Travel Demand Management in Beijing: Opportunities for Green, High-Tech, Equitable Transport

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Prepared by

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EXECUTIVE SUMMARY

Motor vehicle use in Beijing is growing rapidly. While this represents a sign of growing affluence and brings increased amenity for many individual travelers, it also causes increased traffic congestion, premature death and injury from accidents and air pollution, growing dependence on imported oil, and economic and social dislocation. Beijing authorities recognize the need to manage motor vehicle traffic to provide green, cleaner, high-technology transportation and to address pressing equity issues, for rising motor vehicle use imposes harms especially on the poor, the young, the old, and the infirm, while principally benefiting those with the greatest resources.

As Beijing prepared for and conducted a highly successful Olympic Games in 2008, the city authorities demonstrated how traffic could be managed to produce considerable societal benefits: reduced air pollution, less traffic delay, increased use of public transportation, walking, and cycling, and more efficient transportation. As successful as this experience was, it relied on temporary measures such as restricting half of all private motor vehicles from being driven each weekday within Beijing. Since the Olympic Games, authorities have relaxed some of these measures, for example barring private cars only one day in five, based on the last digit of license registration. Major investments in public transportation expansion have contributed to a continued shift to greater public transportation use in Beijing. These provide a foundation for further travel demand management (TDM), which could help ensure that walking, bicycling, and public transportation remain dominant modes of transportation, rather than sharp declining as they are displaced by growing traffic and gridlock.

This report reviews some of the global best practices in TDM world-wide that may be most transferable to Beijing in the next several years, focusing on three most promising strategies where Beijing could advance effective TDM measures: parking management and pricing, regulation of official cars, and congestion pricing or road user charging. The authors recommendations include:

- Beijing should improve routine data collection about the quantity and cost of parking spaces, both on-street and off-street, by time-of-day/week, by vehicle class, by block, across the city, to support better regulation, taxation, and management of parking.

- Beijing should eliminate minimum parking requirements close to high quality public transportation and cap the supply of parking in such areas consistent with mode share goals. It should trim minimum parking requirements elsewhere where possible to support mode share goals and rely more on pricing to allocate scarce parking, Developers should be encouraged or

required to provide convenient bicycle parking, covered or shaded pedestrian pathways, and other amenities in lieu of some parking, and to participate in parking management and transportation management districts that coordinate travel incentives, prices, and policies.

- The City should encourage employer-based parking strategies that help promote carpooling and other alternatives to driving for commuters, including "parking cash-out" or cash-in-lieu-of-parking incentives, preferential carpool parking, employer public transportation commuter subsidies, and bicycle parking and changing rooms at workplaces.

- Beijing should foster use of multi-space pay-and-display meters for on-street parking, as are in wide use in European cities, with time-of-day pricing that varies by neighborhood and block.

- Beijing should consider dedicating a portion of the revenue collected from parking back into the neighborhoods where collected as part of a parking benefits district and use it to improve walking and cycling infrastructure.

- Beijing should adopt the official car reforms used in other major Chinese cities, considering a mobility subsidy as a credit on multi-modal Yikatong cards to give many employees the choice to economize on mobility expenses and chose public transit. The central government – one of the major provider of official cars inside the 2nd ring - should be persuaded to apply similar measures – as far as possible - for national agencies.

- Beijing should prepare now to replace the current license restriction system with a road user charging system over the next several years, relying on traffic cameras and license recognition, as in London and Stockholm. A time-of-day-based road user charge could provide motorists with greater travel choices, raise considerable new revenues that could be devoted to further improvements in public transport, walking, and cycling, and reduce traffic congestion. Beijing authorities should begin detailed evaluation of alternative road user charging system approaches as part of a pilot program to test public response to alternative program designs and use computer transportation models to evaluate alternative scenarios, paying a sample of motorists to test road user charging concepts while monitoring their behavior, and disseminating the results to key stakeholders, the press, and other interested parties. Beijing authorities should evaluate its legal authority to pursue the range of road user charging implementation options and take steps to ensure political support for broader adoption, clarifying its objectives and priorities in pursuing road user charging.

1. Introduction to Travel Demand Management (TDM)

TDM strategies influence behavior by reducing the need for driving through "**pull measures**" that improve proximity and improve the convenience, attractiveness, safety, and affordability of walking, cycling, public transportation, along with other more environmentally-benign travel options, and by "**push measures**" that that price and manage motor vehicle use and street space to shape travel demand.

Without viable alternatives, it is unfair and impractical to push drivers out of cars. People will simply be frustrated and bring political pressure in favor of car domination. Many cities have found that investing in Pull measures alone is expensive and ineffective based on their experience. For instance, when transport planners in Stockholm introduced significant improvements in bus service, they noticed no gain in ridership. Yet when the bus service was paired with a congestion charge measure, travel on public transportation increased by about 5%. They concluded that public transport service alone had very little impact, "Of the 22% decrease in car travel across the charge zone, only 0.1% at most could have been caused by the expanded bus services," (City of Stockholm, 2006).

Just as supply-side transportation measures are a mixture of approaches and scales, so demand-side measures should be. Unless a mix of TDM measures are applied, they may not achieve the desired effects. It is important to pair Push and Pull TDM strategies when developing a comprehensive TDM strategy. Table 1 illustrates a number of Push and Pull strategies. This report focuses on a subset of these, chosen because they may offer key unexploited near-term opportunities for Beijing.

TDM measures often have multiple benefits and support other goals, such as environmental sustainability, or building the local economy and reducing dependence on imports. Vehicle restraint measures, for instance, improve mobility for non-motorized modes, as well as urban quality of life by reducing noise and pollution. However the effectiveness of policy and regulatory TDM measures can depend upon to what degree they are designed to suit political concerns, or politicized. Political expedience can undermine the effectiveness of a TDM measure and discredit the concept. Alternately, supportive policies such as earmarking funds from a congestion charge for public transportation can build credibility and win the political support of non-drivers.

Table 1 Pairing Push and Pull TDM Strategies (selection of measures)

	PUSH	PULL
Policy / Regulatory / Economic	**Restrict car access** -road pricing -congestion pricing -sales tax / import duty -registration fee / road tax -car quota system -parking pricing -parking management -plate restrictions -low emission zone	**Improve transit services** -integrated system and fare structure **Improve bicycle and pedestrian access**
Physical / Technical	**Reduce car mobility** -reduce parking supply -traffic cells -traffic calming **Eliminate obsolete car infrastructure** -reconnect severed neighborhoods	**Improve quality of transit service** -bus rapid transit system -bus lanes -bus priority **Improve bus infrastructure** -quality vehicles -comfortable bus shelters -easy to find route and timetable information **Improve bicycle infrastructure** -bicycle lanes and parking -bicycle route signage and maps -public bikes **Improve pedestrian infrastructure** -safe sidewalks and crosswalks -pedestrian zone
Plan / Design	**Integrated land use planning** -regional spatial planning -transit oriented development -maximum parking requirements	**Planning for non-motorized transport** -street design for bicycles and pedestrian traffic -connectivity of streets -maps and wayfinding aids
Comple-mentary	**Enforcement** **Car Sharing**	**Public awareness** -marketing transit -events like Car Free Day **Commute programs with employers** -flexible work hours, transit pass

Sensitivity of Travel to Pricing

Economists have plenty of solid research showing that prices affect travel behavior, but non-economists often cite anecdotal evidence that travel is insensitive to price, and so argue that price reforms are an ineffective way to affect travel behavior. For example, they will point to a news article showing that a recent jump in fuel prices had little effect on automobile use, or data showing that people who live in countries with high fuel taxes continue to drive automobiles. “Motorists love their cars too much, they won’t give them up,” goes the claim. Such claims are partly true and largely false.

As it is usually measured, automobile travel is *inelastic*, meaning that a percentage price change causes a proportionally smaller change in vehicle mileage. For example, a 10% fuel price increase only reduces automobile use by about 1% in the short run and 3% over the medium run. Even a 50% fuel price increase, which seems huge to consumers, will generally only reduce vehicle mileage by about 5% in the short run, a change too small for most people to notice, although this will increase over time as consumers take the higher price into account in longer-term decisions, such as where to live or work.

But fuel prices are a poor indicator of the elasticity of driving, because over the long term consumers will purchase more fuel-efficient vehicles. Over the last few decades the real (inflation adjusted) price of vehicle fuel has declined significantly, and vehicle-operating efficiency has increased. Real fuel costs are now a third lower, and an average car is nearly twice as efficient. Residents of countries with high fuel taxes tend to purchase more fuel-efficient vehicles and drive fewer annual miles per capita. For example, fuel taxes are about 8 times higher in the U.K. than in the U.S., resulting in fuel prices that are about three times higher. U.K. vehicles are about twice as fuel efficient, on average, so per-mile fuel costs are only about 1.5 times higher, and automobiles are driven about 20% less per year, so annual fuel costs are only 1.25 higher than in the U.S. Similar patterns can be found when comparing other countries with different fuel prices. This indicates that automobile use is sensitive to price.

The relatively low elasticity of driving with respect to fuel prices hides a much higher overall elasticity of driving. Fuel is only about a quarter of the total cost of driving. The price sensitivity of driving is more evident when measured with respect to parking fees and tolls. A modest parking fee or road toll can have a major effect on travel demand. Some of this reflects changes in destination and route, but it also includes changes in mode and travel distance (Pratt, 1999). When per-mile or per-trip costs increase, motorists tend to drive less and rely more on other modes.

Table 2 below summarizes the impacts of various type of pricing changes on car ownership and car use.

Type of Impacts	Vehicle Fees	Fuel Price	Fixed Toll	Congestion Pricing	Parking Fee	Transit Fares
Vehicle ownership. Consumers change the number of vehicles they own.	✓				✓	✓
Vehicle type. Motorist chooses different vehicle (more fuel efficient, alternative fuel, etc.)	✓	✓				
Route Change. Traveler shifts travel route.			✓	✓	✓	
Time Change. Motorist shifts trip to off-peak periods.				✓	✓	
Mode Shift. Traveler shifts to another mode.		✓	✓	✓	✓	✓
Destination Change. Motorist shifts trip to alternative destination.		✓	✓	✓	✓	✓
Trip Generation. People take fewer total trips (including consolidating trips).		✓	✓	✓	✓	
Land use changes. Changes in location decisions, such as where to live and work.			✓		✓	✓

Different price changes have different impacts on travel behavior.

Table 2: Impacts of Pricing on Travel Behavior

Adapted from Todd Litman, "Transportation Elasticities," 2007, www.vtpi.org

2 Beijing's Recently Adopted TDM and Traffic Management Policies

As Beijing has developed its transportation system, with extensive investments in new roads, parking facilities, public transportation, and non-motorized infrastructure, the balance between travel modes has shifted rapidly. Walking and cycling, which once dominated in urban travel, have declined sharply as motor vehicle use has grown. The number of motor vehicles, the share of trips by car, and vehicle-km of travel has risen sharply in the past decade, as Figures 1 and 2 show below.

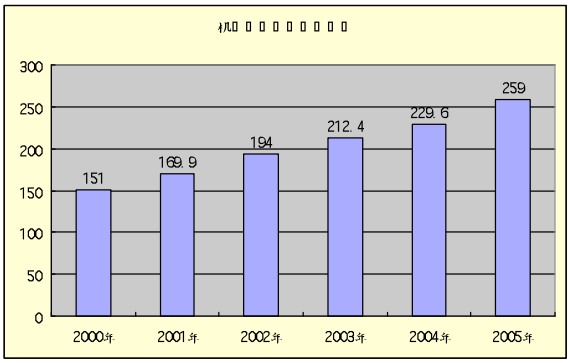


图 北京市机动车保有量增长情况

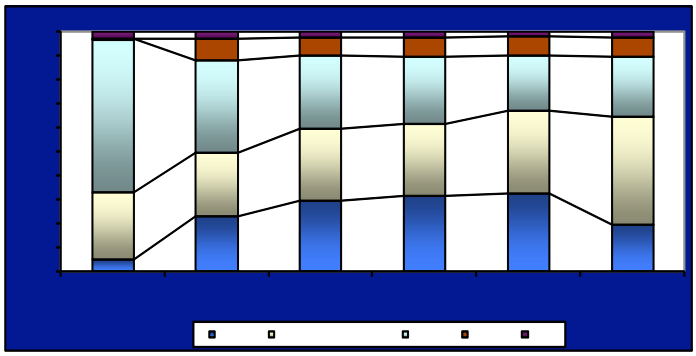


图 北京市交通方式分担率变化情况

Yet Beijing has combined Push and Pull measures for TDM in recent years to achieve significant impacts on travel demand. The Olympics provided an important demonstration of how these strategies can work together. As discussed below, further measures will be needed to help manage growing motor vehicle use in Beijing, especially as incomes rise in coming years.

2.1 TDM policies and performance during the Olympics

2.1.1 TDM policies and measures during the Olympics

Officials in Beijing recognized the need to manage traffic for a successful 2008 Olympic Games experience to help reduce air pollution and congestion. As Table 3 shows, TDM policies and measures were implemented at varying levels immediately before and during the Olympics.

Table 3 Application stages of TDM policies before and after the Beijing Olympics

Period	Start Date	End Date	TDM Policies
Pre-Olympic Transition Period	July 1, 2008 (Before the Olympic Village opened)	July 19, 2008	Every other day odd-even license ban 6AM-9PM for area inside 5th Ring Road
Olympic Restriction Period	July 20, 2008 (After the Olympic Village opened)	Sept. 20, 2008 (Paralympics ended)	Every other day odd-even license ban 3AM-midnight including 5th Ring Road and area inside Olympics special lanes in force Supporting schemes for transit and freight Implement different working hours
Post-Olympic Period I	Sept. 21, 2008	April 10, 2009	
Post-Olympic Period II	April 11, 2009	Ongoing as of August 2009	Every 5th day license ban 7AM-8PM for area inside 5th Ring Road

In a several week transition period before the Olympics, Beijing restricted many vehicles from entering the area inside the Fifth Ring Road between 6 AM and 9 PM based on an odd-even license plate scheme, which kept one-half of the registered vehicles off the streets every day. Certain vehicles were exempted from these restrictions. Highly-polluting vehicles were prohibited all-day, every day, and vehicles from other provinces, regions and cities that entered into Beijing city were required to comply with the emission standard of Chinese National Code. For vehicles owned by China's State organizations, Army garrison in Beijing, Police, Municipal government and enterprise and institutions, 30% were prohibited each day. A campaign called, "Drive Less for a Green Trip," was organized to encourage voluntary reduction in driving. Trucks from other provinces, regions and cities were required to travel around the Beijing region on the 112 National Highway(G112).

During the Olympic Games themselves, the odd-even license plate transition policies and other travel restrictions were further strengthened in Beijing to curb traffic and pollution. Motor vehicle use was prohibited both on and inside the Fifth Ring Road from 3 AM to midnight, using the odd-even license scheme. This restriction also applied to 70% of the vehicles of Party and government organizations in Beijing, as well as for enterprises and institutions in the administrative region. Vehicles from other provinces, regions and cities entering into Beijing were also subject to the odd and even number license

restriction and more stringent vehicle emission standards. These limitations applied to such major roads as the Airline Expressway, Badaling Expressway, and Jingcheng Expresssway. Olympic Special Lanes were designated the inner lanes of 283 km of motorways that connected the Olympic competition stadiums with accommodations for those attending and with other facilities.

Some softening elements were included to address the impact of these motor vehicle use restrictions on the lives of routine car users. When one family owned two vehicles of odd or even number, they were permitted to change the number plate so that they would be able to drive one vehicle per household per day.[1] Vehicles could be driven from midnight to 3:00 AM., regardless of the odd and even license plate number. When roadways had both an Olympics special lane and a bus only lane, private cars can use the bus only lane for driving. For motor vehicles affected by the partial driving restrictions, vehicle and ship revenue and road maintenance taxes and fees were waived for 3 months.

Beijing's public transportation was improved before and during the Olympics by substantially adding services, increasing the number of vehicles, improving operational efficiency, opening new routes and other measures to improve the bus and subway's capacities. Special measures were taken to ensure that freight systems could meet the standard of the city's normal transportation operation to support production and consumer requirements. Freight demand was managed in part by adjusting working hours of various businesses, schools, and enterprises during the Olympic Games.

2.1.2 Road performance impacts of Beijing's Olympic Period TDM policies

These programs had a profound impact on traffic and pollution. Figure 3 shows how the AM peak speed of the road network increased by 22% and the PM peak speed of the road network increased by 23.5%. From the Figure 4, we can also see that the congestion index of the road network in Beijing decreased a lot after the implementation of TDM policies. During the first transitional period of Olympic TDM policies, the congestion index decreased from 5.6 to 2.7, while during the second full Olympic TDM Policy period, the index number continuously become even smaller, dropping to 1.7, which indicates that the traffic becomes very smooth. This no doubt contributed to the sharp drop in air pollution and related public health problems.

[1] This of course also no doubt caused some households that could afford it to purchase a second vehicle. Artificially boosting automobile ownership among the more affluent is an unfortunate consequence of most odd-even license plate restriction schemes. This in turn fosters increased car dependence and driving over time.

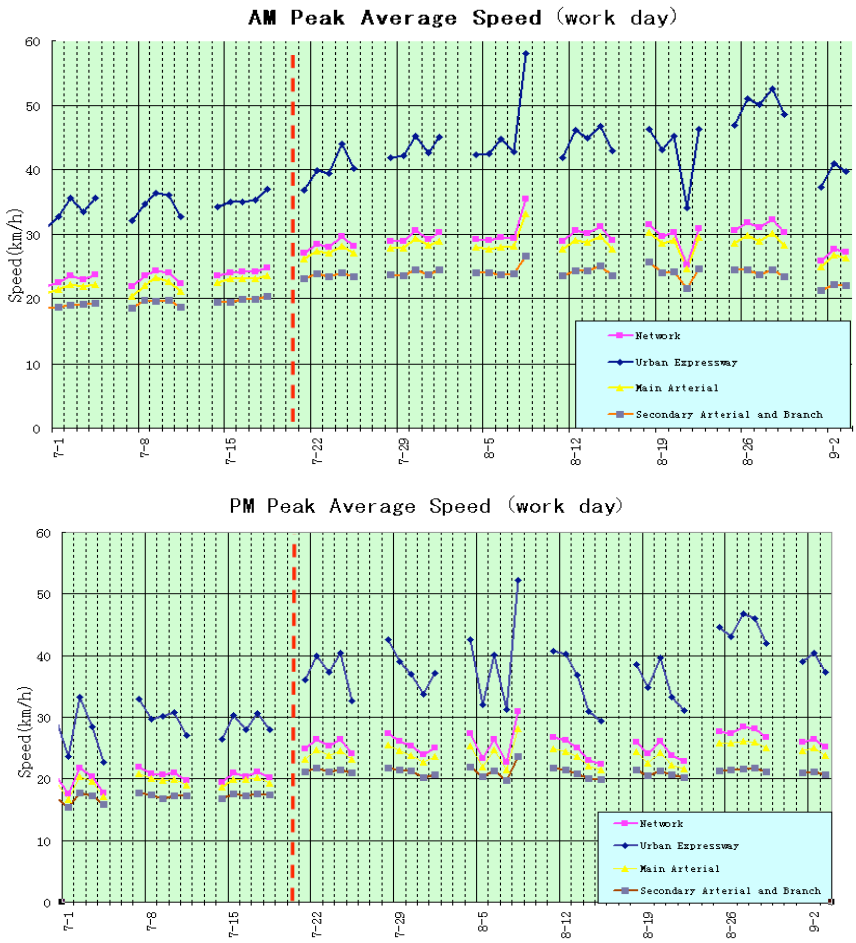
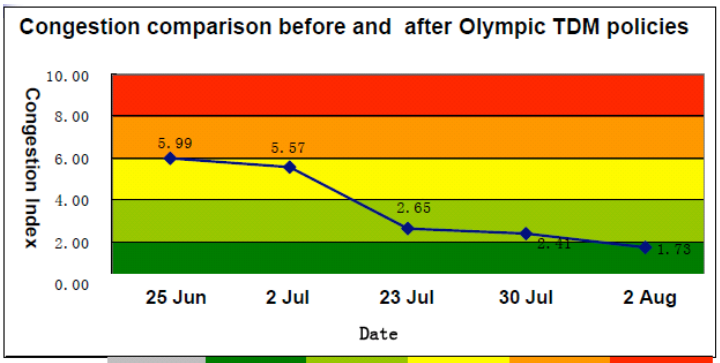


Figure 3 Average speed changes during the AM and PM peak hour in response to more stringent odd and even license plate scheme initiated July 20, 2008



color						
intensity	N/A	Very smooth	Smooth	Light congested	Medium congested	Heavy congested
Congestion Index	——	[0, 2]	(2, 4]	(4, 6]	(6, 8]	(8, 10]

Figure 4 Congestion comparison before and after the Olympic TDM policies

2.2 Current Beijing TDM Policies and Performance

To help address continuing problems caused by rapid growth in motor vehicle traffic, the Beijing municipal government has retained in modified form a number of the TDM measures adopted in preparation for or during the Olympics.

2.2.1 TDM policies and measures at present

(1) Official vehicle management

2009. April 3rd, Beijing Municipal Government issued a notice about ***"Continuously implement traffic demand management"***. It requested: from 2009 April 11, Beijing official agencies continue to restrict the use of 30% of official vehicles each day. At the same time, the use of other vehicles belonging to central state organizations, Beijing official agencies, public institutions and state-owned enterprises, were banned from use one day a week based on the license plate numbers. The restrict area and time period for such vehicles are all roads within the administrative region and during the entirely of the day, from midnight to midnight.[2]

(2) Private vehicles ban one day a week(except for holiday and weekends) , based on the license plate numbers

This measure is for Beijing private vehicles including those entering from other provinces. Based on their license plate numbers, such vehicles are divided into five groups: 1&6, 2&7, 3&8, 4&9, 5&0 with every 13 weeks rotation from 2009 April 11 to 2010 April 10(details see Table 4). Such vehicles are restricted from using roads inside the 5th ring road (but not including the 5th ring road) between 7 AM to 8 PM. In addition, vehicle owners affected by this restriction are offered a reduction in vehicle taxes and charges. [3]

Table 4 Detailed Rotation System

Dates for Rotating Restriction	Monday	Tuesday	Wednesday	Thursday	Friday
2009.4.11-2009.7.10	5&0	1&6	2&7	3&8	4&9
2009.7.11-2009.10.9	4&9	5&0	1&6	2&7	3&8
2009.10.11-2010.1.8	3&8	4&9	5&0	1&6	2&7
2010.1.9-2010.4.10	2&7	3&8	4&9	5&0	1&6

[2] http://shzbj.beijing.cn —***"Continuously implement traffic demand management" Notice from Beijing Municipal Government***

[3] http://shzbj.beijing.cn —***"Continuously implement traffic demand management" Notice from Beijing Municipal Government***

(3) Public Transit Priority

Public transportation continues to be strengthened in Beijing. Currently, the total operation of common buses is 650 routes, with 21,000 buses. Bus right-of-way on roads has been guaranteed by building 258 km bus lanes, bringing the total to 450 km by 2010. High capacity public transportation systems are being developed, adding 6 metro lines totaling 200km by 2015 (which will bring the total Metro system in that year to 561 km), along with 3 new BRT lines, as shown in Figures 5 and 6. A total of 40 billion Yuan (about US$7 billion) per year is being invested by the city government in public transportation capital costs for Beijing. Public transportation fares were also reduced by 60% for general passengers, by 80% for students, and made free for the elderly effective in 2008, as a move to cut traffic and pollution. Public transportation operating costs are increasingly covered out of general government subsidies by the city.[4]

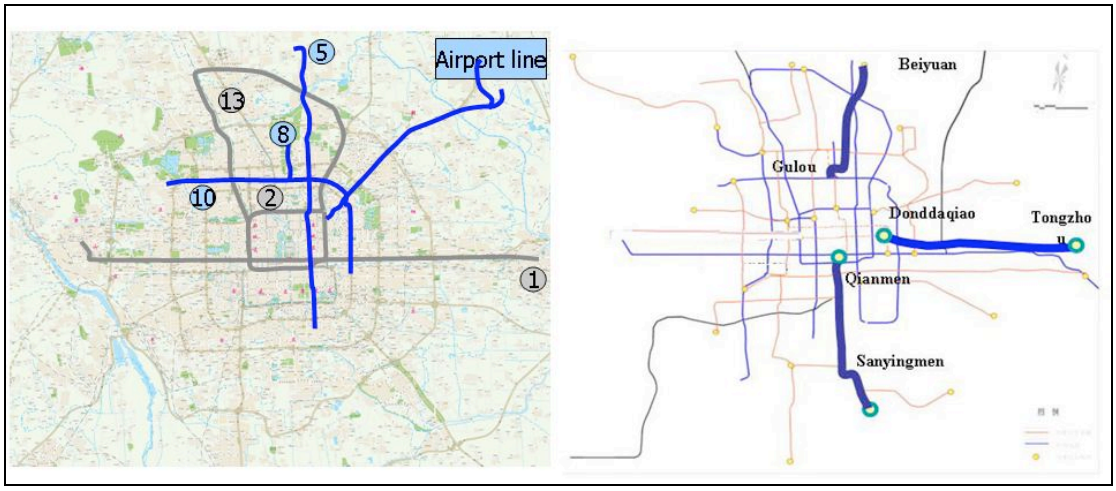


Figure 5 existing metro lines **Figure 6 existing BRT lines**

(4) Car free day

September 16-22, 2007, China held its first "Car free day" in108 cities simultaneously. Beijing, as one of participants, barred motor traffic except for buses and taxis from 7am to 7pm from Wang Fujin Street and Qianmen Street, as shown in Figures 7 and 8. This measure is being implemented on September 22 every year.[5]

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[4] Wen Huimin,Beijing Transportation Research center, ***Sustainable urban transport policies and operation effects of Beijing.***

[5] http://news.xinhuanet.com

Figure 7 Qianmen Street

Figure 8 Wang Fujin Street

(5) Parking management[6]

Parking supply and demand management is one of the most important aspects of TDM and one in which Beijing might learn a lot from best practices in other major metropolitan areas.

In the Beijing Old City traffic is constrained, with parking supply controls and charging polices, including road pricing for special areas when necessary. In the remainder of the Beijing center city, car controls and parking management are modest compared to other major cities in the world. In newer growth areas of the metropolitan area, policies have been very accommodative and encouraging of traffic growth. The total parking spaces are required to account for 1.2 to 1.3 times the number of cars. This is a policy consistent with the strategies that have fostered high levels of car-dependence and erosion of public transportation, walking, and cycling in many other cities, such as the most car-dependent cities in the United States. Thus, it is a policy that will tend to undermine the Beijing city government goals of increasing public transport, walking, and cycling.

The parking space supply requirements for public building in Beijing, adopted in March 2003 as the "Beijing regional construct project design and planning rule" revised parking supply standard for large and middle public building parking places. The requirements are shown in Table 5.

Table 5 Parking space supply requirements for public building of Beijing

Type of Building		Unit	Standard Parking Spaces
Office Building		Per 1,000 gfa	6.5
Shopping Mall	Category I: >10,000 gfa	Per 1,000 gfa	6.5
	Category II: <10,000 gfa	Per 1,000 gfa	4.5
Hospital	City Level	Per 1,000 gfa	6.5
	District Level	Per 1,000 gfa	4.5
Exhibition		Per 1,000 gfa	7
Stadium	Category I: Stadium >15,000 Seats or indoor stadium > 3000 seats	Per 100 seats	4.2
	Category II: Stadium<15,000 Seats or indoor stadium < 3000 seats	Per 100 seats	1.2

[6] Chen Xuemei, ***Beijing traffic and parking polices***. Urban Parking, 2009.03: 14-18.

Residential parking requirements also require a high level of parking provision that strongly encourages increased use of motor vehicles. In 2002, the revised "Beijing new- build and redeveloped residential public service facilities equipped standard" provided the following rules:

- Outside 3rd ring road (including old city redevelopment and additional resident buildings) - 500 parking spaces per 1000 households;
- 2nd ring road to 3rd ring road: 300 parking spaces per 1000 households;
- Inside 2nd ring road, parking equipped standard for old city, dilapidated house redeveloped areas and historical culture protect areas, should be restudied.
- Medium-to-high grade commercial house - 1 parking space per 1 household;
- High grade apartment and villa - 1.3 parking spaces per 1 household.

The March.2003, "Beijing regional construct project design and planning rule" further revised residential parking standards:

- Ordinary residential zones inside and outside 3rd ring road respectively - 3 parking spaces per 10 household and 5 parking spaces per 10 households;
- Apartments: 1 parking space per 1 household;
- Villa: 2 parking spaces per 1 household;

The March.2006, "Beijing residential facilities planning and design standard" residential garages to provide 0.4 to 1.4 parking spaces per 1 household including: 0.3 to 1.3 parking spaces for resident cars and 0.1 parking spaces for public parking.

Beijing's parking charge policies are also being revised. On June 6, 2002, Beijing adopted the "Motor-vehicle parking charge adjustment notice," which required independent underground parking and parking structures to be priced based on the free market for both commercial and residential parking. For daily parking, the price of open parking places inside 4th ring road for small cars is about 2 Yuan (US$.33) per hour, while in the more centrally located core districts of Wangfujin Dongdan-Xidan, Qianmen, Jinrong street, Chaowaidajie, Chongwaidajie, Chaoyang CBD and Zhongguancun, the price of open parking places is 5 Yuan per hour, very low by world standards. The price of parking in large public buildings and parking structures cannot exceed 5 Yuan per hour. For long-term leases, annual rent fee for open parking lots is 1600 Yuan for small car spaces and 2300Yuan for large cars, or

150Yuan and 210 Yuan monthly.[7] On May 1, 2004, Beijing implemented the "Motor-vehicle parking charge timing unit adjustment notice". The notice required the timing unit for parking pricing to be changed from one hour to one half-hour. The price of a space in an open parking lot inside 4th ring road for is 1Yuan/half hour for small cars, and 2.5 Yuan/half-hour in core business districts and large public buildings.

Beijing authorities recognize the importance of adjusting parking policy to better support the city's overall transportation goals. A policy of increasing parking fees has drawn up by the city government and it is likely to be implemented after October 2009. This will likely introduce new parking fee standards, with higher fees for underground parking places, on-street parking, and these will vary by location. This will reduce the frequency that vehicles drive into the city center and shape the pattern of consumption of curbside parking as well.

The city is developing extensive park-and-ride (P&R) lots at public transportation centers, with 13 planned near the center of the city based, 44 P&R lots planned along rail lines, and 30 more P&R parking lots planned in new town areas. In total, 87 new P&R parking lots are planned. With appropriate pricing and better transit, these may help divert some car trips from driving into the city center, but care will need to be taken to also provide attractive and convenient bicycle parking at transit stops, attractive and safe pedestrian access, and good public transportation feeder services to high capacity public transportation lines.

(6) Traffic and public transportation monitoring, measurement, and information systems

Beijing has developed sophisticated traffic monitoring systems that enable it to do important real-time traffic monitoring and management. These track traffic conditions on thousands of roadway links public transportation ridership on rail and buses, taxi trips, and other elements of the transportation system. A comprehensive set of traffic cameras equipped with Automated License Recognition Systems (ALRS) has been developed to help enforce the number-based license plate restriction systems for roadways inside the Fifth Ring Road as well as other strategic elements of the region's transportation system. These provide a solid foundation that could be used not only to support real-time traffic monitoring, reporting, and information systems, but also active traffic management and time, place, and/or distance-based road pricing.

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[7] ***Beijing vehicle parking fee standard***

2.2.2 Performance Measurement of Beijing transportation systems

Beijing has developed an extensive system to monitor road and public transportation network performance. The results show that the combined effects of the Beijing transportation management systems have been effective, although even more can be done. The current transportation management systems are not as stringent as during the Olympics, but are having an impact on traffic and pollution.

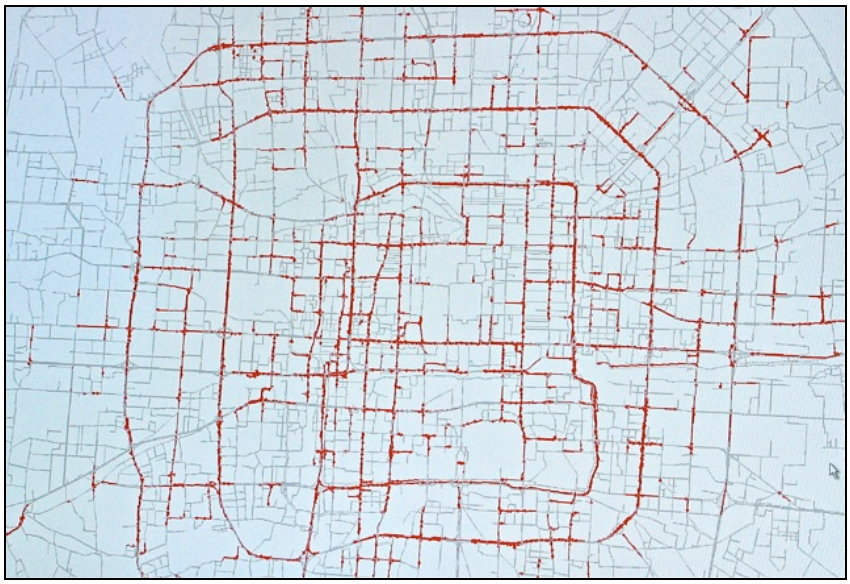

Figure 9 Beijing Has a Modern Traffic Monitoring System

Figure 10 Beijing monitoring system

With Beijing's relaxation of the vehicle restrictions from every other day during the Olympics (a 50% limitation level) to one day a week per vehicle during the post-Olympic period (a 20% limitation level), peak hour speeds and the traffic congestion index both rose, but to levels far less than they would have been without the restrictions. AM and PM peak speeds of road network rose 3.4km/h and 2.6km/h respectively from the base case without any restriction, as shown in Figure 11. The congestion index decreased from 7.54 (without restrictions) to 5.15 (with the 20% limitation level restriction), as shown in Figure 12. And the number of congested hours of traffic decreased from 7h 45min to 2h 30min.

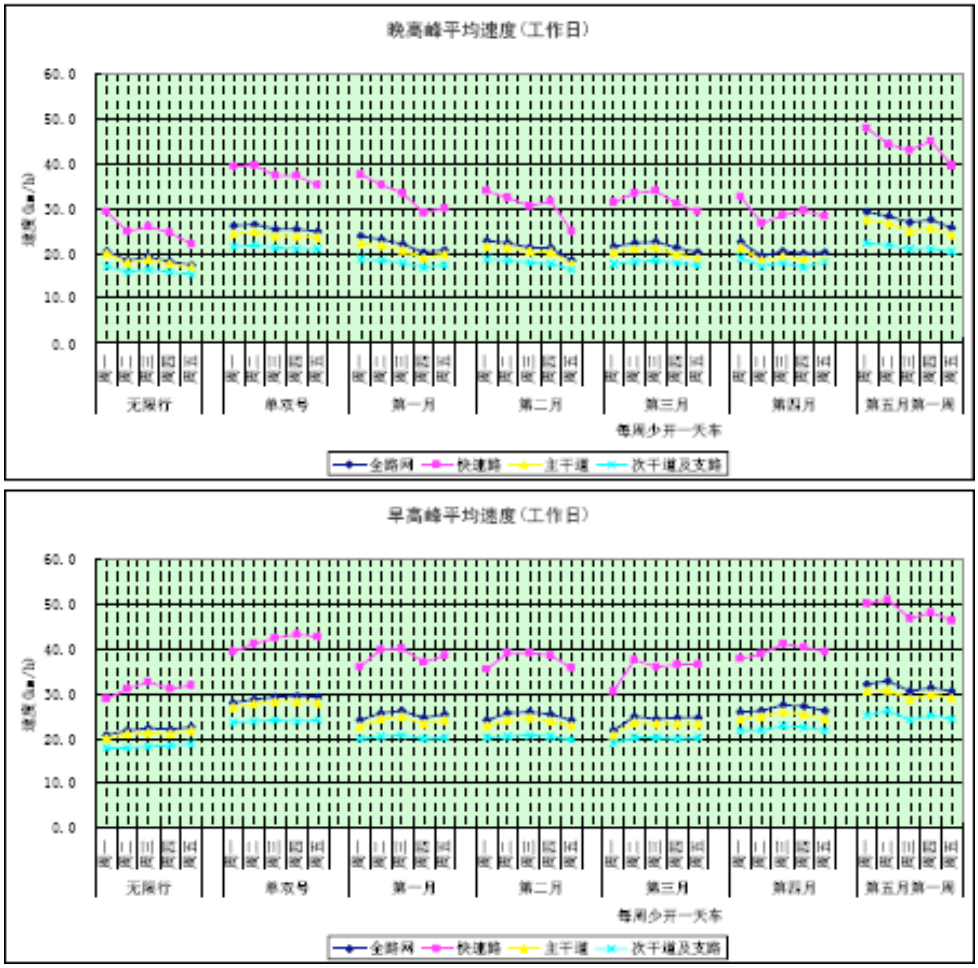

Figure 11 AM and PM peak hour speed comparison

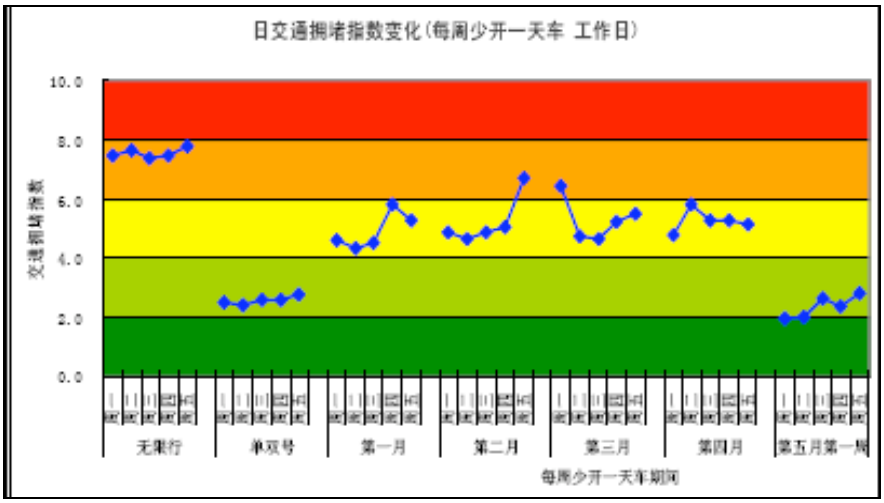

Figure 12 Congestion index comparison

Hidden Costs of Unmanaged Motorization In Beijing

The scale of Beijing's gridlock encompasses more challenges than other megacities. Every day more than 1000 cars are added to the city's already congested streets. In a recent study, Creutzig and He (2009) analysed the social costs of motorized transportation in Beijing in 2005. The analysis was restricted to the area inside the 6th ring road, corresponding to around 10 million inhabitants. The social costs of air pollution and congestion each amounts to approximately 20 billion RMB annually in the lower cost estimate . This is significantly larger than climate change damage costs (1.4 billion RMB per year). However, the magnitude of uncertainty is higher for climate change damage costs than for other disbenefits. In the upper cost estimate, climate change damage is equal in magnitude to both air pollution and congestion. The resulting lower cost estimate is summarized in Table Y.

Beijing case study	Cost estimate in billion RMB (2005)	Monetized co-benefits of city toll
Congestion	22.8	14
Bus speed reduction	5.8	1.5
Air pollution	19.8	5.3
Climate change	1.4	0.4
Accidents	4.0	-
Noise	0.9	-
Total	**54.7**	**21.2**

Table 6. Social costs and co-benefits of a city toll. Source: Creutzig and He

With Beijing's implementation of comprehensive management measures, public transport share has been great improved. The mode share of all daily trips inside the Beijing 5th ring by public transportation has risen from 30.2% to 37.3% from 2005 to 2009. The number of bus passengers rose from 9.67 million to 12.24 million per day. In addition, number of subway passengers is expected by the City Transportation Commission to grow from 1.92 million in 2005 to 3.54 million per day in 2015, when the new Metro lines are all open.

3. LEARNING FROM GLOBAL BEST PRACTICES IN TDM

3.1 Parking Pricing and Management

Parking pricing and management play a key role in travel demand management in cities around the world. Control of the supply, location, and price of parking can encourage more efficient use of parking resources and discourage discretionary car trips. Effective parking management plays a vital role ensuring motor vehicles do not take over public space and crowd out pedestrians, obstruct bicycle lanes, slow public transportation, diminish the efficiency of roads, and destroy green space.

3.1.1 Global Best Practices in Parking

So what are some of the most effective policies, technologies, and best practices used to address the problems of too much parking demand (high occupancy) and insufficient enforcement of existing parking regulations? These are discussed below.

Curb Occupancy

Measuring Turnover versus Measuring Occupancy

Historically, parking meter rates have been determined, somewhat arbitrarily, by politics and "turnover" with the goal of maintaining 100% occupancy. Turnover measures how many vehicles occupy a parking spot in a given time period. A fundamental conceit of current parking practice is that 100% curb occupancy is attainable if the right turnover is established. While in theory full occupancy has some appeal, in practice it is impossible to achieve. 100% occupancy would require a perfect choreography between the arrival and departure of motorists or a queue of waiting vehicles standing ready to occupy each newly vacated space. New York City and San Francisco are both experimenting with variable meter rates charging higher meter prices during periods of highest demand.

Illegal Curbside Parking Can Be a Big Portion of All Parking

In cities with high curb demand, poor enforcement and underpriced curb space combine to produce large scale illegal parking. A large share of curb parking is Illegal, primarily with parkers overstaying time limits or not paying meters. The studies in San Francisco, New York City, Berkeley, and Seattle demonstrate the extent to which illegal parking consumes curb parking capacity. The scale of illegal parking has major implications for street management in many cities.

Parking Enforcement: Technological Transformations

Big city parking managers agree that consistent, frequent parking enforcement is essential if curbside parking rules and meters are to be effective. However, they also agree that illegal parking is rampant, and parking enforcement, especially in big cities, is grossly inadequate, sporadic, and not well distributed.

Detection

There are two major, and very new, technological advances in detecting and responding to illegal parking. These include networked curbside sensors, vehicle mounted scanners, License Plate Recognition (LPR).

Ticketing / Citations

Most large cities and towns employ parking agents, equipped with handheld computers or PDAs. The handhelds scan vehicle windshield registration stickers, print tickets and transmit citation information to a central computer. The next generation of enforcement technology is vehicle mounted detection systems like Autochalk and Autovue which can automatically issue tickets.

Collection and Adjudication

Modern ticketing software significantly reduces errors. This translates into much higher fines payment and fewer voided tickets. Additionally, many jurisdictions use Personal Digital Assistants (PDAs) which photograph illegally parked vehicles.

Curb Pricing Technology

The technological revolution spawned by the advent of the microchip and wireless networking is starting to change how motorists in many cities pay for curbside parking. This is important to policy makers because new, credit card and cash capable, meters and pay-by-phone systems, make variable meter pricing, and higher meter rates much easier to implement than coin only meters. Experts suggest that much of the real technological advance has been in software system integration which allows for secure credit card payment and extremely accurate auditing of cash payments and automated receipts.

Multi-Space Meters

The state of the art in curbside meters are solar powered, wireless, multi-space, pay and display meters. Multi space meters have several advantages over conventional meters, which accrue to both the user and the city. Their ease of payment, capable of handling credit cards, pre-paid cards, cash and taking payment by cell phone, have increased the convenience of metered parking making multi-space meters very popular with the public. From a city's perspective multi-space meters are more reliable than old coin machines which are more frequently out of service due to vandalism or deliberate sabotage.

Pay by Phone

Miami, FL. has the largest pay by phone curbside operation in the U.S. with 5,500 spots and plans to expand to 8,000. However, pay-by-phone is still very new in the U.S., older motorists and those without credit cards have not welcomed it. Adoption has also been slowed by high cell phone charges. Miami motorists using pay-by-phone pay $1.25/hour for parking and a $0.35 charge to their cell phone.

Sensors and data integration

New meters offer opportunities to better monitor curbside occupancy and illegal parking. San Francisco and Los Angeles are among the cities that are experimenting with parking sensors.

Information on Space Availability

Seattle will reduce pressure on curbside parking by directing more parkers to off-street parking garages via the large scale introduction of a real-time Electronic Guidance System which tells motorists via variable message signs and the web what parking availability is in nearby garages. The system is based on those installed in major German and other European cities. It will be operational in 2012.

Institutional Arrangements for Coordinated Parking Management Systems

Parking Benefit Districts and "Revenue Return" to Neighborhoods

Parking meters were invented to open up curb space for short shopping visits to downtown retail areas. Augmented by funding from a special real estate tax, some or all revenue from curb meters pay for new parking structures and often public space improvements. One of the best known parking benefit districts is Old Pasadena, Los Angeles, which was established in 1995.

The most extensive, and oldest, PBDs are in Boulder, Colorado and Ann Arbor, Michigan. Those PBD's are actively engaged in Travel Demand Management and subsidizing and promoting public transit.

Off-Street Parking: Set Maximum Requirements

When cities set minimum standards for parking provision they are requiring that parking be provided, maximum standards allow parking to be supplied. Cities, such as San Francisco, CA, Portland, OR, and Cambridge, MA, have chosen to impose maximum off-street parking regulations.

Eliminate or Reduce Minimum Requirements

The most straightforward parking policy reform planners may pursue would be to **eliminate minimum off-street parking regulations** allowing developers and building owners to decide how many spaces to voluntarily provide.

Shared Parking

The most efficient use of existing parking supply is to share it. The logic behind shared parking facilities is that different uses attract visitors at different times throughout the day. Furthermore, shared parking encourages the centralization, consolidation and reduction of a neighborhood's parking facilities, thus improving urban design and allowing more productive land uses. Several cities such as Portland, OR, Cambridge, MA, Boulder, CO and counties like Arlington County, VA and Montgomery County, MD have successfully implemented shared parking. The highest number of parking spaces demanded among the different time periods would serve as the shared parking minimum requirement.

In-lieu parking fees

Several US cities allow developers a reduction in minimum parking requirements in exchange for a fee paid to the city, which funds construction of public parking facilities. These "in-lieu parking fees" offers key benefits.

Lower Demand for Parking

Many cities world-wide have also pursued policies and regulations that reduce the demand for parking and remove the private sector's incentive to construct more parking. Some of the common approaches include parking cash-out programs, unbundling of parking from real estate, and urban design strategies.

Cash-Out Programs

U.S. employers often provide free parking as a benefit to employees who commute to work, regardless of their choice of transportation. Cash-Out Programs give employees a choice to either accept the free parking or a tax-free transit subsidy, or cash, which commuters who bicycle or walk to work may prefer. In California's 1992 cash out implementation, a study of eight California firms found that the cash out program reduced solo drivers by 11% (Shoup, 1997).

Transit Incentives

Employers, cities, residential property managers and other institutions may contribute to reducing the demand for parking spaces by offering transit incentives to employees and residents. These often take the form of a subsidized bus or rail pass. Some municipalities, such as Montgomery County, Maryland, grant reductions in minimum parking requirements to entities offering employer-paid transit incentives (U.S. Environmental Protection Agency, 2006). Since 1993, Boulder, Colorado, has offered free bus passes to its 7,500 downtown city employees, which are funded by parking meter revenue. The city has found that the Central Area General Improvement District (CAGID) program reduces employee parking demand by 850 spaces, thereby freeing inventory for short-term downtown shoppers (U.S. Environmental Protection Agency, 2006).

Unbundling

Cities such as San Francisco have created mandates for developers to "unbundle" accessory parking spaces from the sale of a residential unit, selling or leasing each separately. The logic is that by including a parking space as part of a residential unit, a seller prevents the buyer from making the choice of whether she needs a parking space or not. While unbundling applies more often to residential developments, some commercial building owners bundle parking spaces with office leases as well. A city may require developers and building owners to unbundle parking spaces through site plan conditions or through zoning (U.S. Environmental Protection Agency, 2006).

Urban Design Best Practices

Cities have used their zoning codes and neighborhood plans not only to limit the number of parking spaces in a district, but also to set design guidelines that regulate or incentivize the location, appearance, and type of parking. Effectively enforced design controls can accommodate parking while preserving the character of a neighborhood. Some have prohibited surface or above-grade parking. Some have prohibited parking in between buildings and the property line facing the street ("strip mall" style parking), limited the location of curb cut entrances to parking facilities (which disrupt the pedestrian experience), and restricted the percentage of a street-facing façade dedicated to a parking use. Some require visual screening for parking lots, architectural treatments for parking structures, and require landscaping.

3.1.2 City Case Studies of Parking Best Practices

The following case studies discuss measures taken in a number of the world's leading cities to manage parking effectively for better transportation system performance.

PARIS

Since 2003, Paris has managed to decrease vehicle kilometers traveled by 13% (Figure 1-1) and private vehicle use through a package of successful measures. Overall on-street parking supply was reduced by 9% (or 14,300 spots), while 95% of free spots were turned into paid parking spaces (Figure 1-2). Roughly 4,000 removed parking bays were instead used to accommodate 1,451 new Velib stations that hold about 20,000 for hire public bikes. Space was also reallocated for motorcycle parking, bicycle parking, disabled parking, and tramway corridor access. Around 6,000 additional parking spots were removed by request of the fire department for improved maneuvering around narrow streets.

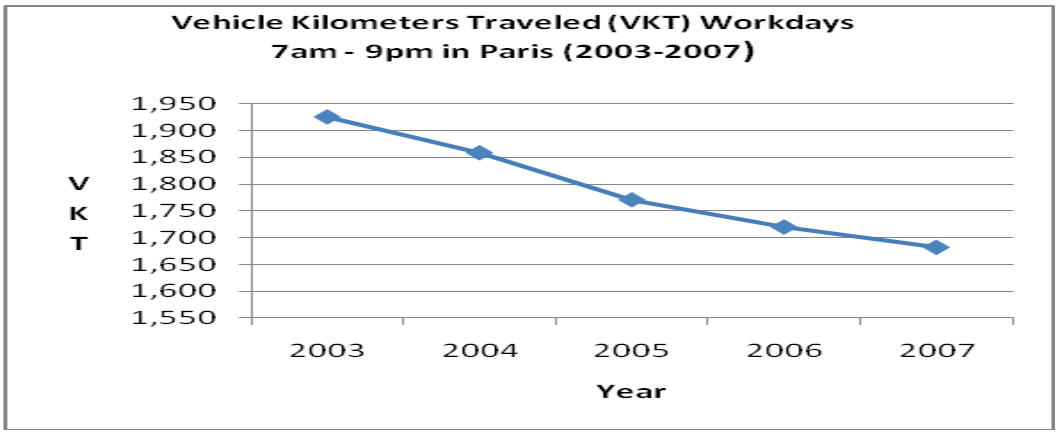

Figure 13 Vehicle Kilometers Traveled (VKT) Workdays 7am-9pm in Paris (2003-2007).

Data Source: Paris Transport and Travel Report (2007)

Figure 14. "Velo" marked curbside spaces in former car parking spots, now used as two-wheeler parking in

Figure 15. Contra-flow bike lanes installed where curbside car parking was removed in Paris.

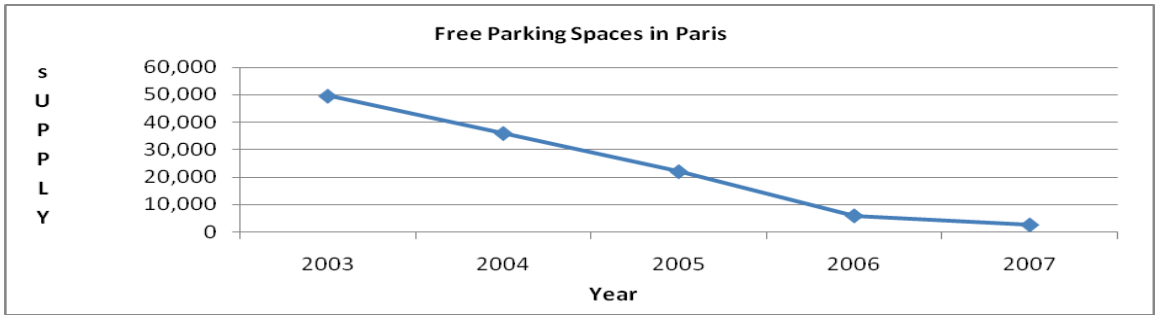

Figure 16: Free Parking Spaces in Paris (2003-2007).
Data Source: Paris Transport and Travel Report (2007)

Between 2003 and 2006, the share of private vehicles in Paris traffic decreased from 68% to 60% (down 8 percentage points). During the same period, 118 km of new bicycle lanes were installed. About 15% of cyclists reported shifting from car commuting.

On-Street Residential Parking Permits

In an effort to limit traffic in Paris, owners of personal vehicles are required to obtain a residential parking card. The card allows for a vehicle to be parked in four city districts near a vehicle owner's home for a period not exceeding seven consecutive days. Paris is divided into 160 metered parking areas. Residential parking is allowed on the residential streets near a vehicle owner's home where pay-and-display meters have yellow dots.

AMSTERDAM

Pay-and-Display Parking

The main transportation issue in Amsterdam is lack of space. Parking fees were introduced as a way to protect air quality and handle the street space better.

The cost of on-street parking in Amsterdam ranges from € 1.40/hour, € 2.40, € 3.00, € 4.00 to the upper most rate of € 5.00/hour in the city center, which is amongst the most expensive street parking in the world. Residents can obtain a special residential parking permit, which in some boroughs requires waiting on a list for ten years since only a finite number of are issued.

Figure 17: P&R facility signage, where a transit pass can be obtained for up to 5 people if a

Figure 18: Curbside pricing adjusted to create some vacant spots and decrease cruising in Munich, Germany

MUNICH

Pay-and-Display Parking

Visitors must purchase a parking voucher at a pay-and-display vending machine, which allows for parking up to an entire day (24 hours). The parking fee is € 1 per hour, but the highest cost is € 6 / 24 hours. Short-term parking zones are sometimes limited to a maximum of 2 hours. The parking fee is also usually limited to working days, Monday through Saturday, and between 09.00 and 23.00 o'clock. At night, on Sundays and for public holidays, parking is usually free. Munich has more than 40 parking zones and around 54,000 on-street parking spaces.[8]

[8] Mobinet: Mobility in the Conurbation Munich.

URL: http://www.mobinet.de/Fachinformation/english/allgemein/startframeset.html

Figure 19: Parking protected bicycle lane in Munich.

Figure 20: Cycle track protected by a bus only lane in Copenhagen after all parking

SAN FRANCISCO, CALIFORNIA, USA

The City of San Francisco, CA, has evolved over the last half century from a municipality that once required one parking space for every new dwelling in the city to one of the most innovative parking management examples in the country. This has occurred through investment in transit, gradual replacement of off-street parking minimum requirements with maximums, parking unbundling, and proactive on-street parking management. A relatively small proportion of the city's residents - about 70% - own a car[9] (Switzky, 2009). Due to its low residential population and high number of commuters, the city introduced many of its parking reforms downtown. Following the opening of the Bay Area Rapid Transit Authority (BART) rail line in 1973, the city authorized a cap of all downtown commuter parking spaces. Minimums do not apply to any use downtown, and a maximum of one space is permitted for every four downtown residential units. Similarly, parking may occupy no more than 7% of an office building's gross floor area – about 1 space for every twenty office workers (Victoria Transport Policy Institute, 2008).

San Francisco has proceeded to eliminate residential minimum parking requirements through the adoption of neighborhood plans for districts close to the downtown, and first through the Mission Bay Redevelopment Plan in 1997.

[9] Nationally 90% of US households own automobiles. New Yorkers own fewer at 48% with only 22% of Manhattan residents owning automobiles

San Francisco's SFpark: Circle Less Live More

San Francisco's SFpark is the largest, and by far the most sophisticated, curbside parking reform project underway in the United States. By the fall of 2009, the San Francisco Municipal Transit Agency's (SFMTA) $24.75 million federally funded project will encompass 6,000 of San Francisco's 25,000 metered curbside parking spots in seven pilot neighborhoods. The heart of SFpark is a Data Management System which sorts a tremendous amount of data collected from the networked array of remote sensors in all 6,000 parking spots plus data from ten to fifteen street cordons. The IT system, which was initiated in May 2009 with 1,000 meters, is able to monitor real-time parking occupancy and cruising in pilot neighborhoods. The project will produce valuable data about the effect of meter pricing on occupancy and will profoundly improve overall knowledge of the effect of parking on traffic and driver behavior.

The SFMTA, controlled by the Mayor, is the only major transit agency in the U.S. to control curbside parking and to receive all parking meter and fine revenue. Thus, the agency has a double financial incentive to properly manage curbside parking: it makes money from meters and fines, plus it saves money from bus operations when it reduces bus service delays caused by circling and double parked vehicles. SFpark is the direct result of a federal Urban Partnership (UPP) congestion pricing proposal made by the City Council controlled SF County Transportation Authority. The project and federal grant were then handed over to the SFMTA, which is controlled by the mayor and has actual authority over the curb. Both agencies were eager to undertake curbside parking reform.

PORTLAND, OREGON USA

The City of Portland, Oregon has for decades served as a model for effective parking management practices. The city's investment in extensive, reliable public transit infrastructure has enabled it to wean its residents and commuters off private automobile transportation. Portland's pro-active approach to parking management began in the early 1970s, when they city's downtown air quality violated federal carbon monoxide standards one out of every three days, leading the city to implement a **parking freeze** at 45,000 spaces in 1972. In 1997 the city lifted the freeze replacing it with a more flexible system of parking maximums and minimums to manage, rather than prevent, parking space construction (Oliver, 1997).

A developer or owner willing to manage its parking supply and demand, such as through sharing its spaces or catering to bicyclists, also benefits from reduced minimums. The city's zoning code allows a

shared parking facility that provides fewer spaces than the combined, separate requirements for each use. Similarly, **bicycle parking** may substitute for up to 25% of required car parking spaces. For every five bike parking spaces the development builds, it may construct one fewer car parking space (City of Portland, 2009).

Parking maximums complement minimums in many neighborhoods. Consistent with the city and state's commitment to public transit, the maximums vary according to a site's distance from bus or light rail –closer to transit less parking is permitted. Several neighborhoods are therefore subject to low maximums.

CAMBRIDGE, MASSACHUSETTS USA

The City of Cambridge, Massachusetts' zoning code specifies both minimum and maximum parking requirements – the latter since the early 1980s (Marshall & Garrick, 2008) – for office, retail, government and university buildings. Offices, for example, are required to provide between 1 and 2.5 spaces per 1,000 square feet. Minimums are reduced for sites that are close to transit, share parking, provide affordable housing, or are near public or commercial parking. Likewise, the planning board allows developments to exceed the maximum in the case of demonstrated unusually high parking demand.

In 1998 Cambridge instituted its Travel Demand Management (TDM) Ordinance, a policy that seeks to lower travel by private automobile by mandating that new developments seeking to add parking to their sites provide alternative transportation resources, such as transit pass subsidies, bicycle parking, priority carpool parking, and other measures. The policy's objective is to reduce generation of single occupancy vehicle trips by 10%, relative to 1990 levels. The city employs a TDM officer to perform annual surveys and counts of parking facilities subject to the TDM ordinance (Marshall & Garrick, 2008).

BOULDER, COLORADO USA

Parking as the cornerstone of sustainable downtown. Boulder is a small city 30 miles from Denver. It has a compact street grid, pre-war neighborhoods, a defined, walkable downtown and an extensive bus system. Boulder also has the oldest, most sophisticated, Parking Benefit District in the U.S. The Central Area General Improvement District (CAGID), was created in 1970. The net result of these policies is to make transit inexpensive, and driving just expensive enough to discourage car commuting, while still keeping curbside parking available and affordable for day-tripping shoppers

and tourists. Key to this is that public garages can charge to maximize use, not revenue. This allows garage prices to be set equal to or below curbside prices.

CAGID's efforts since then have been very successful, becoming the template for other U.S. Parking Benefit Districts. CAGID has: Created a bondable revenue stream from real estate taxes and parking meters; Raised meter rates to create turn-over and raise revenue for bonds and operations; Issued debt and received a federal grant to build a retail pedestrian mall as a town center.; Issued debt to build centrally located public garages, which include ground floor retail; Helped promote seasonal events to attract visitors and promote business; Subsidized Eco Pass bus passes for employees of all businesses downtown.

3.2 Road User Charging

For decades now in most cities around the world, traffic congestion and transportation greenhouse gas pollution has been growing, as inevitable as death and taxes, seemingly as much out of control as the weather. But across the political spectrum, a diverse array of leaders – from London's Mayor "Red" Ken Livingston to the Bush Administration's Transportation Secretary Mary Peters, from New York Mayor Michael Bloomberg to Washington State's King County Commissioner Ron Sims, who is now a top official in the Obama Administration – have been trying in different ways to challenge that notion by advancing congestion pricing.

New technologies have made it possible to collect fees from drivers without needing vehicles to stop at a toll plaza. Fees may be paid electronically with on-board units (OBUs) or chip cards while vehicles are in traffic, or by more traditional means at pay stations. Older toll roads collect fares using coin machines or attendants, with a capacity of 300 vehicles per hour per lane, while new automated toll collection with electronic transponders mounted on overhead gantries use Direct Short Range Communication (DSRC). This keeps traffic free flowing, increasing capacity to 1,600 vehicles per hour per lane or as many as 2,000 or more when designed for fully open road operations.

Singapore pioneered the way for congestion pricing in 1975 by introducing a $3 charge for motorists to enter its central area, aiming to curb severe congestion. Oslo, Bergen, and five other Norwegian cities introduced similar charges between 1986 and 2004 to finance transportation projects and manage traffic. High occupancy toll (HOT) lanes caught a foothold in southern California in the 1990s, then spread rapidly to Texas, Minnesota, Utah, Colorado, and Virginia. Since London's 2004 introduction of a central area congestion charge, Stockholm, Milan, Rome, and others have adopted similar initiatives.

Germany in 2005 pioneered a nation-wide system of emission-based truck tolls on its 12,000 kilometer autobahn network, collected using global positioning system (GPS) satellite technology. The system raised over 3 billion Euro in 2006, cut empty truck haulage and related greenhouse emissions by 15% and doubled the rate at which old, dirty trucks are being retired for newer, clean ones.

In 2007, the Dutch government announced a phase out of charges for owning motor vehicles in favor of motorist charges based on distance driven, with higher charges for driving on busy roads during peak hours and for more polluting vehicles, using GPS based tolling. Learning from experience, this change will start for only trucks in 2011, gradually extending to passenger vehicles over several years. In 2008, the Puget Sound region completed a federally-funded study of how a similar GPS system could manage all traffic across the regional motorway and arterial network. Preliminary findings show how a sample of Seattle area households, given time-of-day road pricing incentives, voluntarily cut their driving by one-fourth. Similarly promising findings come from a federally-sponsored test in Oregon of mileage-based fees, which show how such a system could be phased in over several years to replace motor fuel taxes.

Today cities from San Diego to Shenzhen to Auckland are considering congestion pricing as a key strategy to help manage transportation systems for higher performance. Some of these initiatives aim to use congestion pricing to manage traffic growth and cut greenhouse gas pollution. Others are focused primarily on financing road expansion, with little or no toll revenue available to expand public transportation options. The impacts of congestion pricing initiatives on the environment, equity, overall traffic and land use patterns, not surprisingly, vary as widely as their goals.

Applying congestion pricing to existing roads, which usually yields the clearest and most immediate environmental and system management benefits, has been the biggest challenge. Hong Kong came close to implementing wide area electronic toll collection in the late 1990s, only to abandon the plan due to political concerns over privacy. Five government attempts over the past 20 years to adopt nation-wide road user charges have failed in the Netherlands due to insufficient political support, although a new plan is now moving forward. The United Kingdom's plan for implementing nation-wide road pricing continues to advance in fits and starts in the face of opposition. New York’s recent plans to do congestion pricing won wide support in the city and from the Governor and some legislators, but have been blocked by the state’s dysfunctional politics.

Nonetheless, with the confluence of new information and tolling technologies, transportation finance problems, growing gridlock, and climate change, it looks like congestion pricing is now crossing into the mainstream of transportation planning and policy. A growing share of new road capacity

worldwide is tolled by time-of-day. New policy initiatives to price existing roads for better performance are springing up left and right. Public attitudes seem to be shifting.

The core idea is simple enough. By charging fees based on where and when motorists drive, with discounts during times of low demand, congestion pricing shapes travel choices, matching demand more closely to the available road space, boosting system efficiency, reliability, and travel speed, with revenues used to improve travel options.

Singapore: World Leader in Congestion Pricing and Traffic Management

Worldwide, Singapore is the leader in congestion pricing. Electronic toll charges - on its outer ring road, major arterials, and entryways to both the main central business district and a newer commercial center – are adjusted periodically for each location by hour of the week based on what is needed to keep traffic flowing freely at least 85% of the time.

Pictures from Singapore in 1975 show a city mired in congestion, jammed buses struck in a jam with far too many other private vehicles, evoking scenes from Jakarta or Bangkok today. Flash forward to today and one finds a city transformed, affluent, roads largely free of congestion, outstanding public transportation, a place that, thanks to the quality and efficiency of urban life, competes successfully with American and European cities for both foreign investment and for mobile members of the world's best and brightest labor force. Congestion pricing is a not small part of that success story.

The first congestion charging system in the world was the time-of-day road pricing system for Singapore's Central Business District in 1975, which developed with assistance from the World Bank. It immediately cut by more than half private car traffic into the core. Carpooling rose by 30% and bus use doubled. As Singapore's income has grown by an order of magnitude, the number of cars has grown 2.5 times, and public transportation's share of travel has risen from 4 out of 10 trips to over 6 in 10, thanks to road pricing, a vehicle quota system that manages growth in the number of motor vehicles, and high levels of investment in public transportation and pedestrian-friendly transit-oriented development. Singapore is a leader among the world's major cities both for its slight levels of congestion and its low income-adjusted per capita personal transportation greenhouse gas emissions.

Singapore started with a central area charge in morning peak hours, later extended this to the evening peak and mid-day hours. In 1990, the ring road expressway around the city became subject to the area license fee. In 1998, Singapore implemented electronic tolling, retrofitting all vehicles with tag-and-beacon readers which work with commercially-provided cash cards to automatically deduct a fee when

a vehicle passes a charging gantry. Different reader devices correspond to each vehicle classes, with higher fees for larger vehicles. Singapore's tolls are now imposed at over 70 locations on arterial roads and motorways. With electronic tolling, Singapore was able to adjust toll rates by hour of the week, cutting the fees in some cases by half or more below what they had been with a flat S$3 peak/S$2 mid-day charge (about US$2.00-1.35) per gantry passage.

Stockholm: Despite Partisanship, Congestion Pricing Advances

After a decade of studies, proposals and other setbacks, the City of Stockholm in January 2006 launched a seven-month congestion tax pilot project with a goal of reducing traffic and pollution. The Swedish Green Party pushed their Social Democratic coalition partners to implement the initiative, which was held up for two years by challenges regarding legal authority and procurement. Time-of-day-charges were imposed between 6 AM until 7 PM on weekdays at the 18 entry points surrounding the central core. Twelve new express bus lines, improved services on bus and rail lines, 1800 new park-and-ride spaces came online shortly before the launch, explicitly tied to the charging program.

On its opening day, public opinion ran 2-to-1 in opposition to the initiative, but media and public opinion turned around quickly as people saw the system perform. Traffic fell by 15%, congestion delay fell by 30 to 50%, and greenhouse gases and other pollution dropped by 14% in the core area and by 2-3% in the region. Public transportation ridership rose by 45,000. No ill effects were seen on commercial activity. When the charge was turned off, traffic quickly went back to pre-charge levels.

A majority of City voters affirmed their support for congestion pricing shortly after the pilot project ended, after a campaign in which Al Gore spoke in Stockholm in favor of the congestion charge and most right-wing parties campaigned against it. Yet one of the first decisions of the new a right-wing coalition government that came to power in September 2006 was to reinstate the congestion charge because it worked so well.

In August 2007, Stockholm reinstated the charge to bring back its benefits – travel time savings, reliability, environmental improvements, and better walking, cycling, and public transport options - as well as a growing fund available for road improvements in suburban areas. The exemption for taxis was eliminated. The use of redundant toll transponders for revenue collection was eliminated while retaining the automatic license plate recognition camera-based toll collection system that is at the heart of Stockholm's congestion tax legal enforcement authority. The system is now handling 7-8 million vehicle passages a month, generating monthly revenues of about SEK 16 million, with about a fifth of revenues required to administer the system. Three-fourths of the congestion taxes are paid through

direct debit, with most of the rest paid at retail shops and kiosks. President George W. Bush cited Stockholm's success in discussing his own congestion initiative. Recent Stockholm polls show nearly 2-to-1 public support for congestion charging.

London: Road Pricing Advances through Decisive Leadership

Congestion pricing in London, as elsewhere, resulted only from decisive political leadership, after years of studies. In his 2000 campaign to become Mayor, Ken Livingston made congestion pricing a key issue. On taking office, he quickly put into place a special team to procure, design and implement a system. The new £5 (about US$8) charge went live in early 2003, 26 months after starting procurement. The initiative initially affected about 200,000 vehicles a day operating week days 7am-6.30pm in a congested 21 square-kilometer area of central London.

A 2-to-1 majority of the London public opposed the initiative when it began operation, but opposition quickly turned to wide support upon seeing the results. More than 500 additional buses were added during morning rush hours shortly before the charge began and initiated extensive improvements for pedestrians and bicycles. Congestion dropped by 30% in 2003 and 2004, bus speeds and reliability rose 20% or more, and emissions fell 15%. Bicycle use rose 43% within the charging zone. Livingston won re-election by a growing margin, promising to expand the congestion charging zone.

A doubling of the zone's size in 2007 produced similar congestion reductions in London's West End. The core area charge was raised to £8 for most passenger cars and in October will rise to £25 for the most fuel inefficient vehicles. Fees are less or waived for zone residents and drivers of the highest fuel efficiency, cleanest vehicles. The £130 million in net annual revenues are dedicated to public transportation, but nearly half the revenues are expended administering the charging system. Recent road and utility repairs in the zone have degraded traffic speeds.

A new city-wide London Low-Emission Zone went into effect in February 2008, adapting from the experience of Berlin, Germany and Malmo, Sweden, which operate smaller low emission zones. Heavy trucks that fail to meet recent European Union emission standards now pay £200 (about US $400) a day to drive anywhere in London. Similar charges will extend to buses, minibuses, large vans and ambulances this summer. The zone is projected to cut pollution 16 percent by 2012, and save health cost of £250 million. Transport for London, which oversees the city's trains, buses and roads, is spending £49 million to set up the new zone and £10 million a year to operate it, with annual revenue projected at £46 million.

US Experience With Congestion Pricing: From HOT Lanes to Network Pricing

The HOT lanes which opened in the median of southern California's State Road 91 in 1995 pointed the way to several emerging trends in transportation. It broke new ground for the U.S. in showing how private investment could be mobilized to deliver mobility improvements years before the public sector would be able to finance them. The project was required to meet performance standards, significantly boosting average corridor vehicle occupancy and improving traffic flow. SR-91 showed how automated high-speed time-of-day road pricing could guarantee free-flowing traffic in a congested corridor, with no toll booths nor tossing of coins into baskets. In peak hours SR-91's two managed lanes have been found to carry as many vehicles as move in four parallel unmanaged lanes, at three times the speed. SR-91 shows a way to prevent the loss of effective capacity that occurs routinely on unmanaged lanes when traffic slows to stop-and-go conditions.

Applying that approach widely to existing road networks might deliver huge benefits, but would require a shift in the framing by which the public views transportation. Today most roads are free socialist goods for which consumers wait in queues when there is not enough to go around. If the advocates of congestion pricing prevail, roads of the future will become managed elements of public utilities.

With SR-91 breaking the path, San Diego in 1996 showed a somewhat more transit-friendly way forward for managed lanes: converting existing road space to HOT lanes, with toll revenue dedicated to improved public transportation. The I-15 HOT lane project allowed solo drivers to make use of spare road space in under-used HOV lanes. San Diego's simple supplemental US$60 a month license system was soon replaced by electronic toll collection, then by dynamic pricing, with tolls adjusted every 7 minutes to keep the managed lanes free-flowing. With polls showing 80% approval of the system, San Diego is now building a regional system of managed lanes with express bus services.

Meanwhile, in metropolitan New York, where more than half of all tolls are collected in America, pressures had been building on transportation agencies to introduce congestion pricing to manage traffic. Nobel Prize winning Columbia University economist William Vickery first proposed the idea of congestion pricing in 1952. Working with Vickery, civic advocates like James Tripp of the Environmental Defense Fund convinced New York's Mayor Lindsey to try congestion pricing on East River Bridges in the early 1970s, but authority to do so was blocked in court.

In 2000, the political stars aligned just as the Port Authority of New York-New Jersey was set to issue a toll increase. Thanks to efforts by a civic coalition, the governors of both states saw fit to support a

staff recommendation to increase peak period Hudson River crossing tolls while holding constant charges for non-peak hours for toll transponder users, who make up over 75% of peak river crossing traffic. The $1.50 time-of-day toll differential shifted about 7% of the traffic from the peak hour, yielding even larger congestion reduction. With nearly half the Port Authority's net toll revenues dedicated to improving trans-Hudson PATH passenger rail service, this initiative constituted another important model and a milestone on the path towards wider congestion pricing. Shortly thereafter, modest time-of-day toll differentials were introduced by the New Jersey Turnpike, the Garden State Parkway, and New York Thruway Authority as new toll increases took effect.

New York Mayor Michael Bloomberg made several efforts to implement congestion pricing between 2003 and 2009. Despite winning majority support of the public, business groups, and the City Council, these efforts were blocked by a key state legislator. A daily congestion charge between 6am and 6pm of $8 a day on cars, $21 for trucks, and $7 for low emission trucks entering New York's central core would have cut traffic in Manhattan and produced new revenues of US $250-700 million a year for public transportation. San Francisco region continues to study a central area cordon charge.

Strong leadership from King County Executive Ron Sims and Washington State DOT has put the Seattle region well ahead of other U.S. regions in considering how congestion pricing might deliver high performance traffic management and transit options across the region's entire network of major highways. A nearly completed federally-supported study estimates it would cost about $750 million to create a GPS satellite-based tolling system and about $288 million a year to operate it, potentially generating annual revenues of $3 billion and a 6:1 benefit-to-cost ratio. The study concludes that the technology needed for such toll collection is mature, noting that public understanding and acceptance are the keys to moving forward. In the near-term, the region converted State Road 167's HOV lane into a HOT lane in 2008 and plans are proceeding to finance and manage the failing SR 520 Lake Washington bridge with congestion tolls.

Other initiatives for tolling of existing Interstate road capacity through lane restriping and use of shoulders are advancing in Minneapolis, Los Angeles, and Miami, with federal assistance for HOT lane projects on I-35 and I-95 also supporting new express bus services.

Many Approaches to Road User Charging

Table 8 summarizes road pricing schemes implemented in Europe. The most common design is a cordon ring, where a circle is drawn around the area targeted for congestion relief, and the charge is applied to vehicles crossing this perimeter. The design must ensure that vehicles are unable to evade the charge. Physical features which help to limit access to the charged zone are often incorporated. For

instance, the boundaries of the Stockholm scheme are the rivers surrounding the city center, with the charge applied to vehicles crossing bridges to access it. Drivers may pay the charge by a variety of methods, and the scheme is enforced by cameras monitoring the registration plates of vehicles passing the congestion charge boundary points. Unlike other types of road pricing schemes, congestion charges are only in effect during peak times of congestion.

Table 8: Types of road pricing systems

	Cordon ring	Area license	Corridor toll	Network
Description:	All vehicles entering a certain central city zone defined by a cordon are charged a flat fee when they cross the boundary at peak use times.	All vehicles operating within a central city area during certain times are charged a daily fee.	All vehicles using tolled road, bridge, or tunnel pay a flat fee. In some cases, the fee changes dynamically based on peak use times.	Vehicles pay for each kilometer traveled on a road network. Fees may be differentiated by type of vehicle, emissions class, roads used, and/or peak use times.
Aims:	Reduce traffic congestion in central area	Reduce traffic congestion in central area	Finance a specific road or bridge	Reduce congestion, increase efficiency, finance transport infrastructure
Technology:	Toll plazas and/or plate-recognition cameras	Plate-recognition cameras	Toll plazas and/or tag and beacon system with on-board units	On-board units and GPS satellites
Financing:	Public	Public	Public and Private	Public and Private
Operator:	Public	Public	Public or Concessionaire	Concessionaire
Revenues used for:	Road and public transport improvements	Public Transportation improvements	Road improvements	Road, railway and public transport improvements
In use:	Bergen, Durham, Florence, Milan, Kristiansand, Namsos, Oslo, Rome, Singapore, Stavanger, Stockholm, Tonsbjerg, Tromso, Trondheim, Valletta	London	Czech Republic, England, France, Greece, Italy, Portugal, Spain	Austria, Germany (lorries on autobahns) Switzerland (lorries on all roads) Planned: Netherlands

Source: Transport & Environment, 2007

The design and technology of these schemes ranges from low-tech to state-of-the art. The most basic payment system is a toll collector in a booth, where vehicles must stop to pay. Modern schemes offer

frequent users the option of using an on-board unit, installed in the vehicle, which communicate electronically with units mounted on overhead gates called gantries. This type of scheme is called a tag and beacon system. Vehicles must slow down, but not stop, to pay, which saves motorists time, and they are less expensive to operate due to fewer staff. Tag and beacon systems are in operation in many European countries.

The most modern version of road pricing is also the most comprehensive, capable of charging motorists for travel on an entire road network. Network charging schemes treat road use like consumption of other public utility services, such as water or electricity. Network charging comes closest to the ideal road pricing system described above, where the price of road use varies according to construction and maintenance costs, pollution and noise costs, and the costs of delays to other drivers when road space is in high demand. Thus road users get a direct price signal about how much their trip imposes costs upon society, and may adjust travel accordingly.

Keys to Successful Introduction of Road User Charging

Road user charging cannot be introduced without careful planning. While lengthy deliberation can allow political opposition to sideline progress, efforts at hasty implementation can cause long term setbacks. Successful introduction of road user charging requires the completion of several key actions described below:

- Articulate system objectives: there are many reasons why different authorities have chosen to implement road user charges – new revenue for transportation investments, to cut traffic congestion or pollution, to shift travel to alternative modes, or some combination. Different objectives will drive different system design and management choices and shape the politics of implementation.

- Affirm legal authority: who can implement? Under what conditions? On which facilities? With what authority for enforcement? The legal authority granted by national or provincial governments to local authorities can seriously constrain system design and effectiveness of implementation. When implementing road user charging fewer approvals is definitely preferable to more approvals, as it may take only one opponent to block implementation even when a proposal has popular support and support from multiple levels of government, as was the case recently in New York City.

- Determine implementation framework: What approach is preferred for a region, corridor, or set of facilities – an Area license fee? Cordon charge? Corridor time-of-day tolls? What will be the use of toll revenues? What approach will be used for procurement?

- Design and evaluate road pricing plan: Careful design and consideration of the implementation plan, drawing on global best practice and experts with experience in this arena can help minimize the likelihood of serious setbacks.

- Adopt system plan, financing scheme: Clear decision points are needed to move forward and spur a sense of inevitability to project and program implementation. These can lay the foundation for a timely and expeditious procurement process.

- Procure management and technology services: Road user charging is not like buying new traffic signal systems or new transit fare collection systems, but requires coordinated design, development and integration of complex systems involving hardware, software, operations, enforcement, evaluation, and marketing. Retaining global expertise can help ensure a smoother process.

Cities, like London, that have done a lot of groundwork to build some public understanding, that have recognized legal authority, and have sound motor vehicle registration systems and some institutional capacity in traffic management will typically require at least two years to implement a major new road pricing initiative. Stockholm engaged in discussions of congestion pricing for a decade before implementation and took nearly four years from the decision to implement until opening, due to legal challenges to their authority and to the project procurement process. Cities that have weak motor vehicle registration systems need to address this issue as they move towards adopting road user pricing, as license and registration systems are usually a foundation for enforcement of road user charges.

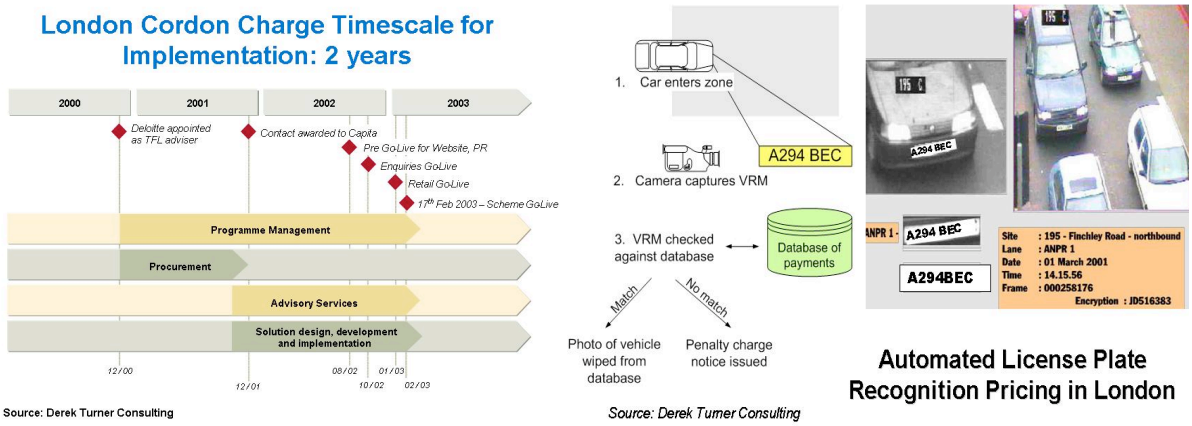

Figure 21: Road User Charging in London

Enforcement authority is needed to:

1. Require valid transponders or other forms of payment from motorists who use electronic road pricing or license plate recognition based priced facilities
2. Authority to photograph license plates of vehicles on priced facilities
3. Authority to obtain registration data from license plate numbers, track down toll violators, curb fraudulent behavior
4. Enforce fines and penalties, including suspension of motor vehicle registrations or motor vehicle operator licenses, in the event of non-payment.

Restrict certain vehicle types from priced facilities

3.3 Management of Official Cars

A growing number of cities in China are seeking to better manage the use of official cars by replacing official cars with a partial transportation allowance to government officials who then can choose to use their own cars, public transportation, walking, or cycling. This saves money for the government and improves transportation system efficiency and cuts pollution.

Many cities have found official cars to have been given out rather too casually to officials who do not really need them. Such cars are often used for personal reasons.. Many cities judge the official cars to be too luxurious and poorly justified by the official's position. The expense of the official cars is high and a burden to the governmental budget. For example, an ordinary car will cost 10,000 RMB for 1,000,000 km running, but the official cars may cost 30,000-40,000 RMB. After the reform of the official cars, many official cars are canceled, and the government gives part of the subsidy to officials who can choose to furnish their own cars. This typically reduces unnecessary car travel and helps the

public to see more fairness in the compensation of government officials. In many ways this is analogous to parking cash-out: taking an existing hidden subsidy for driving and turning it into an explicit payment in which there is consumer choice and the opportunity to save money by driving less.

The government Administration of Harbin has advanced official car reforms beginning in June 2008, with 17 government departments. In April 2009, more than 30 additional departments adopted these reforms. The cash-in-lieu-of car subsidy is distributed directly to employees, in amounts that vary by position and level. As of June 2009, almost all government agencies have undertaken measures to sharply curb the use of official cars in Harbin. These measures and the new incentives have led some officials to buy their own cars, and others to commute by carpools, taxi, public transportation, or bicycle. The Harbin government has an oversight program to help ensure progress in the official car reforms, requiring periodic reporting about visitors who arrive by official cars, about expenses of official cars, and related matters. Personal use of official cars is strictly forbidden.

In 2003, before the official car reform in Qiqiha'er in Heilongjiang province, the expense for the official cars using is 97,629,000 RMB. After the reform, the traffic subsidy provided by the government is only 40,679,000 RMB, a savings of 56,950,000 RMB each year. In June 2004, the Songbei district in Harbin began the reform for official cars for positions under office level cadre, encompassing nearly 400 people included. After two years, the district government calculated it cost 4,280,000 RMB for the traffic subsidy, and it saved 3,490,000 RMB each year between 2004-2007. Eight years have passed since the official car reform in Daqing city in Heilongjiang province. By far, there have been 59 departments carrying on the reform, affecting 402 official cars, 108 of them reserved. In the first year of the reform, this reform saved more than 53,800,000 RMB. The reserved official cars can save 2,100,000 RMB through strict management. Jiangsu province reportedly carried out official car reforms quickly, eliminating over 7,400 cars in the past 5 years in 17 cities and 612 counties. http://www.gov.cn/jrzg/2006-11/11/content_439655.htm. In Huangshi city in Hubei province, 16 departments undertook official car reforms, cutting traffic expenses by over 15% compare with the prior year. http://www.gov.cn/zfjs/2005-10/03/content_74299.htm. In Zixing city in Hunan province, the official cars in all the departments were canceled and all the official cars are managed by a central department service. All the leaders go to work and back with their own car, by bus, or by foot, and half of the money saved was used as incentives for the officials. This has saved 7,500,000 RMB since the reform. http://www.gov.cn/zfjs/2005-10/03/content_74299.htm.

4 KEY OPPORTUNITIES FOR BEIJING

There are key opportunities for Beijing to advance to global leadership in employing TDM to create a high-performance, green, high-technology transportation system that serves people's needs. Best practices from other cities highlighted above provide examples that Beijing can learn from and adapt. Some observations and recommended next steps include:

4.1. Parking Pricing and Management

Improved management, pricing, and regulation of motor vehicle parking is a key area where near-term action by the Beijing government could produce significant changes in travel behavior that reduce congestion, pollution, traffic, and the share of travel made by car while also boosting revenues that could be used to support better public transportation, walking, and cycling.

1. The Beijing Transportation Research Center or Commission should undertake routine periodic data collection to improve information about the quantity and cost of parking spaces, both on-street and off-street, by time-of-day/week, by vehicle class, by block, across the city. This data will provide a foundation for better regulation, taxation, and management of parking.

2. Beijing should eliminate minimum parking requirements for new developments within close walking distance of high quality public transportation and seek to cap the supply of new parking in such areas consistent with explicit mode share goals. The Commission should consider downward revision to minimum parking requirements elsewhere where possible to support mode share goals. By relying more on pricing to allocate scarce parking, the Commission can better discourage an oversupply of parking that fosters excessive car use. The City should encourage unbundling of parking spaces from leases and property purchases where feasible. Developers should be encouraged or required to provide convenient bicycle parking, covered or shaded pedestrian pathways, and other amenities in lieu of some parking, and to participate in parking management and transportation management districts that coordinate travel incentives, prices, and policies.

3. The City should encourage employer-based parking strategies that help promote carpooling and other alternatives to driving for commuters, including "parking cash-out" or cash-in-lieu-of-parking incentives, preferential carpool parking, employer public transportation commuter subsidies, and bicycle parking and changing rooms at workplaces.

4. Given that Beijing has so much off-street parking growth, the city might try to synchronize the pricing of the off-street spaces with the public on-street spaces to eliminate distortions which induce cruising for a cheaper on-street spot.

5. Before building more off-street parking, Beijing should inventory where there may be empty spaces in alternative facilities reasonably nearby, similar to what Stockholm, Washington, DC, and Montgomery County, Maryland are doing. In some cases commercial spots can be shared and also used to satisfy residential and other parking needs during a different time of day.

6. No data has been found on how much of the parking supply is underutilized or saturated in Beijing. Are current or proposed parking rates leading to more optimal conditions? Block-by-block pay-and-display tariff machines are generally a good way to assure a few vacant spots for visitors and to eliminate cruising. Beijing should begin a pilot program to introduce these in key neighborhoods. Fosteriing use of multi-space pay-and-display meters for on-street parking, as are in wide use in European cities, with time-of-day pricing, would provide more opportunities to discover and adjust over time the price for limited parking, consistent with mode share goals.

7. Beijing should consider setting up a new program to entice existing parking space owners to give up their parking privileges in exchange for a year (or more)-long transit pass or other incentives.

8. Beijing should consider dedicating a portion of the revenue collected from parking back into the neighborhoods where collected as part of a parking benefits district and used to improve walking and cycling infrastructure.

4.2. Management of Official Cars

As the capital of China, Beijing hosts a number of national and sub-national agencies, a significant number of them sponsoring official cars. In fact, official cars constitute a high percentage of all cars inside the 2nd ring road. Hence, it may be a prerequisite for road pricing in Beijing (see above) to change mobility subsidies for government and business employees. Beijing should look to adopt the official car reforms used in other major Chinese cities. Perhaps new excise taxes or licensing fees might be imposed on agencies that do not reduce their official car fleets by at least 20% per year over a several year period. A cash-in-lieu-of car subsidy can be introduced for municipal agencies. Alternatively, the mobility subsidy can be distributed as a credit on multi-modal Yikatong cards. This gives many employees the choice to economize on mobility expenses and chose public transit. As the Harbin experience shows, also Beijing municipality can save total expenses on mobility subsidies. The

central government – one of the major provider of official cars inside the 2nd ring - should be persuaded to apply similar measures – as far as possible - for national agencies.

4.3. Congestion Pricing

Beijing has already laid a strong foundation from which a transition to congestion pricing could be made. The city has an extensive network of traffic cameras with Automated License Recognition Systems (ALRS). This is the technology that forms the backbone of successful congestion pricing systems in such cities as London and Stockholm. It could be used to introduce cordon pricing in core areas, such as inside the second or third ring road, or to support a multiple cordon system, as was designed for Oslo and Manchester. It could also support facility-based time-of-day pricing. Such systems could be introduced to replace the every fifth day license based restriction systems now in use.

A transition from license-plate-based day-of-week rationing to time-of-day-based road pricing would simultaneously provide motorists with much more travel choices, raise considerable new revenues that could be devoted to further improvements in public transport, walking, and cycling, and reduce traffic congestion. Time-of-day pricing is much more flexible and can be tailored and adjusted in response to shifting travel demand patterns. With Beijing's motor vehicle registration record databases in relatively good shape for metropolitan area traffic, there is a sound foundation for enforcement.

1. Beijing authorities should begin detailed evaluation of alternative road user charging system approaches as part of a pilot program with several hundred or several thousand households to test public response to alternative program designs, much as has been done in Seattle, Portland, the Netherlands, and other countries. This would involve using Beijing's computer transportation models to evaluate alternative scenarios, paying a sample of motorists to test road user charging concepts while monitoring their behavior, and disseminating the results to key stakeholders, the press, and other interested parties.

2. Beijing authorities should evaluate its legal authority to pursue the range of road user charging implementation options and take steps to ensure political support for broader adoption, clarifying its objectives and priorities in pursuing road user charging.

Beijing: Benefits of a city toll

The role of a congestion charge or city toll in reducing social costs and creating co-benefits was also analysed (Creutzig and He 2009). According to welfare theory, the theoretically optimal toll would maximize congestion relief at the least collective individual cost. It was found that a 27% reduction in car transportation would result in 14 billion RMB per year in driving time saved. Importantly, other social benefits add up to 7.2 billion RMB per year, mostly due to cleaner air whereas climate change mitigation only corresponds to 0.4 billion RMB per year at current carbon prices. An overview of the benefits is displayed in the right column of Table 1. The magnitude of both congestion and air pollution cost make clear that a congestion charge or – more generally – a city toll is an ideal measure for Beijing.

For the average car driver, such a city toll would mean a toll of 35-45 RMB per day. One possible implementation scheme would charge 1 RMB per km inside the 4th ring road and increase to 3 RMB per km inside the 2nd ring road. As a result, the average speed would increase from 21.5 km/h to 27.8 km/h.

City tolling would be highly beneficial not only for the local economy but also for overall quality of life. However a city toll alone is insufficient; motorists cannot switch when no competitive alternatives are available. Together with a city toll, improved public transportation service, bicycle networks, and safer, pedestrian-friendly streets make it easier for drivers to use their cars less. Practically, car owners can more easily switch to other modes. Technically, these measures increase demand elasticity and reduce opportunity costs for car drivers while scaling up the benefits of city tolling. Additionally, the increased availability of rapid public transit allows the reduction of the city toll and thus the burden for car drivers while achieving the same traffic reduction. In London, expanded bus services and the congestion charging scheme resulted in increased bus use (Transport for London 2007).

The combination of measures acts synergistically and can significantly reduce vehicle miles traveled. In Figure 21, the co-benefits of a city with and without extended supply-side measures are detailed. Fortunately, the rapid expansion of public transit and improved bus services are planned for the next years (see section 2) and thus provide the basis for a city toll scheme. A more formal study of the interaction of charging and supply-side measures via demand elasticity can be found in Creutzig and He (2009). The benefits of a combination of measures are depicted in Figure 21.

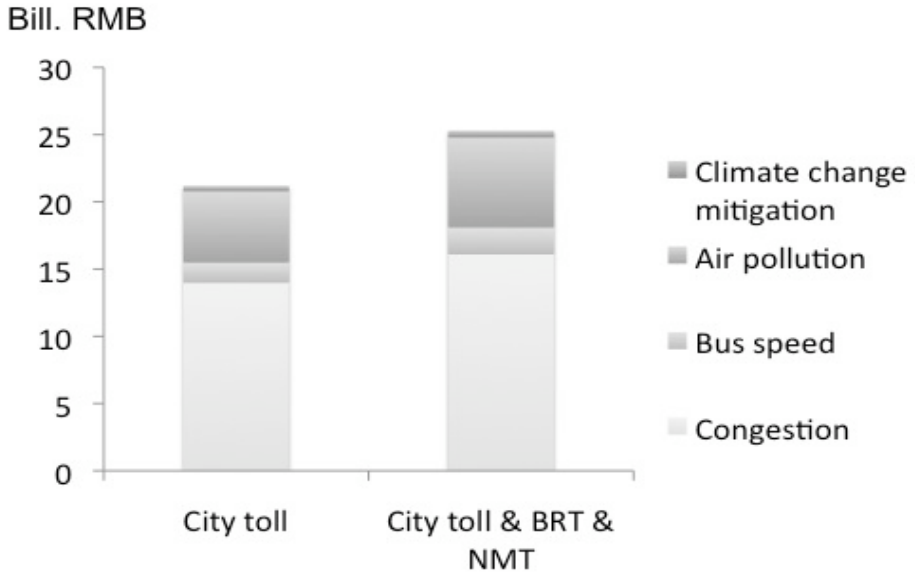

Figure 21 City toll and public transit investment in Beijing.

3. Beijing authorities should evaluate the potential to introduce other user fees reforms for motorists with an eye to shifting fixed costs of motor vehicle ownership to variable costs that are directly tied to how much, when, and where people drive. This should include looking at motor vehicle registration fees, motor vehicle taxes, and motor vehicle insurance. Some countries, like the Netherlands and Singapore, are moving forward to tie a much larger share of motor vehicle costs to vehicle use. A growing number of insurance companies in the U.S. and Europe are offering pay-as-you-drive car insurance which can cut traffic by 8-12% while reducing accidents and overall consumer costs for driving, saving 2/3s of households on their insurance.

Beijing currently has 5 ring roads – ring road 2 to 6 - and 8 radial roads intersecting the 3rd or 4th ring road comprising the urban expressway system. Furthermore, 9 main arteries (3 vertical and 6 horizontal) pass through the area within the 2nd ring. Some expressways such as the Badaling and the Airport Expressway were tolled. The 5th ring road, constructed in 2003, was initially tolled 0.5 RMB/km. However, as alternative routes were available (4th ring road), the 5th ring road was avoided and tolls were abolished in 2004.

Tackling congestion. The design of road pricing depends on the objective. If the aim is only congestion, a charge according to traffic density is appropriate. For example, in Singapore the charge is adopted each three months such that 85% of the traffic is at least 45 km/h on expressways (congestion with hysteresis appears when the average speed drops below 45 km/h). Such a charge varies according to route and time of the day, i.e. peak hour versus off-peak hour. This measure leads to smoother traffic flow but has limited effects on total traffic as car drivers may opt to drive at different time or route. However, for some routes in Beijing peak hour already extends from morning to evening. A city toll tackling congestion may charge from the 4th ring inwards, increasing the fee from about 1 RMB/km to 3 RMB/km inside the 2nd ring. A detailed traffic model, probably to be delivered by BJTRC, is needed for accurate estimation.

Tackling congestion and air pollution. If the objective is to tackle most or all known externalities the strategy may differ. Emissions appear also in uncongested situations, noise is most stressful at night and fatalities are more likely in less congested situations. This perspective calls for an absolute reduction in car transportation. Hence, every km driven inside the 6th ring would be charged at least 1 RMB/km. However, it may still be appropriate to charge more inside the 3rd ring as receptor density is higher here. The price may also vary according to fuel efficiency, weight of the car or emission standard. Such an environmental city toll would not be the first one: The Ecopass of Milan was explicitly introduced to address air pollution. In Milan, cars are charged according to emission class

and PM10 values were reduced by circa 20% in the first six months after the introduction of the Ecopass (Masi, 2008).

Beijing municipality has already considered the introduction of a congestion charge inside the 2nd ring road. A main obstacle is the perceived social dimension of a city toll as many people would be limited in their mobility. The main part of the road pricing revenue could be distributed in equal parts as mobility lump sum to Beijing inhabitants – particularly those inside the charging zone. This lump sum could be loaded onto the so-called Yikatong cards, the store-value contactless smart card currently used for public transportation. Yikatong cards could then also be used for payment of road charges. An introduction of the lump sum would also increase political acceptance of road pricing measures.

A large proportion of vehicles are government or company cars. The management of these official cars is a crucial precondition upon successful implementation of a congestion charge

5 CONCLUSION

There are many opportunities for Beijing to further reduce traffic, congestion, and pollution in ways that will support and spur a healthier, wealthier economy in the metropolitan area. TDM strategies, such as parking management and road user charging will play an important role in this, complementing the improvement of public transport, walking, and cycling opportunities.

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