CHAPTER

7

Sustainable Urban Mobility in Action

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OUTLINE

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INTRODUCTION

There are a large number of possible interventions local authorities can initiate in their jurisdiction that can influence travel behavior, vehicle choice, and use. Local authorities have a key role to play in shaping *urban form* and planning local transport *infrastructure*. With integrated *urban planning* and the ability to regulate, fund, and often even operate public transport services a (small, medium, or large) city can shape the modal structure of its transport system substantially. Several policies that can influence the energy efficiency of the transport sector are driven by the national (e.g., vehicle and fuel tax) or European level (e.g., fuel efficiency regulation), but there are several local policies that can have a similar effect on the choice and use of vehicles, such as road and parking pricing or access limitations (Lah, 2017b).

Within the framework of sustainable transport planning, a package of complementary measures is required to actively manage travel demand and improve transport energy efficiency. This includes improvements to the public transport system as a reliable and affordable alternative to the private car and measures targeting the efficiency of the vehicle fleet (Sims et al., 2014). This section will explore some of these measures and in doing so will focus primarily on measures that can be implemented at the local level. The climate change mitigation potential of these measures will then be tested in two case study cities.

Vital to the success of sustainable urban transport concepts is a mix of measures that improves the efficiency of the vehicle fleet, reduces travel distances via integrated land-use planning, and provides modal alternatives to the private vehicle. Whereas the vehicle fleet policies fall only partially in the jurisdiction of city councils, the land-use planning and modal efficiency are key areas of responsibility for local governments.

Integrated Urban Planning

Integrated land-use planning focuses on higher densities, mixed use, and the integration of public transport and nonmotorized transport

infrastructure. Combined, these factors can reduce travel distances, can enhance the role of nonmotorized modes, and can improve the accessibility and efficiency of public transport. Smart land-use planning only takes effect over longer time scales, but impacts are lasting (Caspersen et al., 2006). Local authorities can largely influence future travel patterns. Thereby, land-use planning decisions of today can ease the traffic management task in the future. Cities can limit the increase in car use and dense urban structures, with mixed-use playing an important role in achieving an efficient transport system (Aljoufie, 2016). Integrated urban and transport planning improves a city's connectivity, providing a better mobility service and shorter trips for inhabitants, and bringing people and places closer together. As part of this, cities may want to consider integrating fares, infrastructure, and operations for integrated public transport planning, and create easy connections with nonmotorized transport (SOLUTIONS, 2016c). Cities that have applied this successfully, such as Copenhagen and Freiburg, show that by properly integrating public transport planning with wider urban planning and nonmotorized infrastructure, urban mobility is more convenient, efficient, and provides better access to services, jobs, education, and social activities. Mega cities prominently feature large investment in public infrastructure as they typically attract greater attention from the national government, whereas medium-sized cities may need even more direct support to develop tailored mobility solutions as they often lack planning and policy capacities.

Sustainable Urban Mobility Planning

Sustainable Urban Mobility Plans (SUMPs) can serve as strategic planning documents that guide the integration of all transport modes and work toward a sustainable transport system within a city (Bongardt et al., 2013). The development of a SUMP includes a number of steps from the identification of the main transport issues in a city, to the development of a joint vision and the identification of specific measures and a process to implement actions (SOLUTIONS, 2016c). The European Commission provides detailed guidelines, which aim to help cities in the development process (http://eltis.org/content/sump-process). A vital component of the process of developing a SUMP is the involvement of stakeholders and the active participation of the public, through dialogue to identify mobility problems, find common objectives, and in selecting solutions (SOLUTIONS, 2016a).

Planning for Sustainable Transport Solutions

The SUMP Guidelines developed under EU-funded projects set out a strategic planning process for local authorities, fostering the balanced development and integration of all transport modes while encouraging a shift toward more sustainable modes. A SUMP aims to solve urban transport problems and contribute to reaching local and higher level objectives for environmental, social, and economic development. A SUMP can help reveal the real challenges that a city faces and explain how conditions will change if the city remains on its present course. It can help ensure that transport proposals are based on a sound understanding of the existing transport system. The process of preparing a SUMP can also help a diverse group of stakeholders to support a common vision and agree on packages of mobility measures to improve the transport system in their city. A successful SUMP can provide a feasible and powerful strategy to tackle urban mobility challenges. Developing a SUMP is an innovative, integrated planning process requiring intensive cooperation, knowledge exchange and consultation between planners, politicians, institutions, and local and regional organizations and citizens, which can be a helpful tool to generate support and create coalitions.

SUMP guidelines: http://www.eltis.org/guidelines/sump-guidelines

Urban Access Regulation

Low-Emission Zones

Restricting access to certain areas of a city, normally the city center, can have a direct effect on local air quality noise pollutions and traffic safety in this area. The effect on greenhouse gas (GHG) emissions depends on the design and complexity of the scheme and the provision and integration of modal alternatives. Access restriction schemes (ARS) are applied in many cities in Europe in different forms and generally aim to restrict access to city districts or specific traffic hotspots in the city (Cervero, 2005). The main objectives are to reduce congestion and pressures on parking spaces, improve safety, and reduce noise and harmful emissions. Basic ARS are easy to adopt, but require enforcement efforts to operate in the intended way (Santos, 2008). There are different types of ARS, including those that control access at specific points (e.g., when crossing a bridge), cordons or areas (e.g., around a specific location), which may differentiate further between different types of vehicles or times of the day. While these schemes can be very effective in managing congestion, noise, and air pollution, they may

have unintended consequences, for example, by banning higher polluting, but potentially more fuel-efficient diesel cars from entering the city, which may induce travel by redirecting to longer routes or encourage the shift to a less-efficient petrol-powered car. Hence, access restrictions should be implemented in combination with other measures that minimize tradeoffs.

Urban Road Tolls/Congestion Charges

One very effective option to improve traffic flows and reduce overall travel demand by avoiding and shifting traffic to more sustainable transport modes is congestion charging, which is an urban road pricing scheme for peak hours (Börjesson et al., 2012; Liu et al., 2009). Congestion charging lies at the intersection of traffic management and travel demand management, as information gained from real-time traffic information systems could be used to improve the pricing mechanisms of congestion charging by introducing real-time variable pricing systems, which can encourage more efficient travel behavior. Congestion charging systems have been operating in Singapore for several decades and were implemented more recently in London and Stockholm. As early as 1975 road pricing was implemented in Singapore to manage the choked streets of the rapidly growing city. First, an Area License System was established, which required a permit to enter Singapore's central area (Ang, 1990). The city entry charge boosted public transport patronage almost immediately after its introduction and led to a 45% reduction in traffic, road site accidents decreased by 25%, and average travel speeds increased from about 20 km/h to over 30 km/h (Lah, 2015b). The system resulted in a public transport share of over 60% in daily traffic, an increase of nearly 20% (SOLUTIONS, 2016b). The success of the system in improving infrastructure capacity, safety, and air quality and reducing travel demand, fuel use, and GHG emissions inspired the congestion charge systems in London and Stockholm, and provided the basis for several feasibility studies for similar schemes for cities around the world (Prud'homme and Bocarejo, 2005).

Good Practice

Despite being a midsized city, Gothenburg in Sweden decided to introduce a congestion charging system in January 2013, which has already been shown to be effective in reducing traffic by over 10% during the charging hours and a similar increase in public transport

continued

ridership. The case of Gothenburg shows that these types of schemes are not only applicable for large cities, such as London and Singapore, but also for midsized cites. The congestion tax applies when drivers enter or exit the congestion tax area and varies depending on the time of the day, from 0 during the night, on weekends, and holidays, to 22 SEK (around €2.30).

More examples: http://urbanaccessregulations.eu

Public Transport Infrastructure, Operation, and Vehicles

A reliable and affordable public transport system is a key element of sustainable urban transport. While providing a similar level of mobility, public transport only requires a fraction of the energy and space compared to a private car. Public transport not only contributes to lower energy consumption and emissions, it also reduces congestion, which improves traffic flows and reduces travel times. As public transport is typically more than twice as energy-efficient per passenger kilometer as individual motorized transport, enhancing the share of public transport in urban passenger transport yields the potential to mitigate rising energy consumption and emissions (Sims et al., 2014). Thus, it contributes to the objective of reducing congestion and at the same time is part of the wider concept of sustainable urban transport. Vital elements to shift transport demand from individual motorized transport to public transport are investments in capacity and reliability and physical integration with walking and cycling affordability and park & ride facilities. Reliability is an important factor for modal choice. The predictability of travel times with metro (MRT), light rail (LRT), and/or bus rapid transit (BRT) compared to a journey in a private car may provide enough incentive to shift from individual to public transport (Brownstone and Small, 2005; SOLUTIONS, 2016c). Public transport systems generally require substantial public investments and the operation often requires continued subsidies. Linking public transport investments with road user charging and parking pricing schemes can help to reduce the pressure on public funds and at the same time create disincentives to use the private car and encourage the use of public transport (Johnstonea and Karousakis, 1999) (Table 7.1).

Car-Sharing

Owning a car is expensive, considering the initial costs of buying a vehicle, insurance, registration, vehicle tax, parking space, and

TABLE 7.1 Selected Measures for Public Transport

Public transport measures	Good practice cities/projects
Light rail systems (LRT)	Light rail or trams are rail systems that operate on urban roads either sharing the street with other road users or operating on a segregated part of the road. Trams are powered electrically and have a high level of service quality in terms of frequency, speed, and reliability. *Examples*: http://www.uitp.org/news/knowledge-brief-LRT
Bus rapid transit (BRT) systems	BRT systems are high-performance bus systems on urban corridors with a high demand for public transport. BRT systems mimic rail systems with an efficient, high-capacity bus-based scheme which often is cheaper and faster to construct. BRT systems can be a solution to public transport challenges, in particular if rail-based systems are not feasible. *Examples*: http://www.uemi.net/toolkit.html
Trolleybus systems	Trolleybuses are buses that run on electricity provided by overhead wires, giving them similar characteristics to rail modes, such as metro and light rail systems, but are normally cheaper to construct and often with greater operational flexibility. *Examples*: http://www.trolleymotion.eu/www/index.php?id = 46&L = 3&id = 3
Battery electric and hybrid public transport vehicles	Electric and hybrid buses are being tested and operated in several European, Asian, and American cities including BEVs (battery or blade electric vehicles), PHEVs (parallel hybrid electric vehicles), and CHEVs (complex hybrid electric vehicles). *Examples*: http://www.eliptic-project.eu/thematic-pillars
Integrated fare systems	London's Oyster card, Bremen's *Mobility pass*, and the Netherland's smart card are some of the many examples of integrated ticketing systems that combine the services of different transport providers in one payment system, which is linked through smart cards and/or apps. *Examples*: http://civitas.eu/collective-transport/ticketing
Bus priority lane	Warsaw introduced a bus priority lane in the city center stretching 7 km in each direction. The bus lane covers the city's main three-lane artery roads and serves three lanes in both directions. As a result the average speed of buses in both directions has increased by 19% to the east city edge and 30% to the city center, with an average of 26 km/h in both directions, from an average 10 km/h before the bus lane was implemented. *Examples*: http://civitas.eu/content/bus-priority-measures

maintenance. Car-sharing schemes are becoming increasingly popular in many cities around the world (Fellowsa and Pitfield, 2000). Among the various providers of car-sharing schemes there are free-floating and stationary systems. Free-floating schemes such as car2go, Multicity, and DriveNow allow for their users to park the car anywhere within a designated zone and facilitate the pickup through GPS-assisted smartphone apps. Users of stationary car-sharing systems, such as Cambio and Zipcar, return the vehicle to designated parking areas, reservation and payments are normally also handled through apps. Charges can be based on time and/or kilometers driven and usually cover all costs including fuel. Most of the free-floating car-sharing providers focus on larger cities and even there focus on the most densely populated areas, which can lead to more competition than complementarity with public transport. Many midsized cities work with providers of stationary sharing schemes, which often have a higher rate of replacing privately owned vehicles.

Good Practice: Car-Sharing in Bremen, Germany

In 2003, Bremen introduced on-street stations designed to create seamless links between public transport and bike and car-sharing, connected with an app and smart card system. The city of Bremen estimates that every car-sharing vehicle that is part of this system replaces between 8 and 10 privately owned cars. While providing access to a car the system gradually reduces vehicle usage and this behavioral change results in reduced GHG emissions and increased use of public transport and active modes. It also reduces the need for on-street parking and expensive underground parking, freeing up public and recreational space, widening sidewalks, and improving bike lanes.

Parking Management

Similar to road user charging, parking management and pricing can help discourage the use of a privately owned car and raise revenue to fund public transport, walking, and cycling infrastructure and improve public spaces. Parking management schemes reduce the number of cars entering the city, which can reduce congestion and encourage the use of public and nonmotorized transport. The parking pricing structure and the level of enforcement are important aspects to consider. A structured fee that differentiates between different zones of a city or times depending on the demand is one aspect that needs strong enforcement to be meaningful. Coordination of parking pricing and zoning among

relevant municipal authorities is another vital aspect. Parking management can be a powerful tool for local authorities to manage car use and to raise revenue (Litman, 2006). Parking management also includes time restrictions and a control of the number of available parking spaces. Parking time restriction for nonresidents, for example, to 2 h, is a proven tool to reduce commuting by car without affecting accessibility to urban shops. In fact, in many cases, shops and other local businesses become more accessible when public space is freed up by a reduced number of parking spots.

Good Practice: Parking Management in Bologna, Italy

The city of Bologna introduced a differentiated parking fee system that is based on the environmental characteristics of vehicles. The wider parking management strategy includes an extension of on-street parking payment areas in the city center from 30,500 to 45,000 spaces, and an extension of the timeframe during which parking fees apply beyond 20:00. Specific high-demand areas are planned to be extended and paid parking permissions for residents for the second car per family are also foreseen.

More examples: http://civitas.eu/content/pricing-and-monitoring-policies-parking

Supporting Walking and Cycling

Nonmotorized modes, that is, cycling and walking, can take a substantial share of the urban transport task, in particular on short distances, and help reducing emissions and energy consumption and reduce congestion. Walking and cycling are especially suitable for urban transport as in cities the majority of trips are over short distances (below 5 km). One fundamental advantage of nonmotorized modes is that they are low-cost modes compared to other transport options, not only for the individual, but also for public authorities (Tirachini and Hensher, 2012). Cobenefits of cycling and walking include health benefits for the cyclists or pedestrians as well as environmental and economic benefits resulting from zero emissions and energy consumption (Santos et al., 2010). While taking up a noticeable share of the transport task, walking and cycling infrastructure consumes only a small amount of space compared to roads, yet this infrastructure is often neglected in transport planning. The provision and maintenance of infrastructure for pedestrians and cyclists is crucial to make these modes more attractive. Separate crossing signals, cycle lanes, and buffers between road and lane can improve safety (Santos et al., 2010).

Good Practice: Walking and Cycling in Helsinki

The city of Helsinki created a pathway for pedestrians and cyclists called Baana that leads from the western harbor area to Kamppi and the Töölö Bay, and is built on a former railway line. Baana is 1.3 km long and on average 15 m wide (it is 34 m at its widest). The pedestrian and bicycle lanes run side by side and are marked with different colors: the bicycle lane is paved with reddish-brown asphalt and the pedestrian lane with black asphalt. In addition to the end points, bicycle access to Baana is allowed by four evenly spaced ramps and pedestrian access by several staircases from streets. There are also accessible entrances at both ends and in the middle of the course.

More examples: http://www.uemi.net/toolkit.html.

Registration Management

A managed approach to vehicle registrations can help limit the number of cars in a city by differentiating registration fees for vehicles, for example, according to their CO_2 emissions or engine size (Ajanovic et al., 2016). This can guide purchasing behavior and can encourage people to opt for cleaner vehicles or more sustainable modes such as public transport and nonmotorized modes (Lah, 2015b). This approach is not common in European cities, but has been implemented very successfully in several cities in Asia, for example, Singapore and Shanghai. Vital to this approach is that the authority to register vehicles lies with the municipality (SOLUTIONS, 2016c).

Prioritizing Electrification Options for Land Transport

Electric mobility can play a significant role in the decarbonization of the land-transport sector. Many e-mobility solutions are readily available, several of which are already cost-effective and can deliver wider socioeconomic benefits, which makes the prioritization of these solutions pivotal for policy decisions in this area (Lah, 2017b). From a societal perspective, the electrification of public and shared vehicle fleets is the more cost-effective option, since these vehicles tend to drive longer distances and serve a substantially higher number of people.

Figs. 7.1 and 7.2 show the estimated cost per passenger kilometer for a range of modes and technologies (electric) in OECD Europe and India. They illustrate that vehicle "life cycle" costs for operating electric vehicles (EVs) are close to (or lower than in some cases) internal combustion engine (ICE) vehicles (Fulton et al., 2017). The importance of different

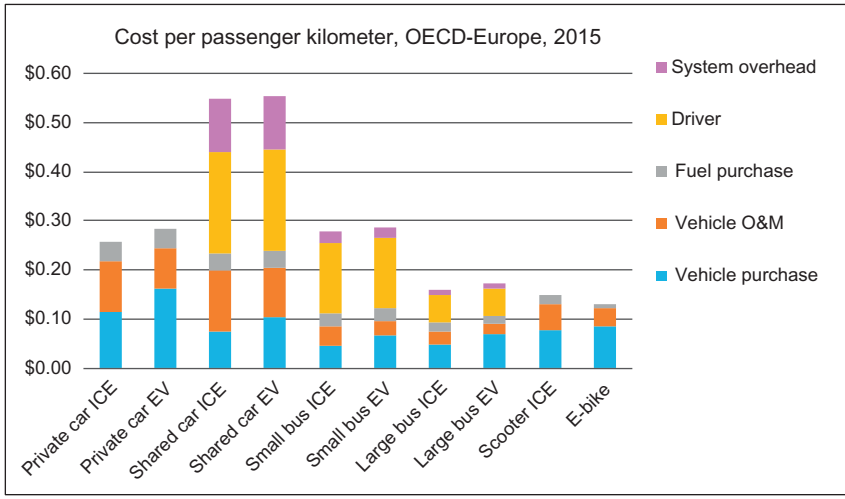

FIGURE 7.1 Costs per passenger kilometer in Europe.

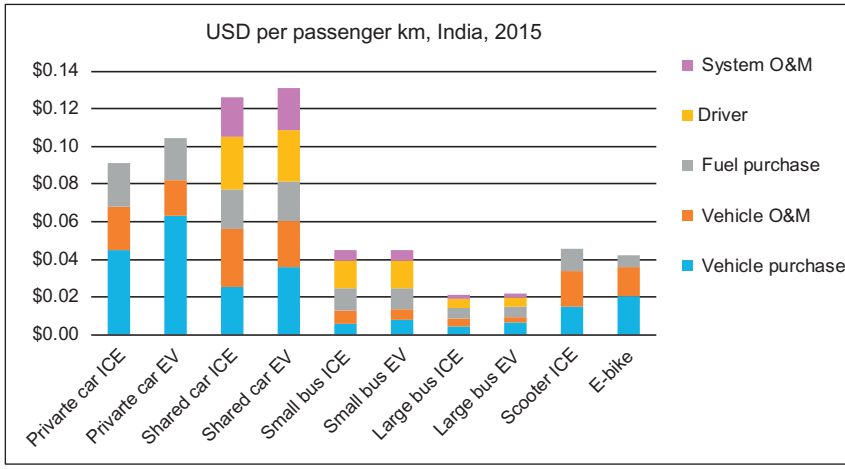

FIGURE 7.2 Costs per passenger kilometer in Asia.

factors (e.g., drivers and fuel cost) differs by region, for example, the low labor cost of the bus drivers, along with higher average load factors in India and other developing economies make public transport modes even more cost-effective than in industrialized (OECD) countries. However, in both cases EV costs are close to competitive on a life cycle basis; this will only improve over time as battery costs continue to drop.

Figs. 7.1 and 7.2 are derived from Fulton et al. (2017), with additional calculations made for this chapter. These figures do not appear in the

original study. Costs are based on 10 years of vehicle operation with a societal discount rate. The cost per passenger kilometer for different vehicle types also changes over time as e-mobility technologies become more cost-competitive. The results of this analysis show that by 2030 the life cycle costs of electric cars are lower than those of an ICE-powered private car. By then the shared modes are even more cost-effective, in particular if automation for public transport is becoming a viable option.

Municipal authorities have a number of options to encourage the purchase and use of EVs. To guide these decisions focusing on the most (cost) effective electric mobility options is an important aspect. The role of a city to regulate or operate public transport fleets and the cost-effectiveness as compared to the electrification of privately owned vehicles gives a clear indication for potential priorities and policy levers. As a regulator for taxi and car-sharing fleets there can be a similar role for cities to encourage shifts to electric mobility. From a societal perspective, subsidies for private cars are not as cost-effective and not as inclusive as support for electric public transport as well as car- and bike-sharing schemes, which can also provide an opportunity to make the first and last mile linked to the public transport network.

Good Practice: LIVE Platform, Barcelona, Spain

Barcelona aims to promote EVs in close cooperation with the private sector. As part of this effort the city established the LIVE platform—a public–private partnership (PPP) to coordinate, monitor and communicate e-mobility activities in Barcelona and the surrounding area. The LIVE platform supports policies and projects to promote e-mobility and supports new start-ups offering EV products and services in the city. It also provides subsidies for charging infrastructure (€2000 per plug for on-street stations and €1000 for off-street stations) and works with private stakeholders to install infrastructure in hotels or shopping centers. The city of Barcelona also provides tax deductions and free parking for all-EVs.

More examples: http://www.uemi.net/toolkit.html

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FACTSHEETS

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CLUSTER 1: PUBLIC TRANSPORT

Solution

Bus Rapid Transit System

In Brief

BRT systems are high-performance transport solutions for urban corridors with a high demand for public transport. BRT is a bus-based alternative to rail systems (metro, light rail, or subway systems) that is cheaper and quicker to construct and provides greater operational flexibility. BRT systems are a solution to public transport challenges and are important in managing the complex transport needs of growing cities with large populations.

Examples

BRT mimics a metro system by using high-capacity buses on city streets on dedicated lines that travel along at high average speeds. The concept prioritizes public transport on urban roads and provides it at a fraction of the cost of a metro system. Today, over 200 cities around the world have such systems, many with different design features, adding up to a total of 407 corridors, serving nearly 33 million passengers per day, and stretching over 5250 kilometers. The features of a full BRT system are:

- Exclusive bus lanes.
- High-capacity buses, either articulated or biarticulated.

- Physically closed stations, controlling the entrance and exit of passengers.
- Prepaid ticketing systems.
- Same-grade entry (no steps to enter the bus).
- Electronic payment collection systems (using smart cards).
- Centralized control systems.
- User-information systems; some examples of BRT systems around the globe include the Curtiba BRT system in Brazil; the TransMilenio BRT system in Bogota (Colombia); the Metrobús BRT system in Mexico City (Mexico); and the Guangzhou BRT (China).

Results

Investing in high-quality public transport systems in developing cities across the world can help meet the growing mobility needs of residents. As most BRT systems use modern rather than conventional city buses, they can clean up local air and reduce GHG emissions. Fewer mixed traffic lanes can also cut the number of traffic accidents. BRT and bus priority systems have become in recent years an attractive solution because of their relatively low capital costs and short construction times compared to rail transport. As these systems gain popularity, a number of studies and planning guides have appeared, illustrating the different design options available and their impact on the operational performance of the systems, and outlining some of the institutional challenges to their implementation. BRT systems are more effective when designed within an integrated network, and linked to land-use management, thus providing a comprehensive citywide mobility vision.

Technical and Financial Considerations

Practice shows that financially self-sustained BRT systems—where the operational costs and, in some cases, the investment costs are only absorbed by income related to the fare—may result in a service that decreases in quality over the years. In most Latin American and Asian countries, subsidies are very low or nonexistent. There are high investments on initial infrastructure costs, funded by government programs, which happen during the construction. However, the responsibility to cover operational costs is in the hands of private operators. Therefore, introducing additional improvements and services—such as increasing the frequency of trips to boost capacity; ensuring the transport is reliable and that stations and buses are clean; installing air-conditioning; providing customer service; and properly maintaining the bus fleet—may affect the operational costs and represent financial barriers. Because of this, there are many discussions on the need to explore subsidy schemes among many of the BRT system operators, especially in Latin American and Asian countries, which do not have such policies.

Policy/Legislation

Obliging a city to have a SUMP has proven to be one of the ideal legal frameworks. By developing a SUMP, cities need to establish clear short-, medium-, and long-term targets, such as encouraging citizens to use more sustainable forms of transport; improving accessibility; reducing GHGs; cutting travel times and congestion on public transport; improving the delivery of services and freight; and identifying transport infrastructure priorities in the near future. In this case, mass transport corridors such as BRT systems can be part of short-term mobility solutions. With a long-term vision, BRT systems, if necessary, can upgrade in the future to higher capacity systems such as rail systems. In terms of the institutional framework, best practices clearly show the need to have a single transport agency within a city that plans, manages, and controls the different transport modes. Overall, cities must accompany public transport initiatives with regulations, programs, and:

- Land-use planning instruments.
- Ecological zoning plans.
- Bus-fleet selection manuals.
- Environmental standards (including fuel efficiency and technology).
- Public transport quality-of-service plans.
- Fare regulations.
- Public transport subsidy schemes.
- Operational regulations. Leading institutions that promote BRT systems are commonly agencies responsible for transport planning, such as mobility ministries, transport departments, and/or planning institutes. The authority level (federal, state, or local) depends on the existing institutional and legal frameworks. It is necessary to coordinate with entities such agencies responsible for the environment, urban development, public space, public works, social and economic development, and social communication; the secretary of state (or related agency at the local level); and the financing agency from the planning through to the implementation stages.

Transferability

BRT systems, first developed in Latin America, have spread across the world to Asia, Europe, and most recently to Africa. Due to the flexibility of the concept (the full features of a BRT system are not needed in each city) it can be easily adapted to different urban contexts; some 200 cities around the world have now introduced bus priority systems. Some European cities have introduced a similar concept, known as bus with a high level of service. The technical teams in each city will find that its features are easily adaptable. When this is not completely

possible, available planning tools such as guides, manuals, or even technical assistance from experts on transport planning can help.

Case Study

Bogotá's TransMilenio BRT System (Colombia)

Context

In 1995, 56% of daily trips made by citizens in Bogotá—Columbia's capital and a city with around 6.5 million people—were by public transport. The city's public transport fleet consisted of old buses and smaller vehicles (estimated at between 21,000 and 30,000 vehicles), which were very polluting, unsafe, and provided a chaotic service. The combination of this with private vehicle travel (22%) led to high levels of congestion and bad air quality. Between 1988 and 1998 the municipality insistently discussed and submitted proposals for a mass transit system—with limited results. In 1998, however, the city began drafting a development plan that included constructing mass transport corridors with specialized infrastructure. The city hoped that through dedicated lanes and stations this would improve connectivity and travel times, and provide better accessibility to cycling and pedestrian infrastructure.

In Action

In October 1999, after a series of political battles with members of the council and private operators, Bogotá created TransMilenio S.A., a transport agency. Its task was to plan, manage, coordinate, and control the delivery of mass transport and create the TransMilenio BRT system. The first stage of the TransMilenio system was to construct 41 km of segregated bus lanes, at a cost of $240 million (€212.5 million), or around $5.85 million (€5.18 million) per km. When the first stage was completed, it provided service to around 800,000 passengers per day. Further stages included buying land and public spaces adjacent to the corridor, sidewalks, and other improvements, at a cost of about $12.5 million per km (€11.07 million). Private operators paid the costs for the vehicle and fare collection systems. In the first phase, funding was available through various sources, the largest through local fuel taxes (46%), federal grants (20%), a mix of other local funds (28%), and a loan provided by the World Bank (6%). The third phase was completed in 2015 with the construction of a massive transfer station, which connects three mayor BRT lines, connecting up to 23,000 passengers per hour at the highest peak in the busiest direction. Nowadays, the TransMilenio BRT runs along exclusive bus lanes, with a passing lane along most of the network. The distance between stations ranges from around 500 m, and

access to them differs, such as by crosswalks in dense urban areas and grade-separated pedestrian crossings (by using pedestrian bridges) in more suburban areas. In the downtown area, there is a section of the corridor, a low-speed zone, where buses and pedestrians coexist, proving that the BRT can be flexible according to each city's needs.

Results

Bogotá's BRT has accomplished what no other city bus system has. It carries up to 48,000 passengers per hour in each direction, with an average speed of 26 km/h. Thanks to the high quality of the system design, it was completed at a fraction of the cost of a regular rail system. In its 15 years, it has become responsible for 40% of trips in the city and is the main form of mobility in Bogotá. It currently serves over 1.9 million trips per day through an extension of 112 km of BRT lines. In 2014, Bogotá incorporated dual services, which comprise of buses with doors on both sides, which allow operation in the confined trunk corridors as well as conventional routes. This addition has been a success as it increases the coverage of the BRT lines without requiring passengers to make transfers, providing a better service for customers. The target is to build a network which Bogotá hopes will reach 388 km and serve up to 7 million passengers per day. More recently, the local administration received support from the national government to continue developing this plan, which includes implementing an integrated transport system—a series of public transport solutions within a city, integrated through its infrastructure, operation, and through the fare.

Solution

Trolleybus System

In Brief

Trolleybuses are buses that run on electricity provided by overhead wires, giving them similar characteristics to rail modes (such as metro and light rail systems), powerful traction and fixed alignments. However, unlike these modes, they are cheaper to construct and have greater operational flexibility. In addition, the combination of rubber tires with electric propulsion makes the trolleybus a mode which performs well and has a low negative environmental impact.

Examples

The trolleybus has been a mode of urban transport since the 1880s, reaching the peak of its development after World War II. The system benefits from the combination of different public transport system

characteristics such as trams and regular buses. It requires cheaper infrastructure than rail; can avoid traffic easily; is quieter than motorbuses; and is more environmentally friendly. Nowadays, due to its several advantages, there are around 300 trolleybus networks in 43 countries, with over 40,000 buses operating around the world. Many major European and Asian cities operate trolleybus systems, including Vancouver (Canada), San Francisco (United States), Geneva (Switzerland), Lyon (France), Athens (Greece), Wellington (Australia), and Moscow (Russia). In many of these places, trolleybuses are the backbone of the public transport system. The features of a full trolleybus system are:

- overhead lines (wires);
- traction wheels;
- pole ropes;
- trolley poles;
- spacious interior design;
- prepaid ticketing systems;
- electronic payment collection systems (using smart cards);
- centralized control systems; and
- user-information systems.

Results

Most of the countries have preserved trolleybuses simply because they help cities grow. Trolleybuses are cheaper than trams, have better hill-climbing traction and can avoid traffic easier. They produce minimal noise, are adaptable to different road characteristics, and last a long time. The only negative impact is the overhead wire which some find unpleasant to look at. In San Francisco, passengers prefer to ride on trolleybuses, with 10%–15% of people using the transport in recent decades.

Technical and Financial Considerations

Trolleybus systems do not cost as much to construct and implement as other rail systems, but they do cost about 30% more than motorbuses. On the other hand, the normal working life of a trolleybus is 20 years, and that of motorbuses is 14; meaning that the annual depreciation is only 9% higher. Installing the power supply and overhead wiring network is expensive compared to the infrastructure needed for regular buses. Nevertheless, a network used by a city intensively and for a prolonged period can recoup the initial costs over some years. The maintenance cost of the overhead wiring is an extra expense, but the overall costs of a trolleybus system are at least 20% less than those for motorbuses. The operating costs of trolleybuses depend largely on the price of

energy. Regarding technical considerations, installing a trolleybus system will require several modifications to urban surroundings.

Policy/Legislation

Mass transport corridors such as trolleybus systems can be part of short- and long-term mobility solutions for small, medium, and even large cities. In terms of the institutional framework, best practices clearly show the need to have a single transport agency in charge of planning, managing, and controlling the different transport modes. Overall, cities must help public transport initiatives with regulations, programs, and:

- land-use planning instruments;
- environmental standards (including fuel efficiency and technology);
- public transport quality-of-service plans;
- fare regulations;
- public transport subsidy schemes; and
- operational regulations.

Institutions

Leading institutions that promote trolleybus systems are commonly agencies responsible for transport planning, such as mobility ministries, transport departments, and/or planning institutes. The authority level (federal, state, or local) depends on the existing institutional and legal frameworks. It is necessary to coordinate with entities responsible for the environment, urban development, public space, public works, social and economic development, and social communication; the secretary of state (or related local agency); and the financing agency from the planning through to the implementation stages.

Transferability

Trolleybus systems, first developed in Europe, spread across the world to Asia, Oceania, North America, and, most recently, to South America. In the past, several African cities also introduced the transport system. Any city can easily implement this system as its light infrastructure makes it flexible to any kind of urban context, topography, and climate. Trolleybuses are a good sustainable transport option for developing countries due to their relatively low construction and operational costs.

Case Study

Castellón and the Region of Valencia (Spain)

Context

Castellón is a coastal Spanish municipality 70 km from Valencia. It has a population of 175,000, and is the center of an urban region that reaches nearly 300,000 inhabitants. In 1994, Valencia introduced a new tramway line which initially carried 20,000 passengers a day, while the complete bus network of Castellón provided service to no more than 15,000 passengers. The region urgently needed a new transport system. A trolleybus system seemed like the best option because it was environmentally friendly; flexible enough to allow partial openings and operation; had the capacity to meet the expected demand at peak hours; and it would be cost-efficient regarding its construction and further operation.

In Action

In 2005, the Valencian regional government decided to introduce a trolleybus transport system, with a 35-km-long network meant to serve the entire urban region and the city itself. To implement the system successfully, the government:

- Defined the technical characteristics for the system: energy supply, electrical infrastructure, a dedicated bus lane, platforms, efficiency, and general layout of the network.
- Defined technical base characteristics.
- Performed dedicated studies for the whole network.
- Conducted a general traffic study in Castellón to consider all possible route interactions inside the old and narrow city streets. The trolleybus divides into seven different and independent sections, and operates in separated lines, which makes it different from other trolleybus systems. The investment in infrastructure of the whole network was an estimated €140 million, not including the cost of vehicles. The first phase of the project was completed by mid-2006. The system was operational in June 2008, and ran every 8 minutes during peak hours. It got students from the town center to the local university in less than 7 minutes—much faster than the 20 minutes it took with the public buses.

Results

The introduction of trolleybus systems in Castellón has successfully satisfied the different requirements of modern and suitable mobility transport issues. These included the cost of implementation, maintenance, and operation, and that the system is demand-oriented, universally accessible, clean, and noiseless. The trolleybus has exceeded expectations. It is now responsible for more than 25% of all rides on Castellón's public transport network, while private traffic between the

university and the city center has decreased significantly. Castellón will extend the system through different phases until it reaches 35 km of dedicated infrastructure. The success of the system has encouraged the Valencian authorities to implement it in other middle-sized cities: similar systems are undergoing planning in Sagunto and Elda, and city authorities are modeling the former planned tramway line between Alicante and San Juan and Muchamiel on a Castellón-like system.

Solution

Electric and Hybrid Public Transport

In Brief

Transport contributes to around 22% of global GHG emissions, and this figure is increasing dramatically by 2.1% per year. To reverse this trend and reduce local air pollution, road-based public transport needs to shift from conventionally fueled vehicles (petrol and diesel) to alternatives such as electric or hybrid EVs, or those fueled by natural gas. Making this shift can significantly reduce GHGs and local air pollution.

Examples

Buses can use energy in two ways; they can either store the electricity onboard in batteries or hydrogen-powered fuel cells, or receive energy from overhead lines or third rails as trolleybuses, metros, trams, and trains do. While battery electric buses are currently operating in several cities, hybrid buses are becoming more common in smart cities. Today, many big urban hubs rely on electric and hybrid buses. In Europe, Luxemburg and Italy, in particular, are forerunners in introducing this technology. BEVs (battery or blade EVs), PHEVs (parallel hybrid EVs), and CHEVs (complex hybrid EVs) are present in many public transport systems, such as Beijing (China) and New York (United States).

Results

Replacing conventionally fueled vehicles with clean technology brings several benefits for both passengers and the environment. EV are more comfortable for passengers because they do not vibrate or make as much noise as regular buses. Moreover, new vehicles with innovative technologies can also have a positive impact on the image of public transport. Citizens will also benefit from cleaner and quieter roads. Using electric or hybrid vehicles in public transport can also have a great impact on the business model of the private sector, and their large-scale deployment in the public transport system will help any city achieve its climate change mitigation targets.

Technical and Financial Considerations

Introducing electric and hybrid vehicles in public transport requires new and costly infrastructure. As the routes for public transport are predetermined, cities need to introduce electric charging stations along these corridors. However, this is an advantage in terms of costs because as the route is already known there will be fewer charging stations. Even if investment costs appear to be very high, cities can recover them in the long term by the reduced fuel consumption. The cost of an electric or hybrid bus is higher than a diesel bus due to the cost of the batteries. Even if this price tends to decrease year after year, it is still more expensive than diesel alternatives, which could present a barrier for small cities that do not benefit from private initiatives or strong political will. Therefore, even though the economic investment needed for BEVs or HEVs seems high, the positive impact on citizens and the environment outweighs the negatives.

Policy/Legislation

Obliging a city to have a SUMP has proven to be an ideal legal framework. By developing a SUMP, cities need to establish clear short-, medium-, and long-term targets, such as encouraging citizens to use more sustainable forms of transport; improving accessibility; reducing GHGs; cutting travel times and congestion on public transport; improving the delivery of services and freight; and identifying transport infrastructure priorities in the near future. Deploying clean vehicles for public transport should be part of an integral city strategy for clean vehicles in terms of refueling or charging infrastructure. Measures such as low-emission zones (LEZs) can prompt the public transport sector to replace vehicles with cleaner alternatives. Ideally, the local administration manages and supports the installation of charging or refueling infrastructure. In terms of the institutional framework, best practices clearly show the need to have a single transport agency within a city that plans, manages, and controls the different transport modes and its quality-of-service standards.

Institutions

Leading institutions that promote BEVs and HEVs are commonly agencies responsible for transport planning, such as mobility ministries, transport departments, and/or planning institutes. The authority level (federal, state, or local) depends on the existing institutional and legal frameworks. It is necessary to coordinate with different entities involved in different sectors, such as the environment, urban development, public space, economic development, and social communication; the secretary of state (or related local agency); and the financing agency.

Transferability

The transferability greatly depends on whether current fuel and electricity prices strongly influence the cost-effectiveness of hybrid or electric buses, and whether the performance of EVs compared to conventional ones (in terms of energy efficiency) can be affected by routing, driving style, temperature, and traffic conditions. Some cities might benefit from local conditions while others may suffer from them. However, reducing air pollutants is independent from the location and thus is transferable across cities and countries. Many cities worldwide have successfully replaced diesel buses with BEVs or HEVs such as Shanghai (China), London (United Kingdom), Bogotá (Colombia), and many more.

Case Study

Hangzhou (China)

Context

Hangzhou, in China, has about 6 million inhabitants. The city encourages nonmotorized transport, which is part of the reason why it has the largest bike-sharing system in the world, with 70,000 bikes and 3000 stations. Some 66% of trips are by nonmotorized modes. In 2005, Hangzhou began introducing electric and hybrid vehicles. However, in the years that followed Hangzhou experienced rapid motorization, registering over 2 million vehicles in 2014. As a result, air pollution increased at an alarming rate. Since 2010, the city has been looking at alternative environmental strategies to tackle this problem.

In Action

In September 2014, Hangzhou ordered 2000 all-electric buses and today there are more than 1500 clean buses circulating the city, around 21% of the bus fleet. The city also introduced electric taxis, with 500 of them currently in service in Hangzhou, traveling an average of 230 km per day. This impressive distance is due to the city installing a high number of battery-swapping stations throughout the city, where taxi drivers can quickly change batteries instead of charging them—eliminating long waits. China State Grid, the electricity provider, owns the batteries and also acts as the charging station operator. This reduces the extra costs of EVs for private and public investors.

Results

Hangzhou has been facing a big challenge in reducing carbon and energy consumption for several years now. Public policies are focused

on implementing and improving sustainable transport, such as public transport, walking and cycling, and new energy vehicles. EV programs have made Hangzhou one of the leading cities in developing low-carbon transport in China. The transport authorities, in collaboration with the local automobile industry, promote new energy vehicles (BEVs and HEVs) and public charging services. However, the city still needs to solve a number of issues. The huge variety of sustainable transport modes and vehicles makes coordination and integration between them problematic. Due to the use of electric and hybrid buses, Hangzhou has reduced the local air pollution attributed to public transport in the city. According to city officials, the use of alternative fuels has also contributed significantly to reducing GHG emissions.

Solution

Integrated Public Transport Network Planning

In Brief

The aim of integrated transport planning is to provide citizens with a high-quality, easily accessible articulated network across a whole city or region. Travelers should be able to move using different forms of transport—such as rail, BRT, buses, bicycles, and even boats. The network should have a unified payment system and connections should be easy to reach, resulting in fewer transfers, reasonable costs, a reliable service, and convenient travel times.

Examples

The most successful cities that have integrated transport planning are Madrid (Spain) and London (United Kingdom). Both cities rely on their different services to comply with the mobility needs of their users, whatever their travel purpose. Their stories are quite different, but ultimately the solution aims toward the same objectives and goals: to provide convenient, high-quality, and integrated mobility systems with optimal connections between origins and destinations. In Madrid, it was only after passenger numbers continued falling year-by-year that the transport agencies—which were competing to provide services to newly urbanized areas—stopped and analyzed the problems. This resulted in the creation of the Transport Consortium of Madrid, an agency in charge of planning, managing, controlling, and regulating the different modes of public transport in Madrid and nearby regions.

Results

Integrated planning improves a city's connectivity, providing a better mobility service and shorter trips for inhabitants, and bringing people and places closer together. As part of this, cities should consider integrating fares, infrastructure, and operations for integrated public transport planning, and create easy connections with nonmotorized transport (such as walking and cycling). The best examples show that by properly integrating public transport planning, the number of passengers goes up. This is because users get more value for money and they consider public transport as a more convenient mobility option. One of the main benefits is that integrated transport systems foster social equity, providing access to services, jobs, education, and entertainment—in brief, access to the whole city. They also result in people using more sustainable modes of transport, which can reduce congestion, emissions, travel times and, if managed properly, even road accidents.

Technical and Financial Considerations

Most technical challenges relate to the ability to design a network that provides highly reliable and comfortable transport with a good information system and a minimum number of transfers. The challenge is greater when creating such a network with limited financial resources, with no subsides, where only income generated by passenger fares covers the costs of the operation. Recently, there have been discussions on providing subsidies to countries mainly in Asia and Latin America (although in some of these countries such initiatives already exist). This is because, depending on the size of the city, the first phases of developing an integrated network can be costly. Best practices show that subsidies for integrated public transport planning may result in better services, higher passenger numbers, and contribute to modal shifts (e.g., switching from the use of private cars to public transport).

Policy/Legislation

As mobility is a fundamental element in the functionality of cities, which influences all sectors, integrated transport planning should be a part of every urban development plan, program, and project. This ensures that cities can develop their public transport networks without worrying about administrative changes at municipal, state, and federal levels. SUMPs could be an ideal way to provide the backbone for specific plans with short to medium timescales—such as plans for traffic, public transport, parking, freight, or cycling.

Institutions

Forming partnerships between all levels of government is the best way to address integrated transport network planning. Each jurisdiction should apply the prescribed principles and processes to reflect their specific needs, priorities, and community aspirations for providing a sustainable transport system. Other local policy areas, such as land-use planning and urban freight, and key sectors, such as environment, energy, social services, and health, should complement and support a public transport system.

Transferability

This type of solution is completely transferable to different cities, and advisable, as integrated planning optimizes resources. In this case, the transferability does not rely on a specific context, but on the will of the different transport agencies to build upon one unique public transport system. It responds to the need of providing transport to satisfy the needs of mobility. This becomes an issue of institutional coordination, but is strongly supported by political negotiation and leadership. The complexity may vary, depending on the scale of the city or metropolitan area and the numbers of stakeholders, which change according to the conditions established in each country. Stakeholders might include agencies from national, regional, and local governments with different levels of hierarchy and competence. Implementation might also include negotiations with unions, service providers, and, in most cases, require modifications to legal frameworks, regulations, or public policies.

Case Study

Montpellier (France)

Context

The population of Montpellier, in the south of France, has been constantly growing over the last 50 years. These brought difficulties because as the urban area increased, so did car ownership and CO_2 emissions. To tackle these problems, the local government developed an urban mobility plan that considered urban planning and public transport in an integral way, with the aim of avoiding urban sprawl and providing quality transport. The objective was to provide urban transport to the growing population; shorten distances in the city or region; and provide regional intermodal public transport.

In Action

To shorten distances in the city and region, Montpellier changed how it used its urban land, and began creating new urban hubs that enable diverse activities. It developed several commercial spaces, offices, housing, urban facilities, and public spaces. Many areas of the city also changed their speed limits to make it safer for pedestrians and cyclists. This provided pedestrians with better access to different activities and services. The local government promoted carpooling programs and limited the number of parking spaces throughout the city. It improved regional transport by constructing four tramlines and creating an intermodal system with buses, trams, regional trains, bicycle parking, and a bike-sharing system. Montpellier's transport company, TaM, operates the tram system, and oversees the public bicycle system, Vélomagg, which has 1200 bicycles and 50 stations. The city also managed parking for private vehicles to make better, more efficient use of the road. All these measures, particularly the bike-sharing system, changed the experience of Montpellier dramatically and improved the mobility of citizens significantly. Thanks to these efforts, the use of public transport more than doubled between 1998 and 2008. The tram network now has an extension of 56 kilometers, and the city is planning a fifth line for 2017.

Solution

Intelligent Transport System

In Brief

Intelligent transport systems (ITS) refer to any information or communications technology that improves the functioning of a transport system. The technology has expanded rapidly over the last 25 years, and today both public transport passengers and private vehicle drivers benefit from ITS on a daily basis—through real-time information on metro and bus arrivals; traffic advisories that warn drivers about upcoming delays; and monitoring cameras that help vehicles stay at a safe speed.

Examples

ITS improve the quality of travel and ensure a more seamless journey for vehicle drivers and passengers. Public transport users most commonly experience ITS through real-time information on the arrival of buses and trains. Several of the world's largest transport systems provide information on route configurations, departure times, and possible delays for many years. The advent of the internet and smartphone technology has also expanded the use of ITS in ways that benefit drivers.

Automatic, camera-based tolling systems allow drivers to pass through tolls at highway speeds, saving time. Cities that want to ensure drivers travel at safe speeds for pedestrians and cyclists now have increased tools to accomplish this, through camera sensor technology. In polluted cities such as Mexico City (Mexico) and Beijing (China), ITS have enabled governments to impose driving restrictions based on license plate numbers, creating incentives for cleaner air.

Results

ITS provide many benefits, both mental and physical, to travelers. If used properly, ITS can reduce accidents, decrease pollution, and optimize fuel efficiency. Individual drivers have more access than ever to real-time information about road conditions, traffic congestion, and the environmental impacts of their choices. Public transport passengers experience fewer delays with continuously updated information about their journey. In addition, government agencies can monitor their road and transport systems to see if they are functioning optimally. Air quality programs, such as Mexico City's Hoy No Circula, traffic monitoring applications such as RESCU in Toronto (Canada), and congestion pricing systems found in cities including London (United Kingdom) and Singapore all exist because of the technological advances that ITS provide.

Technical and Financial Considerations

Developing ITS technology can go hand-in-hand with other research on information technology that governments, NGOs, and private organizations are conducting. According to the US Department of Transportation's history of ITS, "the relationship between industry and the government has progressed into an essential partnership, which has catalyzed the development of new technologies." The ability to pursue large-scale collaboration between public and private entities is essential to the success of ITS. Many developing countries may lack the information technology infrastructure to carry out ITS innovations on a large scale. The cost of wiring an entire transport system to communicate with operators and vehicles is quite high, and in countries with developing or heavily informal public transport networks, the capital and technological resources may not exist. In general, the high levels of capital, manpower, and coordination needed to successfully implement system-wide ITS technology can be provided by governments or PPP, and are not as well suited to the private operators or concessionaires that often run public transport systems in Latin America or Asian countries.

Policy/Legislation

The United States has been a leader when it comes to coordinating ITS initiatives at a high government level, and providing funding on a regular basis through transport programs. The Intermodal Surface Transportation Efficiency Act of 1991 established a federal framework to fund, test, and operate ITS initiatives. Support for ITS innovation was also included in routine US transport funding packages, and the US Department of Transportation coordinates the process. The federal ITS program is governed by a board of directors that include professionals in the fields of standards development, capacity building, and program assessment. In addition to ITS funding that the US Congress specifically earmarks, ITS programs are also eligible for regular federal highway funding.

Institutions

In Europe and the United States, national and subnational entitles (such as US states) tend to have public transport agencies, each of which has a division dedicated to technological innovation and developing ITS initiatives. There are also coordinating agencies at a supernational level, especially in Europe, where ERTICO-ITS Europe serves as a PPP that connects public authorities, infrastructure operators, vehicle manufacturers, and other key stakeholders across the continent. In the United States, each state's ITS chapter holds an annual conference to exchange ideas and best practices about the field, and these conferences are attended by state, local, national, and private representatives. The ITS World Congress is an annual global event coordinated by ITS organizations in Europe, Asia, and the Americas, and alternates between the three continents. Up to 8000 industry representatives attend each event.

Transferability

Because ITS are largely concerned with information technology, the programs are often highly transferrable between countries provided there is a baseline level of organizational capacity. Camera technology, for example, makes possible congestion pricing by capturing license plate numbers, and sends the bills to drivers at their home addresses. Singapore first pioneered the system, and it has since spread to cities including London and Stockholm (Sweden), and would have implemented in New York (United States) were it not for political opposition. The high level of coordination between ITS experts in the public and private sectors also contributes to a culture in which good ideas are able to spread easily across borders, as long as the technical and financial capacity exists.

Case Study

Monza's Traffic Priority System (Italy)

Context

Monza is a regional administrative center about 15 km outside Milan. Despite the city's relatively small population of 123,000, its role as a provincial capital and location at the nexus of several rail lines have led to constant traffic congestion. To tackle this, Monza joined the CIVITAS ARCHIMEDES network, a consortium of several cities in the Czech Republic, Denmark, Romania, Spain, and the United Kingdom that agreed to implement 83 different transport network improvements to improve traffic flow, promote the wider use of public transport, and increase shared-mobility options such as car-sharing.

In Action

Monza implemented a traffic priority system for its public bus system, which suffered from the city's increasing levels of traffic congestion. The main bypass road outside the city was equipped with Urban Traffic Control (UTC) technology at several key intersections, and the city rerouted control of those traffic lights to a single command center that was able to track bus movement in real time. According to CIVITAS, a module first decides which buses need a priority action, depending on several criteria (e.g., a significant delay for a single bus; many buses on the same line being delayed). Then, a decision module weighs the different options for improving traffic flow and chooses the traffic intervention that it deems best suited to the situation. It then directs the traffic signals to give priority to oncoming buses and alters stage timing for several cycles in order to optimize traffic flow. Buses in Monza's system received new equipment that made them easier to track, including a GPS device coded with a latitude–longitude coordinate system and a GPRS communication system able to send information to the central transport command center.

Results

After implementing the UTC system and signal priority for buses, the test corridor along the outskirts of Monza experienced a 5% increase in traffic flow and a 20% increase in traffic density. Signal phases for the traffic lights along the corridor changed from 160 to 150 seconds during peak hours and 160 to 125 during off-peak hours, which allowed cyclists and pedestrians to cross more frequently. Buses along the corridor were able to stay on schedule more easily, and arrive and depart more regularly, although the average passenger did not experience a reduction in travel times. Moreover, given the relatively small scale of

this project (a handful of intersections along a bypass road in a small city), there was not a lot of public recognition or awareness of the improvements to the transport system. The redesign of the city's traffic lights and transport priority system helped lead to a better working relationship between the city government and the technical staff of Project Automation SA, the private company contracted to carry out the project. However, because of the city's relatively small size and lack of large-scale technical expertise, local leaders also recognized the need to equip traffic planners and police officers with more advanced skills. Capacity building will be necessary to carry similar projects out at a larger scale.

Solution

Integrated Fare System

In Brief

In many cities, especially large urban agglomerations, public transport is not provided by a single, unified government agency. Instead, passengers have to rely on several companies who provide services by often poorly integrated transport modes (such as rail, bus, or taxi). These modes frequently have different schedules, route patterns, and fare systems. Integrated fare systems (IFS) are an attempt to create a single fare structure for all city public transport, allowing passengers to transfer seamlessly from one mode to another. This increases the efficiency and attractiveness of all city public transport.

Examples

The advent of the smart card, an electronic payment card stored with a certain amount of money and that can pay fares on all transport options across a city, has been central to the rise of IFS. Generally, information is stored on either a magnetic stripe or a computer chip, as is the case with Hong Kong's Octopus card. Introduced in 1997, the Octopus card allows for contactless payment across the city's many modes of transport, which include rail, bus, and ferry. Users can also make shopping purchases with the Octopus card. The Octopus card was the model for the Oyster card, which serves a similar function in London (United Kingdom). Contactless payments and the ability to recharge an Oyster card from a cell phone or bank account, helps to eliminate waiting times at station kiosks. Additionally, because the Oyster card can store personal information and travel data, it uses a price-capping feature that calculates and deducts the lowest possible fare based on how far and long a customer travels. Finally, the Oyster

card allows London to control the distribution of revenue between transport operators.

Results

Transport systems that have switched their methods of collecting fares over to IFS have generally seen a marked increase in traveler satisfaction. According to the operators of Hong Kong's Octopus card, there are almost three cards in circulation for every person, and 95% of residents between 16 and 65 have a card. Some 12 million daily transactions take place. In London, over 85% of all rail and bus travel is paid through Oyster cards, with less than 1% of travelers paying in cash. Other cities that emulate Hong Kong and London's smart card technologies in some form include Amsterdam (Netherlands), Paris (France), Singapore, and Sydney (Australia). In Switzerland, IFS are used on the national intercity railway system.

Technical and Financial Considerations

The capital costs of overhauling an entire fare collection system and replacing it with a unified digital method of payment are considerable. In London, the city only decided to replace manual payment with Oyster cards after huge increases in the metro ridership throughout the 1990s. As lines at fare collection gates got worse and it became clear the ridership increases would be permanent, Transport for London (TfL) made the decision to invest in smart card technology. However, uniting disparate transport operators under a single fare payment system can be politically difficult. In Hong Kong, the city's five major public transport operators agreed to cooperate in the rollout process for the Octopus card, and the card can now be used citywide. In Sydney, however, the process was more difficult as the New South Wales State Government and a transport contractor could not agree on the proper way to overhaul the city's complex fare system. As a result, millions of dollars and several years were lost to delay, and the Opal card only began its rollout process in 2015. In a place like Mexico City, where hundreds of private concessionaires operate transit routes, similar conflicts would be likely.

Policy/Legislation

Developing and introducing IFS is largely the prerogative of individual transport agencies, which can begin the process of integrating fares and developing smart cards by allocating money for those purposes. However, because many transport systems in large cities are divided among multiple small operators that compete with each other for passengers, it can be difficult to convince them to agree to work together on creating a single fare system. In Los Angeles (United States), for

example, the TAP card is valid on all services run by Metro, the region's largest transit operator, but many smaller transport operators in the region have elected not to join the system, preferring to avoid sharing revenue on a regional basis. Whether or not small agencies can be compelled to join an integrated system depends on the local laws.

Institutions

IFS are usually managed through a smart card or magnetic-strip card technology, and in both London and Hong Kong, the work of collecting fares is contracted out to a private operator. Several private companies form a consortium to supply fare cards and operate the system, and these consortiums receive a license from the municipal transport agency (TfL, for example). In certain cases, these contracts can be voided, as TfL decided to do in 2008 following a number of technical failures with the Oyster card's original contractor. In other cities, where multiple private (or semipublic) operators operate transport services, all the agencies and other major stakeholders must agree to share passenger information and travel data with the technology companies licensed to manage the card system.

Transferability

IFS already exist on multiple continents. More than any single particular piece of technology, the success of IFS depends on whether the local transport culture is such that multiple agencies can agree on fares and operations. The "cooperation within competition" slogan used by Hong Kong's five transit operators might not work in the New York City area, where different agencies operate non compatible systems because of state boundaries, or in many Latin American cities, where hundreds of private operators provide a majority of transport, operate many of the same routes, and only take payment in cash. Even in a city of the latter type, however, the technology to create integrated systems exists. Mexico City's formal transport system consists of a metro, BRT network, and light rail line, all of which travelers can pay for using a single smart card.

Case Study

London's Oyster Card (United Kingdom)

Context

London's transport system is one of the largest in Europe, and includes the metro, bus lines, regional/suburban rail, and several light rail lines. TfL, a public agency run by the Mayor of London, manages

the entire system and carries approximately 6 million commuters daily, about half of whom ride the metro. After a prolonged ridership surge in the 1990s, TfL introduced smart card technology in order to reduce waiting times at fare gates and ease the payment process.

In Action

TfL introduced the Oyster card in 2003, and over the years made several improvements to improve the system and save riders money. In 2005, London introduced "price capping" where travelers would pay no more than the price of a 1-day fare card, no matter how many trips they took or how long their journey was. TfL designed fares to provide riders with an incentive to use the Oyster card instead of cash fares, with discounts of up to 33% on all transport modes. Oyster cards have also been expanded to London's massive bus system, and, as of 2014, city buses no longer accept cash. In recent years, TfL updated its card-reading machines to allow customers to top up their Oyster cards with contactless credit card payments. Passengers can make payments of up to £20 by swiping their credit card in front of the Oyster card reader, with no need to enter a PIN code. The Oyster card has also changed the way TfL has been able to manage its fare revenues, which makes up 40% of all operating costs. By placing all transport modes under a single unified system, TfL has been able to control revenue distribution between operators, prevent losses from fare evasion, and better account for income. Finally, the Oyster card allows TfL to obtain data on passenger behavior and journeys, allowing for more efficient planning.

Results

Since the launch of the Oyster card, TfL has issued around 60 million cards, and an estimated 85% of all rail and bus travel in London is paid for with the card. (The number of riders who pay their fare in cash has dropped to about 1%.) By eliminating the need to purchase tickets at stations, the Oyster card has reduced waiting times at transport stations throughout the city. According to TfL, the card allows busy stations like Liverpool Street to increase their input capacity from 15 customers per gate per minute to 25 customers. Eliminating paper tickets has also reduced fraud and fare evasion, saving the agency £40 million per year. While customer satisfaction with Oyster cards is generally high, some passengers have raised concerns about sensitive travel and financial data. Nongovernmental watchdogs report that contactless payments are a risky technology. Finally, the cost of selling Oyster cards and maintaining a comprehensive, integrated ticketing system has decreased over the years. The cost of sales has dropped 4 percentage points since the introduction of the Oyster card. As contactless payment becomes more popular and the card becomes the default method of payment for all

London transport modes, administrators believe they will be able to rely more heavily on customer self-service machines, online account management, and mobile payment.

Solution

Bus Priority Measures

In Brief

Bus priority measures are low-cost, highly efficient traffic management solutions that suit cities with high traffic congestion. They keep buses moving, boosting mobility in areas that attract many people. Due to their flexibility, measures can combine, but their success depends greatly on effective law enforcement. Because of their low construction and operation costs, cities can apply bus priority measures anywhere, and they are a great option for urban communities of all sizes.

Examples

There is a wide range of bus priority measures, and their implementation depends on the problems that a city might have. The main aim is to improve the movement of buses, while protecting access to bus stops. Introducing exclusive bus lanes on streets with heavy traffic is one option, and can save commuters time. This also makes the service more reliable, attracts more passengers, and reduces costs because fewer buses are required to run the service. Other related measures include bus priority signals, contraflow bus lanes, bus-only streets, parking restrictions, and enforcement cameras. Great examples of cities with bus priority measures are London (United Kingdom), Brisbane (Australia), Edinburgh (United Kingdom), and Mexico City (Mexico). However, to have a comprehensive and coherent strategy for most urban areas, it is important that cities introduce improvements to public transport together with measures to discourage the use of private vehicles.

Results

Bus priority measures allow some bus services to increase their speeds. In some cases, buses using a mix of exclusive lanes and bus priority signals may reach up to 30 km/h—similar to a metro system. Cities that introduced bus priority measures have reduced travel times by up to 10%, optimized their services, and attracted more passengers. Exclusive lanes and special signal phases also help bus services have more control over times and frequencies. To ensure bus priority measures are successful, cities should apply them with other priority measures, spreading the benefits to wider bus services. If these

measures are linked to other improvements—such as more frequent services, improved waiting facilities, passenger information systems, and even park-and-ride facilities—the results may be even better. In combination, these measures improve the image of bus services and attract more passengers.

Technical and Financial Considerations

The costs of bus systems are significantly lower than other public transport systems. This applies to most aspects, such as construction, operation, and vehicles. Maintenance and fuel represent the highest long-term costs. While public rail can cost from $20 to $180 million per kilometer, bus systems cost between $1 and $10 million. In cities in developing countries, prioritized bus systems are very appealing due to their ability to recover the money invested in them, and because they take a relatively short time to construct.

The infrastructure required for a bus line or system is much lighter than other public transport systems. Although the stations, exclusive lanes, and fare collection systems require a special design, they are simpler than those of other transport modes. The infrastructure is also flexible, allowing the routes to be expanded or modified.

Policy/Legislation

Bus networks do not require great modifications to legislation. In most cases, the agency in charge of traffic management may also be the public transport regulator. In terms of the institutional framework, best practices clearly show the advantage of having a single transport agency within a city that plans, manages, regulates, and controls the different transport modes. Overall, cities must accompany public transport initiatives with regulations, programs, and:

- environmental standards (including fuel efficiency and technology);
- public transport quality-of-service plans;
- fare regulations; and
- public transport subsidy schemes.

A city that wants to implement a bus network system should ideally develop a SUMP linked to other land-use planning instruments.

Institutions

The institutions in charge of designing these kinds of measures are usually transport planning agencies such as mobility ministries, transport departments, and/or planning institutes. The authority level (federal, state, or local) depends on the existing institutional and legal frameworks. It is necessary to coordinate with entities such agencies responsible for the environment, urban development, public space,

public works, and social and economic development agencies. Some of the other stakeholders involved in the implementation of this solution might include bus operators, drivers unions, transport agencies, and traffic police. Users' groups are also important in advising these agencies about improvements they believe will make services more attractive to commuters.

Transferability

Bus priority measures are 100% transferable. They are a solution than can be implemented in small, medium-sized, and large cities, with a flexibility that meets different mobility needs: main or complementary trips, long or short trips, lineal or deviated routes, ordinary or express routes. When linked along a route, priority for buses can contribute toward an overall strategy for dealing with urban congestion, especially if supported by measures such as urban traffic control, new traffic management, parking control, and park-and-ride services. However, giving priority to buses can delay other traffic, something that cities should assess in the overall appraisal. However, environmental considerations and overall transport policy objectives may strengthen the case for providing priority for buses, even at the expense of delay to other vehicles. Bus priority measures can themselves be a component in a demand management strategy by reducing the road space available to cars.

Case Study

Brisbane Busway (Australia)

Context

A great number of Australian cities are implementing bus priority systems, due to their low construction and operation cost and high efficiency rate. Brisbane, the third largest city in Australia, is one of them. It has a population of 2 million and between 2001 and 2006, it grew by 11%, the quickest rate in the country. Economically, the city has grown considerably since the end of the last century and has attracted a large number of industries, technological companies, and diverse universities. This forced Brisbane to consolidate and expand the public transport network, with a special emphasis on a dedicated expressway for buses, the Brisbane Busway—which started operations in the mid-1990s.

In Action

The Brisbane Busway began with 50 "green" buses that ran on natural gas. It now has a network of 25 km that authorities can easily extend in the future. Currently it has three lanes (South East Busway, Northern

Busway, and Eastern Busway) that together moved more than 70 million passengers in 2011. The stations show real-time departure and arrival schedules thanks to data provided by Brisbane City Council. The stations have bicycle-parking facilities and are 100% accessible for people with disabilities. In 2007, at peak hours, 294 buses ran through the most critical section of the line, Woolloongabba station. In theory, the system can carry over 18,200 passengers per hour.

Results

Brisbane Busway is Australia's largest prioritized bus system. In its first 6 months, the number of passengers on Brisbane's buses increased by 12% compared to the previous year. The quality of the prioritized bus system convinced many private car drivers to shift to using public transport. After a year of operations, 27,000 people per week used the system. The Busway transformed Brisbane in a positive way, improving the image of the city and the quality of its public transport. A 2002 study showed that the value of real estate near Busway lines increased. Today, the transport network continues to grow, along with the number of users.

Solution

Bike-Sharing and Public Bicycle System

In Brief

A public bicycle system is a relatively new transport concept enabling people to make short trips and/or connect to public transport. The system is based on point-to-point trips, where users can pick up a bicycle at any self-serve bicycle station and return it to any other station within a limited period (around 30–45 minutes). Bicycle-sharing systems have two key advantages for local governments when compared to other transport projects: costs are relatively low and the timeline of planning and implementation is short (i.e., 2–4 years).

Examples

Amsterdam (the Netherlands) introduced the first bicycle-sharing system in 1965, but the city quickly shut it down due to theft and vandalism. By the mid-1990s, other cities tried to introduce public bicycle programs, but it wasn't until 2010 when the concept experienced a major boom around the world. Today, more than 600 cities have bicycle-sharing systems, with the largest in Hangzhou and Shanghai (China), Paris (France), London (United Kingdom), and Washington, DC (United States). Each city has planned and designed the system to

make it its own, taking into account the different and unique characteristics of their urban context. The main features of a bicycle-sharing system are usually:

- a network of stations with an average distance of 300 m between them;
- bicycles with adjustable parts and gears for two different types of users;
- stations with an automated locking system for easily checking bicycles in and out;
- a tracking system that locates the bicycles and identifies the users;
- real-time monitoring of station occupancy; and
- an easy and accessible paying method.

Results

Bicycle-sharing systems fill the gap between public transport and destination points, and satisfy citizens' demand for short trips, reducing the time of commutes. In general, bicycle-sharing systems increase the choices of and accessibility to attractions by giving locals a wider range of destinations beyond their walking range at a low cost. By providing an alternative to the use of private vehicles, this transport mode also helps improve air quality and reduce transport congestion and noise. In addition, cycling brings both physical and mental benefits for its users, and can help improve the urban image of a city and its culture.

Technical and Financial Considerations

Estimating the costs of a bicycle-sharing system depends on a number of factors, such as the size of the system (number of stations and bicycles) and the type of stations and bicycles (infrastructure and technology). Operating costs include maintenance, distribution, staff, insurance, office space, storage facilities, website hosting and maintenance, and electricity (if necessary).

There are several financing options for launching a bicycle-sharing system, such as government funds, federal and state grants, private donations, corporate sponsorship, street advertising contracts, and user revenues. The systems usually perform well at farebox recovery (i.e., the percentage of operating costs recovered by user revenues). In the United States, they showed recoveries from 36% up to 97%, a very high percentage in comparison to the average farebox recovery of the US metro transit systems, which is 35%. A key factor to take into account for the operational and economic success of the system is redistribution, which consists in rebalancing the bicycles that are near capacity to stations that are empty. This represents a great operational

challenge, accounting for up to 30% of the operating costs in the case of European systems.

Policy/Legislation

A city or municipality wanting to launch a bicycle-sharing system should have an effective public transport system to promote connectivity and intermodality through physical and operational integration. Regulations and infrastructure that prioritize cyclists and their safety, such as enforcing the use of helmets and constructing bicycle paths in key roads, should accompany the implementation of a bicycle-sharing system. Cities should plan bicycle paths as a network to work best, enabling users to cycle safely and continuously throughout the area. These measures will help users feel comfortable using a bicycle. Cities should also promote awareness and cultural actions for cyclists and drivers (both private vehicles and public transport), including communications campaigns, free cycling lessons and organized recreational strolls.

Institutions

Bicycle-sharing systems can be public or private, but experience shows that the most successful are a combination of the two. As they are considered public transport, they should be managed like other public transport systems. Planning and management should fall under the control of the local government—in a department such as a ministry for mobility, environment, or similar. Cities should also establish a project management unit to oversee the design, tendering, contracting, implementation, and administration. A second institution involved in the system is the operator. They can be part of the government, or external—either for- or nonprofit. Their main tasks would be to maintain the fleet and stations, redistribute bicycles, provide customer service, process payments, create marketing campaigns, and manage the brand of the system.

Transferability

Bicycle-sharing systems can fit almost any kind of urban context and are a proven effective and cheap mode of transport around the world. Bicycle-sharing has been introduced in over 600 cities, using nearly 1 million bicycles (and counting). Large metropolitan hubs are not the only ones turning to bicycle-sharing systems: Aspen, a small community in Colorado (United States), launched a system of 100 bicycles for its 7000 residents.

Case Study

Mexico City's Bicycle-Sharing System (Mexico)

Context

Mexico City is one of the most congested and polluted cities in the world. For several years, the city has made a great effort to improve public transport and reduce car trips and travel times. The government knows that this benefits inhabitants' health and reduces the strain on government health programs, traffic control, and the city's carbon footprint. Such initiatives include the introduction of a BRT system in 2005, a new metro line (making it a network of 12 lines), the "No Driving Day" initiative and, most recently, the introduction of the Ecobici bicycle-sharing system.

In Action

The Ministry of Environment launched the Ecobici bicycle system in Mexico City in February 2010. The city installed 85 stations in a central neighborhood with offices, housing, and several restaurants and cafes. Citizens rapidly adopted the system, finding that it satisfied their needs for short trips and convenient connections. In the 6 years since Ecobici began, it has grown considerably. The city recently registered 35 million trips, during which users traveled 54 million kilometers. There are now 452 stations located through 42 neighborhoods, an area of 32 km^2. Over 220,000 people use the system of 6000 bicycles. The network connects to 35 metro stations and 54 BRT stations. Ecobici is now the largest bicycle-sharing system in Latin America. The Ministry of Environment also launched other policies to support the use of bicycles in Mexico City. These include the Urban Cyclist Manual, and the Sunday Promenade, Move by Bike, which consists of closing roads on Sundays for cars, making them exclusive for cyclists (or other kinds of recreational uses, such as roller skating and running) and the Cycling School, which provides free cycling classes for people all ages.

Results

Thanks to Ecobici, Mexico City reduced CO_2 emissions by 2400 tonnes. To mitigate that amount of GHG emissions would require the planting of around 7000 trees. The success is mainly due to citizens' shift in transport choices. In a 2014 survey, almost 60% said that before using the system, they never considered the bicycle as a feasible transport mode. Now they do. Users also said that riding a bicycle has a positive effect on their mental health by avoiding the stressful environment of crowded public transport or traffic. Several women also have found

Ecobicycle an escape from sexual harassment, which is a common issue in Mexico City's public transport systems. Sources: Sarah Goodyear. "The Bike-Share Boom," City Makers: Connections (September 2016) Institute for Transportation & Development Policy. The Bike-share Planning Guide (July 2014) Peter Midgley. Bicycle-sharing Schemes: Enhancing Sustainable Mobility in Urban Areas (May 2011) Peter Midgley. The Role of Smart Bike-sharing Systems in Urban Mobility (May 2009).

Solution

Metro Systems

In Brief

The term "metro" is a common international term that refers to subways and heavy rail transit. Metros are the most expensive form of MRT per kilometer, but have the highest theoretical capacity. Because metros have an exclusive right-of-way infrastructure and perform mass and high-speed transit within urban areas and with neighboring urban areas, they could reduce road congestion and travel time, especially with more frequent service and when accompanied by pedestrian-friendly and cycling access and by public feeder systems.

Examples

There are many metro systems around the world. The most well-known are in London (which began operation in 1890, and which now has a 402 km network, 270 stations, and an annual ridership of 1.34 billion journeys a year), Paris (est. 1900; 214 km; 302 stations; 1.52 billion), New York (est. 1904; 375 km; 422 stations; 1.76 billion); Tokyo (est. 1927; 195 km; 179 stations); and Singapore (est. 1987; 170 km; 121 stations; 1 billion). Metro systems generally operate separately from road traffic below-grade, on elevated structure, or at-grade level that run along exclusive rights of way. As metros generally run along major thoroughfares, they are supported by other smaller modes of public transport like buses that serve as feeder systems and by efficient public transport interchange terminals with connections to various public transport services. Integrated or single ticketing contributes to smoother transfers. Apart from their physical infrastructure, successful metros are backed by a back-end operational support or an information and communication technology (ICT) to facilitate service delivery in line with the agreed timetable.

Results

The International Association of Public Transport estimates that metros carried 155 million passengers a day in 2006 and are by far the fastest mode of MRT. They travel at an average speed of 40–50 km/h, while LRT and BRT systems (see Factsheet Bus Rapid Transit System) typically operate between 20 and 30 km/h. Metro systems can transport many people and use space more efficiently than buses or cars, thereby saving emissions. They also consume less energy than buses and cars; a 1-kg equivalent of petrol will allow a single person to travel more than 48 km by metro, compared to 38 km by bus, and no more than 19 km by car. Constructing, operating, and maintaining metro systems also create jobs.

Technical and Financial Considerations

Metro systems are most applicable in areas with more than 5 million inhabitants, in corridors with a trip volume of more than 700,000 trips per day, and with at least $18,000 (€16,000) per capita annual income at the city level, given its high cost of construction and operation. Other prerequisites include competitive fares, a steady and growing prosperous population, and integrating metro systems with other modes. Bus systems can handle moving 30,000 passengers an hour in one direction, but only metro systems can transport over 35,000 people. Rail transport costs $15–30 million (€13.5–27 million) per kilometer and elevated rail transport $30–75 million (€27–67.6 million) per kilometer. However, underground rail transport is estimated to be six times more expensive, reaching $60–180 million (€54–160 million) per kilometer. However, despite the higher costs, they improve the overall mobility of the population.

Policy/Legislation

The emission savings from metros are greater with higher ridership in terms of CO_2 emissions/passenger/kilometer. Therefore, the frameworks for metros should promote their use together with other public transport modes and should attract demand to ensure high ridership. Among the fundamental requisite for metros are clearly articulated roles of the parties involved, especially in PPP arrangements. Metros require large funding and resources for construction, operation, and maintenance. Thus, the generated revenue should be able to cover the operating costs or the infrastructure could deteriorate. Secondly, metros should be integrated with other public transport modes and with key origins and destinations. This indicates a need for land-use planning and long-term transit-oriented development to also ensure mixed-use and walkable development and high-density population

along its route that are within walking distance of the stations, as well as travel demand management to ease crowding situations during peak hours.

Institutions

The lead agency for metros is usually the transport ministry, but because operational subsidies are usually still required for metros, the private sector is involved by way of PPP. The transport and planning ministries should lead in oversight and in identifying station locations aligned with the country's sustainable transport master plan and the city's long-term urban plan. Planning for such a large-scale solution involves different national and local government agencies to model and forecast demand growth, draw up land-use and transport plans, provide ICT, among others, to develop and maintain metros cost effectively. The government should likewise help ensure the participation of the key stakeholders, like residents and retailers, in the community to consider the diverse viewpoints and priorities.

Transferability

Integrated public transport planning would ultimately be an enabler for encouraging shifts toward public transport. Successful metros are generally viewed to be convenient, comfortable, attractive, affordable, efficient and reliable, thus the integration is not only by physical infrastructure with easy interchanges but also through ticketing system integration for seamless transfers between various transport modes. A thorough understanding of cost requirements for metros would allow planners to anticipate operating and maintenance expenses. Another approach is land-value capture, which is a funding instrument used to recover land-value increments (i.e., unearned income of the private land owner) generated from publicly created value generated by public infrastructure investments. Land-value capture is used for financing public transport systems that have intensive capital and operation and maintenance costs like metros, or for furthering transport-oriented developments. Transport agencies and developers could agree to have the latter contribute to the construction of transport infrastructure including public transport services, walkable districts, and public spaces (e.g., parks, bicycle lanes, sidewalks) as their property value would increase.

Case Study

Singapore's MRT

Context

The idea for the Singapore metro system, known as the MRT network, came about in 1967 when urban experts predicted that, as the population and number of motor vehicles in Singapore grew over the next 20 years, traffic conditions would worsen. The MRT went into operation in 1987, and today it is one of the most extensive and efficient rail systems in the world, covering almost every heavy transport corridor of the country. A comprehensive traffic study in 1981 concluded that a mass transit rail system would be more favorable and practical for Singapore, instead of a public transport system, an all-bus public transport one. The Mass Rapid Transit Corporation (MRTC) was officially set up in 1993 to oversee the network and would later be combined with the Registry of Vehicles and Roads and Transport Division to form the Land Transport Authority.

In Action

The MRT runs on four main lines: North South Line, East West Line, Circle Line (which runs along the perimeter of the country's central business district), and the North East Line. While the Land Transport Authority owns the MRT system, private companies operate it. The bus and LRT systems serve as feeder modes to connect residential areas and other light corridors to MRT stations. The MRT operates daily from 5:30 a.m. until midnight, though it extends hours during special holidays. Between 7 a.m. and 9 a.m., trains run every 2−3 minutes, and the average interval for the rest of the time is 3−7 minutes. Passengers can use ticket smart cards to travel on the MRT and the LRT and bus system. Students, senior citizens, and children enjoy special rates. To ease the pressure on the MRT during peak hours, commuters are given incentives when they travel during off-peak hours through an awards scheme. With a registered smart card, travelers can automatically earn one point for every kilometer they travel before 6:30 a.m. and after 9:30 a.m. from Monday to Friday, with additional points available if traveling during the designated "decongesting" hours (6:30−7:30 a.m. and 8:30−9:30 a.m.).

Results

Estimates indicate that the average annual MRT ridership could grow from the current 688 million to 1.3 billion by 2030. According to Singapore's Land Transport Masterplan (2008), the government is increasing the rail transit system density from 31 km per million population to 51 km per million population by 2020. It also sets out three challenges: increasing travel demand and limited land; declining public transport mode share; and changing demographics and expectations.

The Land Transport Authority is also committed to removing physical barriers and ensuring clear passageways, and installing tactile guidance systems and wheelchair-accessible toilets to meet the needs of the elderly and less mobile MRT users.

Solution

Tram Systems

In Brief

A tram system consists of vehicles, which run on tracks on urban roads. They usually share the street with other road users (private vehicles, cyclists, pedestrians), but some lines might also operate on a segregated right of way. The lines or networks on which tramcars operate (known as tramways) are powered by electricity; they are designed to be unobtrusive to allow pedestrians, cyclists, and drivers to freely circulate around them, or on the infrastructure when it is not being used by the trams. Depending on the design and region, trams may also attach to overhead electric wires.

Examples

Many larger cities around the world have introduced tram systems because of their flexibility. Among many others, these include Melbourne (Australia), Newcastle (United Kingdom), Lisbon (Portugal), San Francisco (United States), Budapest (Hungary), and Düsseldorf (Germany). Although some cities use this system as a main transport mode, they often mix it with light rail for longer commutes or bus routes to provide more flexibility in the network. The main features in a tram system include:

- vehicles, usually one to four cars in a tram;
- tramway line or network, and sometimes overhead wiring;
- signaling;
- onboard fare collection system; and
- open station stops, light infrastructure.

Results

Trams save three times more energy than regular buses. People also find them more enjoyable as they do not lurch, swerve, and vibrate as much as buses. Trams are popular in many cities as they are cheap for riders and convenient for cities. They reduce traffic congestion and are environmentally friendly; as they do not use fuel, they do not directly produce GHG emissions. Trams, as with other road public transport systems, use space efficiently; one tram vehicle replaces about 40 private

cars, which take up a far larger area of road space and move far less people. In periods of peak demand, tramcars can easily be added to the trams without needing extra staff, providing a higher capacity than similar transport systems. In Dresden (Germany), the busiest bus lines were replaced with a tram system that now runs every 3 minutes at peak times.

Technical and Financial Considerations

Compared to other rail systems, especially metro systems, tram systems do not cost as much to construct and operate—but they cost considerably more than bus systems. The cost for 1 km of tramways can be up to $75 million (€68.3 million) compared to $8 million (€7.3 million) for 1 km of a BRT line. This is the reason why the latter is more popular in developing countries. On the other hand, tram systems require 20% less maintenance than buses. In short, installing tracks and purchasing vehicles cost a lot, but in the end, the maintenance and operation costs are lower. The life of a tram vehicle is much longer than ICE vehicles, and the cost for propulsion resources is lower than diesel and gasoline buses. In this case, trams are highly cost-effective.

Policy/Legislation

Mass transport systems such as trams can be part of short- and long-term mobility solutions for large, medium-sized, and even small cities. In terms of the institutional framework, best practices clearly show the need to have a single transport agency in charge of planning, managing, and controlling the different transport modes. Overall, cities must help public transport initiatives with regulations, programs, and:

- land-use planning instruments;
- environmental standards (including fuel efficiency and technology);
- public transport service quality plans;
- fare regulations;
- public transport subsidy schemes; and
- operational regulations.

Institutions

Leading institutions that oversee tram systems are public transport planning institutes, public transport companies, and urban transport administrative departments. Institutions that may be involved in introducing tram systems include environmental protection agencies, electric power companies, and mass transport agencies. The hierarchy of the authority (federal, regional, or local) depends on the existing institutional and legal frameworks. It is necessary to coordinate with entities responsible for the environment, urban development, public space,

public works, social and economic development, and social communication. Other institutions might include the secretary of state (or related local agency) and the agency in charge of finances.

Transferability

This type of rail system is adaptable to any situation. This is why there are over 350 tram systems around the world, some dating from the late 19th or early 20th century. Even though a considerable number of these systems were closed during the mid-20th century, in recent years, trams have made a comeback in several European and American cities. Since 1985, 120 tram lines/networks have opened. The flexibility of the tram's light infrastructure makes it adaptable to any kind of urban context, topography, and climate. Even so, developed countries such as the United States, Australia, and several countries in Europe are more likely to introduce trams. Due to its high start-up costs, developing countries find public transport such as trolleybuses or BRT more suitable.

Case Study

Croydon's Tram System (United Kingdom)

Context

In the mid-1800s, the borough of Croydon in south London was rapidly growing and in need of an affordable public transport mode. This gave way to horse-drawn trams, followed by electric trams running in the area. Today, the necessities have not changed much. Croydon and the surrounding boroughs (Sutton, Merton, and Bromley) have been going through a significant urban transformation due to an investment program aimed to improve and encourage the local economy and urban and housing development. The government saw the necessity of providing south London with reliable orbital transport links to serve the developing area. Tramtrack Croydon started construction in 1997 and began operating in 2000 with 24 trams, capable of providing service to more than 200 passengers each.

In Action

The Croydon Tramlink was the first tram system in London since 1959, and became immediately popular. South Londoners quickly adopted the system, and annual passenger numbers grew from 18.5 million in the first year to 27 million in 8 years. The tramway is 28 km long and has 39 stops. Its configuration presents a mixture of exclusive right-of-way in some public roads and street track shared with other traffic.

In 2008, TfL, the local government body responsible for London's transport system, bought Tramtrack Croydon and made a number of improvements to the network, which in some parts was in a poor condition. The system adds more tramcars at peaks hours and when going through key routes, carrying more than 200 passengers—almost three times more than a double-decker bus. A double track has more capacity than a dual carriageway, yet only requires one-third of the space. All trams and tram stops are now accessible to people with a wide range of disabilities. The vehicle floors are level with the platforms, making it easy for wheelchair users, mobility-impaired passengers, and parents with children in pushchairs to board. The tram interiors have color-contrasting grab rails, designated for wheelchair users, priority seats, audible and visual customer information, and door warnings.

Results

According to the chief executive of the Croydon Business Improvement District, the tram network, "has quickly become symbolic of Croydon's connectivity and is a powerful asset for our town center and local businesses, providing easy access for employees, visitors and residents." It has transformed the urban image of south London and the way people move. Surveys show that 20% of Tramlink passengers used to travel by car, meaning that the Tramlink has helped remove private vehicles from the roads—contributing to the reduction of traffic congestion and pollution. Another benefit is that the vehicles are both energy- and space-efficient. Surveys show that customer satisfaction scores remain high along the network. However, the system is soon to face significant challenges as the population in London is growing faster than any other European city—set to reach 10 million by 2030. In 2014/15, there were 32.3 million tram journeys, and this is expected to hit 60 million by 2030. With the important urban redevelopment taking place in the area, trams will be crucial in the movement and connection of people to the main attraction points. The Tramlink is a long-term solution to improving transport quality by reducing waiting times, and providing integration with the new layout of Croydon's town center.

CLUSTER 2: TRANSPORT INFRASTRUCTURE

Solution

Modal Interchanges

In Brief

Intermodal interchanges are places where passengers can change their mode of transport during a journey easily and conveniently. Delivering simpler, more convenient, and better transport interchanges is an essential element of making transport networks more integrated. Journeys by public transport become faster, easier, safer, more reliable, and enjoyable.

Examples

Intermodal interchanges are points where transport modes join with other modes and allow passengers to change easily between, for example, rail, metro, buses, cars, or bicycles. They are key infrastructure elements that provide seamless transport, making public transport an appealing option when commuting or planning a trip. A key is to create nodes (points in a network where lines or paths intersect) that make transferring from one transport mode simpler, more accessible, and friendly. A coordinated service between transport managers and operators is crucial, as is providing good information to passengers related to the options they have when transferring from one mode to another.

Results

Intermodal interchanges minimize overcrowding and congestion; use space more efficiently; and optimize the design and location of key facilities. They also increase passenger satisfaction, and get more people using public transport. The experiences of different cities show that transport interchanges perform a key public transport function, and ensure that transport infrastructure is well connected to the public transport network.

Technical and Financial Considerations

The cost of constructing interchanges is very flexible, depending on the measures included in the project—but constructing them in consolidated urban zones needs large investments. Interchanges should improve travel times and boost the number of travelers on the public transport network, and cities should consider these factors when calculating the costs. The possibility of obtaining direct profits from managing an interchange station adds a dimension of economic profitability to the investment's already-existing social benefits. Using space efficiently and renting commercial retail space can save money or generate income. The principal technical determining factor is the enormous surface area that is required. In addition, the design should respond to three types of needs: those of the transport interchange station, those of the users, and those specifically of the transport modes servicing the station.

Policy/Legislation

Interchanges are crucial in getting more people to use public transport, which makes their city more liveable—a major objective of cities across Europe. National, regional, and local policies should also take into account sustainable transport and urban planning, and cities should implement them in legislation at different levels. Specific regulations on important issues such as fire safety, ventilation and air extraction, safety, and permitted uses are also required for interchanges.

Institutions

The institutions involved in the process depend on the stage of the project. However, the main stakeholders are the interchange owner/manager; the local authority; public transport operators; and the city planning department. Political support is crucial to initiate this kind of project, or at least commitment to the required finances. The infrastructure usually belongs to the local or regional authority and in many cases to the transport operator. Therefore, this kind of investment could be an initiative of the service providers or other stakeholders. However, the authority should make the final decisions together with the transport operator (or the infrastructure manager). Whether or not the infrastructure and public transport services are in different hands, they make decisions in strong cooperation and usually involve third parties to collect the possible benefits to the project and provide solutions for the financing.

Transferability

This kind of infrastructure is transferrable to other cities, considering that it is flexible and has to be adapted to the specific needs and requirements that may arise. These infrastructures have a very positive impact in the city and on urban transport. As part of the EU CIVITAS program's ELAN project, intermodal terminals were studied in Ljubljana (Slovenia), Ghent (Belgium), Zagreb (Croatia), Brno (Czech Republic), and Porto (Portugal) to create a platform for the exchange of experiences and good practice. These kinds of initiatives are very important to reproduce these measures in other cities around the world.

Case Study

The Plaza Eliptica in Madrid (Spain)

Context

The city of Madrid has a long tradition on making intermodality work, with efforts that clearly pay off. In 2004, the Madrid Regional

Transport Authority (MRTA) licensed a public tender for the construction, operation, and maintenance of six intermodal interchanges. The Plaza Eliptica was one of them. The proposal was to build a new underground transport interchange station that would optimize the connection with metro lines 6 and 11 for close to 60,000 bus travelers, particularly once the latter line extends to the city center. This removed street-level bus services, completed the reorganization program of all the bus terminals around the circular metro line, and improved waiting times and transfers of bus users.

In Action

The transport interchange station divides into three levels; the first two of these are for the interurban bus services and the last is for connection with the metro through a general services area. On each bus levels, 10 bays for 15-m-long buses are located around a triangular area or "island"—a layout based on the 14 bus lines that ended their routes in the station on a daily basis. As the heaviest flows of people are passengers getting off buses and going to the metro station, the interchange is designed is a way to channel these flows as directly as possible, without prejudicing other passenger movements. Based on this and the triangular form of the platform, there is a main nucleus in the center of the triangle, with stairs for reaching the metro on level 3 from levels 1 and 2, to channel the flow of passengers descending to the metro. To provide continuity without changes of direction or pointless journeys for transit between levels 1 and 3, on level 2 there is an additional stairway that connects to level 3, continuing the stairway from level 1 to level 2. The work cost €60.7 million ($66 million), paid for by private financing through an administrative concession for the construction and operation of the transport interchange, which was granted to the company for a period of 35 years.

Results

The new Plaza Eliptica intermodal hub gives a glance on a new generation of intermodal interchanges.

Solution

Dedicated Bus Lanes

In Brief

Separating buses from other vehicles in dedicated lanes protects them from traffic congestion and delays and improves the reliability of services. The smoother driving also saves fuel and makes buses a more appealing mode of travel during peak hours.

Examples

Dedicated bus lanes are highly visible and typically marked out. However, fully segregated bus lanes are sometimes appropriate (e.g., for counterflow lanes), though this does remove flexibility in use of the road space (such as for supporting roadworks). Bus lanes may also include access points to residential or industrial areas not available to normal traffic, thereby creating opportunities for new and more effective transport routes. A bus lane could operate "full-time" or only during certain hours, such as on Mondays to Fridays between 07:00 and 09:30. Outside those hours, other vehicles can use the lane. Bus lanes typically allow access to emergency vehicles but may also be opened up to other modes which form part of a door-to-door sustainable transport journey—for example, bicycles, motorcycles, taxis, or even electric cars. Cities may need to monitor the lanes to ensure that other drivers do not misuse them and enforce their status as bus-only lanes. They can do this through sample manual monitoring, CCTV, or automatic number plate recognition systems.

Results

Introducing dedicated bus lanes will have different results for cities depending on the local circumstances and variables. In some municipalities, they have improved journey times to the extent that the benefits (including other bus priority and traffic management measures) covered the cost of installation in just over a year. Other benefits include:

- reduced fuel costs for buses, cars, and other vehicles;
- time savings for travelers;
- more reliable buses; and
- More passengers.

Broken, damaged, vandalized, faded, or worn signs and carriageway markings do not encourage compliance so cities should regularly inspect and maintain the service to ensure that benefits continue.

Technical and Financial Considerations

Dedicated bus lanes are a very cost-effective method for making services more reliable, certainly compared to light rail and rail. However, cities should take the needs of other road users into account through infrastructure audits, modeling, and stakeholder engagement.

Considerations include:

- impact on car drivers (Is increased congestion from reduced road space acceptable? Is there a benefit for cars no longer being held up by buses stopping to collect/drop-off passengers in the same lane?);

- impact on taxi and private hire vehicle journey times;
- impact on delivery vehicles (including access to the kerb side); and
- any increase in safety risk for cyclists or vulnerable road users.

It is also important to understand whether introducing bus lanes improves journey times. Cities will need to consider the length of the route, the entrance and exit points of the lane, the number of bus stops on the way, and existing and forecast traffic conditions. They should also conduct a cost–benefit analysis prior to implementation, with subsequent monitoring to understand the accuracy of projections, and apply the results to future decision-making.

Policy/Legislation

Cities should implement dedicated bus lanes alongside a package of complementary measures to enhance public transport. In many countries, it should be possible to trial a dedicated bus lane for a limited period (e.g., 18 months) to understand the potential impact better. National and/or regional legislation will apply when amending the public motorway.

Institutions

The lead agency for this is usually the city (local transport authority) working in conjunction with local bus operators. National policy frameworks are important to ensuring consistency with schemes in other cities.

Transferability

Many cities in Europe and other parts of the world have implemented dedicated bus lanes and the solution can easily transfer to other cities. Relevant locations are cities with good public transport networks but high levels of congestion, which impede journey times. Cities that experience delays because of buses changing lanes, or because of buses holding up other vehicles when stopping to collect passengers, are also suitable locations. Implementing the measure as part of a package of public transport improvements (such as new vehicles, smart ticketing, enhanced information, new fares, and improved frequency) is desirable for having a greater impact on improving the attractiveness of bus travel.

Case Study

Warsaw's Bus Priority Lane (Poland)

Context

To reduce traffic problems in Warsaw and make traveling by public transport easier, the city began looking for new solutions to improve local traffic conditions. In 2009, the city selected a main traffic corridor connecting the east and central districts as the focus for improvement. This was due to rising traffic numbers and increasing congestion along this route, especially during peak hours, which affected the ability of public transport services to operate efficiently.

In Action

As a result, in September 2009, the city introduced a new bus priority lane. At the time, this was the longest bus lane in Warsaw, stretching 7 km in each direction. The bus lane covers the Trasa Łazienkowska area, which includes one of the city's main three-lane artery roads, crosses the river Vistula, and connects the city center to the eastern edge. Now one of the three lanes in both directions of the Trasa Łazienkowska is a dedicated bus lane, and car traffic is restricted, by a combination of road signs and road markings. After its installation, only buses could initially use the lane. However, 3 weeks later the city allowed licensed taxis to use the lane. To ease the congestion that inevitably occurred in the remaining two lanes, the city introduced two new bus services. The frequency of existing bus services using the route increased and encouraged more people to use public transport.

Results

Warsaw experienced strong resistance from car drivers when introducing the bus lane. However, it has strong support from public transport passengers. Over time, some drivers saw the benefits and are now public transport users themselves. Following an evaluation of the impacts of the bus lanes in November 2009, the most important benefits include:

- The number of bus travelers has significantly increased during all times of the day.
- The average speed of buses in both directions has increased (19% faster to the east city edge and 30% faster to city center, with an average of 26 km/h in both directions, rising from an average 10 km/h before the bus lane was implemented).

Other advantages include more punctual public transport services, a better image of public transport among locals, faster response times for emergency vehicles, and improved traffic safety.

Solution

Improving Nonmotorized Transport

In Brief

Cyclists and pedestrians mix easily. Their speeds are not so different and cyclists can adapt their behavior. Nonmotorized transport infrastructure, which improves the safety and quality of journeys for cyclists and pedestrians, is a broad but important area for ensuring an accessible transport network with better quality of life. Mostly, cities can mix both groups fully, but if an area has many pedestrians, a soft physical separation is preferred. The benefits for cyclists are routes with shortcuts and easy access to destinations in the area. On narrow streets, adjacent or shared-use paths for cyclists and pedestrians can provide a safe and comfortable solution.

Examples

On many city streets, space is constrained and it is not possible to accommodate everything and everyone. The first approach should be to try to free up space by reducing the room given to motorized traffic. This can involve rerouting car traffic and taking out a traffic lane; removing a parking lane; or calming traffic to make mixing possible. Another approach, for cyclists, is to provide an attractive alternative cycling route, but if this imposes significant detours, cyclists will keep using the narrow street. Allowing cyclists to share space with pedestrians in relatively car-free zones avoids detours and makes destinations more accessible to cyclists. Where space is limited along road sections, sharing space with pedestrians can improve safety and comfort for both user groups. Measures can include (for cyclists) clear lanes, cycle streets, and cycle parking; (for pedestrians) clear pavements and pedestrian crossings; and joint infrastructure such as signs and maps; shared paths, crossing points and bridges/tunnels; traffic calming; and lighting.

Results

The benefits in investing in improved nonmotorized infrastructure are broad and the supporting infrastructure can boost the numbers of people walking and cycling. Moreover, as walking and cycling are important links in the multimodal transport network and key elements of a car-light lifestyle, they improve the integration of transport networks. Good infrastructure also helps improve the safety of vulnerable road users, particularly in relation to motorized road users but also by reducing crime. The benefits are also economic: evidence suggests that in areas with many pedestrians and cyclists, businesses experience higher sales figures. In addition, as walking and cycling are good for health,

employees take fewer sick days and are more attentive. In addition, in areas with good cycling access, property values are higher. Finally, more people walking and cycling means that there are fewer vehicles on the streets, which reduces pollution.

Technical and Financial Considerations

Outside of built-up areas, there are few pedestrians and often no pavements. When there is a separated cycle lane, pedestrians often like to use this instead. Because of the low numbers of pedestrians, this causes no real problems. Inside built-up areas, however, there are more pedestrians. They typically walk on a network of pavements and crossings, separated from traffic, including bicycles. Allowing cyclists access to car-free zones (also called pedestrianized or vehicle-restricted areas), helps them avoid detours and gives them easy access to central urban destinations. When space is restricted, providing fully separate infrastructure for cyclists and pedestrians may not be possible, as cities need to respect quality design criteria. Sharing space between cyclists and pedestrians may be the best available option. The safety risk of mixing cyclists and pedestrians is much lower than mixing either with motorized vehicles. However, if pedestrian densities are too high, sharing becomes ineffective, also for cyclists. Specialists generally recommend considering sharing space at values not above 200 pedestrians per hour per meter of available profile width.

Policy/Legislation

In general, cities should improve walking and cycling infrastructure in line with a SUMP or walking/cycling strategy, rather than in isolation. Legally, cyclists can be given access to restricted areas simply by adding a sign, in the same way that residents or delivery vehicles can be exempted. In most countries, cyclists must give way to pedestrians in car-free zones. The status of the area is therefore quite clear to all users. Still, some areas might require additional signs to encourage cyclists to behave as guests. In some countries, such as France, cycle access to car-free zones is the legal default option, unless there are duly justified counterarguments. There, cyclists must cycle at walking speed.

Institutions

The lead agency for improving nonmotorized transport is usually the city or local transport authority, with support from walking/cycling associations or charities. National policy frameworks are important with regard to infrastructure design and implementation.

Transferability

Many cities in Europe and other parts of the world have implemented such solutions and they can easily transfer to other cities. This infrastructure is extensively replicable and is a core characteristic of a town or city with a sustainable transport system.

Case Study

Helsinki's Pedestrian and Cyclist Pathway (FINLANd)

Context

In 1894, the Finnish authorities constructed a railway line on the outskirts of Helsinki. The infrastructure required the excavation of an uncovered canyon some 7 m deep and almost a kilometer and a half long. Helsinki subsequently expanded, surrounding the cutting, which, although crossed by seven bridges, still constituted a gash in the urban fabric. In 2008, the cargo port moved to the Vuosaari neighborhood and work began on a new residential zone in Länsisatama. The railway connection, which transported goods between the port and the station, was no longer necessary. Helsinki created "Baana" in its place—a pathway for pedestrians and cyclists that leads from the western harbor area to Kamppi and the Töölö Bay.

In Action

Baana is 1.3 km long and on average 15 m wide (it is 34 m at its widest). The pedestrian and bicycle lanes run side by side and are identified by different colors: the bicycle lane is paved with reddish-brown asphalt and the pedestrian lane with black asphalt. In addition to the end points, bicycle access to Baana is allowed by four evenly spaced ramps and pedestrian access by five staircases from streets. There are also accessible entrances at both ends and in the middle of the course. Baana is a pleasant green route serving Helsinki, with 180 trees, 4000 bushes, and plenty of flowers. The rugged look is retained as a reminder of the corridor's history; the massive rock and stone walls flanking Baana date back 100 years. Lights, benches, and environmental art improve safety and comfort, and there are facilities for various activities such as basketball, table tennis, and pétanque (boules). Together with the bicycle service center in Kamppi, Baana—which cost around €5 million ($5.5 million)—further promotes cycling in Helsinki, facilitating city center cycling. The service center offers bicycle storage, rental, instant repair, and information.

Results

Baana is not just a path to cycle through as fast as you can, but also a place to relax and play. A sculpture in the shape of the word "Helsinki" carved out of concrete is popular with skaters. Between June and December 2012, around 320,000 cyclists plus an unknown number of pedestrians used it. From January to April 2013, nearly 46,000 cyclists used Baana, as well as pedestrians. An analysis after the reconstruction showed that drivers are observing the speed limits in the streets. The project won the Best Traffic Project prize in the Ways Through Towns competition.

Solution

Innovative, Safe Cycling Infrastructure

In Brief

An innovative and safe cycling infrastructure is crucial in towns and cities that want to boost the number of people cycling. The most successful solutions are those with varying degrees of integration and segregation of bicycles and motor traffic. Properly designed measures together with suitable traffic policies can lead to a huge increase in cycling, which positively influences citizens' quality of life.

Examples

Different types of cycling infrastructure include markings on carriageways, pictograms, colored lanes, reserved or multifunctional lanes, and fully separated (segregated) cycling lanes. Segregated cycling infrastructure is for areas with heavy traffic, where vehicles travel over 50 km/h. Here the paths, ideally a different color, are separated physically either by a green border, a kerb, or through elevation, and are clearly indicated by road signs. One-way paths should be about 2 m wide and two-way paths 2.5 m wide. Solitary cycle tracks away from roads are suitable for inexperienced or less-skilled cyclists. However, they are not as flexible; present safety problems at junctions; take up more space; and cost more money than integrated measures. If roads are too narrow to allow cycle lanes, integrated infrastructure, where cyclists share the road with cars can also be safe and comfortable. Here pictograms and "advisory" lanes can warn motorists of the presence of cyclists—however, cars can still drive in the marked area. Cycle lanes, indicated by road markings, are for cyclists only and cars cannot drive or park on them. Ideally, they should have colored surfaces and a minimum width of 1.5 m. Together with other integration measures, they are more flexible and faster compared to cycle paths, cost less, and need

less space. Where legally possible, cities can also create cycle lanes in one-way streets that go against the flow of traffic. Another important aspect of cycle infrastructure is secure parking facilities, which should be available in places such as public transport stops and stations, shopping centers, offices, and schools. These can consist of simple stands, parking boxes, parking houses, or parking towers.

Results

Creating a safe cycling infrastructure can boost the number of people cycling in towns and cities, and increase its share compared to other transport. Leading cities in this regard are Bremen and Münster (Germany), and Groningen (the Netherlands), where 25%, 35%, and 39% of all trips, respectively, are by bicycle. Such results have a positive effect on traffic in towns, improving safety and congestion and freeing up parking places. Cycling is also beneficial for the environment and public health, and enables older people to stay independent for longer.

Technical and Financial Considerations

Modern approaches to cycling infrastructure should focus on organizing traffic effectively so that all areas are accessible on bike, rather than building many cycle paths. Cycle infrastructure elements must also be part of integrated traffic planning, and the physical planning of the town. They should also fulfill some basic requirements, such as providing well-connected, direct, safe, comfortable, and attractive routes. A big challenge for cities when providing good cycling infrastructure is crossings. Here it is critical to create infrastructure that allows drivers and cyclists to predict each other's movements and for them to be able to make eye contact. Cities must also carefully judge the extent of integration or segregation from motor traffic and consider that more segregation does not necessarily mean more safety. Separated cycle paths on routes with many intersections, for example, are a riskier solution.

Policy/Legislation

Cities should consider cycling as an integral part of an efficient and sustainable urban traffic system. Similar to traffic calming and other activities for sustainable cities, a basic condition for successfully introducing cycling infrastructure is therefore national and local policy aimed at the needs of vulnerable road users instead of individual car traffic. Such policies should revise legislation and technical principles so that they support how cities arrange streets and public spaces. The legislation must also define various elements to modern approaches that support cycling, such as the possibility of allowing cyclists to ride down quieter streets against the flow of traffic, and multifunctional lanes.

Institutions

The institutions involved in this process differ by country. Generally, ministries of transport are the guarantors of technical rules concerning the arrangement of traffic space. Municipalities, often stimulated by local communities and cycling associations, decide on concrete projects, and usually nuance them (sometimes with support of various EU funds). Planning offices are responsible for designing measures. In some cases, the traffic police are involved in the approval of projects.

Transferability

Many cities in Europe and around the world have introduced good cycling infrastructure, and they can be easily transferred to other cities. However, to be a success, cities must have determined leaders, and the necessary legislation and technical standards in place. Local authorities should also tailor the measures to their local conditions, rather than simply replicating them.

Case Study

Hradec Králové's Innovative Bike Tower (Czech Republic)

Context

Hradec Králové is a county town in eastern Bohemia with 9000 inhabitants. Public transport includes buses, trolleybuses, and trains. Its climate and relatively flat landscape make it an ideal place for cycling, and the town is considered one of the most cycling-friendly places in the country. Although cycling is popular in Hradec Králové, the numbers of cyclists have decreased over the last decade. In response, the municipality decided to support cycling, and in 2013 approved a cycling development concept that respects the principles of integrated traffic planning.

In Action

Safe parking was one of the problems that the town needed to tackle. Between 2003 and 2005, the county and the Ministry of Transport funded a number of bike stands, which the town installed near offices, schools, and recreation areas. To improve local bicycle-parking facilities further, Hradec Králové installed a bike tower in 2013. Unlike most cycling infrastructure, the bike tower is nuanced privately; the municipality provided suitable land close to the railway station and public transport terminal. The glass tower—which cost around €300,000 ($335,000)—is 11 m high and has a diameter of 8 m. The fully automated facility offers secure parking places for 116 bicycles for a small fee,

around €0.20 ($0.22)—including insurance. The unit housing the technology is designed in a distinctive way that also optimizes space.

Results

The bike tower is very popular. During the first 30 months of operation, it stored 35,000 vehicles, and its popularity continued to grow. People appreciate comfort and safety and the tower protects their bicycles from both thieves and the weather. As the concept proved successful, the municipality is financing the construction of two more bike towers.

Solution

Pedestrianizing City Centers and Streets

In Brief

Pedestrianizing city centers and streets can improve the safety, air quality, and liveability of public spaces through restricting access to cars and commercial vehicles. Deliveries are typically restricted to certain access times and public transport and/or taxis may or may not be allowed, depending on local access considerations.

Examples

Pedestrian zones (also known as car-free zones) are areas of a city or town reserved for pedestrians only and in which most or all automobile traffic may be prohibited. Converting a street or an area for pedestrians only is called pedestrianization. This aims to provide better accessibility and mobility for pedestrians, to enhance the volume of shopping and other business activity in the area, and improve the aesthetic attractiveness of the local environment. A car-free development generally implies a large-scale area that relies on modes of transport other than the car, while pedestrian zones may vary in size from a single square to entire districts, but with highly variable degrees of dependence on cars for their broader transport links. Pedestrian zones have a great variety of approaches to human-powered vehicles such as bicycles, inline skates, skateboards, and push-scooters. Some have a total ban on anything with wheels, while others ban certain categories, segregate the human-powered wheels from foot traffic, or have no rules at all.

Results

Pedestrianization schemes are often associated with significant drops in local air and noise pollution, accidents, and frequently with increased local retail turnover and property values. Pedestrianization also creates

new space, which can be used for café/restaurant seating, street markets, or by community groups. These factors combined contribute to an increase in the "liveability" of an area. In some instances, this can also help boost tourism to a city. Pedestrianization is also a key component to delivering wider SUMP measures, such as access restrictions and cycling and walking routes.

Technical and Financial Considerations

In some cases, traffic in surrounding areas may increase, due to displacement rather than substitution of car traffic. Therefore, those alternative routes need to be able to support that additional traffic and these potential negative impacts are considered in the decision-making process. Cities that have carried out significant pedestrianization projects have learned a number of lessons. These include that residents expect landscape planning rather than simple physical barriers to prevent motor vehicles from entering, and that engaging local business, installing clear signs, and providing advance notice ensure that changes are made in a timely manner. Local authorities should also address concerns from local businesses that reducing access to cars will result in a decline in sales (for many businesses, the opposite will be true). However, certain businesses could be affected.

Policy/Legislation

Many countries and major cities have developed common design guidelines on implementing changes to the public realm, such as pedestrianization schemes. These typically include common standards for materials, signage, drainage, etc. As with any sustainable transport measure, ideally these should be designed and developed in line with the local SUMP rather than in isolation.

Institutions

The lead agency is usually the city, in association with the local transport authority (if a different organization). In some locations, nearby major landowners may be involved and may provide cofunding if it is in their commercial interests to ensure the scheme is implemented. Cities also need support from local stakeholder groups/organizations, including those representing older people, the partially sighted, taxis, public transport, and freight/delivery companies, to ensure the design sufficiently meets the needs of these different groups.

Transferability

Many cities in Europe and other parts of the world have implemented such solutions and they can be easily transferred to other cities. Substantial pedestrianization requires strong political support and

extensive local stakeholder engagement to address and manage any concerns. Pedestrianization is a key solution suitable for all cities, especially those keen to promote walking, retail, and tourism or address issues such as crime, poor air quality and road safety.

Case Study

Istanbul (Turkey)

Context

Istanbul's Historic Peninsula has been at the center of the 8500-year-old capital city through the Byzantine and Ottoman empires and modern times. During the 1950s and 1960s, rapid urbanization, industrial growth, immigration, and illegal construction made it nearly impossible to create holistic plans for the area. Traffic volume was high, especially on the roads along the coastline and surrounding the peninsula, and parking spaces are in serious demand. The peninsula's daytime population and traffic flow was a significant cause for concern and careful transport and urban planning was required. In 2011, the Cultural and Natural Heritage Preservation Board warned that vibrations by heavy vehicle traffic were damaging the ancient Basilica Cistern.

In Action

In 2010, Istanbul Metropolitan Municipality produced a study that looked into various perspectives concerning public spaces on the peninsula and the interactions between vehicles and pedestrians. It mapped the current problems and potential of the peninsula, and presented a framework for a more people-orientated planning approach. Thanks to the information provided by the report, Istanbul started pedestrian-only transformation projects. First, Istanbul Metropolitan Municipality began work at Sultanahmet Square in 2010. This was followed by the pedestrianization of 295 streets by the Fatih Municipality and Istanbul Metropolitan Municipality between 2010 and 2012 in Eminönü, Tahtakale, Beyazıt, Laleli, Gedikpaşa, and Hocapaşa. The municipality also repaved the newly pedestrianized streets with granite pavestones, updated signalization, and reorganized waste management services. Hydraulic vehicle-stopping barriers were installed, and streets lights and waste containers were renewed. New car parks were also built for tourist buses (each with 150–160 capacity). Istanbul also introduced a number of general rules to be followed for the new streets: during daytime hours (10:00–18:00), the streets and roads are accessible to pedestrians only. During the rest of the day, vehicular traffic is limited; only official vehicles, such as embassy, police, postal service, bank, fire

service, and hospital vehicles are allowed access during daytime hours. Vehicles with commercial licenses are allowed access for loading/unloading outside the hours of 10:00–18:00. Street vendors are prohibited from accessing some streets and roads. Inspections and enforcement are conducted by the municipal police forces of Fatih Municipality. Tourist buses will use only specially designated routes and stops.

Results

Half of local businesses said that the pedestrianization benefited their delivery and collection activities, although 37% disagreed. The increase in street dealers after the pedestrianization was a significant cause of concern with 77% of businesses expressing their displeasure. Seventy-six percent of total respondents felt that the pedestrianization had a positive impact on road safety. Residents said they were pleased with the increased visual quality (58%), strengthened attraction of historical buildings (56%), and improved walkability (52%). There have also been considerable positive changes in the area's air quality. NO_2 levels have decreased by 42%, while SO_2 levels have reached negligible levels and have fallen below urban baseline levels. The average SO_2 levels were reduced by 80% across the peninsula, complying with the urban ambient air quality background measurements in Istanbul and showing parallels with European cities.

Solution

Pedestrian Infrastructure

In Brief

Good pedestrian infrastructure improves the safety and comfort of pedestrians and increases their visibility. It helps reduce traffic speed and the likelihood of serious accidents. Improving traffic safety in towns is predominantly a matter of managing speed and implementing safety elements into road design. Appropriate speed is the cornerstone of safety, and wherever cars often meet vulnerable road users, the speed limit should not exceed 30 km/h. Managing speed in built-up areas then typically comprises of engineering measures that calm traffic, supported by public education.

Examples

Adjusting the design of a road reduces speeds and makes walking more comfortable for pedestrians. Measures include optically narrowing carriageways, arranging appropriately the proportions of traffic space

(e.g., the carriageway must not be the dominant component), suppressing long views of roads (by forming street sectors, or dividing the street to shorter segments), and supporting the impression of the presence of life (setting the greenery and "street furniture," such as postboxes, streetlamps, and benches). Engineering measures such as optimizing the width of road lanes; installing central islands to protect pedestrians, and islands at town gates; extending pavements; creating small roundabouts; elevating surfaces; and installing greenery can affect a driver's behavior psychologically and physically so that they reduce their speed and remain alert. These structural adjustments have a positive impact not only on traffic safety, but also on the aesthetics and humanization of public space, in some cases impacting general safety. Many towns have introduced various ways to calm traffic in their residential areas. The most popular are "Zone 30" areas, which limit the speed at which cars can travel to 30 km/h. Other forms include the "Residential Area" and "Shared Space" concepts, the latter of which is a relatively new concept in managing speed and urban design.

Results

Studies show that the safety benefits of traffic-calming engineering measures and area-wide traffic calming differ considerably. Area-wide measures on average reduce the number of accidents by about 15% (by 25% on local roads, and 10% on main roads). However, sometimes a properly applied, simple engineering measure changes the black spot to a place without accidents. Beside safety benefits, good pedestrianization can also prevent crime and improve the comfort of pedestrians. Its ability to reduce noise and improve the aesthetics of public space contributes to the quality of life of local residents, and in some cases, increases the price of nearby real estate.

Technical and Financial Considerations

Cities can apply pedestrian-friendly measures separately or in various combinations, ways, and extents according to a municipality's specific situation, needs, and financial possibilities. The technical and financial demands of the measures, however, differ considerably. For example, applying a basic form of Zone 30 is highly effective and low cost (the costs include only traffic signs at each entrance to the Zone, and a small local information campaign). On the other hand, traffic-calming measures that include physically reconstructing a street and use of various structural elements (central islands, elevated surfaces, extended pavements, greenery, etc.) are highly effective as well, but require more time, effort, and financial resources. Prices also differ by chosen material, accessories, and initial state of the road. Using a

residential area as an example, the cost of 1 m^2 can range from about €55–185, according to the type and quality of road surface and street furniture.

Policy/Legislation

A basic condition for successful traffic calming and pedestrian-friendly measures is national and municipal policies oriented to the needs of vulnerable road users instead of individual car traffic. Traffic safety must be an integral part of an efficient and sustainable urban traffic system. Municipalities should revise legislation and technical norms so that they support modern forms of arranging streets and public spaces, and enable safe pedestrian traffic and humanizing urban space. First, municipalities should consider the proportions of traffic space (the width of road lanes and pavements). Legislation must also define various modern forms of traffic space (e.g., shared space).

Institutions

The institutions involved in the process differ by country. Generally, the ministry of transport is the guarantor of technical rules concerning the arrangement of traffic space, while municipalities decide on concrete measures and usually finance them (sometimes with support of various EU funds). A city's planning office will usually design the measures. Municipalities should also involve the traffic police, where appropriate.

Transferability

Many cities in Europe and other parts of the world have implemented such solutions and they are easily transferrable to other cities. The necessary legislation and technical norms are crucial to success, as is political will. Nevertheless, cities must tailor the measures to local circumstances rather than simply replicating them. Municipalities should assess the areas where they wish to introduce their measures, taking into account their main functions, the intensity and relationship of traffic, and public opinion.

Case Study

Reducing Heavy Traffic in Lužice (Czech Republic)

Context

Lužice is a village in South Moravia with around 2800 inhabitants. About half of the working people in the municipality, which has an area of about 752.40 ha, commute by train, bus, car, or bicycle. Mostly, locals and people from neighboring villages use the main road that goes

through the village, and before the municipality reconstructed the road in 2006, heavy traffic also used it. The road was in a poor technical state, but also in terms of its design and safety. The carriageway was too wide, pavements were missing in places, and there was no cycling infrastructure. About three to four accidents occurred on the road every year.

In Action

The municipality decided to reconstruct a section of the road completely to reduce heavy traffic, calm general traffic, increase road safety, provide more comfort for cyclists and pedestrians, and cultivate public space. The project included reducing the width of the road from 8 to 6 m; installing central islands; rearranging bay bus stops into stopper stops; creating two small roundabouts; reorganizing parking places; constructing a cycling path; and providing barrier-free pedestrian crossings. The municipality also completely renovated a nearby park and renewed street furniture. The overall budget was 45 million CZK (€1.66 million) of which 30 million CZK (€1.1 million) was covered by the Ministry of Transport and the South Moravian Region, and 15 million CZK (€554,000) by the municipality. The project started in 2006 and finished in 2008.

Results

The reconstruction project improved the comfort of pedestrians and cyclists; provided safe crossings (especially for pupils of the local school); encouraged lower speeds; produced less heavy traffic; and promoted the safe use of bus stops. At time of writing, there have been no accidents since the reconstruction. Moreover, the project connected local cycling paths to regional cycle routes, and ensured appropriate conditions for a project that addressed traffic signs in the town and organized residential areas. An analysis after the reconstruction showed that drivers are observing the speed limits in the streets. The project won the Best Traffic Project prize in the Ways Through Towns competition.

CLUSTER 3: CITY LOGISTICS

Solution

Last-Mile Urban Deliveries with Cargo-Cycles

In Brief

In many cities with severe congestion, trucks and vans struggle to deliver goods into city centers. Using bicycles to deliver small packages

and mail, and tricycles for heavier goods, can be a solution. Electric motors often assist these cargo-cycles, which ride on normal roads, bike lanes, and if local regulations allow even in pedestrian areas.

Examples

Small cargo-cycle companies are emerging in many countries. Some companies have environmental and social objectives and work with public subsidies. Their main objective is to cut emissions and employ young and socially excluded people. For others, efficiency is the key objective, with cargo-cycles providing an opportunity to avoid congestion and use routes that vans cannot. Services provided by cargo-cycle companies range from distributing parcels to delivering goods from large stores to homes. Some companies replace diesel vans that make direct deliveries from a suburban depot, and instead take goods to a small consolidation center before dispatching them to the final customer with a fleet of electric cargo-cycles.

Results

Cargo-cycles have clear environmental advantages: they cut pollution, GHG emissions, and noise; improve safety; and sometimes ease congestion. There is also a benefit to the local economy as cargo-cycle companies create jobs. Cargo-cycles can go where small vans and other light commercial vehicles cannot, such as city centers reserved for pedestrians and tourist areas, and into other areas where diesel vans are restricted. In Copacabana, Rio de Janeiro (Brazil), the Associação Transporte Ativo (Active Transport Association) assessed the activity of the many cargo-cycle operators and concluded that they make a positive contribution to the creation of local jobs.

Technical and Financial Considerations

Cargo-cycles need to have access to the road network, and bus and bicycle lanes to operate effectively. The use of cargo-cycles generally requires one or several depots in the city center for transferring goods from larger trucks from where the cargo-cycles then take over the last mile of distribution.

However, these terminals can be relatively costly and distribution requires logistical planning. From a technical perspective, use of electric propulsion or support technologies involves issues related to the battery, such as chemicals (aqueous sulfuric acid), the risk of the release of hydrogen during loading, and manual handling and operations. For example, in San Sebastian (Spain), cargo-cycle company Txita and the municipality cooperated with an institute of logistics, a university, and the city's public transport managing authority to set up and manage an

initiative, which included a freight consolidation center and clean vehicles for last-mile distribution.

Transferability

Many cities in Europe and around the world have been using cargo-cycles. As last-mile delivery vehicles, they are especially effective in dense and congested major city centers. Several cargo-cycle companies are planning to develop their activities in other cities. For example, La Petite Reine in Paris (France) has already exported its tricycles and Txita has already established its service in other Spanish cities, such as VanaPedal in Barcelona.

Case Study

The Green Link (Paris)

Context

The Green Link (TGL), established in 2009, is a company that delivers parcels in central Paris using a fleet of battery EVs. Before subcontracting last-mile deliveries to TGL, clients were either delivering the goods in central Paris themselves or using a different subcontractor which used diesel vans from the client's depots, located in suburban areas and which had to travel on congested main access routes and on the delivery round-trip within the city center.

In Action

TGL operates three depots in Paris which are supplied outside rush hours either by truck and/or boat by TGL or by its customers. The parcels are consolidated in the hubs before being delivered by clean vehicles. The first parcels arrive at the depots early in the morning, between 07:00 and 09:30, brought in by trucks and vans belonging to the clients. The parcels are unloaded, sorted, and then loaded onto TGL's clean vehicles. The TGL fleet consists of two small electric vans and 28 electric cycles. Some 60 part- and full-time drivers deliver the goods. Most deliveries start in the morning at around 09:00 and end in the early afternoon, usually before 15:00. A few evening rounds collect the parcels. During the deliveries, TGL sends real-time information on the status of their orders to the clients. The main costs are on staff and renting the depots. New cargo-cycles cost €7000, while maintenance amounts to approximately €10 per working day. Other fixed costs include insurance, accounting, and management.

Results

At the end of 2013, TGL delivered 2500 parcels per day. Its environmental profile (with virtually zero tailpipe emissions) and the fact that it emits no air pollutants and produces little noise during deliveries are positive. Thanks to its electric fleet, TGL delivers over 2000 parcels daily and estimates that it has avoided emitting over 100 tonnes of CO_2 and consuming of 30,000 L of diesel a year. A key barrier to growth is the limited availability and cost of suitable depot space in central Paris—something which the municipality could help with. The company's turnover slightly decreased between 2014 and 2015 (down by 6%) after 5 years of growth, and the business is not yet profitable.

Solution

Low-Emission Zones

In Brief

The main objective of a LEZ is to reduce local air pollution by denying vehicles access to a certain area (e.g., the city center) if they do not meet certain criteria, which are typically based on the levels of pollutants they emit. The effectiveness of LEZs is dependent on effective control and enforcement, and remains difficult to prove or attribute to the LEZ alone.

LEZs may cause unintended distributional effects. For example, by targeting highly emitting vehicles, which lower income residents tend to use, or inducing people to drive around the zone, shifting emissions to there.

Examples

LEZs are widespread throughout Europe. They have been introduced in many cities, including London, many cities in Germany, Portugal, Italy, and Greece. LEZs differ in size and dimension, by the type of vehicles prohibited from entering, whether targeted vehicles are excluded or allowed with a fee, and by how they are controlled and enforced. The main types of control and enforcement for LEZs are video surveillance (as found in London) and "visual" control by local police (in Germany).

Results

The main environmental results of LEZs are an improvement in air quality in the exclusion zone. By restricting the entry of more-polluting vehicles into the zones, LEZs decrease emissions of air pollutants, particularly particulate matter (known as PM—the sum of all solid and

liquid particles suspended in air) and nitrous oxides (NO_x). However, LEZs may also generate unintended consequences. For example, vehicles forced to drive around the zone might use more fuel, and emit more GHGs and air pollutants because their trips are longer. This can lead to higher pollution outside the zone, disproportionately affecting the residents of these areas. The results also depend on the efficiency of the control and enforcement. However, an LEZ's effectiveness is, for the most part, unproven due to the difficulty in attributing air quality changes to them alone. As vehicles forbidden to enter the LEZs are generally old, mainly belonging to people on lower incomes or small businesses/entrepreneurs, LEZs can disadvantage poorer residents and tradespeople. When implemented alone, aside from other measures on the use of vehicles (e.g., charging drivers to access roads), LEZs typically change only the types of vehicles entering rather than the number.

Technical and Financial Considerations

From a technical point of view, when considering the implementation of an LEZ, municipalities need to consider the way in which the system is enforced. Possibilities include camera-based (investment heavy, e.g., London), manual visual inspection (person-power heavy, e.g., German cities) or other technologies, depending on existing local conditions and requirements (e.g., RFID transponders). The costs of LEZs depend on the type of control and the cost of changing the transport system to correspond to the new regulations, such as upgrading municipal fleets to meet the new requirements (service fleets and buses). In addition, signage and publicity must inform the public of the LEZ and its boundaries. For LEZs to be most effective, cities should provide road users with alternative means of transport. This might require the provision of better walking, cycling, and public transport infrastructure and/or increasing public transport operating times and frequencies. Lower income residents or businesses may need financial assistance to assist them in upgrading their vehicles or using alternative modes of transport.

Policy/Legislation

In Europe, many cities implement LEZs because they are in violation of the air quality standards set out in the European Union's Air Quality Directive (96/62/EG). Fundamentally, the law governing which types of vehicle may use which roads when must be changed. This may be possible within the municipal remit, or alternatively, regional, state, or national level. In addition, local authorities may need to allocate land for logistics centers, which may require changes to planning laws. Furthermore, it may be most effective to centrally organize/facilitate logistical collaboration (e.g., in logistics centers) or new transport-market organizations (subcontracting the

final deliveries to well-equipped transport companies), which may need legislation.

Institutions

The lead agency for implementing an LEZ is usually the municipality. National policy frameworks are important to provide municipalities or local governments with the authority to issue road traffic regulations.

Transferability

LEZs have been widely implemented in Europe and are present in over 250 cities and regions. The conditions for their introduction are particularly favorable in Asian cities, as they consistently show a high interest in reducing local emissions and in environmentally friendly transportation systems. However, as access restrictions have been implemented in many developing and emerging countries already, future activities in this area could focus on transferring experiences from Asia to Europe or integrating already-existing schemes into a wider sustainable freight transport policy package. A good overview of different kinds of LEZs is on the website of the EU-funded CLARS project.

Case Study

London's LEZ

Context

The Greater London LMZ is the largest in Europe, spanning about 1600 km^2. It corresponds more or less to the inside of London's M25 motorway, which circles the city. The purpose of the LEZ is to improve the air quality and health of Londoners by substantially reducing pollution caused by road traffic.

What makes London's LEZ stand out is its control system. Cameras take a photograph of vehicle plates and compare them immediately with a database supplied by the United Kingdom's Driver and Vehicle Licensing Agency. Foreign vehicles must register with TfL, a process that can take up to 10 working days. Vehicles not meeting the criteria of the LEZ can enter the zone if they pay between £100 and £200 (€126−253) a day. If the charge is not paid, drivers must pay a fine—the amount of which depends on the type of vehicle and how soon the penalty is paid. For example, lorries must pay a penalty charge of £1000 (€1300), or £500 (€650) if paid within 14 days.

In Action

In the first phase of the LEZ that started in February 2008, lorries weighing more than 12 tonnes had to meet Euro 3 standards to enter the zone. In July 2008 other vehicle types, including lorries and vans between 3.5 and 12 tonnes, had to meet the Euro 3 standard. Since January 2012, all lorries must meet the Euro 4 standard. London is considering introducing an ultralow emissions zone (ULEZ) that will ban diesel vehicles, to tackle harmful emissions further and to improve air quality in central London. The ULEZ will operate 24 hours a day, 7 days a week, in the same area as the current central London congestion charging zone (see SOLUTIONS Factsheet Urban Access Regulation). The scheme will apply to cars and motorcycles as well as vans, minibuses, and lorries.

Results

Due to the strict control, the compliance rate for heavy goods vehicles was 98% by the second half of 2008. Only a small number of vehicles, an average of 140 vehicles per week in 2009, chose to pay to enter the zone. Based on the profiles of vehicles entering the zone, the city estimates that the first two phases of the scheme reduced traffic that emitted PMs by 1.9%, lower than the previously projected 2.6%. Besides its environmental impact on PM emissions, London's LEZ also stimulated the evolution of the logistics sector by accelerating investments in new vehicles before 2008 and 2012 to comply with the regulations. Large companies upgraded their fleets to comply with the requirements and improved load factors. Some smaller companies struggled with investments in new vehicles and had to redirect their business to routes outside the LEZ.

Solution

Pickup Points

In Brief

The growth of online shopping and the increasingly complex delivery operations in cities has led to the global development of pickup points—secure locations where customers can collect parcels they have ordered, instead of having to wait for the delivery in person at home. Today there are pickup points in Asia (Japan), Europe (France, Germany, the United Kingdom, the Netherlands), and North America. They help reduce distribution costs, ease congestion, and cut the number of kilometers traveled by delivery vehicles.

Examples

Locker boxes are the most well-known type of pickup point, used mainly by post companies and their subsidiaries. Local businesses—such as convenience stores, video rental shops, or cafes—also serve as pickup points. They allocate space to store packages temporarily and then serve as local depots where customers can pick up their parcels. Some locker-box services, such as the German Post's Packstation, allow businesses and private individuals to collect and return their parcels, free, 24 hours a day, 7 days a week. In France, there are collection-point networks consisting of high street shops, online retailers, and carriers, some of which share their services or have merged. To use the system, a customer buying products online simply adds the postcode and selects the option for a store or locker pickup when placing their orders. Customers receive an email or SMS informing them that their package is ready to pick up, and containing a code with which they can retrieve their parcel.

Results

Many national post services, distributors, and express delivery services have introduced pickup points. Their main objective is to minimize distribution costs. They also reduce the distances needed for delivery vehicles visiting each customer and eliminate the need to reschedule failed home deliveries. This approach has advantages for retailers, customers, carriers, and for the environment. When local stores volunteer to serve as pickup points, this can help them increase their revenue and, in some cases, keep their business alive.

Technical and Financial Considerations

In the case of local stores, the partnerships with shopkeepers are crucial. The first step is to choose businesses that answer the carrier's expectations best (such as favorable opening hours), and which have enough space to store parcels. An investment is necessary to implement the network of pickup points but no investment is required from the shopkeeper who receives personalized support and may earn revenue (a small amount per parcel) from the network, and from customers that visit their business to pick up their deliveries.

Policy/Legislation

Legal issues concerning who is responsible for parcels may be an obstacle to implementation: currently, the legal system is generally missing such regulation, and concerning digital authorization related to registered parcels.

Institutions

Transferability

This solution is transferable to any region, particularly where e-commerce is developing fast, such as cities in Europe, Latin America, the Mediterranean, and Asia.

Case Study

LP EXPRESS 24 (Lithuania)

Context

LP EXPRESS, an innovative urban distribution system of self-service terminals, is a branch of the Lithuanian state-owned Lietuvos paštas (Lithuanian Post). It is the latest addition to the company's service, providing terminals that are available—24 hours a day, 7 days a week—in 41 cities and towns in Lithuania. The terminals allow users to drop off their parcels, send them abroad, and choose other delivery options (e.g., couriers).

In Action

Previously, in Lithuania, parcel deliveries took several days and post-office working hours were inconvenient for people wishing to pick up parcels. Both dropping-off and picking-up parcels involved visiting post offices. Moreover, because post offices provided various services, for which people had to join a single queue, many customers were dissatisfied with the service. To improve postal services, the Lithuanian Post installed pickup points for small parcels in cities around Lithuania. Originally, the points only allowed parcel collection, but locals requested further functions. This lead to the introduction of a self-service terminal system, together with various options for dropping-off and picking-up parcels at the terminal. The charge for diverting a postal item to the self-service parcel terminal is €1, which the recipient can pay with a bankcard at the terminal when collecting the item. A unique IT system supports the new functions, which also allows users to send parcels anonymously. Senders fill out parcel delivery information on a website or using the terminal screen and an SMS or email informs the recipient about the parcel. Parcel tracking is also available on the service website. LP EXPRESS terminals are emptied every day and parcels are delivered within 24 hours.

Results

LP EXPRESS is an efficient service that offers tailored services, and is transferrable around the country. The terminal system is popular with

businesses and private customers. The unique technological features give it additional value and provide opportunities for the self-service terminals to be introduced more widely. Integrating the terminals with other delivery services has given it a competitive advantage. The service is successful because delivery distances in Lithuania, a small country, are relatively short, and collaborating with online shopping businesses has been beneficial.

Solution

Delivery Service Plans

In Brief

Delivery service plans (DSPs) allow organizations or businesses to reduce the number of deliveries to their facilities, promote safe loading, and select delivery companies using environmental criteria. Any building or location that receives deliveries—small, large, or one shared by multiple organizations—can benefit from a DSP.

Examples

A DSP focuses on activities that support an organization or business with deliveries and collections, waste, and recycling. Specifically, DSPs can help to:

- Proactively manage (i.e., combine) deliveries to reduce the number of delivery and servicing trips, particularly during peak times.
- Identify and promote areas for safe and legal loading.
- Select delivery companies that can demonstrate their commitment to following best practice. DSPs can also encourage the use of clean and energy-efficient vehicles to make deliveries, introduce new methods of purchasing transport and goods, and improve loading locations. There are many examples of public/municipal bodies with DSPs, although private organizations can also implement the plans.

Results

The benefits of organizations implementing DSPs are environmental (improving air quality), economic (reducing costs), or societal (being a better, more responsible neighbor). They also meet corporate social responsibility objectives. The EU TRAILBLAZER project has implemented and assessed DSPs in four European cities (Eskilstuna and Växjö in Sweden, Vercelli in Italy, and Zagreb in Croatia). The DSPs saved energy by up to 50% and reduced GHGs by up to 69%.

Technical and Financial Considerations

There may be costs for opening a consolidation center (for delivery companies), for replacing old vehicles with cleaner alternatives, or for transhipments required by the new system.

Policy/Legislation

The EU TRAILBLAZER project states that strong political support is an important factor to achieve the objectives related to an area-wide DSP. The experience in Zagreb has demonstrated that the improvement of freight transport is difficult without improvements in public and private transport. It is necessary to include this measure into the overall organization of transport in both the target area and around the city. The project concluded that this type of measure could be suitable for cities that have similar urban issues. Combining parking management with new technology (e.g., camera controls) contributes to the achievement of the project objectives.

Institutions

Public authorities should coordinate and encourage the development of a DSP if one or several private organizations choose to implement one.

Transferability

There is currently no clear proof of the transferability potential of DSPs.

Case Study

Eskilstuna's DSP (Sweden)

Context

The municipality of Eskilstuna has approximately 8000 employees spread over 750 units (including 84 kitchens) with each receiving between three to four deliveries a week. In addition, it delivers up to 750 hot meals to homes each day. However, poorly coordinated, inefficient delivery systems waste time and money, and result in more trips than are necessary.

In Action

The city developed a DSP in which shipping and its cost were not included in the procurement of goods for municipal facilities. Instead, Eskilstuna procured food deliveries to its municipal kitchens separately, under stringent environmental standards. This separated the costs of

goods and services, and gave an incentive to organize deliveries more efficiently. Under the new model, Eskilstuna created a freight consolidation center to which all suppliers deliver their goods before going to the respective units. Instead of having all distributors driving directly to the units, the goods can be gathered and deliveries coordinated in order to reduce the total amount of deliveries, emissions, and staff time. Another important factor lies in placing stringent requirements on the delivery trucks and their fuel. In order to reduce CO_2 emissions, the municipality plans to replace fuel with 100% biogas produced by the municipality. The municipality calculated that coordinating the supplies would reduce the number of deliveries and cut CO_2 emissions by 43%. Introducing biogas for use in new, smaller vehicles would reduce emissions by 50%. The new system would also reduce the number of kitchen deliveries to two per week.

Results

The DSP has improved the coordination of deliveries and reduced loading and unloading times. As it makes it easier for smaller businesses to supply the municipality, it has also improved local competition for services. Moreover, the reduced number of deliveries with modern vehicles and alternative fuels has cut CO_2 emissions significantly. An assessment by the TRAILBLAZER project showed that thanks to the DSP, Eskilstuna saved 1600 L of diesel per year (a decrease of 50%) and cut CO_2 emissions by 69%.

Solution

Pricing, Taxes, and Subsidies

In Brief

Tax increases for urban freight transport, such as on roads and fuel, are ways in which local governments can stimulate urban freight companies to seek improvements in their services and lower their costs. In the process, transport operators tackle inefficiencies (making them more competitive) and address the negative consequences of their operations, such as congestion, and air and noise pollution. Subsidies and incentives provided by local authorities are also effective ways of encouraging the development of sustainable urban freight distribution operations, if the local legislative framework allows for this.

Examples

Of all of the available measures, road pricing is the most indicative. It includes road tolls, fees based on time, or the distance traveled,

congestion charges, and charges designed to discourage the use of certain classes of vehicle, fuel sources, or more-polluting vehicles. Approaches range from single-road pricing (as in Norway and France), cordon pricing such as London's congestion charge (see also SOLUTIONS Factsheet Access Regulation), network pricing (a fee according to the distance traveled on a network), and area pricing (a charge according to time spent in a specific zone, like in Valletta, Malta). While each approach presents advantages and disadvantages, they tend to be selected based on local conditions and political reality rather than economic theories. Fuel-tax increases are also possible measures. Policies can include removing existing fuel subsidies, increasing vehicle fuel-tax rates, imposing a carbon tax, and applying a general sales tax on fuel.

Results

Financing road infrastructure, reducing peak hour travel, and easing traffic are the main objectives for local governments looking to introduce these charges. An additional tax on fuel (like a carbon tax) or on infrastructure use has two major effects beyond simply increasing price. It reduces fuel consumption and kilometers traveled—thus lowering emissions and improving local air quality—and makes transport operators more competitive and efficient, for example, by forcing them to consider delivering more goods in a single journey. Although fewer trips could lead to less income for operators, it will encourage them to look for ways to maintain their competitiveness, such as using different transport modes, or switching to electric and other energy-efficient vehicles. The tax revenues also give public authorities the financial means to introduce policies on transport and environmental concerns, such as funding for research and development, or investing in infrastructure, or even on other issues such as employment and education.

Technical and Financial Considerations

Both taxes and subsidies, either direct or indirect, can impose a significant impact on existing urban freight transport operations, encouraging operators to adopt sustainable urban freight distribution strategies. When implementing urban road pricing schemes, cities should consider the following:

- Suitable pricing schemes for urban freight transport can improve the speed and reliability of deliveries—benefits that can exceed the costs.
- Road pricing may make urban freight more efficient and foster more sustainable logistics and distribution strategies.
- A demand management approach can generate more benefits for urban freight transport than one focusing on financing.

- Urban transport policy, not only for passengers but also for freight, ought to address road pricing.
- Urban freight issues should receive greater attention when developing road pricing strategies and should acknowledge access regulations, emissions categories, vehicle sizes and types, and ultimately the sizes of the loads vehicles can carry.
- Charges for freight vehicles should be higher than for private cars.
- Paying early attention on to how selected pricing systems can interoperate is critical for preventing incompatibilities.

Policy/Legislation

Taxes are generally levied at a national level, except for toll roads, bridges, and tunnels. In these cases, the toll is not considered as a tax but as a fee (a contribution) for the funding of the particular road, bridge, or tunnel. Municipalities may be able to levy some form of tax or levy on freight distribution activities. The European Union, through the CIVITAS program, has provided direct subsidies, which have allowed city authorities to plan, implement, and monitor innovative measures to promote sustainable urban freight distribution across Europe. The direct provision of subsidies by local authorities is not widely used in urban freight transport because it is likely to be anticompetitive, may lead to state-aid issues, and is likely to be very expensive for city authorities. For these reasons, indirect incentives, which provide cost advantages for compliant operators, provide exemptions from regulatory provisions for behavior that leads to sustainable urban distribution.

Transferability

Fuel taxation policies and indirect incentives (as direct subsidies are not widely provided by city authorities) are both flexible solutions that are quite easy to implement. The range of pricing measures, including the subject and level, is vast, enabling municipalities to tailor them to local conditions and goals. Their specific transferability, however, is governed by the legislative conditions in the country in question, particularly the freedom municipalities have in levying taxes (and on what), and indirectly the influence the municipalities have in relevant higher level (state or national) governments.

Case Study

London's Congestion Charge

Context

London (United Kingdom) introduced its congestion charge in 2003. Operated on behalf of the urban authority by a private company, its main objective is to reduce congestion and the related environmental impacts. Since its implementation, traffic volumes entering the zone have decreased by 18%, delays by 30%, and there has been little or no effect on businesses in the zone.

In Action

The congestion charge is a daily charge for driving a vehicle within a designated zone in the center of London on weekdays between 07:00 and 18:00. There are no barriers and tollbooths, although drivers know when they are entering and leaving the congestion charging zone because of signs along the road. Some 197 cameras enable TfL, the public transport operator, to enforce the congestion scheme. Cameras read the number plates of vehicles entering, leaving, or driving within the charging zone, and check them against the database of those who have paid the charge and those who have registered for fleet or congestion charging. The current standard fee (September 2016) is £11.50 (€14.60) per day if paid by midnight on the day of travel; £14 (€17.80) if paid by the end of the following day; or £10.50 (€13.30) if registered with CC Autopay—an automated payment system which bills a driver's or customer's bank account or credit card each month. There are a range of exemptions and discounts for vehicles and individuals. Businesses with six or more vehicles pay £10.50 per entry/residents living within or close to the zone get a 90% discount, which they pay via CC Autopay. All-EVs and eligible plug-in hybrid EVs can enter the zone free. The ultralow emission discount gives free access to all-electric cars, some plug-in hybrids, and any car or van that emits 75 g/km or less of CO_2 and meets the Euro 5 emission standards. Failure to pay the congestion charge results in a penalty of £130 (€165), reduced to £65 (€82) if paid within 14 days, but increased to £195 (€248) if unpaid after 28 days.

Results

Since the introduction of the congestion charge, there have been no significant traffic-related problems arising from the scheme and traffic volumes in central and inner London have been decreasing year-on-year. The impact on the central London economy is neutral. According to TfL, the scheme delivered real benefits in terms of public transport capacity and performance, reduced road traffic collisions, and improved air quality. However, the impact of the congestion charge zone on local businesses remains a contested issue. Following the example of London,

Stockholm adopted its congestion charge in 2007 and has since experienced a significant cut in congestion and emissions.

Solution

Urban Consolidation Centers

In Brief

Urban consolidation centers (UCCs) are locations in or near cities where freight vehicles deliver goods. These goods are then "bundled" together into large loads and delivered to numerous points across the city—ideally using clean vehicles. UCCs considerably cut the number of kilometers traveled by larger, more-polluting freight vehicles, which saves fuel and reduces emissions, making cities cleaner and healthier for citizens.

Examples

Some UCCs are private and used by a single transport operator, such as Gnewt Gargo in London (United Kingdom); others are public and designed to host several operators working separately, such as Binnenstadtservice in the Netherlands; France's Elcidis in La Rochelle; and Cityporto Padova in Padova, Italy, where 55 operators share the facilities. Motomachi in Yokohama, Japan, hosts three retailer associations with more than 450 shopkeepers sharing the center to consolidate their deliveries.

Results

UCCs can significantly cut the number the kilometers traveled by freight vehicles, save fuel, and reduce emissions such as carbon dioxide, nitrogen oxide, sulfur oxide, volatile organic compounds, and particulate matter. In cities with for examples with historic old towns, these centres also reduce damage to delicate roads, paths, and other infrastructure, and cut noise pollution for residents. A few have been successful in financial terms, but others will need funding support from public authorities after several years of functioning, which can be justified by the positive effects such centers have on the environment.

Technical and Financial Considerations

Some UCCs may be difficult to establish as they raise the prospect of carriers having to hand over parcels to direct competitors and because of some EVs being unable to carry pallets and large parcels properly. However, the main considerations relate to having available space for the UCCs in or near the city center. Battery-powered vehicles also

impose additional constraints for operations and the premises, and the vehicles are small and can cause congestion in the centers. Parking the vehicles might also be difficult, while some locations may not allow underground parking or have enough space to store and charge the batteries.

Policy/Legislation

Strong support from the city is generally necessary for a sustainable public UCC. Agreements between different entities (e.g., the municipality, province, chamber of commerce, and local public transport company) can help smooth the way, and strategic plans with local laws on freight mobility are beneficial. Public funding will also help stimulate UCCs. The Elcidis UCC in France, for example, benefited from strong political and financial support, mainly from the city of La Rochelle. The UCC started in 2001 and the first Elcidis transport operator was given EVs, free access to the UCC (the rent is paid by the city), and received an operating subsidy. Subsidies came from the EU-funded CIVITAS initiative, from the French transport ministry, and from local authorities. In order to minimize the disturbance caused by delivery vehicles (congestion, noise, pollution, damage to streets and sidewalks) local regulations forbade the entry of trucks over 3.5 tonnes into the city. This, of course, was also very favorable to the UCC.

Institutions

Many institutions can help establish UCCs, such as city councils, national ministries, and other agencies. In Paris, the city council, the Ministry of Ecology and the French national energy agency have helped open many urban logistics centers since 2000. The city—whose aim was to reduce pollution and congestion, and improve urban distribution—provided funding for studies and assessment, and spaces with low rents.

Transferability

This solution is easily transferrable to other freight-intensive facilities. There are already companies that own and run UCCs looking to develop their activities in other towns. The main consideration for other cities looking for UCCs as a solution, however, is having enough space available for unloading, sorting, and loading. Large investments and subsidies will also help in transferability, as will schemes to help small entrepreneurs to start UCCs in cities where the concept does not yet exist—such as the Binnenstadservice (BSS) in the Netherlands.

Case Study

Binnenstadservice (the Netherlands)

Context

In the Netherlands the transport industry together with cities discussed the issue of distribution in city centers for many years, particularly the limited accessibility, increased vehicle movement, and congestion, pollution, and insecurity. In 2008, a nonprofit initiative called BSS started in the Netherlands, a franchise with independent local entrepreneurs in every city acting as franchisees. BSS is now present in 15 Dutch cities.

In Action

BSS franchisees operate warehouses and distribute goods on behalf of retailers and other organizations in the inner city. Ideally, the local entrepreneur establishes their BSS depot on the premises of an existing warehouse, whose activities do not compete with BSS. This allows the BSS franchisee to start up activities without huge investments, and operate at a low cost because of the combined functions at the warehouse. The estimated costs in a start-up phase are around €10,000 a month. Goods are unloaded in the warehouse on the edge of a city. From there they are "bundled" into large loads and delivered to numerous delivery points across the city—where possible, with clean vehicles, which the local BSS subcontracts from a local carrier. Empty packaging and other waste, such as paper, return to the BSS depot. BSS Netherlands, the franchise organization, provides the IT system for handling orders and labeling. Shopkeepers do not pay for receiving the goods, only for the additional services provided by BSS, such as collecting packaging. The transport company that delivers the freight to its city center customers picks up the associated costs. The BSS concept is voluntary—that is, interested entrepreneurs must approach the franchise to begin operating. However, some conditions could make cities more favorable for locations for BSS depots. For example, strict time windows for lorries accessing the city center, limited loading/unloading facilities, and strict environmental conditions (environmental zones), will force transport companies to look for cheaper and easier solutions. However, BSS needs many retailers to join to create the critical mass to make it successful. In many cities, BSS started with a public subsidy to allow time to encourage shopkeepers to participate.

Results

In 2010, TNO, a Dutch independent research organization, conducted a study on the effects of cooperating with BSS through an analysis of

two retailers—TWI and Lekkerland—already using the scheme. The results showed that if more cities would use BSS, local authority regulations, such as time and vehicle restrictions, would no longer hinder carriers and shippers, and they would be able to plan transport that is more efficient, with larger vehicles. It would also simplify administrative issues by having only one contract with BSS for many cities.

TNO calculated that, based on different scenarios, carriers and shippers could save between 48%–72% in kilometers traveled by their vehicles; cut delivery times by 60%–70%; reduce costs by 59%–71%; and lower their CO_2 emissions by 47%–71%. The savings vary depending on the type of deliveries, the length of a vehicle's round-trip, the number of kilometers between city and carriers, and the number of deliveries in the city. The more cities that have a BSS depot, the easier it is for shippers or transport companies to make use of the service, because it becomes a common practice. Currently, where BSS does not cover all cities, shippers and transport companies have to deal with different situations and conditions in different cities. The successful introduction of the concept in other cities also depends on the absence of the "not-invented here" syndrome. If the new city wants to invent its own solution, it takes some more time to introduce such a scheme. The slowest cases are in cities where a local government is trying to create their own solution (by procurement, for instance).

Solution

Forums, Portals, Certification Schemes

In Brief

Freight forums and information portals are good solutions for cities that do not wish to regulate too much but wish to encourage good initiatives, provide incentives for voluntary changes of behavior, and enhance the cooperation between local authorities and urban transport operators. Freight forums are the common name of normalized consultation processes with freight stakeholders. They represent one of the most successful strategies for urban freight. Partnerships can lead to a better understanding of the constraints of other stakeholders and allow the development of concerted actions. Consultation processes in urban freight provide opportunities for collaboration between stakeholders who otherwise would not be willing to work together.

Examples

Participants in freight forums are commonly city representatives, freight organizations, shippers' organizations, and trade groups,

together with local citizens' or advocacy groups. Some stakeholders are not always represented well. Small delivery operators usually do not have a representative organization, and some large logistics companies or their organizations are not willing to participate because of a lack of interest. Consultation processes can lead directly to initiatives such as setting up informative municipal portals dedicated to freight (with information on regulations, initiatives, and opportunities) and phone apps. Certification or labeling schemes recognize urban freight operators that demonstrate environmentally responsible behavior and greener deliveries. Certification confers advantages such as extended delivery hours or the use of designated loading/unloading facilities. It may also provide operators with a competitive advantage when bidding for contracts. Labeling can also target cities, vehicles, equipment, or even processes. It can recognize that a city or company has achieved a specific level in sustainability and efficiency of an urban freight operation. Labeling has become a common way of promoting urban freight strategies. There are many examples of freight forums. In France, Toulouse and Lyon set up recognized partnerships on good practices. The most accomplished example is the Paris Charter for Sustainable Logistics (see case study). Freight Quality Partnerships in the United Kingdom are very common, such as the Strategic Freight Holders Club in Urban Areas in Norwich. As for labeling programs, the Freight Operator Recognition Scheme in London is the best example.

Results

As they involve qualitative processes, there are generally no quantitative results regarding freight forums. Qualitative results are extremely positive: freight forum participants, especially freight groups, appreciate being part of a consultation process. In the past, they had often felt ignored by municipal authorities, in contrast to other stakeholders such as retailers, for example. Freight forums are efficient at making freight activities more visible and recognized in the municipal agenda. Freight forums have shortcomings. Some organizations that perform urban freight activities do not participate (such as small delivery companies and courier companies). Some forums lead to good words but little action, and some participants can resent this. Some participants that are involved in labeling schemes are sometimes unhappy about the lack of enforcement of urban freight regulations throughout the city: companies that have a label feel they are virtuous without gaining enough advantage; and nonlabeled companies do not follow the common rules.

Technical and Financial Considerations

Freight forums are easy to establish and very cheap, as they consist mainly of voluntary meetings. However, municipal staff must be

available and knowledgeable. In some cases, hired external experts (such as academics or consultants) lead and organize, and follow the several working subgroups that freight forums can establish. Web portals or phone apps require some initial investments as well as operational and maintenance time.

Policy/Legislation

No specific legislation is involved in freight forums, as they lead to voluntary measures. Certifications and labels require that a city does not overstep its legal power: when providing benefits to a company that has an urban freight label, a city should not disproportionally disadvantage the nonlabeled delivery companies. European laws guarantee freedom of trade and movement: a municipality cannot totally ban access to nonlabeled delivery companies, unless duly justified. Legal action can follow.

Institutions

Cities or metropolitan agencies are best suited to lead the initiative of creating a freight forum.

Transferability

Transferability potential is very high. Cities of all sizes can implement freight forums. Medium-sized or smaller cities may have difficulties attracting freight organizations to participate, as their representatives may not always be physically located in the municipality itself.

Case Study

Paris Charter for Sustainable Logistics (France)

Context

The needs of its businesses and residents generate more than 400,000 deliveries and pickups every day in the city of Paris. The municipal authorities recognize the urban mobility of freight as a major issue for environmental, economic, and planning reasons. One of the main measures taken by the municipality has been establishing a comprehensive freight forum involving many stakeholders. The municipality established a previous freight forum in 2006; the current forum, formed in 2013, is an extension of the first and is still ongoing.

In Action

The main freight forum within Paris is the freight quality partnership created in the wake of the Paris Charter for Sustainable Urban Logistics.

In 2013, more than 80 organizations, institutions, and associations in the area of urban freight transport signed this Paris Charter for Sustainable Urban Logistics, committing themselves to progress in the field of urban logistics. The charter is a framework from which 16 implementation working groups have been permanently established. The 2013 Charter sets out to be concrete, operational, and incentivizing, relying on great involvement on the part of the signatories who undertake to develop or support projects that can assist the implementation of sustainable logistics. The objectives of the Charter are to:

- Assist economic development.
- Reduce the adverse environmental impacts of freight transport.
- Encourage innovative initiatives.
- Prepare and plan for any changes in municipal, national, and European regulations in order to develop, with the industry, the ways and means of applying them.

Results

The Paris freight staff, together with industrial partners, have set up 16 implementation working groups as part of the 2013 Charter. These groups cover the projects defined in the Charter. They range from negotiating the future freight regulations (ongoing), establishing a labeling scheme to inform freight companies better, and promoting innovations in urban freight activities. Two of these projects (Project 2 and Project 5) are looking at urban logistics terminals. They constitute one of the most interesting results of the Paris freight forum experience. Project 5 is about small urban logistics spaces: today, following the work of the Project 5 implementation working group, the new zoning ordinance of the city of Paris signed in July 2016 identifies 70 urban facilities that will be dedicated to logistics activities. Project 2 is about larger logistics facilities, called "logistics hotels." The municipality and the region of Paris together with a logistics real estate developer have been developing a model for these logistics hotels, combining logistics with other elements such as offices, retail, and public services. One major project is under construction and will open in September 2016. Other results and achievements of the Paris Charter include the change in the Paris urban freight regulation (truck and van access ban, LEZ, loading/unloading time windows—ongoing) the launch of a tender for innovative logistics start-ups (2015), and several urban logistics demonstrators (since 2013 and ongoing).

Solution

Vehicle and Operation Restrictions

In Brief

Local authorities often enforce weight and size restrictions on roads or in urban areas to prevent vehicles of a particular size and weight from entering. There are also restrictions on the amount of time delivery vehicles spend loading and unloading their goods. The aims are to reduce noise emissions during the night, cut congestion, and increase the productivity of delivery operations.

Examples

One of the first comprehensive restrictions on delivery times was in the United Kingdom. London's lorry ban, introduced in 1975, stopped trucks weighing over 18 tonnes from circulating at night and on weekends within a delimited area on specific roads. Other cities have chosen different approaches. In Paris (France), large trucks over 29 m^2 are banned during the day but allowed in at night. The same has been true in central Seoul (South Korea) since 1979 and, more recently, in Hanoi (Vietnam). In Manila (Philippines), trucks over 4.5 tonnes cannot travel along 11 arterial roads from 6 a.m. until 9 p.m., and in Barcelona (Spain), the city is testing a silent night delivery program with lorries equipped with antinoise systems. In Rome's historical center, where a high density of deliveries leads to illegal parking for deliveries, the local authority developed a plan with stakeholders that allows night deliveries for trucks weighing above 3.5 tonnes between 8 p.m. and 7 a.m., while vans lighter than 3.5 tonnes need authorization to enter the city center during the night. Other European cities have introduced similar schemes. The national PIEK program in the Netherlands developed a comprehensive strategy to reduce noise associated with urban deliveries, covering new technologies as well as behavioral and training issues. PIEK-labeled vehicles and technologies are now available on the European market.

Results

Access restrictions based on size and weight promote small-capacity vehicles, such as vans and light trucks, can increase congestion and reduce the efficiency of freight transport. Access restrictions also present a major drawback because there are often many different rules in a single metropolitan area: the definition of weight limits or specific delivery time windows can vary from one municipality to another. In addition, regulating truck access needs sufficient enforcement and control, requiring well-trained staff. Without adequate enforcement, freight operators adhering to the rules feel frustrated over nonabiding truck companies. Access restrictions based on time, specifically the promotion of night deliveries, yield more positive results. Night deliveries take place

between 8 a.m. and 11 p.m. They can reduce congestion and increase operational speed. The main problems are the risk of noise emission for residents, security issues for goods and drivers (especially in cities in emerging countries), and the fact that, during daytime, when large lorries are banned, operators might replace a banned lorry by several vans, increasing congestion.

Technical and Financial Considerations

Delivering at night requires a change in some elements of urban supply chains. However, trials and tests have demonstrated that this is not among the main challenges for freight and logistics operators. Finding staff willing to deliver later in the day or very early in the morning can be quite difficult. Labor costs may also rise as a result, although overall, the reduction in total working hours more than compensates the rise in salaries. New technology (as seen in the Netherlands' PIEK program) also dramatically reduces the noise emissions of the vehicles and activities involved in urban deliveries.

Policy/Legislation

Experiments and studies on off-peak deliveries indicate that, to be successful, these regulations must fulfill two conditions: trucking companies must benefit from scale economies in their off-peak operations, and shippers and receivers must perceive a real benefit. The latter suggests that in some cases compensation schemes (financial incentives) may be implemented to offset the cost of off-peak deliveries, should off-peak deliveries be socially beneficial. Regulations to implement off-peak deliveries must be clear and simple, with advantages provided to vehicles equipped with low-noise technologies or handling equipment. Sufficient enforcement is quite important.

Institutions

Local residents may be an obstacle for night deliveries, but this is not always the case. Good communication between shop owners, the municipality, and residents is necessary when introducing night delivery schemes. A municipal transport department engaged in ongoing dialogue with freight operators can initiate this type of initiative. The quality of the program's result improves when the local authority has, for example, a noise specialist being integrated into the process. In deciding whether to grant exemptions, local authorities need to assess the necessary noise reductions against residents' acceptance and the longer term potential results that such programs can achieve. The project can involve truck manufacturers and equipment suppliers. Specific training programs to drivers may also be very helpful.

Transferability

Many cities from around the world have introduced night delivery regulations and these can be easily transferred to other cities. Potential take-up cities are large cities with major congestion problems. The focus should be on promoting off-peak deliveries.

Case Study

Night Deliveries in Barcelona (Spain)

Context

Barcelona experienced high congestion in the morning peak hours toward the city center area and in the evening peak hours toward the suburbs, where logistics facilities are located. This led to high emissions and long driving times for city center deliveries. If off-peak hours were to be implemented, the problem of noise reduction also had to be tackled and new equipment provided to the companies in order to allow them to deliver at night.

In Action

Different retail companies conducted several experiments in Spain involving night deliveries to help them develop a night delivery policy for central cities, including Barcelona, Bilbao, Madrid, Sevilla, and Valencia. The objectives were to reduce congestion while respecting noise legislation. Special trucks, special equipment, and corresponding driver behavior were the conditions required. Barcelona municipality's mobility services have conducted several experiments. Within SILENCE—a 3-year research project cofunded by the European Commission—an experiment in a collaborative program involving the municipal mobility services, the municipal noise unit and five of the city's 10 districts, was conducted. Together, they conducted trials comprising of 14 noise measurements at 11 sites between 2006 and 2007. Involved in the trials were the city of Barcelona (municipal mobility services, municipal noise unit), three private transport operators, and two truck manufacturers (Renault, Iveco). In 2003, retailer Mercadona had conducted a quiet night delivery trial in 2003 with an adapted 40-tonne truck as part of the MIRACLES project. The municipality introduced experimental 6-month exemptions to the traffic regulations, and the traffic police collaborated to measure noise levels in residences close to the supermarket sites. The resources made available were electric lifts, insulating carpets, and kerb adaptations for forklift access. Staff were trained to minimize communication while unloading goods. Truck drivers used cones to signal the area they were using for unloading.

Results

The results were positive. The Mercadona trial showed that it was possible to replace seven medium-sized goods vehicles operating in daytime with two large goods vehicles at night to do the same delivery work. Vehicle technology and the new equipment meant that noise levels did not exceed 65 dB. However, drivers and staff still need to take care when unloading goods during the night in on-street loading bays in front of the shops. The program has generated better knowledge and shows that operators are only partially successful (in 45% of cases) in unloading within the ambient noise conditions. It also identifies which are the most important noise sources—arriving trucks (62% of cases) and unloading goods (15%). One important lesson is that two large 40-tonne lorries at night replace seven medium-sized trucks commonly used during daytime. Off-hour deliveries avoid daytime congestion and allow trips to be cut by around 1 hour. Faster deliveries using bigger vehicles enables the operator to generate savings sufficient to achieve a return on investment of adapted 40-tonne trucks within 3 years and a return on investment for plasticized roll-cages used with 16-tonne trucks of 15 months. Thanks to the success of the trial, in 2010 Mercadona decided to implement a nationwide strategy for night deliveries, reaching one-third of all its stores.

Solution

Rail and Waterways for Freight Deliveries

In Brief

Frequently using rail and waterways for freight deliveries can cut the number of vehicles entering urban areas, reduce emissions, improve air quality for citizens, and reduce the damage to infrastructure caused by heavy vehicles. Using trains and barges is also an efficient way to consolidate urban freight shipments.

Examples

In some cities in Europe, retailers are using waterways and canals to deliver their products to customers. Others use heavy rail—such as intercity, high-speed rail, rural, and freight services. Both types of freight delivery usually still require the use of road vehicles for last-mile deliveries, except for the rare occasions where clients are next to a rail terminal, or located along a waterway. Using heavy rail and waterways to deliver freight function similarly: A terminal located out of the city consolidates the goods and then trains or barges transport them to an urban distribution terminal. From the terminal, they are loaded onto

vehicles (preferable low-emission) and taken to their final destination. Light rail, such as tram and metro systems, is also an option. Large volumes of goods can travel on tramways, but they are rarely suited for freight deliveries and the equipment is not adapted for loading and unloading goods. Underground freight distribution, sometimes considered as a potential sustainable solution, has never succeeded in Europe. There have been various studies, but projects have never reached the demonstration phase, mainly because of track maintenance issues, operational costs, and potentially transporting low volumes of goods.

Results

Using rail or waterways to distribute goods can cut pollution. French retailer Monoprix uses passenger-train tracks during off-peak hours to deliver freight from its suburban warehouse to Paris Bercy rail station. From there, trucks running on compressed natural gas deliver pallets to supermarkets around the city and the suburbs. A 2009 study showed that Monoprix reduced the annual distance traveled by its trucks by 700,000 km, cutting particulates by 36%, and nitrogen oxides by 56%. The retailer's CO emissions went down by 47%, representing a saving of 410 tonnes per year. Noise, however, was a problem; local communities complained of the loud nightly operations in the rail terminal.

Technical and Financial Considerations

Costs are generally high. They may vary according to the capacity of the existing infrastructure. Even when investing in infrastructure is not necessary, using nonroad urban freight transport generally implies additional transhipments and a lack of flexibility that may be costly. Freight deliveries by rail are also noisy for nearby communities.

Policy/Legislation

In many cases, if the municipality does not wish to invest money directly into the scheme, it has to provide a favorable regulatory framework and legal access to the waterway or railway infrastructure. All stakeholders must be part of the project from the beginning and reach mutual agreements before potential political controversies arise. Applying strict EU regulations on air quality can also lay the groundwork for the introduction of such a solution.

Institutions

In the example of Monoprix in Paris, each stakeholder was critical to the success of the scheme: the retailer (Monoprix); its logistics provider (a subsidiary); the different local authorities (the city of Paris, the Paris region); RFF, the French rail network authority; French rail main operator, SNCF (who owned the terminal); and the environment agency.

Transferability

This solution is transferable if there is a good private/public relationship, a will for stakeholders to create a solution together, and a readiness for public authorities and/or an environmental public agency to provide subsidies, especially to accommodate urban transhipment activities.

Case Study

Utrecht's Beer Boat (the Netherlands)

Context

Utrecht has a rich cultural heritage and many canals in its historical center. The many small businesses in the center need frequent deliveries to bring goods, which increases road congestion, emissions, and damage to local infrastructure. Utrecht decided on various measures to alleviate road traffic, including restricting the times during which vehicles could make deliveries; introducing one-way traffic systems; restricting the weight of trucks allowed to enter the city; and alternative means of transport.

In Action

The city decided to use its canals to shift urban traffic from road to waterways to help it preserve the historical city center and relieve the pressure on roads. It introduced the concept of a "Beer Boat" in 1996, a vessel that supplied food and beer to catering and drinking establishments along the canals of Utrecht, shifting cargo from the road. In 2010, Utrecht upgraded the Beer Boat to an environmentally friendly electric boat. Two years later, building on its success, the city introduced another zero-emission boat to carry other products, including waste. Today, four breweries and one caterer use the service to deliver to 65 local stores. The boat was also able to deliver outside the access restrictions imposed by the city, while complying with loading restrictions. Using an installed hydraulic electric crane, the boat driver unloads the cargo while avoiding carrying the barrels, thus respecting local labor legislation.

Results

The Beer Boat was a subsidized low-cost city-center transport solution, which helped decongest roads and cut emissions. It reduced CO_2 emissions by 17 tonnes, NO_x by 35 kg, and PM10 by 2 kg per year. Transferring this solution to other cities would require an existing waterway network, a high original investment, and a clear business

model. The vehicle's use of electricity imposes technical limitations, but good scheduling and overnight charging can easily address this.

CLUSTER 4: INTEGRATED PLANNING/SUSTAINABLE URBAN MOBILITY

Solution

Institutional Cooperation

In Brief

Institutional cooperation is a pragmatic cooperation between organizations, ideas, and policies that helps to deliver an acceptable SUMP that is practically and financially effective. Without institutional cooperation on SUMP objectives and the means of achieving them, a SUMP will be partial and deliver fewer benefits.

Results

Institutional cooperation is a fundamental requirement to produce a SUMP. It creates ownership among institutional stakeholders, helps to attract funding for implementing measures, and enjoys public support. Cooperation between institutional stakeholders could also help to influence the long-term development of the transport network and infrastructure positively toward sustainable mobility.

Technical and Financial Considerations

Institutional cooperation is a topic cities should treat carefully and is a challenge for many planning authorities. A lack of expertise in multi-stakeholder project management, incompatible timeframes, and varieties in transport planning approaches can add to the complexity. Accommodating conflicting views is a necessary but sensitive task to undertake. In addition, each local authority has to develop its own cooperation framework, taking into account local structures and resources and respecting legal cooperation duties. It is crucial to appoint a team or a person within the city administration who is in charge of managing the entire SUMP process and partnership. Those managing the project should have the right set of skills, such as management control or negotiation skills. They should also know when and how to use relevant management tools, such as implementation plans or progress reports. At the beginning of the SUMP process, it is important to define whom to invite into the SUMP partnership. The project management should ensure that partners represent the whole functional area and together have the necessary skills and competences for elaborating and

implementing the SUMP. A successful partnership should have competencies in the SUMP area's transport networks and services, provide the required level of technical excellence in different fields of expertise, and gain political and public support. To complete the partnership, it may be necessary to persuade partners by presenting the benefits of the SUMP partnership for them, the city and the region as a whole. It is important to design a clear agenda together with institutional stakeholders so they know what to expect and how much capacity may be required. Furthermore, the SUMP partnership needs to agree on the project scope, governance, outputs, timescale and resources, and procedures for making decisions. Finally, understanding partners' agendas is crucial for reaching agreement on mobility priorities and measure packages. When the SUMP has taken shape, the project management might use specific tools for detailed planning of, for example, staff resources required for the implementation of each mobility measure and the level of involvement of partners during SUMP delivery.

Policy/Legislation

Institutional cooperation is a crucial element of the SUMP process in all European countries and cities where barriers and benefits related to cooperation are generally very similar. However, because of the nuances of an individual country's legal framework, institutional cooperation (and SUMPs in general) takes place through different processes and within different legal contexts across Europe.

Institutions

Organizations that could cooperate in developing a SUMP include departments within the local authority (e.g., environment, land, and health), municipal agencies, political bodies, neighboring communities, and higher level authorities. As there is no predefined list or ideal number of institutions, selecting organizations is a process which has to be carried out within the specific local context. It can take into account both the existing institutional environment and the specific local needs. In several European Union Member States, the development process has specific legal requirements. In these countries, the involvement of a particular type of partner may be obligatory. In addition, existing internal rules in cities may determine the approach.

Transferability

Project management methodologies can help provide a framework to structure and lead the process of institutional cooperation. Without prior planning and organization, each city and region is required to arrange and agree upon their approach to partnerships with local stakeholders according to their specific governance processes, which can

become complex and time-consuming. There are good practices for project management methodologies that are available for reference to assist with this aspect of the SUMP process.

Case Study

Dresden's SUMP Roundtable (Germany)

Context

The city of Dresden created an ad hoc discussion body to enable balanced and critical discussions to help develop its SUMP. Dresden invited a wide range of partners to sit at this SUMP Roundtable, include representatives of political parties, transport associations, and public transport providers.

In Action

The municipality invited all political parties of the city council to Roundtable, giving them one seat each—six in total. Dresden also involved the German Automobile Club (ADAC) and the German Cyclist's Association (ADFC), and three public transport providers: DVB, Dresden's municipal transport company; the Upper Elbe Transport Association; and national railway company Deutsche Bahn. The mayor of Dresden chairs the meetings. The results of the Roundtable discussions do not replace the final decisions of the elected body.

Results

The development of the SUMP in Dresden presents a good example of how competition and preexisting relationships can convince different partners to join the local SUMP preparation and implementation process. The participation of some political groups made the involvement of the remaining groups very likely, and this cross-party involvement ensured that Dresden's SUMP—which looks to 2025 and beyond—secured long-term political support. Likewise, because of the competing agendas of ADAC and ADFC, both organizations were willing to join the partnership. Roundtable participants brought capacities, skills, and knowledge to the partnership. The competing views of the involved partners also ensured balanced discussions. The SUMP Roundtable requires the SUMP project managers to stimulate input and participation from the public; mediate between opposing specialist views; coordinate meetings; and control the outputs and outcomes. The institutional cooperation process allows more stakeholders to be represented and to participate in formulating a more comprehensive and holistic SUMP.

Solution

Stakeholder Participation

In Brief

A transition toward sustainable mobility requires active support from the public and stakeholders if a city wants to find successful, viable strategies. While stakeholders usually represent positions of organized groups and have a collective interest, citizens are individual members of the public and unaffiliated participants in the involvement process.

Results

A participation process based on dialogue is crucial, for example, for analyzing mobility problems, developing common objectives, and selecting mobility measures. Engaging citizens and stakeholders can create a positive foundation for collaborative planning, improve the knowledge base, consider new ideas and opinions, and increase the public support for sustainable mobility measures.

Technical and Financial Considerations

An engagement strategy is a helpful document, which can facilitate coordination and provides transparency about the participation process and its objectives among participants and the different departments of the administration involved. Depending on the level of experience with participation, it might be helpful to call in an external expert with participation skills to jointly define a well-thought-out framework for engagement.

Policy/Legislation

Stakeholder involvement and citizen participation practices in transport planning vary across European countries and between cities. Several countries have formal, mandatory consultation procedures for medium- and large-scale transport projects, as well as for developing transport plans and SUMPs. Local Transport Plans, for example, which English local authorities are legally obliged to develop, require participation but have no prescribed procedure for the participation process. In France, there is a clear legal framework for the development of urban mobility plans (Plan de Déplacement Urbains), and for the involvement of institutional stakeholders; but it is not very demanding in terms of citizen involvement. In contrast to that, in Flanders, Belgium, law requires that citizens are involved in all local planning activities. A range of Belgian cities have gone beyond the required consultation procedures and developed new participation approaches and routines.

Institutions

Planning authorities need to open up urban mobility development for debate, which means in practical terms to integrate participation activities into the management of the planning process, to allocate resources in terms of budget and staff time, and to develop a communication strategy. Various skills and substantial expertise are needed to plan and carry out participation, which have to be coordinated with other SUMP-related activities, and inputs from citizens and stakeholders need to be fed back into technical planning and political decision-making. For both sides, the planning authorities and the participants, participatory planning needs time and practice.

Transferability

There are many local good practice examples of participation in the SUMP process that are available, from which cities can learn. The various participation formats, models, techniques, and tools that are transferable, however, will need to be specified. Each city must develop concepts that adapt to the local context and conditions, which may include but not be limited to: available budgets, involved stakeholders, citizens' interests/knowledge, and skills and capacities for developing and implementing successful SUMPs.

Case Study

Promoting Cycling and Walking in West Yorkshire (United Kingdom)

Context

CityConnect is a scheme by West Yorkshire Combined Authority (WYCA) in the United Kingdom that promotes cycling and walking, improves access to employment, skills, and education, and reduces CO_2 and improves air quality. It works with businesses, schools, and communities to make active travel easy and attractive. The project focuses on asking for feedback and input from the public at all stages.

In Action

To help deliver and develop the CityConnect scheme, WYCA set up a technical stakeholder board, and a supporting group of interested professionals and citizens. The board held regular meetings where participants would provide local knowledge, technical specialist input, and enable a sense of project ownership to help shape the results and public perception of the project. The advisory group chair—an independent person, but paid by CityConnect—sat on the overall program board.

WYCA also contracted a nongovernmental organization to conduct community participation activities. This NGO enlisted the help of community organizations representing hard-to-reach groups, such as elderly and ethnic minorities, to undertake street audits with residents to understand what improvements could encourage walking in the neighborhoods. Using local groups with good community relationships enabled WYCA to organize effective participation activities quickly and efficiently. WYCA also utilized social media, allowing it to:

- Promote the CityConnect project and inform the public about progress.
- Promote forthcoming activities, events, and opportunities to get involved.
- Act as a conduit for wider discussions about cycling and its role in society.
- Respond immediately to public criticism with further detail about the scheme benefits.
- Enable project "champions" to promote the project to wider audiences.

Results

The CityConnect scheme was an opportunity for WYCA to test new techniques and consider their application when developing a new SUMP for West Yorkshire. For example, it saw the value in using social media, but learned that it needed to be adequately resourced to react and respond to comments instantly, as channels such as Facebook and Twitter are "live" communication tools. It also saw the benefits in engaging hard-to-reach communities, and for this reason, it decided to work with The Youth Association (TYA), a local organization, to help with its SUMP and get the views of young people on their travel difficulties and aspirations for the future. On behalf of WYCA, TYA engaged young people in a number of activities on the following topics:

Travel behavior

- Small groups discussed the difficulty of getting to school, college, or the town every day.

Ambitions for travel

- Young people took part in exercises and games where they agreed or disagreed with statements about their potential travel in the future.

The role of technology

- Games helped young people to understand how technology could improve travel in the future.

Solution

Selecting Measures for SUMPs

In Brief

In many cities, selecting sustainable urban mobility measures is not a rational process. It is often politically driven and led by sectional interests. Local authorities tend not to innovate, but rather pursue long-considered schemes and focus on infrastructure projects and management-based improvements to the infrastructure, rather than considering enhancing public transport or ways of managing demand. Having a thorough process in place for selecting measures enables cities to choose those that can meet its SUMP vision and objectives, and overcome identified problems.

Examples

Identifying the most suitable and cost-effective SUMP policy measures should start once a city specifies its SUMP vision and objectives, and it identifies the problems it needs to overcome. A city should start with a long list of possible measures, which it then reduces into a shortlist based on how appropriate they are to meet the SUMP objectives, before assessing them in more detail. These two stages involve a process of "option appraisal," which consider a measure's effectiveness, acceptability, and value for money. The city then considers the most promising measures and projects for implementation at a later stage in the SUMP process.

There is an increasingly wide range of policy measures available to European cities. The EU-funded Eltis, CIVITAS, and EVIDENCE projects provide individual examples; more recently, EVIDENCE assessed the performance of 22 categories of policy measures. However, these sources are limited by the lack of empirical evidence on many of the newer policy measures, and a lack of understanding of the principles of transferability of performance from one context to another. The CH4LLENGE Measure Option Generator provides information on 64 types of policy measures, with a number of case study applications for each. Guidance developed like KonSULT, an online option generator, seeks to encourage a rational approach based on evidence of best practice based on 64 measures and over 200 case studies.

Results

While cities can implement individual measures, it is more common for a SUMP to have a package of measures, which reinforce the effectiveness, acceptability, or value for money of each. No single measure on its own is sufficient to achieve a city's objectives or overcome its problems. Most cities will include several policy measures in their SUMPs

and need to think about how these different measures might interact. This is the concept behind creating a policy package—the key to which is identifying which measures will work well together, or which ones cities need to make other measures viable. Developing packages can start in the option-generation step, but is more common once a city develops a shortlist of measures and projects. It can then appraise potential packages using the same option appraisal procedures.

Technical and Financial Considerations

Selecting the right measures is a challenge. Cities have a wide range of measures available, such as building new road and rail infrastructure, providing new public transport services; managing the road network more effectively; encouraging behavioral change; providing improved information; charging for using the transport system; and modifying development patterns to reduce travel demands. It is too easy to overlook more effective solutions. Many stakeholders and politicians will also have preconceived ideas on what should be done, and evidence suggests that these solutions are often not the most cost-effective.

The most cost-effective measures are often the ones with the highest level of indirect benefits. Split responsibilities, lack of funding, and public opposition limit what is possible. Furthermore, a SUMP is likely to draw on several measures. However, the SUMP's performance and the city's ability to implement it depend on how these measures are packaged. Finally, a SUMP needs to be more than a wish list of measures.

Institutions

Selecting measures requires various institutional stakeholders to collaborate—such as planning authority professionals, engineers, and decision makers—and input from community stakeholders on what measures, or packages of measures, may most effectively address the local issues.

Transferability

Many cities are facing the same or similar problems when completing a SUMP, and may have a portfolio of possible measures they could plan and implement to address and overcome these challenges to improving mobility. Many cities also have a variety of good practice measures already in place that can serve as models to introduce into other locations and adapt to each unique city or regional context. Perhaps one of the most important considerations when selecting measures is to identify measures rationally with the participation of stakeholders to ensure cities address specific local needs with the appropriate measures.

Case Study

Case Study: Removing Ghent's B401 Viaduct (Belgium)

Context

As a part of its SUMP, Ghent is developing a project to remove its B401 viaduct highway exit, which currently leads directly to the city center, into a more sustainable transport corridor.

In Action

To help select the appropriate measures, Ghent engaged with stakeholders to enable cooperation between local and regional authorities within the planning process. It also exposes stakeholders to the realities, constraints, and compromises of potential options. The city also defined an advisory and stakeholder group to identify local and detailed issues through strategy development and analysis, and enable designs to be appraised by experts and people with local knowledge. It also empowers "nonlocal authority" parties in decision-making, and reduces potential for media criticism by including critics.

Results

Ghent's measures include replacing the viaduct with park-and-ride infrastructure, and developing bicycle and public transport connections to the city center. It may also reroute vehicles to various points of access from the R40 ring road around the city. This measure could divide the total volume of traffic and improve air quality, reduce noise, provide new public space as well as opportunities for improvements to general quality of life in this area of the city.

CLUSTER 5: NETWORK AND MOBILITY MANAGEMENT

Solution

Parking Management

In Brief

In Europe, growing and shrinking cities and districts are very often relatively close to each other, and allow for daily commutes from one center to the other. The number of people traveling to these areas for work, education, shopping, and leisure is increasing. Furthermore, middle-class households can afford a car for at least traveling at weekends and for nonroutine trips during the week. All these trends mean

that in most attractive inner-city districts there is not enough parking available, making effective parking management increasingly important.

Examples

Policy and planning solutions in European cities for residential parking range from motivating residents with pricing schemes, to getting them to park their cars outside dense districts and not next to their apartments. Municipalities offer parking options with easy access to public transport at the city periphery for much lower yearly costs than that what it costs to park in dense residential areas. Other examples include urban planning concepts that ban residential parking as far as possible from dense city districts, and arrange public transport routes so that each place of residence is no more than 15 minutes from a public transport stop. European cities also try to channel commuters into publicly or privately managed parking facilities (preferably outside the most densely populated area) and allow fewer parking spots in public spaces. Although managing parking spaces is expensive, this is widely accepted by the public, who are willing to pay the associated costs.

Results

Good parking management schemes reduce the number of cars entering the city, can cut congestion, and can encourage travelers to use alternative means of transport that improve the environment.

Technical and Financial Considerations

Cities must consider the difference between public and private parking. While public parking is under the control of the municipality and measures can be carried out (as long as they are publicly acceptable), private, off-street parking can only be influenced to a limited extent and in some cases building laws can override municipal interest. Establishing park-and-ride facilities along commuter routes keeps commuters out of cities but also requires the necessary public transport options. More and more cities nowadays introduce differences between resident and nonresident parking. This often leads to an effect where areas neighboring such restricted zones become such zones themselves in order to avoid parking problems created by the spillover effect.

Depending on the type of technology used and the need to build new infrastructure (e.g., garages, information systems, etc.) costs can vary considerably. Income generated from parking fees can normally cover these costs on a long-term basis. The way in which cities spend revenues once the investments are covered can have a considerable influence on how acceptable the scheme is to the public. Parking management schemes can also be unsuccessful if cities do not carry out

enforcement strategies. On the other hand, they need to provide easy payment options, for example, via smartphones, to ensure compliance.

Policy/Legislation

Implementing new parking management schemes is not only a matter of technology but also of institutional change and a significant change of current practices. The issue is actually very political: new parking management policies are very dependent on an appropriate window of opportunity in city council politics. Parking management strategies and their potential benefits require changing zoning and planning practices as well as changes in organizational and institutional frameworks.

Institutions

City governments primarily implement parking management strategies. In city regions, coordinating policy among local governments within these regions is crucial. With the implementation of novel parking management schemes, local administrative practices also have to change.

Transferability

The different solutions are easily transferrable to other cities, assuming that the relevant legislative basis exists and the public accepts it.

Case Study

Case Study: Barcelona's Parking Restriction Scheme (Spain)

Context

In 2005, Barcelona introduced a parking restriction scheme to reduce the continuously increasing number of cars entering the city. In addition to reducing congestion, the goal was to encourage travelers to use alternative means of transport and improve the environment. The city assigned parking zones for local residents, reducing the number of parking spaces available for nonresidents and improving the use of public spaces (e.g., reducing illegal parking).

In Action

Barcelona introduced three parking categories. Blue parking places (àrea blava): cars can park in these places at any time of day for between 1 and 4 hours. Drivers must buy a parking ticket and display it in the window. Prices may vary depending on location. Green parking spaces (verdes preferences): residents with a permit can park free in

these spaces during the times and days specified on the parking meters. Other cars can park any time of day with a valid pay-and-display ticket, which drivers can buy in the parking meters. The green area is completely free all day during August every year. Green exclusive parking zones (verdes exclusivas): if parking places do not have dividing lines for each space it is a "verde exclusiva" zone, which means that only residents with permits can park in the spaces. Since 2013, a parking payment app has been available and allows payment by smartphone at over 40,000 parking places in the green and blue zones.

Results

The introduction of the pricing restriction scheme has improved traffic flow and reduced incoming daily traffic in the areas covered by the parking zone. Other modes of transport, meanwhile, have experienced an increase in passengers, while average speeds in the city, and illegal parking, are down. The measure must apply together with others that help improve public transport, support cycling and walking and, in general, support more sustainable transport. Local residents and commuters should have a choice of alternatives to ensure mobility.

Solution

Access Restrictions

In Brief

ARS aim to restrict and enable access to city districts or network intersections. These strategies can reduce congestion and parking stress, improve traffic safety and network operations, and help reduce direct emissions. ARS must be easy to administrate and execute; lead to as little delay as possible for cars entering or leaving; be easily adjustable to meet future needs; and, if applicable, allow easy payment for both residents and nonresidents.

Examples

There are four types of ARS, based on points, cordons, area licenses, and distance or time:

1. Points: Restrictions applied when crossing a bridge, or entering a small section of the city.
2. Cordons: Restrictions applied for crossing a cordon, which may vary with time of day, direction of travel, vehicle type, and location on the cordon. There could be a number of cordons with different rules/prices.

3. Area licenses: Restrictions applied for driving within an area during a period. The rules may vary with time and vehicle type.
4. Distance or time: A pricing restriction based upon the distance or time a vehicle travels along a congested route or in a specified area. It may vary with time, vehicle type, and location.

Results

ARS have been widely implemented in Europe with a high variety of diverse approaches. Every scheme has multiple objectives, the primary ones being to reduce traffic congestion, improve the environment (e.g., air quality), and generate revenue to invest in enhancing local transport. The positive impacts citizens can expect are calmer traffic, better quality of life, improved public transport, fewer accidents, and reduced pressure on parking spaces. Shops, businesses, and areas close to the restriction zones may experience negative impacts due to increase parking pressure. Many schemes were responsible for immediate improvements, although, over time, traffic started to increase again—albeit not at the same rate expected without the measure.

Technical and Financial Considerations

Depending on which type of access scheme a city introduces, its installation is both technologically and financially demanding. Overall running costs and the costs of enforcement are key considerations. There are lessons to be learnt from ARS in different urban environments that cities should carefully consider before introducing similar schemes. Pilot runs of the scheme have proved extremely helpful in several cities. However, they must be of the highest quality in order to avoid backfiring, and should be associated with adequately planned information and awareness campaigns. The bureaucracy and procedures associated with the scheme, most notably concerning vehicle registration, must be as simple as possible and handled in a single process (a "one-stop shop"). ARS information should be multilingual and available online for local and visiting travelers. Effective and stringent enforcement should increase, and nonmotorized infrastructure, such as reclaimed road space, should be improved and promoted.

Policy/Legislation

Plans for establishing ARS must undergo a formal ex ante assessment. Ideally, this can take the form of a fully fledged cost–benefit analysis. Alternatively, it should also adopt qualitative/quantitative techniques, such as a cost-effectiveness analysis or a multicriteria assessment. Whatever the methodology adopted, cities must share the assessment transparently with stakeholders, including users. If necessary, legislation must be adapted to allow the introduction of such ARS.

Institutions

Municipalities should implement such schemes locally, but they must also involve those affected, such as those living nearby and those who regularly enter the zone of the scheme (e.g., commuters). Getting local residents and businesses on board is crucial for the success as well and, in many cases, it is necessary to find the right window of opportunity.

Transferability

Each city is unique and requires its own assessment as to which types of ARS are suitable. Cities can also build on the experiences of other local authorities—about both technological and administrative procedures, and those regarding the political process. Schemes following a transport-demand management approach have been especially successful. They have generated significant benefits, including increasing network reliability, fewer travel delays, reducing congestion, and other related positive environmental impacts. In some cases, however, the long-term impact was less than originally planned.

Case Study

Case Study: Stockholm's Congestion Charge (Sweden)

Context

Stockholm introduced its congestion tax in 2006 after a long debate and a 6-month trial. The motivation was to reduce traffic congestion and improve the environmental situation of central Stockholm. The tax was under much discussion, especially by residents living outside of the proposed zone but working in Stockholm who argued that they should have a say. In the time since the city put in the control points, however, the debate has calmed down considerably. The system is working smoothly and the actual cost of passing these stations is acceptable to most residents, and central Stockholm has been getting cleaner since the tax went into action.

In Action

A number of national and regional authorities were involved in the design and implementation with some changes to legislation by the Swedish parliament. A number of other measures supported the introduction of the congestion tax, such as increasing capacity in the bus service and in the underground system. After the trial of the congestion tax, the city held a public referendum in September 2006, which led to agreement by the voters. There was some criticism because only central

Stockholm could participate in the vote, not adjoining regions also affected by the tax. In August 2007, Stockholm permanently introduced the congestion tax. The amount of tax depends on what time of the day a motorist enters or exits the congestion tax area. There is no charge on Saturdays, Sundays, public holidays, or the day before public holidays, at nights (18:30–06:29), nor during July. Car owners receive bills once a month. Notable exceptions at the beginning of the scheme from the congestion tax were cars that used an alternative propulsion system (electric, gas, etc.) although this has now been phased out.

Results

The Stockholm city congestion charge has cut congestion and encouraged a change in behavior by residents. Improving public transport so that it could offer viable alternatives was very important. Since the introduction, the overall acceptance of the tax has even increased. The original targets of the congestion tax (which were to decrease traffic and congestion, enhance accessibility, and improve the environment) changed in 2007 to include that it should help finance new road infrastructure in the Stockholm region. Number plate recognition technology to identify vehicles entering and leaving the zone has been a success.

Solution

Traffic Management

In Brief

Managing traffic in urban areas is a complex issue, involving different agencies and partners. However, if done right it can reduce congestion, emissions, pollution, and parking pressure; facilitate freight delivery; and make the best use of available resources and infrastructure. It can also increase the share of sustainable transport modes, safety, and accessibility.

Examples

Traffic management effectively requires different approaches that influence travel behavior. These include charging motorists to enter a city; restricting the access of vehicles to urban areas based on their emissions; and managing traffic flow, parking, and the access of freight vehicles. Improving public transport, information on available travel options, and the accessibility of nonmotorized transport can also help. By using the array of real-time traffic data now available from cameras, sensors, and cars, traffic management systems can also help control

traffic by, among others, being able to change traffic lights, set speed limits, and give advice to travelers on public transport options. To be effective, traffic management must be flexible and react dynamically to current and expected traffic situations. The next step in the evolution of traffic management is Traffic Management 2.0 (TM 2.0), where vehicles interact with each other, road infrastructure, and traffic management centers, and allow different users to share data and exchange information.

Results

Using different technologies and information sources gives a better overview of traffic situations, communicates measures, and provides alternatives to travelers. Providing better information and communication channels for travelers can directly influence their travel behavior and choices before and during their trips. Besides reacting to traffic situations (such as accidents) after they have happened, traffic management sees upcoming challenges and responds appropriately to avoid or minimize problems.

Technical and Financial Considerations

Traffic management uses different technologies and approaches, so the set up will be different for each city and based on its existing mobility, information, and communication systems. However, as different systems become more integrated, bringing different organizations together, challenges will arise. It is also an opportunity to create a system that evolves from being static and reactionary to one that is dynamic, and proactively avoids problems before they happen. This will better support policy goals and contribute to a sustainable and integrated transport system. Depending on the size and complexity of the system, the investment and running costs can be considerable but often necessary to achieve policy goals and ensure that the mobility system runs smoothly.

Policy/Legislation

Relevant policies and legislative frameworks depend on the type of traffic management and measures a city wants. Providing information and recommendations will be more favorable than measures that travelers feel directly and which have an impact on their travel patterns (such as congestion charges, emissions zones, and parking management). Privacy and security may become an issue as traffic management systems generate information and link data together—as will data ownership, especially when using data from different transport operators and travelers. As traffic management systems use more data sources they must guarantee a minimum level of data quality.

Institutions

Modern traffic management needs data and information from many different institutions, stakeholders, and partners. Traffic and transport authorities and administrations are directly concerned in managing traffic but also have to provide data in a correct and timely manner. Public transport operators at the different regional levels provide information on schedules and delays, while police give data on accidents and are relevant for formulating contingency plans. Included also should be road operators, who often have a traffic management center and provide traffic and road warnings (e.g., on the radio).

Transferability

Each city is different, making a direct transfer difficult to impossible. For example, a lot depends on the existing mobility infrastructure, traffic management systems, and levels of integration of different stakeholders, policy goals, and existing challenges. Many larger cities already have some kind of traffic management system, making it possible to learn from different examples.

Case Study

Grand Lyon's Traffic Prediction Tool

Context

Grand Lyon is an area that encompasses the city of Lyon and most of its suburbs. It has 1.3 million inhabitants and is the second-largest metropolitan area in France. It also has the second-largest public transport network, on which there are 900,000 journeys per day. Some 500,000 cars enter the city of Lyon each day and nearly 50% of the 4 million daily trips take place in cars. Although road traffic has decreased in the past, Grand Lyon is encouraging residents to use more sustainable modes of transport and increase the efficiency of the existing transport system. For this purpose, Grand Lyon's traffic management center examined the integration of a traffic prediction tool into its existing traffic control system.

In Action

Between 2013 and 2014, Grand Lyon created a tool that makes it possible to predict traffic patterns 1 hour ahead, and manage traffic in real time for 3000 km of urban roads. It uses a network of 800 sensors, 255 video cameras, and a telecommunication system that collects and distributes data. Within the urban area, the traffic center controls 1600 traffic light intersections, and 50 variable-message signs. This network allows

Grand Lyon to schedule traffic lights at intersections, manage "green-waves" (when a series of traffic lights are coordinated to allow a continuous traffic flow in one direction) and prioritize public transport. Furthermore, drivers and travelers are provided real-time information on traffic, events, the weather, parking places, the bicycle network, free bike services, car-sharing, and carpooling. It is very important for the operator to react very quickly and make appropriate decisions. Indicators quickly and unambiguously describe the results of each scenario and send the simulation-tested commands to the field. The predictions can extract many traffic indicators and activate relevant alerts. They also qualify the planned scenarios using predefined indicators and choose the most appropriate for current situations and predetermined constraints (based on the city's transport policy). It is also possible to replay simulations to get a better understanding of each of the phenomena involved, increase knowledge about the network and come up with new scenarios that may help optimize traffic conditions.

Results

Studies show that Grand Lyon's traffic prediction tool is reliable 80% of the time, and that it frees up 20% of the area's road capacity. The tool allows the operator to view the impacts of its actions locally and regionally and to tackle congestion it predicts will occur 1 hour ahead. This system moves away from reactive management based on real-time situations toward proactive management based on 1-hour traffic predictions. Strategically, the goal is to avoid or reduce congestion, and therefore use the road's capacity over time better. Operators can simulate different scenarios according to different strategies and travel policies to assess their relative impact on the network.

Solution

Multimodal Journey Planners

In Brief

A multimodal journey planner is a software application that allows users to plan a single trip using multiple modes of public and private transport. It is usually accessible on computers and other digital devices (e.g., smartphones). It provides integrated travel suggestions and encourages the use of sustainable transport.

Examples

Good multimodal journey planners allow travelers to make informed choices depending on their travel preferences and needs. Typically, they

have access to real-time data; provide door-to-door routing with visual maps; show information on where to buy tickets (or have software with which to purchase them); and provide real-time travel information in case of disruptions. They should also be able to effectively compare door-to-door travel times, costs, and emissions between public transport and car journeys, and allow travelers to book and pay for a journey regardless of how many types of transport they use. There are two types of approaches related to multimodal journey planning systems and services. A large-system approach (big data) can be commissioned by cities or city regions, such as in Lyon (France) or Torino (Italy), or nationally like in the Czech Republic; or an open-data strategy, where data owners (city governments, network and fleet operators, service providers, etc.) provide data in a standardized data-exchange format. Private companies can then use these data to develop applications for journey planning. In both cases, there must be a sound level of cooperation between all parties involved.

Results

Multimodal journey planners help increase the use of public transport and reduce transport emissions and congestion. Public transport is more accessible to travelers, and travel times are more predictable (especially if real-time data are available). They show users new travel options, provide help on where and how to change between modes, and allow them to easily buy and hold tickets. Ideally, the different companies involved will also have more customers, and support a shift from motorized individual transport to public transport, include sharing systems, and thus have a positive effect on the transport network and the environment.

Technical and Financial Considerations

The main issues are opening up information and management systems run by different operators and linking them to dedicated platforms. Different standards for data and data exchange already exist to support such a move. The use of smartphones greatly increases the accessibility for travelers; however, data security and privacy are issues that need careful consideration. Fairly distributing collected fares and guarding sensitive company data are also important, and here concepts such as using a trusted third party to oversee operations are useful. Supporting projects that highlight multimodal solutions can be the first step.

Ultimately, it should be a win−win situation for all, but the competitive situation between the different operators is a factor, especially when booking and paying for trips. They must incorporate existing information systems, and here it is possible to draw on experiences in

Europe. The use of existing standards and data-exchange formats will greatly enhance European cities to potentially introduce similar multimodal journey planners.

Policy/Legislation

Policies should encourage the cooperation of different transport operators, especially those belonging to the municipality. In Europe, the PSI Directive already defines which kind of data must be publically available and is a starting point, as journey planners need different types of spatial data in order to operate.

Institutions

Public transport companies should take the lead, but they should also encourage other operators to participate. Very much depends on the level of cooperation between different stakeholders and the level of trust that has been built up. Independent start-ups and smaller operators can be more agile and help come up with creative solutions to support multimodal integration.

Transferability

Good multimodal journey planners require good cooperation between a numbers of parties, the level of which can vary from city to city, and region to region. In the absence of such cooperation, stakeholders must have enough time to build trust between one another, and ensure the willingness of all partners to contribute to such a system. Many transport operators already have an information system and allow booking and ticketing, but many only for their own transport options. Each city has its own transport structure and a solution will not always be directly transferable to another city. However, looking at existing different solutions and experiences can help support the implementation of multimodal journey planners in other cities and regions. In many cases, barriers are more on an organizational level than on a technical one.

Case Study

Vienna's Multimodal Journey Planner (Austria)

Context

Viennese citizens have been able to use AnachB, a multimodal journey planner, since its creation 2009. AnachB combines data from a range of sources provided by different transport operators and organizations

(ranging from public transport, road maintenance, police, taxi companies, etc.) to provide up-to-date traffic information for travelers.

In Action

Vienna has integrated public transport under a common framework with harmonized tariffs and tickets. In 2006, the ITS Vienna Region was founded to support the development of high-quality and up-to-date transport services. These services should consider and integrate all modes of transport (including park-and-ride and bike-and-ride facilities), all of which are available for free on AnachB. A traffic model calculates the real-time traffic situation for the whole area, and this information is projected on a digital database known as the graph integration platform (GIP), covering the whole network. Partners, municipalities, and regional governments continually update the highly detailed GIP and use it in day-to-day work for administrative purposes. Different partners can also use AnachB services for their own platforms and services, meaning they always have the most up-to-date information combined with their own individual services. Data from the GIP database is now also available to the public under the open government data policy.

Results

The development of GIP and AnachB helped bring together the operators and stakeholders relevant for supporting multimodal transport. High-quality and up-to-date information is now available to all of the partners involved and travelers know that all systems that use these databases have the same quality and reliability. Continually updated, it allows the users to choose between different combinations of modes of transport (public transport, cars, bikes, walking, etc.) and optimization criteria, and provides other relevant information.

Solution

Car-Sharing

In Brief

The advantage of owning a car means that there is always a vehicle available, but this comes with considerable drawbacks. Besides the initial costs of buying a vehicle, there are running costs, the need for a parking space, driving a car much larger than necessary for the trip, and general upkeep and services. In the 1990s, private car-sharing schemes started in Europe, promoting the idea of a car used by more than one person, thus utilizing it much better, and sharing fixed costs

between those involved. It would sometimes even eliminate the need for a second car and reduce the need for parking spaces.

Examples

Car-sharing schemes are particularly popular in urban/semiurban areas with adequate public transport and short distances between destinations. Depending on the number and types of cars available, users can select vehicles based on the purpose of travel. These grassroots initiatives were normally nonprofit and could only work as long as people were willing to organize them in their spare time. Nowadays, larger organizations have taken this over, which has also led to a greater availability of different car-sharing schemes. In general, there are two types of car-sharing schemes: floating and stationary. Floating car-sharing (e.g., car2go, DriveNow) allows the driver to park the car anywhere within a designated zone so that the next user can pick it up. Mobile applications show the car's location, and allow the next driver to book and find it. With stationary car-sharing (e.g., Zipcar), users return vehicles to designated parking areas. Both systems have their advantages and disadvantages and, very often, legal constraints and city regulations will favor one system over the other. Payment can be time and/or distance based, and apps usually have an option to comment on the status of the car. Payments cover all costs including fuel, making it very easy for customers to calculate the expected fee.

Results

People that use car-sharing services have more flexibility with their choice of transport, and can benefit from the convenience/advantages of a car without having to own one. The availability of cleaner models means that drivers can choose lesser polluting cars and, depending on individual travel patterns, car-sharing can be considerably cheaper than owning a car. It also reduces the pressure on cities to provide more parking spaces. The number of cities having one or more car-sharing scheme available has increased considerably in the past few years, as have the number of companies offering such a service. In some cases, established transport operators offer this as an additional service to customers (e.g., Flinkster by Deutsche Bundesbahn).

Technical and Financial Considerations

The financial burden on cities depends on the kind of agreement the city and the car-sharing company make and if infrastructure measures (e.g., for stationary sharing) are necessary. Ideally, as mentioned above, other transport providers would integrate car-sharing and offer it together with their service.

Policy/Legislation

Implementation very often depends on coming to an agreement between a car-sharing company and city administration, especially regarding parking policies. Car-sharing is also an opportunity to have more environmentally friendly technology, such as EVs, more widely used by the public. Introducing more cars into a city with scarce parking spaces can initially increase pressure. However, if popular, people will own fewer cars in the future thanks to the availability of car-sharing services. Cities may also have to revise building codes (e.g., requirements for a parking space for each housing unit) to make car-sharing attractive.

Institutions

Normally a car-sharing organization approaches a city to agree how to establish a service. Both stationary and floating car-sharing services need decisions on where to park their cars and how they fit in any existing parking regulations. One way to attract car-sharing companies is to create packages that allow them to utilize public space at a reduced or no cost for a certain amount of time.

Transferability

Cities interested in introducing car-sharing face similar challenges. Of course, depending on what type of car-sharing (stationary or floating) they favor, these will differ to an extent. Integrating other modes of transport depends also on the traffic systems already in operation in each city. Car-sharing companies that operate on a regional or national level will already have learned from previous implementations.

Case Study

Bremen's Car-Sharing Scheme (Germany)

Context

In 2009, Bremen introduced its own development plan to help make car-sharing more sustainable. The plan provides space for car-sharing stations, integrates car-sharing in new urban developments, coordinates with public transport, and creates strategies for raising awareness. Getting away from ownership to the smart use of cars (i.e., whenever needed) is an important aspect. Bremen's goal is to have 20,000 car-sharing users by the 2020.

In Action

In 2003, Bremen introduced on-street stations that connect different modes of transport (cycling, public transport, and car-sharing). The online booking and smart card access to the cars make them user-friendly.

New housing developments can already consider car-sharing and thus reduce the need for parking spaces.

By the end of 2014, 10,000 car-sharers registered in the city, with more than 200 cars at 55 stations (known as "mobile points"). A number of different operators offer car-sharing, targeting different user groups with a variety of options (e-cars, e-bikes, etc.). Bremen's slogan "use it, don't own it" is at the heart of a marketing campaign to convince citizens of the benefits of car-sharing. These measures accompany actions to support peer-to-peer car-sharing, where private individuals can offer their car through professional platforms to others who want to use it for a certain period.

Results

Bremen estimates that every car-sharing vehicle replaces 8–10 private cars. This has an overall impact on emissions created by manufacturing of cars and a continuous impact due to behavioral changes (more use of public transport, etc.). It also reduces the need for on-street parking and underground parking, freeing street space for other uses, such as widening sidewalks, developing bike lanes, installing green space, etc. Bremen expects the impact to increase further, as it introduces new mobile points.

Solution

Cooperative Intelligent Transport Systems

In Brief

The basic principle of cooperative intelligent transport systems (C-ITS) is that road users exchange information among each other and with infrastructure elements such as traffic lights or signs in real time and at high speeds. The technology can help implement city policies and strategies, and support policies to prioritize specific vehicle classes, such as public transport or emergency vehicles. Improved traffic management can further support smart-city goals in terms of energy efficiency and reducing CO_2 emissions.

Examples

C-ITS works by cooperative parties—ITS stations located in vehicles or in roadside units—exchanging information with each other by using standardized message sets. In principle, there are two data transmitters: the vehicles; and the infrastructure leading to communication paths between vehicles (car-to-car), between vehicle and infrastructure (car-to-infrastructure), and between infrastructure elements (infrastructure-to-infrastructure). Vehicles and infrastructure systems connect wirelessly. The receiving ITS station analyzes the data and makes use of the information depending on the service and application. A couple of European and national research and demonstration projects have developed and tested common communication standards and basic C-ITS applications over the past decade. European projects like Coopers, CVIS, SafeSpot, eCoMove, and FREILOT have demonstrated the technical feasibility and benefits of C-ITS.

Results

C-ITS can result in real-time traffic information; improved road safety (by avoiding accidents and reducing severe injuries through, for example, information on bad weather and road works), increased efficiency by supporting a consistent traffic flow; foresighted driving (e.g., where a driver can adjust their speed to ensure they arrive at traffic lights when they are green); and enhanced driving comfort.

Technical and Financial Considerations

A key to successfully introducing C-ITS is to follow common communication standards that ensure that vehicles and traffic infrastructure are speaking "the same language." Vehicle manufacturers, operators of transport infrastructure, and providers of mobile devices, such as smartphones or other navigation platforms, must agree this between themselves before implementation. Car manufacturers must introduce this technology in their vehicles and on the telematics infrastructure side along motorways (e.g., sensors, roadside units, and cables for data transfer). Several cities have installed Signal Phase and Time (SPAT) and Map Data (MAP) within projects (e.g., Compass4D), as in Verona (Italy) and Berlin (Germany). SPAT/MAP works by centralizing the monitoring of signal changes and hybrid communication (mobile and local G5) toward the users. There are technical challenges when deploying SPAT/MAP. One is to coordinate numerous suppliers of traffic controls and software so they reach the same quality, an issue which standardization could tackle. In addition, handling information within vehicles may result in different speed and stop advice, dependent on the supplier.

Policy/Legislation

Standardization bodies like ISO and ETSI have prepared certain frequencies for traffic applications. The European Commission set the relevant legal basis for common deployment in Decision (2008/671/EC) on the harmonized use of radio spectrum in the 5.875–5.905 MHz frequency band for ITS safety-related applications. This decision guarantees that this band is exclusively reserved worldwide for cooperative transport systems, to harmonize the conditions of the availability and efficient use for safety-related applications of C-ITS. Based on the European mandate M/4533, ETSI and CEN (another standardization body) are to develop the minimum set of standards to support the interoperability of cooperative systems for intelligent transport in the European Community.

Institutions

Cities play an important role, as do infrastructure providers, in the transformation process. They have the chance to steer and exploit the process, for example, to improve traffic management and to support smart-city ambitions. The first challenge for cities will be to decide to which degree they want to be involved in the transition of the mobility system, and which role they intend to play: regulator, procurer, financer, owner, equipper, or enabler. Private operators and municipalities must cooperate and establish mechanisms for exchanging data, and agree upon how to finance and maintain the intelligent infrastructure.

Transferability

In demonstration and implementation projects the organizational and technical foundations, such as system specifications for C-ITS, are currently being developed by motorway operators and public institutions. Industrial partners develop applications through field tests, and then turn these into products. In addition, the automotive sector has developed a couple of cooperative systems that it will implement in a new generation of cars in the near future. The challenge will be to interlink the traditionally autonomous subsystems in vehicles, road infrastructure, and traffic control, to become a single connected mobility system in a real environment. One major European milestone was the joint signature of the Memorandum of Understanding on the Cooperative ITS Corridor Rotterdam–Frankfurt–Vienna between the Netherlands, Germany, and Austria. This will introduce a basic set of C-ITS services together with vehicle manufacturers along this corridor, resulting in the first vehicles and telematics infrastructure resulting. The participating countries have started national projects to finance and implement this on their road networks and simultaneously

established a strategic coordination mechanism to support harmonization between the countries.

Case Study

C-ITS in Austrian Cities

Context

Cities do not implement C-ITS applications at the same time and to the whole infrastructure network. In its C-ITS strategy, Austria will develop and apply a phased model that will introduce selected applications, mainly on the primary road network. For Austrian cities in the first phase, applications related to traffic lights are of primary interest. The technology enables the transparent prioritization of public transport (such as buses and trams) and of emergency vehicles at intersections. Integrating and controlling traffic lights supports the green and efficient driving of all vehicles and the safe and comfortable crossing of intersections, even by blind and visually impaired pedestrians. Collecting data from all C-ITS users provides a detailed up-to-date picture of the traffic situation and supports traffic control and intermodal traffic management. Allowing a consistent traffic flow can save energy and emissions, reduce the number of accidents, and cut traffic caused by searching for parking spaces. Furthermore, local information on park-and-ride locations and public transport could contribute to a modal shift toward more environmentally friendly transport modes. Austria considers cities to be the most important partners, because without their involvement it will not be possible to extend the introduction of C-ITS to secondary and urban networks. This expansion is crucial, as the main goal is not only to improve efficiency and safety locally, but to spread the benefits to the whole traffic network. The following nonexhaustive list provides an overview of possible C-ITS applications for the "Day One" rollout phase of C-ITS and the potential benefits in a city environment.

Results

For European cities the main benefit of C-ITS is providing better information on the movements of vehicles. This gives data to traffic signaling systems about individual vehicles approaching, for example, intersections. The systems can control the vehicles across the total road network to ensure an optimal flow. In addition, the signaling system can receive information on specific vehicles—such as buses, trams, emergency vehicles, or EVs—which can ensure priority signaling according to a city's policy. This can have also have a positive effect on

traffic flow and safety, minimizing the number times a vehicle has to stop, and potentially resulting in fewer accidents. By receiving real-time data from vehicles, cities can significantly improve the understanding of the local and global traffic situation on the road network. Traffic control centers can set more effective traffic management measures, optimize traffic flow in the city, and reduce congestion, which can save energy and emissions. This can also support the municipality in its smart-city strategies, and encourage vehicles to drive more efficiently (if, for example, drivers would know when the traffic lights ahead are set to change). Transmitting local hazard warnings, and related speed recommendations, directly into vehicles can improve traffic safety. Municipalities can also save money by scaling down expensive vehicle detection systems, such as inductive loops, or CCTV, that are no longer necessary.

CLUSTER 6: CLEAN VEHICLES AND ELECTRIC MOBILITY

Solution

Registration Management and Number Plate Auctions

In Brief

Managing vehicle registrations and auctioning vehicle number plates limits the amount of cars in a city by linking car ownership to possessing some form of permit. In addition to, or instead of, setting a limit on the number of vehicles, municipalities can charge a fee for owning a vehicle, potentially based on its fuel efficiency and emissions. This can also encourage people to use cleaner vehicles or more sustainable modes such as public transport and nonmotorized modes.

Examples

Singapore implemented a vehicle quota system in 1990, where car owners had to bid for a limited number of 10-year licenses to register a vehicle. Today, Singapore's vehicle ownership rate is very low compared to similar cities. Likewise, Shanghai and Beijing (China) have also implemented quota systems to limit the growth of car ownership (Börjesson et al., 2012). In 2000, Shanghai was the first city in China to use auctions for owning a car, which includes bidding for license plates. Over the years, this mechanism changed from an auction with a reservation price to one without and underwent a homogenization of imported and domestic vehicles. Since 2008, auctions are now open auctions, which allow more transparency.

Results

Restricting vehicle registrations helps curb the increase of vehicles in a city and cuts congestion. Yet, as it cannot influence the existing levels of private cars, or private mass transport, fuel consumption is unlikely to change. Revenues from license plate auctions can pay for more public transport infrastructure. However, they are not socially inclusive: auctions will always favor wealthier people and leave out a big percentage of the population. Beijing's system of spreading license plates via a lottery is fairer, but the system cannot generate revenue for public transport. It often chooses winners who cannot afford or do not want to buy a car—and the license is not transferable. Other criticisms include the possibility of being able to avoid paying the auction price by registering the car in another region. In addition, the auction price continues to rise and further excludes poorer people. Psychologically, the results are less optimistic. By restricting vehicle ownership in the ways done in Shanghai or Beijing, private cars can become a status symbol and a "must-have" even more than before. Even though the car registration is restricted, people will try to find other ways to own a car.

Technical and Financial Considerations

No technical efforts are required to introduce vehicle restriction measures in cities or urban areas. Depending on the type of restriction (lottery, auction, etc.) finances can be kept to a minimum or can be regained through the process.

Policy/Legislation

The example of Beijing shows some policy examples for vehicle registration: 1990: Restriction of total numbers of vehicles; 1998: Parking certificate system on newly purchased vehicles to lower vehicles in the inner city; 2004: Parking certificate system was replaced by a vehicle purchase tax; 2005: High investment rate in public transportation; 2007: Implementation of a low-price transport policy.

Institutions

The lead agency is usually the local transport department. The auctioning system can generate funding which can then be redistributed to public and nonmotorized transport infrastructure.

Transferability

There have been examples around the world of vehicle restrictions of different kinds. These methods can be set in place without too much technical or financial costs. Depending on the reaction of the public,

cities can introduce a unique system of vehicle control and restriction depending on their needs.

Case Study

Restricting car Ownership in Beijing and Shanghai (China)

Context

The number of cars in Chinese cities, much like the country's GDP and urban population, is growing rapidly. In Beijing, one of the most polluted cities in the world, the city registered 2 million vehicles in 2004, and that number rose to 5 million in 2014. As a result, introducing driving restrictions in urban areas seemed necessary.

In Action

Beijing began restricting vehicles in the city center to limit pollution and congestion and to promote public transport in time for the 2008 Olympics. In 2011, the city started a vehicle license lottery to decrease vehicle growth, congestion and traffic levels, and fuel consumption in the city.

Every month the residents of Beijing can register to be part of the lottery. The Beijing system is designed differently to a scheme in Shanghai, which is based on auctions of a limited number of license plates, which puts a clear cap on vehicle growth in the city. This has proven to be much more effective in managing the size of the vehicle fleet.

Results

The success of the systems in Beijing and Shanghai depends on the design, in particular the integration of a vehicle quota. In Beijing, the city's lottery scheme led to the creation of a black market in which license plates were sold at record prices with little impact on managing the growing demand. Registering vehicles via a lottery also does not bring extra revenue, and about 10% of lottery winners did not buy a car, meaning that the permits expire unused. However, auctions generate extra revenues, and in Shanghai, this is being used to upgrade infrastructure or provide public transport. The Shanghai case shows that early action and auctioning a limited number of license plates can be very effective in managing the growing numbers of vehicles. Shanghai adopted the policy in 1994, before the demand for cars began to surge in the city. After realizing that the lottery scheme did not have the desired impact, Beijing adopted the vehicle quota approach in 2011. However, 5 million vehicles were already on the streets by then,

contributing to congestion and air pollution. The number of vehicles in Shanghai grew much slower, to 3.5 million cars.

Solution

Managing Electric Two-Wheelers

In Brief

Electric two-wheelers, such as motorcycles, scooters, pedelecs (pedal-assisted electric bikes), and mopeds, have many positive characteristics compared to their petrol equivalents. In particular, they produce less air pollution and CO_2 emissions, and less noise. Also, two-wheelers, when they are used instead of cars, improve the overall safety in the city and can increase the mobility of low-income citizens. Smart use of measures can foster an increase in the share of electric two-wheelers in a city amid growing overall numbers of petrol-powered two-wheelers (PTWs).

Examples

Electric two-wheelers are popular in many Chinese cities, in many cases driven by outright bans on their fossil-fueled equivalents. Murcia (Spain) installed public charging stations for electric two-wheelers to encourage the deployment of electric motorcycles and electric bikes. As part of the CIVITAS Initiative, Rome (Italy) introduced about 400 electric scooters and suitable recharging infrastructure. In addition, Rotterdam (Netherlands) and Barcelona (Spain) installed charging infrastructure for electric scooters and bicycles—and the latter launched the first electric scooter-sharing project in 2013. Naples (Italy) promoted electric two-wheelers by cooperating with manufacturers to offer discounts for electric scooters and pedelecs. To help replace fossil-fueled two-wheelers (or passenger cars) with electric two-wheelers, cities can write a plan with appropriate goals based on an examination of the role and implications of electric two-wheelers in the entire local transport system. Measures in the plan could include banning nonelectric-PTWs, providing dedicated parking, creating charging areas and separate lanes for electric two-wheelers, and special waiting areas at intersections for motorcycles, or excluding electric two-wheelers from city tolls.

Results

Conventional two-wheelers contribute substantially to pollution in cities. When switching from conventional to electric two-wheelers, the emission of hydrocarbons and carbon monoxide can be largely avoided. Promoting electric two-wheelers can help raise awareness and change

the behavior of citizens and tourists in favor of using more sustainable forms of transport. Electric two-wheelers provide a more affordable, and more sustainable, alternative to fossil-fueled cars, especially for low- and middle-income groups.

Technical and Financial Considerations

In contrast to electric cars, charging electric two-wheelers is relatively easy and requires less infrastructure, and to date a number of small projects have demonstrated that there is potential for electric two-wheelers (in China they are gaining popularity). However, in many cities their benefits are diminished because of insufficient regulations and enforcement, and because they are not integrated properly within the transport system. In addition, cities should develop or improve charging infrastructure and guarantee charging sites. Increasing the amount of energy that batteries can store is important in allowing electric two-wheelers to travel further distances between charges, although less so than for electric cars. Regulations should be implemented to enforce the use of sustainable lithium batteries instead of the cheaper, short-life sealed lead acid (SLA) batteries. Technological improvements are also necessary to improve the affordability of electric two-wheelers. Electric bicycles have the potential to cause accidents due to their higher speeds (for unaccustomed riders) and traffic regulations and infrastructure not designed with them in mind. Similarly, as they also have no turn indicators or horn and are noiseless, these are further points of accident potential. In the past, some cities have implemented isolated measures regarding electric two-wheelers such as an integrated citywide electric two-wheeler plan. Improving the regulation of their use can reduce safety issues. Kuala Lumpur (Malaysia) and Taipei (Taiwan) have reduced accidents by introducing motorcycle lanes and waiting boxes at junctions.

Policy/Legislation

Subsidies for electric two-wheelers can stimulate their sale. Governments also should provide the right incentives for private investors to research and develop electric two-wheelers. Recharging and driving distance remains a technological challenge which the industry needs to tackle. In China, the 2004 law on Road Traffic Safety defines electric bicycles and scooters as nonmotorized vehicles, and imposes a speed limit on them of 15 km/h. However, it is easy to exceed this speed limit by 5–20 km/h unconsciously, which poses a significant danger. China's example shows the need for strict regulations from the beginning to avoid accidents and unintended unlawful behavior. Other considerations include prohibiting the sale of SLA batteries, requiring the registration of electric two-wheelers, implementing recycling

regulations, and adapting infrastructure (e.g., creating special lanes for electric two-wheelers).

Institutions

Electric two-wheelers face the same challenges and have the same benefits for most urban areas. Travel is increasing in cities, and with that typically comes increased congestion, discouraging people from using buses. Where private transport is favored, two-wheelers provide a sensible alternative to cars, albeit with many negative side effects (e.g., air pollution and noise). Electric two-wheelers mitigate many of those negative effects, and can be charged with standard electrical outlets, avoiding the need for new and dedicated infrastructure.

Case Study

Shanghai (China)

Context

China is the world's largest electric two-wheeler manufacturer and exporter, and the country with the highest number of electric two-wheelers. The national government is responsible for type approval of vehicles, and thus for defining what counts as a bicycle and what as a motorcycle. As of 2006, bikes with "functioning pedals" are classed as pedelecs, with the result that essentially electric scooters are classed as bicycles, and are subject to the same rules and limitations. Furthermore, many of the regulations are "recommended," or easily circumvented (e.g., easy-to-remove speed limiters), which has led to some problems.

In Action

While the Chinese national government is responsible for type approval, the cities have power over how the standards are enforced and over traffic management. In 1996, in response to air quality problems and excessive car use, Shanghai banned the sale of petrol-powered scooters, and as of 2006 the only two-wheeled vehicles allowed to be sold in Shanghai are LPG, electric, or human powered. The ill-defined regulations regarding power output, maximum speed, licensing requirements, safety equipment (lights, indicators, etc.) governing electric two-wheelers has led to safety problems, and led to Shanghai banning some types in 2016. In addition, the solid waste from electric two-wheelers is considerably higher than conventional bikes and scooters, mostly from battery disposal. While electric two-wheelers do not have a dedicated infrastructure they have to either compete with cars or bicycles and pedestrians. Both can lead to an increase in

accidents. While cars can move more people, electric two-wheelers are mostly only providing mobility for one or two persons. This leads to an increase in two-wheelers in the street and can have a negative effect on congestion in cities.

Results

The petrol-scooter ban in cities such as Shanghai have seen a sharp increase in the numbers of electric scooters and motor-bikes with now over 200 million electric two-wheelers on the roads in China. However, there has been a push-back in many cities in China on e-bikes and scooters as they were involved in a large number of crashes. Fig. 7.2 shows the difference in modal share between Shanghai and Chengdu (both electric two-wheeler friendly, Chengdu without LPG infrastructure) and Beijing, which is hostile to electric two-wheelers, and, as expected, has a lower share of e-bike use.

Solution

Electric Taxis

In Brief

Gasoline- or diesel-powered vehicles cause severe problems. They pollute the air, emit GHGs, produce noise, and consume increasingly expensive fossil fuels. EVs are a promising alternative that can address these problems and contribute to a sustainable transport system. Taxis are highly visibility in cities and switching the fuel on which they run can raise awareness of how electricity can be an alternative to fossil fuels. They can serve as role models and bring consumers and customers into closer contact with the technology.

Results

EVs offer several advantages compared to gasoline or diesel vehicles:

- Zero exhaust emissions—EVs do not produce any exhaust emissions during operation.
- Reduced noise pollution—As EVs generate no propulsion noise, these vehicles are very quiet at low speeds (usually below 30 km/h).
- Increased independence from fossil fuels—A variety of resources can produce electricity, including renewable sources (solar, wind, geothermal heat, water).
- Reduced GHG emissions—EVs can help mitigate the effects of climate change. This potential is highest if the electricity comes from renewable sources.

Technical and Financial Considerations

High prices, and immature supporting infrastructure and service facilities, are currently stopping the taxi industry from using EVs. Local governments need to actively improve the framework conditions for electric taxis and encourage taxi operators to use them. Due to charging requirements, the daily operating time of electric taxis is usually lower than regular taxis. In addition, the limited battery capacity causes electric taxis to lose some long-distance customers. As EVs may need up to 8 hours to fully charge, this can be problematic for taxi drivers and businesses as they might needed a vehicle to operate 24 hours a day, or according to unpredictable schedules. With taxi drivers only earning money when the vehicle is being used, and because EVs have a limited range, EVs may not be for them. To minimize these disadvantages, it is important to create a good network of quick-charging points. Swapping batteries can also reduce the problem of long charging times, and taxi operators can use the method if their electric taxi fleet consists only of a specific model, or models using the same batteries. Innovative business models can reduce up-front costs for taxi operators. For instance, several vehicle manufacturers can offer the option to buy the vehicle and rent or lease the battery. A third party can also function as a battery provider. This business model is recommended especially in the case of battery swapping.

Policy/Legislation

Local governments can support electric taxis by providing financial incentives such as subsidies or low-cost loans for investments in vehicles or infrastructure. They also need to coordinate the development of charging infrastructure. In China, for example, due to its franchise system for the taxi industry in cities, local governments have a strong control over taxi operations. Initially, cities can also reduce charges or introduce free licenses for electric taxis. Operating taxis in certain areas, which are very sensitive to noise or local air pollution, can be restricted to electric taxis. In the long term, licenses might be only attributed to EVs.

Institutions

In addition to the traditional taxi industry, vehicle manufacturers and charging infrastructure providers can be important stakeholders in introducing a local electric taxi fleet. Vehicle manufacturers might provide third-party funding for charging stations and service facilities, as taxis are an important market. Charging infrastructure operators might function as battery providers in a battery-renting system. Taxi drivers and service staff should be trained in handling EVs.

Case Study

Singapore's Electric Taxi

Context

The city of Singapore in southeast Asia has a growing population and is experiencing related transport issues, such as pollution, noise, and congestion. Many people use the public transport system, while some trips need to be flexible and done individually with one of the 27,700 taxis in the city. Some 15% of all trips in Singapore are by taxi.

In Action

Electric taxis in Singapore need a flexible charging time because the vehicles need to be available for 24 hours. They also need to provide air-conditioning, which does not consume additional energy that limits the distance vehicles can travel. New electric models can have a range of up to 350 km and manufacturers have reduced the charging time to only 90 minutes. However, more data on real-life conditions is needed to properly assess how the EV fleet is operating.

Results

More EVs will force the government in Singapore to develop and expand the EV charging infrastructure quicker. Developing an electric taxi fleet will also generate more data that can improve the production of electric taxis, and improve urban infrastructure and consumer behavior.

Solution

LPG/CNG Taxis

In Brief

A number of cities have introduced taxis that run on compressed natural gas (CNG) or liquefied petroleum gas (LPG) instead of conventional petrol or diesel, as they reduce air pollution and noise. However, the CO_2 benefits vary and emissions may be even higher than an efficient diesel-powered vehicle.

Examples

In Delhi and Ahmedabad (India), air quality problems forced the city to convert taxis and auto-rickshaws to run on CNG. As part of the process, Ahmedabad ensured that there was an adequate CNG supply and number of filling stations, and made conversion kits for vehicles available. In addition, the city offered financial incentives to rickshaw drivers

along with soft loans. Similarly, Madrid (Spain) has installed CNG/LPG refueling stations and provided grants to taxi drivers to convert their vehicles. Italy and Poland have the highest market share of CNG vehicles in Europe, and are the most important markets for LPG vehicles. Germany and Spain have the most CNG vehicles.

Results

CNG/LPG vehicles are as reliable as conventional diesel vehicles. However, compared to a diesel engine, CNG/LPG engines must be larger to have the same power. New technologies have minimized previous problems with sparkplug leads and fuel regulators. The newer the technology, the better the results of the fuel economy—which can be as much as 10%–15% lower than diesel. Although the maintenance costs for CNG/LPG vehicles can be higher, they will continuously improve with further research. Emission rates have been shown to be significantly lower with CNG/LPG vehicles: carbon monoxide is 75% lower, nitrogen oxides 49% lower, hydrocarbons and nonmethane hydrocarbons 4% lower, and carbon dioxide 7% lower.

Technical and Financial Considerations

Favorable taxes can help sales of CNG/LPG vehicles. However, the effect will likely be short-lived, with sales returning to normal once the measures are removed. The costs of CNG/LPG vehicles also depend considerably on the models and price policies of the individual manufacturers. The financial gain for costumers depends heavily on future environmental policies and CO_2 emission targets. This is the case of the Euro 6 emission standard from 2015 onward, where vehicles have to pass stricter exhaust emission (especially nitrogen oxide, NO_x) controls, incurring possible additional costs for conventional diesel vehicles. One technical consideration is the limited availability of fueling station infrastructure, which is an inconvenience for drivers. Investing in better infrastructure is necessary to encourage CNG/LPG vehicles. To foster the introduction of CNG/LPG in local taxi fleets, cities should consider a combination of different instruments, such as financial incentives for the vehicles/fuels (e.g., in the form of subsidies, loans for vehicle conversion, and tax rebates), providing sufficient refueling stations, and restricting conventional taxis. Loans can help vehicles or fleet owners to bear the initial conversion cost of switching to CNG/LPG. Sufficient refueling infrastructure is key for the measure's success; this can be installed through PPPs to limit the cost to municipalities.

Policy/Legislation

Germany, for example, subsidizes CNG/LPG by not applying mineral oil tax to it. Studies show that CNG/LPG vehicles are cost-competitive

when subject to energy tax benefits. Even though the German government is subsidizing CNG/LPG vehicles, they currently account for only around 1% of vehicles in Germany, according to the German Federal Motor Transport Authority. Of LPG cars in use in Germany, most are conventional diesel cars converted to LPG, while newly produced cars are mainly CNG-powered. Experts predict that sales will decline after 2018 when subsidies are withdrawn. The competitiveness of CNG/LPG vehicles is reliant on extending the driving range of vehicles and improving fueling station infrastructure.

Case Study

Converting Delhi's Auto-Rickshaws to CNG (India)

Context

According to the WHO, Delhi is the most polluted city in the world, with an annual average PM2.5 level of 153 $\mu g/m^3$, 15 times the recommended average of 10 $\mu g/m^3$. While there are many nontransport sources of this pollution (e.g., crop burning in surrounding areas, festival fireworks), transport, and particularly diesel vehicles, contributes up to 23% of this pollution. While natural gas consumption in the Indian transport sector was around 2% in 2010, this is expected to increase in the future. Out of about 60,000 taxis in India's capital, Delhi, 27,000 still run on conventional diesel, which has been officially banned in the country since May 2016.

In Action

In a bid to address smog and other problems, in 1998 India's Supreme Court ruled that commercial passenger vehicles must operate on CNG. The deadline for compliance had been extended several times, but the ruling was finally enforced from April 2016. Auto-rickshaws (three-wheeled small vehicles, also known as tuk-tuks), ran on either two-stroke petrol or diesel engines. In 2002, the Delhi municipal government banned diesel- or petrol-powered rickshaws. A 1997 Supreme Court decision capped their numbers at 55,000, but that cap has since been increased by 45,000. The government of Delhi also subsidized a loan package, which allows taxi owners to convert their vehicles into CNG vehicles.

Results

Most Delhi auto-rickshaws are now CNG-powered. The 55,000 auto-rickshaws were not enough to meet demand, and the use of private cars and car-taxis (often diesel-powered) has soared, with negative

consequences for congestion, road safety, and environmental factors, as CNG-powered rickshaws are smaller, lighter, and cleaner (assuming the same engine type) than cars.

Solution

Fuel Economy Standards

In Brief

Fuel economy standards, or variants such as CO_2 emissions standards, aim to improve the fuel economy (and thus the emissions) of vehicles on a per-kilometer basis by imposing an upper limit on vehicles at the point of purchase. For policy-makers, the key benefit of fuel economy standards compared to other mechanisms is the need to deal with only a relatively small number of car manufacturers, whereas other policies usually target a vast number of individuals.

Examples

Various types of vehicle standards have been implemented around the world. Japan introduced standards based on the fuel consumption per distance traveled, while the European Union adopted standards based on CO_2 emissions per kilometer traveled. In the United States, California's standard considers all GHG emissions. Another option is to implement vehicle standards based on the energy use (MJ/km) of the vehicle (Creutzig, 2016). Even though different standards are based on the same objectives, their design can lead to different effects. Fuel efficiency standards for car manufacturers aim to ensure a supply of efficient vehicles and thus reduce overall fuel consumption. Standards based on fuel volume (per distance driven) may exclude alternative fuels such as electricity. A standard based on energy intensity allows the inclusion of alternative fuels, but similar to a standard based on volume of fuel, different fuels' GHG intensities are not accounted for. In this case, the standard must differentiate between fuels. Establishing GHG emission standards directly limits new vehicles' exhaust GHG emissions, including CO_2, along with the whole suite of GHG emissions from the rest of the vehicle, such as refrigerants from the air-conditioning system and other powerful GHG gasses.

Results

While vehicle efficiency standards improve average vehicle efficiency over the medium- to long-term, system-wide efficiency improvements are modest. For example, the EU voluntary agreement

improved average light-vehicle fleet fuel economy by about 10% between 1996 and 2008. However, in the same period, total passenger-car CO_2 emissions fell by only 4%, indicating a substantial rebound effect. Ambitious limits will accelerate technological innovation, as adopting advanced technologies will be required to meet the targets. Setting long-term targets also offers certainty to vehicle manufacturers; crucial for them to make investments in new technologies.

Technical and Financial Considerations

The interplay of various organizations is important for the success of a fuel economy standard. National and international organizations with relevant expertise should provide technical advice. A baseline must be established first, which requires significant financial and technical resources. It is advisable to work within a network to profit from the expertise of other countries and cities.

Institutions

Fuel economy standards are typically handled as an aspect of vehicle homologation and will be handled by the body responsible for homologation normally at a national level. EU countries are one exception, as the EU itself handles vehicle homologation. Similarly, countries may simply apply other countries' standards, or share them across countries, in which case the specifics would need to be examined to determine the agency responsible.

Transferability

As the policy will usually be applied at a national level, a body (e.g., a city) wishing to introduce such policies must have influence with the responsible agency. Given the complexity in setting the limits described in "Technical and financial considerations" above, the policy's transferability is limited to countries with the technical and financial resources to set sensible limits. Smaller countries, especially without local manufacturing capacities, should align themselves with international standards to ensure a ready and reasonably priced supply of vehicles.

Case Study

Chile's Policies on Fuel Efficiency

Context

Chile has a history of improving of policies related to fuel efficiency, especially since developing a center for vehicle control (3CV) in the late 1990s and prohibiting the import of used vehicles into the country.

Recent regulations and improvements include a vehicle labeling system for low-duty vehicles (2010), a feebate system for car purchases (2014), tax reform (2014), developing a rebate scheme to renovate taxi fleets, and future plans to broaden the scope of the labeling system.

In Action

Chile has compiled relevant data of vehicle efficiencies that makes it possible to develop suitable policies according to the country's needs. The Centro Mario Molina Chile (CMMCh) has produced a thorough methodology for assessing a baseline on emissions and basic data for existing fleets in Chile. It projects that vehicle fuel efficiency will improve in the medium term and achieve the 2050 goal of 50% reductions. However, the country has room for improving the implementation of complementary measures, such as travel demand management (pricing, regulatory policies aimed at excessive travel in motorized vehicles), fleet renovation (and scrappage) schemes, improving public transport services, creating policies for nonmotorized transport, and other policies that are not directly related to fuel efficiency but to transport as a whole.

Results

The overall result of the implementation of fuel economy standards is to reduce GHG emissions. Because of adopted policies, consumer behavior and awareness changes among drivers. This is important for customer purchasing behavior, but also vehicle use, which in combination are aimed to substantially reduce CO_2 emissions.

Solution

Promoting EVs

In Brief

Gasoline- or diesel-powered vehicles cause severe problems. They pollute the air, emit GHGs, produce noise, and consume increasingly expensive fossil fuels. EVs are a promising alternative that can address these problems and contribute to a sustainable transport system. Cities can actively promote EVs among private companies and individual vehicle owners and encourage them to replace their diesel or gasoline vehicles with electric ones. A holistic strategy that informs and promotes EVs, rather than less successful standalone activities, is key to driving this change.

Examples

The solution consists of two main elements. First is creating an organizational and administrative framework for developing and implementing an e-mobility strategy. Dedicated working groups and roundtables can help municipal departments work together and coordinate with e-mobility stakeholders (such as electricity suppliers, car-park operators, and car manufacturers). A local e-mobility strategy and related action plans are important to conduct coherent promotional activities. Second, cities should implement specific measures. Cities around the world have tested different policies and measures to entice the public and companies into embracing EVs. These include:

- Introducing reduced or free parking for EVs, as in Oslo (Norway).
- Exempting EVs from congestion charges or city tolls, as in London (United Kingdom).
- Giving EVs access to lanes reserved for cars with a driver and one or more passengers, as in California (United States).
- Providing subsidies or low-cost loans for EVs, as in Hangzhou (China).
- Organizing test rides and promotional events, as in Hannover (Germany).
- Offering EVs in car-sharing schemes, as in Barcelona (Spain).

In addition, cities must address the need for charging infrastructure. Even though private stakeholders usually install and operate charging infrastructure, municipalities can accelerate the process by organizing working groups that bring together relevant stakeholders. The city can provide parking lots for public charging facilities and recommend that developers consider charging infrastructure for new buildings.

Results

EVs offer several advantages compared to gasoline or diesel vehicles:

- Zero exhaust emissions—EVs do not produce any exhaust emissions during operation.
- Reduced noise pollution—As EVs generate no propulsion noise, these vehicles are very silent at low speeds (usually below 30 km/h).
- Increased independence from fossil fuels—A variety of resources can produce electricity, including renewable sources (solar, wind, geothermal heat, water).
- Reduced GHG emissions—EVs can help mitigate the effects of climate change.

This potential is highest if the electricity comes from renewable sources. However, simply replacing a conventional vehicle with an

electric one does not address wider transport problems such as congestion, traffic safety, and the extensive use of land for parking and roads. Therefore, cities should integrate an e-mobility strategy into a wider system of sustainable mobility.

Technical and Financial Considerations

Advanced battery EVs are relatively new and the technology is still developing. Due to the limited distances EVs can travel, charging requirements, and the limited number of available models, EVs might not fulfill the needs of all vehicle owners. However, EVs are suitable, for instance, as delivery vehicles or service vehicles, especially in urban areas. Today, an EV usually costs more than a conventional vehicle. However, EVs cost less to operate and to maintain. The cost efficiency of an EV also depends on the local framework conditions—such as fuel/energy prices, taxes, subsidies—and how much the vehicle travels a year. Company cars usually travel a lot, so EVs offer organizations lower total costs of ownership than conventional vehicles. A city should carefully assess the potential negative side effects of promoting EVs. For instance, opening bus lanes to EVs can affect bus services, and free parking for EVs can encourage people to stop using public transport (and from walking and cycling) to drive personal cars. Therefore, cities should align promoting EVs with wider urban mobility objectives. For example, replacing gasoline-powered cars with electric two-wheelers provides even stronger benefits than a one-to-one substitution.

Policy/Legislation

The best local activities link to national or regional schemes for promoting EVs. In some cases, a respective national legislative framework is required to implement policies for promoting EVs locally. To grant privileges to EVs they also have to be easily recognized; in Germany, the 2015 Electromobility Act introduced a registration sticker for EVs. The Act also sets the legislative framework for cities to offer privileges such as lower parking fees, the use of bus lanes or allowing them into areas where regular traffic is restricted. However, cities are responsible for implementing the privileges. Tax incentives (such as annual vehicle and fuel taxes) or subsidies for clean vehicles provided by the national government also influence the success of local EV promotional measures.

In addition, a strong national framework on norms and standards for EVs and related technologies is required for large-scale roll out. This links to vehicle and charging technology, and to the data and accounting interoperability of charging providers.

Transferability

This solution is replicable in other cities. Cities should carefully select individual measures for promoting EVs based on their local circumstances and national framework conditions. The amount of GHGs that cities can cut also depends on how much carbon local electricity providers emit. The benefits of reducing local air pollutants from vehicle tailpipe emissions are transferable across cities and countries. Replicating specific measures to provide privileges for EVs might not be possible in some cities due to the lack of a national legislative framework. Socioeconomic and cultural factors, such as people's purchasing power and their environmental awareness, can also influence the success of the measure.

Case Study

Promoting EVs in Barcelona (Spain)

Context

Barcelona is the second-largest city in Spain, with about 1.6 million inhabitants. In Barcelona, public transport has a modal share of 40%, private transport accounts for 27%, and nonmotorized modes for 33%. Barcelona decided to promote EVs to reduce emissions and noise, to lower the dependency on oil, and to improve living conditions and public health. About 30% of the Spanish automotive industry is located in the metropolitan area of Barcelona. The city sees e-mobility as an option to provide opportunities for technical and economic development and to ensure the global competitiveness of the car industry. The new SUMP of Barcelona includes, as one of the main strategies, the promotion of e-mobility. Spain's national government supports EVs with direct purchase subsidies and tax deductions.

In Action

Barcelona implemented several measures to promote EVs in the private sector. In 2009, it created the LIVE platform—a PPP to coordinate, monitor, and communicate e-mobility activities in Barcelona and the surrounding area. The platform is led by Barcelona City Council, the AMB (the public administration of the metropolitan area of Barcelona), and the Government of Catalonia, and is open to all private entities with an interest in e-mobility. The LIVE platform coordinates the e-mobility plans of various levels of government, spreads information, and raises awareness among companies. In 2014, it had a budget of €164,000 to carry out its activities. Five working

groups within LIVE holistically address e-mobility: (1) Knowledge and Communication; (2) Legal Framework; (3) Fleets and Test Beds; (4) Infrastructure and Energy; and (5) Industrial Transformation and Innovation.

LIVE actively supports policies and projects to promote e-mobility and supports new start-ups offering EV products and services. It also provides subsidies for charging infrastructure (€2000 per plug for on-street stations and €1000 for off-street stations) and works with private stakeholders to install infrastructure in hotels or shopping centers. Furthermore, the city provides tax deductions and free parking for all-EVs. In new public car parks, 2% of the spaces are reserved for EVs. The platform also developed a guide for current and potential EV users, and it operates an EV helpdesk. With LIVE's support, Barcelona introduced a flexible electric motorbike-sharing system, which residents and visitors can use. An additional scheme allows visitors to rent electric motorbikes at their hotels. It also developed specific charging stations for electric two-wheelers.

Results

Due to its e-mobility activities, many around the world recognize Barcelona as a city that has embraced EVs. The city has about 250 charging points, of which about 130 are for electric motorbikes. Catalonia has about 1000 charging stations and the region is seeing increasing registrations of EVs; in 2015 it registered 663. About 15 start-ups formed, offering e-mobility products and services. The LIVE platform is an effective system of governance that promotes e-mobility in the city.

Solution

Electric Vehicles in Municipal Fleets

In Brief

Gasoline- or diesel-powered vehicles cause severe problems. They pollute the air, emit GHGs, produce noise, and consume increasingly expensive fossil fuels. EVs are a promising alternative that can address these problems and contribute to a sustainable transport system. Municipalities can encourage the use of cleaner vehicles through the way they manage their own fleets, specifically by introducing clean vehicles in the fleets of the municipality and municipal enterprises. This requires energy efficiency and environmental performance to be considered for vehicle purchases.

Examples

Cities can use EVs for collecting waste, cleaning streets, and other local authority services. Vehicles in these fleets are very suitable for battery electric drive systems because their operational range is usually limited and many of them are running on fixed routes. Furthermore, these vehicles are often parked in larger vehicle depots, so that charging infrastructure can be concentrated. Energy savings and emission reductions of EVs are particularly high in driving cycles with frequent stops and short distances.

Results

EVs offer several advantages compared to gasoline or diesel vehicles:

- Zero exhaust emissions—EVs do not produce any exhaust emissions during operation.
- Reduced noise pollution—As EVs generate no propulsion noise, these vehicles are very quiet at low speeds (usually below 30 km/h).
- Increased independence from fossil fuels—A variety of resources can produce electricity, including renewable sources (solar, wind, geothermal heat, water).
- Reduced GHG emissions—EVs can help mitigate the effects of climate change.

This potential is highest if the electricity comes from renewable sources. By increasing the number of EVs in its fleet, a municipality can serve as role model for private enterprises, and by demonstrating the applicability of clean vehicles, the city can share its experience with new vehicle technologies. Besides reducing emissions, the operation of cleaner vehicles can also result in long-term cost savings.

Technical and Financial Considerations

Despite subsidies, investment costs for EVs can be higher than for conventional vehicles. However, due to lower operating and maintenance costs, the total costs of ownership can be lower than for conventional vehicles. If electricity from city-owned renewable energy systems is used, economic and environmental benefits are even higher. The number of available EV types and models is rapidly increasing, however, for special-purpose vehicles, it might be necessary to convert from a combustion engine to an electric drive system or coordinate with manufacturers for custom-built vehicles. To select the optimal technology in terms of drive system (e.g., hybrid vs all-electric), battery size, and charging strategy, municipalities must consider the operation purpose, the vehicle type, and typical usage patterns. As a first step, a city should analyze its existing fleet according to driving distances, the times when

the vehicles are not being used, and operational purposes. Based on this, cities can identify vehicles that are suitable to be substituted with electric ones, and charging infrastructure requirements. External experts can assist municipal fleet managers in this task and provide detailed planning and cost comparisons of different vehicles. Existing fleet management systems and routing might need to be adapted to account for charging requirements. Ideally, drivers and service staff should receive training to ensure they can properly handle the EVs. Cities can also cooperate with car-sharing companies or leasing companies to reduce procurement and maintenance costs. EVs used by the municipality can be made available during weekends or evenings to municipal employees or the public (e.g., in car-sharing schemes) to promote EVs among the public.

Policy/Legislation

Municipal procurement guidelines may oblige departments and municipal enterprises to purchase fuel-efficient, low-emission vehicles. Especially where municipal enterprises operate local public transport, waste collection, or street cleaning services, procurement guidelines are applied to large vehicle fleets. An accounting system structured so that long-term savings remain with the investing department can increase the ambition to use clean and fuel-efficient vehicles. This is especially important, as investment costs for fuel-efficient or alternatively fueled vehicles can be higher than for conventional vehicles. To avoid investment costs, alternatively, municipalities can substitute their vehicles for alternatively fueled car-sharing vehicles.

Case Study

Rotterdam's Municipal EV Fleet (Netherlands)

Context

The city of Rotterdam is the second-largest city in the Netherlands and has about 620,000 inhabitants. The city set a target to achieve a 25% share of electric or hybrid EVs in the municipal fleet by 2014 to be a role model for inhabitants and other cities.

In Action

The city, in cooperation with two private companies—a local energy supplier and a grid operator—launched a trial with a total of 75 EVs and plug-in EVs and 100 drivers in 2012 and 2013. The city used the cars in the carpool of the companies and the municipality. These consisted mainly of passenger cars and light-delivery vehicles. Rotterdam

also installed 120 charging stations. The trial monitored the technical performance of the vehicles, and conducted surveys with the test drivers. The project was promoted at events, through brochures and a dedicated website. The city shared the lessons it learned with other professional fleet owners. Based on the experience during the trial, Rotterdam concluded that fully EVs could replace 60% of the cars owned by the city. The two local energy suppliers who participated in the trial had larger range requirements, thus only 18% and 27% of their fleets were suitable to be replaced by EVs.

Results

Rotterdam says that the EVs drove more than 700,000 km during the trial. This cut the amount of CO_2 the city's vehicles emitted by 67% and particulate matter emissions by 10%. The trial also meant that the city completely stopped emitting NO_x. This calculation considered well-to-wheel emissions and the Dutch energy mix. During the trial, the city gained extensive knowledge regarding the use of EVs, safety, energy consumption, impact on the environment, and effects on the electricity grid.

Solution

Infrastructure for Clean Vehicles

In Brief

When countries plan to introduce alternative fuels for vehicles, this also usually involves building additional infrastructure such as CNG refueling stations or EV charging stations. By providing support for installing of refueling/charging stations, a city can reduce the barriers for adopting alternative fuels/energy carriers.

Examples

A city can install its own charging facilities or provide the necessary land. Several cities in Europe foster the adoption of EVs by supporting the installation of charging facilities. Rotterdam (the Netherlands), for instance, offered subsidies for charging stations and installed charging facilities on public ground. London (United Kingdom) has done the same. CNG infrastructure for buses can be shared with private vehicles and municipal fleets under some conditions. Closely cooperating with electricity suppliers or car dealers can speed up the installation of recharging/refueling facilities. Stockholm (Sweden) and Lille (France) had similar experiences with biogas fuel stations.

Results

A network of refueling or charging infrastructure is essential for using alternative fuels. It can reduce the anxiety of potential EV users who worry about how far they can travel, and thus positively influence purchasing decisions.

Technical and Financial Considerations

To plan a charging network, the current and future demand needs to be assessed first. The assessment considers local market size forecasts for different fuels/technologies, vehicle developments (e.g., in terms of range), different usage models, and target groups. Studies show that private EV users usually charge their vehicle at home or at work. However, logistic companies, taxi operators, and public transport operators have specific requirements, which should be accounted for by involving them in the needs assessment. Even though some operators might install their own private charging infrastructure, they might need space in the public area provided by the city. Rapid direct current (DC) charging stations should be mainly built in public parking lots, on streets, and in other public places. Conventional alternative current (AC) charging stations should be installed in the parking lots of residential areas, business buildings, enterprises, and public institutions. AC charging stations have significantly lower investment costs compared to DC charging stations. The most fundamental need of consumers who intend to buy EVs is not only that charging infrastructure is available, but also that is also compatible to their EV. The harmonization and interoperability of charging facilities has different dimensions:

- the physical format of the socket and the plug at the vehicle and the charging station;
- the digital communication protocol between the battery management system of the car and the charger (proper communication with the battery's power level ensures safe charging); and
- financial interoperability between different charging station providers, in terms of payment and membership.

ID system

- Harmonized information—Real-time information about the location and availability of all charging stations is provided to the user (e.g., via integration on an IT platform). The planning of EV charging stations should fully consider the current status of regional power transmission and distribution networks, as charging stations can have a strong effect on the local electricity grid. Supply security of CNG or biogas is needed for reliable operation of the gas refueling infrastructure.

Policy/Legislation

In general, a city can steer the installation of charging infrastructure by allocating or leasing reasonably priced land to charging infrastructure providers and by linking subsidies for charging infrastructure to the adherence of the municipal charging infrastructure plan. Besides subsidies and favorable tax policies, cities need to establish a supportive regulative framework and should enhance the cooperation among relevant stakeholders, such as property management authorities, electricity and/or fuel providers, and charging infrastructure operators. The requirement of building permits for on-street charging points can ensure that they do not obstruct traffic (both motorized and nonmotorized) or rescue routes, and guarantee the location is accessible and in line with the development plan. To ensure that public charging stations are accessible for charging, parking needs to be restricted to EVs with an active charging process. The municipal traffic office has to install no-parking signs.

Institutions

Private or state-owned companies or individual vehicle owners usually install and operate charging infrastructure. However, there is still limited interest in EV charging infrastructure by private stakeholders because of the low number of EVs. As EV charging infrastructure costs are high and business models for providing public charging infrastructure are often not yet profitable, cities need to actively promote the installation of charging infrastructure. Besides subsidies and favorable tax policies, cities need to establish a supportive regulative framework and should enhance cooperation among relevant stakeholders such as property management authorities, electricity providers, and charging infrastructure operators.

Transferability

Many cities around the world support the use of clean vehicles by ensuring that respective charging/refueling infrastructure is available. Their experience can be transferred to other cities taking local context conditions into account. The willingness of the private sector to invest in refueling/charging infrastructure depends, among others, on the number of clean vehicles in operation. National incentives and regulations for the market development of clean vehicles and respective infrastructure can act as supportive factors.

The CO_2 mitigation potential of CNG or EVs compared to diesel or petrol vehicles depends on the gas supply structure (e.g., transport energy, leakage, share of biogas) and on the GHG intensity of the electricity mix (e.g., influenced by share of renewable and carbon-intensive

fossil sources), respectively. However, benefits to the urban environment and public health from the reduction of local air pollutants from vehicle tailpipe emissions are independent from the location and thus transferable across cities and countries.

Case Study

Developing EV Charging Infrastructure in Rotterdam (Netherlands)

Context

In the Netherlands, the national government provides strong fiscal incentives for EVs. The city of Rotterdam is the second largest in the Netherlands, with about 620,000 inhabitants. The city aims to reduce its CO_2 emissions by 50% by 2025 compared to 1990 levels and to improve the local air quality. To achieve this, the city among others strongly supports the use of EVs.

In Action

Rotterdam provides support for the initial installation of public and private charging stations. Companies or individual owners of EVs usually parked on private grounds can receive a subsidy of up to €1000 for the installation of a charging station on their property. If they use renewable electricity, the city also reimburses the energy costs during the first year. EV owners without private parking facilities can apply to have a public charging station provided by the municipality in the close vicinity. To foster the installation of charging facilities in parking garages, the city published a manual providing guidance on charging infrastructure installation in car parks.

Results

Rotterdam was the first city in the Netherlands that started installing charging infrastructure in 2011. At the end of 2014, 1367 charging points were already established in the greater Rotterdam area. The city plans to increase its charging network event further. In cooperation with municipalities in the surrounding areas, Rotterdam plans to install an additional 4000 charging points in the region, of which 1800 will be located in the city.