Bike-sharing systems provide public access to bicycles for a limited time. Some provide free access to members and others charge a monthly or yearly fee. Some schemes operate stations across an entire city and others are intended for commuters. But they all have a common goal: improving the cycling culture in cities and encouraging people to cycle more.
The role of bike-sharing in urban mobility

Bike-sharing schemes can be defined as ‘short-term urban bicycle rental schemes that enable bicycles to be picked up at and returned to any self-service bicycle station, which makes bicycle-sharing ideal for point-to-point trips’. In general, bike-sharing systems are introduced to increase mobility choice, improve air quality and reduce congestion. The basic premise of the bike-sharing concept is sustainable transportation. They differ from traditional, mostly leisure-oriented bicycle rental services, in the following ways:

- They can be taken from one location and either returned there or at another location;
- They provide fast and easy access;
- They can include diverse business models;
- They make use of applied technology such as smart cards or mobile phones; and
- They are often integrated with a municipal or regional public transport system.

The first generation of bike-sharing schemes began in Amsterdam (The Netherlands) in 1965. Known as ‘white bicycles’, they were used for a single trip and left unlocked for the next person to use. This scheme in Amsterdam helped to increase the number of cyclists, as it offered the possibility of travelling by bicycle to people who did not already own one. The second generation was introduced in 1995 in Copenhagen (Denmark). The main differences with the first generation was the possibility to unlock the bike with a 20 DKK coin deposit that was refunded on bicycle return. The system also introduced an annual membership and fee and was the first large-scale massive bike-sharing scheme with thousands of bicycles available. The third generation was the biggest step in the development of bike-share schemes in the world. For first time, they were successfully introduced outside of Europe and became well known worldwide. This third generation was introduced in 1998 in Rennes (France).

The system has some major differences compared to the first and second generation of bike-share schemes, such as smart card access, automatic docks and stations, real-time information, and offering an initial period of time free of charge.

This European concept has been successfully exported globally. If in the twentieth century, almost all bike-sharing schemes were in Europe, in 2011, there was an estimated 375 such schemes operating in 33 countries in almost every region of the world using around 236,000 bicycles. At the time of writing there are nearly 1,000 bike-sharing schemes around the world with an estimated fleet of more than 1.2 million bicycles. Even though bike-sharing is a relatively new phenomenon, it is already becoming an important means of urban transport in cities all over the world.

Bike sharing has a key role to play as part of sustainable and smart urban transport networks. It provides a complementary transport offer to buses, trains and trams and generates multiple benefits:

- It enables a modal shift from cars, which in turn helps to reduce congestion and transport-related air pollution and CO₂ emissions. By contributing to lower car use, bike-sharing schemes benefit car users as well as the wider city population through reduced road congestion, making the city more attractive to visitors and improving accessibility across all social groups.

- It supports wider goals such as improving residents’ quality of life and health, making city centres more attractive and liveable and creating local jobs for the installation and operation of the schemes.

The reasons for implementing a bike-sharing scheme and the benefits are diverse and differ according to the perspective of the stakeholder. Some of the principle direct and indirect benefits are listed in the table above.

The Bike-Share Planning Guide from the Institute for Transport & Development Policy, helps to bridge the divide between developing and developed countries’ experiences of bike-sharing. It is useful in helping to plan and implement a bike-share system regardless of the location, size, or density of a city. The guide provides the following certain common features that many of the most successful systems share:

- A dense network of stations across the target area, with an average spacing of 300 meters between stations;
- Comfortable, commuter-style bicycles with specially designed parts and sizes that discourage theft and resale;
- A fully automated locking system that allows users to check bicycles easily in or out of bike-share stations;
- A wireless tracking system, such as radio-frequency identification devices (RFIDs), that locates where a bicycle is picked up and returned and identifies the user;
- Real-time monitoring of station occupancy rates through wireless communications, such as general packet radio service (GPRS);
- Real-time user information through various platforms, including the web, mobile phones or on-site terminals at bike-share stations; and
- Pricing structures that incentivise short trips helping to maximize the number of trips per bicycle per day.

In most cases, financial backing is needed as most of the schemes are not financially self-supporting. Most bike-sharing schemes need to be backed by a large transport operator or by public resources, either through direct funding or indirectly through Public-Private Partnerships (PPPs). Most of the services are provided by PPP but there are other operators such as non-profit organisations, public transport (train companies) and local governments. Funding mechanisms include fees paid by users, municipal budgets and public-private partnerships. The following table provides an overview on different bike-sharing business models.

<table>
<thead>
<tr>
<th>Provider</th>
<th>Business Model</th>
<th>Examples</th>
<th>Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advertising Company</td>
<td>Provide and operates system in exchange for advertising rights</td>
<td>Vélib’ (Paris)</td>
<td>JCDecaux (FR)</td>
</tr>
<tr>
<td>For-Profit</td>
<td>Provides and operates system for a profit with minimal government involvement</td>
<td>BiKeR (Białystok)</td>
<td>Nextbike (DE)</td>
</tr>
<tr>
<td>Local Authorities</td>
<td>Contracts with provider to install and operate system for a fee</td>
<td>Bicing (Barcelona)</td>
<td>Clear Channel (USA)</td>
</tr>
<tr>
<td>Non-Profit</td>
<td>Provides and operates system with the support of local authorities</td>
<td>Bycyklen (DK)</td>
<td>CityBike Foundation of Copenhagen (DK)</td>
</tr>
<tr>
<td>Public Transport Operators</td>
<td>Designs, owns and operates the system</td>
<td>ČD (Kroměříž)</td>
<td>ČD railway (CZ)</td>
</tr>
<tr>
<td></td>
<td>Provides and operates system to enhance public transport</td>
<td>Bike House (Teheran)</td>
<td>Teheran Municipality (IR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Call a Bike (DE)</td>
<td>Deutsche Bahn (DE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OV-Fiets (NL)</td>
<td>Netherlands Spoorwegen (NL)</td>
</tr>
</tbody>
</table>
Before the CIVITAS I project MIRACLES (2002 – 2006), efforts were already being made to increase the level of cycling in Winchester, in terms of cycling’s share of the modal split and number of journeys being made by bicycle. The county council had been working with the Winchester Cycle Forum to expand Winchester’s cycle network and ensure the reallocation of road space to cyclists and pedestrians. CIVITAS MIRACLES aimed to build on this work.

The major initiative within this measure was the innovative Bikeabout scheme, focused on continuing improvements to the cycle network throughout the city. The Bikeabout scheme offered members of the public free loan of bicycles. Users paid a one-off registration fee and could then borrow a bicycle as often as they liked, at no additional charge, for up to 24 hours at a time. The scheme was piloted early in 2004 at the University of Winchester and was officially launched during Bike Week in June 2004. By the end of the project Bikeabout was operating from four locations, including the original pilot site at the university and a site close to the railway station. As a result of consumer demand, additional nodes at St Catherine’s Park and Ride and Winchester Tourist Information Centre were introduced in 2005. To complement the Bikeabout scheme, improvements were made to cycling infrastructure and information. Over 200 secure bike stands were installed around the city centre. Where possible, signage was also improved to indicate safe routes linking various public transport terminals, leisure sites, large employers and educational establishments. A pocket cycling map was produced and distributed via information centres, community forums, at sustainable transport events and through the Bikeabout scheme.

Cycle parking surveys showed the peak number of bicycles parking in Winchester increased by 46 percent between 2002 and 2005. This demonstrated that the potential benefits of the Bikeabout scheme were being realised, with some evidence that scheme members were switching from the private car to a Bikeabout bicycle.5

CIVITAS I | Winchester (UK): Creating new cycling opportunities with Bikeabout
During the 1990s, cycling as a means of daily transport was virtually non-existent in Burgos. Although 60 percent of residents were bicycle owners, cycling was regarded as a weekend or leisure activity. Nevertheless, the topography and layout of the city are ideal for bicycle use as it is flat with plenty of wide avenues and green spaces. Some of the reasons for the low modal share of cycling were identified in a 2003 survey. They included the incomplete cycling network, poor weather conditions, and the common perception of cycling as something for young people and students. The measure was therefore designed to increase bicycle use in the city among students and commuters, and to install suitable infrastructure for a bike-sharing.

The BICIBUR scheme was launched in March 2006 with an ambitious plan by the city council to offer the public the possibility of using a bicycle for free for a few hours to travel around the city. A total of 400 bicycles were available to the public, with the aim of offering an alternative to private motorised vehicles and to reduce pollution and congestion. The city council was responsible for designing and developing the system, including bike-share stations accessed by smart card, with the help of cycling and neighbourhood associations. The locations of the stations were chosen according to the need for bicycles on a daily basis. The system features a computerised user point that reads the user’s smart card and provides information on the bicycles that are available, how to travel in the city by bicycle, and how to lock and unlock bicycles and use the stations. All bicycles are fitted with an intelligent recognition system. The bike-share system started with four installations around the city, each with 15 bicycles. Between 2006 and 2008, the system registered over 3,100 members and loaned out over 20,000 bikes. Due to its widespread success, the system was expanded to include 16 bike-share stations, one for each area or neighbourhood in Burgos. The system also now offers 20 electric bicycles for longer trips such as to the industrial zones. To complement the scheme, an additional 15 km of new cycle lanes were constructed in the city, bicycle parking was installed, and maps of cycle network were provided.

The bike-share scheme was successfully established and is in operation in the city. By the end of the CIVITAS II project CARAVEL in 2009, there was a 300 percent increase in cycling. Other actions to promote cycling have given Burgos the highest rate of kilometres of cycle lanes per 10,000 inhabitants in Spain. In addition, more than 230 facilities for parking bicycles have been installed.

The city of Utrecht wanted to further promote cycling and give priority to bicycle as the main mode of transport within the city. A measure called ‘Public and Rental bikes’ was designed with the aim of implementing a bicycle rental system with a dense network of stations to pick up and return bicycles. The goal of this measure was to increase the availability and use of rented bicycles among commuters and visitors in the city. The longer-term objective was to reduce the amount of short trips within the city centre by cars and increase the modal split towards sustainable modes. A large proportion of short trips in Utrecht’s city centre were carried out by car. Many of these could easily be made by bicycle. The results from a survey led to the development of the initial plan to implement several bicycle rental stations located at spots which were attractive to commuters and visitors. It seemed more viable to place 30 to 50 stations at strategic locations in the city than several hundred scattered throughout. After the first feasibility study was conducted, the decision was made to continue the measure within the CIVITAS PLUS project MIMOSA (2008 – 2012). A project group was formed to set up a market consultation and to interview companies that would be able to provide the city with a bike-sharing system from November 2008 until February 2009. The goal was to enter into a dialogue with bike-sharing companies.

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5 Image: © www.disfrutaesburgos.com/
Bike-sharing schemes have expanded rapidly throughout Europe in recent years as cities search for ways to increase cycling, meet increasing mobility demands and reduce adverse environmental impacts. The introduction of technological solutions has resolved many of the problems of vandalism and theft experienced by earlier bike-sharing programs, and bike-sharing is now popular and trendy, especially among younger users. A key ingredient for success in any city is the availability of an extensive and continuous cycling or car-free network.

Apart from the CIVITAS examples mentioned above, there are plenty of bike-sharing systems in European cities, as well European projects and initiatives. Bicing in Barcelona (Spain), Vélib’ in Paris (France), and CityBike in Vienna (Austria) are examples of bike-sharing in major European cities, whereas VeloCittà and OBIS offer insights as European projects concerning bike-sharing.

Bicing was launched in May 2007 with 750 bikes and 50 stations located near metro stations and major parking areas in Barcelona. By 2014, it had expanded to 6,000 bikes and 420 stations. The system is highly accessible with docking stations every 300 metres. Some 22 kilometres of new cycle lanes have been developed to link docking stations with the city’s cycling network. The system has over 180,000 subscribers and the yearly user fee is EUR 47.16 including tax, which makes it the city’s cheapest public transport option for residents. Bicing membership cards are only sent to addresses in Catalonia in an attempt to prevent tourists from using the system. This limitation was agreed between Barcelona
city council and local bicycle hire companies, who feared competition from Bicing. Bicycle hire companies and the city council also agreed to enforce a ten-minute interval between returning a shared bicycle and taking a new one. This is another measure to bar tourists from using the system. As of 2012, two percent of journeys in Barcelona are undertaken through cycling while walking, public transport, and individual motorised transport account for 40 percent, 33 percent and 25 percent respectively.\(^8\)

- The Vélib’ system in Paris is highly accessible with docking stations every 300 metres and more than 230 km of cycle lanes. Launched on 15 July 2007, the system comprises around 14,500 bicycles and 1,230 stations distributed across Paris and in some surrounding municipalities, with an average daily ridership of 96,000 in 2013. Vélib’ is operated as a concession by the French advertising corporation JCDecaux. Since December 2011, Vélib’ has been complemented by Autolib’, an electric car-sharing scheme operating on similar principles.\(^9\) The first half hour of usage is free of charge with a subscription to the system, and an unlimited number of such free trips can be made per day. After the first half-hour, time is charged in 30 minute increments. The aim is to encourage the rapid turnover of bicycles, and the rates are also designed to avoid competition with private bike rental companies. Users need to take out a subscription, which allows for an unlimited number of rentals during the subscription period. Among the 260,000 long-term subscribers (2013), a majority of them use Vélib daily to go to work or school. After one year of operation, Vélib recorded 27.5 million trips, representing an average of eight to ten users per bicycle per day. As of 2010, three percent of journeys in Paris are undertaken through cycling, while walking, public transport, and individual motorised transport account for 61 percent, 27 percent, and 9 percent respectively.\(^10\) Additionally, Paris mayor Anne Hidalgo inaugurated a new bike-sharing system for children called P’tits Vélib’ on 18 June 2014. The new system is designed to teach children and toddlers how to cycle safely within the city. Different models are available for hire for different age groups, and are available from selected locations across Paris.\(^11\)

- Since 2003 Vienna has offered both residents and tourists a low-cost way to cycle in the city via the Citybike system. For an initial registration fee of EUR 1.00, trips under an hour are free. The affordability of the system and offering the first hour for free aims to prevent users from borrowing bicycles for over an hour, an aim which statistics show is being realised - 97 percent of users hire bicycles for less than an hour. As of 2014, 120 stations with more than 1,500 bicycles are available across Vienna. Furthermore, many stations are sited at public transport stops, including metro, tram, bus, and local train stations. This allows users to easily integrate other forms of public transportation with bike-sharing. Bicycle stations are equipped with a touchscreen and offer services such as a station map. Maps are available that show up-to-date information on how full the stations are, allowing users to plan where to return their bicycles after traveling. Stations tend to lie within a kilometre of each other. Problems are communicated directly to the Citybike Vienna team through the station management. In 2014, 580,000 registered users travelled approximately 980,000 trips with a total of three million kilometres cycled. In Vienna, studies show that 50 percent of the journeys taken by car are about five km in length, and could therefore be done by bicycle. Therefore, Citybikes can be used for both functional and leisure activity. As of 2014, seven percent of journeys in Vienna are undertaken by bicycle, while walking, public transport, and individual motorised transport account for 26 percent, 39 percent, and 28 percent respectively.\(^12\)

- The VeloCittà project (2014 – 2017, co-funded by Intelligent Energy-Europe) brings together ten European partners whose goal is to increase the number of people that use bike-sharing. Furthermore, VeloCittà brings together five existing urban bike-sharing systems that are not currently meeting the ambitions they have set. The participating cities are Burgos (Spain), Krakow (Poland), London (United Kingdom), Padua (Italy), and Szeged (Hungary). Possible causes for unsatisfactory performance from individual bike-sharing systems could be insufficient active users or the techniques or the business cases used. The main aim is to identify and solve such market and organisational barriers.


\(^11\) A video about P’tits Vélib’ is available here: http://www.dailymotion.com/video/x1zpufl_le-velib-pour-les-petits-arrive-a-paris_news

\(^12\) Citybike Vienna, Official Site, accessed January 20, 2016, http://www.citybike Vienna.at
Bike-sharing first emerged in Europe as a transportation mode 45 years ago. Since then, bike-sharing systems have evolved to address geographic and technological demands. Bike-sharing has expanded to all continents and its growth also has undergone three evolutionary stages as mentioned above. Notable growth in third-generation bike-sharing systems has led to a diversity of business models, with operators ranging from advertising companies to non-profits. Despite global growth and their clear potential to reduce greenhouse gases and fuel consumption, aspects such as long-term demand and sustainability are uncertain. There are numerous obstacles, such as limited supporting infrastructure (docking stations, cycle lanes), theft, high technology costs, funding considerations, and safety issues. More in-depth understanding and research on bike-sharing is needed. This includes bike-sharing’s social and environmental benefits, a better understanding of the conditions for success, the advantages and drawbacks of different business models, the application of new technologies, and the potential role of public policy in maintaining this mode and supporting its expansion.

A fourth generation of bike-sharing has been proposed to resolve these problems and present an answer to future challenges that builds on the third-generation of bike-sharing. This potential new generation could be based on demand responsive, multimodal systems, improving safety, comfort, access, and ease of use. This emerging bike-sharing generation is characterised by flexible, clean docking stations, smartcard integration with other transportation modes such as public transportation and car sharing, and other technological advances including free-roaming, GPS-tracked bicycles that do not need stations, touch screen kiosks, and electric bicycles.

There is a wide range of technology options for bike-sharing depending on the level of investment available to the scheme operator and the benefits for the user. However because of the varied nature of the different options available, it is unlikely that one single development will be recognised as the future standard. The table below summarises the key components of a bike-sharing scheme and the most relevant technological innovations.
<table>
<thead>
<tr>
<th>Component</th>
<th>Relevant technologies</th>
</tr>
</thead>
</table>
| Bicycles                   | - Real-time on-bike information on navigation, public transport schedules, local events, information about the bicycle (such as remaining battery charge) and the availability and location of nearby docking stations
- GPS tracking to aid positioning and navigation systems, reduce risk of bicycle being lost or stolen, or reduce the need for docking stations
- Solar panels fitted to bicycles to power electronic components
- Pedal generators applied to electric bicycles and cargo bikes and reducing the need for batteries and charging infrastructure
- Accelerometers to detect a bicycle being moved or interfered with without authorisation
- Sensors to detect attempts to tamper with or break locks
- Better design and use of more advanced materials to make bicycles robust but lightweight
- 'Smart' bike locks that fit to standard bicycles and connected with smartphone apps, allowing small-scale bike-sharing schemes where individual owners can offer their own bicycles for hire |
| Docking stations           | - Mobile stations that can be relocated by the operator to match demand at short notice
- Stations that collect energy generated by cyclists to feed it back to the grid
- Free-roaming, GPS-tracked bicycles that do not need stations, improving convenience and reducing installation costs
- Designation of areas where users are encouraged to return their bicycles in schemes without fixed stations as a means of reducing unpredictable distribution |
| User payment and access systems | - Ticketing systems integrated with wider public transport network so that users with smartcards for other modes do not need a separate key or smartcard to access bike-sharing
- On-bike payment systems for payment without kiosks or stations
- Payment through use of saved account details for other online purchases |
| ITS Technology             | - Integration of data into online journey planners so that details of bike-sharing options appear alongside alternative options for travel by default
- Integration of bike-sharing with wider fares system so that multimodal tickets can be purchased which cover bike-sharing schemes
- Use of smartphone applications for journey planning and real-time information on the availability of bicycles and stations
- Use of smartphone applications to connect individual bicycles owners and users in a peer-to-peer bike-sharing system – negating the need for a single public provider |
| Bicycle distribution system | - Locking technology fitted to bicycles as an alternative to stations, which have limited capacity |
| Peer-to-peer               | - Integration with existing bike-sharing schemes or bike rental
- Integration with car sharing or other peer-to-peer services |

In order to maximise the benefits, bike-sharing schemes should be fully integrated in a city’s public transport system and available to the widest range of users by being as user-friendly as possible. This can best be achieved through the use of Intelligent Transport Systems (ITS) and by offering inclusion of electric bicycles. ITS is a cross-cutting theme EU transport policy, as it can contribute to a large number of key objectives and strategic priorities including sustainable and resource-efficient transport, reduced congestion, and road safety. The integration of ITS in bike-sharing schemes is important for policymakers in order to maximise the value of their investment and the benefits of the scheme to users. Electric bicycles will increasingly be included in bike-sharing schemes as a way to attract new users and extend the reach of the scheme by allowing riders to cover longer distances. They offer a larger potential for use as car substitutes in more sustainable and smarter cities.