Reducing Carbon Emissions through Transport Demand Management Strategies

A review of international examples

Final report

On behalf of

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

TRC 北京交通发展研究中心 Beijing Transportation Research Center

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Layout: Andrej Sosedow

Beijing, 30/06/2012

The Project Context

China's economic growth over the past three decades has had some undeniably positive effects on the country's development but it has also led to a massive increase in motor vehicle travel and associated traffic problems, especially in large cities. In Beijing, over five million cars cause severe local air pollution and traffic congestion as well as increasing parking problems and accident costs.

Transportation GHG emissions have become a key challenge for sustainable development in China and globally. Neither roadway expansion nor the development of new car technologies alone can solve these problems; in fact, these strategies often reduce one problem but aggravate others. Transport demand management (TDM) offers truly sustainable solutions which will help in achieving multiple planning objectives.

The aim of this project is to build capacities and competencies to enable Beijing municipal authorities to quantify and model the impact and benefits of various TDM strategies. This will help officials in Beijing and other major urban centers in China identify and implement the most effective and beneficial set of TDM measures.

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the Beijing Transportation Research Center (BTRC) are the implementing partners. GIZ is a global service provider in the field of international cooperation and professional training for sustainable development. BTRC's mission is to conduct systematic research on transport development strategies for policies and planning in Beijing and to present recommendations on these measures and action plans to the People's Municipal Government of Beijing.

The project is supported by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Beijing Municipal Commission for Transportation (BMCT).

In order to achieve the aims, the project is organized along three work streams

- Work Stream 1: TDM Policies and Measures – BTRC and GIZ cooperate to identify at least three TDM measures for GHG reduction in Beijing and learn from Chinese and international best practice
- Work Stream 2: Emission Scenarios, Modelling and Monitoring – A monitoring system for GHG emissions will be developed
- Work Stream 3: Dissemination – Measures and tools will be discussed with and disseminated to at least 5 other Chinese cities

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1 On the Pathway to a Low-Carbon City

Cities around the world are facing increasing environmental, social and economic challenges caused by inefficient urban transport systems, including excessive traffic congestion, road and parking facility costs, traffic accidents, consumer costs, energy dependence and pollution emissions, plus inadequate mobility for non-drivers. A key to solve these problems is to apply *transport demand management (TDM)* (also called *mobility management*) to increase overall transport system efficiency and create low-carbon cities.

Conventional transport planning solutions, such as expanding road infrastructure often have contradictory effects: purchase and use of cars – that usually drive long distances and have the highest emissions per kilometre travelled – is encouraged and subsequently greenhouse gas emissions are increasing rapidly. In contrast to that, innovative and effective transport demand management solutions help to achieve multiple planning objectives. Hence, they can ultimately reduce carbon emissions through reducing transport activity (vehicle kilometres travelled – VKT) and shifting people to less carbon-intensive modes of transport.

Chinese cities have committed themselves to increasing energy efficiency and reducing carbon emissions. In addition to traffic congestion, parking and accident problems, motor vehicle travel is a major energy consumer and pollution emitter, so transport policy reforms are important for achieving these goals. Chinese cities are now making policy and planning decisions that will determine the future efficiency of their transport systems: a combination of investments in alternative modes, pricing reforms, and smart growth land use policies can make Chinese cities world leaders in transport efficiency and emission reductions.

Based on the existing knowledge in China about TDM strategies, the aim of this report is to discuss the potential of TDM strategies to contribute to climate change mitigation and identify the most promising options for Chinese cities.

Learning from international best practice can help Chinese officials identify the most effective greenhouse gas emission reduction strategies. This report reviews a variety of policies and measures and evaluates their emission reduction potential. We recognize that the impacts and benefits of these TDM strategies can vary significantly depending on where and how they are implemented. It is important to adapt these approaches in response to local conditions and needs. Therefore the report focuses on success factors for successful policy formulation and implementation.

2 TDM Emission Reduction Strategies

Efficient cities require multi-modal transport systems which include walking, cycling, public transport, automobile travel[1], delivery services and telecommunications. Excessive automobile mode share reduces urban transport system efficiency by creating traffic and parking congestion, accident risk, pollution and has a negative effect on land use pattern and urban density. As a result, cities must limit motor vehicle travel to increase efficiency and enhance their liveability, a process called *transportation demand management* or *TDM*. The considerable co-benefits of sustainable transport Policies in Chinese cities include reduction of air pollution and congestion, traffic safety improvements of cyclists and pedestrians and improved reliability in bus service (Creutzig and He, 2009).

***TDM* is a general term for policies and programmes that increase transport system efficiency by changing travel behaviour, such as how, where and when people travel.**

Cities vary significantly in their energy efficiency, with far lower per capita energy consumption and climate change emissions in wealthy Asian cities such as Hong Kong, Singapore, Tokyo and Seoul than in European and North American cities, as indicated in Figure 1. These reflect differences in transport and land use policies, including the quality of transport options available, roadway design and management, fuel and parking prices, and land use development patterns (Kenworthy 2002). Even Asian cities can increase their energy efficiency with cost effective strategies (Böhler-Baedeker and Hüging 2012).

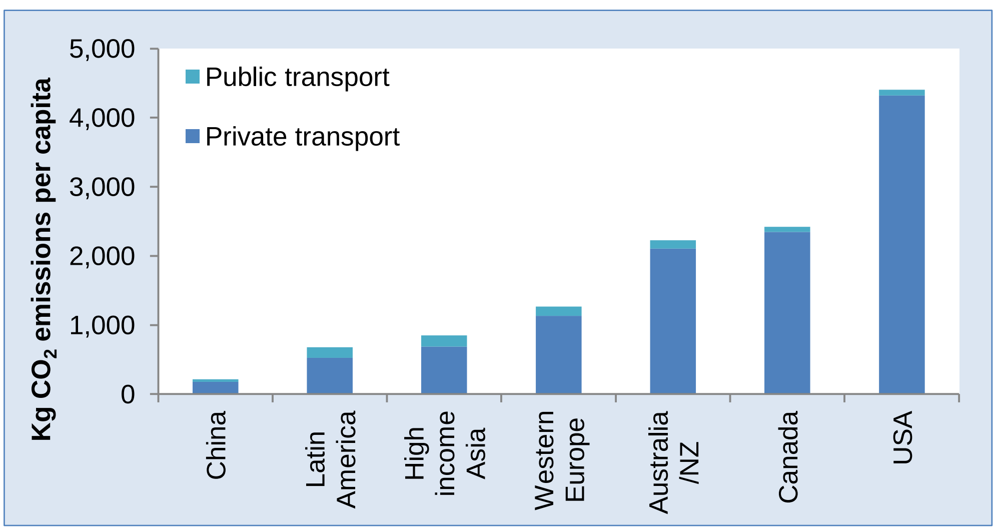


Figure 1: *Per capita transport carbon emissions* Source: Kenworthy, 2002

[1] In this report, *automobile* refers to any personal motor vehicle, including cars, light trucks, sport utility vehicles, motorcycles, and even small farm vehicles when used for personal travel.

As consumers become more affluent, their transport demands change: they tend to purchase more mobility, and higher quality transport services that provide more convenience, speed, reliability, comfort and amenities. This does not mean, however, that wealthy cities necessarily become automobile dependent. Cities that improve efficient transport options (walking, cycling and public transit), implement efficient pricing strategies, and have supportive land use policies can have efficient transport systems despite increasing incomes. As a matter of fact, some of the richest cites in the world have large shares of public and non-motorised transport, e.g. Zurich, Copenhagen, Vienna, and Amsterdam.

Figure 2 lists various types of TDM strategies that are further elaborated on in chapter 4. For further details on TDM strategies also see GIZ 2003-2011 and VTPI 2011.

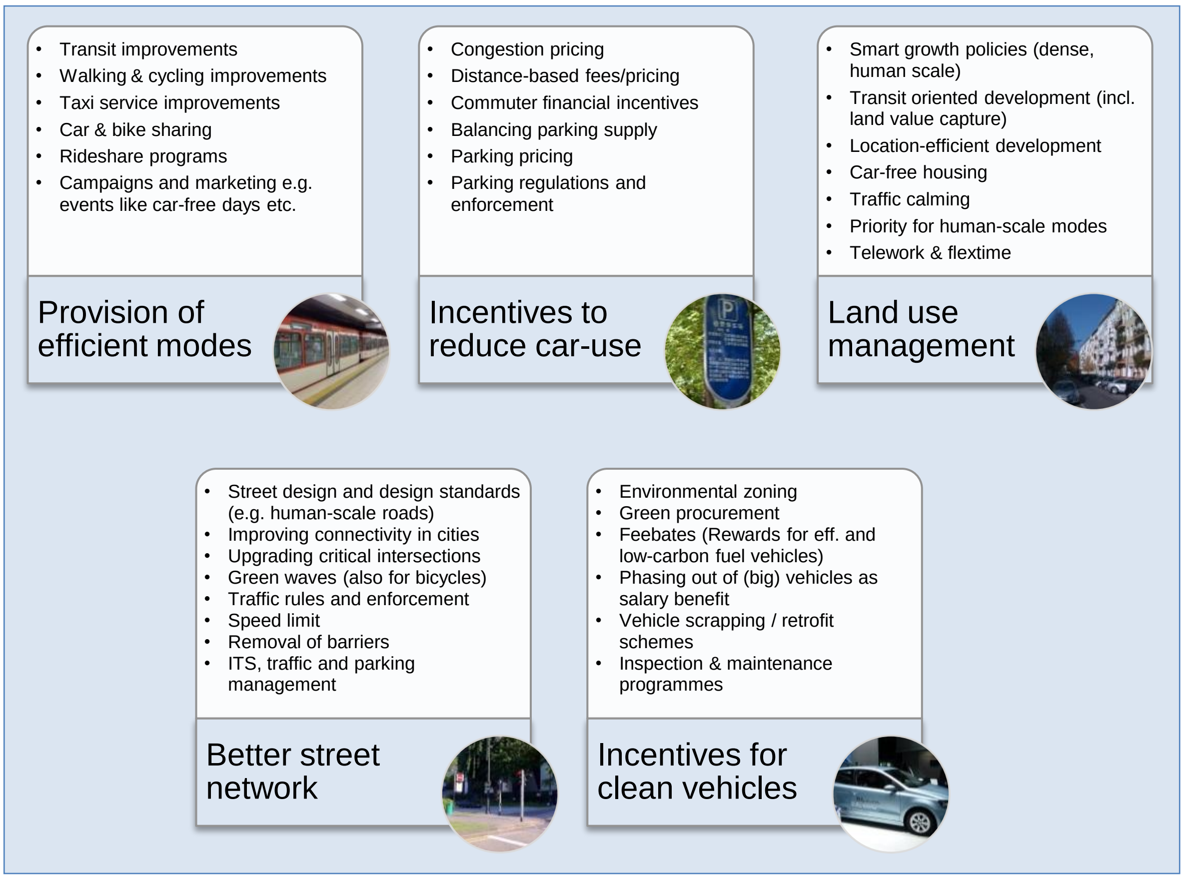


Figure 2: *Urban transport demand management strategies* Source: Own compilation

2.1 TDM Approaches from Measure to Strategy

Transportation demand management strategies tend to be most effective and acceptable if implemented as an integrated programme that includes both *pull* strategies (sometimes called *carrots*) and push strategies (sometimes called *sticks*). Only a well-integrated efficient transport system where modes are not only of high quality itself but integrated into a system has the potential to reduce GHG emissions and to achieve substantial co-benefits (economic development, improved quality of life, higher energy efficiency, reduced externalities).

"Push" strategies involve economic measures lowering the attractiveness of inefficient transport behaviour, i.e. price reforms while "Pull" strategies improve the attractiveness of efficient transport options, including walking, cycling, public transport, delivery services and telework. Transportation demand management strategies often have synergistic effects (implemented together, their total impacts are greater than the sum of their individual impacts). For example, improving public transit services in an area by itself may only reduce vehicle trips by 5%, and increasing parking prices may only reduce vehicle trips by 10%, but if implemented together they may reduce trips by 30% because they give travellers both incentives and disincentives to change their behaviour.

It is useful to implement TDM strategies as integrated programmes, that include a combination of "push" and "pull" incentives, such as road and parking space increases, that help finance walking, cycling and public transit improvements.

TDM strategies can also have indirect impacts. For example, improving public transit services, smart growth land use policies, and options such as carsharing (vehicle rental services that substitute for vehicle ownership) allow households to reduce their vehicle ownership, which leverages additional vehicle travel reductions (see figure 3). In a typical situation, 10-20% of commuters who shift from driving to public transit will reduce their household vehicle ownership, and these households will reduce thousands of annual non-commute vehicle-kilometres since they no longer have a vehicle sitting at home ready for use.

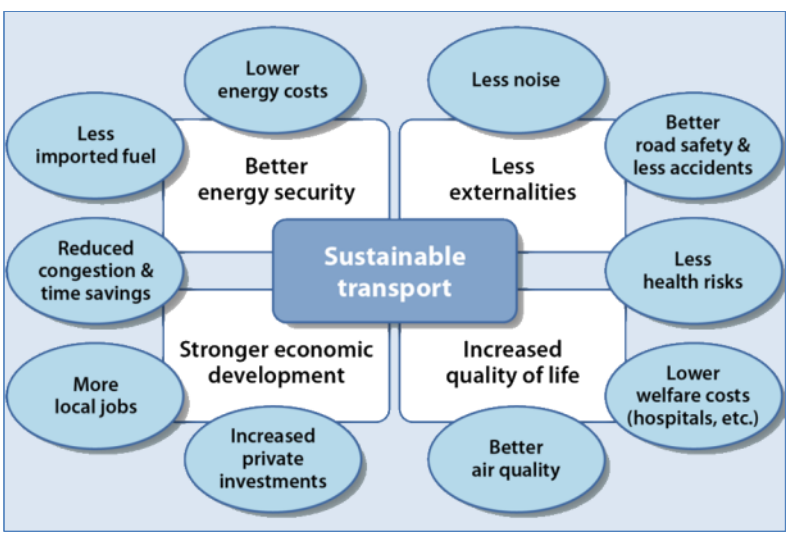


Figure 3: *Co-Benefits are often overlooked when assessing a TDM measure. Considering benefits such as a reduction in external costs, an improved life quality, economic development and energy security can justify TDM measures.*
Source: Böhler-Baedeker and Hüging, 2012 (adapted)

Conventional transport planning tends to overlook or undervalue many of these benefits and so tends to undervalue transportation demand management. For example, when evaluating a public transport improvement or pricing reform, transport planners often focus primarily on congestion reduction objectives and overlook co-benefits such as reduced parking problems, improved mobility for non-drivers, and reduced traffic accidents that result if commuters shift from driving to public transport. Similarly, when evaluating emission reduction strategies, environmental planners often focus on emission reductions and overlook co-benefits such as congestion reductions and consumer cost savings. In general, a more comprehensive analysis which considers a wider range of objectives and impacts, tends to justify more TDM strategies.

Special care is needed when applying these models in developing and emerging country conditions. Although average incomes may be low overall, car-owning households tend to be relatively wealthy and therefore less sensitive to prices. Travellers in developing country cities may face special deterrents to using alternative modes, including poor quality walking and cycling conditions, crowded and dirty public transit services, crime risk and social stigma. It is important to consider such factors when modelling impacts, evaluating benefits, and designing TDM programmes. This can help design strategies that are most effective and beneficial because they respond to consumer demands.

Picture 1: *If high quality, comfortable and well integrated non-motorised transport infrastructure is available, even more affluent road users shift to bicycles.*

Photo by Anja Wu, Cracow (Poland), 2009

2.2 The TDM Impact Chain on Carbon Emissions

Transport emission reduction can be quantified using the *ASIF* (Activity – Structure – Intensity – Fuels) framework, summarized in Table 1. Transportation demand management helps to achieve the first two objectives: it reduces total travel activity and shifts travel to less carbon intensive modes. This report focuses on these two aspects. Strategies that help achieve the second two categories (increase vehicle fuel economy and shift to less carbon intensive fuels), are called *clean vehicle technologies* because they reduce emission rates per vehicle-kilometre. All of these strategies can reduce climate change emissions. However, transportation demand management strategies tend to provide significant additional benefits, besides GHG emission reductions, often called *co-benefits*. These additional benefits should be considered when evaluating emission reduction strategies.

Table 1: *The ASIF framework*

Name	Description	Strategy examples
	Transportation demand management	
A – Reduce transport *activity*	Reduce the total amount of passenger- or ton-kilometres that occur.	Smart growth land use policies; transport pricing reforms
S – Change the modal *structure* of travel	Shift travel to less carbon-intensive modes (walking, cycling and public transport).	Improve walking, cycling and public transport. Transport pricing reforms
	Clean vehicle strategies	
I – Reduce the energy *intensity* of each mode	Increase the energy economy of each mode (less energy consumed per pkm/tkm).	Regulations or pricing incentives to encourage sales of more fuel efficient vehicles; fuel price increases
F – Reduce *fuel* carbon content	Shift to less carbon-intensive fuels, such as diesel and biogas.	Regulations or pricing incentives to encourage sales of alternative fuel vehicles Gasoline price increases

There are several steps between a TDM policy or programme, its travel impacts and the ultimate emission reduction. Figure 4 displays the logical framework of the impact chain from the policy design to the greenhouse gas reduction: A *policy change* intends to change *transport options and incentives*, e.g. better walking and cycling conditions, and increased fuel and parking prices. This subsequently leads to a change in individual preferences through an adjustment of

Clean Vehicle Strategies

Clean vehicle strategies are not evaluated in-depth in this report. However, transportation demand management complements cleaner vehicle strategies by minimizing rebound effects, which refers to the additional vehicle travel that results if more efficient or cheaper alternative fuelled vehicles reduce vehicle operating costs. For example, if regulations or pricing incentives cause a motorist to choose a 6-liter-per-100-kilometre vehicle instead of a 9-liter-per-100-kilometre, their fuel costs per kilometre will be a third lower, so they are likely to drive more annual kilometres. A typical motorist will drive about 12% more if their fuel costs decline by 33% (assuming a -0.4 price elasticity).

actual money spent on transportation and/or reduced travel time (decreased opportunity costs of time), or simply through improved convenience. Accordingly, a *change in travel patterns* (e.g. change in modes) occurs. Finally the sum of changes results in a *travel impact*. The travel impact then directly results in changes of *transport related emissions*.

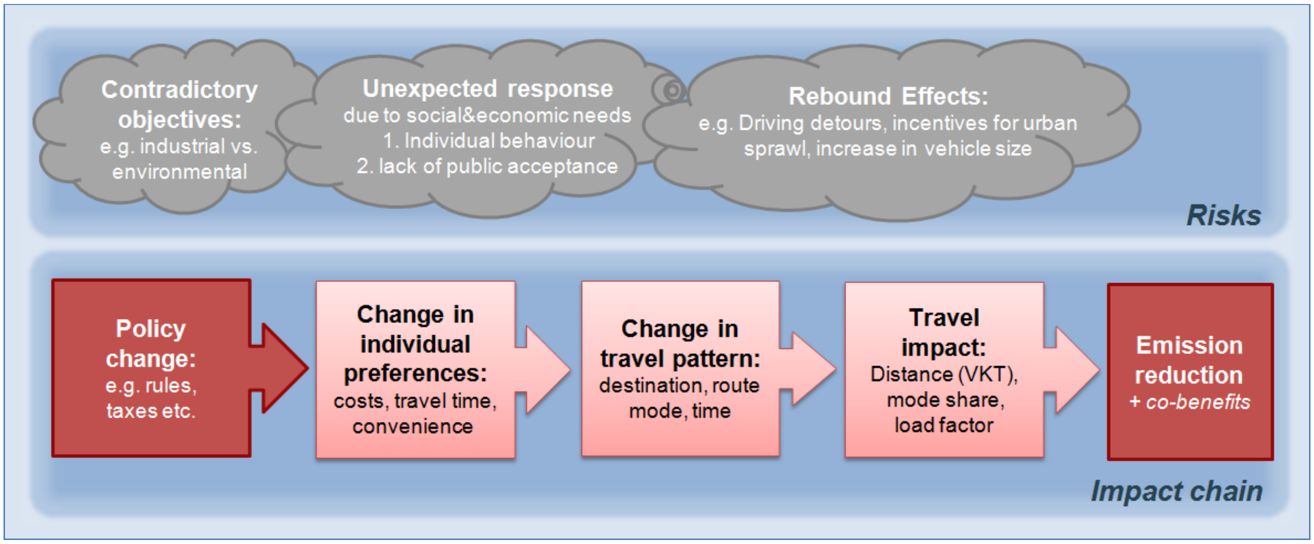


Figure 4: *The impact chain of TDM polices and measures on carbon emission reduction*

A policy's impacts and benefits are affected by local conditions, including geography, urban design, traffic conditions, economic factors, and community preferences. For example, non-motorised transport (walking and cycling) may be more difficult to promote in areas that are hilly, experience extreme weather, have heavy motor vehicle traffic, and where these modes are stigmatized. This does not mean that it is impossible to increase non-motorised transport in such areas, in fact, walking and cycling activity is increasing in cities around the world, but these obstacles should be addressed in program planning, for example, by introducing lighter bikes with multiple gears, building suitable walking and cycling facilities, improving motor vehicle traffic control, and promoting walking and cycling as healthy and enjoyable activities suitable for a modern lifestyle.

The underlying reason is that the effectiveness of policies is related to a sound adoption to local context: The details of policy formulation matter.

Several steps are usually required for effective *policy formulation*. The following describes these steps and common obstacles and risks that they must overcome.

1. It is best to begin with clearly defined goals (what you ultimately want to achieve, such as improved mobility or reduced air pollution) and objectives (specific ways to achieve goals, such as reducing vehicle traffic volumes and introducing cleaner (less polluting)

vehicles). Sometimes different government agencies have incompatible objectives, i.e. the Ministry of Environment and its agencies want to reduce total transport volume for environmental considerations while Ministries related to Industry and Economic development want to promote transport volume for economic reasons. The principal risk during policy formulation is that competitive planning of policies between agencies harm each other's success. It is therefore important to develop inter-agency cooperation in order to minimize conflicts and delays, and identify win-win policies that help achieve multiple objectives (such as TDM strategies that reduce traffic congestion and air pollution).

2. Transportation demand management policies, such as improvement of resource efficient modes, pricing reforms and smart growth land use policies influence the amount and type of travel people choose. These may include various types of travel changes. For example, public transit service improvements tend to attract travel from other modes to transit, while congestion pricing typically causes motorists to shift to other routes, travel time, modes and destinations. Some of these changes may be difficult to predict, and not all are beneficial. For example, some new passengers attracted to improved transit services may shift from non-motorised transport, which would consequently not reduce emissions. Similarly, converting a parking or traffic lane into a bus lane may raise political opposition if it is perceived as being underused or harmful to motorists. It is important to anticipate such problems and respond to them in policy design and communication with the public.

3. Some travel changes may lead to traffic rebound effects, meaning that less congestion attracts private vehicles and longer detours are made because areas are avoided.

4. Changes in travel pattern lead to travel impacts measured through reduced vehicle kilometres travelled, reduced modal share of private vehicles, increased modal share of non-motorised transport and public transport, and a higher occupancy rate in private and public vehicles. Rebound effects can reduce the impact on travel, for example, if the ability to telecommute allows some people to live further from their worksite, resulting in fewer but longer commute trips.

5. Different types of strategies have different types of travel impacts. The travel impact will consequently reduce emissions and has several other benefits such as increased mobility, time benefits, road safety and reduced congestion. The reduction of carbon emissions can be utilised as a valid proxy indicator for the overall impact of the strategy. If a policy reduces CO_2 emissions it can be regarded as successful as this implies that the positive travel impact was not outweighed by rebound effects.

3 Towards GHG Reduction: Review of Good Practice TDM

This section concentrates on the evaluation of case studies that successfully implemented the respective measures (see figure 5). The focus of the analysis is (a) the potential to change travel behaviour and reduce GHG emissions and (b) the success factors, why positive effects actually occur. The measures were chosen according to their emission reduction potential, covering both push and pull strategies and their relevance to Chinese cities (table 2). The following strategies are covered:

A) Supply of high-quality low carbon modes and infrastructure (pull)

- ✓ Public transit service improvements
- ✓ Walking and cycling improvements

B) Incentives to reduce car-use (push)

- ✓ Road pricing and congestion charging
- ✓ Parking management and pricing
- ✓ Vehicle travel restrictions
- ✓ Corporate Mobility Management programmes

C) Urban development and land use

- ✓ Smart growth land use policies

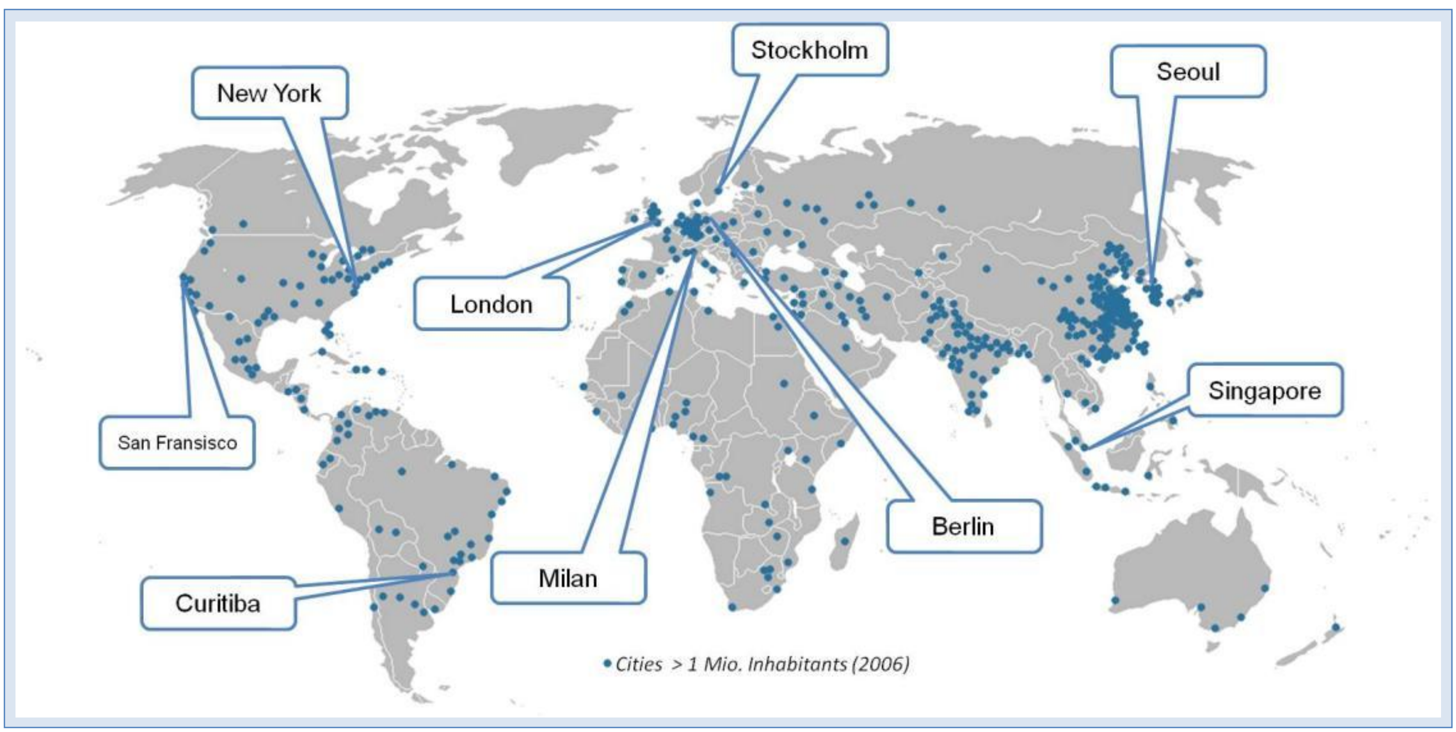


Figure 5: *Case studies covered in detail in the following chapters*

There are many more TDM policies and measures such as car-sharing, flex-time commuting policies, taxi regulation and delivery services. However, the report focuses on the most important policies and measures that form the basis of low carbon urban transport systems: While public transit and non-motorised modes traditionally have been very strong in China, the "push" strategies are much weaker. Parking policies often lack enforcement, prices are traditionally low and there are few associations that organize TDM programmes in companies or communities (Corporate Mobility Management programmes). In addition, urban land use development is a crucial cross-cutting aspect of sustainable urban transport.

Table 2: *TDM travel impacts and relevance for Chinese cities*

	TDM strategies	Travel impacts and GHG reduction	Relevance to Chinese cities
Pull	**Public transit service improvements**	Increases modal share of public transit and reduces car-driving for all travel purposes GHG reduction most effective, if implemented city-wide	Almost all Chinese cities upgrade their public transit systems. But in many of them, the overall travel-chain from-door-to-door does still not provide high levels of convenience.
Pull	**Walking and cycling improvements (non-motorised transport)**	Increases modal share of walking and cycling for short distance trips (up to 5 km) and reduces car-driving for all travel purposes GHG reduction especially high, if implemented in mixed-use city quarters or as feeder to public transit	Traditionally non-motorised modes were strong in China. Currently walking and cycling lack a positive image in society and infrastructure for bikes has been reduced. However, it is still better than in many other countries and there is a strong trend toward electric bikes.
Pull	**Corporate Mobility Management programmes**	Reduces automobile travel especially for commuting GHG reduction especially high, if major employers participate	Many employers in China do not yet apply TDM programmes. A growing number of Chinese companies develop environmental or sustainability strategies.
Push	**Parking management and pricing**	Reduces automobile travel GHG reduction most effective, if implemented city-wide and high quality public transit systems are in place	Parking is a key challenge in many Chinese cities. First steps have been taken but it still is a long way to comprehensive parking strategies. The growing numbers of automobiles require urgent action.
Push	**Efficient road pricing**	Reduces urban-peak automobile travel, especially for commuting GHG reduction highly depending on zone where applied	Congestion pricing is so far not implemented in Chinese cities. There might be some potential in very congested areas, especially if combined with vehicle restrictions.
Push	**Vehicle restrictions**	Reduces automobile travel in certain times or areas GHG reduction highly depending on time when or zone where applied	Many Chinese cities have experience with vehicle restrictions. However, so far these are not yet linked to emission rates or pricing.
Smart growth land use policies		Shifts modes and reduces vehicle travel (VKT) simultaneously GHG reduction especially high in a long-term perspective of more than 10 years	Many Chinese cities are auto-oriented and separate living and working. Considering the rapid growth of urbanization (up to 15M people move to cities every year) such strategies are of utmost importance.

The selection of TDM strategies also reflects the fact that carbon emission reduction is not the only objective of Chinese cities. Congestion, critical air pollutants and noise pollution are major drivers for decision-makers to especially engage in demand management.

For each selected TDM measure the report describes (1) travel impacts and emission reductions, (2) implementation requirements and (3) gives examples and case studies for illustration. Throughout the case studies in section 3 risks and obstacles and ways to mitigate them will be discussed. For easy reading, risk mitigation or success factors are marked with an umbrella throughout the document.

Fuel Taxes – National Level TDM

A crucial aspect of TDM policies - fuel pricing - is not part of this report. This is due to the fact that fuel subsidies and taxes are national level policies that cannot be decided by decision-makers in cities. However, the effects might be rather high and go far beyond urban transport.

Different TDM strategies affect different portions of total vehicle travel, congested travel, and fuel consumption. For example, in a typical city about 20% of vehicle travel is for commuting, about half of which is to major activity centres (downtowns, shopping malls, campuses, etc.), so a Corporate Mobility Management programme that reduces automobile commuting 10% will reduce total regional vehicle travel 2% (10% of 20%), or 1% (10% of 10%) if it only applies to activity centres. Such trips may represent a majority of congested travel but a smaller portion of energy use. As a result, TDM strategies that concentrate on urban activity centres, such as transit improvements and major employer trip reduction programmes, tend to be particularly effective at reducing congestion, parking costs and local pollution, but provide smaller accident, energy and GHG emission reductions. Strategies that affect all travel, such as fuel tax increases and distance-based pricing, tend to provide greater crash, energy and emission reductions, but smaller reductions in congestion, parking costs and local emissions.

3.1 Public Transit Service Improvements

Public transport (also called public transit, urban transit and mass transit) includes various rail, bus and van services that provide mobility to the public. Public transport plays an important role to provide sustainable urban mobility. It is an essential part of an efficient urban transport system because it is relatively space and energy efficient. In addition, high quality public transport can also help reduce automobile travel indirectly, by helping to create transit oriented neighbourhoods where residents tend to own fewer motor vehicles and rely more on alternative modes than occurs in automobile-dependent areas (for details see section 3.7).

Transit Service Improvements:

... reduced carbon dioxide emissions by 200,000 tons in Bogotá (Colombia) within three years.

... led to a decrease of energy consumption and pollution emissions by 13% in Freiburg (Germany) from 1990 to 2006.

... reduced vehicle travel in Portland by 15% compared to the U.S. average from 1990 to 2006.

Different types of public transport tend to serve different types of users and provide different types of benefits. Some transit services are primarily intended to provide basic mobility to low-income groups. These transit-dependent passengers lack the option of driving (so called captive drivers). This requires inexpensive public transit services which connect lower-income neighbourhoods with services and jobs. Travel speed, convenience and user amenities are less important to serve this market. However, achieving TDM objectives, such as reducing traffic and parking congestion, energy consumption and pollution as well as emissions requires high quality service that attracts discretionary travellers or non-captive drivers (people who would otherwise use an automobile). To achieve this objective, travel speed, comfort and convenience are more important than affordability.

As consumers become more affluent they tend to demand higher quality transportation services. If public transport only offers basic quality service, with slow, crowded and dirty buses and trains, and poorly coordinated networks, people will shift to automobile transportation as soon as they can become more affluent, because the transit system fails to accommodate the demands of wealthier consumers.

Experience in cities around the world indicates that wealthier travellers will use public transport if it offers high quality service, especially for commuting purposes. This often requires more comprehensive evaluation than previously applied in transport planning in order to identify the service improvements that can attract affluent travellers out of their cars. For example, although commuters who have no viable alternative will ride on a hot and crowded bus or train, many affluent travellers will only use public transport if they have a comfortable seat and air conditioning, and even high-income commuters might leave their cars at home if buses or trains have on-board refreshments and Internet services so they can use they can make use of their travel time for work or leisure.

Chinese cities are in a difficult situation. They are facing rapid social economic development with significant consequences for the public transport system. Not only poor people are moving into cities (urbanization) but an urban middle class is emerging at the same time. This causes a dilemma for transport planners: Serving the needs of the poor, i.e. affordable public

Picture 2: *People using overcrowded buses instead of bicycles in Beijing (P.R. China)*

Photo by Daniel Bongardt, 2011

transport service, while at the same time managing the demand for individual motor travel of the emerging middle class. Hence, public transit systems have been criticized for poor service quality, including crowded trains and buses, and inadequate stations, and for lacking amenities such as wheelchair accommodation. This also explains a widely known phenomenon in Chinese cities: Increasing public transit ridership – as this is more and more attractive and affordable for poor people – and at the same time increasing car traffic – as higher income groups are more and more oriented towards car-driving. This happened at the costs of non-motorised transport – the main transport mode in the 1980s and early 1990s.

In order to achieve a shift from cars to public transit (or at least keeping people in the system) and subsequently reducing GHG emissions high convenience and fast transport is essential. The following box describes "quality indicators" for public transport that could be used to benchmark high quality and hence help cities to improve their service level.

Optimizing Public Transport

There are many possible ways to optimise public transit and to make it more attractive to discretionary travellers without having to increase network capacity:

- Increase in service - increased frequency and longer operating hours
- Transit priority, including bus lanes, queue-jumper lanes, bus-priority traffic signals and other measures that reduce delay to transit vehicles. Most urban roadways with more than four lanes should have exclusive bus lanes and other design features to ensure that transit is relatively fast and reliable.
- Convenience improvements, such as reduced crowding, better seats and cleaner vehicles
- More convenient, integrated payment systems, including prepaid fares, electronic payment systems and integrated transfers
- Lower fares, discounts, attractive fares for occasional users and employer subsidies
- More convenient user information through signs, websites and mobile telephone applications that provide information on transit routes, fares and real-time vehicle arrival predictions
- Improved integration between transfers and between fare payment systems, as well as better connections with other modes such as bicycling, ferries, trains and airports
- Improved stops and stations, including shelter (enclosed waiting areas with heating in winter and cooling in summer), seating, washrooms, refreshments, Internet services, and other convenience features. This is a particularly important type of improvement in many large city transit systems where passenger traffic volumes often exceed station design capacity.
- Transit oriented development, including more compact development and improved pedestrian and bicycle conditions around transit stations
- Improved security for transit users and pedestrians
- Park and ride facilities (parking lots located at stations and stops)
- Amenities such as refreshments (tea and coffee service), on-board Internet access and work tables, particularly for longer-distance public transport services
- Services targeting particular travel needs, such as express commuter buses, special event services and various types of shuttle services

The Indian Ministry of Urban Development published a comprehensive **"Service Level Benchmark for Urban Transport"**. The document can be downloaded at: http://urbanindia.nic.in/programme/ut/Service_level.pdf

From a policy making perspective, the regulative framework between operators and government is a crucial aspect in enforcing good quality. It is essential that operators, regardless of whether they are private or government owned, have well designed incentives to operate with low costs and high quality service delivery at the same time. Minimum quality requirements between operator and government need to ensure that compensation and profit of the operator is based on indicators. The quality can be measured through a benchmarking with other cities or countries or a benchmarking over time that shows an improvement in quality of local operators (see case study "Seoul" at the end of the chapter for an incentive based approach).

Furthermore, for a transit system to be attractive it must be organized as an integrated system that provides convenient, comfortable and safe door-to-door travel. From the user perspective it is the full trip chain (door-to-door journey) that matters. If the overall public transport system is not comfortable, user satisfaction will maintain low and trips will be pursued with other modes of transport. A good integration (convenience in accessing and changing between lines e.g. through adequate planning of the links between subway and bus station as well as ticket integration is key for achieving high quality and thus for achieving a shift and thus for achieving emission reductions.

Comprehensive analysis is needed to identify the most cost-effective transit service improvements to attract discretionary travelers. This usually requires market research using user surveys, focus groups and demand models to identify the factors that may discourage travelers from using public transit on busy corridors, and the specific improvements and incentives that will attract more discretionary travelers.

Many large cities may develop both rail and bus services. Rail services are appropriate for longer-distance trips on a few corridors with very high demand (tens of thousands of peak-period travelers) and high quality bus service is important to serve other routes, feeder lines and local circulation. Many cities are now implementing various types of bus service improvements, often called comprehensive Bus Rapid Transit (BRT), which include bus lanes and traffic signal priority to maximize speed and reliability, frequent service, large capacity vehicles, prepaid fares to speed loading, attractive stations and vehicles, integrated fares, and coordinated marketing that emphasizes brand quality. These improvements both increase public transit service quality and make transit travel more attractive. A BRT network often requires converting traffic or parking lanes to busways, but this loss of traffic and parking capacity is more than offset if just 10% of automobile trips shift to public transit. If subway or

BRT stations are integrated with pedestrian and cycling improvements, feeder bus services, and local planning that encourages increased development in station surroundings, including services (shops, schools, healthcare, etc.), worksites and high density housing, the effects are impressive.

3.1.1 Travel Impacts and Emission Reduction

Figure 6 illustrates the impact chain from public transport improvements to a reduction of emissions through shift and avoid, i.e. the reduction in inefficient automobile travel. High quality public transit services can attract a significant portion of discretionary travellers (change in individual preference), particularly if implemented with complementary strategies such as parking pricing and cash out, walking and bicycling improvements, and smart growth land use policies. Where high quality transit exists, typically 20-60% of commuters will use it when travelling to major activity centres such as downtowns, malls and campuses.

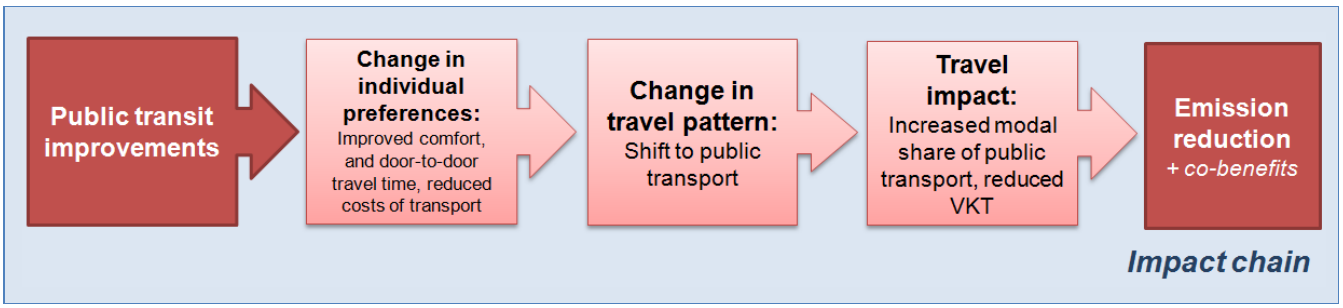


Figure 6: *Impact chain of public transit improvements*

In addition a transit-oriented neighbourhood that has local services, good walking conditions and frequent, comfortable transit services is important for individual users to shift. Residents of transit-oriented communities tend to own fewer vehicles and drive 20-60% fewer annual kilometres than they would in an automobile-dependent location (Litman 2008; CARB 2010-2011, see section 3.7).

The "Improve" Option

Cities that regulate or "own" public transport providers can increase the efficiency and reduce emissions per bus-kilometre through:

- Operational improvements (more direct routes and reduced empty backhauls).
- Newer, cleaner diesel buses.
- Alternative fuels (biofuels and CNG) and electrification
- Reduced loading delays (by using prepaid fares)
- Reduced congestion delays (by using bus lanes and bus priority signals)

Examples from Around the Globe

Portland, Oregon (USA), has implemented several successful transit projects including the MAX regional rail system, Portland Streetcar, Intercity Passenger Rail, Corporate Mobility Management programmes and the OHSU tramway. Figure 7 illustrates how per capita transit ridership increased between 1970 and 2002.

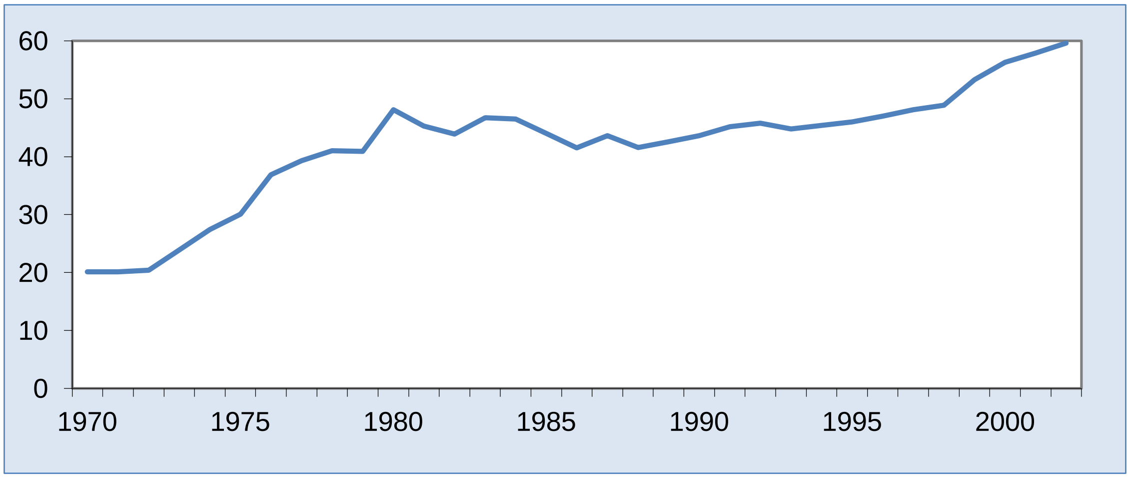


Figure 7: *Annual transit trips per capita in Portland. Oregon region per capita transit ridership approximately tripled in Portland due to various transit improvements.*

As a result of Portland's efforts to improve travel options and its smart growth land use policies, during the last two decades Portland's per capita average vehicle mileage has declined compared with U.S. national trends, as illustrated in Figure 8.

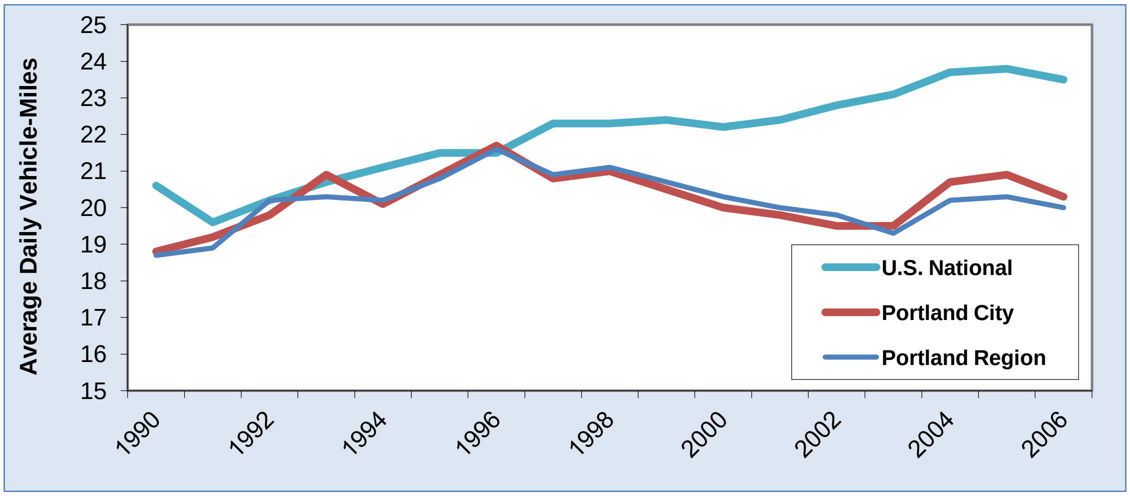


Figure 8: *Portland vehicle travel trends. Portland vehicle travel has declined about 15% compared with the national average due to transportation and land use management policies.*

Source: Metro, Portland Regional Government. www.oregonmetro.gov/index.cfm/go/by.web/id=26796

The City of **Freiburg** (Germany) has significantly increased walking, cycling and public transit travel and reduced per capita automobile use through a combination of tram and bus network improvements, walking and cycling improvements and supportive land use policies. In spite of rising per-capita income, vehicle km of car use per capita in Freiburg declined by 7% on all roads and by 13% on residential roads from 1990 to 2006. As a result, from 1992 to 2006, per capita energy consumption and pollution emissions declined 13% to a level that is 89% of the German average; traffic fatalities are only 3.7 traffic fatalities per 100,000 inhabitants vs. 6.5 in Germany overall and 14.7 in the USA; and public transport service requires only 10% of its operating costs to be subsidized through government funds, compared to 28% for Germany overall and 65% in the USA. (Pucher et al. 2009)

The German city of **Berlin** increased its public transport fare revenue more than 22% in three years by restructuring the transportation network as part of an integrated marketing strategy. Traffic simulations demonstrated that improving frequency on the main lines could shorten travel times and attract many new customers to public transportation. In addition, lines outside the core network with little utilization were identified where service could be reduced to achieve significant cost savings with only a slight ridership decline. New premium products, the MetroBus and MetroTram, were introduced in 2004 and expanded in 2006. Today, the MetroBus and MetroTram run on the 26 most important routes, 24 hours a day at very short intervals. They are intensively marketed with convenient user information. The new MetroBus and MetroTram products have achieved great success, with passenger volume on some lines rising by more than 30 percent. Overall, the bus operator (BVG) has gained more than 21 million new trips per year and reduced its annual operating costs by more than 9.5 million Euro.

Picture 3: *Walkway, cycle path, tramway tracks and street aligned and with appealing design in Freiburg (Germany)*

Photo by Robin Hickman, 2003

In **Bogotá** Colombia's TransMilenio bus rapid transit (BRT) began operation with one line in the year 2000 and has since expanded to 9 lines totalling 84 km (54 mi). In 2009 the system averaged 1,400,000 daily riders. Fares are 1600 Colombian pesos per trip (about $0.85) paid using contactless smart cards. TransMilenio operates entirely without government subsidies.

The main lines run red articulated buses in the centre of main avenues, or troncal. Access to most stations is by bridges over the street. Most of these routes have four bus lanes to allow express buses to bypass buses stopped at a station. As of May 2010 the main TransMilenio system had 1,500 buses, plus 410 regular feeder (alimentadore) buses to stations. These feeder lines operate without dedicated lanes, are not articulated and are green. There is no additional fare to use the feeder buses. Seventy-five percent of Bogotans rate the system as good or very good. Problems include overcrowded buses, long waiting times and pickpockets. The city plans to eventually build 388 km of route.

Bogotá has also developed many pedestrian and bicycle paths in conjunction with TransMilenio. Five percent of trips in Bogotá today are by bicycle. Many TransMilenio stations have large bicycle parking facilities.

Picture 4: *Public transport must be accessible, convenient and fast. Giving priority to transit like the BRT system in Bogotá (Colombia) makes buses attractive for more affluent citizens.*

Photo by Carlos Pardo, 2009

TransMilenioII is the first bus rapid transit system that secured credits for CO_2 reduction through the UNFCC Clean Development Mechanism (CDM). The projected savings of CO_2 from 2006 to 2012 is 1.7M tons. The actual reduction of CO_2 emissions was in 2006 60%, in 2007 52% and in 2008 30% of the estimated reduction. The yearly average reduction was 68,000 tons.

More on the estimation methodologies: Hook et al. (2010), Carbon Dioxide Reduction Benefits of Bus Rapid Transit Systems Learning from Bogotá, Colombia; Mexico City, Mexico; and Jakarta, Indonesia

3.1.2 Case Study: Public Transport Reform in Seoul

Many cities are now developing BRT networks. Seoul, South Korea, a rapidly-growing mega-city, was experiencing severe traffic congestion, pollution and health problems. In response, in 2002 Mayor Lee Myung-Bak and his team at the Seoul Development Institute implemented various transport and land use innovations (see case study in chapter 3.2.4 "Reclaiming Road Space in Seoul"), including a reduction in downtown road space, and a new BRT system that includes more than 5,000 high-quality buses, operating on 107 km of median busways. On those median bus lanes any other traffic but trunk route buses is prohibited. The BRT system was not planned in isolation. One of the main targets of the reform was to improve the integration between the already existing, extensive subway system (with 2.5 billion passengers per year in 2010) and the bus network as they were competing instead of complementing each other.

Seoul introduced bus colouring that made it easy for customers to identify the bus (e.g. yellow buses for inner-city travel, green buses for feeders to the metro system) on 400 restructured bus routes that are fully integrated into the subway system from a geographic location, schedule and ticketing point of view. One ticket can now be used for inter and intra modal transfer. The route system was reformed under the principle of organically linking the subway and bus systems with no break in the public transportation network.

Prior to the inception of the reform, there was no formalised bus management system. Now every bus is equipped with GPS to evaluate real time location and continuously improve services (speeding, missing designated stop sign, driving with open doors and other misconduct can easily be detected).

Impact

As a result, public transit customer satisfaction has improved, bus accidents have declined and transit ridership has increased. Traffic congestion was reduced and liveability improved, particularly in the downtown core. On the three initial BRT corridors, bus speeds rose up to 85% in the morning rush hour and up to 99% in the afternoon rush hour. The express buses using the median lanes carry six times more passengers than other road lanes used by cars in the same corridor. The benefits of the 2004 reforms have been system-wide. Until 2010 the number of passengers of buses and subways increased by 12.8%. The number of persons seriously injured through bus accidents decreased by 95% and the number of fatalities by 45%

(Kim et al.). Private vehicles in use decreased by 2.8% in the entire city and by 6.57% in the city centre from 2004 to 2008. Although reduction in CO_2 emissions was not quantified, the reduction of private vehicle transport is a good indication for the reduction of emissions. The modal share of bus transport increased from 26% to 27.8% which is significant considering that the share decreased in the years before. The share of subway increased from 34.6% to 35.2% while automobile decreased from 26.9% to 25.9%.

Picture 5: *Red coloured bus on special bus lane in Seoul (South Korea)*

Photo by Buis, 2009

Success Factors

Reliability/Convenience

The reform was planned focussing on many details to provide a world class public transport system. A high quality implementation was pursued in many aspects such as a bus management centre that provides scientific bus management and real time bus operations but also less expensive but efficient aspects such as the functional division of bus colours and the revision of bus numbers according operational areas. Further an integrated smart card system (T-Money) for every mode of public transportation that allows free transfers to different transit services making the shift of modes considerably more convenient was introduced. Fares are now charged on distance travelled and not on a flat-rate basis. As most trips included an interchanging of modes the fare adjustment led to reduced costs of travelling for the customers. Before the reform even to switch buses a new ticket had to be obtained. According to a survey of customer satisfaction, the reform of the integrated fare system was the most popular element of the public transport reform. By now 95% of all passengers use the smart card to travel with public transport in Seoul.

Stakeholder Consultation

Typically for comprehensive reforms, opposition groups tried to argue against the reform. To mediate between these groups (especially the private bus operators) and government a Bus System Reform Citizens Committee was established consisting of different public and private institutions. The Committee decides on important matters such as fares and routes.

Performance Based Incentives (Governance)

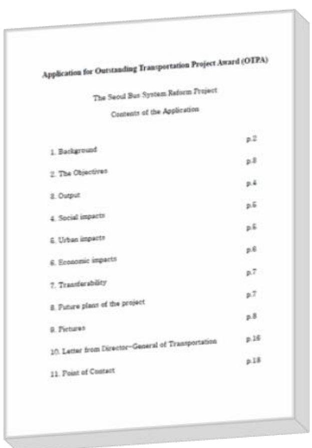
Before the bus reform in 2004 the entire bus system was privatized with several different private operators. Government had neither influence on routes nor service level, nor schedules. Only fares were determined by government. This led to the typical problems of privatization combined with a lack of incentive-based performance regulation. Private bus operators had an incentive to maximise revenue through reduction of costs and consequently reducing service quality. At the same time, maximising the number of people in a bus was the only way to increase revenue. This led to overly crowded buses, speeding and consequently frequent accidents. From 1989 to 2002 the amount of passengers declined by 50%, leading to further reduction in revenue for the private operators. In 2004 the city government moved away from the comprehensive privatization scheme to a semi-public operation system.

With the reform in 2004 the Seoul Metropolitan Government increased its control over the entire system by recapturing command of the bus routes, schedules and fares while leaving the operation with private firms. The quality problem was solved with an incentive based approach. Private companies are reimbursed for operation costs and a profit margin based on the vehicle/km travelled instead of passenger trips. The operating costs are calculated by the average costs of the most efficient half of all operators. This way the other operators had an apparent incentive to improve their efficiency. Additionally private companies are forced to jointly manage their revenue to decrease overhead costs. From 2003 to 2009 government saved some 421 US $ in subsidies. (Pucher et al.) A profit margin is only distributed to the 70% best performing companies based on a service measuring system that assesses various indicators including the quality of service delivered. This is to ensure that companies do not lower the quality of service to reduce costs.

Part of Comprehensive Strategy

See case in chapter 3.2.4. "Reclaiming Road Space in Seoul" for the complementing change in land use. Additionally the City of Seoul has implemented a number of push measures such as congestion charging and increased fuel taxes and parking fees.

More information on the **Seoul Bus System Reform Project** can be downloaded at:
www.easts.info/activities/awarding/award_project/otpa2007_SeoulBus.pdf


Application for Outstanding Transportation Project Award (OTPA)

The Seoul Bus System Reform Project

Contents of the Application

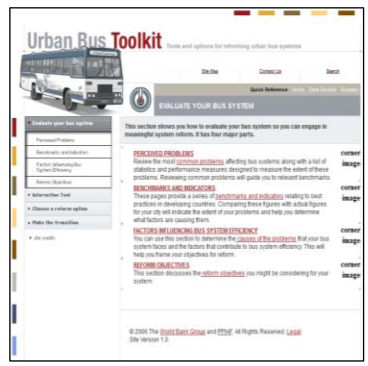
1. Background p.2
2. The Objectives p.3
3. Output p.4
4. Social impacts p.5
5. Urban impacts p.5
6. Economic impacts p.6
7. Transferability p.7
8. Future plans of the project p.7
9. Pictures p.8
10. Letter from Director-General of Transportation p.16
11. Point of Contact p.18

More information on **Transit Improvements** in general:

BRT Planning Guide

www.sutp.org
(info on transit, walking, cycling)

Urban Bus Toolkit



www.ppiaf.org

The documents are also available in Chinese.

3.2 Walking and Cycling Improvements

Walking and cycling (together called *non-motorised* or *active transport*) serve many important roles in an efficient and affordable transportation system. Many urban trips rely entirely on walking or cycling and most public transport and automobile trips involve walking links, for example between bus stops or parking facilities and destinations as well as for

Walking and Cycling Improvements:

... increased the modal share of cycling in Berlin from 1998 to 2010 by 50%.

... decreased on-site pm pollution by 65% through the Cheonggyecheon River Project in Seoul.

... reduced accident-related injuries by 63% on the Broadway in New York.

circulation around a shopping district. Pedestrian improvements are often an important way to encourage public transit travel and to support more efficient parking management (for example, one parking lot serving multiple destinations).

Improve sidewalks, paths and crosswalks

Improvement of sidewalks includes the extension of the functional width of a sidewalk (part of a sidewalk that is not disturbed by obstacles such as signs, garbage cans etc), painting of crosswalks, security lightning along sidewalks, street furniture and covered areas for transit passengers. Crucial improvements to reduce accidents are safe crosswalks. Pedestrian countdowns, pedestrian islands or overpasses can significantly reduce accident risks and improve walkability. To ensure safe crossing cars should not be allowed (enforcement!) to turn right on red lights. Such improvements are relatively inexpensive compared with other transport infrastructure projects. In areas where foot traffic is especially high it might be feasible to close roads for foot traffic altogether (see New York case study).

Establish and enforce non-motorised facility standards

Many sidewalks are inadequately designed, constructed or maintained. Teams of specialized design and enforcement experts, which include members who use wheelchairs and other mobility aids should be established to assist planners and property owners improving pedestrian facilities so they accommodate all users.

Create bicycle paths, lanes and boulevards

Bicycle boulevards can be in the form of a street closed to through car traffic but not bicycles and pedestrians. The most important parts to improve bicycle infrastructure are design and enforcement. Lanes need to be clearly separated from car traffic and violation by car drivers needs to be strictly enforced.

Develop bike parking and changing facilities

Provide bicycle parking (for example, in downtown areas), require developers to provide bike parking in new buildings by law, and bicycle storage and changing facilities at worksites for bicycle commuters. To improve interchanging of modes safe, visible and secure bike parking needs to be provided close by bus or subway stations.

Develop bike sharing programmes

In some cases potential bicycle users are discouraged by the lack of a bicycle. Bicycle rental services that support utilitarian cycling, with bicycles that can be rented in one location and left in another can significantly increase the usage of bikes.

Bike Sharing in Paris – Vélib'

France's Capital Paris has launched a comprehensive bicycle sharing scheme in 2007. With 20,000 bicycles and 1450 bicycle stations across Paris and its municipalities Vélib' is one of the largest scale bike sharing systems in the world and is complemented by an electric vehicle sharing scheme called Autolib'.

Bike availability of bikes and parking is displayed on a website, on an iPhone app and at every rental station. Before renting a bike the user has to subscribe either online or at the rental station. The first 30 minutes of trips are always free of charge. The usage charge increases from 1€ per hour up to 4€ per additional half-hour. A bonus system gives a 15 minute credit for every time a bike is parked on an elevated return station.

If a user arrives at a rental station that does not have an open spot the system automatically grants another free fifteen minutes of rental time to ensure that the bike can be returned.

The system is operated by a private company that currently employs 285 full-time employees. 100,000 cyclists use the service daily. The number of cyclists in Paris increased by 40% in the last three years. Other metropolitan cities like New York recently introduced similar projects.

More at: http://en.velib.paris.fr

Picture 6: *The bike sharing scheme "Vélib'" in Paris (France) is one of the most comprehensive ones in the world with 1450 stations, 110,000 daily ridership and 20,000 bikes.*

Photo by Gideon, 2007

3.2.1 Travel Impacts and Emission Reduction

As illustrated in the figure below, pedestrian and cycling improvements can reduce vehicle travel directly, when people shift trips from automobile to public transport, and indirectly if non-motorised transport improvements help increase public transit travel and support more compact development. For these reasons, non-motorised improvements are important TDM strategies themselves, and support other TDM strategies.

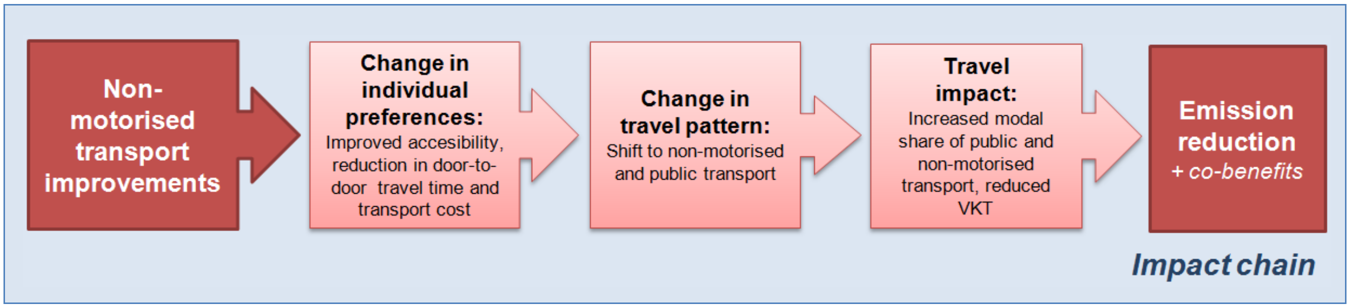


Figure 9: *Impact chain of non-motorised transport improvements*

Comparisons between Germany and the U.S. indicate that transport and land use policies can significantly affect walking and cycling activity. Between 2001 and 2008, the proportion of "any walking" was stable in the U.S. (18.5%) but increased in Germany from 36.5% to 42.3%. The proportion of "any cycling" in the U.S. remained at 1.8% but increased in Germany from 12.1% to 14.1%. In 2008, the proportion of "30 minutes of walking and cycling" in Germany was 21.2% and 7.8%, respectively, compared to 7.7% and 1.0% in the U.S. The increases in walking and cycling activity in Germany occurred despite rising incomes, and occurred among virtually all demographic groups.

Between 1998 and 2000 Bogotá, Columbia built 344 km of separate bike paths that connect to public transport services and major destinations, implemented the Ciclovia programme which closes 121 km of major urban roadways to cars and encourages recreational activities on Sundays and holidays, created extensive car-free zones and streets, removed cars from many public spaces, and promotes walking and cycling transportation. This has increased bicycling mode share from 0.8% in 1995 to 3.2% in 2003, and Ciclovia participation grew from 5,000 in 1974 to over 400,000 in 2005.

In the 1960s some Davis, California citizens lobbied for bike lanes to make bike travel safer. As a result, Davis created the first bike lanes in postwar America. After 1967, transportation in Davis was oriented toward the bicycle. The city's Public Works staff developed many innovative designs and programmes, which were fine-tuned in Davis and then applied elsewhere. Davis now has 50 miles of bike lanes and 50 miles of offstreet paths in a 10 square mile city, making a highly functional bicycle transportation system. Bicycle commute mode share (22% in 2010) is the highest, and per capita annual automobile travel is the lowest among U.S. cities.

Non-motorised transportation improvements can provide a variety of benefits to users and society. Some benefits, such as improved user convenience and comfort benefit existing users. Other benefits result if non-motorised travel improvements increase use of these modes and attract travellers who would otherwise drive. Some benefits result if such projects help create more compact, walkable communities, which provides additional vehicle travel reductions and other benefits such as habitat protection.

Walking and cycling improvements can provide significant emission reductions. Non-motorised travel tends to substitute for short urban trips for which automobile travel tends to be particularly fuel inefficient because engines are cold and traffic is congested. In addition, non-motorised improvements tend to support public transit travel and more compact land use development which tend to provide additional vehicle travel reductions.

Human-scale Road Design

Human-scale road design (also called complete streets and streetscaping) refers to roadway design practices that ensure that roadways (particularly busy urban roads) are designed to accommodate walking, cycling and public transport in addition to automobile travel, with adequate sidewalks and crosswalks, and where demand is sufficient, bike lanes, bus lanes and bus stops. This recognizes that streets are places where people engage in various activities, including, but not limited to, motor vehicle travel. Implementation of complete streets, road space reallocation and streetscaping requires changes to transport funding allocation (more funding for redeveloping existing roadways rather than funding roadway expansion), roadway planning practices, and professional development (planners and engineers need to apply new analyses and design tools). Road capital projects require lengthy intergovernmental communication. Departments responsible for buildings, street design, transport, economic development agencies, department for sanitations, department for public works and private contractors usually have to be involved in any major changes in street design. That is, formalized intergovernmental cooperation is a crucial necessity for these projects (see New York case study). Examples are:

Context-Sensitive Roadway Design Standards

The Smart Transportation Guidebook provides specific recommended roadway design features (desired operating speeds, travel lanes, lane width, shoulder width, parking lane, bike lane, median, curb design, sidewalk width, and buffer between traffic and pedestrians) for different types of roadways (regional arterial, community arterial, community collector, neighbourhood collector and local road) for various land use conditions.

Home Zones

The British government has developed policies to allow highway authorities to designate streets as "home zones," residential streets with limited traffic speeds. Within these zones, street activity, including play, will be lawful. Design speeds will be less than 20mph - probably 10mph. Signs will be posted at the area edges to indicate their special status. Designs will include shared surfaces (no curbs), landscaping and play equipment. The federal government will distribute funding to local agencies for planning and implementation. More information: www.homezonenews.org.uk

3.2.2 Case Study: Bicycle Planning in Berlin

Discussed in more detail in chapter 3.5.2 below, the City of Berlin had to find solutions to reduce emissions from private vehicle use in the city boundaries. As one result the city developed a bike strategy to increase the modal split of bicycle trips, to reduce accidents, to increase interchanging between public transports and bicycling and to ultimately increase liveability in Berlin. The target was to increase trips by 50% until 2010 from a modal share of 10% in 1998 to 15%. To achieve this objective the daily amount of bicycle trips had to increase by 100,000. €8 million were spent on the project over 10 years.

To achieve this, a catalogue of measures was proposed and approved by the Senate in 2004:

- More and better bike lanes
- Easier orientation
- More parking options
- Improved connectivity to public transport
- Integration of mobility awareness into school curricula
- Safety measures (Traffic lights turn green for cyclist first, blinking traffic light for trucks to increase awareness, separated bike lanes for turning, increased visibility of crossings, improved sign network for recommended bike routes, improved enforcement)
- Public awareness

Impact

By 2009 the bicycle modal share increased to 15% compared to 10% in 1998. 43% of all trips in Berlin are made by non-motorised transport.

Success Factors

Intergovernmental Coordination

The State Senate established a bike council consisting of different administrations and institutions that are concerned with bicycling (Administration for Planning and Development, Administration for Education, Youth and Sport, Representatives

from environmental agencies, Police, local construction agencies, Public transport operators, experts from universities). The measures were distributed among these stakeholders to ensure commitment and accountability for each measure.

Convenience

The website of the City of Berlin provides a multi-modal trip planner that will show the fastest and cheapest mode of transport for the trip of choice. It considers current congestion, constructions and points of interests on the route.

3.2.3 Case Study: Green Light for Midtown New York City

Photo by Terabass, 2009 (CC-BY-SA 3.0)

The Broadway is one of New York's most famous and busiest roads. Although the road is used by 4.5 times as many people as vehicles, only 11% of the space is currently allocated for pedestrians. Broadway at Times Square has 137% more pedestrian crashes on average than any other avenue in town.

In 2009, New York City closed sections of Broadway at Times Square and at Herald Square to motor vehicles. Between Times Square and Madison Square, two lanes of Broadway were converted from mixed traffic lanes to bike lanes and walkways. Removing Broadway from the system resulted in 8% and 66% increases in green signals for 7th and 6th Avenues (intersecting Broadway) at Times and Herald Squares. To improve safety for pedestrians the main measure was to simplify intersections. Making the road less reduced the distance pedestrians had to cross and consequently reduced the number of directions from which vehicles approached the intersection. Due to the success of the project it has been decided to construct the plazas and corridor treatments with permanent materials.

Impact

Northbound travel speed data from taxi GPS systems collected in West Midtown showed a 17% improvement in travel speed from fall 2008 to fall 2009, compared with an 8% improvement in East Midtown.

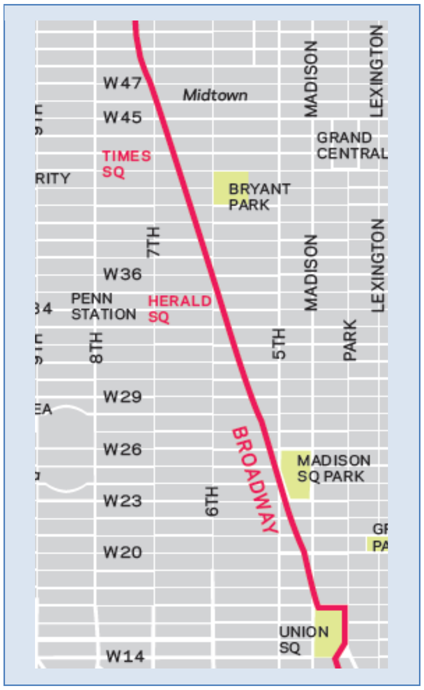


Figure 10: *Project area*

Source: New York City (Department of Transport), Greenlight for Midtown Evaluation Report, p. 5

The speed of southbound taxi trips declined by 2% in West Midtown while East Midtown showed a 3% increase. The speed of eastbound trips in West Midtown improved by 5% and westbound trips improved by 9% in fall 2009 compared with a year earlier; East Midtown showed improvements of 2% for eastbound trips and 7% for westbound trips. Field travel time surveys show a 15% improvement in travel time on 6th Avenue and 4% improvement on 7th Avenue.

Bus travel speeds improved by 13% on 6th Avenue. Injuries to motorists and passengers in the project area are down 63%, pedestrian injuries are down 35%. 80% fewer pedestrians are walking in the roadway on Times Square. At the same time 84% more people are actually staying in the area to eat, shop, photograph etc. resulting in a positive impact on businesses. 74% of New Yorkers surveyed agree that Times Square has improved dramatically over the last year.

Success Factors

Planning Guidelines and Intergovernmental Cooperation

NYC founded an inter-agency task force to develop a comprehensive guideline for liveable street design based on extensive research. The New York City Street Design Manual provides policies and design guidelines to city agencies, design professionals, private developers and community groups for the improvement of streets and sidewalks. It is a comprehensive resource for promoting higher quality street designs and more efficient project implementation. The Manual builds on the experience of innovation in street design, materials and lighting that has been developed around the world, emphasizing a balanced approach that gives equal weight to transportation, community and environmental goals. It is designed to be a flexible document that will change and grow, incorporating new treatments as appropriate after testing. Examples of applicable projects include capital and non-capital projects, such as street reconstructions and resurfacings, operational and traffic control treatments, street work associated with new or renovated buildings, and other public or private construction projects that include roadways, sidewalks, and plazas. Because cities are complex and diverse systems, street designs must be tailored for the particular needs and opportunities created by the local context, uses, and dimensions of streets.

The Manual is intended to help:

- Set appropriate goals for each project
- Provide a framework for design decisions
- Establish a clear and consistent design review process
- Serve as a central, comprehensive reference guide

Stakeholder Consultation

The Department of Transport extensively involved stakeholders in the development of the project. Local businesses, community boards and building owners were involved to discuss concerns and get insight into the local situation.

Part of Comprehensive Strategy

Undoubtedly the main part of the Green Light for Midtown project was removing Broadway from the traffic system at Herald and Times Square. At the same time, several coordinated traffic changes were implemented in tandem with the Broadway closures to reach

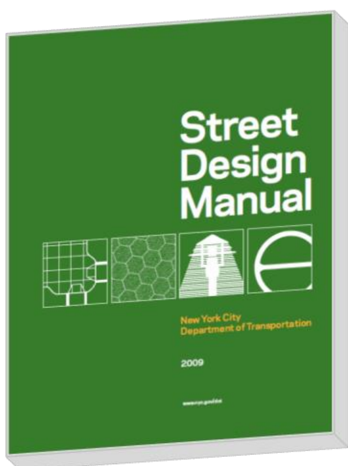
Picture 7: *Times Square after reconstruction*

Photo by New York City Department of Transport, NYC (USA), 2009 (CC-BY-ND 2.0)

Pictures 8, 9: *Broadway on Herald Square before (top) and after (bottom) being closed off to vehicles*

Photo by New York City Department of Transport, NYC (USA), 2009 (CC-BY-ND 2.0) the project goals. Changes range from roadway geometry alterations to traffic signal timing adjustments, crosswalk shortenings and parking regulation changes. Many other projects were implemented based on the design guideline and the concept of "complete streets" to ensure that all modes (walking, cycling, public transit and automobile) are considered in the design. For example, in 2007, the City completely redesigned Ninth Avenue in Manhattan. Major project elements included shortening the pedestrian crossing distance and developing an innovative bicycle path. The project uses pavement markings, signs, traffic signals and raised concrete islands to create a unique, safe and enjoyable street. The project dramatically improved walking and cycling conditions, street aesthetics and commercial parking. The project did not increase traffic congestion. The improvements were implemented quickly, relying mainly on new pavement markings and traffic signal changes, with minimal construction.

More Information on New York



New York City Department of Transportation (2009), **New York Street Design Manual**
www.nyc.gov/html/dot/html/about/streetdesignmanual.shtml

New York Department of Transport (2010), **Green Light for Midtown Evaluation Report**
www.nyc.gov/html/dot/downloads/pdf/broadway_report_final2010_web.pdf

3.2.4 Case Study: Reclaiming Road Space in Seoul

During the last half century Korea has evolved into a modern industrialized country with rapidly growing vehicle ownership. Its capital city, Seoul, developed along the Cheonggyecheon River. During the last four decades Seoul grew into a megacity with more than 20 million residents in the metropolitan region. Between 1960 and 1980 the city paved over the Cheonggyecheon River and built an elevated highway through the downtown. By 2000 this highway carried more than 168,000 vehicles per day.

However, instead of heavily investing in the expansion of road infrastructure, Seoul restored elevated highways to a pedestrian friendly environment. The Cheonggyecheon River project started in 2003 and required the dismantling and demolition of the elevated highway, and the uncovering of the historic 5.8 km waterway that ran underneath. The project is estimated to have cost approximately US$281 million.

Impact

The stream has become an enduring tourist attraction, drawing an estimated 18.1 million visitors by the end of 2008. Development has been heavily invested into residential construction, and property prices have risen at double the rates compared to the rest of the city. Fears that construction and conversion of the highway would harm local businesses did not materialize. In fact, in relation to other parts of the city, the number of businesses increased. The most noticeable changes have been in environmental quality. The removal of some 170,000 cars from this artery has created a 3.6°C reduction in temperature. Air flows freely along the path of the stream, creating a cooling wind corridor. The particulate matter pollution dropped by 54% along the project site. There was a 2.3% reduction in vehicles entering the downtown area, an increase of 1.4% and 4.3% in bus and subway ridership respectively. The NO_2 concentration was reduced by 30% while the PM_{10} concentration reduced by 11%. A 2005 public survey showed respondents overwhelmingly noticed improvements in air and water quality, noise and smells.

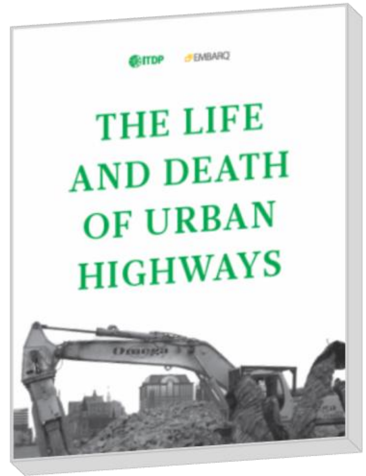
Further Information on Urban Highway Conversion Projects

EMBARQ and ITDP give an overview about recent highway conversion projects:

www.embarq.org/sites/default/files/EMB2012_Life_and_Death_of_Urban_Highways.pdf

The Congress for New Urbanism's "Highways to Boulevards" programme describes successful highway conversion projects in various cities around the world. In each case, reducing road space improved the city's liveability and supported economic development without creating gridlock:

www.cnu.org/highways

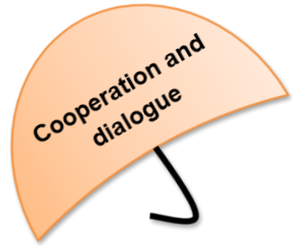


Pictures 10, 11: *The Cheonggyecheon River in Seoul (South Korea) before (top) and after (bottom) the project. Claiming back urban space from road vehicles can dramatically improve the liveability of cities.*

Photos by Seoul Development Institute

Success Factors

Institutional Framework



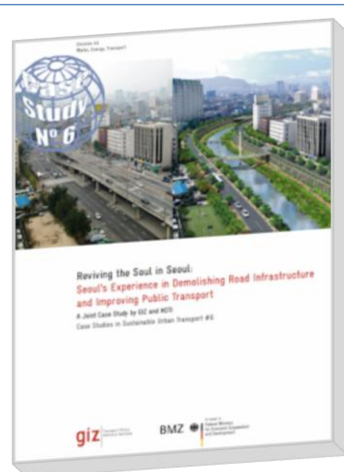
A major project like the demolishing of a highway and its transformation into a people friendly environment usually involves several governmental and private institutions. The **institutional framework** in Seoul was very conducive to a major capital project like this. The Seoul Metropolitan Government was the main and only responsible agency and took the entire responsibility for restoring the Chenggyechoeon River. The fiscal and human resource capacity was entirely provided by the Seoul Metropolitan Government. To ensure that planning and implementation received the necessary public support, the government founded the Citizen's Committee for Cheonggyecheon Restoration for the stakeholder consultation process. At the same time, the Cheonggyecheon Restoration Centre was incorporated to provide the technical background, to conduct research and to support the planning activities.

Comprehensive Strategy

To address traffic problems the programme included changes to the downtown traffic system recommended by the Cheonggyecheon Restoration Research Corps. This included a major new bus network with bus-only lanes on major corridors, integrated fares and information systems, pedestrian improvements, bicycle networks, and improved parking management. The restoration of historic bridges and cultural sites required negotiations among different groups to determine the best approach. A major success factor was the improvement of public transport in the project area. See chapter 3.1 "Public Transit Service Improvements" for a more detailed case study of the Bus Rapid Transit in Seoul.

Further Information on the Cheonggyecheon Restoration Project

"Reviving the Soul in Seoul" can be downloaded at www.sutp.org in the case study section. The publication is a joint study by GIZ and the Korea Transport Institute (KOTI).



3.3 Road Pricing and Congestion Charging

Efficient road pricing includes road tolls (a toll for driving on a particular roadway), priced lanes (one lane that is priced to minimize congestion on an otherwise unprized but congested highway) and cordon fees (a toll for driving into an area, such as downtown). Congestion pricing refers to roadway user fees that are higher under congested conditions and lower, or not applied at all, under less congested conditions, in order to reduce traffic volumes to more optimal levels. Some cities apply a variety of road pricing systems simultaneously (see Singapore example below).

Efficient Road Pricing:

… reduced CO_2 emissions by 19%, bus delays by 50% and decreased congestion by 30%, in London.

… reduced peak hour traffic in Trondheim by 10%.

… increased traffic speed in Singapore by 22% while total traffic reduced by 13%.

These fees may be intended to reduce traffic congestion, raise revenues, or both, and are considered the best way to apply the user-pays- and pollutant-pays principle. That is, environmental and infrastructure (development and maintenance) costs should be reflected in the costs of using a road. Many jurisdictions, including China, use road tolls to finance new inter-city highways. A few cities also use various types of congestion fees to manage travel demand (e.g. Milan applies congestion charging and an environmental zone scheme).

Private Sector Involvement

An increasing number of toll roads systems are implemented by private companies. Diverse models were implemented with different successes. PPP models for pricing projects vary from long-term concessions for design, build, finance, and operation of a facility to short-term operation and maintenance contracts. These models can provide accelerated project completion, cost savings, improved efficiency, quality, and system performance. PPPs can also provide access to new sources of private capital and relieve pressure on scarce public resources. PPPs require a strong regulatory framework that ensures high quality service delivery by the private actor. There are various competitive bidding and performance based contract options. In some cases PPPs may lead to high transaction costs.

Interstate 15 – Dynamic Congestion Pricing

Since 1996 a 13-km reversible high occupancy vehicle (HOV) facility in the median of Interstate 15 in San Diego was opened to solo drivers who pay a toll using electronic transponders. Since March 1998, users of the Express Lanes have been charged a toll that varies dynamically with the level of congestion. Several variable message signs are posted in the areas prior to the entrance to the Express Lanes. These indicate the highest fee that toll users should expect to be charged, with tolls ranging from 50 cents to $4 per one-way trip under regular conditions, and otherwise as high as $8. Variable message signs inform drivers of the going rate. Traffic flow is monitored in the Express Lanes to ensure that service on the HOV lanes is maintained at free-flow conditions (level of service C). This is to encourage as a primary objective the higher occupancy rate per vehicle. Media response thus far has generally been positive. Some of the programme's revenues are used to fund a new express bus service. Further information:

More information on Interstate-15 electronic HOT lanes: www.argo.sandag.org/fastrak

Toll Roads

The primary objective of toll roads is revenue generation for road infrastructure development and maintenance. Hence, users are typically either charged for the distance travelled on a toll road or when crossing a toll bridge or tunnel. Especially in the case of public-private partnerships, the target is not to ease congestion as less traffic would result in less revenue. The operator will choose the toll accordingly. Nevertheless, several countries, e.g. Norway, cross-subsidize public transport with revenues from their toll roads. In Germany, heavy goods vehicles (over 12 tons) are charged when driving on the motorways. They are charged according to their emission standards, number of axles and distance driven. The scheme charges cleaner vehicles lower fees having led to a 10% increase in registrations of low-emission lorries. Toll roads may ensure more efficient road use for private and public trips. In Germany, the share of trucks making return trips without load (empty haulage trips) fell from 16.5% to 10.2%, which is a 40% reduction (Doll, 2007). Toll roads are usually a national instrument that requires a nationwide regulatory framework.

Picture 12: *Electronic road pricing (ERP) system on expressway in Singapore*

Photo by Manfred Breithaupt, 2010

Congestion Charges

Both toll roads and congestion charging impose fees for road usage. Whereas toll roads mainly focus on financing maintenance of inter-city highways, congestion charging is a transport demand management measure to reduce traffic congestion and consequent environmental damage. Ideally, the fee is regulated by the current road congestion conditions as a way to reduce traffic volumes to an optimal level. This would result in higher fees during rush-hour and lower fees when traffic volume is low. Congestion charging can have different forms:

- Cordon Pricing: A fee is paid when entering a congested area (which is often the CBD). The fee is usually higher during peak hours.
- Area license: Vehicles purchase a (day) license when operated within a defined area.
- Priced lanes or corridors: Vehicles using a specific road lane, tunnel etc. are charged a fee. When applied on bridges or tunnels, financing is usually the primary objective. Charging a specific lane (high-occupancy toll) targets a reduction in congestion. The road user can choose whether he is willing to pay for faster transportation. This is often considered a "fair" solution compared to charging for all lanes of the road. At the same time flexible fees need to be implemented to ensure that the charged lane is always less congested. Priced lanes and corridor pricing have been used on a number of tunnels in Hong Kong, the Namsan tunnels in Seoul, as well as on the expressways in Singapore.

3.3.1 Travel Impacts and Emission Reduction

Although roadway user fees and congestion charges can reduce vehicle travel on a particular road or area, they generally only apply to a minor portion of total vehicle travel and so tend to provide only modest emission reductions. For example, London's cordon charge only applies to about 2% of total regional travel, of which vehicle travel declined by about 15%. Similarly, most highway tolls only affect a minority of total regional travel.

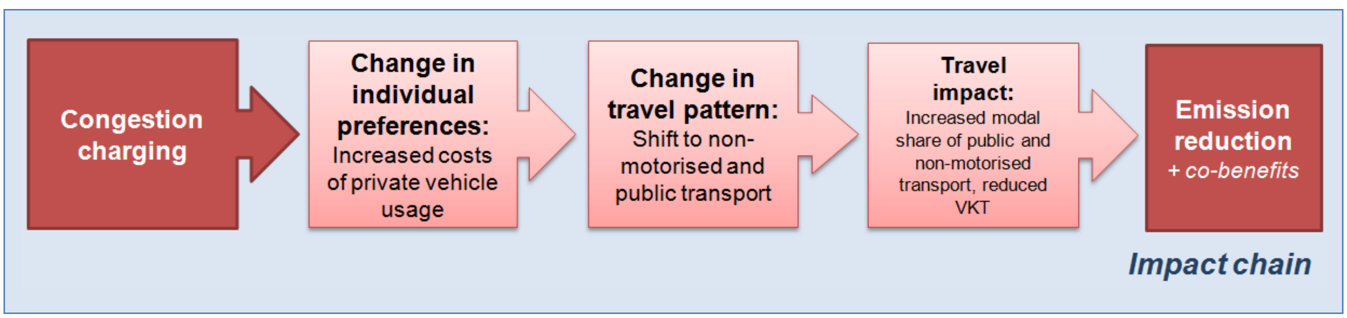


Figure 11: *Impact chain of congestion charging*

> **Trondheim** (Norway) introduced a city toll system where vehicles are tagged and pay according to the time they enter the city area (double between 7-9 am and 3-5 pm) and according to the type of vehicle (vehicles above 3.5 tons always pay double). Most of the lanes are reserved for tagged cars that do not need to stop at the toll gates. **Manual toll stations can be used by short-term visitors and tourists**. Payment options vary from paying at service stations and online payment to specific salutations for short-term visitors. Peak hour traffic dipped by 10%. The main purpose of the measure was to finance road infrastructure.

However, comprehensive road pricing, which applies to most regional roads, rather than just a small area, can cause much larger travel reductions, and so can provide much larger benefits. Road pricing is particularly effective if implemented as part of an integrated programme that includes improvements to alternative modes. See below under examples the Singapore, London and Stockholm case study for further information on the travel and environmental impact.

Emission reductions depend on the amount of vehicle travel reduced. Emission reductions can be proportionately larger than vehicle travel reductions if urban road pricing reduces traffic congestion, so a 10% reduction in vehicle travel may provide a 12-15% reduction in emissions.

Evaluating Costs and Benefits of Road Pricing

Efficient road pricing can help achieve a variety of planning objectives, including revenue generation, congestion reduction, road and parking facility cost savings, accident reductions, energy conservation and emission reductions. The magnitude of benefits varies depending on the system design. Most road tolls and cordon pricing schemes, such as those in London and Stockholm, only apply to a limited number of very congested roadways and so tend to be most effective at reducing traffic and parking congestion, but because they affect only a small portion of total regional vehicle travel they do relatively little to achieve other objectives such as reducing accidents, energy consumption and pollution emissions. Region-wide road pricing, such as in Singapore, vehicle-kilometre charges and fuel price increases are more effective at achieving these objectives.

Economic evaluating of road pricing projects should consider the following impacts:

- Implementation and operational costs
- Costs to motorists and revenues to government agencies (these are economic transfers)
- Congestion reduction benefits (travel time savings, improved travel reliability, vehicle operating cost savings, increased bus transit operating efficiency, etc.)
- Co-benefits (environmental gains, increased traffic safety)
- Reduced consumer surplus to travellers who forego driving
- Incremental costs and revenues from increased public transport demand
- Impact on private businesses in affected area (losses to businesses that rely heavily on customers who drive and gains to businesses that rely on customers who travel by other modes and are attracted to areas with reduced automobile traffic)

Determining the right level of charge when implementing toll roads is one of the prevalent challenges. Theoretically, the charge is levied to internalize external costs. The charge should be based on the difference between total (costs of driving a car and costs borne by third parties) and private costs. The challenge is that ex-ante the demand equation and hence the demand elasticity are not easy to determine (it depends on the local situation such as alternative routes, alternative modes of transport, etc.). Therefore, it is difficult to determine the socially optimal level of the charge. However, the price elasticity is generally higher in corridors where public transport is better developed and hence a more convenient alternative. An integrated approach that implements congestion charging (push) and improves public transport (pull) therefore leads to a more significant shift to public transport with a lower toll charge (high cross-price elasticity). In Singapore's electronic road pricing (ERP), prices have been adjusted frequently and provided interesting data on price elasticity of the demand.

The **Elasticity of demand** (percentage response in demand to a price change) for the usage of private vehicles can in some cases vary considerably between increased fuel prices and congestion charge. While most literature considers short-term elasticity of fuel price increases to be around -0.1 to -0.15, the short term-elasticity of congestion charges in London is between -0.42 and -0.47 for the initial price of £5 but only -0.16 for the increase from £5 to £8. In Singapore the elasticity on expressways lies between -0.19 and -0.22 and, opposed to London, grew over time. (ToL 2008, Olszewski 2005)

Further information on ex-post evaluation:

The Stockholm Toll: An Economic Evaluation (2006), Remy Prud'homme and Pierre Kopp

Figure 12: *Swedish "road toll" sign*

Elasticity grew over time, meaning that road users became more sensitive to changes in prices and more rapidly changed their mode of transport or time of travelling. An on-going monitoring of prices and traffic flow is hence suitable.

3.3.2 Case Study: London Congestion Charging

Since February 2003 the city of London has charged a fee for driving private vehicles in its central area during weekdays as a way to reduce traffic congestion, add bus lanes and raise revenues to fund transport improvements. This has reduced traffic congestion, improved bus and taxi service, and generated revenues, some of which have been spent to improve public transport services. Drivers in the central parts of London spent 50% of their driving time in queues adding up to an estimated $3-$6 million being generated every week. When launched in 2003 the toll was £ 5 (ca. 8 US$) and was increased to £8 in 2005. In 2011 the charge was differentiated if paid the day after entering zone £11, £10 paid in advance or on the day of travel and £9 if registered with Auto Pay. The charge is collected from Monday to Friday from

7am to 6pm. Since 2011 electric-vehicles, vehicles emitting less than 100g/km of CO_2 and meeting the Euro 5 standard and vehicles with more than 9 passengers are allowed to enter the zone free of charge. Residents within the restricted zone receive a 90% discount. Exemptions are also made for taxis, public transport, disabled people and emergency vehicles. The congestion charging area has been adjusted since the "western extension" has been first added and later removed.

Although revenue was much smaller than expected due to high implementation and operational costs, 80% of revenue was invested in public transport and another 11% in road safety measures.

Impact

Before the implementation of congestion charging a 10-15% reduction in traffic volumes and a congestion reduction of 20-30% was modelled. After implementation congestion was reduced by about 25% percent and traffic levels by 20% in the first two years after implementation. However, congestion slowly increased thereafter and stabilised at a reduction of 8% compared to the pre-toll situation. Around 110,000 motorists pay the charge daily. In the first two days the traffic levels fell by 25% while drivers stated that journey times cut in half. Transport of London, the administration responsible for the scheme, found out that in the six months after implementation 60,000 cars less were driven in the zone compared to the year before. Around 50-60% shifted to public transport and 20-30% avoided the zone. The modal share of care automobile reduced from 12% to 10%. This lead to a reduction of congestion delays of buses by 50%.

This scheme is estimated to have reduced traffic related CO_2 emissions by 19% and fuel consumption by 20% within the charging zone, due to a combination of reduced vehicle travel and reduced congestion delay. These benefits further arise because the traffic is moving faster and emissions are higher, per km, at very low vehicle speeds and frequent stop- and-go. Traffic speed increased significantly by 37% from 13km/h to 17km/h. The expected increase in emissions from buses have been mostly offset by the widespread introduction of particle traps to the new and existing bus fleet as well as the introduction of newer technology bus engines.

Success Factors

Stakeholder Consultation

Traffic congestion is considered a major problem in London. Before the charging scheme was introduced, more than 80% of residents stated that congestion needs to be reduced. Nevertheless, only 40% supported the congestion charging scheme. This could be due to the fact that more than 50% believed that congestion charging would not reduce congestion. Whereas after implementation 75% believed it has reduced congestion. Interest groups widely criticised the plans of a city toll. Nevertheless, the mayor made the implementation of road pricing part of his agenda for the electoral campaign which he won and guaranteed public back-up afterwards. Furthermore, the political power of London's mayor is broader than compared to most other European cities. Hence, after being elected carrying out the scheme was easier. Nevertheless Transport for London conducted an 18-month stakeholder consultation to ensure all concerns were addressed. A survey within a business group (London First) indicated the success of the programme: The majority (69%) felt charging had no impact on their business, 22% reported positive impacts on their business, and only 9% reported an overall negative impact.

Picture 13: *Entry into the central zone of the congestion charged area*

Photo by Carlos Pardo, London (United Kingdom), 2008

Local Circumstances

Public Transport in London was already widely made use of before the cordon scheme was implemented. 85% of passengers entering the city centre were previously travelling with public transport. That is, there was an alternative to the private car in place which also explains the high price elasticity mentioned above. However, public transport especially the subway is very crowded so the dedicated funds (£130 million pounds are committed for a further improvement of public transport) need to ensure an increased capacity of public transport. As a result the subway ridership only increased by 1% whereas bus ridership increased by 14%.

The street layout in London was another success factor in reducing congestion within the city. Traffic could easily be diverted to the outer ring road and hence reducing congestion in the city boundaries. Although there is 10% more traffic on the peripheral roads, journey times on them have not increased and congestion even slightly reduced, in part because traffic signal systems on these roads were adjusted in anticipation of these traffic shifts. These local circumstances cannot easily being adopted to other cities as the availability and quality of alternative roads might not be sufficient and may lead to relocation of congestion. London's experience shows that congestion pricing is technically feasible and effective, and that it is possible to overcome the political and institutional resistance to such pricing. However, it requires a suitable combination of travel and political conditions, including widely dispersed benefits and the ability to overcome public scepticism. Compared with other cities London has a particularly small portion of automobile commuters, and many of them reside outside the city. As a result, a relatively large portion of voters perceive direct benefits from the fee.

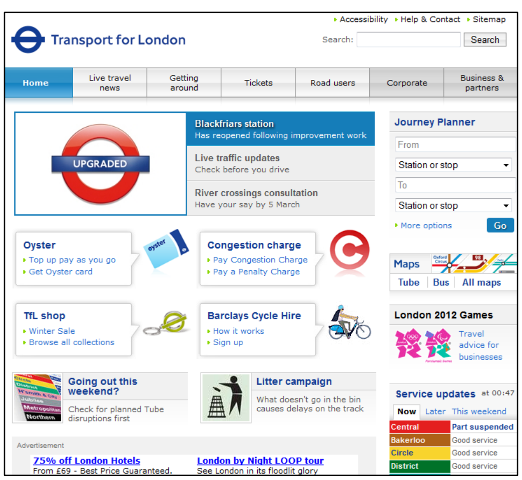
Comprehensive Strategy

Although congestion charging tends to receive the greatest media and technical attention, it represents only part of London's transportation demand management programmes. Improving walking and cycling conditions, and improving bus service, made possible in part by congestion charging revenue, has also contributed significantly to reducing traffic volumes and associated problems such as congestion, accidents and pollution.

Weaknesses

Planned as cordon pricing the fee is neither based on the amount miles a vehicle is driven within the charging area (once paid the fee once can drive limitless in the charging area) nor based on the level of congestion. The congestion charges therefore do not reflect the marginal user costs but rather average externalities. However, a flat fee can be used as it is less sophisticated. Once drivers are used to a new system it is easier to implement an upgraded system with variable fees. Widely criticised are the high overhead costs of the system. Nearly 40% of London's congestion pricing revenues are used to cover pricing administration costs – but unit costs decline as systems expand so costs are distributed over more vehicle travel. Hence, the implementation for large metropolitan cities is more cost efficient than for smaller cities. The City of London significantly underestimated the costs of the congestion charging scheme. The costs were nearly double as high as expected. This was mainly due to higher costs of enforcement than expected. At the same time, revenue was considerably less than projected. The success in reducing the number of vehicles higher than expected was a set back from a revenue point of view. Further, the higher number of exempted cars led to a cut in revenue but to an increase in share of low-emission vehicles.

More Information



The Transport for London website provides extensive customer services, data and monitoring as well as evaluation reports: www.tfl.gov.uk

3.3.3 Case Study: Singapore Cordon and Congestion Pricing

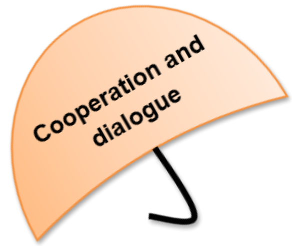
Singapore first implemented an Area Licensing Scheme (ALS), which required vehicles to have an Area license to operate within specific areas, in 1975 and then a Road Pricing Scheme for expressways. To enter the restricted area, drivers had to purchase a paper license (US$ 2.20 daily or US$ 43 monthly). Highly occupied vehicles, i.e. four persons minimum, were given free entry. A major disadvantage of the paper-based area licensing scheme was that, once the licence was bought, the vehicle could enter the area as often as desired and was not charged a higher fee when the roads were congested. To address this problem, the ALS was replaced by Electronic Road Pricing (ERP) in September 1998. It is designed to minimize traffic congestion and maintain optimal traffic speeds of 45 to 65 km/h for expressways and 20 to 30 km/h for arterial roads. The charging area is divided into central business districts (cordon pricing), expressways and ring roads (congestion pricing). There are no toll booths and there is no need to reduce speed for detection. The in-vehicle unit accepts cash cards and communicates with detectors when passing under gantries and the respective charge is deducted from the card. The amount varies by time of day (rush hour is 2-3 times more expensive), type and size of vehicle (taxis and passenger cars according to engine capacity, goods vehicles and buses and others) and the type of road (arterial and expressways). Different vehicle types are equipped with different in-vehicle units and can therefore easily be detected. The cash card can also be used to enter parking facilities without having to stop.

Impact

Several Studies have concluded that the ERP has reduced congestion and pollution significantly and, in conjunction with a comprehensive TDM strategy maintained high mobility (see success factors below). The establishment of the restricted zone (RZ) within the ALS scheme led to a reduction of 31% of traffic in the city area which is mainly due to motorists not using the CBD as a bypass. Through the ERP the morning peak hour traffic was reduced by 7-8% compared to the ALS system. This is mostly due to a reduction of multiple trips within the restricted zone. The total traffic decreased by 13% while traffic speed increased by 22% in the RZ. Off-peak traffic was reduced by 7,6% while evening traffic increased by 28%. This is due to a reduction of charges compared to the ALS system during evening hours. A total of 80,000 kilogram of CO_2 emissions were reduced (ITDP 2011). ERP's revenue significantly exceeds its operation costs. Hence, surplus can be used to improve the public transport system.

Success Factors

Cooperation and Dialogue



The Land Transport Authority of Singapore operates under the Ministry of Transport (MoT). It is a result of a merger between the Registry of Vehicles, Mass Rapid Transit Corporation, Roads and Transport Division of the Public Works Department of the MoT and the Land Transport Division under the Ministry of Communications. Through this merger one organization is able to implement pull and push measures without avoidable transaction costs and boundaries between institutions. Further the exchange of valuable information that is usually difficult between separate organisations was simplified.

Comprehensive Strategy

ERP was part of a comprehensive strategy that included integrated land use and transport planning. Through this planning approach a better mix of employment and residential uses decreased the need to travel. The highest building density is concentrated at and around train stations to guarantee maximum accessibility. In addition to the ERP and the land use planning, Singapore provides a high quality public transport system with a rail system (mass transit and light rail) as a backbone, a BRT system with priority lanes and integrated contactless ticketing. Currently the modal split of public transport is higher than 60%. The strategy is complemented by a vehicle quota system (bidding for tender).

Picture 14: *The mix of TDM measures has greatly reduced congestion.*

Photo by Carlos Pardo, Singapore, 2008

High Public Acceptance

The second success factor is the high public acceptance in Singapore. The ERP is considered fair as it charges on the basis of the user-pays-principle while vehicle tax rates have been lowered. It is further considered convenient because of its high technological standards. Furthermore, embedding and communicating comprehensive strategies that include alternatives for private car ownership such as public transport increased acceptance. Information on ERP was mostly published in Newspapers and on TV, Radio and the Internet. Brochures were distributed to every car owner.

Reliability

During a test period cars were equipped with the in-vehicle unit, but not charged, which helped to solve technical errors and to get familiar with the system. Over a 9-month period, five million transactions were tested before implementation. The reliability is another important factor why the system is widely accepted (less than 0.03% of in-vehicle units have technical problems).

Enforcement

The last success factor is enforcement. In case of insufficient credit on the device or no system having been installed, cameras automatically take a picture of the violation vehicle and send it to the closest control centre (0.5 % of 260,000 daily transactions involve violation mostly by motorists who forgot to insert the card).

More Information on Singapore

Website of the Land Transport Authority Singapore: www.lta.gov.sg

Implementing Road and Congestion Pricing - Lessons from Singapore, Jeremy Yap Ministry of Transport Singapore (2005)

Road Pricing: Singapore's Experience, Chin Kian Keong (Land Transport Authority Singapore) (2002)

3.3.4 Case Study: High Acceptance of the Stockholm Congestion Pricing System

Starting in January 2006 the City of Stockholm, Sweden, began charging vehicles entering the inner city area on weekdays between 10 and 20 kronor (US$1.27 to US$2.54) per trip depending on whether entered during peak hours or not. The trial period ran for seven months, and on 17 September 2006 Stockholm residents voted to make the system permanent. The Stockholm toll was intended to reduce congestion (10-15% reduction in number of vehicles entering the restricted city area), to improve the environmental situation, road safety and the street-level environment. In 2005, just before the trial period started, other measures were taken to improve the traffic situation including expanded transport services (new bus routes, more frequent rail, new park and ride facilities). There are 18 control points located at Stockholm city entrances and exits. Almost 30% of the vehicles within the restricted zone are free of charge (e.g. taxis, buses, alternative fuel cars for 5 years, foreign cars, hybrid vehicles). Evenings (after 6.30pm), weekends, the month of July and holidays are free of charge.

The decision to implement congestion charging in Stockholm was made by Parliament on national level as the congestion charge is treated like a tax.

Impact

Objective	Achievement during trial period
Reduce traffic by 10-15%.	25% reduction
Increase average speed.	Travel time reduced by 30-50%
Reduce emissions.	CO_2: -14% to -18% NO_x: -8% PM_{10}: -9%

The Stockholm toll reduced traffic volumes by about 25% and during peak hours by 22% during the trial period. One year after the trial the reduction within the zone compared to 2005 lessened to 18%. The smaller effect over time is on one hand due to a large number of drivers who decided not to drive directly after the toll was imposed and on the other hand due to the increasing number of vehicles driving with alternative fuels that are exempted from the charge. The number of alternative-fuel vehicles registered in the zone, increased from 3% during the trial to 13% in 2008. During the trial the toll removed 100,000 vehicles from the roads during peak business hours and increased public transit usage by 40,000 users per day (4.5% increase). Hence, almost half of the reduced trips were absorbed by public transport. After making the system permanent, the transit usage increased up to 80,000 more users per day compared to 2005. About 350,000 vehicles per day pay the fee, generating between 3,500,000 and 21,000,000 kronor (US $500,000 to $2.7 million) in daily revenue, not counting revenue from the 630 kronor (US $77) fee charged to those who forget to pay the tax. Retail sales in central Stockholm shops increased compared with the same month in 2005, including significant increases in grocery sales in central neighbourhoods, which probably reflects increased purchases by area residents who are more likely to shop locally rather than drive to shop. Surveys show that exemption from the congestion tax is the single most significant incentive for those buying alternative-fuel vehicles in Stockholm. The influx of low-carbon cars helped cut greenhouse gas emissions in the congestion zone by 14-18% (CO_2) and in the greater Stockholm area by 2-3%. NO_x was reduced by 7%, and particulates (PM_{10}) by 9%. Taxis are no longer exempted from the tax, as they were during the trial, but even though a proportion of taxis are using alternative fuel vehicles, this does not fully account for the rapid increase in the number of passages by alternative fuel vehicles.

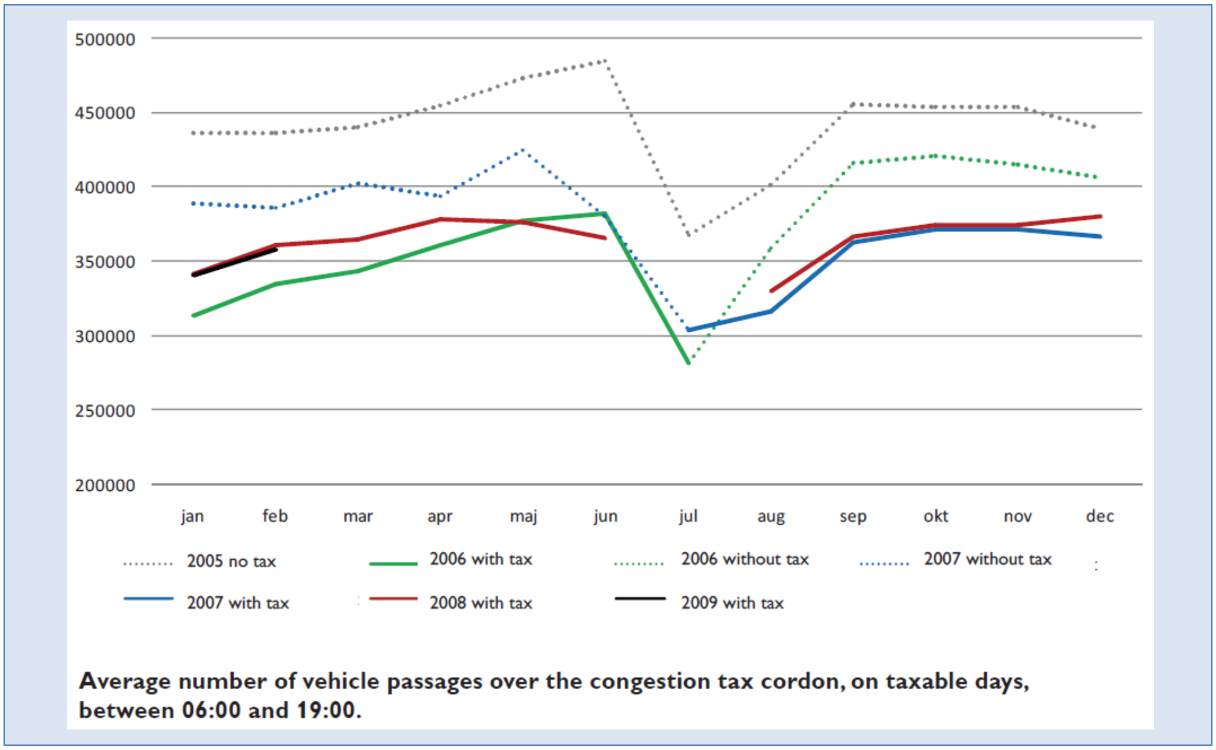


Figure 13: *Analysis of the effects of the congestion charge in the years 2005-2009. It displays the average number of vehicle passages over the congestion tax cordon on taxable days between 06:00 am and 7:00 pm.*

Source: City of Stockholm; www.stockholm.se/trangselskatt

The City of Stockholm further concluded that only 0.1% of the reduction in traffic volume was due to expansion of public transport. This is mainly due to a bus network that was rather effective even before the trial period. Therefore the increasing market share of public transport is mainly a result of higher costs of car travel. Mostly middle income groups changed their pattern travels as lower income groups usually already use public transport whereas higher public transport groups have the means to pay the toll fee and usually have a higher value of time (due to higher salaries as the opportunity cost).

Many cost-benefit analyses (CBA) were conducted ex-post using actually observed data and no estimations (using the variables explained above in "Benefits and Costs"). While consumer surplus was negative (mostly due to the paid charges), there is a positive socioeconomic surplus (investment costs not included). If one considers the value of time for service and professional travellers being rather high, compared to leisure time, their benefit was much higher than the congestion charge they had to pay.

The Stockholm trial had considerable side effects. Even outside the restricted zone traffic reduced so the often feared shift of congestion to other roads did not materialize. Only one free of charge city bypass experienced slight increase in traffic. The inner city traffic around the cordon zone decreased by 15%. Road safety seems to have improved in the cordon area.

Although the short evaluation period (7months) makes it difficult to evaluate the effect of the toll on road safety the decline in accidents with injuries is estimated between 9-18%. The effect of higher speed on accidents is much smaller than the effect of reduced vehicle kilometres travelled (between 40 and 70 personal injuries per year). No visible effects have been observed on car pooling or park-and-ride. Further, no significant noise effects were observed.

Success Factors

Public and Stakeholder Involvement

The public attitude towards the toll system was positively affected by the trial period. The fact that the public was involved in whether the toll should remain or not led to a high public acceptance as more residents had incentives to inform themselves about the purpose and the projected effects. The trial period itself was a success. The City was able to collect valuable data during this period indicating benefits for most users. At the same time the effects of a more "liveable city" through pollution and congestion reduction was visible.

The evaluation of the trial period involved interest groups, authorities and experts and had a strong academic backup from universities. Before introducing a congestion charge in Stockholm, 51% of the residents stated that the charge is a fairly/very bad decision. After the trial only 42% maintained this opinion. 54% considered it fairly/very good. 35% of the residents stated that after implementation their opinion of the toll improved. After the system was made permanent, 67% are in favour of the congestion charge. One has to consider that the first poll was slightly biased by the fact that the system was already installed so the question whether to make it permanent or not was also influenced by the fact that considerable sunk costs (costs that cannot be recovered) had already been incurred.

Reliability and Convenience

The Swedish Road Administration contracted private partners to install the system. New technology is used for detection, enforcement and payment. Vehicles are registered automatically by cameras that photograph the number plates. Those vehicles equipped with an electronic on-board unit (transponder using RFID - Radio Frequency Identification technology) for direct debit payment are also identified through this means. If not equipped with an on-board unit, payment can be made via bank transfer or paid at local selected shops. 65% of drivers use the automatic debiting, 22% prefer manual payment at shops while the remaining pay via internet transfer. As the charge varies in accordance with the time of day, drivers are informed on electronic boards on the current pricing level. The proportion of data which was handled without loss reached 99.997 per cent showing that the system is very reliable.

More Information on Stockholm

Stockholm City Administration:
www.stockholmsforsoket.se/templates/page.aspx?id=183

Several cost-benefit analyses and case studies were reviewed and quoted and can be found in the bibliography.

3.4 Parking Management and Pricing

Vehicles require a parking space at every destination. Most urban areas have two to four off-street parking spaces for each motor vehicle (one at the owners' home, one at their worksite, and parking spaces at other destinations such as stores), plus various on-street parking spaces. These parking facilities are costly to build and operate, an urban parking space often costs more than the vehicles that occupy it, and policies that increase vehicle parking supply often have undesirable indirect impacts by encouraging urban sprawl. In addition, vehicle parked on sidewalks and pathways tends to degrade walking and cycling conditions and drastically slow down public transport and hence make it less desirable as an alternative to private vehicles.

Parking Management and Pricing:

… increased the modal share of public transport from 20% to 48% over 20 years in Portland.

… reduced traffic by up to 9% in Park Slope, New York.

Parking Management as Part of Mobility Management in Munich

As an attractive city for business and residents, Munich is expecting a rapid increase in private vehicles in the greater Munich area. Through various parking management policies Munich is expecting a two percentage points lower modal share of private vehicles compared to the baseline scenario. The approach includes the following measures:

- Improved steering of **parking demand** (maximum parking time, expansion of parking fees, resident parking)
- **Management of supply** (parking information, multiple usage of private parking space: public parking during business hours, private parking from 5pm to 7 am)
- **User-oriented** supply management (e.g. park and ride)

To ensure high-quality evaluation the City of Munich developed an IT based monitoring system in conjunction with the Technical University of Munich to monitor the success through random surveys, enforcement data and parking ticket evaluation (duration and total amount of tickets).

The parking management approach is part of a comprehensive mobility management strategy that includes:

- Expansion of **public transport** network (underground, bus corridors, trams), improved harmonisation and integration of schedules
- Rehabilitation of road network and concentrated expansion of regional highways
- Construction of a **City Logistics Terminal** (improved efficiency of train to city freight trucks transshipment to increase competitiveness compared to road freight transport).
- **Mobility Management** (e.g. job tickets, traffic information, traffic flow management)
- Expansion of **non-motorised transport** network (pedestrian and bicycle network, 3000 parking spaces for bicycles at bus and tram stations, marketing)

Sources: Presentation "Parkraummanagement München: Ein Teil der Gesamtkonzeption zum ruhenden Verkehr" by Dipl.-Ing. Christine Weis-Hiller and "Verkehrsentwicklungsplan" (2005), both published by Munich Department of Urban Planning and Building Regulation

Types of Parking

Table 3 defines and illustrates various types of parking facilities, and describes their rule they can play in an efficient parking system. These categories overlap, for example, a surface parking lot can be unpriced, priced but serving a single destination, or commercial. Parking facilities that are priced and serve multiple destinations tend to be used most efficiently.

Table 3: *Parking facilities that are priced and serve multiple destinations tend to be most efficiently used.*

Type		Costs and density	Role
On-street (or curb) Designated parking spaces located within a road right-of-way, usually in the curb lane.		Moderate construction costs and high density (relatively little land used per space) because they require no driveway.	Convenient to use, and can serve multiple destinations. On-street parking should be managed for maximum efficiency.
Surface parking A parking lot directly on the ground (either paved or unpaved).		Low to moderate construction costs. Low density (they require lots of land per space, including driveways and circulation lanes.	Inefficient if they serve a single destination. Should be minimized and managed for efficiency.
Structured or underground Any multi-story parking structure (often called a parking garage, parkade or ramp), including parking facilities within or under a building.		High construction costs but relatively low land costs and high densities.	Supports compact development but must be efficiently managed to justify their high construction costs.
Priced (or metered) Any parking facility where motorists are charged directly for use, including on-street metered parking, and off-street lots where motorists pay by the hour, day, week, month or year.		Varies. Can be applied to any type of parking structure.	Pricing tends to encourage efficient use of parking facilities.
Commercial parking A for-profit parking lot available to any motorist and serves multiple destinations.		Varies. Can be applied to any type of parking structure.	Tends to be efficient because it is priced and usually serves multiple destinations.

Photos by Todd Litman

In the past, cities tended to solve parking problems simply by increasing supply, for example, by converting more curb lanes and sidewalks into parking, subsidizing the construction of municipal parking facilities and by increasing the number of parking spaces required in new development. However, this is costly and unfair. It encourages motorists to use parking facilities inefficiently, for example, commuters parking all day in prime locations that should be available for delivery vehicles and customers, leading to parking congestion and causing motorists to cruise for available parking spaces, which increases urban traffic congestion and air pollution. Because parking facilities are used inefficiently, more parking spaces are needed to serve an area, which increases total costs. Abundant, subsidized parking encourages increased automobile ownership and use, which exacerbates other transportation problems, including traffic congestion, accidents, energy consumption and pollution emissions. Parking subsidies are unfair because they force everybody to pay for parking facilities regardless of whether they use them.

Picture 15: *Parking spaces painted over a cycle path in Beijing (P.R. China)*

Photo by Daniel Bongardt, 2011

In recent years many cities have started to apply a new parking planning *paradigm* (that is, a new way to define parking problems and evaluate potential solutions). This new paradigm reflects the following assumptions:

- There are many types of parking problems, including inadequate or excessive supply, too low or high prices, inadequate user information, and inefficient management
- Parking facilities should be managed for efficiency, to maximize their value and minimize the number of parking spaces needed to serve each area.
- As much as possible, users should pay directly for parking facilities.
- Parking should be regulated to favor higher priority uses and encourage efficiency.
- Parking requirements should be flexible to reflect demands in each situation.
- Parking management solutions should be considered and applied whenever they are more cost effective than expanding parking supply.
- Intelligent Transport System technology should be implemented for easy parking process, park space availability check and quick payment options

More efficient parking management can significantly reduce the number of parking spaces required to serve an area. It includes more sharing of parking spaces among different users and buildings, regulations and pricing that favors higher value users for the most convenient parking spaces (such as favouring delivery vehicles and customers over employees and residents for the spaces in front of a store or factory), and better user information to help motorists choose the parking space that best meets their needs.

Efficient parking pricing means that, as much as possible, motorists pay directly for using parking facilities, with higher rates where parking facilities are more costly to build, or where parking facilities are congested. This means, for example, that municipal governments charge for on-street parking in commercial and residential areas, that businesses charge for parking or offer their employees a choice between subsidized parking or its cash equivalent (called *parking cash out*), and that parking spaces are rented separately rather than automatically included in the rent of apartments and offices (called unbundling).

Old Versus New Parking Paradigm

Automobile parking is an important component of an urban transport system, but there are various possible ways to provide parking. The older planning paradigm assumes that motorists should have on-site or on-street parking provided free or for minimal charge at each destination. This is common in automobile-oriented suburban areas where it is difficult to walk between destinations. Municipal governments support this by applying generous minimum parking requirements in zoning codes, and maximizing the supply of on-street parking.

The new paradigm assumes that motorists will usually use neighbourhood parking facilities and walk to their destinations. This is common in multi-modal urban areas where it is easy to walk between destinations. Municipal governments can support this approach by encouraging development of commercial (private, for-profit) parking services and efficiently managing on-street parking through effective regulations and pricing, and by improving user information and walking conditions in each district to insure that parking spaces are always available, and motorists can easily find an available parking space and reach their destinations. This new paradigm supports and is supported by other transport and land use policies, including more compact, mixed land use development, and improving walking, cycling and public transit in an area.

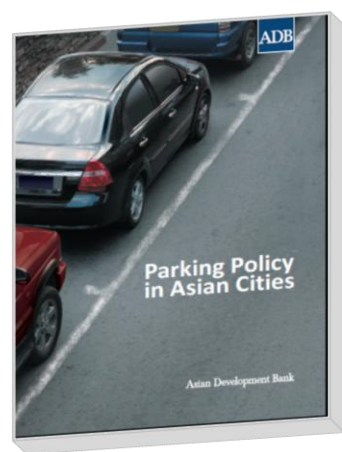
Many areas apply a combination of these approaches, with some on-site parking to serve some visitors, including deliveries, visitors, customers and people with disabilities, but use of shared, off-site parking for a major share of trips, particularly commuters and residents. Shifting toward the new paradigm supports more sustainable urban development and so should be favoured by public policy.

The old paradigm assumes that every building should include enough on-site off-street parking (parking facilities within or adjacent to the building) to serve all visitors. The new paradigm strives to use parking facilities efficiently by encouraging more sharing of parking among different types of users and destinations, using more off-site parking, and in some cases, by encouraging travellers (particularly commuters) to user other modes of transport. Most major cities (e.g. New York, Tokyo, Singapore, London, Paris, Berlin etc.) around the world are shifting from the old to the new paradigm, and so are developing policies that support efficient parking management (Kodransky and Hermann 2011). This is one of the most effective TDM strategies suitable for local implementation.

In most communities, a significant portion of parking is either unpriced or inefficiently priced. As much as possible parking prices should vary to reflect demand, with higher rates at times and places with higher demand with a target of insuring that at least 15% of parking spaces are unoccupied in any area, and shorter time units (motorists should pay by the minute or hour, rather than by the day, month or year, so they have incentives to reduce the amount of time they park) and no discounts for longer-term users.

A study by Barter (2010) for the Asian Development Bank investigated parking regulations, supply, pricing and management practices in various Asian cities including Beijing, Guangzhou, Hong Kong, Seoul, Taipei, Tokyo, Ahmedabad, Dhaka, Bangkok, Hanoi, Jakarta Kuala Lumpur, Manila and Singapore. It found that, although these cities are very dense, with high land values and intense congestion, most have adopted planning practices designed to insure adequate parking supply and low prices, including generous minimum parking requirements for new development, and un-priced or low-priced on-street parking, particularly outside of commercial areas. Parking pricing is widespread, although poorly regulated and enforced. The study found that a significant proportion of parking is free-of-charge for motorists, even in dense cities with high property prices and therefore high opportunity cost for parking space.

More Information



Paul Barter (2010): *Parking Policy in Asian Cities*, Asian Development Bank (www.adb.org); at http://beta.adb.org/publications/parking-policy-asian-cities

Various parking management strategies are described below. They are usually best implemented as an integrated programme in conjunction with other TDM strategies in order to maximize their effectiveness and benefits.

Reduced and more flexible minimum off-street parking requirements

Although most cities have minimum parking requirements in their zoning codes, many experts believe that they are unnecessary and can be harmful because they increase development costs in higher density areas, and they increase vehicle ownership and use. Instead, many experts recommend that cities greatly reduce or totally eliminate minimum parking requirements so developers can decide how much parking to supply in their buildings, and allow private companies to provide commercial parking facilities in each district to serve motorists based on market demand. Many cities are reducing or eliminating their parking requirements, particularly in downtown areas and transit-oriented developments. For example, in 1997 the city of Victoria, British Columbia eliminated parking requirements in the Harris Green neighbourhood which is adjacent to downtown. In subsequent years numerous condominiums and apartments were constructed, most with fewer than half the number of parking spaces that would be required by the city's regular zoning code, and some without on-site parking at all, since residents who own vehicles can park them in nearby commercial garages.

Reducing minimum parking requirements is a foundation for other parking management strategies by giving property owners an incentive to implement other parking management strategies. For example, if a 100 employee office building is constructed with 100 parking spaces, the building owner will have little incentive to implement efficient parking management since that will result in some parking spaces being unused. If the building is constructed with fewer parking spaces, the operator will have an incentive to implement strategies such as shared parking, efficient pricing, and encouragement for commuters to user alternative modes.

Beijing's current parking requirements are relatively low, as indicated in the following table. As part of the city's transportation demand management programme the city should maintain these low requirements or eliminate them, at least in business districts, and instead encourage development of commercial operators in each neighbourhood. Office buildings in Beijing are equipped with multi-level parking spaces, which should best be efficiently priced and not subsidized for the commercial offices. This tends to be most economically efficient and equitable because these parking spaces are shared and priced. Further, Beijing is exploring Park and Ride in the periphery of the city.

Table 4: *Car parking requirements in selected Asian cities (Barter 2010)*

City	CBD office building	Non-central office building	Non-central shopping center	Average requirements
	Spaces per 100 m² of gross floor space			
Beijing	0.5	0.5	0.3	0.35
Tokyo	0.3	0.3	0.4	0.36
Singapore	0.2	0.5	0.5	0.42
Hong Kong	0.4	0.6	0.4	0.46
Dhaka	0.5	0.5	0.5	0.50
Guangzhou	0.6	0.6	0.6	0.60
Ahmedabad	0.7	0.7	0.7	0.65
Taipei	0.7	0.7	0.7	0.67
Seoul	0.1	1.0	1.0	0.78
Hanoi	1.0	1.0	1.0	1.00
Manila	1.3	1.4	1.0	1.19
Jakarta	1.0	1.0	1.7	1.33
Bangkok	1.7	1.7	2.6	2.15
Kuala Lumpur	1.5	2.6	2.7	2.83
Sydney	0.0	3.3	4.0	2.83

Globe and Mail, 30 January 2012

Parking being squeezed out in Vancouver

by Frances Bula,

At Graham McGarva's architecture firm, only five of the 20 employees commute to work by car. And that's a high ratio compared with other workplaces nearby. So he knew already that office parking downtown was becoming less of an essential item. But the point was really driven home when his firm, VIA Architecture, went to work on a new office tower that will face the city's former train station, now its top transportation hub for commuter rail and buses.

The owner of the site, at 320 Granville, is tearing down a 50-year-old parking garage that is becoming less profitable every year. And, in the new 32-storey office tower that will be built in its place and likely house as many as 1,800 people, Mr. McGarva is including only 133 parking spots – less than half of what would have been required two decades ago and a quarter of the norm in the 1960s.

He's not the only one – other office builders in Vancouver are doing the same. "We're all seeing different aspects of that trend," Mr. McGarva says.

"In the old days," says Vancouver's planning director, Brent Toderian, "they would have had to not only build the parking required for the new construction" – about 300 stalls – "but you would have had to replace the parking of the old garage." In this case, the parkade that will be torn down has about 500 spaces.

Vancouver's 1997 transportation plan capped downtown parking and banned new roads. Since then, the number of car trips and parking spots has gradually declined, even while the number of jobs and overall trips in the central city have increased. Back then, the parking standard was one stall for every 1,000 to 1,500 square feet. Today the figure is far less – and negotiable for every building. That's in spite of the fact that today's buildings hold twice as many people in these open-plan, cost-cutting times.

Last year marked a big change in parking behaviour as commuters responded to a new 35-per-cent tax on parking stalls in commercial lots, higher on-street parking costs, and the new Richmond-to-Vancouver rapid-transit line built for the Olympics that has proven to be a huge hit with the downtown crowd.

Parking revenue collected at city-owned garages dropped by 9 per cent, while funds from on-street parking, traditionally an ever-increasing moneymaker, did not rise as much as the city's finance department had been counting on. The trend is also showing up in the underground lots of commercial buildings, both in the downtown peninsula and the city's second downtown along Broadway. The city's transportation engineer, Jerry Dobrovolny, commissions a usage survey every two years. "There's a high vacancy rate in the majority of those buildings. And the studies show the vacancies are rising. At the peak – noon to 2 p.m. – some are only half full," Mr. Dobrovolny says.

For proposed office buildings, predicting what's needed is a tricky business. Put in too many spaces and you've added a big expense that makes no money. Put in too little and you may have trouble leasing the building.

"Notwithstanding what developers want to do, I have to build something I can lease," says Tony Astles, an executive vice-president at Bentall Kennedy (Canada) LP, which has been building and leasing office buildings in Vancouver for decades. "Parking is a negative drag on your pro forma, yes. But tenants are slow to respond to the evolution that's been occurring. And that evolution is only two years old."

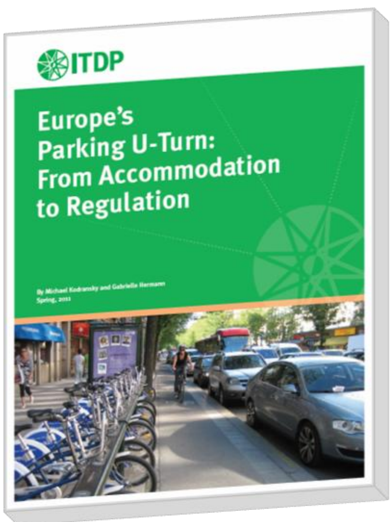
Mr. Astles says the toughest part of his leasing job at Bentall's Broadway Tech Centre is convincing prospective tenants that they really don't need the same number of spaces they had in suburban business parks far from transit. To convince the doubters, Mr. Astles introduces them to other tenants who believed they needed a high level of parking and then found that more employees commuted by bus than by car once they had better transit options. Sometimes prospective customers can't be convinced. Corporate real-estate broker Glenn Gardner has had tenants reject downtown buildings where they couldn't secure the standard amount of parking.

"Law firms, large mining companies, accountants – they want the convenience of parking in their building," said Mr. Gardner, who is with Avison Young's Vancouver office. Sometimes they just want the convenience of having a 24-hour downtown spot. Former B.C. attorney-general Geoff Plant, now back at his practice at the blue-chip law firm Heenan Blaikie LLP, rides his bicycle to work three or four times a week from the west side of Vancouver. He still has a parking spot, however, which he uses when he and his wife attend evening theatre events. But, he says, "I do wonder how much longer that will make sense." Every year, he commutes more often by cycling, walking or jogging and uses his spot less.

Web: www.theglobeandmail.com/report-on-business/industry-news/property-report/parking-being-squeezed-out-in-vancouver/article2319946

If a city does impose minimum parking requirements, it should provide adjustment factors that reduce the requirements for development that is more accessible locations (such as buildings located in a walkable, mixed use neighbourhood or near a transit station), for efficient parking pricing (if motorists pay directly for using a parking space), or for implementing other demand management strategies (for example, if an employer has a commute trip reduction programme, or if a residential building has a carshare vehicle on site). For example, after a technical review the City of Vancouver significantly reduced its parking requirements and now offers a Sustainable Transportation Credit Programme that allows developers more flexibility based on specific location and circumstances, such as being located near a major bus route to rail station, if they have carshare vehicle parking, and if they provide transit passes to building occupants.

More Information



Michael Kodransky and Gabrielle Hermann (2011), *Europe's Parking U-Turn: From Accommodation to Regulation*, Institute for Transportation and Development Policy (www.itdp.org); at www.itdp.org/documents/European_Parking_U-Turn.pdf

Limit Parking Supply

Some cities limit the maximum number of parking spaces developers may build in certain areas, such as downtowns in order to limit total downtown traffic and encourage more efficient parking management. For example, Portland, Oregon set a limit of 40,000 total parking spaces in their downtown, which has increased public transport mode share from 20-25% in the 1970s to 48% in mid 1990s. Similarly, for more than thirty years both Zurich, Switzerland and Hamburg, Germany have prohibited any net increase in city center parking supply. When a new off-street space is built (for example, in a new building), an on-street space is removed and converted to other uses such as wider sidewalks or bikeways. In addition, outside the city center Zurich only allows developers to build new parking spaces if the surrounding roads can absorb additional traffic without congestion, and the air can handle additional pollution without violating ambient air quality norms. This policy has helped make Zurich one of the most liveable cities in Europe.

Encourage Sharing of Parking

Efficient parking management encourages various types of sharing, so each parking serves multiple users and each parking lot serves multiple destinations. For example, rather than an office building, a shopping center and a restaurant each having an exclusive on-site parking lot it is more efficient if these three building share one or more parking facilities since the office parking demand peaks during weekdays, the shopping center demand peaks during evenings and weekends, and the restaurant parking demand peaks during evenings. In some cases buildings have no on-site parking, but in many cases they have some on-site parking supply but rely on shared off-site parking for a portion of demand, for example, a shopping center that has parking for delivery vehicles and some customers, but relies on nearby off-site facilities for employee parking and overflow parking.

Public policies can encourage this type of sharing in several ways. Governments can either build parking facilities or encourage commercial operators to supply parking in each district. They can manage city-operated parking facilities efficiently though regulation and pricing of on-street parking and any off-street parking lots they control (for example, at municipal buildings). If cities impose minimum parking requirements they can offer in lieu payments, so developers are allowed to contribute toward the construction of a central parking garage rather than building their own parking on-site. Governments and business organizations can perform local parking studies, develop local parking plans, keep track of local parking supply (so for example, a business can easily identify nearby parking spaces that may be available for rent to meet growing parking demand), and establish transportation management associations that provide local parking management services.

Expand Parking Pricing

In most cities, a major portion of parking is unpriced, including on-street parking in residential areas, and off-street parking provided by businesses to their employees and customers. Cities can install parking meters on more streets, charge more for their off-street parking spaces (for example, charge employees for parking at government offices and public schools), and encourage businesses to charge for employee and customer parking.

Picture 16: *Sophisticated parking meter in Ann Arbor, Michigan (USA)*

New York City's Park Smart

New York suffers from high levels of driving around to find parking and double parking. It negatively affects public transit, non-motorised transport and general traffic flow. At the same time, a small percentage of New York streets are metered. According to studies by the advocacy group Transportation Alternatives, driving around to find an unoccupied parking space makes up for 28% of traffic in lower Manhattan's Soho and 45% of Traffic in Park Slope, Brooklyn. To improve parking availability and reduce circling for parking, ParkSmart was introduced. The public resistance towards meters in New York is high. To change the public's attitude pilot programmes in six neighbourhoods were rolled out to improve existing meters. During the trial period meter rates were raised during peak hour (from 1$ to 2$) and maximum parking time reduced to one hour (the driver has to manually recharge after one hour). The pilot programme was thoughtfully planned together with local planning and community boards and well received by the public. The first two pilot programmes are now permanent. Results from the 6-month trial period in Greenwich Village show that parking space occupancy declined from 77% to 71%. The reduction of drivers parking for more than an hour was 12%. 18% of drivers stated that the new meter rates affected the duration of parking whereas 13% reduced their trips into the trial neighbourhood. 61% stated that it was easier to find parking after the new meters were installed. After the successful trial period the meter rate for peak hour has been increased to 3$/hour. In Park Slope the reduction of drivers parking for more than an hour was even higher with a 23% reduction. Total traffic was reduced by up to 9%. The community involvement led to a decision to expand the programme area and to compromises to suit the local situation (conversion from 1h to 2h maximum parking in restaurant area, truck delivery zones, more bicycle tracks, parking at non-functioning hydrants).

Prices should be higher at times and locations with higher parking demand, so occupancy seldom exceeds 85% in an area. Prices should favor short-term users, for example, with rates that increase for longer stays. New payment systems allow more convenient and variable pricing.

Use convenient, electronic payment systems that accept coins, bills, credit card, telephone and Internet payment; only charges for the amount of time a vehicle is parked; allows prices to be adjusted by time and location; and automatically provides receipts and reports transactions for auditing (see New York and San Francisco example). It is important to only allow manual recharging as remotely recharging e.g. via phone contravenes maximum time parking strategies.

Encourage Unbundling

Encourage parking *unbundling* (parking spaces are rented separately from other building space). For example, rather than charge $1,000 per month for an apartment with one "free" parking space, charge $900 per month for the apartment plus $100 per month for each parking space needed, so residents are not forced to pay for parking spaces they do not need. Encourage employers to *cash out* free commuter parking (employee that are offered a subsidized parking space can choose instead to receive its cash equivalent if they do not drive to work).

Parking unbundling is already common in many markets, including many North America and European cities where previously parking was automatically included with building space.

Improve User Information

Improved user information can allow motorists to identify parking locations and prices so they can choose the best option for each trip. Motorists want to know which parking facilities are closest to their destination, their prices, whether a space is actually available, and how to walk from their parking facility to their destination. This can include maps, signs, websites, mobile telephones and vehicle navigation systems indicating the location and price of parking options.

Buckman Heights, Portland, Oregon

The Buckman Heights mixed-use development in Portland, Oregon has unbundled parking as part of a comprehensive strategy to reduce the number of parking spaces required. The development is located near the walkable city center, nine blocks from light rail and near high-frequency bus routes. Buckman Heights is a 144-unit mixed-income apartment building with 58 on-site parking spaces (0.4 spaces/unit); tenants pay $15-30/month for parking. Buckman Terrace is a 122-unit apartment building with 70 structured parking spaces (0.57/unit); tenants pay $50/month for parking (as of 2006 when this information was collected). The developers also took advantage of a Portland zoning provision that allowed them to eliminate 14 required on-site parking spaces at Buckman Heights apartments and substitute 56 secure, covered bike parking spaces.

Local governments can produce brochures and websites that identify the location of parking facilities, indicate parking prices, describe parking planning and management activities, explain parking regulations, describe opportunities for citizen involvement, and answer other common questions about parking issues. Cities, business districts and individual facilities (such as shopping malls, hospitals and schools) can produce an *access guide* that provides concise, customized information on how to reach a particular destination, including information on parking options. Parking information can be incorporated into other visitor materials, such as event announcements, yellow pages and newspaper advertisements. All materials should have parking programme contact information, such as a telephone number or website.

Picture 17: *Information board displaying the approximate number of currently available parking spaces in Dresden (Germany)*

Photo by Belka, 2009

Cities can support the development of *advanced parking management systems* (APMS) which provide real-time information through the Internet and in-vehicle navigation systems to help motorists quickly find a parking space. These systems increase user convenience, reduce delays, driving and illegal parking, increase parking facility utilization, and encouraging shifts to alternative modes. Cities can help develop such systems by establishing parking supply, price and occupancy information standards. For example, a municipal transportation agency can require all commercial parking operators to report the number of parking spaces they rent and prices at each parking lot, and in the future, when electronic systems are developed that report parking lot occupancy, this information can be uploaded automatically to a website, and made available by mobile telephones and vehicle navigation systems.

Improve Parking Enforcement

Improved parking regulation enforcement, including more frequent enforcement, fines that increase if fines are unpaid, and systems that enforce citations such as wheel locks and requirements that all traffic and parking fines be paid before a vehicle can be re-registered. Enforcement is an integral part of a comprehensive parking management strategy. Illegal parking has considerable costs to third parties. Doubled parked vehicles are a danger to other road users including non-motorised road users. They delay emergency vehicles, buses and therefore add indirectly to emissions and travel costs. In addition, cars exceeding the parking limit force other road users to spend more time looking for parking. Recent Studies show that enforcement is frequently neglected. As a result up to one-third of vehicles are parked illegally. High fines have not influenced driver's attitude due to poor enforcement.

Parking Enforcement in Seoul

The city of Seoul, South Korea established the TOPIS traffic control center which monitors major arterials with closed circuit television cameras. If a vehicle stops or parks illegally, they record a time-stamped image of the vehicle and its license plate. After five minutes, if the vehicle has not moved, a second set of images are recorded, the license number automatically read using optical character recognition, and a parking ticket is sent to the motorist. After another ten minutes a tow truck is dispatched to remove the vehicle. This system has greatly reduced traffic delay and accident risk caused by illegally parked vehicles at relatively low cost. Some cities have contracted out parking enforcement, which tends to reduce costs and increase enforcement.

Picture 18: *TOPIS traffic control center in Seoul (South Korea)*

Photo by Manfred Breithaupt, 2009

Recent enforcement technology includes:

- Curbside sensors (sensors fixed at parking and inform respective agents about illegal parking)
- Vehicle or license plate recognition (vehicle mounted scanners determine whether a vehicle is parked illegally, that of a registered resident or even stolen)

Innovative strategies cut costs of enforcement. The City of Chicago attached license plate recognition cameras to 100 street-cleaning vehicles to enforce time-limits. Sometimes new technology is difficult to apply as they can be costly and, in the case of camera based systems, often restricted by law forbidding photo enforcement.

Employee Parking Management - Cash Out Rotterdam

The Erasmus Medical Centre employs around 10,000 people. As survey of employees and visitors travel patterns shows that 80% of patients travel by car to the hospital and 45% of employees commuted with private vehicles while a significant share lives within 5-6km from the hospital. As the Hospital faced a significant shortage of parking they introduced supply and demand measures. As for the supply they constructed a new car park. The hospital then further introduced a cash out scheme. Employees are required to pay for parking according to arrival time: €1.50 for arrival during peak hour, €4 for arrival during peak hour and living within 5 to 6 km from hospital, €0.50 a day when arriving during off-peak hours. If the employee decides to take public transport, employees were credited €0.10 for every km not travelled by car. The hospital communicated the approach in advance via newsletters, intranet and a service point. The number of commuters travelling by car has dropped from 45% to 20-25%. Although employee mobility management projects are often conducted through private initiatives, they should be encouraged by government. This can be in form of regulation (see TDM programs) or incentives in the form of competitions that will ensure publicity for the winner.

Source: SUTP, *Transport Demand Management Training Document*, 2009

3.4.1 Travel Impacts and Emission Reduction

Parking management and pricing reforms apply primarily to personal travel in large urban areas where land prices are high and parking facilities can serve multiple destinations. These strategies are already applied in Chinese cities, but additional implementation can be justified. For example, if currently about 20% of parking is efficient priced, policy reforms may increase this to 50% (a 30% gain), providing additional vehicle travel reductions.

Efficient parking management is one of the most effective TDM strategies, particularly if implemented as part of an integrated programme that includes improvements to alternative modes and smart growth development policies.

- Cost recovery parking fees (prices recover the full cost of providing a parking space) typically reduces vehicle ownership by 5-15% when applied to residential parking, and reduces vehicle trips by 10-30% when applied at other destinations.
- Some parking management strategies, such as unbundling residential parking, tend to reduce vehicle ownership (some households will own a vehicle if they can park it free, but not if they must pay for a parking space), which tends to leverage additional vehicle travel reductions.

- Efficient parking management can reduce the number of parking spaces needed in an area, which allows more compact development, which tends to leverage additional vehicle travel reductions.
- Parking regulations and pricing may cause motorists to change parking location. This may be desirable if it results in more sharing of parking facilities (such as employees parking at the edge of downtown, where parking is cheaper), or undesirable if it causes spillover impacts.

These impacts can vary depending on conditions. Impacts tend to be greater if there are good transport options. For example, pricing residential parking will reduce vehicle ownership more in areas with good walking and cycling conditions, high quality public transit services, and carsharing (vehicle rental services designed to substitute for personal automobile ownership).

More efficient parking management tends to significantly reduce the number of parking spaces needed serve a particular destination, and so can provide significant savings and benefits. Motorists benefit directly if improved management reduces parking congestion, improves user information, or increases their transport options. Businesses and cities benefit if efficient parking management reduces the number of subsidized parking spaces they must provide. Many parking management strategies also reduce vehicle trips, which helps achieve most TDM objectives.

Since parking management can be an effective travel reduction strategy, it can also be an effective emission reduction strategy. Emission reductions are usually about proportionate to vehicle travel reductions, so if parking pricing or cash out reduces affected vehicle travel by 20%, their energy consumption and pollution emissions will probably decline by about the same amount. Efficient parking management that reduces the amount of land needed for parking facilities can provide additional emission reductions by reducing sprawl and heat island effects (additional solar heat gain from pavement).

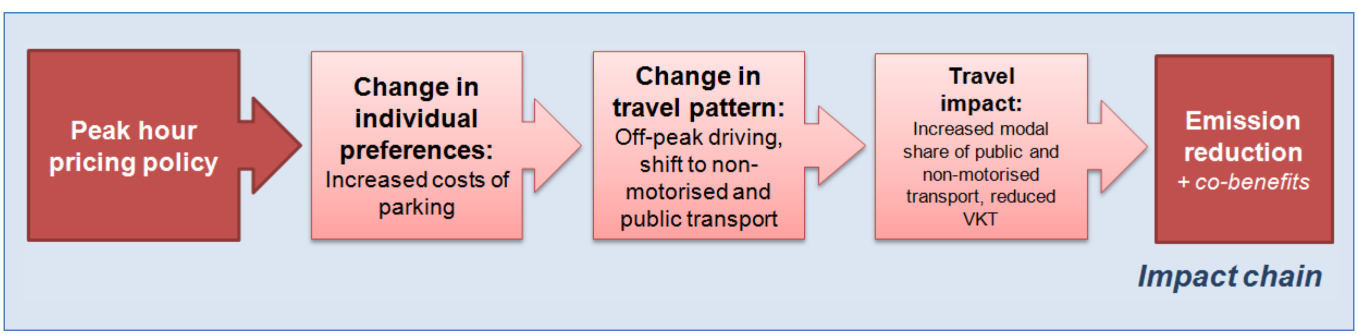


Figure 14: *Impact chain of peak hour pricing policy*

The figure above shows the effect of Peak-Hour Pricing Policy (a policy change) that increases parking prices (a price change), which reduces driving, shifts travel to alternative modes and changes the travel times, which reduces traffic congestion, accidents, energy consumption and pollution emissions (co-benefits) and ultimately reduces CO_2 emissions.

Basic Features of Parking in Japan

- Very little on-street parking exists, 1.1% of total registered parking. On-street parking is controlled and has been decreased by traffic police.
- Every vehicle is required (prior to its registration) to have its own fixed and exclusive garage (shako) or other space sufficient to accommodate it. (controlled by the police, Shako Law, 1958)
- Parking is prohibited on most commercial district streets, although vehicles often park illegally for short stops. Parking regulation enforcement was privatized in 2006 which seems to have improved effectiveness.
- Department stores, shopping centers and shopping street cooperatives in CBD usually provide free parking to shoppers who spend more than, say, 2,000 yen.
- Cities provide parking information including directional signs and real-time parking utilization information through mobile phones and on-board vehicle navigation systems.
- Zoning codes are flexible, allowing developers to build parking garages in most locations, including commercial and residential districts.
- Large shopping malls with abundant parking supply have attracted economic activity away from downtowns in most cities.

Source: Matsumoto, 2009

3.4.2 Case Study: San Francisco "SF-Park"

The San Francisco Municipal Transportation Agency (SFMTA) has implemented a comprehensive smart parking system to help manage congestion. This system will improve a significant portion of the City's parking supply, including: 13 city-controlled parking garages, one city controlled parking lot, and approximately 25% of the City's on-street metered parking supply. In its first phase the project was rolled out in 8 pilot areas and 3 control areas with no technology changes but significant data collection. The primary strategies used to achieve the City's parking management goals include demand-responsive pricing to manage parking towards availability targets, expanded hours of priced parking, enhanced parking regulation enforcement, and new parking information systems. These strategies are supported by new technologies including networked in-street parking sensors and parking meters that support various forms of payment, including coins, smart cards, as well as credit and debit cards. Demand-responsive pricing is made possible by wireless sensors that collect real time information on occupancy level. The system is then able to charge higher prices at times and locations where demand is high. The range is from $0.25 to $6. This is to insure that motorists can nearly always find a parking space on each block. The performance target is 85% maximum occupancy, so at least 15% of parking spaces are available even during peak periods. Most of the parking spots have a maximum time limit of four hours. Rates are adjusted per block according to its occupancy. The project costs of SFPark were estimated to be $24.75 million.

Impact

Efficient parking pricing can reduce parking problems and encourage use of alternative modes of transport. A survey of San Francisco Bay Area Commuters indicates that those who pay directly for parking drive less than half as often as commuters who receive free parking, as indicated in the table below. A comprehensive study has not yet been launched as the pilot project was recently started. A first evaluation and the citywide launch are planned for 2013.

	With free parking	Without free parking
Drive alone in a car	75%	37%
Use transit	5%	43%

Source: Commute Profile 2005, A Survey of San Francisco Bay Area Commute Patterns, RIDES for Bay Area Commuters, Inc. August 2005. Region-wide telephone survey of 3,600 commuters sponsored by the Metropolitan Transportation Commission (MTC).

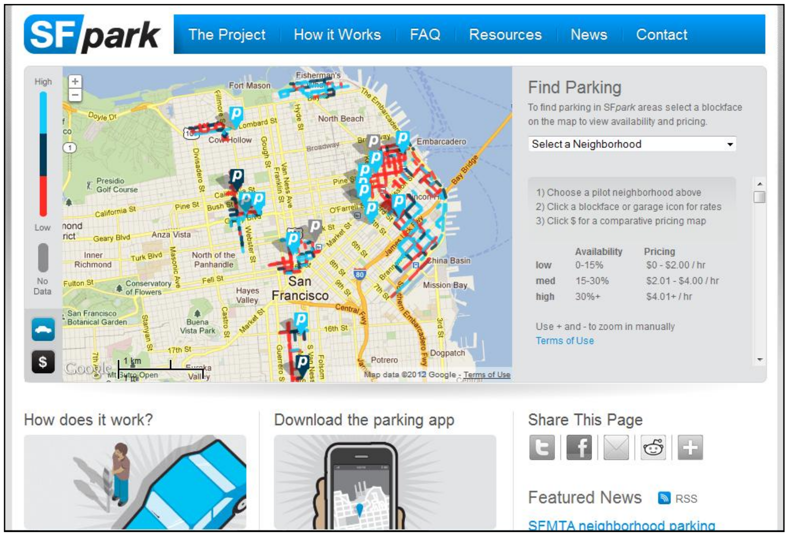
Success Factors

Data Availability

The SF*park* project required the development of a data warehouse, transactional, and asset management system, and comprehensive data collection about the City's publicly available parking supply, both on and off-street and existing parking regulations. Geographic information systems were used to allow detailed analysis of parking facility location and demand patterns. The programme used the resulting information to set prices based on demand, with higher parking meter rates at times and locations where demand is greatest, in order to insure that all motorists can virtually always find a parking space near their destination.

SFPark in San Fransisco, USA

In 2012 San Francisco won the Sustainable Transport Award for its variable-rate and demand responsive parking management, the Pavement to Park programme and the expansion of the bike network. Additional information: www.st-award.org



Picture 19: *The San Francisco Transportation Agency gives live information on parking prices and availability per SMS, on a website (www.sfpark.org) and via mobile phone applications. The site provides much additional information on payment options, the stakeholder consultation process and other relevant topics.*

Vision

The project went through a competitive grant programme which resulted in 80% of the project being funded by the U.S. Department of Transport (DoT) under the Urban Partnership projects aiming at relieving congestion.

Governmental Cooperation

The San Francisco Municipal Transportation Agency (SFMTA) is responsible for both parking and public transport management. The agency is the result of a merger between San Francisco Municipal Railway, the Department of Parking and Traffic and the Taxicab Commission. The consolidated approach

- combines all aspects of transport planning and management (non-motorised transport, safety of all modes, public transport, parking management, network planning),
- lowers transaction costs (focus on project delivery and not on interagency coordination),

- avoids inter-governmental competition and ensures smooth and comprehensive planning (integration of modes).

Performance-Based Incentives

Picture 20: *SF Park phone app showing availability of parking space*

Picture by SFMTA, 2011

The funding of the Agency's activities is based on performance-based incentives. SFMTA is funded by the Municipal Transportation Fund which is solely to be used for the operations of the agency. The amount of funding is, apart from a base fund from the overall city budget, directly correlated to the performance of SFMTA through the collection of fares in public transport and revenues from parking.

Hence there is an apparent incentive to efficiently manage parking as it can generate revenue through collection of money from meters as well as from fines. At the same time, as double parking and circling is reduced, the speed of public transport can increase which effectively saves money in bus operations and increases public transport attractiveness. Channeling back the increased income from parking fares to public transit was widely communicated to the public (ITDP, 2010).

Enforcement

San Francisco's SFpark is making use of current technology to enforce parking. Sensors are embedded into the parking spots. More consistent parking enforcement is applied using a combination of low- and high-tech strategies that will improve enforcement's cost-effectiveness such as curbside sensors, vehicle mounted license plate or vehicle recognition.

Stakeholder Involvement

Apart from the interdisciplinary team within SFMTA, the SFpark project was supported by several important stakeholders especially from the academic field. The project engaged local community leaders before the project was released to the public. This way the opinion and business leaders in San Francisco were aware and had an opportunity to raise concerns. Planning adjustments were consequently communicated via mail and presentations. Parking Control Officers and Parking Meter Repair personnel were engaged throughout the planning and implementation phase.

Reliability and Convenience

Payment is convenient through credit cards, prepaid SFMTA smartcards, cash and PayByPhone options. Real time information about occupancy is made available via message signs, iPhone applications and text message. Technical errors were solved within pilot phase.

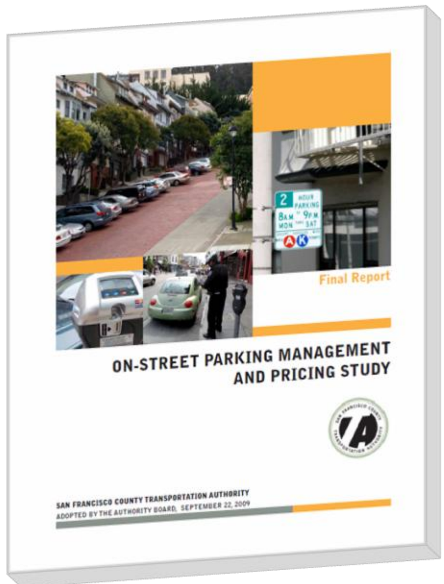
Part of Comprehensive TDM Strategy

Beginning in 2005, San Francisco began to demand from developers in some neighbourhoods to unbundle accessory parking spaces from the sale of a residential unit. The pilot programme began in a single neighbourhood and was subsequently extended to other neighbourhoods.

In 2008, San Francisco made unbundled residential parking a requirement throughout the city. The city also encourages unbundling of rental housing parking. The 141-unit Symphony Towers apartments development was granted a variance and allowed to construct only 51 spaces (rather than the 141 required by the zoning code) because of its use of unbundled parking and provision of two car sharing parking spaces in the building.

In some areas of San Francisco, **maximum parking** was introduced. The current guideline ensures that parking does not account for more than 7 percent of the gross floor area of a building. San Francisco, being a city of commuters, heavily invested in **public transit**. The Bay Area Rapid Transit (BART) connects San Francisco with other bigger cities in the Bay Area (e.g. Oakland, Berkely, Pittsburg). BART is very popular due to its high frequency and relatively high average speed, its integrated ticketing and good integration into bus feeder lines.

More Information



San Francisco (2009): *On-Street Parking Management and Pricing Study*, San Francisco County Transportation Authority (www.sfcta.org); at www.sfcta.org/content/view/303/149

3.5 Vehicle Travel Restrictions

Vehicle Travel Restrictions:

… reduced particulate matter pollution in Berlin by 58% in 2012 compared to the baseline scenario.

… reduced traffic volume by 21% in the first year of Ecopass in Milan.

Various regulations restrict *ownership* and *utilization* of private vehicles. Numerous, especially Asian, cities use auctions to limit car ownership and number plate restrictions to reduce traffic volume. Car free days, car free roads or peak-hour driving restrictions are further alternatives to mitigate congestion and environmental consequences of urban transport. A new and successful trend is the combination of congestion charging and environmental restrictions. Many cities in Europe restrict the usage of cars in accordance with the current atmospheric pollution situation. Environmental or low emission zones that restrict the entry of a vehicle into the restricted area if the vehicle does not meet certain environmental criteria are gaining popularity, especially in Europe.

> **Vehicle quota in Singapore**
>
> Singapore has successfully used auctions to limit the total number of vehicles registered in the city. The resulting fees exceed the value of most cars, essentially doubling vehicle purchase costs. The Land Transport Authority (LTA) determines the quota for each vehicle category every year. To register a new car everybody must go through a bidding process and, if successful, a Certificate of Entitlement is obtained. This programme is successful because Singapore has very high quality public transit and taxi services meaning few residents need a personal automobile. Some other Asian cities (including Delhi, India and Hanoi, Vietnam) are considering increasing vehicle purchase and registration fees, primarily as a way to generate funding for public transit improvements.

Vehicle Number Plate Restrictions

Vehicles are restricted to drive in an area based on the registration plate. The aim is to reduce private vehicles in use. The restriction can be limited to certain vehicle types, to days or areas. Number plate restrictions are often undermined by an increase in car ownership, as households register a second car in order to avoid restrictions. Counter measures to prevent ownership of a second car are limiting the restriction to peak hours and banning vehicles with several different, rotating numbers on the number plate from driving. Taxis are usually excluded from the restrictions and are therefore used more. This reduces the environmental and congestion reduction impact of such a scheme. However, the advantage is that implementation is not very costly and usually easy to enforce. The short-term effect on traffic reduction can be significant. Usually number plate restriction targets a reduction in congestion and only considers environmental aspects as a co-benefit.

Low Emission Zones

Vehicle restrictions for designated areas that are based on whether a vehicle's emissions are over a set emission level are called low emission zones (LEZ). It is a restriction scheme especially for highly polluting vehicles. However, the restriction differs among the LEZs. Some cities ban heavy goods vehicles, some restrict or charge according to the emission standard of every vehicle that wants to enter the zone. Although the approach is often national with a regional implementation (see case study Germany below), in some cases the

Picture 21: *Environmental Zone and direction signs near Stuttgart (Germany)*

restriction is limited to a local initiative e.g. a motorway LEZ. Low emission zones that include charging schemes are becoming increasingly popular in European cities as they are considered an effective measure in achieving the pollution reduction targets of the European Union. The major objective of LEZs is to improve the health of residents in the city by reducing particulate matter (PM_{10} and $PM_{2.5}$) and nitrogen dioxide (NO_2) emissions. If combined with a charge in accordance to emission standards it may also target a reduction of vehicle traffic and consequently reduced GHG.

3.5.1 Travel Impacts and Emission Reduction

Travel impacts can vary significantly depending on the type of vehicle restrictions and where they are implemented. Singapore's vehicle ownership restriction programme is considered successful because it is integrated with other TDM strategies, including high quality walking, cycling and public transit, and efficient road pricing. However, vehicle ownership restrictions often have small overall impacts, or may fail if residents find ways to circumvent these policies. For example, a lottery system may encourage more households to apply to register a vehicle in order to obtain (and perhaps sell) vehicle registration rights. Some motorists may register their vehicles in other jurisdictions.

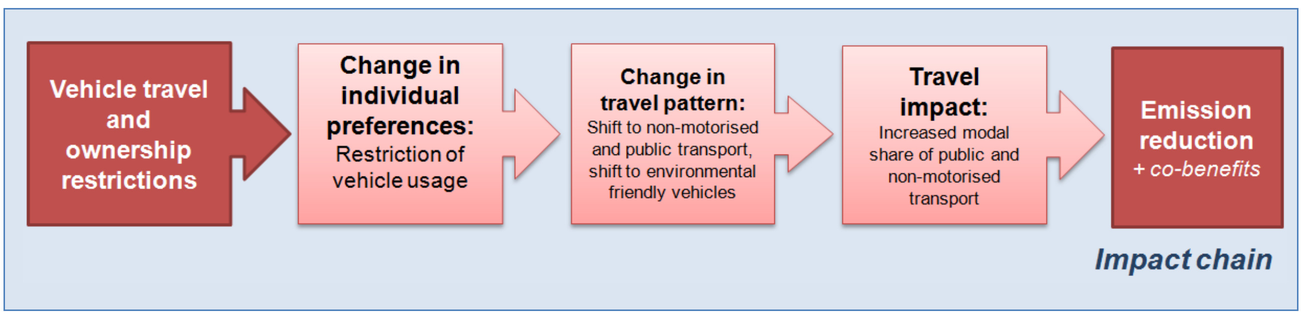


Figure 15: *Impact chain of vehicle restrictions*

Vehicle ownership restrictions lead to a forced shift to alternative modes of transport and consequently to an increased modal share of non-motorised and public transport. Modest increases in vehicle registration fees are unlikely to cause much reduction in vehicle ownership or vehicle travel. Restrictions that prohibit motorists from driving one weekday may cause some commuters to take taxis, some trips to shift days (for example, shifting an appointment to another day), or cause some households to purchase additional vehicles so one is always available. Restrictions on non-residents driving in a particular neighbourhood may shift travel to other destinations but cause little reduction in total vehicle travel. Vehicle travel restrictions such as environmental zones, if

The UK Department for Transport has sponsored a programme called **"In Town Without My Car!"**, which supports car-free days in cities and towns. The DFT has produced an "In Town Without My Car! - Good Practices Guide", which describes how to organize such events, and outlines numerous successful case studies.

implemented solely, usually have no significant impact on the traffic volume but rather on the fleet composition. If implemented in form of a combined environmental and congestion based pricing scheme (see chapter 3.3 on road pricing and congestion charging) it increases the costs of vehicle usage and additionally leads to a change in the vehicle fleet to more environmental friendly vehicles and additionally induces a shift to other modes of transport.

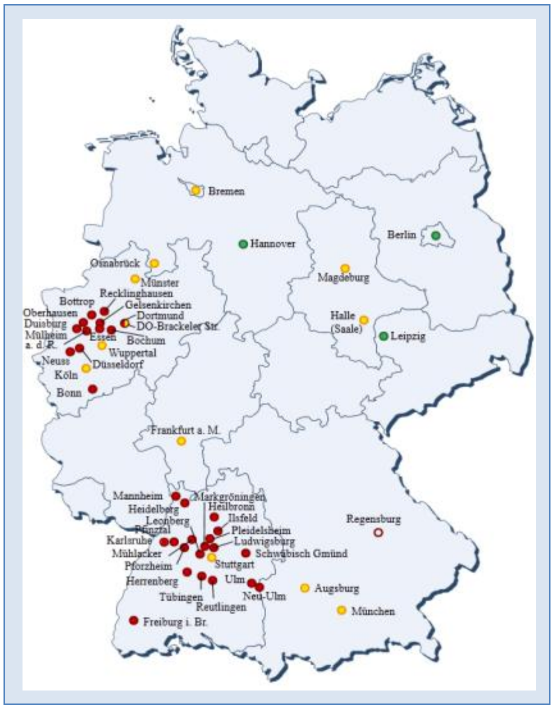


Figure 16: *An overview of all environmental zones in Germany. Red dots account for cities with the least restriction (yellow, red and green badges are allowed), yellow dots stand for cities that allow yellow and green badges and green dots for cities with the highest restriction (only green badges).*

Source: Markus Baumer, 2012 (CC-BY-SA 2.0 Ger.)

Restrictions on vehicle ownership and use can reduce vehicle travel (see impact chain figure 15), although their long-term benefits may be relatively small if households respond by purchasing new or second vehicles or by deferring travel to other times. Costs include regulation enforcement, and costs to motorists from reduced vehicle travel. Other planning objectives like road safety are not an aim, however, LZE can help to improve the conditions for non-motorised transport and in this way support the effects of complimentary measures.

To the degree that these restrictions reduce vehicle use, they can reduce emissions. Environmental zones can further lead to a low emission fleet as it encourages purchasing more efficient vehicles, if the restriction is based on emission standards, or an upgrade of diesel engines with a particulate filter. However, environmental zones have an impact on local pollutants but the impact on CO_2 emissions mainly depends on its design. If the environmental zone leads to a reduction in traffic (see Milan case study) the CO_2 emission reduce accordingly. If traffic is not reduced and only the fleet composition changes, the impact on CO_2 emissions is not significant.

Implementation requirements vary depending on the type of restriction. Environmental zones often require a national legal framework. It is essential that the national government defines the regulatory support i.e. the emission classes, signing, tax regulations and enforcement standards. However, based on the subsidiary approach local authorities should be responsible for its final design to be able to apply it to local circumstance (see Germany case study). A difficulty in the implementation of environmental zones is the treatment of the government fleet, bus operators, emergency vehicles or other service vehicles. Often these vehicles do not fulfill the demanded criteria and are exempted from the zone which reduces its impact. Most of the light and heavy duty vehicles are equipped with a diesel engine that has a higher capacity in comparison to a private vehicle. At the same time diesel engine emissions can be up to 30 times higher and be reduced by 90% with a particulate filter. That is, including these vehicles in the environmental zones has a substantial impact.

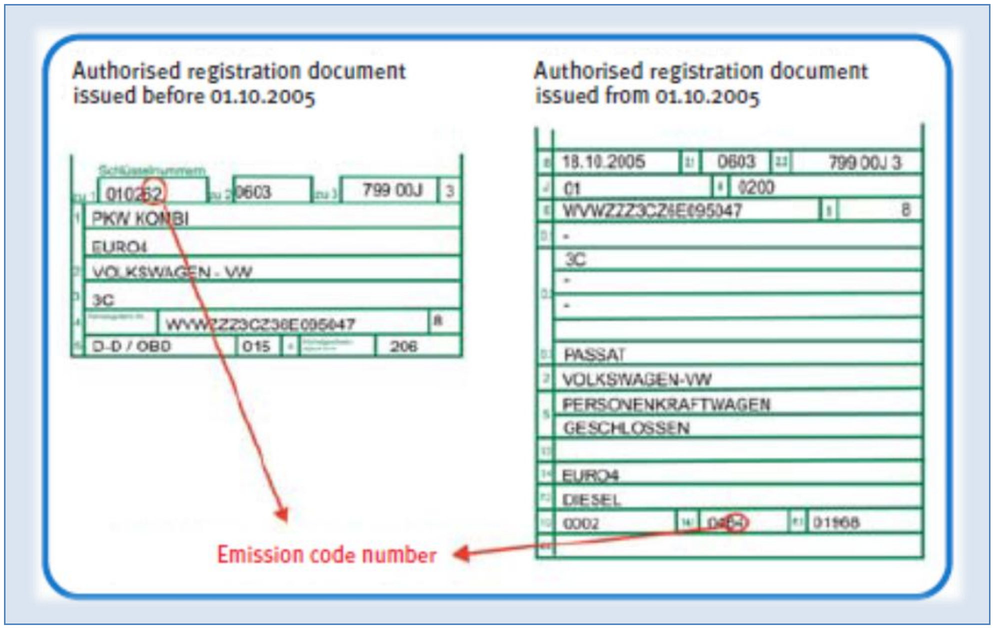


Figure 17: *Vehicles that are registered in Germany receive a sticker based on a specific emission key number in the vehicle license and on a potential certificate indicating that a diesel particulate filter was installed.*

Source: Berlin's Environmental Zone from 2008 – What Drivers need to know (2007), Berlin's Senate Department for Health, Environment and Consumer Protection

3.5.2 Case Study: Low Emission Zone in Berlin

Cars per citizen: 0.32
Environmental zone: 88km²

In Germany, so called Environmental Zones ("Umweltzonen") are applied mostly by cities that exceed the pollutant emission threshold set by the European Union and are embedded in Air-Quality Plans. Currently around 50 environmental zones in Germany are in operation.

The legal and regulatory framework is defined by national law and regulations. Comprehensive strategies are, in line with the subsidiary principle, implemented on city or state government level in order to consider local conditions. All environmental zones in Germany are marked with the "Environmental Zone" sign (see figure 18). Nationwide, every car wanting to enter the restricted zone, is categorised based on the European emission standards Euro 1-4. Accessing the zone without meeting the emission standard leads to a penalty of up to EUR 40. The obligatory addition to the environmental zone sign informs the driver about the required badge to enter the zone. Table 5 gives an overview about the requirements for diesel and petrol vehicles for entering the environmental zone. The green badge for example is granted for all diesel engines that meet the Euro 4 or 3 (with particulate filter) emission standard or petrol vehicles with a catalytic converter.

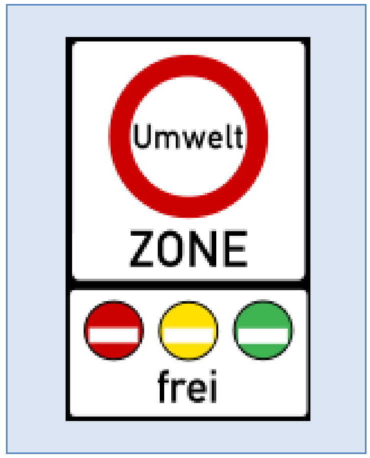
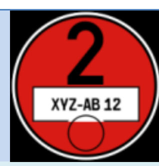
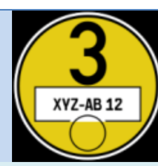


Figure 18: *Environmental zone sign. The colours on the bottom indicate which cars are allowed in the zone.*

Table 5: *Three emission classes*

	No sticker			
Requirement for diesel engine	Euro 1 (or worse)	Euro 2 or Euro 1 with particulate filter	Euro 3 or Euro 2 with particulate filter	Euro 4 or Euro 3 with particulate filter
Requirement for petrol engine	No catalytic converter			All petrol engines with catalytic converter and all LPG or natural gas vehicles.

In Berlin, the emission levels defined by regulations of the EU were widely exceeded. As a result, Berlin was required to develop a clean air action plan that defines measures to reduce emissions to meet the respective level. The plan's core instrument was a two stage implementation of an environmental zone. Almost one third of Berlin's residents live in the environmental zone and it is the most polluted area.

Stage 1: All vehicles must at least meet the requirements of emission class 2 (red badge). Vehicles with red, yellow or green stickers were allowed to enter the zone. Stage 1 has been effective since January 2008.

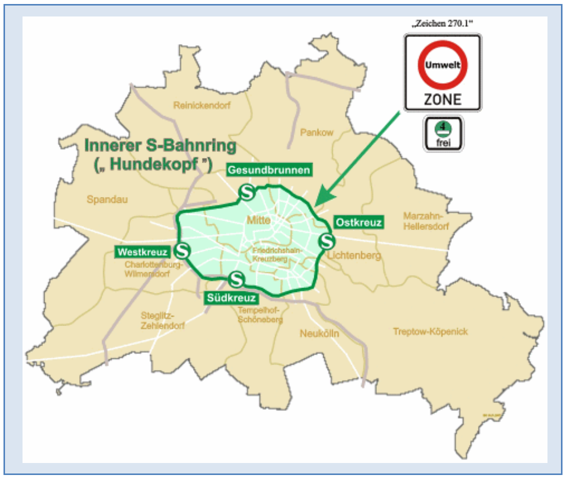


Figure 19: *Low Emission Zone Berlin*

Stage 2: Only vehicles within emission class 4 (green badge) or vehicles of emission class 3 that cannot be upgraded with particulate filters are allowed in the environmental zone. Berlin is one of three cities in Germany that implemented stage 2. The development from stage 1 to stage 2 is only relevant for diesel engines as petrol vehicles either do not get a badge at all (without catalytic converter) or get a green badge (with catalytic converter). Stage 2 has been effective since January 2010.

Impact

In the first stage, particulate matters were reduced by 25% and Nitrogen oxides by 15% compared to the baseline scenario. In the second phase, particulate matter were reduced by 58% in relation to the baseline scenario (see figure 20) and Nitrogen oxides by 20%. The emission reduction was achieved equally by the modernization of trucks and private vehicles. The fleet composition in the entire Berlin city area changed rapidly: Compared to baseline estimations, the percentage of trucks with green badges doubled and the percentage of diesel vehicles increased from 61% (projected percentage without environmental zone) to 87% (actual portion in 2011). The share of diesel engine vehicles with green badges increased by 38% from 2006 to 2011. The fleet composition adjustment was mostly due to installation of diesel particle filters. There are no significant differences in the composition of the fleet outside and inside the environmental zone.

Without the environmental zone Berlin would have exceeded the European PM_{10} emission standards for ten more days in a year. In 2010 the PM_{10} concentration was 7% smaller compared to the baseline scenario. However, due to the short analysis period, results are partly dependent on weather and climate conditions, which can influence PM emissions.

The environmental zone had no measurable impact on the traffic volume neither inside nor outside the zone and hence no impact on CO_2 reduction. (Rauterberg-Wulff, 2011). This is especially due to the fact that it focus on standards for pollutants (Euro) and not CO_2 emissions or the fuel economy. There is also no link between the zone and pricing or specific times when entry is even more restricted.

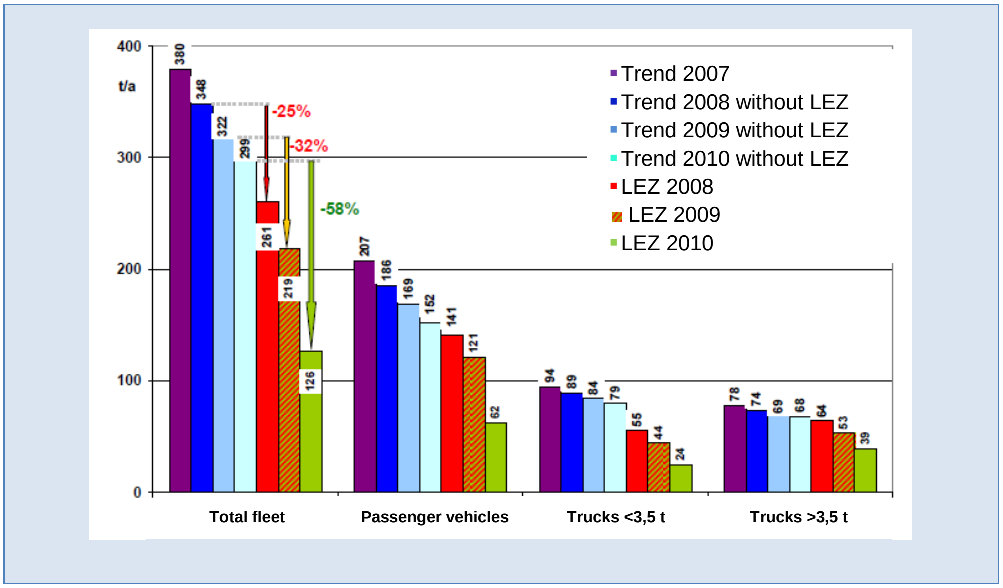


Figure 20: *Reduction in particulate matter*

Source: Senatsverwaltung für Gesundheit, Umwelt und Verbraucherschutz (2011), page 17.

Success Factors

Comprehensive Strategy

The LEZ in Berlin is part of the Clean Air and Action Plan. Undoubtedly, the LEZ was the core measure of the action plan but it is accompanied by several of other measures:

1. Improved parking management with a focus on peak-hour pricing.
2. Technical improvements of the bus fleet (diesel filter and LPG engines).
3. Expansion of speed limits on high-concentration roads. (Although the effect of reduced speed is not significant, it may lead to a spread of traffic flow)
4. Expansion of public and non-motorised transport
5. Introduction of high environmental standards when purchasing municipal vehicles
6. Other non-transport measures

Local efforts were supported by the federal government with a wrecking bonus. This was a subsidy that vehicle owners could obtain after an old car was demolished and a newer car registered. The objective was a "greener" fleet and to support the automobile industry. Further, tax cuts for vehicles with a diesel particulate filter and support to local governments in upgrading bus fleets were provided.

At the same time the validity of stickers all over Germany in any environmental zone ensure that drivers do not have to adhere to different standards in different German cities.

Linkage to Local Circumstances

The actual implementation of the environmental zone is left in the hands of the local authorities. This ensures that the environmental zone and its restrictions are designed in a way that suits the local situation (geography, fleet composition, industry characteristics etc.).

Further Reading

More information can be obtained from the website www.berlin.de/umweltzone. The information is available both in German and English.

Further, general information on how Berlin is planning and monitoring its clean air initiative is published at www.berlin.de/sen/umwelt/luftqualitaet. Here you can find: Real-time information on the air quality, the Clean Air and Action Plan available to download, information on air quality over the last few years and the air pollution index of all main roads in the environment atlas.

3.5.3 Case Study: Milan Low Emission Zone and Charging

Centre of the **Lombardy region** with 9.5 million citizens

Cars per citizen: 0.6

Ecopass area: 8km²

Ecopass was a trial emission-based charging system in Milan, Italy. In contrast to the objectives of the schemes in Trondheim (financing of road network), Stockholm (reduction of congestion and financing of public transport), London (mitigation of congestion and increasing bus travel speeds) discussed in Chapter 3.2, "Efficient Road Pricing", Ecopass' main objective was to reduce environmental impacts of urban transport through a targeted change in fleet composition. Hence, the charge differentiation was not based on travel time or congestion levels but on the vehicle emission standards. This approach was chosen mainly due to the fact that Milan was one of the cities with the highest particulate matter concentration in Europe. In a referendum in 2011, 80% of Milan's residents voted in favour of extending Ecopass. The successful trial period was consequently upgraded in 2012 into a combination of a common congestion charging system in the form of cordon pricing together with an emission based system called Area C.

During the trial period from 2008 to 2012, the limited traffic zone was controlled by cameras that recorded the license plate numbers and automatically determined the pollution class of the vehicle as specified in its registration booklet. The area had 43 gates at which the cameras were placed. The costs of implementation were rather low as the camera system was already in place for traffic control measures. The fee was charged between 7.30 am and 7.30 pm during weekdays. The emission group of vehicles was similar to the German model above. However, the limitations for gasoline cars and the direct charging of vehicles constitute a major difference to the German environmental zones. Gasoline vehicles and lorries (Euro 3 and later), diesel cars and lorries (Euro 4 and later) and vehicles with alternative fuel engines were not charged. All other cars were charged up to US$12 for entering the zone. Additionally, in Milan there was 50% rebate for the first 50 entries per year and a 40% rebate for the subsequent 50 entries.

Picture 22: *Ecopass area sign*

Photo by Damien Meyer, Institute for Transportation and Development Policy, Milan (Italy), 2009 (CC-BY 3.0)

Furthermore, residents within the scheme area were able to get discounts. For a comparison between Berlin and Milan in terms of restrictions according to emission standards see table 6.

Table 6: *Comparison of entry requirements for Milan and Berlin*

Emission standard	Berlin		Milan (Ecopass)		Milan (Area C)	
	Diesel	Petrol	Diesel	Petrol	Diesel	Petrol
Euro 0	No entry	No entry	10€ (all vehicles)	5€ daily charge	No entry	No entry
Euro 1	No entry	Entry allowed (with catalytic converter)	5€ daily charge 10€ freight vehicles 10€ buses	2€ daily charge	No entry	5€
Euro 2	No entry	Entry allowed (with catalytic converter)	5€ daily charge 10€ freight vehicles 10€ buses	2€ daily charge	No entry	5€
Euro 3	Only with particulate filter	Entry allowed (with catalytic converter)	5€ daily charge (also freight vehicles) 10€ buses	Free	No entry	5€
Euro 4	Allowed to enter	Entry allowed (with catalytic converter)	Free with particulate filter (also freight vehicles) 5€ buses	Free	5€	5€
Euro 5	Allowed to enter	Entry allowed (with catalytic converter)	Free with particulate filter (also freight vehicles) 5€ buses	Free	5€	5€
LPG, Electric, Hybrid	Green badge		Free		Free	

In 2012, the new political leadership decided to extend the scheme to the so called "Area C" which is a congestion charging system in conjunction with environmental based charging. The area remained the same compared to the Ecopass scheme. The objective of the scheme is now to reduce congestion and to collect revenue to increase public transport supply. Every vehicle has to pay 5€ (residents 2€) when entering the restricted area. However, diesel vehicles with emission standards below Euro 3, and gasoline Euro 0, as well as vehicles longer than 7 metres, are not allowed to enter the zone. Hybrid vehicles, bi-fuel natural gas vehicles, public utility vehicles are exempted from the charge. After having achieved a considerable change in fleet composition through Ecopass through Area C, both environmental and traffic reduction objectives can be achieved with the new scheme. The charge is collected between 7.30 am and 7.30 pm.

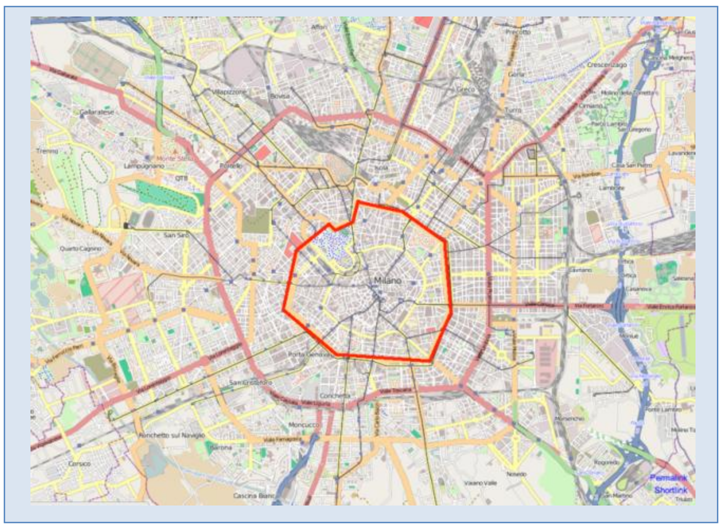


Figure 21: *Ecopass traffic restricted zones*

Source: Ita140188, 2007

Impact

Since 2008, European regulations require that the daily average of PM_{10} should not exceed 50 µg/m³ for more than 35 days a year. The City of Milan exceeded this threshold in 2005 with a total of 151 days. In 2010, two years after the charging system was implemented, the threshold was exceeded with a total of 86 days. In the first year, PM_{10} decreased by 19%, NO_x by 14%, and CO_2 by 15%. These results are quite similar to the ones discussed in the case studies of the congestion charge system in London and Stockholm. However, the restricted zone in Milan is 8 with km² much smaller than the one in London (22 km²) and Stockholm (47 km²). This large reduction in local pollution was mainly due to the fact that transport was the main polluting sector as Milan has one of the highest European car ownerships, ranked second just after Rome (Italy). In order to ensure that environmental zones are successful the contribution of the transport sector should be scientifically confirmed.

Compared to Berlin, the scheme in Milan led to a significant reduction in traffic volume. In the first year, traffic volume decreased by 21%. In the first 6 months of 2010, the reduction compared to the baseline scenario was 12%. However, compared to the year 2009, traffic increased by 2% in the first 6 months of 2010. This was due to the rapid change in the composition of the fleet that allowed more cars to enter the restricted area. The number of vehicles entering the charged zone belonging to the classes that are charged (see table 6) was reduced by 70%. This was one of the reasons why the City moved to the more comprehensive Area C charging system.

The speed of public transport (bus) increased by 9.3 km/h on average. However, the effect is attributable to both the Ecopass scheme and the improvement in the bus network (e.g. reserved lanes).

Since Area C has only been in operation from January 16, 2012, a comprehensive impact assessment is not yet applicable. Nonetheless, during the first week of implementation, traffic was reduced by 37% and there were reductions in black carbon (-30%), ammonia (-37%), carbon dioxide (-29%), oxides of nitrogen (-14%) and particulates (-24%). (Data source: Russo et al. (2011))

Picture 23: *Monitoring cameras for Area C. With 8km² the environmental zone is much smaller than the ones in Berlin, Stockholm or London. Nevertheless, the success was outstanding.*

Photo by Ita140188, April 2012

Success Factors

Comprehensive Strategy

Milan exceeded the regulated emission limits set by the European Union several days a year. This required a more comprehensive strategy than the emission based charging. The policy package is part of the "Piano Generale del Traffico Urbano". The main objective of the plan is more efficient transport planning without major infrastructure investments. It includes short-term policies such as traffic calming measures, new bus lanes, increased bus frequency, increase in parking restriction and fees, and medium-term policies such as park-and-ride facilities. Together with the start of Area C in 2012, the City of Milan increased the number of bus trips by 166 per day with an increased capacity of 30,500 seats daily.

3.6 Corporate Mobility Management Programmes

A Corporate Mobility Management (CMM) programme is an institutional framework for implementing a set of TDM strategies. Such a programme has stated goals, objectives, a budget, staff, and a clear relationship with stakeholders. It may be a division within a transportation or transit agency, an independent government agency, or a public/private partnership. These can include:

Corporate Mobility Management Programmes:

… reduced 48,000,000 miles of vehicle travel per year in a project in Northern California.

… increased the use of public transport within 2 years by 22.5%, cycling by 1.6% and car-pooling by 3.1% and reduced solo car use by 11.5% at hospital in Arnhem (Netherlands).

- *Commute trip reduction programmes* use education and promotion campaigns, incentives (such as parking pricing or transit pass subsidies) and service improvements (such as increased public transit services, rideshare matching, bicycle parking, and favorable flextime and telework policies) to encourage their employees to use resource-efficient commute modes.
- *School and campus transport management programmes* use various strategies to encourage students and staff to use resource-efficient modes.
- *Transportation management associations* (TMAs) are non-profit, member-controlled organizations that provide transportation and parking management services in a particular area, such as a commercial district, mall, medical center or industrial park. This allows multiple businesses and other employers to coordinate their efforts.
- *TDM marketing programmes* investigate traveler needs and preferences, identify and overcome barriers to use of more efficient travel modes, and promote more efficient travel. This can include market surveys, direct marketing, promotion campaigns, new services, and special events (such as *car-free* events).

Specific evaluations of carbon reduction effects of CMM programmes are rather limited, however, to the degree that CMM programmes reduce vehicle travel they tend to reduce energy consumption. Comprehensive CMM programmes can often reduce affected motor vehicle travel 10-30% compared with what otherwise occurs. Most programmes focus on a specific type of travel, such as commuting, cover a limited geographic scope, or are limited to strategies that can be implemented by a particular organization. Models exist to help predict the travel impacts of a specific commute trip reduction programme, taking into account the type of programme and worksite. These include the TRIMMS (Trip Reduction Impacts of Mobility Management Strategies) Model (www.nctr.usf.edu/abstracts/abs77704.htm), Commuter Model (USEPA 2005), the CUTR_AVR Model (www.cutr.usf.edu/tdm/download.htm), and the Commuter Choice Decision Support Tool (www.ops.fhwa.dot.gov/PrimerDSS/index.htm).

BASF, Ludwigshafen, Germany

With 53,000 employees BASF, a large company in the chemical industry, is a major contributor to local commuting traffic. To reduce commuting by private car they established a working group to develop a transport plan made up of 11 interconnected projects:

- Designated car pool parking facilities close to the factory entrances, providing convenient interchange to the company bus system
- Extensive on-site bus system
- Better integration with the public bus system and rail network (working hours changed to match schedules, better service frequencies, more convenient routes)
- Reduction in the number of company vehicles
- Promotion of the use of cycles through the registration of 25,000 private cycles for the company site, the provision of 15,000 company pool cycles and the provision of 10 kilometres of on-site cycle tracks

These measures led to an increase in the number of car pool vehicles carrying 3 people from 50 to 1,300 within 7 years (an equivalent decline of 2,600 vehicles, assuming that the two additional employees would have used a private car alternatively) and a reduction of on-site car accidents of 44% within 3 years.

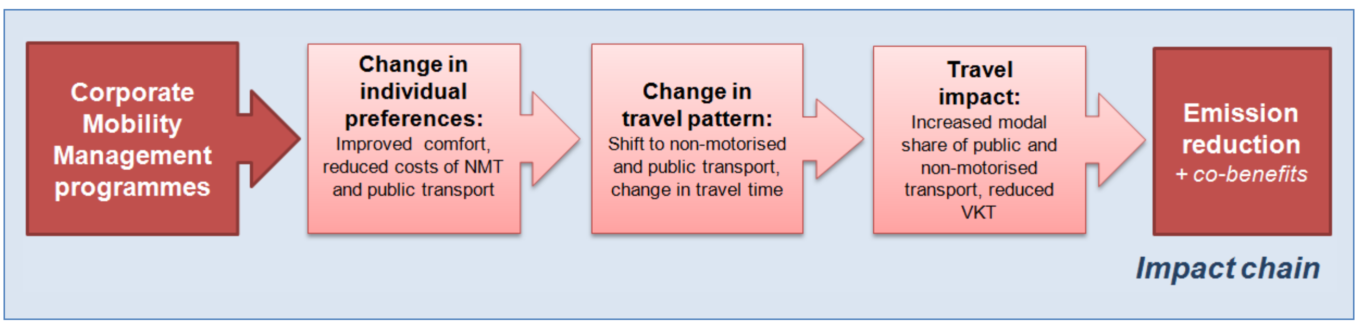


Figure 22: *Impact chain of Corporate Mobility Management programmes*

Kaiser Permanente

Kaiser Permanente (KP), a large health care provider, is taking great steps in northern California to point out the connection between health, air pollution, and using alternative methods of transportation. The KAISERider programmes provides employees and patients with a wide range of transportation services, offering transit and vanpool subsidies, rideshare matching, preferential carpool parking, transit information distribution, a guaranteed ride home, bicycle parking and showers, shuttle buses, telecommuting, and prize drawings for programmes participants. As a result, nearly one-third of the work force uses transportation alternatives an average of three days per week, which eliminates 48,000,000 miles of vehicle travel per year and a significant amount of automobile pollution.

More information: www.epa.gov/oms/transp/comchoic/waytogo.htm

Rijnstate Hospital, Arnhem, The Netherlands

The Rijnstate Hospital in Arnhem with around 2700 employees reacted on a shortage of staff parking with the following measures:

- Promote Cycling (subsidy for purchasing bikes, maintenance service)
- Public Transport (reduced train fares, guaranteed ride home when public transport is not available after hours)
- Car Pooling (Reserved parking, guaranteed ride home in case of emergencies)
- Parking Management (the hospital examined possible transport modes for all employees. Employees receiving car-oriented travel advice can park at a reduced price and only employees working night shifts can park for free)

Within 2 years, use of public transport increased by 22.5%, cycling by 1.6% and car-pooling by 3.1%. Over the same period, solo car use declined by 11.5%.

Source and more information:
www.mobilitymanagement.be

Corporate Mobility Management programmes tend to provide a variety of benefits. Most programmes implement at least some strategies that directly benefit users, including walking, cycling and public transit improvements (such as worksite bike racks and bus stops); permission for employee telework and flextime; and positive financial incentives such as parking cash out and commuter financial benefits. To the degree that CMM programmes reduce vehicle travel they tend to reduce traffic congestion, road and parking facility costs, accidents, energy conservation, emission reductions, and to the degree that they increase walking and cycling activity, they increase public fitness and health. Targeted CMM programmes can help address specific problems, for example reducing parking problems at a particular building or commercial district. CMM programmes often change the time of travel away from the peak-hour which does not reduce traffic but congestion.

CMM programmes tend to increase the effectiveness and cost efficiency of other TDM strategies. For example, a CMM programme can promote cycling in a community, making investments in bicycle lanes more effective, and it can encourage employers to cash out free parking (offer commuters the option of receiving cash instead of a subsidized parking space if they use another travel mode), which increases the cost efficiency of investments in public transit service improvements. The magnitude of these impacts and benefits depends on the scale of the programmes, its effectiveness, and the portion of total trips it affects.

Corporate Mobility Management programmes may be encouraged or required by local, regional or state/provincial policies. Trip Reduction Ordinances (TROs) require developers, employers, or building managers to provide incentives for occupants or employees to use alternative modes. Programmes and ordinances can be implemented state/region wide or by local jurisdictions, and take many different forms. Ordinances can require a certain reduction in trips with penalties and rewards set for achievement or nonattainment of goals. To minimize administration costs, mandatory TROs often apply only to large employers (those with at least 50 or 100 at a worksite), although this limits their effectiveness since the majority of employees in most areas work for smaller companies. Smaller employers can form a Transportation

Management Association (TMA) to provide trip reduction services in a particular commercial district or mall.

To establish a Commute Trip Reduction programme, a business usually develops corporate goals and objectives, policies and procedures, and services and benefits. Travel surveys are important to plan and evaluate programmes. CTR programmes may be managed by an in-house Employee Transportation Coordinator, a specialized transportation services company, or a local TMA. Organizations such as the Association for Commuter Transportation provide resources for developing such programmes and training staff.

Case Study: King County METRO Commute Partnership Programmes

The King County (Seattle area) METRO Transit Agency has developed a comprehensive commute trip reduction programme. The table below lists the programme components. A detailed description of each component can be downloaded from their website. METRO also provides general support and resources to employers to develop commute trip reduction programmes and integrate these efforts with parking, land use and transit management activities.

Table 7: *Commute Partnership Products, King Co. Metro* (www.transit.metrokc.gov)

Product	Description
Alternative Work Schedules	Compressed or flexible work schedules allowing employees to work longer hours in fewer days
Biking and Walking	Alternative commute mode that can be subsidized
Business Use of Vans	Programme making Metro commuter vans available for use by employees (at that worksite) during the business day
Carsharing	Convenient and economical alternative to owning a personal vehicle
Commuter Bonus	Non-taxable voucher programme that encourages employees to take the bus, a vanpool or a ferry
Commuter Bonus Plus	Voucher programme to encourage employees to commute by carpool, or walking and biking
Carpools	Alternative commute mode that can be subsidized
Custom Bus	Special service for areas with limited bus service
Datamatch	Computerized ride matching service to encourage employees to "share the ride"
Flex Pass	Comprehensive discount pass programme that can be customized to include commute incentives
Home Free Guarantee	Programme that ensures an emergency ride home for employees using alternative commute modes
Parking Cash-out	Programme for offering employees a choice between a subsidized parking space, and cash
Pass Subsidy	A variety of options for businesses interested in purchasing employee transit passes
Preferential Parking	Programme that reserves worksite parking spaces for those employees commuting by carpool & vanpool
Ridematch	Computerized ride matching database and mapping service
Rideshare Plus	Customized service approach for carpool and vanpool formation that employers can contract for
Tax Laws	Some helpful guidelines about commute-related tax issues that provide advantages for both employer and employee
Vanpools	Programme that supplies vans to groups of employees to share

GIZ Mobility Management

GIZ has several mobility management instruments in place:

Promoting cycling: Expansion of bike parking, services for cyclists (showers, lockers), bike + business campaign (www.bikeandbusiness.de)

In 2009 GTZ, a precursor organization of the GIZ, won the bike + business award.

In 2010 GTZ was named "the most bike friendly employer" in a German federal competition.

Job ticket: GIZ staff can use local public transport free of charge between their homes and the GIZ office. The ticket is financed by staff abstaining from taking two half-days of leave. In 2009 over 1070 job tickets were issued with 27% of staff commuting by public transport.

Raising awareness: Public transport information on intranet, information on environmental issues, campaigns, lift share notice board

Promotion of rail travel: GIZ reimburses on-duty travel costs within Germany by car to the value of a second-class rail ticket

Promotion of electric mobility: In-house charging station, awareness raising events (includes trying out)

More information on innovative German and European Mobility Management:

www.eltis.org and www.sutp.org (case studies)

3.7 Smart Growth Land Use Policies

Smart growth is a general term for policies that integrate transport and land use decisions, for example by encouraging more compact, mixed-use development within existing urban areas, particularly near transit stations. It corrects existing policies and planning practices that encourage more dispersed, automobile-oriented development (often called *sprawl*). It generally involves a variety of transport and land use policies which include:

- *Strategic planning.* Establish a comprehensive community vision which guides individual land use and transportation decisions. For example, insure that new housing developments, factories, hospitals, schools and commercial centers are located in or near existing cities, on major transit routes rather than scattered across the countryside.

- *More compact development*. Higher densities located within existing developed area, instead of lower-density development sprawling throughout an urban region.
- *Increased land use mix*. This means that as much as possible, housing, stores, schools, worksites and recreational facilities are located close together, within the same neighbourhoods, blocks and even the same buildings (for example, buildings with shops on the ground floor, offices on the second floor, and housing above).
- *Encourage a mix of housing types and prices*. Develop affordable housing near employment, commercial and transport centers. Develop second suites, apartments over shops, lofts, location-efficient mortgages and other innovations that help create more affordable housing.
- *Create self-contained communities (often called "complete communities" or "urban villages")*. Reduce average trip distances, and encourage walking, cycling and transit travel, by locating appropriate land uses close together. For example, develop schools, shops and recreation facilities in or adjacent to residential areas so do not need to drive to another neighbourhood for school, shopping and sports activities.
- *Improve non-motorised travel conditions*. Improve sidewalks, paths and crosswalks, implement traffic calming and traffic speed control, and build attractive streets with pedestrian amenities (trees, awnings, benches, etc.).

Picture 24: *Oxford (United Kingdom) is a relatively dense, compact city with many parks and a fabulous tree canopy. High-density can also be high-quality.*

Photo by Robin Hickman, 2009

- *Encourage Transit Oriented Development (TOD)*. Increase development density within walking distance (0.25 to 0.50 miles) of high capacity transit stations and corridors, and provide high quality pedestrian and cycling facilities in those areas.
- *Foster distinctive, attractive communities with a strong sense of place*. Encourage physical environments that create a sense of civic pride and community cohesion, including attractive public spaces, high-quality architectural and natural elements that reflect unique features of the community, preservation of special cultural and environmental resources, and high standards of maintenance and repair.

- *Develop connected path and road networks.* Create well-connected streets and paths, with short blocks and minimal cul-de-sacs.
- *Keep streets narrow.* Use traffic management and traffic calming to control motor vehicle traffic speeds.
- *Improve street design to create complete streets.* Use road space reallocation, access management, road diets, and traffic calming to insure that walking, cycling and public transit are convenient and comfortable, and to accommodate other street activities such as strolling, playing, shopping, sightseeing, eating and special events.
- *Preserve greenspace.* Preserve open space, particularly areas with high ecological and recreational value. Channel development into areas that are already disturbed.

3.7.1 Travel Impacts and Emission Reduction

Smart growth tends to increase walking, cycling and public transit travel, and reduce automobile travel. Travel impacts vary depending on many factors, including the combination of strategies that are implemented, how and where they are implemented. Smart growth strategies tend to be most effective if implemented as an integrated programme. For example, residents of dense, high-rise apartments may still drive if their buildings are located in isolated, automobile-dependent areas, but if located on walkable streets with shops and high-quality public transit nearby, residents are likely to significantly reduce their vehicle travel. An integrated smart growth programme can significantly reduce total vehicle travel. Residents of smart growth communities typically drive 20-60% less than they would in automobile-oriented development. Total impacts depend on the portion of regional develop that occurs based on smart growth principles. In rapidly-growing cities the potential travel reductions and impacts tend to be particularly large since a major portion of land use patterns can be influenced.

Picture 25: *Due to walkable streets and high-quality public transit the London Borough of Hounslow (United Kingdom) has a high modal share of walking, cycling and transit.*

Photo by Maxwell Hamington, 2008

Table 8: *This table summarizes typical impacts of various land use factors on travel activity.*

Factor	Definition	Travel Impacts
Regional accessibility	Location of development relative to regional urban center	Reduces per capita vehicle mileage. Central area residents typically drive 10-30% less than at the urban fringe.
Density	People or jobs per unit of land area (acre or hectare)	Reduces vehicle ownership and travel, and increases use of alternative modes. A 10% increase typically reduces VMT 0.5-1% as an isolated factor, and 1-4% including associated factors (regional accessibility, mix, etc.).
Mix	Proximity between different land uses (housing, commercial, institutional)	Tends to reduce vehicle travel and increase use of alternative modes, particularly walking. Mixed-use areas typically have 5-15% less vehicle travel.
Centeredness (centricity)	Portion of jobs in commercial centers (e.g., central business districts and town centers)	Increases use of alternative modes. Typically 30-60% of commuters to major commercial centers use alternative modes compared with 5-15% at dispersed locations.
Network connectivity	Degree to which walkways and roads are connected	Increased roadway connectivity can reduce vehicle travel and improved walkway connectivity increases non-motorised travel.
Roadway design	Scale, design and management of streets	Multi-modal streets increase use of alternative modes. Traffic calming reduces VMT and increases non-motorised travel.
Walking and cycling conditions	Quantity, quality and security of sidewalks, crosswalks, paths, and bike lanes	Improved walking and cycling conditions tends to increase non-motorised travel and reduce automobile travel. Residents of more walkable communities typically walk 2-4 times more and drive 5-15% less than in automobile-dependent areas.
Public transit quality and accessibility	Quality of public transit service and whether neighbourhoods are considered transit-oriented development (TOD)	Increases ridership and reduces automobile trips. Residents of transit oriented developments tend to own 20-60% fewer vehicles, drive 20-40% fewer miles, and use alternative modes 2-10 times more than in automobile-oriented areas.
Parking supply and management	Number of parking spaces per building unit or acre, and how parking is managed and priced	Tends to reduce vehicle ownership and use, and increase use of alternative modes. Cost-recovery pricing (users finance parking facilities) typically reduces automobile trips 10-30%.
Site design	Whether oriented for auto or multi-modal accessibility	More multi-modal site design can reduce automobile trips, particularly if implemented with improvements to other modes.
Mobility management	Strategies that encourage more efficient travel activity	Tends to reduce vehicle ownership and use, and increase use of alternative modes. Impacts vary depending on specific factors.
Integrated smart growth programmes	Travel impacts of integrated programmes that include a variety of land use management strategies	Reduces vehicle ownership and use, and increases alternative mode use. Smart growth community residents typically own 10-30% fewer vehicles, drive 20-40% less, and use alternative mode 2-10 times more than in automobile-dependent locations, and larger reductions are possible if integrated with improved regional transit and more efficient transport pricing.

A number of studies indicate that smart growth can reduce costs for public services, such as water and sewage, roads and schools (Burchell, et al. 2000). Smart growth tends to benefit consumers by improved housing and transportation options and affordability. Residents of communities with more efficient land use save thousands of dollars annually in transport costs.

Smart growth can provide substantial energy conservation and pollution emission reductions, although it may increase pollutant concentrations and therefore exposure to pollutants with localized impacts, such as noise and carbon monoxide. Smart growth can increase traffic congestion *intensity* (the delay that motorists experience when driving during peak periods) but tends to reduce per-capita congestion delays because residents drive less and take shorter trips. Smart growth communities tend to have much lower per capita traffic fatalities compared with sprawl.

Picture 26: *Urban sprawl tends to create and expand suburbs, whose dominant form of development is dispersed, with many trip origins and destinations, which in turn make efficient public transit and non-motorised transport difficult.*

Photo by Allan Ferguson, San Diego, California (USA), 2008

Community Travel and Emission Modelling

The study, An Assessment of Urban Form and Pedestrian and Transit Improvements as an Integrated GHG Reduction Strategy evaluates the effects of various urban form factors on vehicle travel and carbon emissions. It found that increasing sidewalk coverage from a ratio of 0.57 (the equivalent of sidewalk coverage on both sides of 30% of all streets) to 1.4 (coverage on both sides of 70% of all streets) was estimated to result in a 3.4% decrease in VMT and a 4.9% decrease in CO_2 emissions. Land use mix had a significant association with both CO_2 and VMT at the 5 percent level. Parking cost had the strongest associations with both VMT and CO_2. An increase in parking charges from approximately $0.28 per hour to $1.19 per hour (50th to 75th percentile), resulted in an 11.5% decrease in VMT and a 9.9% decrease in CO_2 (Frank, et al, 2011).

More information: www.wsdot.wa.gov (research)

Smart growth costs can include additional planning, construction and operating costs need to develop higher density facilities and increase travel choices. Higher-density, infill development may increase local traffic congestion and exposure to noise and air pollution, although regional traffic and pollution tends to decline if residents drive less. Increased density can reduce the amount of greenspace within an urbanized area, although it can increase total regional greenspace by reducing per capita area of land development. These negative impacts can be reduced through high quality implementation with appropriate design features (such as noise insulation and carefully located parks), but these mitigation activities may also involve additional costs. Smart growth planning is especially cost-efficient when implemented in new developments and costly if it is involved restructuring existing quarters.

Residents of smart growth communities tend to produce 20-60% lower transportation emissions than they would in a more automobile-oriented, sprawled location. (JRC,2011) Total impacts depend on the portion of regional develop that occurs based on smart growth principles. In rapidly-growing cities the potential emission reduction impacts tend to be particularly large since a major portion of land use patterns can be influenced.

Greenhouse Gas Emission Reduction Through Land Use – Carbon Footprints in Three Different Neighbourhoods in Toronto (Canada)

East York - 1.31 tCO2e/cap (residential only)

High-density apartment complexes within walking distance to a shopping center and public transit:

1.31 tCO_2e/capita

Etobicoke - 6.62 tCO2e/cap (residential only)

High-density single family homes close to the city center and accessible by public transit:

6.62 tCO_2e/capita

Whitby 13.02 tCO2e/cap (residential only)

Suburbs with large, low-density single family homes that are distant from commercial activity and public transit:

13.02 tCO_2e/capita

Table 9: *Comparison of carbon footprint in residential areas*

Source: Dan Hoornweg/World Bank 2010, blogs.worldbank.org/climatechange

Smart growth is generally implemented by various federal, state/provincial and local policy changes, and changes in business decisions such as how to design new developments and where to locate worksites. It is most effective if implemented as an integrated set of policies and programmes, including walking and cycling improvements, high quality public transit development, parking management and Corporate Mobility Management programmes, in addition to land use policy changes.

Washington State Growth Management

The Washington State Growth Management Act (GMA), passed in 1990, provides coordination among state and local governments to encourage more resource efficient development. Most communities are using their GMA plans and development regulations to make and stick to decisions about growth and development, while continuing to monitor, update and improve their growth management work. State grant and loan allocations favour GMA plans and the projects.

More information: www.ocd.wa.gov/info/lgd/growth/vision.html

Austin, Texas Smart Growth Matrix

The Smart Growth Matrix is a tool to assist the Austin City Council in analyzing development proposals within the Desired Development Zone. It is designed to measure how well a development project meets the City's Smart Growth goals such as: 1) the location of development; 2) proximity to mass transit; 3) urban design characteristics; 4) compliance with nearby neighbourhood plans; 5) increases in tax base, and other policy priorities. If a development project, as measured by the matrix, significantly advances the City's goals, financial incentives may be available to help offset the high cost of developing in urban areas. These incentives may include waiver of development fees and public investment in new or improved infrastructure such as water and sewer lines, streets or streetscape improvements, or similar facilities. These incentives require City Council review and approval.

More information: www.ci.austin.tx.us/smartgrowth

GreenTRIP

GreenTRIP is an innovative certification programme that rewards residential infill projects that apply comprehensive transport management strategies to reduce traffic, energy consumption and pollution emissions. Designed to complement LEED certification, which focuses on building design, GreenTRIP measures how connected a community is and what resources and incentives are provided to help use alternative transport modes, including walking, cycling, ridesharing, public transit and carsharing.

More information: www.GreenTRIP.org

Plan-It Calgary

Plan-It Calgary is a planning process to develop a comprehensive regional plan that responds to demographic changes, environmental and health objectives, consumer affordability and government fiscal constraints. A number of studies were commissioned for the plan that examined in detail planning objectives and solutions, including transportation policy reforms and smart growth land use policies. This included analysis of the economic and environmental impacts of compact and dispersed land use development patterns.

More information: www.calgary.ca/planit

Maryland Smart Growth

In 1997 the State of Maryland passed the Priority Funding Areas legislation that limits most state infrastructure funding, economic development, and other programme spending to areas that local governments designate for growth. This is intended to facilitate the redevelopment of brownfields and provide tax credits to businesses creating jobs in a Priority Funding Area.

More information: www.op.state.md.us/smartgrowth

3.7.2 Case Study: Transit Oriented Development in Curitiba

As early as the 1960s Curitiba (Brazil) developed a comprehensive Transport Master Plan. The main idea was to develop mixed land- use along transport corridors to minimize the need to travel. In 1974 the first BRT line was opened along one of these corridors to increase public transit ridership. Current zoning allows only high-rise and mixed development (10 to 20 story buildings) along BRT corridors. Mixed land use, that is a diverse development of commerce, employment and residences along the corridors, targets a reduction of the actual need to travel as well the distance of each trip undertaken. As one moves further away from the corridor buildings become smaller, less dense and lastly it turns into strictly residential areas. The BRT is the heart of this transit-oriented development and features speed buses that only connect transport centres over long distances as well as short distance buses (stops every 500m).

Impact

The impact can be best measured by the amount of travellers commuting by public transit and by the average distance residents travelled. In the 1970s about 7% commuted by public transit. In 2006 almost 75% used public transit to commute to work. This is equal to 23,000 passengers per hour, more than New York the United States' most transit oriented city (Garrick et al. 2006). Curitiba's Public Transportation Integrated Network maintains 2,100 buses (1,500 in its urban perimeter and another 600 in the integrated metropolitan ones). Of these 1,500, 1,280 operate on a daily basis and transport 2,040 million passengers each and every workday (1.55 million from within the Curitiba area, totalling 800 thousand passengers that pay fares; and 490 thousand from within the Metropolitan Area of which 230 thousand pay fares). Buses travel every day along all the routes of Curitiba and surrounding areas, distributed among 385 different lines (285 of them urban and 100 in the metropolitan areas) and five thousand bus stops. In addition to these bus stops, there are 351 tube-stations and 29 integrated terminals.

The smart growth approach in Curitiba has undoubtedly led to an attractive environment. Curitiba was able to attract skilled workers and diverse industries.

A good indication of the quality of life is firstly the higher GDP and a lower unemployment rate than the Brazilian average. Secondly liveability indicators such as green space per residents give a good indication on how attractive a city is. Currently Curitiba has 55m² of green space per resident - A much higher rate than the 16m^2 per resident recommended by the World Health Organization.

Picture 27: *Cities are places where people and activities come together (businesses, universities, museums etc.) which increases accessibility and reduces transport costs. This can be supported by transit-oriented development i.e. high density and mixed land use along transport corridors like in Curitiba (Brazil), cities can move to a low-carbon transport sector.*

Photo by Walter Hook, 2008

Success Factors

There is no doubt that Curitiba benefited from its highly dynamic mayors who supported and pushed for innovative mobility solutions. The underlying success factor is that already in the master plan the main principle was to give priority to cheaper and cleaner modes of transportation as well directing the growth of the city along five linear mixed land use transport corridors. Further the plan includes many programs to improve the environmental and social sustainability of the city (Garrick, 2006).

In addition, Curitiba dramatically improved its allocation of public space to pedestrians with major car-free areas in the city centre. The pedestrian zones also act as feeder services to the BRT system by easing pedestrian movements towards stations. However, not only the city centre is built in a pedestrian friendly manner. Most major roads have large walkways providing a safe environment for pedestrians. Also bicycles are well integrated into the bus system. Currently 150 km of bikeways have been built. Bicycle parking allows cyclists to conveniently store their bikes on site.

3.8 Success Factors Across TDM Measures and Case Studies

The various examples in the sections above show a variety of success factors. Table 10 gives an overview about the most common factors contributing to the success of the TDM policies discussed in the case studies and allows drawing some lessons for other cities. As a conclusion, four success factor groups were identified in the systematic review of case studies:

1. Cooperation and dialogue
2. High quality implementation
3. Part of a comprehensive strategy
4. Innovative Technology

Only the first three were systematically reviewed in the case studies and are reflected in the following table. However, Innovative technology, e.g. promotion of clean and energy efficient vehicles, is a crucial success factor to offset rebound effects.

Table 10: *Summary of success factors of all case studies*

		Cooper-ation and dialogue		High-quality implementation					Strategy		
		Inter-governmental cooperation	Institutional set-up	Reliability/comfort	Stakeholder consultation	Linkage to local circumstances	Ex ante data availability	Enforcement	Part of vision or strategic plan	Part of comprehensive TDM strategy	Marketing (small scale best practice)
Public transit service improvements											
Bogotá	Bus Rapid Transit			✔	✔					✔	
Seoul	Bus Rapid Transit	✔	✔	✔						✔	
Non-motorised transport											
Berlin	Cycling infrastructure and management	✔		✔							
New York	Human-scale road design	✔		✔	✔						
Seoul	Reclaiming of road space	✔			✔					✔	
Parking management and pricing											
Chicago	Long-term lease of curbside parking (privatisation)		✔		✗			✔		✗	
New York	Escalating parking fees, peak hour parking, hour-limit parking, new design of onstreet parking	✗		✔	✔					✔	
Portland	Freeze of parking space, flexible land use management									✔	
San Francisco	Introduction of maximum parking requirements, reform of curbside parking, parking unbundling	✔	✔	✔	✔		✔		✔	✔	✔
Seoul	CCTV parking supervision and enforcement			✔				✔		✔	
Efficient road pricing											
London	Fee on driving in central London (rebate for residents and some exempted vehicles)				✔	✔	✗			✔	
Singapore	Electronic Road Pricing	✔		✔				✔		✔	
Stockholm	Congestion pricing with exemptions for alternative-fuel vehicles				✔					✔	
Vehicle restrictions											
Berlin	Environmental Zone	✔				✔		✔	✔	✔	
Milan	Environmental Zone									✔	
Singapore	Vehicle registration quota									✔	
Smart growth land use policies											
Curitiba	Transit oriented development									✔	

✔ - Consideration of success factor contributed to effectiveness of TDM measure

✗ - Non-consideration of success factor contributed to failure or reduced effectiveness of measure

Cooperation and Dialogue

The *Intergovernmental Cooperation and Coordination* between agencies was often mentioned as a crucial aspect in the smooth implementation of projects due to the fact that through cooperation, competitive planning can be avoided. The level of competitive planning can be diverse. On high level policy making it can be a contradiction between economic and environmental goals while on implementing level it can be a lack of integrated planning of different modes (e.g. subway vs. bus). Different public private dialogues and mediation forums, working groups and other bodies can mitigate the risks of adverse planning.

Transaction costs can be significant if many agencies, public and private stakeholders are involved. Mediation and general coordination can be a lengthy and costly process. The *institutional set-up* (contract and organisational design) needs to be suitably designed. E.g. agencies were often merged to one coordinating institution to achieve essential synergy effects. At the same time the contract design in form of *incentive based contracts* between operator and policy making institution is crucial in terms of the sustainability of a TDM policy. Many projects in the case study review were particularly successful if the incentives were suitably distributed. For example, if private companies operate a bus system they need incentives both in terms of efficiency and quality. Contracts between the tendering agency and the private operator need to be designed accordingly. Within public agencies incentives can lead to very successful TDM strategies. If revenue from enforcement (e.g. enforcement of parking fees) or fares is channelled back to the agency that is providing the service there is an apparent incentive for efficient enforcement and production. Investments can be linked to revenue or performance based contracts used (quality performance rewarded).

High Quality Policy Implementation

To avoid unexpected responses to policies as described above, a high-quality policy implementation needs to be pursued. Government agencies need suitable human capacity, planning guidelines and quality data to ensure that the transport system is reliable and convenient and to ensure that the public is well integrated in the planning process:

Reliability and Convenience: Mode choice is usually made on the basis of costs, convenience and time. The success and public acceptance of a TDM measure is hence directly correlated to its convenience and reliability. Using new technology for parking management, congestion pricing or bike sharing can increase public acceptance greatly. But not only technology leads to higher reliability. The integration of modes through suitable location of bus and subways stops including the availability of non-motorised transport infrastructure, integrated schedule management and the integration of fares are major success factors for an alternative to private vehicle usage.

Stakeholder Consultation: The involvement of the public and relevant stakeholders is crucial as without public acceptance projects are seldom sustainable. Across case studies in Asia, Europe and the United States, innovative approaches for stakeholder consultation were applied. The main target is not only public acceptance. Through public consultation important information can be obtained as the community is usually much better acquainted with the local situation and problems. Public involvement can be in the form of forums, community boards, online feedback or more formalized in public private partnerships. A constant flow of information is important to ensure that the public is aware of the reasons behind the measures. E.g. the public acceptance of congestion charging is usually higher after its implementation. When informed about the benefits beforehand public resistance can be reduced.

Through well-designed *Marketing* the success of small-scale pilot projects can be demonstrated and acceptance on both a political and a public level can be ensured.

All push measures require efficient enforcement. The case studies reviewed above highlight innovative ways of enforcement. Pull measures like an improvement in the bicycle framework conditions only work if measures against illegal parking on bikeways are enforced. Efficient enforcement can be achieved by an incentive driven institutional design.

Picture 28: *This integrated interchange point provides a bus stop, a train station and a taxi stop very close-by, which also minimises walking distance for people with impaired mobility and helps visitors orientate.*

Photo by Affemann, Singapore, 2008

Part of Comprehensive Strategy

Impacts of TDM measures can be multiplied if not planned in isolation. To avoid rebound effects, policies should be embedded in *a comprehensive strategy*. A combination of push and pull measures can ensure that no rebound effects occur. To be specific, a reliable and well-integrated public transport (pull) is the backbone in any attempt to provide sustainable mobility options opposed to private vehicle usage. In order to shift from private vehicles to public transport usage restrictive measures (economic instruments, vehicle restrictions etc.) and a well integrated alternative has to be provided. For short- and feeder trips this can be in form of non-motorised transport for longer trips in the form of public transport.

If the measure is *Part of vision or strategic planning* it ensures that the long-term goals are well defined and regardless of changes in implementation responsibilities continuously pursued. The environmental zone in Berlin or the parking management in San Francisco are part of a vision of improved liveability in cities. Long-term visions are often supported through financing options by the central government (U.S. DOT competitive grant programme "Urban Partnership", or Europe's "Clean Air Initiative").

The previous sections describe the impact on carbon emission reductions along the impact chain. The four success factors identified could be integrated into the impact chain logic.

The success factors *protect the impact chain* of policies against the risks described above: conflicting objectives during policy formulation, unexpected response to policies and rebound effects.

Figure 23 below illustrates the need for a sound policy formulation and implementation process. Only if a policy change is not challenged by conflicting policy objectives, a high-quality implementation is ensured, the measures are jointly implemented with others as part of a comprehensive strategy and innovative technology is considered, the expected emission reduction effects will occur.

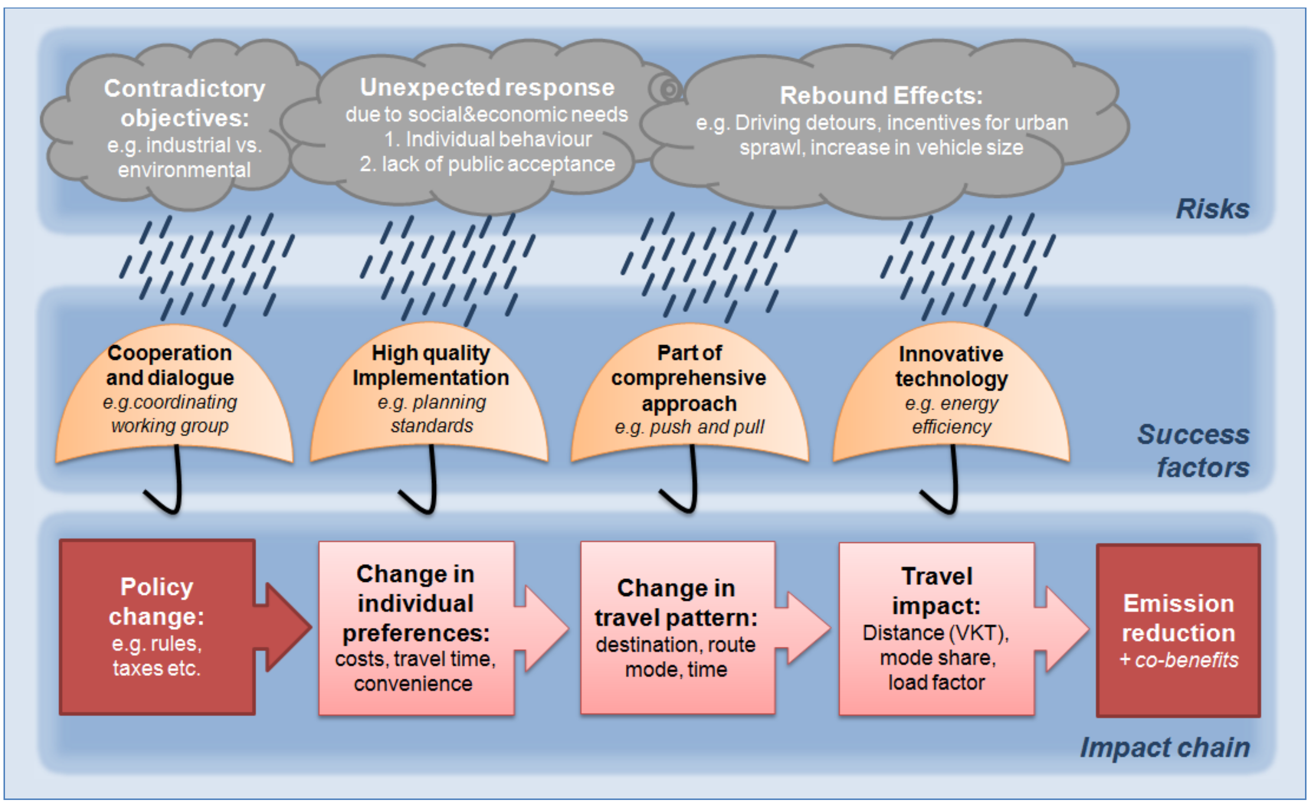


Figure 23: *Success factors to mitigate risk in the impact chain logical framework*

4 Practical Steps Towards Effective Emission Reduction

This chapter describes the critical steps to implement a sustainable low-carbon transport system, that is, by reducing emissions and achieving co-benefits. The steps can guide action regardless of whether a policy is already in place or existing policies did not lead to a desired result. Moreover, when policies are in place and do not lead to the expected outcome, quality reviews should be pursued. Every phase has underlying support processes that ensure that the success factors discussed above are considered. Fundamental for all project steps is the permanent development of competencies through technical training and the establishment of conducive institutional arrangements and institutional learning. The suggested policy development process is shown in Figure 24.

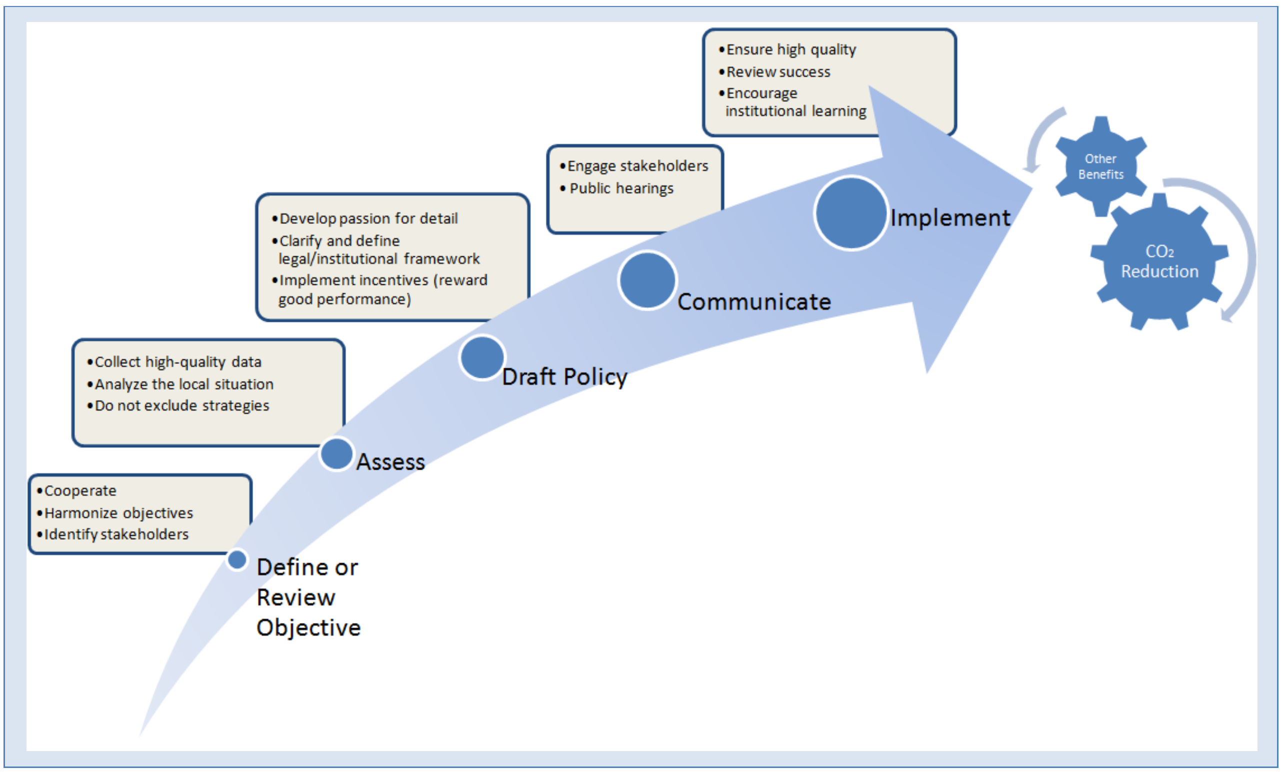


Figure 24: *Policy development process*

Phase 1: Describe Planning Objectives

The first step in the development of a low-carbon mobility strategy is the accurate definition of planning objectives. Conventional transport planning assumes that the primary planning objective is speed. That is, faster modes outshine slower modes. It evaluates transport system performance based primarily on the ease of driving, using indicators such as roadway level-of-service and average traffic speeds. Alternative strategies that have co-benefits are excluded right from the initiation of the planning exercise. As a result, it favors automobile travel in planning decisions such as facility investments, roadway design and land use planning.

An efficient transport system responds to user needs and preferences, and encourages travellers to use each mode for what it does best.

The new transport planning paradigm recognizes that travel demands are diverse. It expands the range of solutions that can be applied to solving traffic problems. Moreover, it expands the range of solutions that can be applied to move towards a low-carbon transportation system. It does not only include roadway expansion and improved vehicle design, but also improvements to alternative modes, more efficient pricing and smart growth land use policies.

Defining a reduction in CO_2 emissions or energy consumption as the primary target helps to reduce the risk that suitable strategies are excluded. Reduced CO_2 emissions are a good indication of a well-functioning comprehensive strategy. E.g. the policy objective is to reduce vehicle traffic in the city centre. If the policy option city toll is chosen, the indicator for a successful implementation is the amount or average speed of vehicles in the city centre. However, if the traffic is only diverted to other parts of the city the transport system did not increase its efficiency. Neither the general public nor motorists will be satisfied with the policy outcome. This utilization of CO_2 emissions as good indicator (a proxy indicator that measures the effect of a policy on behalf of other indicators such as traffic volume) determines these rebound effects as early as in the planning stage and helps to identify solutions to expected rebound effects (e.g. improved transit facilities in the city boundaries).

Many Chinese cities (e.g. Beijing, Guangzhou etc.) have decided on a variety of policies and measures. Bundling various measures is an important first step, but developing a comprehensive strategy also includes analysing carefully the synergies and contradictions towards the objectives. Even beyond the strategy, it is necessary to identify conflicting policy objectives that may risk meeting the objectives.

Picture 29: *Many Chinese cities experience traffic congestion and the various negative effects associated with it (pollution, noise, long travel times, etc.). These will not be mitigated by simply diverting vehicles or constructing more streets.*

Photo by Carlos Pardo, Jinan (P.R. China), 2008

Support Process 1: It is essential to ensure as early as in the planning phase that governmental institutions align and harmonize their planning objectives. Incidentally, drafting stakeholder landscapes and subsequently deriving a working group helps to align targets and avoids competitive planning. E.g. a housing development agency increases minimum parking requirements while the transport authority introduces higher parking fees to encourage alternative modes of transport. The outcome of inter-agency cooperation should be a joint, comprehensive strategy based on a long-term joint vision.

Phase 2: Assess Needs and Challenges

Chinese cities can justify implementing a broad range of TDM strategies. Most residents as well as the economic development will experience an overall benefit from policies that improve efficient transport modes, discourage automobile travel and create more compact, multi-modal communities where residents seldom need an automobile. The second step is to analyse the needs and challenges in the city carefully. Transport Research Centres (TRCs) or Urban Planning and Design Institutes (UPDI) are perfectly suited to do so.

The new planning paradigm requires new analysis tools, including user preferences, economic costs and benefits as well as emission reduction effects. An important tool for urban transportation decision-making is the ex-ante analysis of the estimated effects of policy options. This requires better transport-related data, but also the development of tools and guidelines for quantifying travel impacts and emission reductions.

At this stage it is essential to evaluate the benefits, costs and implementation requirements of these strategies. Identify the best combination, including “push” and “pull” strategies and consider leverage effects of a simultaneous implementation.

Support Process 2: The availability and interpretation of high-quality data is of utmost importance in this phase. The data needs to deliver valuable information on the local circumstances that need to be considered in the “assessment stage”. E.g. information on stated preferences and price elasticity needs to be evaluated to assess the consequences of concurrent push and pull measures. Having carefully formulated the objective in Phase 1 ensures that cost-benefit analyses estimate the effects ex-ante (e.g. compare the CO_2 reduction potential of different policies based on the estimated travel impact) without excluding potential strategies.

Phase 3: Policy Drafting

After having chosen the policy with the highest benefit-cost ratio or, as a proxy indicator, the highest CO_2 reduction potential, the detailed design and implementation strategy needs to be drawn up.

The policy does not only entail the external rules and obligations but also the internal procedures. Policy drafting procedure:

- Clarify the problem that the policy is addressing and the vision behind it (purpose)

- Clarify the legal framework and the agencies' authority to draft the policy, interaction with other policies (legal grounds)
- Define key terms (definitions)
- Define prohibitions and requirements of the policy (provisions)
- Define target group (exemptions and specification)
- Define responsibilities for enforcement, provision for fines (enforcement)
- Review policy with target group and stakeholders (quality check, see Phase 2)

Picture 30: *Efficient and consumer-oriented public transit in Seoul (South Korea) is rewarded through a higher share from the collective fare fund, which proved to be an adequate incentive.*

Photo by Buis, 2009

Support Process 3: A high-quality policy needs time. Every step should be drawn-up with some passion for detail. The definition of enforcement rules and principles is essential as well as the proper definition of the legal framework. As far as enforcement is concerned, the approach should be incentive driven. That is, the quality of implementation and the sustainability (e.g. through enforcement, performance rewards) should be interrelated. Examples:

- Seoul's public transport reform. High-quality performance is rewarded through a higher share from the collective fare fund. There is an adequate incentive to perform efficiently and consumer-oriented.
- San Francisco: The revenue from parking enforcement is channelled back to the authority that manages and plans parking. There is an adequate incentive for enforcement.

Defining the legal framework is important to avoid conflicting inter-agency responsibilities. E.g. the parking fee level should be determined by the agency that monitors occupancy level.

Phase 4: Communicate and Inform

Responses to policies can be diverse and differ, not only, between cultural groups, income groups and age groups. In order to change attitudes and preferences it is essential to inform the public about the objectives and reasons for the specific policy. Showing the benefits (that should outweigh the costs) often changes the public view towards more restrictive measures. Arguments include:

- *Size and density.* Chinese cities are large, dense and congested, so TDM strategies that encourage use of space-efficient modes (walking, cycling, ridesharing and public transit travel), and reduce traffic and parking congestion are particularly appropriate and improve the liveability of a city.

- *Growth rates*. Chinese cities are rapidly growing and establishing their future transport and land use patterns. Improvements to resource-efficient modes and smart growth land use policies can help provide emission reductions and other benefits for many decades.
- *Investment constraints*. Although Chinese cities are investing significantly in new transportation infrastructures, it is not possible to build everything. As a result, they should implement cost effective TDM strategies that reduce the need to expand roads and parking facilities, and help achieve other planning objectives.
- *Vehicle ownership*. Although vehicle ownership is growing, a majority of urban Chinese households will never own a personal automobile. As a result, improvements to alternative modes (walking, cycling and public transport), and innovative options such as carsharing and telework, will help improve the productivity and quality of life of the majority of residents.
- *Growing incomes*. Many Chinese city residents are becoming more affluent. It will therefore be important to develop higher quality transportation options and suitable incentives, so middle- and higher-income households do not all become automobile dependent.
- *Commitment to energy conservation and emission reductions*. China is committed to increasing energy efficiency and reducing pollution. China wants to position itself as a forerunner in environmental protection. This is evidently visible through the ambitious 12th national 5 year plan and the low carbon city approach by the Ministry of Transport. Communicating inventive mobility solutions to the general public can improve attitudes and change preference towards more sustainable, innovative transport modes. It is essential to communicate the emission reduction and travel impact potential of a policy to gain public acceptance.

Support Process 4: To not only inform but also to engage the public is an important aspect during phase 3. A public stakeholder consultation process can give important feedback for the policy design and ensure public acceptance of a policy. The consultation process should be on a technical (e.g. with Universities and Research institutes) but also on a community level (e.g. community boards).

Phase 5: Implementation

Chinese cities are at a stage where many TDM policies are already in place. To ensure that the existing as well as new policies lead to the envisaged impact, high-quality implementation and revision is essential. Residents will consider a transport system as being of high quality when the door-to-door transport is *convenient and fast* (suitable integration of modes, short distances, accommodating diverse needs), *reliable* (enforcement is crucial e.g. to ensure that dedicated bus or cycling lanes are functional) and *affordable*. For example, some city residents have physical disabilities, and this is likely to increase as the population ages. In addition, Chinese cities want to attract tourists, families with children and local businesses who often carry luggage and use hand carts. As a result, it is useful to develop universal design and special services to accommodate these travel needs.

Consequently, a high quality implementation benefits from carefully designed project phases 1-3. For example, having collected the right data on demand elasticities helps setting the right price for e.g. a toll road, ticket fares or a fuel tax. At the same time, it is therefore imperative to not plan in isolation but to consider the entire door-to-door mobility demand to ensure that modes are suitably integrated. E.g. buses, non-motorised transport facilities and subways need to be planned in such a way that schedules are aligned and interchanging is convenient (short distances, integrated ticketing).

Picture 31: *Quality matters! It is not about deciding about policies, it is about ensuring the best possible implementation. High-quality implementation in Bilbao (Spain) shown in this picture, is reflected in human-scale road design (calming of road traffic, separated bicycle lanes, pedestrian crossings), convenient integration of non-motorised traffic and transit and pleasant design.*

Photo by Robin Hickman, 2008

The TDM policies identified in this report help ensure that as the country becomes more affluent, residents will continue to use efficient transport options and avoid problems of automobile dependency. Transport patterns and the amount and type of travel that people use vary significantly due to policy and planning practices. If policies are designed and reviewed to ensure that they are of high quality (affordable, convenient and fast) then even residents of cities with efficient transport policies tend to drive much less and rely much more on efficient modes (walking, cycling and public transport) than equally wealthy residents of cities that encourage automobile travel.

Chinese cities can become leaders in transport policy innovation – but world-class implementation is needed. Otherwise the danger to fail is high.

The strategies described in this report will require a variety of institutional reforms, implementation programmes and capacity building so implementation of the most suitable and best implemented TDM strategies is ensured. If fully implemented to the degree justified by economic principles, these strategies can result in Chinese cities achieving vehicle travel patterns similar to those in other wealthy Asian cities such as Seoul, Singapore and Tokyo. No single TDM strategy can achieve this.

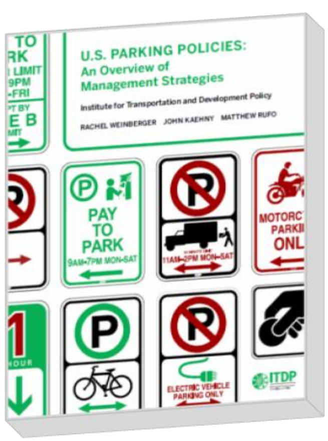
Support Process 5: During the implementation phase frequent quality revisions are crucial. This can be in the form of stakeholder and expert hearings, through frequent travel data monitoring and evaluation. Through this approach, policies that were suitable in the beginning but designed imperfect or less effective due to changes in the environment (see environmental zone in Milano) can be improved. This learning process is crucial to improve the future design of policies. Small-scale trial implementation should be encouraged to improve public understanding on the one hand, and to identify and address technical problems and other concerns with the policy on the other hand (learning process).

An Example: Implementation Requirements of Parking Management and Pricing

Parking management is best implemented as an integrated programme that includes various strategies that can change over time in response to the needs of a particular time and place. Below are specific steps.

1. Develop a strategic parking management strategy (a long-term, comprehensive plan) that identifies the short-, medium- and long-term policy reforms and programmes to implement in a particular area. Integrate the parking management plan with strategic transport and land use plans. For example, target parking management plans in growing urban areas with traffic and parking congestion problems and transit-oriented development.
2. For each urban district perform a parking study which determines parking supply, price, utilization, violation and enforcement conditions. Use this information to evaluate parking problems and management options, for example, areas where parking is often unavailable, poorly enforced or experiencing spillover problems (motorists parking where they should not), and opportunities for more improved management.
3. Test the measures and implement them in one district as a demonstration and evaluate the effects before applying them to all districts. Make sure that implementation is of high quality, regulations are effective and adapted to specific needs and illegal parking is enforced. Communicate the benefits of parking management.
4. Improve parking regulation enforcement.
5. Efficiently price municipal parking. Establish targets for expanding when and where parking will be priced. Where parking supply is inadequate, encourage commercial parking development.
6. Improve user information.
7. Eliminate or reduce minimum parking requirements in zoning codes. If minimum parking requirements are applied, develop standard reductions for appropriate geographic, economic and management factors, such as proximity to transit stations and carshare services, pricing and unbundling, shared parking arrangements with nearby parking facilities, and implementation of commute trip reduction programmes. If minimum parking requirements are applied, allow in lieu payments toward shared parking facilities as an alternative to on-site parking.

More information:



Review of several Parking Management Solutions in the US:
ITDP 2010, US Parking Policies

5 Conclusion: Towards TDM 2.0 in Chinese Cities

Chinese cities are experiencing rapid economic development. This is generally beneficial and deserves support, but it does create a new set of problems associated with affluence. If they are not properly addressed, much of the gains from increased wealth will be offset by increased problems.

As a matter of fact, Beijing and other Chinese cities already experience severe traffic problems. International surveys rank Beijing as the city with the most severe traffic and parking congestion, air and noise pollution problems (among others see IBM (2011)). Related health problems are also increasing. These problems will become even worse if vehicle ownership and use continues to grow. In the 12th five Year Plan (2011-2015), the Chinese government plans the further development of the road network including seven new freeways, nine expressways (North-South), 18 throughways (East-West) with all towns and nearly 90% villages accessible by vehicles. This further increases the number of on-street vehicles, and significantly increases GHG emissions.

Fortunately, solutions do exist. Cities around the world are implementing various transportation demand management strategies that increase transport system efficiency. This provides numerous economic, social and environmental benefits. Worldwide experience

Picture 32: *The retail hub, which is a major redevelopment of the Liverpool (United Kingdom) city centre, offers excellent passage and linkages to neighbouring attractions.*

Photo by Robin Hickman, 2009

indicates that, with more rational policies, planning practices and high quality level during implementation, even the largest cities can be efficient and liveable.

Some people mistakenly think that TDM is “anti-car”. In fact, motorists can benefit from these strategies because they provide road and parking congestion reductions, improved safety, and a reduced need to chauffeur non-drivers. Some people assume that, because they are good for the environment, those strategies must be harmful to the economy. However, many of these strategies in fact reflect market principles, and they reduce overall costs, which increases economic efficiency and productivity.

The key is to plan for people first, and then accommodate motor vehicles, rather than planning for vehicles and then trying to accommodate people.

Examples around the world, some of them discussed in this report, prove that transport demand management is successful in achieving multiple planning objectives and reducing GHG emissions. In this regard, the impact chain discussed above shows that overall GHG emission reduction is a good indicator to describe the accomplishment of other benefits. It allows integrating planning objectives and helps ensuring that the planning institutions strive to achieve a high quality implementation.

Picture 33: *Different modes of transport can coexist in Beijing (P.R. China) as well as in any other city.*

Photo by Rau, 2010

Many TDM policies are in place in Chinese cities. Many municipal governments also bundled a package of measures in order to deal with the growing number of cars (e.g. Beijing issued 28 TDM Measures in 2010). However, still policies are not as successful as expected. And finally, only the achievement of the expected results counts. Taking a comprehensive approach means, that policy packages need to be carefully adapted and fine-tuned to the local needs. This can be done along the impact chain and the various risks that occur on the way to GHG reduction. However, it also requires very good knowledge about the local situation: Only if analysing competing planning objectives and understanding the status-quo it can be determined whether new strategies, an improved integration of the policies or a revision of policies is needed. Hence, there is a need to analyse the current performance of the transportation system, whether adequate policies exist and if there are problems in the implementation of existing policies.

Finally, improving performance is possible if there is

(a) A clear understanding how the picture shall look like (objective);

(b) The main puzzle pieces that it takes to complete the picture (policies);

(c) An idea of how to put the pieces together (cooperation and joint strategy).

Based on the findings of the report, five approaches are considered most effective in terms of their potential to reduce GHG emissions (having the Chinese context in mind). It is not (only) about drafting new policies, it's about achieving the next level of TDM that could have a signal effect for other metropolitan cities worldwide. The report suggests a high-quality and sophisticated implementation of the following:

1. Parking management and other complementary forms of limiting car use in specific areas, e.g. congestion charging, low emissions zones. See San Francisco (page 63) and Milan example (page 75).
2. Supply high-quality public transport (e.g. bus reforms, pricing reforms) and convenient interchanges between bus and subway. See examples of Seoul (page 19) and Singapore (page 43).
3. Improve the situation for cyclists and pedestrians. The infrastructure in Beijing is often available. Improve enforcement and non-infrastructure measures! See example of Cycling Master Plan in Berlin (page 27).
4. Involve private stakeholders and include the public. Further develop policies that encourage CMM programmes for employers (commuting). See Rotterdam example.
5. Re-think urban development and road design to improve the situation for both motorised and non-motorised transport. See New York and Seoul as examples.

Picture 34: *Effective street design providing ample space for different modes of transport and plants in Beijing (P.R. China)*

Photo by Daniel Bongardt, 2011

Such a comprehensive approach requires high quality implementation to achieve success: What is the optimal number of parking spaces, what is the optimal fee? What is the best standard for the design of cycle paths, what the optimal link between bus and subway? It requires plenty of information and constantly learning from success and failure. It needs continuous evaluation of success.

Being unsuccessful in the first try does not mean you fail, it means you learn a lesson for the next round.

There are many more options than just the ones listed above like, e.g. school bus programmes, campaigns (www.walkingschoolbus.org), car-sharing or pooling approaches, that might be complementary and beneficial as well. But most of these strategies only work, if a sound basis – as described above – is implemented in a high-quality way.

In addition, transport demand management needs to include one critical question: How much road space for cars is enough? At what level of car-oriented street supply TDM policies are no longer effective, as incentives for car-use are just too high? This key question for urban transport systems can only be answered on the ground, in cities that collect information and balance the need to travel (demand) and the supply of space for cars and other modes.

Only if the supply side is relatively stable and clear, the effects of demand management are predictable.

Many cities around the world have successfully implemented TDM measures. Not every city was successful with identical measures. But all of them have a few features in common:

1. Continuously developing policy objectives towards a common vision: Relatively stable understanding of what shall be achieved and what needs to be done – even if some of the decisions are not so popular in the beginning. This is the basis for comprehensive packages that further develop over time.
2. Selecting TDM policies carefully and adapting them to local needs: This requires a high degree of coordination between actors.
3. Implementing the policies in the best possible way: Ensuring world-class transport demand management is only possible through continuous evaluation of success and learning.

Figure 25 shows some of the cities that implemented high-quality TDM policies with outstanding success. **Is Beijing going to be one of them?**

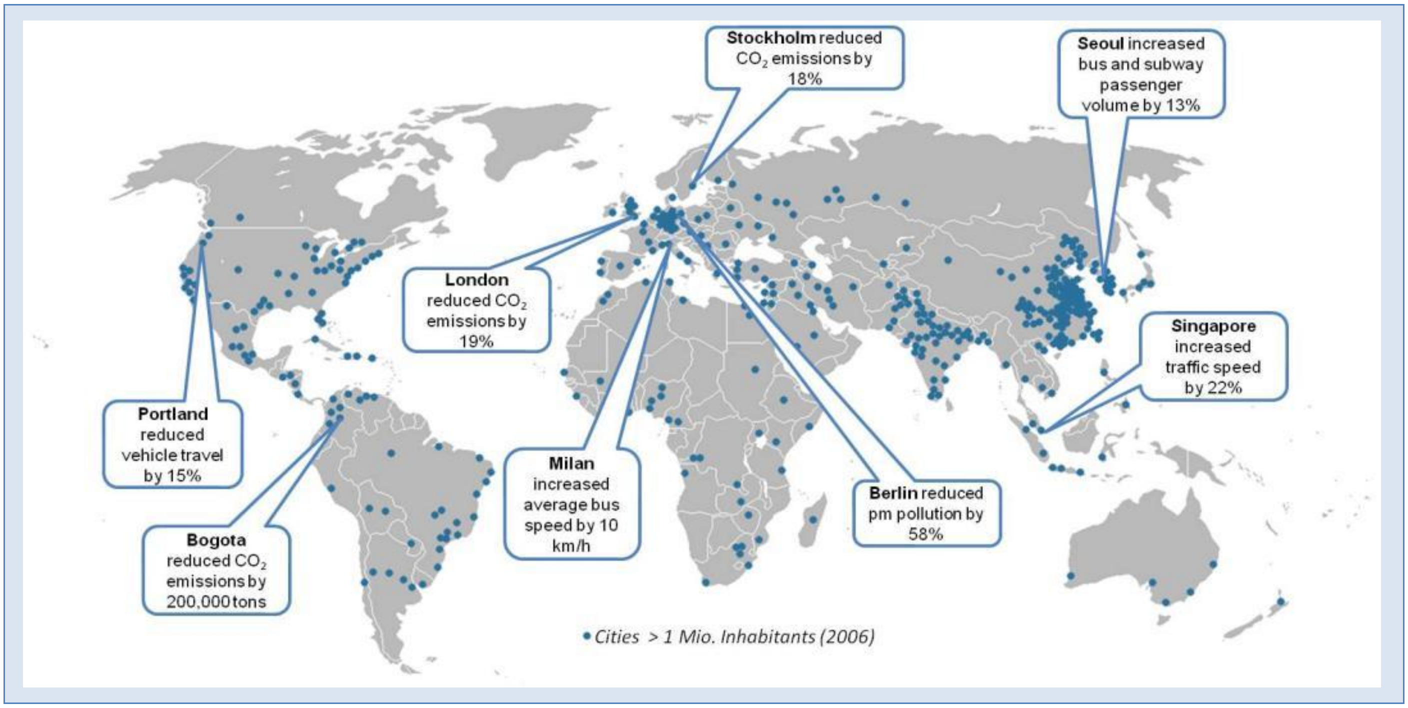


Figure 25: *Exemplary achievements of the cities described in the case studies*

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