

THE IMPACT OF ELECTRIC BUSES ON URBAN LIFE

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INTRODUCTION

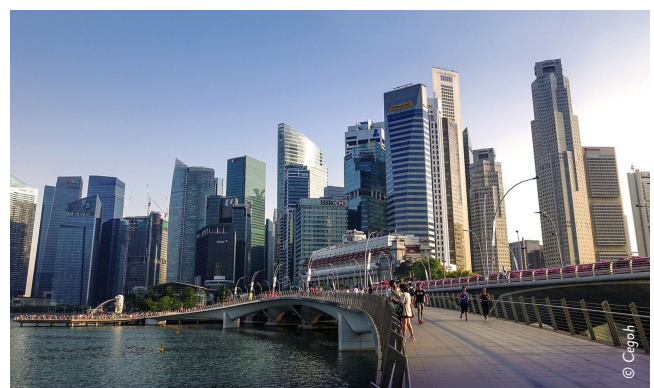
To meet their transport emissions reduction targets, many cities are setting up transport strategies, considering electric mobility and more specifically electric buses for their public transport networks. These political choices are part of cities' efforts to improve air quality in urban spaces, not only to take part in the global effort to combat climate change but also to make cities healthier places to live in. Apart from the positive local impact of electric buses on cities' air quality, these changes have infrastructural impacts on urban space and on the organisation of the transport network. Impacts will vary according to the technology chosen and the level of deployment. Rethinking the interface between the bus and the urban infrastructure may result in a better integrated mobility and higher quality of life in cities.

The objective of this policy brief is to provide decision makers, urban planners and authorities with an overview of the benefits electric buses can bring to cities and to help them understand their various infrastructural impacts on urban spaces and space needs.

BENEFITS OF ELECTRIC BUSES FOR CITIES

INCREASING URBAN QUALITY OF LIFE: AIR QUALITY AND HEALTH

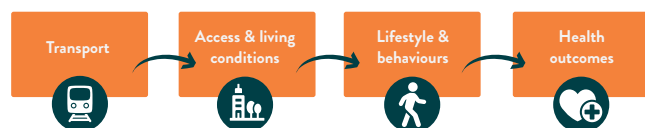
Today in Europe, GHG emissions linked to transport account for 25% of total GHG emissions of which urban buses account for 8%¹ (per passenger per km). Renewing and modernising bus fleets to cleaner technology, is always an opportunity for cities to improve the quality of transport and reduce polluting emissions, despite the technology chosen (lower norm of diesel, CNG or electric). Electric buses are part of this renewing process to modernise a network and improve air quality. By replacing their conventional buses with fully electric buses, cities wish to cut CO₂ emissions linked to transport and fine particles at exhaust such as PM and NO_x which are known to have negative effects on citizens' health. Since fully electric buses do not emit any emissions at tailpipe and are quiet, they are often put forward in political strategies to enhance health and quality of life in urban centers.



1. EU Commission Expert Group on Clean Bus Deployment; D2 Procurement and Operations.

Many cities in Europe, but also across the globe, are deploying transport strategies to make a shift from individual car use to public transport, walking and cycling in order to achieve their goals of emissions reductions. London's transport strategy aims to have 80% of all trips by either public transport, cycling, walking or zero emission buses by 2025. By 2050, London aims to have a zero emission transport system. Paris has the same objective to transform its bus fleet to electric or bio-CNG by 2025.

Electric buses represent one important link in a mobility strategy chain, but their positive impact will be maximised if the transport network is efficient, accessible and of quality. Those factors are usually the main incentives to attract customers, pushing citizens from individual transport and pulling them to the public transport network. All of this combined will have a significant impact on air quality, and citizens' quality of life and health. However, special attention must be put on the cost and benefit of electric buses, considering the long-term financial impacts in terms of health benefits compared to the financial cost of the system.



Relationship between transport and health²

FOSTERING THE CITY'S ATTRACTIVENESS

An efficient and attractive bus network has a strategic importance for a city. It promotes and relays, along with the other transport modes, the image and the attractiveness of the city, fostering social cohesion and economic dynamism. Integrating and implementing electric buses in a public transport network is an opportunity for cities to review their mobility strategy and the image of the bus in the city. Redefining the interface between the bus and the urban infrastructure can greatly contribute to provide a more integrated and safer access to bus services, and thus improving the perception of buses in cities.

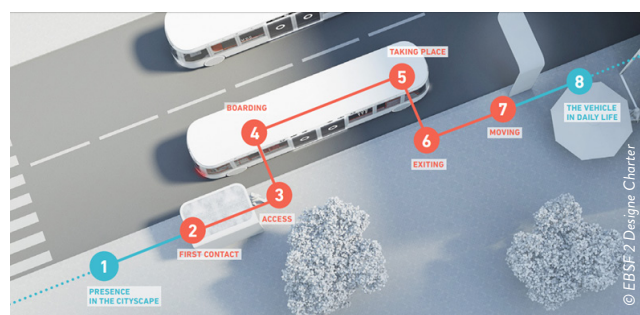
From a marketing point of view, renewing a bus fleet is a tool for cities and public transport companies to market the improvements on the public transport system. It shows their dynamism, modernism and that they care and respond to citizens and customers' needs and expectations. Electric buses can increase this awareness with innovation, and the positive impact on clean air and noise reduction.



92% of RATP (Paris) users riding on electric buses think it will contribute to better air quality and 93% of them say it enhances the images of the operator and shows that the operator cares for its customers.

RETHINKING THE DESIGN OF THE VEHICLE AND ITS STATIONS

The technology transition is an opportunity to innovate in terms of vehicle and infrastructure design and bus integration in the city. An electric bus is an innovative urban passenger vehicle. It is appealing for public transport and enhances cityscape, representing a new modern urban object. It improves customer experience and boosts the city's image. Electric buses allow designers to envision a new architecture for the whole bus experience: from re-vamping the bus and bus stations' design, to their accessibility, visibility and integration in the urban landscape. To get the full perspective of the bus ecosystem, the Design Charter has integrated the views of passengers, operators, manufacturers and city leaders. It puts forward the presence of the electric bus in the city and how recognisable it is in the urban landscape: from the first contact of users at the stations to its access and the boarding.³



The improvements done on a bus system can have a positive impact on passengers' perspectives and the modal shift. These improvements can include:

- Cleaner technology
- Improvements to bus stop design
- Improvements to vehicle design
- Cleanliness
- Comfort

The improvements attract citizens to the network, increasing ridership and therefore revenues for public transport companies.

2. UITP, (September 2018). Integrating Mobility Health Impacts in Decision making. Policy Brief.

3. European Bus System of the Future 2, (2017). Design Charter for Innovative Electric Buses.

INDOOR BUS STOP IN GOTHENBURG

Gothenburg (SE) has demonstrated the feasibility of an 'indoor' bus stop for increased attractiveness of bus systems, while solving technical challenges associated to maintaining a comfortable temperature. This innovative bus stop has been appreciated by travelers (83%) and the trend appears to be consistent since it was launched within the frame of the ElectriCity Project⁴. The majority of travelers appreciate the total sheltering from weather, the cosy-looking interior design and the possibility to board the bus at any time.

This indoor bus stop clearly shows that the technology can be successful and benefit the passengers.



IMPACT OF CHARGING INFRASTRUCTURES ON URBAN SPACE

For municipalities and public transport companies, shifting from conventional buses to electric buses implies some fundamental changes, depending on the scale of deployment.

Following the results of the ZeEUS project⁵, the planning phase is crucial for the success of future electric bus systems. A wide range of stakeholders will have to identify together what solutions will meet the needs of the city strategy, and decide on the scale and pace of deployment. Choosing the right technological solution according to the local context, natural conditions and operations specificities is a real challenge that requires close collaboration between the city authority and all involved stakeholders. This can be facilitated by an in-

depth feasibility study on the system needs, which will support the decision on which application and technological solution are the most suitable for the operational environment and urban structure.

OVERVIEW OF CURRENT CHARGING STRATEGIES AND TECHNOLOGIES

Today, there are three main charging technologies:



Low power charging through cable and plug-in (overnight)



High power charging through conductive charging with physical connections



Fast charging through inductive charging with a transfer of energy through a magnetic field for fast charging

With regards to the charging strategies, the below underlines different possibilities:

- **Opportunity charging:** (low/high power) which consists of charging the bus along the line, either at selected bus stops or at the head/end of the line using inductive or conductive charging. Both technologies allow quick charging through high power. The bus can either charge when needed along the line at the available charging points or is required to charge along the line at pre-identified charging points. Batteries need to fully recharge overnight as well. This charging strategy enables the operator to use small batteries, but these will need to be suitable to high power.
- **Overnight charging:** (low power) which consists of charging the batteries at night in the depot using plug-in or conductive systems. The battery is charged when the bus is stored in the depots. This system requires large and heavy batteries to store enough energy.
- **Combining depot charging and opportunity charging:** (low/high power) which consists of both low power charging over night at the depot and high power opportunity charging at head/end stations or at the depot. It allows smaller batteries sizes.

4. Electricity, (2019). Exciting cooperation for sustainable public transport.

5. www.zeeus.eu

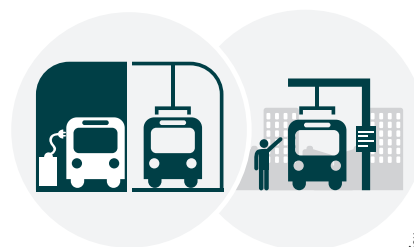
DEPOT CHARGING



OPPORTUNITY CHARGING



COMBINATION



Source: Heliox

In the case of battery trolleybuses, the In-Motion-Charging (IMC) technology allows the trolleybus to operate off-wire along concrete parts of the route. This increases the flexibility of the operation (maneuvering, route deviations, etc.) and requires less catenary length.

In brief, depot charging requires larger batteries on board and investments for a large set of chargers and the associated charging intelligence. Opportunity charging allows smaller batteries on board and requires building infrastructure at the selected locations.

IMPACT ON PUBLIC INFRASTRUCTURE AND SPACE

The different charging systems have different infrastructural, space and visual impacts on the city.

Opportunity charging requires building new infrastructures to provide the energy and charge the vehicles along the line. The city has to find and make space for those infrastructures, and/or segregate the space for the buses so that they can charge properly without being blocked by parking vehicles and without stopping the general road traffic. For buses charging at end stations during the operations, a number of charging points might be necessary which may require substantial urban space to allow smooth charging and easy bus manoeuvre. The amount of space needed will depend on the number of bus lines, the headways and schedules. The charging infrastructure and the need for exact positioning of the buses at the roadside contact systems have direct implications on

the design of terminal bus stops, waiting or parking areas and terminal loops. Generally, there is a demand for an increase of 15-30% of floor space^{6,7}. Together, with the city and the energy provider, the public transport company has to design the network and identify suitable spaces.

NAMUR ELECTRIC SUBSTATION

In Namur (BE), electric buses are charging overnight and also using opportunity charging at the end of the line, which required the installation of an electric substation. This substation has been integrated close to the charger. The visual integration can also be considered in future urban developments.



6. <http://ebsf2.eu/>
7. www.zeeus.eu

Conductive charging poles for pantographs as well as electric substations have a visual impact on the streets and their surroundings. Municipalities may therefore want to regulate their design to comply with the visual identity of the city. Moreover, the installation of surface charging infrastructure needs space underground for infrastructure foundations and may also infringe some safety and public space regulations or other specific regulations. An example of this is the snow regulation in Stockholm for the design of urban objects to make them compliant for safety issues.

STOCKHOLM SNOW REGULATION

In Stockholm (SE), the pantograph design and location (kerb, sidewalk) have to comply with the snow regulations. This is to keep passengers or pedestrians around the bus station safe from accumulated snow falls.



Inductive (wireless) charging from the ground has no direct visual impact but needs space underground and heavy construction works to accommodate the charging devices. Depot charging may require less on-street infrastructure building. However, depots need to be adapted to park the buses efficiently for their charging time, their manoeuvre, to house the necessary equipment for the energy supply as well as the IT systems managing the charging, which is essential in the case of larger fleets. The public transport company will also have to ensure that enough power is served by the electricity network on the spot. These elements may lead to the need of either building new depots or enlarging existing ones due to higher space demand. Moreover, the location of the depot will need to be reviewed to operate electric buses efficiently. The (re)development of bus depots might also be an opportunity for their transformation and modernisation with ambitious building programmes combining different purposes, e.g. housing, offices, commercial or other services.

For city authorities, the large-scale deployment of electric buses requires careful planning in close collaboration with the public transport company and the energy supplier.

INDUCTIVE CHARGING IN LONDON

In London (UK), Transport for London tested inductive charging, with a semi-automated charging process at both ends of a busy route with high frequency. The experiment carried out was positive: no visual intrusion and a high level of route electrification. Drivers and passengers also like the buses due to a smoother ride. The placement of the inductive chargers needs to be carefully considered to maximize ease of approach. Operational improvements can be made around ensuring charging of buses is carried out all the time. There are heavy installation requirements to ensure the ground stability for the exact positioning of the bus. The ground works for the installations of the chargers are very demanding and require significant excavation and sub-surface capacity.



The city will need to consider the accessibility impacts of the charging infrastructure, competing space with active travel modes and other accessibility requirements (e.g. wheelchair, baby carriages etc.), as well as other space demands for sub-surface services capacity such as additional power cables or media cables. The city shall support the provision of the required urban space, for example, the installation of new power cables to bring the energy to stations. This space might not be available or might be scarce. Additionally, it will require the support from the energy provider to advise on suitable connection points.

When implementing the charging infrastructure in public spaces, the following field of applications need to be considered:

- Acquisition of land
- Cable routing on public roads / pavements
- Road markings for bus stops
- Compliance with limit values according to noise guidelines
- Installation approval in public space areas
- Bus stop design
- Design of the charging equipment and its immediate surroundings
- Safety aspects of the charging infrastructure

EINDHOVEN BUS DEPOT

In Eindhoven (NL), buses recharge at the depot using opportunity and overnight charging. The bus depot is located less than 1km away from the head and end of the line.



PARIS CENTRAL BUS DEPOT

In Paris (FR), RATP will adapt 25 bus depots for its future electric buses and bio-CNG fleet. All bus depots are centrally located or in the near peripheral area. One bus depot is under a residential and office building. The electric buses will run with high battery capacity and recharge overnight. Paris region plans to have 100% of clean vehicles by 2025.



The selected electric bus technology and charging strategy should be adapted to the general urban structures and the required bus operations, and not vice-versa.

BENEFITS OF SHARING EXISTING PUBLIC TRANSPORT INFRASTRUCTURE FOR ENERGY PROVISION

In terms of energy supply, the deployment of electric buses can create some challenges for the energy grid. To power full electric bus fleets, reinforcements on the grid are often needed to support the charging, especially in the case of fast charging. The city and the transport authority have to ensure that there is enough power available in the city and for the network to charge the buses. Making use of the existing electric infrastructure from the tram or metro networks may represent a potential for electric buses and should be considered from the start of the planning. Taking advantage of transport hubs at rail stations or at main metro or tram stations, by using them as central recharging points for several bus lines, can be a considerable gain of space and money.

Moreover, making charging infrastructure available for other types of users such as shared cars, shared bikes, and other electric vehicles including freight can optimise the benefits of the e-mobility uptake for cities. Checking that the electricity can be made available is also essential, as most cities are restricted from providing access to the public transport grid to bus operators or other e-mobility services. Relaxing some regulations may be required to optimise the power demand. As demonstrated in the ELIPTIC Project⁸, the lack of city-wide charging infrastructure is a barrier for the deployment of electric mobility. Making public transport charging infrastructure available for all types of electric vehicles (e-buses, e-cars, e-bikes, e-trucks etc.) could be much more cost-effective than standalone infrastructures but this should not endanger the public transport service provision.

There are often complex relationships and contracts between the various stakeholders and the regulations with regards to the use of the grid. In these cases, some public transport companies running metro or tram networks may prefer to have their own grid and build their own infrastructure for electric buses, allowing them to control, manage and maintain the system independently. Having the energy managed by the city or the transport authority could facilitate the work of operators willing to turn to electric buses and push for standardisation.



Standardisation and interoperability of the charging infrastructure is key to enable fleet upscale and meet the needs of cities and public transport companies in terms of e-mobility strategies and plans.

METRO STATION AS ENERGY SUPPLIER IN BARCELONA

In Barcelona (ES), a pilot is currently in operation, consisting of two metro electric substations. It supplies energy to an en route opportunity charging station for one electric bus line, seven opportunity and two overnight charging stations at the depot, Triangle. This test could be carried out upon solving the legal challenge that did not allow the metro company to act as an energy supplier. The test was carried out in partnership between the two TMB group sister companies FMB and TB.



TRANSPORT PLANNING AND OPERATIONS

Introducing electric buses in a fleet does not mean replacing one type of bus for another.

In fact, the whole system changes; from the planning to the operational phase. The training of the staff and the safety aspects will also have to be reviewed.

PLANNING

According to the results of the ZeEUS Project, one of the main challenges that city authorities and public transport companies face when implementing fully electric bus systems is their capacity to plan the operations and re-design the network. Low and high power charging technologies have different impacts on the scheduling of the systems. Cities need to be aware that the deployment of fully electric bus fleet implies a good planning phase and system design in cooperation with all stakeholders involved.

8. ELIPTIC Project⁸ is a EU Horizon 2020 project which evaluated various approaches and technologies for electrifying public transport. The project demonstrated that the further take-up of electric vehicles can be done in a cost efficient way by integrating multi-purpose charging into existing public transport infrastructures. More information available at: www.eliptic.eu

OPERATIONS MANAGEMENT

Once the operational context has been analysed and the charging strategy identified (depot charging, opportunity charging or a combination of both), the operators will have to review its operations to take into account the driving capacity of the buses. Designing the optimal electric bus technology, charging strategy and bus operations can also be done in parallel with the involvement of all actors.

The range, which is the maximum distance that the bus can be driven on fully charged batteries, is influenced by: routes topography and characteristics, weather conditions, weight of the vehicle, number of passengers, driving style, and vehicle efficiency.

During the design phase it is therefore necessary to take into account the following aspects:

- Average and maximum mileage per day
- Service scheduling (frequency, stopping time, charging time in depot and/or at fast charging stations)
- Line route and topography
- Position of the bus depots and position of the opportunity charging equipment
- Availability of power supply for charging equipment
- Climate conditions

In the case of depot charging systems, the battery capacity will determine the range of the bus, thus the routes and schedules. As batteries take a substantial amount of space and weight in the vehicle, the amount of passengers on the bus could be reduced. The operator might then need to run additional or larger buses. However, this is set to become a lesser consideration as technology emerges. The RATP Bus Project 2025 shows that their depot charging scheme does not have any impact on the number of passengers. This is also emphasised by studies recently carried out in Oslo (NO) by Ruter, showing that recent developments in bus lightweight body design allow the needed maximum passenger capacity even for buses with big batteries. However, the empty weight of the bus should be checked before purchasing the buses as there are big differences in the market. The location of the depots have to be well analysed, considering the distances to cover. It is estimated that depot charging configurations are best when located in cities centres or close to bus routes. The combination of low power depot charging and high power opportunity charging at end stations or bus stops gives more flexibility to the operator. However, this system may require some additional buses on the lines to replace the charging buses during the operations to maintain the same level of service.

BARCELONA EN ROUTE OPPORTUNITY CHARGING

Two studies were carried out in Barcelona to simulate the operation of two future fully electric premium bus routes:



one horizontal (flat) route



one vertical (mountainous) route

En route opportunity charging stations (EROCS) were located at both ends. These studies showed that, in order to keep the same operating level of service as for non e-routes:

- Two EROCS are needed for a horizontal route, with one at each terminal. Whereas only one EROCS is needed for a vertical route, at its lowest terminal
- Two charging points are needed at each EROCS
- Their total number of buses must be increased by 10% on both horizontal and vertical routes

OSLO BATTERY BUSES

In Oslo, Ruter will expand to 115 electric buses during 2019. 72 articulated buses will charge at the depots, using 300kW high power charging via pantograph. Two examples for weight of batteries and vehicles (without passengers) are listed below.

Mfg	Battery capacity	Battery weight	Vehicle including battery
1	348kWh	2,600kg	18 tons
2	170kWh	3,000kg	21 tons

@ Ruter

For full opportunity charging systems, no additional buses should be needed as the bus is available all the time for the operations and charging times are included in the scheduling. Nevertheless, reserve buses are needed in case of problems occurring on the line.

There is no one size fits all approach.

Urban density and travel demand need to be well considered and analysed to ensure buses will be able to cover the travel demand.

TRAINING SKILLS AND SAFETY ASPECTS

The training of bus drivers and bus maintenance personnel is also an important part of the deployment of electric buses. Yet, it can be challenging. This is why some operators may prefer to sub-contract this work to the manufacturers. Battery technology requires new technical skills in terms of vehicle handling, driving, maintenance, etc. Public transport companies managing their energy grid, with qualified staff working on the rail infrastructure (tram or metro), they will have a great advantage as they already have the knowledge and experience of electric infrastructure.

The deployment of electric buses and fleets imposes new requirements for maintenance in terms of safety aspects, due to the new type of equipment in the garage and on board, new tools for fleet management and maintenance. Apart from the general trainings such as maintenance of buses and equipment, energy equipment use and energy-efficient bus driving methods for drivers, staff will also need to be trained on safety aspects and emergency procedures.

First responders such as firemen, police, and other rescue services will also need to be trained on the specificities of electric buses and their related charging technologies to know how to deal with incidents. All staff involved in the operations of the electric buses should be trained to ensure a good understanding of the vehicle's technology, the charging infrastructure components, the safety aspects and the reporting procedures in case of failures and challenges related to their operations.



COOPERATING WITH THE INTERNATIONAL ASSOCIATION OF FIRE AND RESCUE SERVICE

To help rescue services respond when a new technology is introduced, UITP and the International Association of Fire and Rescue Service have signed a MoU on bus safety specifications to inform first responders in case of traffic accidents involving buses. This will promote the use of the ISO standard 17840 and help make new propulsion vehicles recognisable through specific pictograms. It will provide rescue sheet and emergency response guide to rescue teams.



CONCLUSION

Deploying electric buses in a city, as part of an integrated mobility strategy, is an opportunity to rethink the design of the bus system, improve the quality of the service, its interaction with the urban space and boost the image of the city. However, deploying fully electric bus fleets have infrastructural and visual impacts on the city. Planning and building charging infrastructure takes time due to procedures and required permits for the civil works, installations of the connections and storage capacity. These constraints must be properly planned not to delay the operations. To ensure an efficient deployment, electric buses and their infrastructures must adapt to the general urban structures and bus operations schemes.

Deploying electric buses is not the only solution to solve the problem of air quality in urban spaces. To help cities achieve their goals to become healthier places to live in, electric buses have to be part of a zero emission mobility strategy including investments in an efficient public transport network, walking and cycling infrastructures and traffic calming measures. Before any decision, it is crucial to carry out an in-depth feasibility study on the suitability of the technology given the local context, including operational, regulatory and funding frameworks. As the technology is evolving fast and batteries efficiency will improve in the coming years, decision makers should consult 'sister' cities with previous experience to gain insights into technical aspects and implementation processes. A step-by-step approach with a gradual upgrade of the system, focusing first on priority zones with critical air pollution levels can be a first step.

Consider electric buses as part of a zero emission mobility strategy and not as the only solution.

BEYOND CLEAN FLEETS RENEWAL, TOWARDS LIVEABLE CITIES



RENEWAL OF OLD BUS FLEETS
TOWARDS CLEAN TECHNOLOGIES



**POLICIES TO FOSTER
THE MODAL SHIFT TO
MULTIMODAL PUBLIC TRANSPORT**



**MULTIPLIER EFFECT ON AIR
QUALITY, URBAN MOBILITY,
CITIZENS' HEALTH**



FULLY ELECTRIC BUS FLEET

Shenzhen Bus Group Company Limited is a story that is catching international media attention. Shenzhen (CN) is the only city in the world to have converted its entire bus fleet of 16,700 buses to electric buses. Their fleet is larger than that of the rest of the world combined. They were instrumental in bringing electric buses from an experimental stage to a viable product. The maintenance regime is digitalised and data-driven. Shenzhen Bus is slowly setting a global benchmark for other bus companies around the world to follow. They also operate one of the largest electric taxi fleets.

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RECOMMENDATIONS

- Consider electric buses as part of a zero emission mobility strategy and not as the only solution
- Upgrade fleet to fully electric according to the city's needs and strategy and/or its electric mobility strategy (or equivalent), setting the frame of the electric bus deployment plan
- Identify the most suitable solution based on the city's characteristics and bus operations needs
- Apply the 'system approach' to identify stakeholders and set up cooperation at each stage of the project (planning, installations and operations)
- Know local regulations and policy framework for efficient planning and installation process, avoiding delays (permissions and connection points)
- Consider the physical impacts in the city: charging poles design, urban space needs and space for electric bus depots
- Develop a set of recommendations/indications on the visual impact that public transport

infrastructures (bus stops, charging points, power substations and transformers, etc.) have on the public space in order to make them compliant with the city's visual identity

- Consider the strategic positions of bus depots for efficient operations
- Plan for the extra buses according to the strategy and technology chosen, and maintain the same level of service
- Standardise the charging infrastructure and make it interoperable for other bus operators and other e-mobility services
- Share the grid between bus operators and other e-mobility services without impacting the service
- Carry out a feasibility study to understand operational framework conditions
- Consider the long-term financial impact in terms of health benefits compared to the financial cost of the system
- Exchange with experienced cities, knowing that a one-size-fits-all solution does not exist



This is an official Policy Brief of UITP, the International Association of Public Transport. UITP has more than 1,600 member companies in 99 countries throughout the world and represents the interests of key players in this sector. Its membership includes transport authorities, operators, both private and public, in all modes of collective passenger transport, and the industry. UITP addresses the economic, technical, organisation and management aspects of passenger transport, as well as the development of policy for mobility and public transport worldwide.

This Policy Brief was prepared by the UITP Transport and Urban Life Committee, a working group of international public transport strategy and planning experts. The goal of the Committee is to create better cities for people to live in through the better integration of public transport and urban planning, economic development and social inclusion.

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