP speeds up the research and decision making process that leads to initiating bike share programs.

Cons: A potential disadvantage or risk of PPP based projects is the lack of control over genuine public duties. Since supply of mobility is regarded as a primary need of the public, a PPP program bears the risk that the system is deprived of public control. For example, in

cases where the private partner runs the program and expects to maximize revenues, cost-cutting may jeopardize the quality of the bikes/docks, safety and the success of the program as a whole. Furthermore, they may aim to raise fares beyond an affordable level. Thus, the initial advantages of having a private investor in order to get the program off the ground can be lost. [181]

Bicing Bike Program - Barcelona

Barcelona's modern bike-sharing program was officially inaugurated in 2007. The system's purpose was to cover the small and medium daily routes within the city while reducing pollution, noise and traffic congestion. Bicing, Barcelona's primary bike-sharing system, consists of more than 400 stations and over 6000 bicycles. The City Council and Clear Channel, an American mass media company headquartered in San Antonio, Texas, manage and maintain the program. The city pays the operator (Clear Channel) to build and run programs out of other city revenue streams[182]. The contract is negotiated every year.[183] The program is one of largest PPP bike-sharing schemes in Europe and it currently has about 150,000 members and serves over 60,000 daily users.[184]



BICING station in the city center of Barcelona[185]

Vélib Bike Program - Paris

Vélib, launched in 2007, has over 14,000 bicycles and 1,200 bicycle stations located across the city, boasting an average daily ridership of 85,811 in 2011.186 The program was first proposed by the Paris Mayor at the time. Today, Vélib is financed and operated by the French advertising corporation JCDecaux in an agreement with the city municipality to have exclusive rights to operate and maintain the bike-sharing program in Paris. The income generated by Vélib', estimated at €30 million annually, goes to the city's general budget. In return, the city of Paris gave JCDecaux rights of on-street advertising placements.187 Vélib is the longest running PPP bike-sharing scheme to date.

Citi Bike - New York City

New York City's Citi Bike program is the most recent example of a successful PPP. Citi Bike received the majority of its funds from Citibank and MasterCard, which put forth $45 million to pay for the majority of the bike infrastructure costs. NYC's Department of Transportation oversees the program while Alta Bike Share manages the day-to-day operations. This bike-sharing program is now the largest bike-sharing program in the United States. This system has 6,000 bicycles with 330 stations, serving parts of New York City.[188] The program has gained a tremendous amount of attention world-wide. Kicked-off in the first half of 2013, the program now has a total 68,000 annual subscribers in just six months.

Barclays Cycle Hire - London

London's Barclays Cycle Hire (BCH) has a highly successful PPP bike-sharing program controlled by public stakeholders - the city of London. The program is contracted to Serco Group by the city of London, and it is partially funded with sponsorship fees from Barclays Bank.189 However, neither Serco Group nor Barclays Bank has any stake in the program. The city of London is fully responsible for the costs of operating and maintaining the program. In 2010, BCH operated with over 5,000 bicycles and 315 docking stations distributed across the City of London area and parts of eight London boroughs.190 As of March 2012 the program has about 8,000 cycles and 570 docking stations, and has recorded over 19 million journeys.191

Rio de Janeiro in Brazil has a relatively new PPP bike-sharing scheme. The program started in 2011 and is sponsored by the municipal government of Rio de Janeiro in partnership with Banco Itaú, and operated by Serttel, a private concessionaire.192 The bike sharing system has 600 bicycles available at 60 rental stations located in 14 neighborhoods throughout the city.193

Private Models

Private models, or privately owned and operated models, are models in which a private operator provides all funding for equipment and operations, with minimum involvement of government. For-profit companies specializing in providing bike-share programs are emerging worldwide with the aim to take financial advantage of the need of alternative modes of transportation in highly populated cities. Presently, these types of programs are more common in areas with high tourism potential, one such example is DECOBIKE at Miami Beach, Florida[194]. However, to date there are no C40 cities with a fully private business model.

Pros: There are several advantages of adopting a private model over PPP or public model. A private company may be more flexible to demands and new technologies. Moreover, a private company concentrates on its core business and may run the system in a customer-friendly and effective manner. [195]

Cons: A disadvantage of the private model lies in the lack of involvement by the public sector. If the city officials are not advocating for sustainable modes of transportation, privately funded bike-share programs opportunities will be limited in success.

Public Model

In the Public Model, the city's local authority fully operates the bike-sharing program like other modes of transit. The city funds, initiates and operates the bike-sharing system. [196]

Pros: The advantage of this model lies in the complete control of the government over the program, avoiding the economic uncertainty of the private sector.[197]

Cons: Gov't not flexible enough to use the newest technology, takes longer to implement in general

Cities such as Beijing, Changwon, and Buenos Aries, have implemented the public funding scheme model. In addition, San Francisco is current in midst of adopting a public bike share model.

Bike Share - Beijing

Beijing initially started with a private bike sharing scheme. China's capital first attempted to develop bike share dates back to 2005, when several private companies began their services separately. These initiatives peaked in 2008. Due to high management costs, low returns, confusing charging standards and few governmental subsidies, these programs proved unsustainable. Beijing re-launched its program in 2012. Beijing has a large-scale public bike-sharing program. A public bike rental service aimed at providing an alternative, low-carbon transport service to residents was first tried in Beijing's Dongcheng and Chaoyang districts, which have high traffic flow. The service was then extended to Daxing and Yizhuang districts. Unlike the terminated private company bike-share system of the 2008 Beijing Olympics, this service is operated and owned by the city of Beijing.[198]

Bike-sharing station in Beijing[199]

Bay Area Bike Share - San Francisco

The Bay Area Bike Share is a pilot project in partnership with local government agencies including the Air District, San Francisco Municipal Transportation Agency, Sam-Trans, Cal-train, the County of San Mateo, the San Mateo County Transportation Authority, the City of Redwood City and the Santa Clara Valley Transportation Authority.[200] San Francisco's bike share system has 350 bikes. In San Francisco, the program is managed and maintained by the BAAQMD, the regional government agency that regulates sources of air pollution within the nine San Francisco Bay Area Counties, with the support of the SFMTA. Also, the SF Bicycle Coalition will continue to be leading the way educating people on the safest and easiest way to commute by bike.[201]

Non-Profit Model

The least popular funding model for bike- share programs within C40 cities bike-share programs is the non-profit model. A non-profit bike-share program can be originally initiated by an organization either created for the operation of the service or one that folds the bike-sharing service into its existing services. Currently, Houston and Austin are the only C40 city with a non-profit run bike share program.

Houston's program is managed and operated by Houston Bike Share, a non-profit whose mission is to implement, expand and operate a Houston-based bike share program that will be environmentally friendly, financially sustainable and affordable. The first phase of the program was funded through the US EPA's Climate Showcase grant, the second and the third phase are funded through sponsorship of Blue Cross and Blue Shield of Texas and the US Department of Energy. [202]

BIKE SHARE TECHNOLOGY

Overview

Technology has played a major role in the bike-sharing evolution. Each generation has been marked by technological advancements that have helped bring about more efficient systems and foster greater popularity. Kevin Hardman, launch director of Midwest BikeShare Inc., explains, "The reason (bike sharing) has been proliferating is because of technology."[203]

Technology plays an important role for both the user and the system sponsors and operators. Better technology makes biking easier and more convenient for bike riders. This includes the comfort and usability of the bike itself as well as for the checking in and out processes. Bike sponsors and operators should utilize the best technology to manage the fleet and improve operational efficiencies.

According a report by T.aT. - Students Today, Citizens Tomorrow, "technology-driven bike share programs have many common elements including equipment and systems (e.g., bike fleets, parking and locking mechanisms, user interface and check-out protocols, and station networks), as well as maintenance and management requirements (e.g., fleet and station maintenance, status information systems and bicycle redistribution systems)."[204]

Bicycles

During the 1st Generation launch in Amsterdam 50 standard bikes were painted white, which differentiated them from privately owned bikes. Since then, shared bikes have become much more "high tech" and distinctive.

Although bike-sharing bicycles may differ by manufacture and look, many have similar design elements. These include sturdy frames, comfortable seating, easily adjustable seats, 3 to 8 speed gears, automatic lights, front and rear fenders, and chain guards.[205] Good shared bicycles should be: easy to use, adaptable to body size, reliable, distinctive, and resistant to vandalism and theft. Due to wear and tear, the bikes must be especially sturdy and are generally heavier than standard bikes. [206] They also tend to have a look that is unique to the bike-sharing program, which is accomplished through color, design, and advertising. This differentiates them from public bikes.

Citi Bike of New York City (45-pounds, nitrogen-filled tires, three-speed gears, and self-powered LED lights [207]

E-bikes are a 4th generation technological enhancement to bike-sharing programs. They broaden the participation rate for users who need help riding or for use in hilly locations. They employ a rechargeable battery, (up to 20 hrs.), that provides pedal assistance.[208] [209]

Helmets

Interestingly, although helmet technology has improved over time, many bike-sharing programs do not require the use of helmets. Although helmets may help improve bike safety, many bike-sharing participants do not travel with their own helmet. There are some systems with helmet kiosks, but this adds to complexity and costs. Further, a helmet requirement may discourage people from participating in bike-sharing programs. For instance, some believe that Melbourne, Australia's bike-sharing program faltered because of the requirement that users wear helmets.[210]

Docking Stations

The first docking stations began in the 2nd Generation in Copenhagen in 1995. These were fixed stations that were coin operated. In the 3rd Generation the docking stations became much more advanced. Such stations utilized docking ports or bars to lock bikes and user interface mechanisms. Most systems require a registration process that must be done before the bike is checked out through smart card or cell phone technologies although some systems just require a credit card when accessing the bike.[211]

Smart Card kiosk for checking in/out [212]

Docking stations usually fall into one of three categories; Fixed-Permanent; Fixed-Portable, and Flexible. Fixed stations are designed so that a bike can lock into the dock. These stations can be permanent or portable. Fixed station technology improved throughout the years due to technological advances.[213] [214] Newer generation docking stations have reduced the issue of theft and vandalism, which was a big concern and cause for failure of some previous programs. Alison Cohen, president of Alta Bicycle Share, an urban bike share operator in Portland Oregon states that "the highest priority has to be a physically secure system." She explains Alta's bike stations are built by Public Bike System of Montreal that in an ad shows a picture of a Ford 150 with a rope connected to a bike that couldn't pull the bike out of the dock.[215]

Flex stations can either be simplified racks or street fixtures that use smart locks placed on the bikes. These station-less systems require bicycles equipped with electronic locks and GPS and wireless communications. This eliminates the need for expensive, fixed biking docks. Users can register for bikes on-line and then use a PIN to unlock the bike. [216] [217] [218]

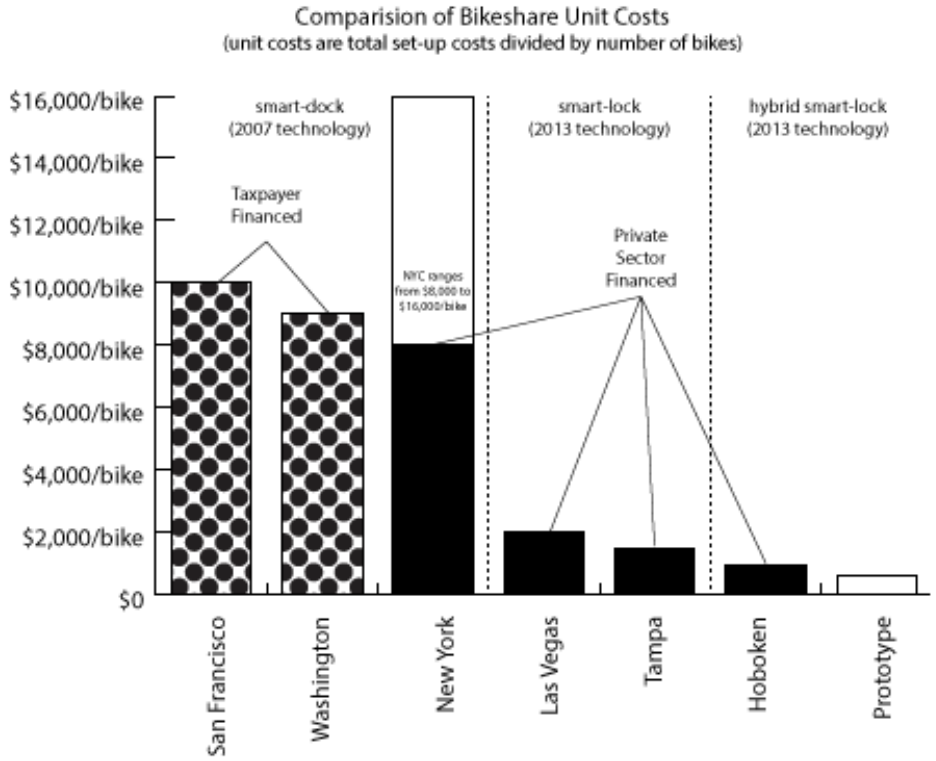
Bike Locks

Bike lock technologies are either locking systems in which a bike locks to a designated bike docking station or the locks are placed on the bikes themselves and can be secured to a variety of locations. With dock locks, smart cards and credit cards are the primary way to pay for and unlock the bike from the rack. The other method is to have the lock placed on the bike rather than the dock. These are called Smart Locks and the systems are often termed dial-a-bike or call-a-bikes. [219]

Dock-based locking mechanism [220]

A four digit personal PIN code unlocks the bicycle that you can then re-park at a hub location or at other bike racks in the system area. U bar Locks are on the bicycle themselves rather than docking stations, so the bikes can be relocked at simpler bike racks or to any pole in multiple locations, thus deleting the need for automatic docking stations. [221] [222] [223]

E3 Think's Tom Glendening points out that Smart Lock bike technology is seen by some as a disruptive innovation to the older smart dock technology. Advantages of Smart Locks/Smart Bikes are lower set up and operating costs, smaller footprint (less docks), and ability to source from multiple suppliers. Glendening explains that New York City's program has an $8,000 – $16,000/bike set-up cost (with new technology Smart Docks) while Hoboken, a pilot bike-sharing program (with Smart Locks), costs less than $1,000/bike. [224].



Smart-Dock and Smart-Lock Cost Comparison [225]

Clean Tech

Use of clean energy is another technological enhancement to bike-sharing systems. Grid powered stations are more expensive and inflexible and rely on electricity from the city utility. Solar powered stations are more environmentally friendly, flexible, and cheaper to implement. For instance, Capital Bikeshare, one of the U.S.'s largest and most successful bike sharing programs, has rental stations that are powered by solar panels. This allows flexibility as to where to place the stations since they do not have to be wired to the electric grid. Stations cost less and can be moved as well. [226]

Photovoltaic powered RFID-based payment tower sends signals to central system to track bike check out and returns. [227]

Bike Distribution & Maintenance

The maintenance and logistics of bike share programs are large operational issues. Bike distribution is an important concern when bikes are not at needed locations, especially during peak need periods. The movement of bikes to level out distribution by staff and vehicles can be inefficient, time consuming, expensive, and environmentally unfriendly, thus defeating some of the benefits of bike-sharing systems. Better technological tracking and user incentives such as increased free time or rebates for docking at specific stations, are measures that will help with the distribution problems. GPS and RFID systems help companies track bikes so they know were the bike loading imbalances are occurring. Such systems can also help with thefts.

Fleet upkeep is also a concern. For example, cities like Barcelona have 2 or 3 flat tires at every station and Copenhagen must replace 15% of their fleet a year.[228] To help with maintenance issues, newer bike docks are installing repair buttons. When a user has a damaged bike they press the button to alert the company to take it out of service. This allows the bike share operator to improve the availability of bikes.

Integrated Transit

Integration with transit is another emerging trend with bike sharing that is aided by technology. Single payment systems and integrated RFID technologies make it easier for users and planners to link longer-term rail or bus services with bicycles for the “last mile”. Benefits are an enlargement of the area covered by the transit system and more use of transit alternatives, as well as improved congestion and pollution.[229]

Summary

It is no surprise that advancements in technology and bike-sharing popularity go hand-in-hand. Improved technology. The ubiquity of smart phones, technological advances in bike design, GPS tracking, and Internet-based ticketing systems to reserve bikes along with other modes of public transportation helps make bikes easier to access and ride, and bike systems more efficient and profitable. Therefore, bike-sharing popularity increases and all the stakeholders benefit.

Case Study: Social Bicycles (SoBi)

Social Bicycles is a Manhattan based start up that is partnering with Hoboken, NJ for a pilot bike program. SoBi is an example of a 4th Generation technology for bike sharing. SoBi has shifted the focus from 'Smart Racks' to 'Smart Bikes' by using wireless technology placed upon the bike itself to make bike-sharing systems more cost effective and scalable. Station-based systems are more expensive because they require more space, energy hook ups, and infrastructure outlays. This can make the process to implement slower and more difficult to manage, especially as it relates to bike distribution. SoBi offers a solution that may provide higher growth and larger scale adoption because capital costs are less and existing bike racks can be used. [230] [231]

The communication technology is placed in a solar powered box on the back wheel. Real time GPS data allows the company to track the bikes which is helpful for bike distribution as well as for city planners to know the biking patterns. [232]

Participants can use the Internet or mobile apps to find and reserve bikes at hub locations. Or they can make a reservation directly from the keypad interface that is on the bike. Personal information of mapped rides and other stats such as distance traveled, calories burned, C02 reductions, and money saved can be stored and shared on the Internet, including through tweets. The SoBi bike experience therefore becomes a "lightweight social network", according to Ryan Rzepecki, co-Founder of SoBi. [233]

SoBi bikes have on-board computers, mobile communication systems, and GPS [234]

Case Study: Copenhagen

Copenhagen is an example of a 4th Generation bike-sharing technological solution that emphasizes advanced technology and integrated transportation. Copenhagen's Cykel DK is a non-profit that will be operated by the cities of Copenhagen and Frederiksberg along with Denmark's national railway system (DSB). Cykel DK will launch with 1,260 bikes at 65 stations. Bikes have GPS screens (Android or iPhone tablets) built in to the handlebars that provide services such as bike and train reservations and ticketing, train schedules, and bike dock locations. Bike riders will use the tablet to enter their credit card information to unlock the bike. This allows commuters to move easily from destination to destination by bike, train, bike, etc. [235]

According to Paul DeMaio, “I’m not sure if I’ve seen a bike-share technology that will truly take us into the 4th generation of bike-share, but from what I’ve read so far, it’s looking like this could be it.” [236]

Handlebar based GPS system allows Copenhagen bike-share users to plan journey with other modes of public transportation, track route, and order tickets. [237]

Case Study: Changwon, Republic of Korea

Changwon is the eighth most populated city in Korea with a population of approximately 1,100,000. Changwon has identified Climate Change as biggest problem facing the world and in 2008 instituted it’s NUBIJA bike-sharing program as a practical response to climate adaptation and mitigation. NUBIJA (which stands for Nearby Useful Bike, Interesting Joyful Attraction) has been designed to be a leading model of urban sustainability in the world and the extensive use of technology is one of the program’s hallmark features.

NUBIJA project developers underwent extensive research of other bike sharing programs across the world and used the best ideas for Changwon. Technological features included specially designed bikes with special handles, self-locks, and Radio Frequency Identification Devices (RFID). Other features include solar energy powered bicycle terminals, cell phone data transfer, and a transit discount system for integrated transit between NUBIJA bikes and city buses.

NUBIJA has been a quick success. In less than three years the program has grown ten-fold as terminals increased from 20 to 230 and bikes from 430 to 4500. Importantly, the transportation mode of bikes in Changwon grew from 3.2% in 2006 to 10% in 2011 with a target of 20% by 2020.[238]

Changwon, Korea NUBIJA bike sharing dock [239]

CRITICAL SUCCESS FACTORS

Overview

Given the wide acceptance and broad reach of bike share across the world there are many examples of what works and what does not work. Overall, for a bike share system to be sustainably successful, it must be functional, accessible, viable, and acceptable. Further, it is important to track performance in order to gauge and share success, (and failure). To ensure success, key performance indicators should be established, monitored, and analyzed.

Functionality

A bike share system must be able to work. This means that bikes and docking systems must be operable and reliable. Bikes must be working and easy to ride. 3rd and 4th generation technological advancements have contributed greatly to the functionality of bike systems. Better docking, locking, and tracking technology has helped greatly with theft and vandalism. Higher tech bikes, card payments, and bike tracking mechanisms all aid with improved functionality. This benefits the system user as well as owner/operator. Bike share systems installation must be able to fit the city's capabilities. This includes where docking stations are situated, how they are powered, and how easy are they to set up. Bike share systems must take into account weather and topography. In colder seasons, bike systems may have to shut down. Other inclement weather may also affect bike share use, including excess heat, rain and storms. Cities with hills have challenges with bike share as the bikes end up down the hill but are not ridden as frequently uphill. Financial incentives for users to ride up hills and electronic and other forms of pedal assistance help.

Accessibility

Bike systems must meet the challenges of bike distribution, so that bikes are available at docks and in a balanced manner. If all the bikes are in one part of the city and the participants are in others, it will not be successful. Docking stations must be in well-placed locations and not too far apart from one another. A well-defined city bike infrastructure, such as dedicated bike lanes is important. Bike share, when integrated with other forms of transit, can be a 'win-win'. The commuter benefits because their commute is made easier and the city benefits because it encourages use of public transportation, (vs. private motorized transportation).

Viability

Bike programs must be feasible and practical and meet city and stakeholder requirements. Although not all systems will be economically "profitable", they can bring positive ancillary benefits that must be factored into success. A feasibility study including a cost benefit analysis of bike share should include financial costs as well as environmental and social benefits. Bike share must also be economically viable for the participant. Membership and temporary pricing models are important to attract the regular and occasional user. Prices must make sense and be affordable.

Acceptability

The bike share program must have acceptance among the public and support from the municipality. A city and its partners should ensure that there is proper awareness of the bike-sharing system that will encourage positive public attitude towards biking. Bike-sharing must be seen as integral to the city and as a benefit to transportation, public health, the environment, and business.

NEW METHODS FOR GHG EMISSIONS CALCULATIONS

Transportation Projects and GHG Emissions

Transportation projects go through a process similar to any large-scale project. First there is a preliminary study to bring forward the over arching principles and steps to solving an identified problem. Environmental impact statements, financial reports and preliminary engineering design are developed to detail the project while funding is sought.

While local benefits of these projects are easy to quantify, funding can also be justified for the global benefit of transportation initiatives by reducing GHG emissions, linking projects to new and diverse funding sources. The following is a list of transportation projects that have demonstrated a link to GHG reductions:

- Pedestrian Projects
- Bike Share projects
- Bikeways projects
- Rural Roads Improvement
- Urban Roads Improvement
- Rural Expressways
- LRT/MRT Projects
- BRTS Projects
- Railway Projects
- Commuter Strategies
- Pricing Strategies
- Eco-Driving
- PAYD (pay as you drive) Insurance/Car Sharing

All the project types listed have a demonstrated and quantifiable method of estimating GHG emission savings, and are in fact quantifiable in the preliminary planning stages.

Method One: Guidelines for Calculating Greenhouse Gas Emissions

Similar to stationary source emissions inventory, transportation sector projects have both direct and indirect emissions with a slight variation on emissions estimates. The variability of GHG emissions for a project is due to the impact of one or more of the following factors:

- Vehicle fuel efficiency
- Greenhouse gas intensity of fuels used
- Total transportation activity
- Selection of transport mode
- Capacity/occupancy of transport

The sequence for calculating GHG emissions begins with establishing a dynamic baseline that includes all known local data. Direct emissions are calculated by assessing the change in GHG emissions that are expected to be credited to the project's implementation period. Direct post project emissions are those that continue beyond the implementation period.

Indirect emissions account for the largest area for GHG emissions reductions. These emissions include impacts from capacity building, removal of market barriers, replication and market expansion. Indirect emissions require subjective judgment related to expansion of emission savings and all estimates require a conservative approach. The final estimate creates a range of emissions.

Assumptions for a GHG calculation should be made cautiously and conservatively. The method of calculation must be transparent and replicable. All emissions are expressed and converted into carbon dioxide equivalent. Transportation projects have a set timeframes of ten years for vehicles and twenty years for infrastructure. All future GHG emissions reductions cannot be discounted.

Emissions of CO_2 are closely linked to selection of fuel use. While consideration of CO_2 is important in estimating GHG emissions, it is also important to consider the global warming potential of non-CO_2 greenhouse gases; the 100-year global warming potential is typically used. The following table is from the Intergovernmental Panel on Climate Change (IPCC).

Global Warming Potential of Greenhouse Gases

		Global Warming Potential Time Horizon		
Gases	**Lifetime (years)**	**20 Years**	**100 Years***	**500 Years**
Methane (CH_4)	12	72	25	7.6
Nitrous Oxide (N_2O)	114	289	298	153
Hydrofluorocarbon (HFC-23)	270	12,000	14,800	12,200
Hydrofluorocarbon (HFC-134a)	14	3,830	1,430	435
Sulfur Hexafluoride	3200	16,300	22,800	32,600

Black Carbon is second only to carbon dioxide as a climate-forcing agent. Shifting to a non-fossil fuel energy source and new engine technology mitigate black carbon. No global warming potential has been assigned to black carbon.

Proposals for baseline technologies need to contain an expected emissions factor, expressed in kg of CO_2e for each vehicle kilometer traveled (VKT) by mode and vehicle type.

Calculating Baseline CO_2e Emissions

The collection of observation based data and metrics improves the project and makes it easily replicable. While travel demand data governs a transportation project, it is important to also account for data that works with the emissions model. The following are examples of data that leverages both demand and emissions:

- Traffic counts
- Origin and Destination
- Local fuel options
- Emissions testing

Understanding integration of a project into the existing transportation infrastructure is an important piece when documenting an emissions reduction estimate. Along with the calculation of GHG reduction, a narrative of the emission reduction scheme should introduce the project strategies. The following should be included in the emissions inventory:

- Description of the characteristics of the transportation sector
- The development and transportation activities prior to the initiative
- Land use and development patterns
- Market to be transformed
- Local traffic counts
- Emissions factors
- Fuel cycle
- Lifetime of the project

Finally, the baseline calculation must include all transportation modes impacted within the project area shifting multiple modes to one mode. A baseline for each proposed intervention is necessary if multiple project modes are being proposed.

Calculating Direct Emissions

Emissions reduction occurs when there are less emission in the transportation sector after the project is completed than there were before. This requires not only a benchmarking of carbon after the project but a model to estimate the projected emissions. This step allows for model refinement and more accurate estimating in the future. Direct emissions are those solely attributable to the projects emissions. The following is the formula for calculating direct emissions from a project:

$$[CO_2e\ Direct] = [E] * [c] = [e] * [l] * [c]$$

- *CO_2e Direct* – Direct GHG emissions savings in metric tons of CO_2
- *E* – cumulative fuel or energy saved; in volume/mass of fuel or KWh of electricity
- E=∑(l*e)
- *c* - CO_2e intensity of fuel/energy
- *e* – average annual fuel/energy replaced; in volume/mass of fuel or KWh of electricity
- *l* – average useful lifetime of equipment in years

When direct emissions are calculated, an awareness of secondary direct emissions from policy reform, changes to fuel standards and land use changes must also be taken into account. Secondary direct emissions require subjective judgment and are calculated by multiplying a causality factor to the direct emissions calculation and adding the two together. The causality factor is as follows:

- Level 5 = The initiative's contribution is critical and nothing would have happened in the baseline, causality = 100 percent
- Level 4 = The initiative's contribution is dominant, but some of this reduction can be attributed to the baseline, causality = 80 percent
- Level 3 = The initiative's contribution is substantial, but modest indirect emission reductions can be attributed to the baseline, causality = 60 percent
- Level 2 = The initiative's contribution is modest, and substantial indirect emission reductions can be attributed to the baseline, causality = 40 percent
- Level 1 = The initiative's contribution is weak, and most indirect emission reductions can be attributed to the baseline, causality = 20 percent

Calculating Direct Post Project Emissions

The difference between direct emissions and direct post project emissions is that direct post project emissions occur beyond the timeframe of the normal project monitoring system. Emissions occurring when funds recycle are considered separately. These funding mechanisms include partial guarantee facilities, risk mitigation facilities and revolving fund. Once again, a conservative assumption is necessary to quantify the emission and is calculated as follows:

$$[CO_2e\ direct\ post\text{-}project] = [CO_2e\ direct\ ]* [TF]$$

- *[CO_2e direct post-project]* are emissions saved with investments after the project, supported by post-project financial mechanisms
- *[CO_2e direct]* are direct emissions savings to the degree that they are supported through the mechanism that causes the post-project impacts
- *[TF]* is a turnover factor, determined for each facility based on assumptions on the fund leakage and financial situation in the project country

The turnover factor is the number of times a fund volume is expected to be invested and then reinvested. The first turnover counts toward direct emissions while each subsequent turnover is attributed to the direct post project emissions impact. Finally, it should be noted that the estimate of direct post project emissions has a high degree of uncertainty than the direct GHG emissions and should always be reported separately.

Calculating Indirect Emissions

Emissions reductions include estimates of long term impacts of the transportation initiative and contain data and assumptions to complete the estimate. It is not easy to assess long term emissions impacts after completion. Because of this two methods are employed to generate a range of indirect emissions impacts.

Calculating Indirect Emissions – Bottom up Approach

The bottom up approach to indirect emissions is a conservative estimate for the number of times a project is likely to replicate. Expert opinion is required to determine market potential for replication. This estimation forms the lower limit of the indirect emissions range.

There are four factors to consider when determining a replication factor:

- Market potential for replication
  - A conservative estimate of real potential
- Project quality
  - High quality, full featured projects are more likely to succeed
- Project activities that encourage replication
  - Publication of results
  - Public outreach
  - Educational outreach
  - Capacity building
  - Study tours and exchanges
- Local benefit
  - Projects that demonstrate a balance between local and global benefit

For example, a BRT starts with a savings of 200,000 tons of CO_2e. Judging the local condition for the 10 year lifetime of the project, an additional 5 BRT programs will be adopted in the state, region or country at the same level of GHG reduction. The GHG reduction is multiplied by the assumed factor for replication to find the bottom up reduction. The following is the formula for the indirect emissions bottom up approach:

$$[CO_2e \text{ indirect bottom-up}] = [CO_2e \text{ direct}] * [RF]$$

- *[CO_2e indirect bottom-up]* are emissions saved with investments after the project, as estimated using the bottom-up approach, in tons of CO_2e.
- *[RF]* is a replication factor, i.e., how often will the project's investments be repeated during the 10 years after project implementation, determined by expert and reflects the degree to which the project emphasizes activities which encourage replication.
- *[CO_2e direct]* is an estimate for direct and direct post-project emission reductions, in tons of CO_2e.

Due to a lack of historical data, there are no empirical assessments of the replication factor because there hasn't been enough systematic observation, post project evaluations or standard methods of reporting the key performance indicators. For now, generalized replication factors will have to do.

Calculating Indirect Emissions – Top down Approach

The top down approach to indirect emissions uses the entire regional market as the starting point for the project. The assumption is that removing barriers and building capacity has the strength to leverage the entire market. For BRT in one city, inclusion of the entire regional bus fleet is an example of the potential market of indirect emissions estimates. The results are optimistic and represent the upper limit of the range for indirect GHG emissions for the project.

The emissions estimate begins with the size of the market and market influence for specific transportation infrastructure; how many adjacent cities can support the proposed infrastructure, capacity and investment into a similar transportation initiative. The number is then corrected downward if it is unfeasible to replicate the project within the 10-year completion period; if no project can be completed then a causality factor is used. The following describes the five levels of causality that can be used in factoring the indirect top down emissions estimate:

- Level 5 = The initiative's contribution is critical and nothing would have happened in the baseline, causality = 100 percent
- Level 4 = The initiative's contribution is dominant, but some of this reduction can be attributed to the baseline, causality = 80 percent
- Level 3 = The initiative's contribution is substantial, but modest indirect emission reductions can be attributed to the baseline, causality = 60 percent
- Level 2 = The initiative's contribution is modest, and substantial indirect emission reductions can be attributed to the baseline, causality = 40 percent

- Level 1 = The initiative's contribution is weak, and most indirect emission reductions can be attributed to the baseline, causality = 20 percent

The formula to calculate the indirect top down emissions is as follows:

$$[CO_2e \text{ indirect top-down}] = [P10]*[CF]$$

- $[CO_2e$ indirect top-down] are GHG emission savings in tons of CO_2eq as assessed by the top-down methodology.
- [P10] is technical and economic potential GHG savings with the respective application within 10 years after the project (not including direct and direct post-project impacts).
- [CF] is a causality factor.

Method Two: Transport Emissions Evaluation Models for Projects (TEEMP)

The Institute for Transportation and Development Policy (ITDP) with partners has developed a series of excel-based, free-of-charge spreadsheet models collectively called the Transport Emissions Evaluation Models for Projects (TEEMP). The TEEMP tools were initially developed for evaluating the emissions impacts of Asian Development Bank's transport project and have been modified and extended for Global Environmental Facility projects. The TEEMP tools are sketch models, which enable the estimation of emissions in both "project" and "no-project" scenarios and can be used for evaluating short to long-term impacts of projects. TEEMP primarily evaluates the impacts of transport projects on CO_2 emissions and to some extent air pollutant emissions using data gathered during project feasibility and actual operations. The TEEMP tools have been developed in such a way that required input data are based on information that is available and easily accessible.

A general transport emissions estimation manual, as well as project-specific emissions estimation tools are available for roads construction and rehabilitation; railways; bus rapid transit (BRT); metro rail transit (MRT); bikeways; bike sharing schemes. Tools are also available for estimating the impacts of other transport strategies such as eco-driving, pay-as-you-drive insurance, pricing and commuter strategies. TEEMP is currently being enhanced to improve accuracy and functionality, and make it easier to use for widespread application in Asia, Latin America, and elsewhere.

Information and the TEEMP spreadsheets can be found at the following websites:

- http://www.stapgef.org/calculating-greenhouse-gas-benefits-of-global-environment-facility-transportation-projects/
- http://cleanairinitiative.org/portal/TEEMPTool

APPENDIX

UN CITY AGGLOMORATION

C40 Cities
UN Population Projections of Urban Agglomerations with 750,000 inhabitants or more*
2010 - 2025

Region	Country	C40 Cities	Population (000)				Growth 2010-2025			Regional %
			2010	2015	2020	2025	total	percent	% of total	2025
TOTAL C40			**1,422,356**	**1,475,517**	**1,568,516**	**1,660,311**	237,955	17%		**100%**
Africa			**28,501**	**31,708**	**37,381**	**43,034**	**14,533**	**51%**	**6%**	**3%**
	Eqypt	Cairo	11,031	11,194	13,254	14,740	3,709	34%		
	Ethiopia	Addis Ababa	2,919	3,279	3,881	4,705	1,786	61%		
	Nigeria	Lagos	10,788	13,121	15,825	18,857	8,069	75%		
	South Africa	Johannesburg	3,763	4,114	4,421	4,732	969	26%		
Asia and Oceana			**1,147,507**	**1,179,697**	**1,250,425**	**1,321,870**	**174,363**	**15%**	**73%**	**80%**
	Australia	Melbourne	3,896	4,244	4,612	4,962	1,066	27%		
		Sydney	4,479	4,844	5,254	5,646	1,167	26%		
	Bangladesh	Dhaka	14,930	17,382	20,064	22,906	7,976	53%		
	China	Beijing	15,000	18,079	20,781	22,633	7,633	51%		
		Hong Kong**	7,072	7,311	7,608	7,886	815	12%		
		Shanghai	19,554	22,963	26,121	28,404	8,850	45%		
	India	Delhi NCT	21,935	25,629	29,274	32,935	11,000	50%		
		Mumbai	19,422	21,214	23,661	26,557	7,135	37%		
	Indonesia	Jakarta	9,630	10,470	11,638	12,822	3,192	33%		
	Japan	Tokyo + Yokohama	36,933	38,197	38,707	38,661	1,728	5%		
	Republic of Korea	Changwon***	949,108	958,599	1,006,529	1,056,855	107,747	11%		
		Seoul	9,751	9,740	9,849	9,867	116	1%		
	Pakistan	Karachi	13,500	15,500	17,729	20,190	6,690	50%		
	Singapore	Singapore	5,086	5,375	5,597	5,801	715	14%		
	Thailand	Bangkok	8,213	9,281	10,265	11,235	3,022	37%		
	Vietnam	Hanoi	2,809	3,539	4,201	4,810	2,001	71%		
		Ho Chi Minh City	6,189	7,330	8,535	9,699	3,510	57%		
Europe			**74,635**	**79,652**	**84,123**	**87,823**	**13,188**	**18%**	**6%**	**5%**
	Denmark	Copenhagen	1,182	1,261	1,330	1,397	215	18%		
	France	Paris	10,516	11,097	11,681	12,163	1,647	16%		
	Germany	Berlin	3,450	3,511	3,586	3,669	219	6%		
		Heidelberg****	150	150	150	150	0	0%		
	Greece	Athens	3,382	3,551	3,728	3,912	530	16%		
	Italy	Milan	2,916	2,914	3,018	3,129	213	7%		
		Rome	3,306	3,303	3,416	3,538	232	7%		
		Venice*****	269	269	269	269	0	0%		
	The Netherlands	Amsterdam	1,049	1,092	1,153	1,212	163	16%		
		Rotterdam	1,010	1,041	1,097	1,154	144	14%		
	Norway	Oslo	898	986	1,073	1,160	262	29%		
	Poland	Warsaw	1,718	1,748	1,792	1,850	132	8%		
	Russia	Moscow	11,472	12,144	12,478	12,576	1,104	10%		

C40 Cities
UN Population Projections of Urban Agglomerations with 750,000 inhabitants or more*
2010 - 2025

Region	Country	C40 Cities	Population (000)				Growth 2010-2025			Regional %
			2010	2015	2020	2025	total	percent	% of total	2025
	Spain	Barcelona	5,488	5,891	6,230	6,511	1,023	19%		
		Madrid	6,405	7,214	7,752	8,098	1,693	26%		
	Sweden	Stockholm	1,360	1,485	1,595	1,695	335	25%		
	Switzerland	Basel******	188	188	188	188	0	0%		
	Turkey	Istanbul	10,953	12,459	13,791	14,897	3,944	36%		
	United Kingdom	London	8,923	9,348	9,796	10,255	1,332	15%		
North America			97,122	104,067	110,810	117,144	20,022	21%	8%	7%
	Canada	Toronto	5,485	5,905	6,298	6,682	1,197	22%		
		Vancouver	2,235	2,403	2,583	2,765	530	24%		
	Mexico	Mexico City	20,142	21,706	23,239	24,581	4,439	22%		
	United States	Austin	1,266	1,384	1,499	1,613	347	27%		
		Chicago	9,545	10,199	10,832	11,434	1,889	20%		
		Houston	4,785	5,153	5,509	5,854	1,069	22%		
		Los Angeles	13,223	14,081	14,907	15,687	2,464	19%		
		New Orleans	858	921	984	1,044	186	22%		
		New York	20,104	21,326	22,487	23,572	3,468	17%		
		Philadelphia	5,841	6,270	6,690	7,095	1,254	21%		
		Portland	2,025	2,199	2,371	2,540	515	25%		
		San Francisco	3,681	3,969	4,254	4,531	850	23%		
		Seattle	3,298	3,563	3,823	4,076	778	24%		
		Washington, DC	4,634	4,988	5,334	5,670	1,036	22%		
South America			74,591	80,393	85,777	90,440	15,849	21%	7%	5%
	Argentina	Buenos Aires	13,370	14,151	14,876	15,524	2,154	16%		
	Brazil	Curitiba	3,118	3,468	3,761	3,990	872	28%		
		Rio de Janeiro	11,867	12,380	13,020	13,621	1,754	15%		
		Sao Paulo	19,649	21,028	22,243	23,175	3,526	18%		
	Chile	Santiago	5,959	6,355	6,748	7,089	1,130	19%		
	Colombia	Bogotá	8,502	9,650	10,579	11,369	2,867	34%		
	Peru	Lima	8,950	9,843	10,695	11,503	2,553	29%		
	Venezuela	Caracas	3,176	3,518	3,855	4,169	993	31%		

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