UNITED NATIONS
DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS

Commission on Sustainable Development
Nine teenth Session
New York, 2-13 May 2011

BICYCLE-SHARING SCHEMES: ENHANCING SUSTAINABLE MOBILITY IN URBAN AREAS

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Background Paper No. 8
CSD19/2011/BP8

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Bicycle-sharing Schemes: Enhancing Sustainable Mobility in Urban Areas

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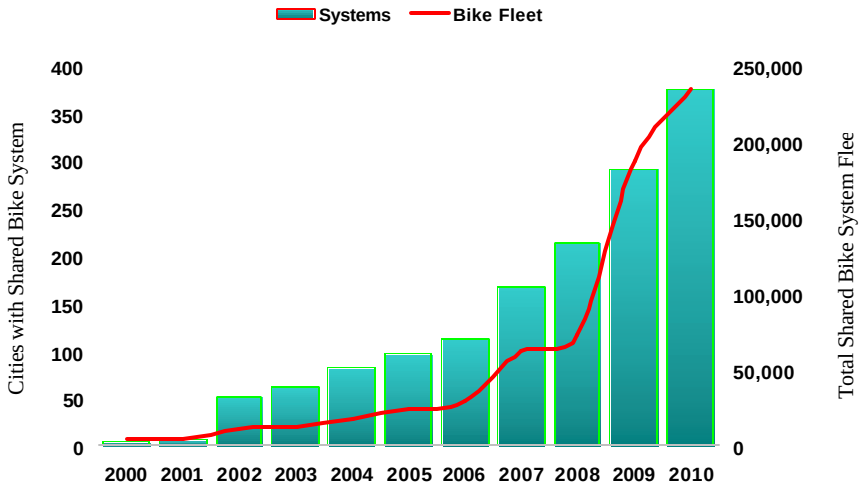
I. OVERVIEW OF BICYCLE-SHARING SCHEMES

1. Also called "Public-Use Bicycles" (PUBs), "Bicycle Transit", "Bikesharing" or "Smart Bikes", bicycle-sharing schemes comprise short-term urban bicycle rental schemes that enable bicycles to be picked up at any self-serve bicycle station and returned to any other bicycle station, which makes bicycle-sharing ideal for point-to-point trips (New York City Department of City Planning, 2009). The principle of bicycle-sharing is simple: individuals use bicycles on an "as-needed" basis without the costs and responsibilities of bicycle ownership (Shaheen, 2010)

2. Over the past ten years, bicycle-sharing schemes have developed from being interesting experiments in urban mobility to mainstream public transport options in cities as large and complex as Paris and London. Ten years ago, there were five schemes operating in five countries (Denmark, France, Germany, Italy and Portugal) with a total fleet of 4,000 bicycles (the largest was Copenhagen with 2,000 bicycles). Today there are an estimated 375 bicycle-sharing schemes operating in 33 countries in almost every region of the world using around 236,000 bicycles[1] (the largest is Hangzhou with an estimated 40,000 bicycles). As can be seen from Figure 1, the rate of growth in bicycle-sharing schemes and fleets has been very rapid since 2008 and has probably outstripped growth in every other form of urban transport.

[1] Author's estimates based on detailed research as of October 12, 2010

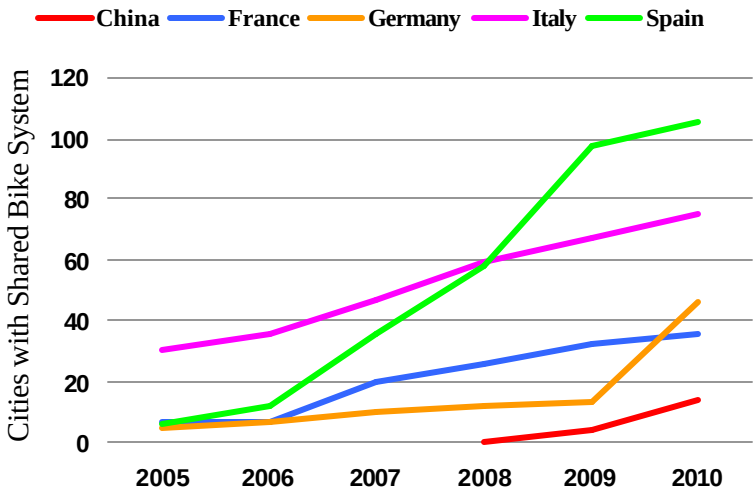
Figure 1
Growth in bicycle-sharing schemes and fleet 2000-2010



Source: Author's estimates based on detailed research as of October 12, 2010

3. Undoubtedly, the widely publicised success of the Vélib' system in Paris has generated considerable interest in this innovative approach to urban mobility. However, as can be seen in Figure 2, bicycle-sharing schemes were expanding in Italy and Spain (more rapidly than in France) before the inauguration of the Paris system in 2007, and this growth has been principally in medium- to small-sized towns with systems of 50 bicycles or so. Therefore, not only are bicycle-sharing schemes attractive, it would appear that they are also highly adaptable to different types of cities and city sizes.

Figure 2
Growth in bicycle-sharing schemes in selected countries 2005-2010



Source: Author's estimates based on detailed research as of October 12, 2010.

4. Bicycle-sharing schemes have evolved dramatically since their introduction in the 1960s. The first generation schemes that were introduced in Amsterdam (1965), La Rochelle (1976) and Cambridge (1993) provided free bicycles to borrow and return from any location. There were no incentives to care for the bicycles and return them in good condition. With the exception of the system in La Rochelle, this resulted in the schemes being closed due to vandalism and theft of bicycles. To address these issues, a new "second generation" set of systems began in 1991, in Farsø and Grenå, Denmark (DeMaio, 2009). By 1995, the first large scale scheme (called Bycyklen or City Bikes) was introduced in Copenhagen. These third generation systems took the form of a "bicycle lending library" (Metrolinx, 2009) with a membership or annual fee. They used custom-built "heavy duty" bicycles with non-standard components to reduce theft. They were relatively simple systems and cost little to install. Some used manual tracking of bicycle rentals, and most included multiple rental and return locations with coin operated locks to secure the bicycles. Although these schemes were more dependable, with less vandalism and fewer thefts, the introduction of smartcard technology in the late 1990s would usher in the third generation schemes that have enabled bicycle-sharing to become what it is today.

5. The first bicycle-sharing scheme to use smartcard technology was the "Vélo à la Carte" system introduced in 1998 in Rennes, France. Other systems soon began to develop in France (Lyon, 2005), culminating in the opening of the famous Vélib' system in Paris in 2007. These third generation systems used improved bicycle designs, sophisticated docking stations and automated smartcard (or magnetic stripe card) electronic bicycle locking and payment systems. Some initiated the use of GPS (Global Positioning System) to track bicycles to prevent theft. Operators used networked self-service bicycle stations which communicate with a central computer system and Radio Frequency Identification (RFID) technology to monitor the location of bicycles in the system (New York City Department of City Planning, 2009). Many introduced the use of web sites to provide users with real time information on bicycle availability at docking stations (both features are now an integral part of modern bicycle-sharing schemes). Most were public-private partnerships and were mainly developed and operated by major advertising companies. In nearly every case, the companies provided and operated the systems in exchange for free billboard advertising.

6. Potential "fourth generation" design innovations are already under development including movable docking stations, solar-powered docking stations, electric bicycles and mobile phone and iPhone real time availability applications. Of these innovations, the introduction of electric bicycles is likely to be the most significant in terms of attractiveness. The evolution of bicycle-sharing and the different generations of bicycle-sharing programmes are summarized in Figure 3.

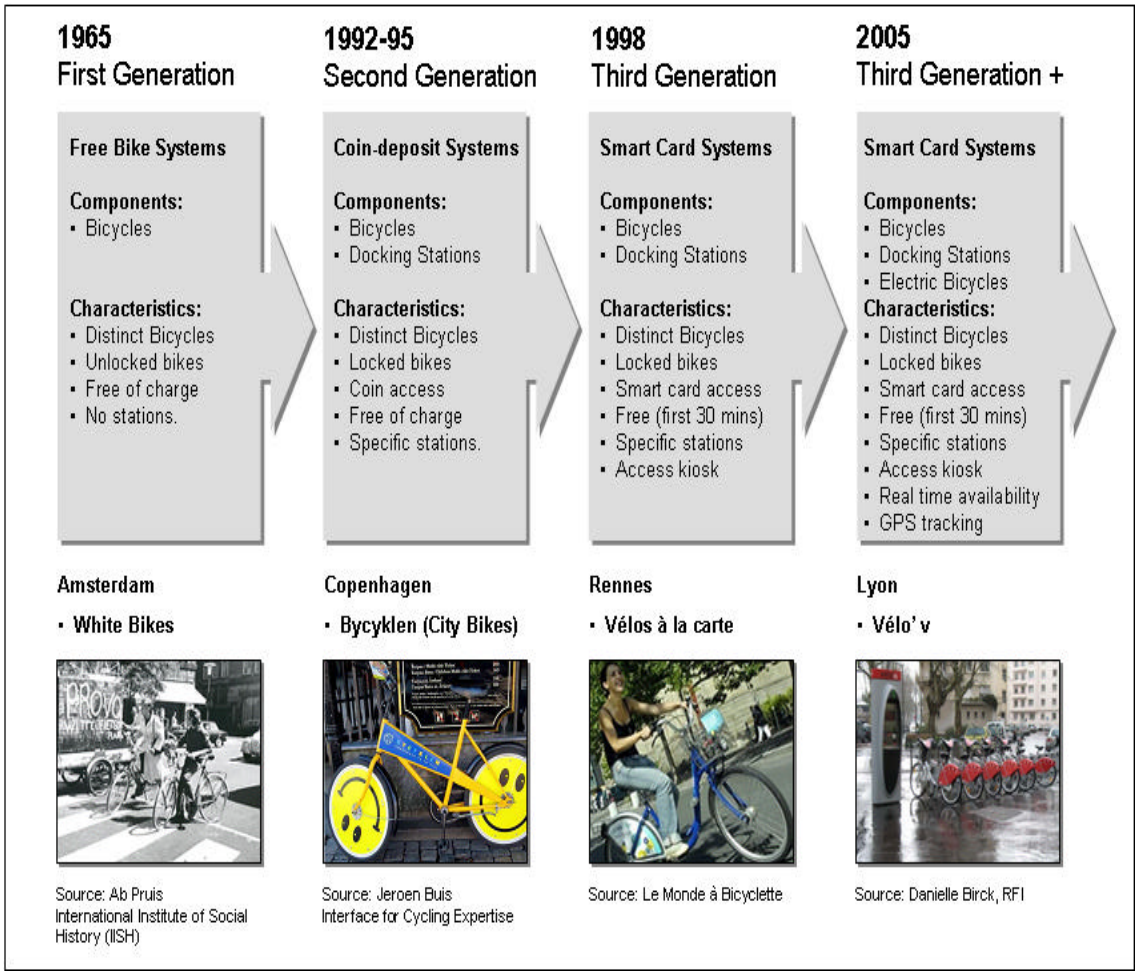
7. In 2008 there were 213 bicycle-sharing schemes operating in 14 countries using 73,500 bicycles. With the exception of the system in Washington D.C., all systems were operating in Europe. Within two years there has been a 76 per cent increase in the number of systems and the bicycle fleet has more than doubled. There are currently 375 bicycle-sharing schemes operating in 33 countries using 236,000 bicycles. Although just over 90 per cent of the systems are located in Europe, nearly 50 per cent of the global bicycle-sharing fleet is now located the Asia and Pacific region.

8. Since 2008 and within Europe, bicycle-sharing has expanded to the Czech Republic, Ireland, Latvia, Monaco, Poland, Romania and Switzerland (with a new system about to open in Hungary). There has been a remarkable growth in Spain where the number of systems has

almost doubled from 58 to 97 between 2008 and 2009, enabling Spain to claim to be the country with the most systems in the world (with currently 105 systems or 28 per cent of global systems).

9. Outside Europe, systems are now operating in Australia, Canada, Japan, New Zealand and Republic of Korea, and for the first time in developing countries - Brazil, Chile, China, India, Islamic Republic of Iran and Mexico.

Figure 3
The evolution of bicycle-sharing programmes



Source: Adapted from Dhingra, Chhavi and S. Kodukula, 2010.

10. It is estimated that 32 systems are currently being planned in 16 countries, the majority (23) of which would be outside Europe. New countries include: Colombia, Cyprus, Israel, and Turkey.

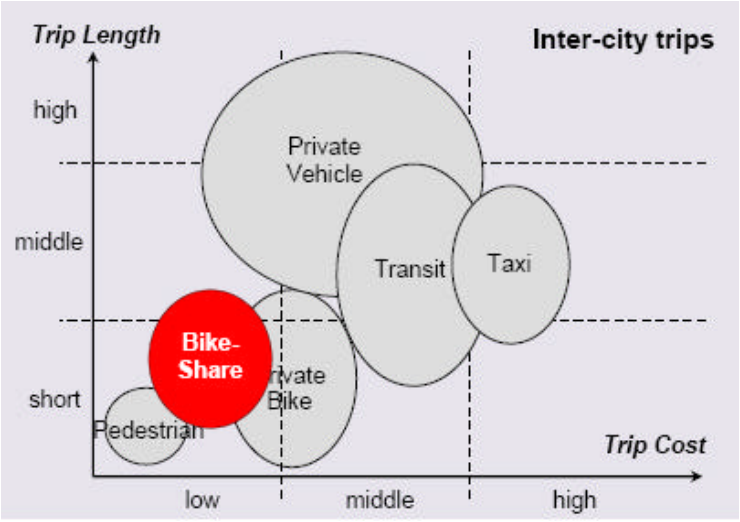
A. Rationale for bicycle-sharing

11. The ultimate goal of bicycle-sharing is to expand and integrate cycling into transportation systems, so that it can more readily become a daily transportation mode

(Shaheen, 2010). In general, the rationale for introducing bicycle-sharing is to promote cycling, increase mobility choices, improve air quality and reduce congestion. It is also seen as a means to promote the viability of public transport by providing an "extension service" for the "first/last mile" - the distance which many consider to be too far to walk between home and public transport and/or public transport and the workplace (Shaheen, 2010).

12. Although travel distance by mode varies from country to country and city to city, most people are willing to walk up to 10 minutes. Cycling distances generally fall within the 1km to 5km range. Bicycle-sharing can therefore fill an important niche in the urban transportation system in terms of trip length and costs (Quay Communications Inc., 2008) as shown in Figure 4.

Figure 4
The role of bicycle-sharing systems in urban mobility



Source: Quay Communications Inc. 2008.Trans Link Public Bike System Feasibility Study. Vancouver.

13. Bicycle-sharing can also fill another niche in urban transportation: speed of implementation. Bicycle-sharing schemes can be installed relatively quickly. In Paris, the initial 700 docking stations and 10,000 bicycles were installed in less than six months and the system doubled in size six months later.

14. Table 1 summarizes the rationale for bicycle-sharing in terms of the objectives articulated by cities for their respective systems.

B. Manual and automated systems

15. There are basically two types of bicycle-sharing systems: those that are considered "manual" and those that are "automated". The differences between these two types of systems, as documented in the "Guide on the implementation of public bicycle systems in Spain" (published by the Institute for Diversification and Saving of Energy in 2007) and the "Bike Sharing Guide" (published by Transport Canada in 2009), are presented below.

16. A manual bicycle-sharing system is one where transactions related to taking out and returning a bicycle is supervised by staff. Manual systems can, but do not necessarily, involve information technology for keeping track of the use of bicycles and monetary transactions. Generally speaking, a computerized tracking system is required when there are multiple pick up and drop off points for the bicycles. Examples include most of the "C'entro in Bici" systems in small to medium size towns in Italy.

Table 1
Objectives of selected bicycle-sharing schemes

System	Objectives
Barcelona Spain	• Improve interchange between different modes of transport, and promote sustainable travel. • Create a new individual public transport system for citizens' habitual travel needs. • Implement a sustainable, health-inducing service fully integrated with the city's public transport system. • Promote the bicycle as a common means of transport. • Improve quality of life, reduce air and noise pollution.
Göteborg Sweden	• Raise the status of cycling. • Promote using bicycles for short distance trips.
Lyon France	• Help create a more sustainable transportation system in the region by launching a public bicycle system that provides a new mobility option for short trips. • Help achieve transport and land use planning objectives including pollution emission reductions, reduced traffic congestion, road and parking cost savings, consumer cost savings, energy conservation, reduced crash risks, improved public health, and support for smart growth land use development.
Montreal Canada	• Encourage the use of public bicycles instead of cars for short, inner-city trips
Paris France	• Act on air quality and public health • Improve mobility for all • Render the city a more beautiful and agreeable place to live in • Encourage economic vitality • Reinforce regional solidarity
Washington DC	• Provide as many transportation options as possible and reduce the level of congestion, especially downtown

Source: Curran, A. 2008. *TransLink Public Bike System Feasibility Study.* Vancouver: Quay Communications Inc.

17. In an automated bicycle-sharing system, transactions related to taking out and returning bicycles are unsupervised – the systems rely on self-service. Bicycles are either locked to special electronically controlled racks or are equipped with an electronically controlled lock of their own. In the former case, the racks are either coin-, credit card-, or electronic key card-operated. In the latter case, the locks on the bicycles have a combination pad; users must call or send a mobile phone text message to the bicycle-sharing operator to obtain a combination to unlock the bicycle. By definition, automated systems rely heavily on information technology for user interface, system control and monitoring. With credit card-, key card-, or mobile phone-operated systems the identity of bicycle users is known. In case of theft or damage to bicycles, the users can be held responsible. Coin-operated systems, such as the Bycyklen system in Copenhagen, do not keep track of user identities. Most systems are

now automated and use smart card technology. The "Call a Bike" system in Germany and the Domoblue/Onroll systems in Spain use mobile phone technology.

C. City size and service densities

18. In their policy recommendations for the development of bicycle-sharing systems in Europe, the New and Innovative Concepts for Helping European Transport Sustainability (NICHES) consortium suggested that a minimum population of 200,000 is required to support an automatic bicycle-sharing system (Bührmann, 2007). The "Guide on the implementation of public bicycle systems in Spain" makes a similar recommendation, and adds that both automatic and manual systems would be appropriate for smaller towns (IDAE, 2007) as illustrated in Table 2. This policy has in fact been implemented throughout Spain following the publication of this Guide.

Table 2
Type and scale of bicycle-sharing system relative to city size and density

City population	Density	System type	Scale of bicycle-sharing network coverage
> 200,000	High	Automatic	Throughout the city
	Low	Automatic	In the city centre or high density areas
50,000 - 200,000	High	Automatic	Throughout the city
	Low	Manual	At public transport stations and public facilities (community centres, sports facilities, etc.)
< 50,000	High	Automatic	At main activity centres (main public transport stations, commercial centres, health centres,
	Low	Manual	At public transport stations and public facilities (community centres, sports facilities, etc.)

Source: IDAE (Instituto para la Diversificación y Ahorro de la Energía). 2007. Guía metodológica para la implantación de sistemas de bicicletas públicas en España. Madrid.

19. The scale of bicycle-sharing network coverage is relatively dense in French cities such as Paris (9.6 bicycles per 1,000 inhabitants), Lyon (6.4/1,000) and Rennes (4.8/1,000) compared with other European cities such as Copenhagen and Stockholm (both 4.0/1,000), Barcelona (3.7/1,000), Brussels or Frankfurt (both 1.1/1,000), Oslo (0.5/1,000) and Vienna (0.4/1,000).

D. Topography and climate

20. Cyclists generally dislike going up inclines of more than 4 per cent and avoid inclines greater than 8per cent. In cities with slopes under 4per cent, topography is not a limiting factor. However, with slopes between 4 per cent and 8 per cent, topography does become a significant constraint. Cyclists will go down the slope but will refuse to go up. Bicycle-sharing stations at higher elevations will tend to empty, while those at lower elevations will tend to fill up. This problem occurs in Barcelona, whose centre lies at the bottom of a bowl-shaped valley. Users happily take bicycles downhill into town but take other modes of transportation to go back uphill, leaving the bicycles behind. In Barcelona's case, the problem is overcome through redistribution: a larger-than-usual fleet of redistribution vehicles continuously takes bicycles from low-lying stations to uphill stations.

21. In Europe, public bicycle systems have been successfully implemented in cities with very different climates – from Nordic climates in the Scandinavian countries to warm, dry climates in France and Spain. Systems in Northern Europe tend to shut down during the colder months while others remain open year-round. In Copenhagen, for example, the Bycyklen system shuts down between early December and early April.

E. Bicycle priority and safety

22. For bicycle-sharing to function effectively, cyclists must be able to move around the city easily and safely. A network of bicycle lanes and dedicated bicycle paths, although not absolutely essential, is clearly an asset. Most cities with bicycle-sharing systems have such networks or have developed them in parallel with the installation of the system. As can be seen from Table 3, the network length has no relationship with the scale of the system. It is not the network length that matters, it is the fact that such a network exists and is in good repair.

Table 3
Length of bicycle lane network in selected cities

Country	City	System	Fleet Size	Stations	Bicycle Lanes (kms)
Brazil	Rio de Janeiro	PedalaRio	250	19	140
Canada	Montreal	BIXI	5,000	400	600
Italy	Milan	BikeMi	1,400	104	123
France	Lyon	Vélo'v	4,000	343	265
Republic of Korea	Daejon	Ta-shu	224	18	192
Norway	Oslo	Bysykkel	1,200	120	250
Poland	Krakow	BikeOne	155	13	99
Spain	Barcelona	Bicing	6,000	400	177
Sweden	Stockholm	City Bikes	2,000	180	760
UK	Reading	OYBike	21	3	60
USA	Denver	Denver B-cycle	500	50	160

Source: Author's estimates based on detailed research as of October 12, 2010

23. Cities that have adopted urban mobility plans that promote public transport and restrict car use with demand management and traffic calming measures, undoubtedly provide a bicycle friendly environment for the introduction of bicycle-sharing systems. Most bicycle-sharing cities have adopted broader urban mobility policies that promote cycling and limit car use.

24. The self-serve nature of bicycle-sharing programmes limits their ability to provide helmets. Most jurisdictions where bicycle-sharing systems operate do not require cyclists to wear helmets. While not having to wear a helmet simplifies the use of bicycle-sharing systems for one way trips or trips combined with public transport, as the user does not have to carry a bulky helmet before and after using the system, for many people this poses a safety risk. There is a considerable body of research that appears to find both in favour of and against bicycle helmets, with a reported 31 papers in favour of helmet wearing or legislation, compared with 32 against There is hardly any research on the issue with regard to bicycle-sharing systems.

II. COMPONENTS

25. Automated bicycle-sharing systems typically comprise the following components:

A. Bicycles

26. Shared bicycles need to be easy to use, adaptable to users of different sizes, mechanically reliable, resistant to vandalism or theft and distinctive in appearance.

27. Most bicycle-sharing systems are equipped with bicycles that weigh between 16kg to 22kg and are heavier than typical personal bicycles. They are sturdy and designed to be used between 10 and 15 times a day in all weathers. They have the following features: internal hub gears with three speeds, internal hub brakes, an enclosed chain, an adjustable seat, mud-guards, reflective strips on the wheels, front and rear lights, a bell, a kickstand, a portable lock, a handlebar mounted bag rack or a basket; and wide, air filled tires.

28. Most bicycles come equipped with a Global Position System (GPS) unit, a Radio Frequency Identification (RFID) tag, or other type of tracking mechanism. This function is typically used in fleet management and retrieval of lost or stolen bicycles (Alta Planning + Design, 2009).

29. To discourage theft, bicycles typically have a single standardised design, a consistent livery and a distinctive look (Quay Communications Inc., 2008) in order to distinguish them from all other bicycles. In addition, to make them unattractive to potential thieves, they are made in such a way that special tools are required to disassemble them and their components are incompatible with other bicycles.

B. Docking stations

30. The Transport Canada Bike Sharing Guide groups docking stations into the following three categories:

31. Fixed-permanent: Figure 6(a): A fixed bicycle-sharing system is one in which bicycles are locked to designated racks when not in service. In most cases, bicycles are attached to the rack via a specialized coupling system. The racks therefore act in essence as "stations". The vast majority of bicycle-sharing systems feature fixed stations.

32. Fixed-portable: Figure 6(b): Montreal's BIXI system has introduced a significant innovation to the fixed system concept: portable modular stations. Service terminals and the bicycle stands are mounted onto sets of rectangular platforms to form two types of modules: main modules having a service terminal and three bicycle docks and secondary modules having only bicycle docks. Each station requires one main module; the number of secondary modules can vary, depending on the required number of bicycle docks at the given location. As the stations are solar powered and wirelessly networked, they are completely self-contained and no wiring is required for installation. As a result, station installation consists merely of placing the modules in the desired location; there is no need for anchoring them to the ground. It is therefore time-, labour-, and cost-efficient. BIXI docking stations can be erected or disassembled in 20 minutes and they can be moved easily to respond to demand or to provide "mega" docking stations for special events (New York City Department of City Planning, 2009).

33. Flexible: Figure 6(c): A flexible bicycle-sharing system is one in which bicycles do not need to be locked to designated racks or stations. In this case, the bicycles have a general purpose locking device, such as a chain or a cable, which allows the bicycle to be locked to any stationary object when not in use (e.g., a standard bicycle rack, a traffic sign, a parking metre, etc.). In addition to the built-in chain or cable lock, there may also be locks that block the bicycle's drive train and steering.

Figure 6
Examples of docking stations

(a) Fixed-permanent (Paris)

Source: Luc Nadal

(b) Fixed-portable (Montreal)

Source: Yvonne Banbrick

(c) Flexible (Copenhagen)

Source: hostelworld

34. The distribution of docking stations is dependent on the size and configuration of the city. In Paris and Barcelona docking stations are spaced 300 meters apart.

C. System access and user registration

35. To access bicycles at docking stations, users need to unlock the bicycle from the stand. There are mainly two locking technologies involved in bicycle-sharing systems. In the first, bicycles are checked out from an automated bicycle rack with the use of a smartcard or magnetic stripe card. The second technology provides an automated lock on the bicycle itself and relies on the user to communicate via mobile or pay phone for the entry code.

36. Most systems require users to register prior to accessing bicycles at the docking stations and offer multiple options to register and pay for using the bicycles (e.g., smart card or credit card). To encourage casual and tourist use, registration is usually quickly and easily handled at each docking station. Requiring pre-registration can create a barrier to use, but will likely increase rider accountability and reduce bicycle theft (Alta Planning + Design, 2009).

37. The registration and access process is usually handled at specially designed kiosks located at each docking station. The Vélib' station kiosk illustrated in Figure 8 is typical of most smart bicycle-sharing systems. As described in the Bike Sharing Guide by Transport Canada (Gris Orange Consultant, 2009), the kiosk has the following features:

Figure 7
A Vélib' station kiosk

Source: Gris Orange Consultant. 2009. Bike Sharing Guide. Transport Canada: Ottawa

A. Advertising space. For supplemental revenue generation.
B. Touch-sensitive screen. For user interface.
   - Purchase of day, week, or annual passes, using the credit/debit card terminal (D).
   - Information on how to use the system
   - Information on bicycle and parking space availability at other stations in the network
   - Available in eight languages: French, English, Spanish, German, Italian, Arabic, Chinese and Japanese
C. Key card reader. For registered users with annual memberships or NaviGO public transit cards users. Allows users to check account information, such as usage charges.
D. Credit/Debit card terminal. Accepts credit and debit cards. Used in conjunction with touch sensitive screen to purchase day, week, or annual passes.
E. Card dispenser. Dispenses temporary (one-day and one-week) passes purchased at the terminal.

38. Once the card has been issued by the kiosk, the user simply brushes the card against the bicycle attachment point. The user is identified and the bicycle is released by the docking station.

D. System status information systems

39. All of the major systems and many smaller systems provide real time information on websites about bicycle availability for each docking station in the system. Most also include maps with bicycle lanes marked, and some provide weather updates.

40. One company has launched an application called "AllBikesNow" that uses the functions of mapping and geolocation of the iPhone to simplify access to their bicycle-sharing service in 23 cities by providing information in real time about bicycle availability at docking stations and the status of the user's account. The AllBikesNow application provides real time information on where to find a bicycle, where to return it, where to find a station near a given address, the status of the user's account and how much they spent on their last journey.

E. Maintenance programmes

41. Maintenance and logistics are large operational issues, especially in the largest of bicycle-sharing programmes with the average bicycle operating up to 180,000 km per year. Users in Barcelona report that the largest problem with the bicycles is the tires, and that there are typically 2 or 3 bicycles with flat tires in every station. In Copenhagen ten to fifteen percent of bicycles must be replaced each year. Four mobile units check the fleet daily there. In Paris the Vélib' system has a support centre on a barge that moves between 12 landing points on the river. It features a shop with 10 mechanics for smaller repairs. The more

seriously damaged bicycles are transferred daily to a facility outside the city (Quay Communications Inc., 2008).

F. Bicycle redistribution mechanisms

42. An optimized network needs more than large numbers of conveniently located stations; it must also anticipate the asymmetric travel demands of most large cities. Not surprisingly stations located at the top of hills are chronically empty of bicycles – as the customers ride down the hill but do not wish to make the return trip uphill. Bicycles also tend to collect in stations in the city centres and stay there. Ideas for re-balancing the system, other than a dedicated team with a vehicle, can include a premium to return bicycles at a lower elevation or conversely a credit for each bicycle returned to a higher elevation. Vélib' introduced such a programme in early 2008 (Quay Communications Inc., 2008).

III. INVESTMENT, MANAGEMENT AND SOURCES OF FINANCE

A. Capital and operating costs

43. Capital costs include bicycle purchase, docking station equipment and construction, license or purchase of the back-end system used to operate the equipment, member access cards, purchase or rental of maintenance and distribution vehicles, and installation. From the analysis of several systems shown in Table 4, capital costs can range between $3,000 and $4,500 per bicycle. (New York City Department of City Planning, 2009).

Table 4
Capital costs of bicycle-sharing systems

City	Montreal	New York	Washington DC	Lyon	Paris
Program	Bixi	2007 Estimate	SmartBike Expansion	Velov'	Velib'
Operator	Stationnement de Montréal	ClearChannel Adshel	ClearChannel Adshel	JCDecaux	JCDecaux
Number of Bicycles	2,400	500	500	1,000	20,600
Capital Cost	No Data	$1,800,000	$1,800,000	No Data	$90,000,000
Capital Cost/Bicycle	$3,000	$3,600	$3,600	$4,500*	$4,400

All data provided by the operators or providers unless otherwise noted.

* This figure is cited to European programs in general in Becker, Bernie, "Bicycle-Sharing Program to Be First of Kind in U.S.," The New York Times, 27 April, 2008

Source: New York City Department of City Planning 2009. *Bike-Share Opportunities in New York City.* New York.

44. Operating costs include maintenance, distribution, staff, insurance, office space, storage facilities, website hosting and maintenance, electricity charges for the docking stations, membership cards and warehouse/storage fees. From analysis of several systems shown in Table 5, operating costs range between $1,200 and $1,700 per bicycle, excluding the estimates made for New York (New York City Department of City Planning, 2009).

Table 5
Operating costs of bicycle-sharing systems

City	Montreal	Lyon	Barcelona	Washington DC	Paris	New York
Program	Bixi	Velov'	Bicing	SmartBike Expansion	Velib'	2007 Estimate
Operator	Stationnement de Montréal	JCDecaux	ClearChannel Adshel	ClearChannel Adshel	JCDecaux	ClearChannel Adshel
Number of Bicycle	2,400	1,000	3,000	500	20,600	500
Operations Cost	No Data	$1,550,000	$4,500,000	$800,000	$35,000,000	$972,000
Operations Cost/ Bicycle	$1,200	$1,500*	$1,500**	$1,600	$1,700	$1,944

All data provided by the operators/providers or the city unless otherwise noted.

* Buhrmann, Sebastian, Rupprecht Consult Forschung & Beratung GmbH, "New Seamless Mobility Services: Public Bicycles;" Niches Consortium

** Nadal, Luc, "Bike Sharing Sweeps Paris Off Its Feet," Sustainable Transport, Institute for Transportation and Development Policy, Fall 2007, Number 19

Source: New York City Department of City Planning 2009. *Bike-Share Opportunities in New York City.* New York.

B. User Fees

45. Subscription and rental fees are collected by all the major bicycle-sharing systems. In order to make bicycle-sharing attractive and encourage use, membership and use fees are kept low. Most systems offer the first 30 minutes free of charge with increasing prices for each additional 30 minutes to ensure that bicycles are available for users throughout the system.

46. In Paris, the Vélib' system earned over €30 million in its first year in membership and user fees. Since the costs of the programme are covered by a billboard contract, this money goes entirely to the city of Paris as revenue. In Barcelona 100,000 subscriber registration fees alone will generate $3.5 million in revenues while in Lyon 15,000 subscribers will provide $100,000 in registration revenue (New York City Department of City Planning, 2009). Table 6 presents a comparison of user fees in Lyon, Paris, Barcelona and Frankfurt undertaken by TransLink Vancouver in 2008.

Table 6
A comparison of user fees in Lyon, Paris, Barcelona and Frankfurt

User Costs	Lyon	Paris	Barcelona	Frankfurt
Registration	$7.30	$47.00	$35.00	$7.30
1st 30 minutes	Free	Free	Free	$3.50
2nd 30 minutes	.73	1.60	.44	$3.50
Next hour		9.64	.44	$7.00
Full day	$34.38	$46.25	$96.58	$21.92
Average Annual Income	$32,000	$32,000	$31,800	$54,100

Source: Curran, A .2008. *TransLink Public Bike System Feasibility Study.* Vancouver: Quay Communications Inc.

47. Most systems are subsidised, with the shortfall between user fees and total costs made up through business models that use general revenues, advertising revenues, parking revenues, government grants or sponsorship.

C. Business models

48. Over the years, several models have evolved for developing, operating and funding bicycle-sharing schemes. Operators include local governments, public transport agencies, advertising companies, for-profit companies, and non-profit groups (Shaheen, 2010 and DeMaio, 2009). Funding mechanisms include user fees, municipal budgets, and resources from public-private partnership agreements. Table 7 provides an overview of bicycle-sharing business models by type of operator.

49. Many bicycle-sharing systems are operated as public private partnerships (PPPs) with one of three large advertising companies (Cemusa, Clear Channel or JCDecaux). Typically, a city municipality provides the company with advertising space on street furniture (such as bus shelters) and billboards in exchange for the company providing and operating an off-the-shelf bicycle-sharing system. The advantage for the municipality of using this business model is that little or no direct public funding is required to set up and operate the bicycle-sharing system. Consequently, the system can appear to have little or no cost to the taxpayer. However, although public money need not be spent on the system, there is still a cost to the municipality in the form of forgone advertising revenues (Gris Orange Consultant, 2009).

50. The major sources of funding for bicycle-sharing systems are public-private partnerships which account for 48 per cent of all systems. The three largest outdoor advertising companies (Cemusa, Clear Channel and JCDecaux) account for 20 per cent of all systems and three smaller non-advertising related suppliers (Centroinbici in Italy and ITCL and Onroll in Spain) account for 28 per cent. The public sector (comprising municipalities, public transport agencies and municipal parking agencies) accounts for 30 per cent of all systems. NextBike, one of the few for-profit operators accounts for 7 per cent of all systems. New companies are setting up in China. The "Forever Bicycle Company" accounts for 4 of China's 14 systems. The largest system in the world, in Hangzhou, is a municipal operation that is managed by the Hangzhou Public Bicycle Transport Service Development.

51. Access to large scale grant funding is rare. The European Commission, through its CIVITAS programme, has provided support for the development of bicycle-sharing schemes in selected cities. The most significant programme was in Spain, where the Institute for Diversification and Saving of Energy (IDAE)[2] provided €2.5 million in 2008 to support the development of 56 bicycle-sharing schemes with a total of 8,463 bicycles (IDAE, 2008).

[2] The Instituto para la Diversificación y Ahorro de la Energía (Institute for Diversification and Saving of Energy, or IDAE) is a State-owned business entity that reports to the Ministry of Industry, Tourism and Trade through the State Secretary for Energy.

Table 7
Overview of bicycle-sharing business models

Provider	Business Model	Examples	Operator
Advertising Company	Provide and operates system in exchange for advertising rights	Roma'n'Bike (Rome, Italy) Vélib' (Paris, France) Bizi (Zaragoza, Spain)	"Bicincittà" (Italy) by Cemusa (Spain) "Cyclocity" by JCDecaux (France) "SmartBike" by Clear Channel (USA)
Local Authorities	Contracts with provider to install and operate the system for a fee	AranBike (Aranjuez, Spain) Bicing (Barcelona, Spain) Bicibur (Burgos, Spain)	Onroll (Spain) Clear Channel (USA) ITCL (Spain)
	Designs, owns and operates the system	Aarhus Bycykel (Denmark) Bike House (Teheran, Iran)	Municipality of Århus (Denmark) Tehran Municipal Government (Iran)
Public Transport Operators	Provides and operates system to enhance public transport services	BIXI (Montreal, Canada) Call a Bike (Germany) OV-Fiets (Netherlands) Vélos jaunes (La Rochelle, France)	Stationnement de Montréal (Canada) Deutsche Bahn (Germany) Netherlands Spoorwegen (Netherlands) Régie des transports communautaires Rochelais (France)
For-Profit	Provides and operates system for a profit with minimal government involvement	StadtRAD (Hamburg, Germany)	Nextbike (Germany)
Non-Profit	Provides and operates system with the support of local authorities	Bycyklen (Denmark)	CityBike Foundation of Copenhagen (Denmark)

Source: Adapted from Shaheen, Susan., S. Guzman and H. Zhang. 2010. *Bikesharing in Europe, the Americas, and Asia: Past, Present, and Future*. Washington D. C. : Transportation Research Board Annual Meeting. Table 15. 2

52. National railway companies in Germany and the Netherlands have provided extensive bicycle-sharing systems linked to their stations, initially for the benefit of their passengers but subsequently for any user. These systems are funded through a combination of general revenues and user fees. Municipal public transport agencies and parking agencies are important sources of operating funds. In Barcelona, part of system financing comes from on-street parking revenues and the remainder comes from subscriptions. This is the only system where there is a clear cross-subsidy from motorists to cyclists.

Table 8
A comparison of operating and financing structures

	Advantages	Disadvantages	Example
Public Private Partnership Design, Build, Operate, Maintain, Finance	• All logistics handled by the private sector partner • Partial control by public owner during some phases of project • Relieved of operating detail and performance risk	• Loss of revenues from advertising • Risk of public backlash to increased levels of outdoor advertising • Difficult to enforce performance standards	Paris
Design, Build, Operate, Maintain	• Partial control by public owner during some phases of project • Retain control of public spaces Relieved of operating detail	• Competition for public funds • Difficult to assure performance standards	Barcelona
Design Build	• Complete control through all phases of the project. • Retain control of public spaces Complete control over network configuration, performance, pricing and marketing details	• Competition for public funds • Assume all Operating Risk	Munich, Berlin, Frankfurt

Source: Curran, A. 2008. *TransLink Public Bike System Feasibility Study.* Vancouver: Quay Communications Inc.

IV. BENEFITS AND IMPACTS

53. There is very little meaningful data on benefits or impacts of bicycle-sharing schemes. The most noticeable benefit is increased bicycle use. In Lyon, the use of bicycles increased by 44 per cent within the first year of the Velo'v operations (Bührmann, 2007) and in Paris there was a 70 per cent increase after the launch of Vélib' (Shaheen, 2010).

54. There is limited data available on changes in mode of travel before and after the introduction of bicycle-sharing. Data from Barcelona, Lyon, Montreal and Paris suggests that there is little impact on reducing car use. The percentage of car or motorcycle trips replaced by bicycle-sharing in these cities ranges from 2 per cent to 10 per cent. In fact, the shift is mainly from public transport to bicycle-sharing (see Table 9). A user survey of the Vélib' system undertaken in 2008 found that 19 per cent of users stated that Vélib' allowed them to make trips that would have otherwise been impossible and that 20 per cent of users stated they used cars less.

Table 9
Trip type replaced by bicycle-sharing in selected cities

Type of Trip Replaced	Bicing Barcelona	BIXI Montreal	Vélib' Paris	Vélo'v Lyon
Bus or Metro	51%	33%	65 %	50%
Car or motorcycle	10%	2%	8 %	7%
Taxi		8%	5 %	
Walk	26%	25%	20 %	37%
Bicycle	6%	28%		4%
New Trip		4%		2%

Sources: Buis, J., 2008; Curran, A, 2008; Bachand-Marleau, J., 2010.

V. CHALLENGES AND OPPORTUNITIES

A. Challenges

55. The challenges faced by bicycle-sharing systems concern theft and vandalism, helmet use, topography and climate, and a tendency to exaggerate benefits that may end in discrediting bicycle-sharing as a sustainable approach to reducing car use and dependence.

56. **Theft and vandalism**: Despite the use of custom components and user identification technologies, theft and vandalism of bicycles is a major challenge in many systems. Paris has the highest rate of theft and vandalism of any bicycle-sharing system. Within the first two years of operation, nearly the whole system fleet of 20,600 bicycles had to be replaced at a cost of 400 Euros per bicycle. Some 7,800 bicycles were stolen and 11,600 bicycles were vandalized beyond repair. The Hangzhou's system and the system in Montreal have so far experienced relatively low theft and vandalism rates (Shaheen, 2010).

57. **Helmets:** The main hindrance in some regions to implementation of bicycle-sharing programmes is helmet laws or helmet culture. For many years, it had been assumed that no Australian city would install a bicycle-sharing system because of national mandatory helmet laws. Melbourne launched its system in June 2010 and in October 2010 opened a pilot programme whereby users can purchase helmets for A$5 from vending machines and either keep them, or return them to a convenience store for recycling and receive A$3 cash back (VicRoads, 2010). A different approach has been taken in Mexico where Mexico City repealed its helmet law in February 2010 to make way for a bicycle-sharing system (MetroBike, LLC. , 2010).

58. **Topography and Climate:** Cycling in hilly conditions may be appropriate for the Tour de France but it can be very dissuasive for city commutes. Slopes between 4 per cent and 8 per cent are a significant constraint and slopes above 8 per cent are impractical. Year round hot and humid climates are clearly not conducive to cycling either. Many systems close in the winter (e. g. Montreal) due to ice and snow. Pedelecs (bicycles that provide electric power while pedalling) and E-Bikes (bicycles that provide electric power without pedalling) are clearly attractive options to overcome these challenges (but not ice and snow). While some systems are introducing electric bicycles on a pilot basis, the cost and weight (as well as the range) of current models are not conducive to mainstreaming this form of technology. Undoubtedly this will change as models become cheaper and lighter in weight. Until then, topographic and climatic conditions will tend to limit the application of bicycle-sharing schemes to cities that are relatively flat and temperate.

59. **Exaggerated Benefits:** According to an online survey of 1,432 people in Montreal conducted in the summer of 2010 by researchers at McGill's School of Urban Planning, the vast majority of trips (86 per cent) replaced sustainable modes such as walking, or rides on personal bicycles or public transport. While eight percent of BIXI users replaced taxi trips, only two percent of the respondents used a BIXI instead of driving, revealing that official estimates of CO_2 reduction due to the implementation of the programme were exaggerated (Bachand-Marleau, 2010). This shows that proponents of bicycle-sharing systems need to be more cautious in their estimates of potential benefits and that more research is needed on the impacts of bicycle-sharing systems on reducing car use.

60. **Inexperienced Cyclists:** In some cities there have been complaints from motorists that cyclists who use bicycle-sharing schemes tend to be inexperienced riders who do not follow the traffic rules. This can be overcome by training programmes.

B. Opportunities

61. The rapid growth in bicycle-sharing schemes over the past two years outside of Europe, and especially in South East Asia and Latin America, is an indicator of the attractiveness of such systems and their adaptability to different situations. Opportunities for success are clearly evident but from experience with past and current bicycle-sharing schemes, these opportunities will depend on several key factors that are summarized in Table 10, below.

Table 10
Success factors in Bicycle-sharing schemes

Factor	Description	Importance
Bicycle Re-distribution	Mechanism to address asymmetrical demand for bicycles by location	**? ? ?**
Cycling infrastructure	Quality and quantity of designated cycling space – dedicated bicycle lanes, intersection facilities, slow streets	**? ? ?**
Density and Trip Demand	Demand for one way trips in multiple directions	**? ? ?**
Maintenance	Bicycles and access terminals in good operating condition	**? ? ?**
Network Configuration	Location specific network design based on system objectives and travel demand	**? ? ?**
System Accessibility	Cost of use including monetary and convenience costs	**? ? ?**
Bicycles	Bicycle specifications respond to user demographics and operating conditions	**? ?**
Docking Stations	Terminals are visible and user interface is good	**? ?**
Public Attitudes to Cycling	Perception of mode, willingness to 'share the road', willingness to utilize mode	**? ?**
Quality of Public Transport	Capacity to motivate residents to forgo auto trips to CBD	**? ?**
Weather & Topography	Amount of Precipitation, Hills	**? ?**
Safety & Security	Terminals and cycling facilities are well lit and patrolled as necessary	**? ?**
System Availability	Hours of Service	**? ?**
Technology Platform	Speed of access, real time information, privacy and security of data	**? ?**

Source: Curran, A. 2008. *TransLink Public Bike System Feasibility Study.* Vancouver: Quay Communications Inc.

62. In addition, there are several external factors that will have a bearing on success. These include bicycle priority measurers and bicycle lanes, effective and efficient public transport systems and the perception of safety by users.

VI. POLICY RECOMMENDATIONS

63. The rapid development and expansion of bicycle-sharing in recent years shows that it is an attractive and adaptable urban mobility concept. Drawing on successful European experiences, bicycle-sharing systems are now beginning to be implemented in Asia, Latin America, the Middle East and North America, and for the first time in developing countries. There are very few guidelines or manuals on how to develop such systems and there is an almost complete absence of policy recommendations.

64. The only up-to-date and comprehensive set of generic guidelines that exists is the "Bike Sharing Guide" published by Transport Canada in March 2009. This draws heavily on the "Guía metodológica para la implantación de sistemas de bicicletas públicas en España" published by the Instituto para la Diversificación y Ahorro de la Energía (IDAE) in Spain in 2007. The "Guia" was the first attempt to develop guidelines for the development of bicycle-sharing systems and was published to help Spanish cities apply for funds from IDAE. Elsewhere, systems are being developed and adapted in an almost "ad hoc" manner, partly by system promoters and partly by word of mouth.

65. In some cases, individual cities are undertaking and publishing comprehensive bicycle-sharing feasibility studies that adapt European "best practice" to local conditions (London, New York City and Vancouver). These provide useful insights into what are the potential costs and benefits of bicycle-sharing and what it would take to make it happen in a specific city context. In 2008, Transport for London undertook a detailed feasibility study for introducing a bicycle-sharing scheme in central London (Transport for London, 2008). The key findings from this study provide the following comprehensive set of policy recommendations that are sufficiently generic to be applicable to developing a bicycle-sharing scheme almost anywhere:

- Annual subscription or registration promotes ownership of the scheme for the general public. Registration also enables the deposit system to work and eases the charging mechanism allowing accounts to be billed directly.
- A strategic pricing structure is required which may differ depending on the business model. The length of the free period of use, the scale of price increases and the type of charge can all be used to manage demand and promote usage in accordance with the type of scheme, as defined in the business model.
- Smart card usage makes it particularly easy to access bicycles.
- Station location choice is imperative to create an effective, safe, usable network and to minimise the requirement for bicycle redistribution. Where redistribution is required, this should be done in an environmentally friendly and efficient way.
- Innovative methods to identify land to locate stations will be needed, such as making use of existing on-street car parking spaces in Paris.
- The bicycles need to be robust and must dock easily into a secure docking station. They could potentially be used up to 10 times a day. They will be outside at all times and open to vandalism and damage. They must be sturdy, strong and secure, while at the same time easy to manoeuvre. They also need to be as difficult to steal and vandalise as practicably possible.
- Maintenance must also be easy, with as much work completed on-site as possible. Standardised parts, on site storage facilities and versatile trained staff will help this process run smoothly.

- The scheme needs to be visible and easily identifiable to its customers. Any potential scheme would be self-promoting, with more and more people using the scheme, increasing its visibility, promoting further growth in usage.
- 'Teething' problems should be ironed out as soon as possible after the introduction of a scheme as users will switch away quickly if the scheme is problematic. This can be achieved with the targeting of demand through a phased introduction of the system.
- Finally, project governance should be made clear from the start. The implementation of schemes in cities which have established strong, effective working relationships has been far quicker and smoother.

66. In addition, it is evident from the schemes that have been successfully implemented in Europe and elsewhere that bicycle-sharing schemes are successful within cities that are committed or at least interested in sustainable development. Without an effective public transport system and some form of demand management policy, bicycle-sharing will not be effective. Bicycle priority measures (such as cycle lanes) are essential ingredients for bicycle-sharing users to feel safe about cycling in any city.

67. Experience to date with bicycle-sharing in developing countries is limited to Brazil, Chile, China, India, Islamic Republic of Iran and Mexico. There is hardly any information on system costs, operations or performance. In the case of China, the systems are very similar to those in Europe. In Guangzhou, the first phase of the bicycle-sharing system has been developed along the city's Bus Rapid Transit (BRT) corridor to serve demand from the upcoming Asian Games.

68. For bicycle-sharing to be an attractive option in any city, the following urban mobility elements are essential: (i) An effective public transport system which can be integrated physically and operationally with bicycle-sharing; and (ii) A bicycle lane network and associated bicycle priority measures at intersections that enable users to cycle safely and continuously throughout the area covered by the bicycle-sharing scheme.

69. Although there are cities with bicycle-sharing systems without these facilities, the larger systems have extensive cycle lane networks and good public transport systems (both bus and rail-based). Table 11 shows the extent of bicycle lane networks in selected cities with bicycle-sharing systems.

Table 11
Bicycle lane networks in selected bicycle-sharing cities

City	System Fleet	Bicycle Lanes (kms)
Barcelona	6,000	177
Copenhagen	2,000	1,000
London	6,000	800
Lyon	4,000	265
Montreal	5,000	600
Paris	20,000	370

Source: Author's research

70. Bicycle lanes alone will not guarantee safety. There must be an effective enforcement system in place to ensure that cyclists are in fact protected. According to a recent article in the Chinese media, dedicated bicycle lanes have only just started to appear in

Guangzhou but are frequently disregarded by car drivers or pedestrians, rendering cycling through Guangzhou a perilous task (Guangzhou Interactive Information Network Company: Life in Guangzhou, 2010).

71. In most developing country cities, the lack of bicycle infrastructure in the form of cycle lanes or cycle paths combined with the lack of enforcement of traffic laws presents a major challenge for the introduction of any form of bicycle-sharing system. In addition, and in most cases, the public transport systems are inadequate. Hence the integration of bicycle-sharing with public transport at bus stops and/or stations is usually not possible. The rapidly expanding introduction of BRT systems in developing country cities may present an opportunity to incorporate bicycle-sharing systems and the required bicycle lanes as an integral part of the BRT design and operational plan.

72. In order to function effectively, bicycle-sharing systems rely on smart card technology, GPS tracking and real-time bicycle availability information on the internet. In most cases, users need to register with a credit card to discourage theft. Hence, bicycle-sharing's dependence on credit cards is critical and as most people in developing countries in Africa, Asia and Latin America may not have credit cards this will severely limit usage. In the case of New Delhi (India) a valid Indian ID-Card, Voter Card or Driving License is kept as a deposit until the return of the bicycle at the station. This approach excludes the one way point-to-point trip that is one of the key advantages of the bicycle-sharing concept. As a result, system usage is very low with an average of 11 customers per station in a city of 14 million.

A. Intensified information sharing

73. There is no central repository of information on bicycle-sharing. The most up-to-date guidelines are over one year old and are designed specifically for conditions in Canada. As more and more cities develop bicycle-sharing systems there is going to be a growing need for reliable and comprehensive information on costs, benefits and what it takes to design, implement and operate such systems. Cities such as New York and Vancouver that are considering bicycle-sharing have almost had to start from scratch in researching case studies, developing approaches and estimating costs and benefits.

74. There is a need to establish a "focal point" on bicycle-sharing or "Bicycle-sharing Centre". This could take many forms and be supported in a number of ways. At this stage it is important to explore how it could assist cities interested in embarking on bicycle-sharing, especially in the developing world. There is also a need for a database of bicycle-sharing systems.

B. Guidelines and manuals

75. There is an urgent need for guidelines and manuals. They could be generic in nature but also geared to the specific needs of cities in different regions. They should be updated frequently and should be available in at least the major languages.

C. City networks

76. Although some cities are clearly learning from each other in an informal and ad hoc way, the benefits of establishing a global bicycle-sharing city network would be enormous. The purpose would be to share information, knowledge and expertise and contribute to the global database. In addition, cities would be able to collaborate on applied research and on developing innovative solutions. The network would be a prime source of assistance and advice for cities planning new systems as well as cities considering expansion, upgrades or changes to existing systems.

D. Sources of development aid

77. Cities in developing countries would benefit from bi-lateral aid and funding from the World Bank and the regional development banks. As the development of bicycle-sharing in developing countries is a very recent activity, it is not surprising that these institutions have little to no experience in the role of bicycle-sharing systems in developing country situations. This needs to change as there certainly will be requests for funding as more and more cities become aware of the potential for bicycle-sharing and see the developments in China and Latin America.

E. Demand projections

78. There is hardly any information available on how the demand for bicycle-sharing has been estimated. Undoubtedly the operators of the existing schemes JCDecaux have undertaken some form of market research to estimate the take up of their respective systems. Without this information it is somewhat difficult to judge the success of a system. The Bicycle-sharing Guide states simply that if a mobility study has not been carried out, the general rule is to deploy a public bicycle system in the metropolitan core, where the population and employment densities are the highest. As systems become more and more sophisticated and embedded in the urban transport system as a whole, the need for more solid demand projections will be become apparent. It is not too early to begin to develop robust and simple methodologies to achieve this.

F. Pilot projects

79. Given the different characteristics of developing country cities, there will be a need to develop new and innovative approaches to bicycle-sharing that will draw on current experiences in Europe and elsewhere. The best way to move forward on this would be to undertake a series of pilot projects, ideally supported by the development banks and/or bilateral aid. Ideally these should be regional programmes that recognise local conditions.

G. Urban mobility plans

80. Most bicycle-sharing schemes have been introduced in cities that have established sustainable urban transport policies and plans. In these cities, bicycle-sharing is seen as an element of sustainable urban mobility and in most cases the requisite cycling infrastructure has therefore been put in place before the schemes commence. Equally important to the success of bicycle-sharing is the role of public transport. From the limited data available, it is evident that most bicycle-sharing trips are made as part of a public transport trip. The integration of bicycle-sharing and public transport within the framework of a sustainable urban mobility policy is therefore highly desirable. Cities that are considering the introduction of bicycle-sharing will need to be aware of the need to develop sustainable urban mobility policies and will probably need help and guidance. Specific guidelines and manuals should therefore be produced on the role of bicycle-sharing in urban mobility, especially for cities in developing countries.

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