Urban Transport Strategy to Combat Climate Change in the People’s Republic of China

This publication examines the problems and issues of urban transport in relation to climate change in the People’s Republic of China. It reviews international and local best practices for addressing such challenges. It also identifies policies, strategies, and measures to reduce CO₂ emissions from the transport sector and recommends applicable options for implementation in the People’s Republic of China.

Possible strategic measures to reduce CO₂ emissions include (i) identification, selection, and implementation of “win–win” travel demand management measures that improve both the urban environment and the traffic situation with no budgetary burdens; (ii) removal of administrative barriers and distortions to urban efficiency and effectiveness that require administrative changes and reforms; (iii) legislative changes and physical investments to be considered after the “win–win” options have been exhausted; and (iv) strengthening of knowledge management and building of capacity for integrated sustainable transport management to mainstream transport energy conservation and greenhouse gas reduction.

About the Asian Development Bank

ADB’s vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region’s many successes, it remains home to two-thirds of the world’s poor: 1.8 billion people who live on less than $2 a day, with 903 million struggling on less than $1.25 a day. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.
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The People’s Republic of China (PRC) has experienced rapid economic growth for the past 30 years, averaging more than 9% annually since 1978 and 10.5% annually from 2001 to 2010.

Economic growth has brought rapid urbanization. Around 300 million to 400 million people migrated from the countryside to the cities in a single generation. The PRC’s urban population accounted for 26% of the national population in 1990 and has reached 50% by the end of 2010. Urban areas now contribute 80% of the gross domestic product.

The emergence of suburban areas that have sprawled around many cities due to migration has made it more difficult for people to rely on biking and walking as means of transportation. As per capita incomes have risen, there has been a continuing shift toward using private vehicles for urban transport. The number of registered vehicles increased from about 1 million in the early 1990s to nearly 61 million in 2010. Between 2001 and 2010, the number of registered private vehicles increased at an average annual rate of 25%.

While the rapidly increasing number of vehicles can be seen as a sign of a flourishing economy, it nevertheless brings to the fore a number of associated problems. These include traffic congestion, deterioration in the quality of service and efficiency of both private and public transport, road accidents, air pollution, and greenhouse gas emissions.

This study on urban transport strategy examines how to develop a more sustainable urban transport system in the PRC, taking into account the quality of user services, the environment, and energy and land use. The study is part of the Asian Development Bank’s initiative to support greener and more sustainable transport that aims to provide society with a transport system that will leave a smaller physical footprint, use less energy, and produce less carbon dioxide and other harmful pollutants. Careful planning and relevant design are key elements in achieving this.

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Abbreviations

ADB – Asian Development Bank
BRT – bus rapid transit
CDM – Clean Development Mechanism
CO₂ – carbon dioxide
DOE – designated operational entity
EU – European Union
GDP – gross domestic product
GEF – Global Environment Facility
GHG – greenhouse gas
LPG – liquefied petroleum gas
MOT – Ministry of Transport
NAMA – nationally appropriate mitigation action
NDRC – National Development and Reform Commission
PRC – People’s Republic of China
UNFCC – United Nations Framework Convention on Climate Change
US – United States

Weights and Measures

g/km – grams per kilometer
km – kilometer
kph – kilometers per hour
km² – square kilometer
ppm – parts per million
VKmT – vehicle-kilometers traveled
VMT – vehicle-miles traveled

Currency Unit

(as of 30 March 2011) yuan (CNY)
CNY1.00 = $0.152
$1.00 = CNY6.560
The People’s Republic of China (PRC) has sustained a high rate of economic growth over the past 30 years. The improvement in the economy coupled with rapid urbanization has placed an enormous strain on transport and mobility in the urban centers. Uncontrolled growth in urban road traffic and rising congestion are now visible in virtually all of the PRC’s large and megacities. The tremendous increase in the number of vehicles on the roads has led to increased oil consumption and increased greenhouse gas emissions, including carbon dioxide (CO₂). Currently about 6% of the PRC’s CO₂ emissions originate from the transport sector, and this is expected to increase rapidly in the future. Given its scale and significance for global climate change, the emerging urban transport problem will be the biggest transport challenge for the PRC in the coming years. This publication examines the problems and issues of urban transport in relation to climate change in the PRC. It also reviews international and local best practices for addressing such challenges. Moreover, the study identifies policies, strategies, and measures to reduce CO₂ emissions from the transport sector and recommends applicable options for implementation in the PRC.

The current policy, institutional, and regulatory framework in the transport sector in the PRC is the result of incremental development over many years. It lacks an integrated sustainable urban transport policy to encourage a holistic approach to meeting transport demand.

Best international and domestic practices show that comprehensive urban transport strategies geared toward alternative fuel use, travel demand, and transportation system management approaches have achieved significant reductions in energy consumption and CO₂ emissions. A useful conceptual tool to examine this issue of climate change mitigation from an urban transport perspective is the “avoid–shift–improve” approach. “Avoid” emphasizes reducing the need to travel, “shift” encourages shifting to more energy-efficient modes of transport, and “improve” indicates the need to adopt improved technologies for higher energy efficiency.

“Avoid” strategies can ensure that urban transport provision and urban development are closely coordinated to create more livable cities with shorter journey times and journey distances. An emphasis on nonmotorized transport can lead to avoidance of motorized trips. “Shift” strategies call for multimodal transport systems that encourage the use of more sustainable transport modes. This includes the development of high-quality urban mass transit systems, such as metro rail and bus rapid transit, which attract people from private vehicular modes to public transport. Such projects require considerable investment and sophisticated approaches to financing, tariffs, technology, and operations.
As exemplified in London, Singapore, and other cities, pricing mechanisms can play a crucial role in discouraging private vehicle use and at the same time generate additional financial resources for expanding and enhancing the public transport networks and systems. “Improve” strategies require controls on vehicles and fuels and development of alternate fuel sources. With these controls in place, the adverse consequences of motorization can be mitigated by lowering the quantum of global and local emissions.

Finally, financing mechanisms can play an important role in leveraging and incentivizing urban transport projects that reduce greenhouse gas emissions. The Global Environment Facility (GEF) and the Clean Development Mechanism (CDM) are examples of such mechanisms. The GEF has provided a valuable but limited source of financing for low-carbon transport. The CDM has played a limited role, having been designed mainly with a view to supporting clean energy projects rather than those for urban transport. Nationally appropriate mitigation actions, which refer to a set of policies and actions countries may undertake as part of a commitment to reduce greenhouse gas emissions, may offer further prospects for garnering additional financial support for carbon mitigation projects in the future. These may become an important part of the post-2012 climate change framework for the transport sector. This may offer the PRC and other developing countries more opportunities for obtaining international financial support for actions to mitigate climate change in the urban transport sector.
Problems, Issues, and Challenges

Transport is an important part of most economic activities but it also causes negative environmental impacts. One such impact is the emission of greenhouse gases (GHGs), which contribute to climate change. Climate change can include changes in rainfall patterns that can lead to severe flooding or extreme drought. Impact will vary greatly in different areas of the world. These are expected to be more severe in developing countries, as geography and lack of resources to adapt make them more vulnerable. It is therefore vital to limit the effects of climate changes due to transport-related GHG emissions.

Effects of Climate Change in the People’s Republic of China

The People’s Republic of China (PRC) is already grappling with some of the worst environmental effects of climate change, including air pollution, desertification, water scarcity, and flooding. According to the Food and Agriculture Organization of the United Nations (FAO) (1997), the annual expansion of land desertification increased from 1,600 square kilometers (km²) in the 1970s to 2,100 km² in the 1980s. By 2000, nearly 3,625 km² had dried up and become deserts. This is mainly due to climate change and human economic activities. Flooding is another problem in the PRC, which causes high human casualties and enormous economic losses.

Box 1  Desertification and Water Scarcity

In its arid northern and northwestern reaches, the People’s Republic of China is experiencing an expansion of its deserts. Desertification and sandstorms cause billions of dollars in damages each year and affect millions of people. Fertile grasslands the size of Israel turn barren every year.

Source: [People’s Republic of] China Climate Fact Sheet: http://knowledge.allianz.com/climate/country_profiles/177/climate-profile-china-facts
Air Pollution

Air pollution is another effect linked with GHG emissions. Air pollution is particularly bad in northeastern PRC where a significant number of factories and manufacturing plants are located. A study done by the World Health Organization estimated that the amount of airborne suspended particulates in northern PRC is almost 20 times more than the World Health Organization standard for safe levels. Severe automotive air pollution affects the health and welfare of people. According to PRC government sources, about a fifth of urban Chinese breathe heavily polluted air. The air pollution and smog in Beijing and Shanghai are sometimes so bad that the airports are shut down because of poor visibility. Coal is the country’s number one source of air pollution. The PRC gets 80% of its electricity and 70% of its total energy from coal. Furthermore, expanding car ownership, heavy traffic, and low-grade gasoline have made cars another leading contributor to the air pollution problem in PRC cities.

Energy Consumption

The PRC is the world’s second largest economy and second largest oil consumer. Figure 1 shows its crude oil consumption from 1980 to 2006. In the past 26 years, the PRC’s oil consumption increased on average by nearly 6% annually and 300% overall. This
Air Quality in Beijing (left) and Lanzhou (right)

Figure 1

Crude Oil Consumption in the People’s Republic of China

Source: United States Energy Information Administration.

has tremendous impacts on the environment. He et al. (2005) mention that a major cause of the increase in PRC oil consumption is the rapid growth in the number of motor vehicles.

Transport-related oil consumption accounts for about 25%–30% of total oil consumption in the PRC. Figure 2 shows the breakdown of diesel and gasoline consumption from 1997 to 2002. The oil consumption growth rate during this period was 9% while the
total consumption from the road transport system increased by 55%. Since emissions of GHG from transport are mainly caused by the combustion of motor vehicle engines—and in effect, the use of oil—transport sector carbon emissions may be expected to increase transport-related oil consumption.

Figure 3 illustrates total carbon dioxide (CO₂) emissions in the PRC from 1995 to 2007. It shows that CO₂ emissions increased by 96% from 1995 levels with an average annual growth of 6%. This figure shows the total CO₂ emissions in the PRC including nonmobile sources.

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**Figure 2  Transport-Related Oil Consumption in the People’s Republic of China**

![Figure 2](image)

Source: Adapted from Table 4 of He et al. (2005), p. 1504.

**Figure 3  Total Carbon Dioxide Emissions in the People’s Republic of China**

![Figure 3](image)

Purpose of the Report

The increase in GHG emissions, particularly CO$_2$, is a major factor leading to climate change. Increases in GHG emissions come mainly from mobile and nonmobile anthropogenic sources. Emissions from transportation sources need to be studied and addressed to be able to limit these emissions to address climate change while at the same time improving the welfare of individuals and increasing their mobility and accessibility.

This report tries to (i) identify the problems and challenges of urban transport in relation to climate change in the PRC, (ii) review international and local best practices to address such challenges, and (iii) propose implementation options that can counteract the negative impacts of transport activity in the PRC.

Funding mechanisms for addressing climate change in transport are also discussed.
The PRC has been experiencing urbanization at an unprecedented rate over the last decade. The population in urban areas more than doubled from 1990 to 2009, as shown in Figure 4. Comparing the rate of urbanization with other countries (Figure 5), the PRC’s rate of urbanization is very high. Rapid urbanization is mainly the effect of rapid economic growth, and the PRC’s economy has sustained an average annual growth rate of 9.8% for the past 30 years.

**Figure 4  Population in the People’s Republic of China, 1990–2009**

Urban Land Use and Transport Planning

In the PRC, urban transport planning, urban spatial and land use planning, and urban infrastructure construction are treated as different elements of urban overall planning. The responsibilities are divided between different public agencies. As a result, these interdependent aspects of urban development are not systematically planned in a coordinated and integrated way, but rather treated as independent from each other with no coordinated guidance. This has resulted in piecemeal and poorly coordinated urban development that does not adequately serve the needs of those living and working in urban areas.

This is illustrated by the PRC’s Urban Planning Law and the Regulation of Urban Planning Formulation. These only have technical contents and individual transport planning components, and there is no requirement for a complete procedure in terms of urban integrated transport planning. Because there is no coordination mechanism between transport planning and urban transport demand, it is hard to provide for appropriate urban infrastructure construction in residential, commercial, and industrial parts of the city.

Built-Up Area and Person Trips

The PRC has about 9.56 million km² of land area; about 94% of the population lives on 46% of the land. The urban built-up area in the PRC is expanding rapidly, from 224,393 km² in 2000 to 336,598 km² in 2006, up by 50% in the span of 6 years.

Rapid urbanization and the improvement of citizens’ standard of living have contributed to the increase in the number of daily trips by urban citizens. The rapid expansion of
urban built-up area has led to increases in urban residents’ trip distances. For example, in 2005, Beijing residents’ average trip distance reached 9.3 km (excluding walking), up by about 16% from 2000 and 55% from 1986.

Motorization

The PRC has been experiencing rapid motorization. Figure 6 shows the increasing rate of motorization growth from 1985 to 2006 for different countries. The figure shows that the overall number of automobiles per 1,000 people in the PRC is much lower than developed countries such as France, Japan, the Republic of Korea, and the United States. However, it had the highest growth rate of automobiles per 1,000 people from 2000 to 2006. At the current growth rate of 10.2% for automobiles, it will catch up with the United States in 37 years.

From the perspective of urban transport and urban environment, the PRC’s rising private car population will lead to large increases in urban transport energy consumption, which will cause increased GHG emissions. Hence, the control of private car ownership and use has become an important social and political challenge in the PRC.

According to the National Development and Reform Commission (NDRC), the total gasoline consumption of Beijing was 1.06 million tons in 2000, and increased by 122% to 2.35 million tons in 2005. Shanghai consumed 1.33 million tons of gasoline in 2000 and 2.42 million tons in 2005. More than 90% of this gasoline was used for transport,
with urban passenger transport taking the biggest percentage and a smaller share used for intercity passenger and freight transport. The NDRC study shows Beijing’s gasoline consumption for motorized vehicles was 0.9 million tons in 2000 and 2.1 million in 2005. The corresponding figures for Shanghai are 1.1 million tons in 2000 and 2.0 million in 2005. Cars accounted for 80% of the total gasoline consumption.

Figure 7 provides a comparison of growth rates for different transport modes in the PRC from 1995 to 2007. The annual growth rate for private car ownership increased from 21.7% in 1995 to 51.5% in 2007. On the other hand, the growth rate for taxi ownership has decreased over the past 10 years. In 1995, the annual growth rate for taxi ownership stood at 28.2%, but it fell to 2.2% in 2003 and recorded negative growth in 2006 when the State Council issued a nationwide memo that outlined suggestions for giving the highest priority to urban public transportation development. In order to increase energy efficiency in the transport sector and alleviate congestion, the memo emphasized the need to modify laws, regulations, and standards to promote well-regulated development and reform the investment and financing support for privately operated, government-supervised urban public transport systems. Thus, as shown in Figure 7, public transport has been increasing since 2006.

However, private car ownership has been increasing by more than 20% per annum for the past 10 years and has not shown any sign of slowing. Based on this trend, unless active policy measures are instituted to change urban travel habits, the rapid increase in the number of private cars will have an impact on urban transport structure and will lead to a sharp rise in transport energy consumption and GHG emissions.
Public Transport

In recent years, the number of operating public buses, trams, and subways grew annually by 8.9% (Figure 8).

Moreover, public transport operating distance grew from 59,961 km in 1995 to 125,845 km in 2007. The type and structure of public transport vehicles have been changing constantly (Figure 9). The number of compressed natural gas public buses has been increasing relatively fast with a growth rate of 16%. In contrast, the number of public buses powered with liquefied petroleum gas (LPG) was down by 8.9%. A slight reduction was also seen in the number of trolleybuses.

CNG = compressed natural gas. LPG = liquefied petroleum gas.
The volume of vehicles, distance, and passenger volume of rail transit have also risen considerably in the past few years. Compared with 2005, the length of operating routes rose by 37.2% in 2006, from 444 km to 609 km. In the same period, the number (standard unit) of operating rail transit vehicles grew 12.4%, from 6,133 to 6,892, and the passenger transport volume of rail transit grew from 1.6 billion person-kilometers to 1.8 billion person-kilometers (Figure 10). This shows that the PRC is moving toward a stage of fast rail transit development.

The rapid growth of public transport, especially rail transit, is set to reduce GHG emissions and promote sustainable urban transport. The growing share of alternative fuel vehicles is increasing, thus improving efficiency of energy use and diversifying energy sources. The PRC government’s policy guidance and fiscal subsidies have led to improved and increased public transport infrastructure development.

**Carbon Dioxide Emissions from Urban Transport**

Various researchers have estimated transport-related energy use and carbon emissions. He et al. (2005) developed a model to estimate oil consumption and CO₂ emissions from the PRC’s road transport sector. They also forecasted future trends up to 2030. Wang et al. (2006) projected motor vehicle growth, oil consumption, and CO₂ emissions through 2050. Similarly, ADB (2009b) also analyzed and forecasted CO₂ emissions and suggested policies and action plans for the resource optimization of the road industry in the PRC. The three studies estimated CO₂ emissions using three main factors: vehicle population, distance traveled, and fuel consumption rates.

**Vehicle Population in Beijing and Shanghai**

The “numbers of operated vehicles” (or the vehicle population) is a readily available transport statistic in the PRC. The data used in this section was taken from official
statistical books. Table 1 shows the vehicle population in Beijing and Shanghai for the years 2006 and 2007. Considering that Shanghai has a larger population and higher per capita income than Beijing, it is surprising that Beijing has a much larger registered private car population (2.1 million) than Shanghai (0.6 million). This is largely due to the vehicle quota system used (vehicle plate auction for new registered vehicles) in Shanghai since 1994. Table 1 also shows that Beijing has much fewer operated motorcycles than Shanghai. This is due to urban road traffic management measures in Beijing, which restrict motorcycle use as follows:

- From 7:00 a.m. to 8:00 p.m., motorcycles are forbidden in Chang An Avenue (since 16 December 1998).
- Motorcycles are forbidden at all times on the second to fifth ring roads (since 8 December 2000).
- All motorcycles with Beijing B license plates and plates from other provinces are forbidden inside the 4th Ring Road, side roads excluded (since 1 July 2001).
- In Beijing, it is hard for new motorcycles to get a license plate because of the limits imposed on new license plates.

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Beijing 2006</th>
<th>Beijing 2007</th>
<th>Shanghai 2006</th>
<th>Shanghai 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public bus</td>
<td>18,950</td>
<td>18,753</td>
<td>16,899</td>
<td>16,672</td>
</tr>
<tr>
<td>CNG bus</td>
<td>3,243</td>
<td>3,752</td>
<td>281</td>
<td>281</td>
</tr>
<tr>
<td>LPG bus</td>
<td>307</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trolleybus</td>
<td>572</td>
<td>642</td>
<td>385</td>
<td>272</td>
</tr>
<tr>
<td>Taxi</td>
<td>66,646</td>
<td>66,646</td>
<td>48,022</td>
<td>48,614</td>
</tr>
<tr>
<td>Ferry</td>
<td>n.a.</td>
<td>n.a.</td>
<td>53</td>
<td>53</td>
</tr>
<tr>
<td>Metros</td>
<td>967</td>
<td>1,130</td>
<td>746</td>
<td>858</td>
</tr>
<tr>
<td>Light rail</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>244</td>
</tr>
<tr>
<td>Streetcar</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Private car</td>
<td>1,810,417</td>
<td>2,120,973</td>
<td>509,400</td>
<td>612,900</td>
</tr>
<tr>
<td>Motorcycles</td>
<td>262,000</td>
<td>n.a.</td>
<td>1,241,500</td>
<td>1,259,700</td>
</tr>
<tr>
<td>Military car</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Agricultural vehicles</td>
<td>n.a.</td>
<td>n.a.</td>
<td>14,000</td>
<td>13,400</td>
</tr>
<tr>
<td>Total vehicles for civil use*</td>
<td>2,753,798</td>
<td>3,072,192</td>
<td>2,381,300</td>
<td>2,536,000</td>
</tr>
</tbody>
</table>

CNG = compressed natural gas, LPG = liquefied petroleum gas, n.a. = not available.

* “Total vehicles for civil use” means all kinds of vehicles for commercial and noncommercial purposes, both privately and non-privately owned, excluding vehicles for military use. It covers buses, trolleybuses, taxis, private cars, motorcycles, agricultural vehicles (tractors), and other motor vehicles.

Source: The authors, based on various applied statistics books in the People’s Republic of China.
Table 2 shows the numbers of new registered vehicles in both Shanghai and Beijing, as well as the dealing price for the vehicle plate quota in Shanghai. This understates the number of vehicles in use in Shanghai because some residents circumvent the license plate and auction system by registering vehicles in neighboring jurisdictions.

Commercial vehicles in the PRC are classified according to transportation, storage, post, and telecommunication data. These classifications cover all commercial transport modes operated in all PRC cities. Table 3 gives the total fuel consumption (converted into tons of coal equivalent) in commercial "transport, storage, and post" in 2006 and 2007 in Beijing and the PRC.

Electric bicycle (e-bike) production and sales have increased rapidly in the PRC since the turn of the millennium. Production increased tenfold from 58,000 in 1998 to 580,000

<table>
<thead>
<tr>
<th>Shanghai</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
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<tr>
<td>Vehicle plate quota (new registered vehicles)</td>
<td>14,000</td>
<td>15,900</td>
<td>31,850</td>
<td>53,068</td>
<td>71,800</td>
<td>78,000</td>
<td>65,000</td>
<td>77,500</td>
</tr>
<tr>
<td>Average dealing price (yuan)</td>
<td>14,416</td>
<td>14,444</td>
<td>27,848</td>
<td>34,349</td>
<td>30,640</td>
<td>33,897</td>
<td>38,347</td>
<td>47,815</td>
</tr>
<tr>
<td>New registered vehicles (for civil use)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>138,079</td>
<td>156,909</td>
<td>169,715</td>
<td>205,156</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beijing</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>New registered vehicles (for civil use)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>339,344</td>
<td>270,744</td>
<td>342,176</td>
<td>349,197</td>
</tr>
</tbody>
</table>

n.a. = not available.


<table>
<thead>
<tr>
<th>Data</th>
<th>2006</th>
<th>2007</th>
<th>Data Source(s)</th>
<th>Issuer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>5,633,900</td>
<td>7,176,000</td>
<td>Beijing Statistical Yearbook and [the People's Republic of] China Energy Statistical Yearbook</td>
<td>Beijing Statistics Bureau, NBS, and NDRC</td>
</tr>
<tr>
<td>PRC total</td>
<td>185,830,000</td>
<td>206,430,000</td>
<td>[People’s Republic of] China Statistical Yearbook</td>
<td>NBS</td>
</tr>
</tbody>
</table>


Source: The authors, based on various statistics books in the PRC.
in 2001, and reached almost 20 million in 2006, when the PRC e-bike fleet reached 45 million. E-bikes use only 2% of the fuel per 100 kilometers compared with a typical car in the PRC. However, e-bikes are officially prescribed as nonmotorized vehicles and are, therefore, not registered in the statistics of motorized vehicles.

### Vehicle Distance Traveled, Fuel Economy, and CO₂ Emission Factor

Vehicle-kilometers traveled (VKmT) is defined as the distance a vehicle traveled in a year. It is usually measured from the odometer readings of vehicles at registration. The values of VKmT used in this study were taken from available literature (Wang et al. 2006 and He et al. 2005). Fuel economy is measured by the amount of gasoline consumed by a vehicle for every 100 kilometers of travel. Fuel economy data was taken from the National Development and Reform Commission (NDRC), which publishes the fuel economy data (liters of fuel consumed per 100 kilometers) based on the actual on-road situation for most car brands and types in the PRC. CO₂ emissions can be estimated using VKmT data; however, it is usually more accurate to estimate the total emissions from the fuel consumption (as this is the more reliable data source) and allocate these emissions to the vehicle types using VKmT data and data on relative fuel efficiencies. To make the calculation easier, this study assumes that the CO₂ emission factor in the United States (where it is the same for diesel and gasoline) is sufficiently applicable to Beijing and Shanghai, and thus only one value was used for all types of vehicles. Table 4 shows the average VKmT used for different vehicle types.

The total CO₂ emissions from different vehicle types in 2007 are shown in Table 5. It can be seen that the estimated CO₂ emissions from Beijing are 2.76 times higher than from Shanghai accounting only for private cars and taxis. For Shanghai, this is clearly a low estimate, as the number of registered vehicles in Shanghai is a lot lower than the actual number due to the leakages in the vehicle quota system implemented in that city.

It is also important to note that private cars are a significant contributor to total emissions, accounting for 29% of emissions from traffic in Beijing and 66% from Shanghai. Commercial vehicles in Beijing contributed about 65% of the total emissions. Thus, it will be appropriate for solutions for minimizing CO₂ emissions to be concentrated on these segments of the vehicle population.

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>VKmT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxi</td>
<td>100,000</td>
</tr>
<tr>
<td>Private and business car</td>
<td>16,000</td>
</tr>
<tr>
<td>Commercial vehicles</td>
<td>20,000–50,000 km</td>
</tr>
</tbody>
</table>

**Table 4: Average Vehicle Distance Traveled Used in the Study**

VKmT = vehicle-kilometers traveled.

* For light duty vehicles, adapted from Wang et al. 2006. Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO₂ Emissions through 2050.

* For heavy duty vehicles, adapted from Wang et al. 2006. Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO₂ Emissions through 2050.

Sources: Wang et al. 2006 and He et al. 2005.
Table 5  Carbon Dioxide Emissions from Urban Transport in Beijing and Shanghai, 2007

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Tons CO₂ equivalenta</th>
<th>Beijing</th>
<th>Shanghai</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private cars</td>
<td></td>
<td>6,785,417</td>
<td>1,960,790</td>
</tr>
<tr>
<td>Taxis</td>
<td></td>
<td>1,332,587</td>
<td>972,037</td>
</tr>
<tr>
<td>Commercial vehicles</td>
<td></td>
<td>15,213,120</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>23,331,124</td>
<td>2,932,827</td>
</tr>
</tbody>
</table>

CO₂ = carbon dioxide.

* With assumed fuel economy of 8.6 liters/100 kilometers and 3.2 kilograms CO₂/1 kilogram of fossil fuel for all vehicle types.

Source: Authors’ calculation.
Best Practices for Sustainable Transport Initiatives

Strategies for reducing energy consumption and CO₂ emissions from urban transport can have a significant impact in mitigating the effects of climate change. Barter and Raad (2000) suggested the following approaches:

- shifting transport to environmentally sound, affordable, and health-promoting modes;
- reducing the need for motorized transport by adapting appropriate land use policies and through urban and regional planning; and
- relating the costs of transport more closely to distance traveled and internalizing transport-related environmental and health costs and benefits.

The term “sustainable transport” refers to meeting or helping meet the mobility and accessibility needs of the present without compromising the ability of future generations to meet their needs. It is also used to describe forms of transport that minimize fuel consumption and emissions of CO₂ and pollutants. Sustainable transport provides the basis for devising instruments and strategies for the reduction of GHG emissions and the improvement of mobility and accessibility in cities.

Dalkmann and Branigan (2007) have suggested the following sustainable transport instruments and assessed their potential contribution to the reduction of greenhouse gas emissions:

- **Planning instruments**, covering the legal and regulatory framework for land use planning (master planning). City-level planning instruments focus on developing and providing planning methods, as well as a framework for their local application, that help reduce or optimize transport and encompass integrated land use and transportation planning, where the latter covers private, public, and nonmotorized transport modes and their respective infrastructures. In practice, this can considerably reduce the need for motorized travel by bringing people and the activities they seek closer together. Closer access can mean increased volumes of travel, which can financially justify provision of new public transport infrastructure or upgrading and increased attractiveness of existing transportation. In this way, land use planning can be an important long-term instrument for reducing energy use and GHG emissions.
• **Regulatory instruments**, covering technical standards to be monitored (emission limits, speed limits, parking regulations, and space allocation) and production processes. These can be used to restrict the use of certain motorized vehicles, but also to influence both types of vehicles used and compliance with vehicle performance standards and road regulations. The national authorities should permit local variations in some such standards depending on the local environment and traffic conditions.

• **Economic instruments**, covering fuel taxes, road pricing, parking fees, purchase taxes, fees, levies, public transport subsidies, and emissions trading. While the national authorities should be careful to avoid economic instruments that could induce significant numbers of users (individuals and corporations) to register vehicles in a neighborhood “tax haven” or travel excessive distances to fill their tanks with cheaper fuel, they should allow for use of technologically operational transport pricing instruments designed to optimize the local degree of congestion and diversion of car travel to public and nonmotorized transport, as well as to reduce redundant trips.

• **Information instruments**, covering public awareness campaigns, mobility management and marketing schemes, cooperative agreements, and maximizing fuel efficiency while driving or eco-driving activities. While awareness campaigns can be run in the mass media on a national scale, it is often more effective to use locally prepared, easily accessible information about the advantages of shifting car travel to public or nonmotorized transport and about eco-driving practices.

• **Technological instruments**, covering fuel improvement, cleaner technologies, devices that directly treat vehicle exhausts (such as catalytic converters), and cleaner production. National policy instruments, together with changes in transport pricing policies, can be used to bring about technological shifts in the auto industry, oil refineries, and supply chains of motor fuels so as to make it profitable for both producers and users of vehicles and fuels to shift to modes and vehicles that use cleaner fuels with less GHG emissions.

### International Good Practice Experience in Urban Transport

The following section discusses the policies, instruments, and strategies that countries have used to improve their transport systems while minimizing GHG emissions.

#### Ensuring Public Transport Priorities through Legislation

Countries use legislation in various ways to mandate, promote, and subsidize public transport:

• **France**: Attaches importance to the coordination of different laws and regulations, and promote the development of public transport. From 1995
to 2001, France has enacted several laws related to urban public transport. Among them, the Clean Air Act and the Cooperation Act for City Revitalization are the most important, and fully reflect the government’s guiding role through policies that give priority to the development of urban public transport. The guiding law about domestic transport enacted in France in 1982 stipulates that the government needs to provide reasonably priced public transport for all citizens. Meanwhile, the authority for managing public transport is transferred to local government, which establishes a specialized agency of transport. In this model, 10% of transport operation enterprises are directly affiliated with a transport agency while the other 90% are licensed to operate under contract, following a transparent bidding process.

- **Germany**: Guarantees the funds for public transport construction through legislation and realizes the optimization and integration of public transport resources. To provide enough funds to implement a policy of giving public transport priority, and to clarify the authority for distribution and use of funds, Germany has enacted the Financing Act for Rural Community Transport and the Regionalization Act, prescribing (i) the amount to be invested by the government to promote the priority policy and construction of public transport, and (ii) the distribution and use of federal investment.

- **United States**: Uses legislation to encourage the development of public transport. In the United States (US), strengthened legislation has been an important means of addressing problems of urban traffic jams and air pollution. From the beginning of the 20th century, the US government has promulgated many national laws and regulations to normalize and encourage the development of public transport, such as the Urban Public Transportation Act, the Support Act for Urban Public Transportation, the Intermodal Surface Transportation Efficiency Act, and the Transportation Equity Act for the 21st Century. The latter two, which were promulgated in the 1990s, have prescribed that the federal government must provide subsidies to public transport.

**Strengthening the Management and Control of Transport Planning**

Transport planning is an integral part of formulating urban transport policies. Responsible agencies should be able to manage and develop strategic transport policies in an integrated way. Below are examples of transport policies of relevant agencies that promote integrated land use and transport planning:

- **The European Commission**: Formulates urban transport policies. In Urban Transport Policies for Sustainable Development, the European Union (EU) Transport Commission has pointed out that to improve transport, security, sustainability, competitiveness of cities, and people’s living standards, local government must draw up a plan for urban transport. The comprehensive transport plan of the EU has taken rising transport demand into consideration and promotes coordination and compatibility between transport planning and land use. Moreover, the integrated transport plan is considered part of the strategic plan for urban development.

**Offering Investment and Financing Mechanisms for Public Transport**

Some national governments offer budget support or subsidies to cities (local governments) for engaging in active promotion of public transport and nonmotorized transport:

• **France:** Maintains balance between revenue and expenditure through financial appropriation. In Paris, a plan is usually drawn up by public transport enterprises every 3 years. Based on that, the Transport Management Committee checks and verifies the passenger transport revenue. In 1971, tax on transport was first levied in Paris. Since then, the difference between revenue and expenditure, except for the part compensated by the tax, has been met through public financial subsidies. In Paris, before 2001, the central government provided 70% of the subsidy and local government provided 30%. In subsequent years, the central government's share dropped to 51% while the local government’s contribution increased to 49%.

• **Japan:** Uses various sources of funds for public transport construction. In Japan, funds for public transport construction are provided mainly from central and the local government appropriations and loans. Part of the central government appropriation is from taxation on sales of gasoline, diesel oil, and liquid gas; part of the local government contribution is from charges for various transport facilities, and the rest is met from low-interest loans from banks. Generally speaking, when new public transport facilities are established, the central government is responsible for providing 50%–60% of funds, the local governments provide 25%, and the rest comes from low-interest loans. In Tokyo, nongovernment organizations are considered to be a new source of funds for transport facilities. The nongovernmental developers can provide substantial capital for new roads and railways.

• **Norway:** Uses revenues from private transport to finance public transport. In Norway, the national government wanted to accelerate the introduction of a national transport plan to favor public transport investments and use over road development in urban areas. The largest city governments were offered financing for upgrading the local public transport networks as an incentive to introduce and commit to congestion pricing for cars. So far, Oslo’s political majority has not been persuaded to follow this approach. The fee paid by cars for entering the city (crossing the cordon) remains the same at all times of day and does little to relieve congestion. The national government is refusing the city the central government subsidy for the city’s transport plan.

• **United States:** Provides subsidies to promote the development of public transport. Since the 1970s, public funding and operational subsidies were provided for public transport in the US. Responsibility for investment in
public transport is generally shared among governments at different levels. Unprofitable public transport enterprises can even attract considerable subsidies to promote expansion of public transport services.

### Improving the Access and Operation Mechanism for Taxis

A license-controlled market access system is adopted for taxi operations in most countries and governed by city authorities. In London, to be a taxi driver, applicants need to pass many strict examinations, reviews, and health checkups. In the Republic of Korea, the government has been gradually reforming taxi regulations since 1993, and control over market access is now even stricter than in London.

### Pricing Transport for Energy Efficiency

A menu of national taxes, fees, and levies is available to stimulate the purchase and use of small, fuel-efficient cars and/or cars based on nonpetroleum fuels. Most Western European countries use high fuel taxes (much higher than in the US and most developing countries) as well as annual license plate fees and varying levels of vehicle purchase taxes. Countries with a large auto industry, such as Italy, Germany, and Sweden, make less use of new vehicle purchase taxes, whereas non-auto producing countries, such as Norway and Denmark, do not have strong auto industry political interests and use such taxes more.

High vehicle purchase taxes are an important source of government revenue in most European countries. At the same time, these taxes make people, particularly in urban areas, think twice before becoming car owners. Most European countries now have vehicle taxes (on initial purchase and/or registration and sometimes on annual ownership as well) that are progressive with respect to either engine volume or factory-declared CO₂ emissions per kilometer driven. This policy penalizes the purchase and ownership of heavy sports utility vehicles, sports cars, and conventional large sedans relative to cars with small efficient engines regardless of fuel type. For cars with particularly low emissions (e.g., hybrid engines and electric cars), these taxes are set very low or removed.

Given that it is politically impossible to demand that all old automobiles be replaced with new ones, some countries have adopted a policy of tax incentives. If the emission level of a purchased new automobile is lower than a state-declared emission standard, the purchaser can be exempted from certain taxes. This has been adopted in Germany, the Netherlands, and Sweden, and has proven efficient and effective.

In Europe, gasoline and diesel fuels are highly taxed. The pump price varies a little with octane and fuel quality as well as with the international market prices of the fuels, but tends to fall in the range of CNY10–CNY14 equivalent per liter. Such high pump prices also encourage the choice of fuel-efficient vehicles and switching to public transport or nonmotorized transport. CO₂ taxes on fuels are sometimes incorporated into fuel taxes, as is practiced in Norway.
Some countries also use tax differentiation between close fuel substitutes to stimulate road users to choose clean fuels. Sweden introduced reduced taxes on “green” diesel (i.e., diesel with lower CO₂ content) and increased taxes on conventional diesel. This quickly encouraged oil refineries to produce “green” diesel and car users to switch to this cleaner fuel.

Intra-country vehicle tax differentiation has some limitations because it can lead to an increase in vehicle registrations in neighboring jurisdictions within the country. This has been experienced in Shanghai following the introduction of license plate quotas and vehicle registration auctions. Intra-country fuel price differentiation through fuel taxes can face similar obstacles.

Standards for Energy Use and Greenhouse Gas Emissions

In the EU, a voluntary agreement with the association of vehicle manufacturers set a GHG standard of 165 grams per kilometer (g/km) CO₂ for 2002. This was achieved because emissions from diesel-fueled vehicles are on average 10% lower than for gasoline-fueled vehicles (155 g/km CO₂ vs. 172 g/km CO₂). The agreement set a standard of 140 g/km CO₂ for 2008, with a possible extension to 120 g/km CO₂ for 2012. Between 1995 and 2002, Japan improved its fleet average fuel economy to tighter levels than the EU and is now in the process of proposing yet stricter fuel efficiency standards. Assuming no change in the vehicle mix, these targets imply a 23% improvement in 2010 in gasoline passenger-vehicle fuel economy and a 14% improvement in diesel fuel economy, compared with the 1995 fleet average of 14.6 kilometers per liter.

Land Use Planning

Transport GHG emissions and urban land use are closely linked. First, population density influences transport GHG emissions. A survey of 21 cities (eight in North America, six in Europe, five in Asia, and two in Australia) suggested that transport GHG emissions per capita is inversely related to population density in both Europe and the US (Kennedy et al. 2009). Although the population density of the surveyed European cities broadly compared with the North American cities, they had considerably lower transport-related GHG emissions per capita. Two explanations were suggested: (i) the European countries had more stringent land use policy and a more compact pattern of urban development, and (ii) public transport in Europe was better and more widely developed while usage of cars was restrained by high fuel taxes and parking charges, and in some countries supplemented with high purchase and ownership taxes on cars.

Transport GHG emissions are also influenced by the pattern and distribution of city centers. Hayashi and Roy (1996) found that transport conditions were greatly improved and transport GHG emissions per capita decreased by 14.1% and 16.4%, respectively, in cities of the two countries where the number of city subcenters were doubled. Siqi Zheng et al. (2009) studied variations in CO₂ emissions from urban households in the PRC and the US. They correlated emissions with city-level attributes such as population, population growth, income, temperature, and urban form. They found that
“larger cities tend to be more transit-oriented and less dependent on cars. Population density is associated with lower levels of emissions from taxi use and buses.” Based on emissions data and urban characteristics from the PRC’s 35 major cities, they found that “an increase of 1,000 people per km² on average is associated with a reduction of CO₂ emissions per household of 0.424 ton from use of taxis and 0.837 ton from the use of buses. This may indicate shorter average travel distance and/or much more effective urban public transportation. Just as in the US, compact development leads to lower carbon emissions.” The same study suggests that having a dense population and multiple urban subcenters can shorten the average travel distance of the residents. These also induce mode switching from private cars to public transport or nonmotorized transport, which reduce transport energy consumption. This is well-illustrated by the experience of Oslo, Norway, during the past 3 decades, as described in Box 2.

The demand for travel (both the number of motorized trips and their length) can be significantly reduced through “mixed land use,” where the various forms of land use—such as residential houses, offices, shops, and public services—are not separated in different city quarters, but mixed within close proximity of one another. Planning for high population and job density areas with a variety of land uses makes provision of public transport more attractive because higher frequency of service becomes feasible. The relative attractiveness of public transport can be further enhanced by complementary measures such as high parking charges for cars and limiting parking space availability.

Box 2 Sustainable Urban Mobility Planning: The Case of Oslo

A universal observation is that persons living in the urban periphery travel three times longer by motorized transport than those living near the city center, and a lot more if they travel by car. This explains much of the increased urban transport energy consumption observed worldwide.

The Oslo metropolitan area has 1.1 million inhabitants. Since the mid-1980s, Oslo has followed a deliberate policy of containing spatial expansion while supporting high economic growth. As a result, urban population density in greater Oslo grew significantly in the first decade of this millennium and increased by more than 11% within the municipality of Oslo.

The concentration of urban development in the Oslo metropolitan area has helped to reduce growth in overall motorized travel and particularly in car traffic. Through more compact urban development, which facilitated the financing of improvements in the public transport systems and the presence of a toll ring around the inner parts of the city, the municipality of Oslo managed to limit traffic growth to 25% during 1992–2005, compared with 34% for the country as a whole (where population growth was much lower than in Oslo).

As a result, Oslo received the European Sustainable City Award in 2003 in competition with 60 other European cities.

A policy of reserving land for specific development uses alongside public transport corridors has been implemented in various cities including Curitiba, Brazil; Hong Kong, China; and Singapore to enable the provision of low-income housing in transit-friendly locations (Hook and Wright 2002).

Karekezi, Majoro, and Johnson (2003) have estimated that benefits or savings from effective urban land use planning, combined with various traffic management schemes, can result in energy savings of 20%–30% for bus operators, together with other energy savings from reduced congestion (more smooth driving at higher speeds) and mode shifting to public transport and nonmotorized transport.

Experience from high-density urban areas in developing countries is more relevant for PRC cities. Urban densities in developed country cities is much lower, and experience from Swedish cities indicates that even if land uses are highly mixed, the population density and specialized employment patterns around a sprawling city are insufficient to reduce the share of work commuters going to other parts of the city to below 70%.

The cities of Curitiba, Copenhagen, and Singapore offer interesting examples for how major cities link urban transport with land use planning:

- **Curitiba**: Apply the concept of ribbon development and guide urban development along the transport axes. In the 1970s, the concept of ribbon development and the urban design model of development along axes were applied in the planning of Curitiba, Brazil. Through a series of planning controls for zoning land use and other stimulant measures, the city has developed outwardly along five axes.

- **Copenhagen**: Take measures that are suitable for local conditions and put forward the “Finger Plan.” Copenhagen has put forward the “Finger Plan,” which points out clearly that the city needs to be developed outwardly along several narrow roads, which are separated by development-restricted green areas, while retaining the function of the existing part of the city. The plan envisages that rail transport will be built prior to or simultaneously with the development of land along these roads.

- **Singapore**: Pay much attention to planning and coordination, and manage and control public transport development through different means. Since the late 1960s, Singapore has followed an approach to integrated planning of land use and transport. The development models of “group formation in cities” and “mixed development” have been effective in reducing the total amount of travel. Good overall city access and convenient transport services for the public are provided to begin with. By requiring land development to follow the legal planning procedures, the coordinated development of land use, transport, and environmental protection is guaranteed.
Urban Travel Demand Management

Travel demand management is the restraint of demand for travel to match the transport capacity available. It concerns trying to match demand to the level of traffic that is considered to be acceptable. Travel demand management policies include measures aimed at (i) increasing the average occupancy of vehicles, (ii) reorienting travel to off-peak periods, (iii) redirecting travel to less congested alternative routes, and (iv) reducing the total travel demand.

Road pricing

Using currently available information technologies that can be mass-produced at low cost, road pricing appears to be a most attractive policy instrument for internalizing the costly externalities caused by urban traffic congestion. It is a very flexible instrument that can be tailored to local circumstances in both space and time. Road pricing has been designed in several ways (road tolls, congestion pricing, cordon tolls, high-occupancy toll lanes, vehicle use fees, road space rationing, and various combinations of these). The common denominator is that it is based on usage: those who contribute more to congestion pay more, and those who use the roads less or at less congested times pay less. The travel impacts of road pricing depend on the type and magnitude of fees, where the fees are applied, what alternative routes and modes are available, and what is assumed to be the alternative.

The first and most prominent example of active road pricing was introduced in Singapore as congestion pricing for entering the central business district during peak hours with cars not fully occupied. Since 1998, this area licensing scheme has been electronically operated. During a 25-year period when population doubled and travel demand tripled, it reduced traffic volumes by more than 50% and almost doubled average traffic speeds and accessibility in the central business district. An important part of Singapore’s traffic restraint success was the simultaneous large-scale investment in high-quality citywide public transport coverage at affordable prices and a doubling of parking fees. Electronic road pricing is used to decrease traffic volume in the central business district by 7%–8% during morning peak and off-peak hours. In 2004, an average of 260,000 electronic road pricing transactions per day generated revenues of $55 million per year.

A congestion charge was introduced in central London in 2003, equivalent to $16 per day, for vehicles entering and traveling within this zone. The scheme is enforced by a network of automatic number plate recognition cameras that monitor vehicles entering and circulating within the charging zone. The scheme has reduced congestion by 30%, increased traffic speeds by 37%, and reduced the number of trips entering the zone by some 65,000–70,000 per day with very little adverse effect on the business activity in the zone. Traffic-related CO₂ emissions have been reduced by 17% and fuel consumption by 20%. The revenue generated is retained locally and used for improvements in the city’s public transport services.

Stockholm, Sweden, established a congestion charge zone in the inner city in early 2006, charging entering vehicles in the range of $1.27–$2.54 per trip. This has removed
100,000 vehicles per day during peak hours, increased public transit ridership by 40,000, and reduced the traffic volume by 25%. Political resistance was initially encountered, but the system has now become popular because of the multiple benefits experienced by the majority of the population (ADB and Department for International Development of the United Kingdom 2006, p.36).

Several years ago, road pricing was introduced in Seoul, Republic of Korea, on the heavily congested tunnels linking the southern part of the city to downtown. Except on Sundays and national holidays, a fee of $2.20 was charged for private cars with fewer than four persons on board. This reduced peak period traffic volume by 34% and average driving speed increased by 50%, from 20 kilometers per hour (kph) to 30 kph. Since the charge was limited to the two tunnels only, traffic increased by 15% on alternative routes. This pricing scheme was combined with improved intersection traffic signaling and increased enforcement of on-street parking rules on the alternative routes. Average travel speeds also went up on these streets.

Other cities also practice various forms of road pricing. In Canada and France, variable tolls have been used to reduce congestion on toll roads since the 1990s. In Norway, three cities—Bergen, Oslo, and Trondheim—have a road pricing cordon around the city. In Oslo, the entry charge does not change at different times of the day and therefore does not work as a congestion charge, but it still reduces car travel (a 5% reduction was observed after the introduction of the scheme in 1990) and diverts travelers to public transport and nonmotorized transport.
Non-toll alternatives to congestion pricing

There is still political resistance to congestion pricing in many cities. Sometimes, it is argued that the poor can ill-afford to pay the actual cost of travel during peak hours and therefore that congestion pricing is an anti-poor policy. As has been documented in studies in various cities, congestion pricing would actually affect very few poor people, socially captive households (e.g., parents who have to enter the congestion-priced area during rush hour to bring children to kindergarten). Travel surveys in European cities show that the number of these parents is so small that they could probably be identified and compensated by other means. One could achieve effective management of rush-hour traffic by, for example, introducing congestion pricing for cars carrying fewer than 3 or 4 persons.

Pay-as-you-drive insurance fees are a non-toll form of pricing being used by some insurance companies. When the insurance cost of a car is directly linked to each trip and its length, this affects decisions on where and when to travel by car.

Car sharing

Car sharing makes a fleet of vehicles available for use by members of a car-sharing group, with fleet management transferred to a central organizer. Users access the vehicles from shared-use lots such as transit stations, neighborhoods, or employment centers. This increases public transport ridership and decreases parking demand. In many cities where cars are expensive to own and operate and where individually owned cars would stand idle most of the time in expensive parking spots, car sharing is in use. Sharing the car ownership and operating costs has been possible as members have personalized cards that provide access to all cars wherever they are parked. From an efficiency perspective, one significant feature of car sharing is that it converts virtually all fixed vehicle ownership costs to usage-based fees. This makes it particularly attractive to low- and middle-income households.

Car sharing, launched in 1987 in Switzerland and later in 1988 in Germany, came to North America via Quebec City in 1993. As of 1 July 2008, 18 US car-sharing programs had 279,174 members sharing 5,838 vehicles, and 14 Canadian car-sharing programs had 39,664 members sharing 1,667 vehicles. Extensive travel surveying and matched pair analysis have shown that car sharing— independent of other factors—typically results in seven fewer vehicle-miles traveled (VMT) per day. VMT reductions from car sharing have been found to be even more dramatic in Switzerland, where car owners who sold their vehicles and became mobility car-sharing customers reduced their annual mileage driven by 72%.

Following encouraging experiences in Canada, Europe, and the US, Singapore introduced a car-sharing scheme and established such a company in 1997. Since then, three more privately initiated car-sharing companies have been established there. Based on the encouraging experience from Singapore, a car-sharing company called Kar Klub was established in Kuala Lumpur, Malaysia, on a small scale in 2006.

A co-benefit of car sharing is its contribution to reduced demand for parking space. Twenty households typically share each car-sharing vehicle, thus reducing parking costs
and the need to park around workplaces and residences. This has the double benefit of (i) reducing the need for setting aside costly central business district land and residential area land for parking spaces, and (ii) reducing the amount of travel (and resulting congestion) and associated fuel consumption when looking for parking spaces.

**Parking policies**

Parking policy is about the provision of parking spaces and the pricing of these spaces. Close enforcement of curbside parking rules can significantly enhance the carrying capacity of urban streets (such is the experience in Seoul, Republic of Korea), and removal of curbside parking can postpone or remove the need for costly widening of urban arteries. In industrialized countries, most cities include parking design requirements as part of building codes and residential area planning. One way of reducing car travel to the city center is to restrict the supply of parking spaces in commercial buildings. Parking charges can also be designed to fluctuate throughout the day in relation to variations in demand and length of parking period.

Effective parking policies should be seen as an integral part of proactive land use and transport planning. Implementing city ordinances that require one parking space unit per dwelling unit in apartment buildings increases construction costs per dwelling unit (typically around 20%) and also reduces housing density by as much as 30%, but it also decreases the possibility of on-street parking that causes narrowing of road space.

Parking pricing may take many forms, including employer-provided parking “cash-out” benefits and variable financing for on- and off-street parking. With parking cash-outs, employees may choose to receive a cash payment in lieu of any parking subsidy (e.g., free parking on company grounds), thus giving employees an incentive to find alternatives to driving to work alone during peak periods. In practice, this can be offered as the cash value of a monthly parking space in lieu of the space itself, or in the form of free vanpooling or transit cards, with the difference between the free parking value and the free transit being paid out in cash. Employees are free to decline the cash offer and keep the free parking space. Both employers and employees stand to benefit from such schemes, and they can enhance employers’ reputation in terms of corporate social responsibility. The potential congestion-reduction effects can be quite significant, as is evident from the experience of three US states:

- **California:** In eight case studies in Southern California, implementation of parking cash-out schemes among 1,700 employees led to an 11% reduction in commute trips and a 12% reduction in commute VMT.
- **Washington:** In Seattle, a similar arrangement yielded a 10% reduction in employee parking demand.
- **Minnesota:** In Minneapolis, a parking cash-out scheme led to an 11% shift to alternative commuting modes (i.e., away from drive-alone car use).

Variable pricing of off-street parking on public spaces is another complementary option worth considering. Monthly fixed-price parking subscriptions encourage usage of the rented space, since the variable cost is close to zero once the ticket has been paid for.
It is better if parking spaces can be rented only at the time of use and on an hourly basis. To discourage private car use in congested areas, it is useful to have variable hourly off-street parking fees, with maximum fees for arrival during peak hours and much lower charges during off-peak periods. This has been successfully practiced in Oslo, Norway. Considering the political obstacles in many cities to introducing congestion pricing for driving, such flexible pricing of metered parking spaces (both on- and off-street) can, to a certain extent, represent a more palatable substitute for congestion pricing.

A crucial component of parking supply restrictions is consistent enforcement. Such restrictions should apply not only to private cars, but to corporate and government cars as well. Their contribution to congestion and GHG emissions are the same regardless of ownership. If certain trips are considered more vital than others, then the willingness to pay to travel is also higher. Parking spaces in public and commercial areas in the central business district (open or underneath buildings) should be regulated and charged based on the expected contribution to congestion and overall GHG emissions of the car trips they generate.

**Car-free days**

Car-free days have been implemented in a number of cities around the world to reduce car use in congested areas. The most common approach has been to ban cars from travel on certain weekdays based on the last digit on their license plate. In other cases, on car-free days no private vehicles are allowed to enter or circulate within the urban area (cities that have used such practices include Athens, Bogota, Lagos, Manila, Mexico City, Santiago, Sao Paulo, and Seoul). In Bogota, the first car-free day was implemented in 2000. It banned private cars from traveling within the urban area between 6:30 a.m. and 7:30 p.m., and led to a 20% improvement in speeds. Several million people had to travel by public transport, bicycles, and other forms of nonmotorized transport. Since then, car-free days have been used to promote the city’s bicycle and bus network. The short-term benefits are similar to road pricing schemes: reduced congestion and faster average speeds, leading to reduced fuel consumption and lower GHG emissions.

However, such schemes are less efficient than road pricing for reducing GHG emissions because

- some people will be encouraged to buy a second car with a different number plate;
- some people will retain an older “gas guzzler” as a second car instead of trading it in for a new energy-efficient one; and
- in some cases, if effective inspections and controls are not in place, some people may try to circumvent the restriction by getting fake license plates and changing them from day to day.

In some EU countries, low-emission zones have been introduced in some cities. In these zones, vehicles or classes of vehicles that cannot meet a prescribed standard of emissions are prohibited entry. Invoking of such measures may be linked to observed levels of certain air pollutants (these can vary in certain cities for climatic and topographic
reasons), or the low-emission zone system may be permanent. Some cities ban trucks at certain times of the day. In Germany, this now applies to older vehicles that do not meet current emission standards. Owners of such vehicles must trade them in for new ones that meet the standards or switch to public transport. However, low-emission zones are rather costly and demanding in terms of monitoring and enforcement, both in terms of staff and technological equipment.

**Traffic management**

Traffic management measures include sophisticated traffic signal systems (area traffic control systems) to secure steady traffic flows. This can significantly increase the carrying capacities per lane of the affected streets, and thus reduce congestion and increase speed. This will in itself reduce fuel use and GHG emissions for existing traffic, even if car volumes are not reduced. However, it also makes car use more attractive, so that car use increases. The net GHG emission effect may, therefore, be small, perhaps even negative. In Organisation for Economic Co-operation and Development countries, such systems have led to 2%–5% emission reductions overall. In cities in developing countries, where the initial (baseline) situation is much worse, the potential GHG savings could be much higher. If combined with travel demand management measures and parking supply restrictions, the overall GHG-reduction effects could be very substantial and significant planned road infrastructure investments could be postponed or avoided.

**Planning for and Promoting Attractive Public Transport**

Several countries have promoted the use of public transport to be able to attract users. Some examples of measures adopted by different countries are as follows:

- **France:** Attach importance to connection, transfer, and service quality. As early as the 1970s, the Government of France gave priority to the development of public transport. The city government of Paris has adopted many appropriate measures, such as constructing a “model transformation center.” The center improves the condition of public transport facilities by improving space design in stations or hubs, making efficient time schedules, developing interconnectivity of subway operations with other public transport services, and promoting integrated ticketing to raise the utilization rate of public transport.

- **Germany:** Use joint operation mechanism for regional public transport. In Germany, operation of public transport is jointly managed by the public and private sectors. Intra-city travel in German cities is usually connected by trams, light rail, and buses. The light rail system is owned by a public transport company, while buses may belong to different operators, usually privately held or owned, based on routes. Public transport services are seamlessly operated in cooperation with the private sector.

- **Singapore:** Adopt measures of three-dimensional transferring and multimodal coordinated transport. Door-to-door transport and seamless connection services have been promoted strongly in Singapore. By introducing comprehensive transfer centers, coordinated multimodal transport, and efficient ticket-price management, the government was able to closely connect work, shopping, and
other activities through the public transport system. This contributes to efficient public transport use, and walking to various locations is encouraged as transfer distances between different means of transport are shortened.

In recent years, several Asian cities have put into place various forms of rail-based public transport systems. Bangkok, Manila, and Shanghai have installed light rail systems, while several PRC cities and Delhi have invested in metro systems. While such rail-based systems tend to have a high public profile, they cater to a rather modest share of overall urban trips (usually less than 10%) while requiring large subsidies due to the extremely high investment cost.

**Tram System in Vienna, Austria**

*Bur rapid transit*

The trend in many cities worldwide is toward bus rapid transit (BRT) systems that offer low investment cost and low operating cost. These systems have the flexibility to respond to the preferences of urban commuters and usually consist of high-capacity buses (most often articulated) operating in exclusive bus lanes, with rapid loading and unloading of passengers at stations that provide level boarding platforms, electronic fare pre-payment, and obstacle-free waiting areas, and have access to feeder services. Such systems include centralized, coordinated fleet control, which provides monitoring and communications to schedule services and respond to problems that arise along the routes. When investing in such systems, city authorities usually carry out traffic flow improvements at the same time, including bus priority traffic lights, enforced elimination of left turns, continuity given to right turns, and improved signposting.

BRT seeks to combine the high capacity, high frequency, and punctuality and smooth travel advantages of a metro system with the low costs and flexibility of a bus system. Compared with a standard bus service, BRT systems, with dedicated right-of-way, can provide many more passenger miles without increasing rolling stock and personnel.
BRT systems are often organized as public–private partnerships. Their low investment and operating costs have proven conducive to public–private operations. The best-performing BRTs, such as those in Bogota and Guangzhou, have been observed to match the carrying capacities of metros (36,000 people per peak hour per direction on a two-lane per direction corridor in Bogota).

Innovative Operating Models for Urban Public Transport

Several models for operating public transport are being used by different cities. Some urban public transport are managed and operated by the state, others are wholly private. Some examples of operating models applied in the different cities that have been proven to be effective are discussed.

- **Chicago: Model of unified management and operation.** The urban public transport system of Chicago, which includes subways and buses, is independently managed and operated by the Chicago Transit Authority. It is in charge of all station facilities, routes, vehicles, drivers, and conductors. The revenue and expenditure budget for infrastructure investment and operation of public transport is annually submitted by the Chicago Transit Authority to the local authority for approval.

- **Curitiba: Separation between management and operation of public transport.** The model of separation between management and operation of public transport has been adopted in Curitiba, Brazil. The whole system is managed by an urban public transport company (URBS), which is administered by the city government, with private bus operating enterprises affiliated with it. The latter obtain licenses for bus operation through competitive bidding. Their ticket earnings must be deposited in the specialized account of URBS, which controls the mileage of those enterprises and provides subsidies for them according to their completion of mileage.

- **Seoul: Operation through bidding and distribution based on the mileage.** The department responsible for public transport in Seoul publishes a plan for the urban transport system and the associated estimated operating cost. Enterprises sign a standard operation agreement after independent consultations. After negotiations between the enterprises and the department, a specific plan is worked out, submitted to the government for approval, and then implemented. As for the operation of routes, the operational rights of established enterprises for some routes are considered and respected, while enterprises for new routes are chosen by means of competitive bidding. The distribution of earnings is determined by the respective mileage of the operators. In addition, the government examines and evaluates the service and the operation of different enterprises, and then provides subsidies to enterprises based on predetermined criteria.

Measures to Promote Nonmotorized Transport

The volume of nonmotorized transport depends very much on the topography and climatic situation in the urban area concerned. In cities where both climate and
topography are favorable, there are a number of steps that the urban authorities can take to make nonmotorized vehicles more competitive in relation to cars, motorcycles, and public transport. Inconvenience and safety (including fear of theft of bicycle) are key obstacles that affect people’s decision to use nonmotorized transport.

Denmark and the Netherlands have pioneered bicycle use. Both countries are topographically well-suited for bicycling, and densely populated. Both have created comprehensive, continuous cycle networks that feature separate cycle lanes or safe integration with other modes of transport, and have provided easy access to the cycle networks. Employers and schools have provided the kind of end-stop facilities needed by bicycle users (e.g. lockers, bicycle racks, showers).

Progress in the promotion of bike use in some developing countries is also of interest in this context. In Bogota, Colombia, over a 3-year period at the end of the 1990s, 330 kilometers of fully grade-separated bicycle lanes were built, coupled with bicycling promotion programs. As a result, bike use increased from 0.6% to 4.0% of all trips.

**Impacts of Coordinated Urban Transport Measures on Greenhouse Gas Reduction**

Urban authorities in Bogota, Columbia, implemented a coordinated and integrated urban transport plan, focusing on a 22-corridor BRT system, which was the most cost-effective and attractive public transport option. This integrated plan included 200 kilometers of bike lanes and 17 kilometers of shaded pedestrian lanes as the preferred nonmotorized transport system to be integrated with the BRT. It also provided a number of travel demand management measures (including a “car-free day” system, which restricted 35% of the vehicle fleet), doubling of parking fees, a 20% increase in gasoline prices, and physical measures to prevent illegal parking on the sidewalks. Because of these measures, over a 4-year period, the percentage of private car and taxi trips decreased from 19.7% to 17.5%. Public transit passenger trips increased from 67% to 68%, and bicycle trips rose from 3.5% to 4.0%. The implementation of the combined measures is estimated to have reduced CO₂ emissions by 318 tons per day from 1997 and grown rapidly year by year. Some 90% of these savings can be attributed to mode shift and 10% from efficiency gains within the public transit system.

**Urban Transport Policy Experience in the People’s Republic of China**

**Regulatory Framework for Climate Change**

Like most countries around the world, the PRC has been giving more emphasis to climate change and energy-saving issues in recent years. A number of national strategies, laws, policies, and programs aimed at saving energy and combating climate change were launched during the past 10 years. In the PRC’s 11th Five-Year Plan (2005–2010),
a very ambitious target was set to reduce energy consumption per unit of GDP by 20% by the end of 2010. The 12th Five-Year Plan (2011–2015) proposed that CO₂ emissions per unit of GDP is further reduced by 17% while energy consumption per unit of GDP is to be cut by 16%. To achieve these targets, the National Development and Reform Commission selected 1,000 energy-intensive enterprises for its “Top 1,000 Enterprises Energy Efficiency Program” (Yun 2007). Unfortunately, this program does not cover transport, even though energy consumption by the transport sector accounts for at least 6% of the PRC’s total energy consumption and is growing at 6%–9% (World Bank 2007). However, energy efficiency in the transport sector is being supported by the PRC’s National Climate Change Program (NDRC 2007), Energy Conservation Law (effected since 1 April 2008), and various Ministry of Transport (MOT) policies, including through use of vehicle tax, clean vehicle technology, public awareness, public transport, standards, eco-management, alternative fuels, etc.

Overview of Low-Carbon Urban Transport Initiatives in PRC Cities

The available practices and associated policy reform instruments for supporting low-carbon urban transport in the PRC may be divided into five categories:

- regulatory instruments
- economic instruments
- planning instruments
- information instruments
- technological instruments

These are discussed below and summarized in Tables 6–9.

In addressing the impacts of climate change through sustainable transport instruments, it is important to recognize that cities are also able to benefit from a range of co-benefits, including improved air quality, reduced noise from traffic, increased road safety, and other social and economic benefits.

Regulatory instruments

Car-free development

Car-free development can encompass a range of restrictions on motor vehicle use. Several cities in the PRC have implemented car-free days. Since June 2004, the rapidly developing city of Shenzhen has held its own “Green Action Day” on World Environment Day. In 2005, this car-free day resulted in an estimated 100,000 Shenzhen residents giving up their cars for the weekday commute. In Beijing, car-free days based on plate numbers were introduced in October 2008. Cars with plates ending with a particular number cannot travel within the 5th Ring Road on designated weekdays. The ban applies from 6:00 a.m. to 9:00 p.m. for private and government cars. Violators are liable for a CNY100 ($15.29) fine. After introduction of this regulation in the spring of 2009, China Daily reported that the average vehicle speed rose by 10% to 43 kph.
Many cities, particularly Shanghai and Beijing, have established car-free zones and streets in shopping and historical areas. On Nanjing Road in Shanghai, all motorized vehicles except trams are banned, and pedestrian flows are among the highest in the world (GTZ 2005).

**Emission restrictions and labeling**

In 2001, Beijing introduced an environmental labeling system for vehicles. High-emission vehicles that are below EURO I standard are identified with yellow labels, while green labels are provided to newer vehicles with more updated emission systems. High-emission vehicles are being slowly phased out and limited from entering the city center. On 1 March 2008, Beijing initiated a new EURO IV standard, 2 years ahead of schedule, specifically for the Olympics. Beijing was the first city to implement this stringent standard. The EURO IV standard is the fourth stage of emission and testing standards for vehicle emissions including hydrocarbon, nitrogen oxides, carbon monoxide, and particulate matter. These standards are among the most rigorous in the world for new vehicles. As a result, Beijing’s new standard is more stringent than in Australia, Canada, and the US. According to the Beijing Environmental Protection Bureau, the change from EURO III in 2005 to EURO IV in 2008 will reduce vehicle emissions by 50%. In 2009, Europe switched to a new EURO V standard. Beijing is

<table>
<thead>
<tr>
<th>Car-Free Development</th>
<th>Emission Restriction and Labeling</th>
<th>Vehicle Quota System</th>
<th>Parking and Idling Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cities</td>
<td>Beijing, Shanghai, Shenzhen</td>
<td>Beijing, Shanghai</td>
<td>Shanghai</td>
</tr>
<tr>
<td>Measures</td>
<td>Car-free campaign; regular car-free day by license plate; permanent car-free zone</td>
<td>Tight schedule for updating vehicle emission standards</td>
<td>Vehicle quota system and license plate auction in Shanghai</td>
</tr>
<tr>
<td>Co-benefits</td>
<td>Less traffic in peak hours; less congestion; less emissions and energy use</td>
<td>More fuel efficiency; less CO₂ and other emissions; enhanced eco-vehicle demand and technical innovation</td>
<td>Limitation of vehicle population and reduce vehicle use</td>
</tr>
<tr>
<td>Disadvantages</td>
<td>Not convenient for car users, may not be sustainable. Ineffective use of vehicles compared with incentive-based total demand management</td>
<td>More costly vehicles; takes time to have full impact</td>
<td>Subject to leakages because some vehicle owners register their cars outside to save registration fees, and then use the cars in Shanghai</td>
</tr>
</tbody>
</table>

Source: Authors.
also planning to upgrade to EURO V in 2012. This will be about 2 years ahead of most other PRC cities.

**Vehicle quota system**
To relieve urban traffic flow congestion by limiting new vehicle population, Shanghai has used a vehicle quota system since 2000. The quota of new vehicle plates is traded annually in an auction system. The vehicle plate quota has increased more than five times from 2000 to 2007, while the dealing price rose from CNY14,000 to nearly CNY50,000 regardless of vehicle price, type, and fuel efficiency. Initially, there were concerns that many residents were circumventing the system by registering their vehicles in neighboring jurisdictions. However, Chen and Zhang (2011) suggest that the system has been successful in reducing car ownership demand in Shanghai. Chen and Zhao (2011) indicate that the effectiveness of the system improved after measures including license plate recognition technology were introduced to restrict use of vehicles registered in their jurisdictions. They also mention that this policy has raised substantial revenue that has been used to improve public transport, which has helped ensure public acceptance.

**Parking and idling regulations**
Many PRC cities, particularly the more advanced ones, have sophisticated parking and idling restrictions. These restrictions are often implemented alongside parking pricing measures. The fine for illegal parking in most PRC cities, such as Beijing, Hangzhou, and Shanghai, is around CNY200 ($30.58). In Zhuhai, drivers who leave their vehicles idling in residential areas and hospitals are also liable to be fined.

**Economic instruments**

**Fuel taxation**
Fuel tax increases the price of traveling and thus has an indirect effect on individual travel behavior and decisions (GTZ 2007). It provides an incentive for drivers to reduce their VMT, and therefore can contribute to fuel savings and, as a direct result, the mitigation of GHG emissions. The fuel tax revenues can be used to pay for the cost of providing and maintaining infrastructure. Fuel tax is not, however, an effective instrument for addressing the issue of congestion as it cannot be varied to the extent of congestion.

Hainan province has implemented a local fuel tax since January 1994. Although the fuel tax has provided a significant source of revenue, Hainan’s case cannot be considered a “good practice” of fuel taxation. The primary aim of Hainan’s fuel tax reform was to replace the road and bridge tolls, maintenance fees, and road transport management fees with the fuel tax to reduce revenue collection cost and ensure stability of revenues. The tax rate is not set for the purpose of addressing environmental and climate change concerns. There is little evidence to suggest that the fuel tax in Hainan helped to reduce car use, fuel consumption, or emissions.

**Incentives to stimulate hybrid, electric, and fuel-cell cars in several cities**
The PRC is providing policy incentives to speed up the spread of energy-saving cars in 13 pilot cities (Xinhua News, 2 February 2009). The Ministry of Finance and the

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Ministry of Science and Technology jointly issued a circular on providing subsidies to users of hybrid, electric, and fuel-cell cars in Beijing, Shanghai, and 11 other major cities. Public transport, taxi companies, postal services, and public offices were encouraged to use more energy-saving vehicles. The government promised to assist companies and institutions that purchase and use such vehicles by providing lump sum subsidies to offset the extra purchase cost of fuel-efficient cars. Under a trial scheme for public transport operators, taxi firms and postal and sanitary services in cities such as Beijing and Shanghai are to receive rebates of CNY28,000 ($4,268) to CNY250,000 ($38,109) for green vehicles, including electric, hybrid, and fuel-cell vehicles.

The central government has encouraged local governments to subsidize the development and introduction of energy-friendly cars. Buyers of hybrid cars in the southwestern city of Chongqing are to receive a CNY43,000 ($6,500) subsidy from the local government. This applies to the Jiexun brand of hybrid sedan made by Chongqing Changan Automobile Company. In late 2008, the Chongqing government ordered 10 Jiexuns from Changan and set a target to increase the number of hybrid vehicles in the city’s public sector to 1,000 units in 3 years. The vehicle price is CNY140,000 ($21,341).

Table 7  City-Level Good Practice in the People’s Republic of China: Economic Instruments

<table>
<thead>
<tr>
<th>Cities</th>
<th>Fuel Taxation</th>
<th>Eco-Vehicle Incentive</th>
<th>Parking Pricing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hainan</td>
<td>Many cities</td>
<td>New energy vehicle</td>
<td>Variable charges for different times and locations; develop parking charge system using I-Pass card</td>
</tr>
<tr>
<td>Change road financing from toll and fees to fuel tax</td>
<td>(hybrid, electric, fuel-cell buses, and taxis) demonstration programs; central and local subsidies for e-vehicle charging station construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Many cities</td>
<td>Large fossil fuel savings compared with all alternatives; less pollution and less CO₂</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less congestion and emissions</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors.
The most effective of all available car-focused policy measures to optimize congestion and emissions reductions in large cities is congestion pricing. However, it will only be effective when planned and implemented with major upgrading of accessibility for commuters via public transport. At present, there is no example of congestion pricing in the PRC, although several of the most congested cities are understood to be considering introduction of congestion pricing in the future.

**Planning instruments**

**Planning for bus rapid transit**

Kunming launched the first modern busway in the PRC in 1999 with technical support through the Kunming–Zurich Sister City Partnership. A public transport master plan was also developed with Swiss assistance. The average operating speed increased 68% to 15 kph while the average passenger waiting time decreased by 59%. Bus ridership increased 13% at its opening because of the improved service. Due to the improved operating speeds, the operating company was also able to reduce its fleet size by nearly half.

Kunming currently has a 40-kilometer network of six median-based BRT lines. These follow an open system with few physical barriers for most of the alignment. Services are provided by several private operators. The network carries 1.2 million passengers per day and serves about 75% of the city center within a reasonable walking distance. The capital cost has an average of only around $0.5 million–$0.8 million per mile as few advanced BRT features have been included.

**Bus Rapid Transit in Guangzhou, PRC**

Source: Institute for Transportation and Development Policy, People’s Republic of China.
Kunming transportation officials are incrementally implementing other BRT features to maximize the benefits of the existing busway network, and are planning to expand the network beyond the city center and into the suburbs. The facilities will be progressively upgraded and modernized with more use of passenger information displays at stations and intelligent transportation systems.

A dedicated BRT system opened in Guangzhou in February 2010, which has a bus ridership of about 805,000 passenger trips per day. The average peak hour speed is 18 kph, which is comparable to other BRT systems. The capital cost is about CNY30 million ($4.4 million) per kilometer, which is cheaper than the Bogota BRT.

The Guangzhou BRT has a 22.5-kilometer dedicated busway located at the center of the roadway. It has an advanced design that includes real-time next bus information displays and pre-board fare collection systems using smart card technology. Buses are propelled by LPG, which emits significantly less pollutants compared with diesel-fueled buses. Because of the success of this system, which garnered the Institute for Transportation and Development Policy world award as the “Best Sustainable Transport Project,” it is being extended to cater to other areas not yet reached by the current system.

**Planning for nonmotorized transport**

Walking and cycling are essential in any successful sustainable urban transport strategy as they do not produce any direct emissions. As emissions from motorized transport are highest at cold start of the engine, short trips are disproportionately polluting. These shorter trips are most suitable for nonmotorized modes.

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Transport authorities face difficulties when trying to encourage people to shift their transport mode to cycling and walking, as these are often perceived as unattractive alternatives to motorized transport, primarily due to inconvenience and safety concerns in developing country cities (World Bank 2007). Lack of protection from the weather, the topography in some cities and countries, the health and physical fitness of the intended cyclist, and personal security concerns (e.g., fear of bicycle theft) add to the perceived unattractiveness of walking and cycling.

A number of improvements can be made to encourage cycling and walking. These include the creation of continuous cycle networks, possibly featuring separate cycle lanes or integrated with other transport modes. Employers and educational

### Table 8 City-Level Good Practice in the People’s Republic of China: Planning Instruments

<table>
<thead>
<tr>
<th></th>
<th>Bus Rapid Transit</th>
<th>Paratransit, Walking</th>
<th>Nonmotorized Transport</th>
<th>E-Bike</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cities</strong></td>
<td>Kunming</td>
<td>Many cities</td>
<td>Many cities</td>
<td>Many cities</td>
</tr>
<tr>
<td><strong>Measures</strong></td>
<td>Public–private partnerships for bus rapid transit</td>
<td>Nonmotorized transport network planning</td>
<td>Dedicated infrastructure (e.g., bike lanes) and facilities for cycling, walking, and other modes of nonmotorized transport</td>
<td>Low-cost, fast, and door to door; access to use bicycle lanes and bicycle parking facilities</td>
</tr>
<tr>
<td><strong>Co-benefits</strong></td>
<td>Attractive alternative to car and taxi use; efficient use of bus fleets; faster and more reliable service; less CO₂; lower investment cost</td>
<td>Shift to non-CO₂ modes; health benefits for public</td>
<td>No CO₂; less noise</td>
<td>Large fuel and time savings compared with alternatives</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td>May attract users of nonmotorized transport and e-bikes</td>
<td>Slow; need for high level of public awareness</td>
<td>Less convenient for longer distances</td>
<td>Poor control over unauthorized producers of illegal high-speed e-bikes; poor control over recycling and safe disposal of lead batteries; rampant use of illegal e-bikes by users of nonmotorized transport and public transport</td>
</tr>
</tbody>
</table>

Source: Authors.
institutions also have a role to play in encouraging walking and cycling, for example, by providing facilities such as lockers (for storing cycling/walking equipment), bicycle racks, and showers. A key instrument for encouraging a mode shift to walking and cycling is the use of awareness campaigns and information, which may also include the development of cycling and walking routes and maps (Sloman 2003, Hook and Wright 2002).

**Information instruments**

**Eco-driving training and campaign**

Eco-driving is not a new concept for PRC cities. Similar to most developed countries, the PRC has been promoting and implementing eco-driving practices in many cities. Most eco-driving training and campaigns are conducted by the private sector under the supervision of local or central governments. Eco-driving was identified as one of the most important good practices under MOT’s Demonstration Campaign of Energy-saving Projects in the Transport Sector (Phase I in 2007, Phase II in 2008, Phase III in 2009). During the campaign, MOT selected Anhui Hefei Vehicle Passenger Transport Company, Fujian Automobile Transport Company, and Zhenjiang Road Transport Association as the eco-driving champions to demonstrate eco-driving co-benefits, skills, and fuel-saving knowledge. As reported by the bus company in the city of Hefei, adoption of eco-driving has produced a 4% fuel savings since 2006, equivalent to about CNY5 million ($762,195) per year.

On 7 July 2009, Zhengzhou Yutong Bus Company launched a nationwide eco-driving campaign called Yutong Cup Eco-driving Championship. This is supported by the Henan Transport Department. Two hundred bus companies in 15 provinces attended the first round of the championship. The best performer recorded a 39% fuel saving (with fuel efficiency of 15.15 liters per 100 km) by applying eco-driving skills. An eco-driving handbook was also issued by the Yutong Bus Company and disseminated among participating bus companies, drivers, and other stakeholders. Similar to other eco-driving handbooks, this handbook discusses fuel saving concepts and eco-driving skills. The good practices in the handbook were shared during the championship, which also enhanced the image of bus companies in terms of social and environmental responsibility.

**Public awareness campaign**

The national Energy Conservation Awareness Week is one of the most influential public awareness campaigns conducted by most PRC cities. It was initiated by the government in 1999 to continuously enhance public awareness of resources, energy, and environmental conservation. During the 2009 Energy Conservation Awareness Week, MOT launched Phase III of the Demonstration Campaign of Energy-saving Projects in the Transport Sector and disseminated a free eco-driving handbook to the public. Many cities have also conducted “car-free day” campaigns to promote public transport, cycling, and walking.

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3 All competitors used the same bus model (Yutong ZK6127H, 12 meters long). Without eco-driving, this bus has an average fuel efficiency of 25 liters per 100 kilometers (Yutong statistics 2009).
Car-sharing awareness

On 26 February 2009, Hangzhou’s traffic administration department launched a pilot program to encourage residents to carpool when traveling in the city. This made Hangzhou the first city to encourage residents to carpool.

Table 9  City-Level Good Practice in the People’s Republic of China: Information Instruments

<table>
<thead>
<tr>
<th>Eco-Driving</th>
<th>Public Awareness Campaign</th>
<th>Car-Sharing Awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cities</td>
<td>Many cities</td>
<td>Many cities</td>
</tr>
<tr>
<td>Measures</td>
<td>Training combined with championship, funded by enterprise, supported by city government</td>
<td>Campaign for various energy-saving activities</td>
</tr>
<tr>
<td>Co-benefits</td>
<td>Knowledge sharing, fuel/emission reduction</td>
<td>Knowledge sharing, fuel/emission reduction</td>
</tr>
<tr>
<td>Disadvantages</td>
<td>Major gains only over longer term</td>
<td>Major gains only over longer term</td>
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Source: Authors.

Technological instruments

E-bikes

E-bikes that comply with standards are characterized by low energy consumption, low pollution, low costs, and low accident rates, combined with high mobility and high operating efficiency (Weinert, Ma, and Cherry 2007). Unlike conventional bicycles, e-bikes are attractive for use in both flat and hilly cities.

With retail prices of CNY1,000–CNY2,500 (about $152–$381) and no extra fees or charges, e-bikes have become very popular with low- and middle-income families. E-bike users can save 50% on door-to-door journey time compared with using bus transport and 30% compared with bicycle travel.

E-bikes are designed to run 30–50 kilometers on a single charge. At current fuel prices and average energy use, e-bikes cost CNY0.8 per 100 kilometers ($0.12 per 100 kilometers) compared with CNY12 ($1.83) for a motorcycle and CNY40 ($6.10) for a car. For a 15-kilometer trip, direct GHG emissions from use of an e-bike are close to zero, compared with 0.2 kilograms per person for a bus with 40 passengers and 1.1 kilograms per person for a car with 4 occupants.

In 1999, Shanghai started to promote e-bike use within the city. As of 2006, the only two-wheeled vehicles allowed to operate were liquefied petroleum gas (LPG) scooters, e-bikes, and bicycles. These rules are enforced effectively in Shanghai (Weinert, Ma, and
E-Bike in the People’s Republic of China

Cherry 2007). Figure 11 shows the effect of this regulation on e-bike growth relative to other two-wheeled vehicles in recent years in Shanghai. One reason for such a high proportion of LPG scooters in Shanghai is that in 1998, the taxi fleet switched to LPG, and thus an extensive fueling infrastructure was developed throughout the city. After the rapid growth of e-bikes from 2002 to 2004, Shanghai’s e-bike population reached 1.35 million in 2006, the highest ownership level of any city in the PRC. Chengdu is also promoting e-bikes extensively. In Chengdu, where gasoline scooters are also banned, e-bike mode share has surpassed that of bikes.

The attractiveness of e-bikes is further enhanced by their contribution to high road and bicycle lane capacity utilization, since on a per-passenger basis e-bikes require half the road space that cars require. In addition, e-bikes have an impressive traffic safety record by PRC standards. Feng, Jiang, and Chen (2007) found that in Ningbo the accident fatality rate per 10,000 cars was 8.31 persons, but it was only 1.3 for e-bikes.4 In the same study of 18 PRC cities that permit e-bike use, they found that e-bikes not only supplement the public transport system, but have quickly captured the largest trip share among the competing modes for various trip purposes, including commuting, shopping, sending children to school, and social visits.

4 It is common practice in the PRC to present traffic safety statistics in numbers per 10,000 vehicles instead of per 10,000 vehicle-kilometers.
Some concerns about e-bikes: From a health and exercise perspective, one may note that e-bikes tend to replace walking or riding a conventional bicycle. Very few car users switch to e-bikes at current car taxes, parking charges, and fuel prices.

Considering the current and future e-bike users, the growing use of e-bikes is unlikely to reduce urban traffic congestion in PRC cities unless the costs of using cars for commuting is drastically increased through increased fuel prices, increased private and public parking costs, and congestion pricing.

From a pollution perspective, there are several issues. While the direct emissions per person-kilometer from e-bikes are very low, they use electricity, and therefore contribute to increased electricity consumption and thereby generate increased CO$_2$ emissions and locally polluting sulfur dioxide emissions from coal-fired power plants. When estimating the net CO$_2$ emissions impact on a citywide or national scale, one has to take into account that much of the increased use of e-bikes rely on people who previously used bicycles and walking. On the other hand, the convenience and low user costs of the e-bike in congested cities are likely to make many urban commuters postpone the purchase of their first car. Since the CO$_2$ emissions per person-kilometer of an e-bike are only 2% of the emissions of an average car, the CO$_2$ reduction effects of such postponed car purchases should not be ignored.

While net CO$_2$ emissions affect the global climate situation, the local pollution from coal-based power production to supply electricity for e-bikes will vary significantly between cities, depending on their source of power supply (coal, hydropower, wind power, etc.), city topography, and the level of local pollution prior to increased use of e-bikes.

A significant environmental reservation associated with e-bikes is lead pollution associated with the production, recycling, and disposal processes for batteries over
the life cycle of the e-bike. ADB (2009a) notes that lead emissions per passenger-kilometer are higher for e-bikes than for buses because the latter get many more passenger-kilometers from each (much heavier) battery they use. The growth in e-bike use is therefore contributing to rising lead pollution. This includes pollution from lead mining and battery disposal along with harmful leakages due to unregulated informal sector recycling and smelting of lead batteries. Legislation is currently being drafted in the PRC to strictly regulate the size and environmental performance of the battery production industry. The PRC should draw upon the many examples of successful battery recycling schemes in industrialized countries. They tend to include taxation, deposit refund, and purchase discounts.

Lead batteries are currently attractive for price reasons. Technological alternatives are commercially available (nickel–metal hydride and lithium ion batteries), but currently only at much higher (typically quadruple) prices. As these new battery technologies continue to improve, the price difference will narrow. Today, the more costly batteries have lower weight, higher energy densities, and two to three times the life span of a lead battery.

While these other types of batteries also contain chemicals and metals that must be disposed of, they can offer preferable options to lead batteries. The introduction of such new batteries could be accelerated if the producers and sellers were to provide purchase credits on more favorable terms to low- and middle-income buyers. City authorities should consider active engagement with e-bike producers and sellers to speed up this transition.
Climate Change Funds for Urban Transport

Over the past 2 years, more than 16 international funds and mechanisms have been established to support climate change mitigation and adaptation. This proliferation of funds is unprecedented, but there are considerable shortcomings in the implementation arrangements and effectiveness of the funds, particularly for developing countries trying to access the funds. Most funds have not clarified their relationship with the United Nations Framework Convention on Climate Change (UNFCCC), referring only to vague commitments to work to support the goals of the convention. Today, only a few funds and other mechanisms work directly under the auspices of the UNFCCC. These include the Clean Development Mechanism (CDM), which is an arrangement under the Kyoto Protocol, and the Global Environment Facility, which was established at the United Nations Conference on Environment and Development in 1992 as the funding mechanism for implementation of projects under global environmental agreements.

The Clean Development Mechanism

An industrialized country that wishes to utilize credits from a CDM project in a developing country must obtain the consent of the developing country. Using methodologies approved by the CDM executive board, the applicant (the industrialized country) must make the case that the carbon project would not have happened otherwise (additionality) and must establish a baseline estimating the future emissions in the absence of the project. The case is then validated by a third-party agency, called a designated operational entity (DOE), to ensure the project results in real, measurable, and long-term emission reductions. Next, the executive board decides whether or not to register (approve) the project. If a project is registered and implemented, the executive board issues credits, called Certified Emission Reductions (commonly known as carbon credits), where each unit is equivalent to the reduction of one metric ton of CO₂ or its equivalent, to the project participants. These are based on the monitored difference between the baseline and the actual emissions, verified by the DOE.

In principle, any transport sector investment in a CDM-eligible developing country would be a potential candidate for the CDM if it meets both of the following conditions:
• it results in reduced GHG emissions over the project lifetime; and
• it is not financially viable, so that it would not be undertaken unless external funding in some form (e.g., CDM) is provided.

By 1 March 2009, 4,000 projects had pending CDM approval and registration, and 1,431 projects had been registered by the CDM executive board as CDM projects. These were almost entirely energy sector projects. Only one of the many submitted urban transport projects had been approved. The rest had either been rejected or were still pending DOE approval.

The Clean Development Mechanism and Urban Transport Projects

The bus rapid transit (BRT) methodology developed by Grutter Consulting in 2007 is so far the only UNFCCC-approved large-scale CDM transport sector methodology. It was modeled on the TransMilenio project, which details a step-by-step baseline methodology for BRT projects. The methodology is applicable to project activities that reduce emissions through the construction and operation of a BRT system for urban road-based transport and can also be applied to extensions or expansions of existing BRT systems.

Clean Development Mechanism Financing of Urban Transport Projects in the People’s Republic of China

The PRC is by far the largest source of registered carbon credits under the CDM, accounting for more than 48% of those generated globally as of February 2008. It has been enterprising in developing CDM projects and provides a relatively low-risk investment environment compared with many other developing countries. In recent years, the PRC has been eager to use the CDM in facilitating its own sustainable development and is willing to contribute to GHG emissions reduction by joining CDM programs. The PRC has had several hundred CDM cooperation projects successfully registered with the United Nations. These are expected to reduce CO₂ emissions by 113 million tons annually. CDM projects have boosted the development of renewable energy, accelerated the improvement of energy intensity, and enhanced awareness of the seriousness of climate change on the part of relevant government departments, enterprises, organizations, and individuals.

BRT systems have been established in many PRC cities, including Beijing, Changzhou, Chongqing, Dalian, Hangzhou, Jinan, Kunming, Shijiazhuang, and Xiamen. Chongqing has been planning to register its project with the CDM and trade its carbon credits in the global market. The additionality aspect of the CDM is difficult to justify in a
Climate Change Funds for Urban Transport

Chinese BRT system because in many large cities, demand could easily exceed 20,000 passengers per direction per hour during peak periods. Indeed, Hook and Wright (2002) argue that there is no reason why the system, once constructed, should require operating subsidies of any kind, even at fare levels equivalent to current fares. Normally, a BRT system with greater than 5,000–6,000 passengers per direction per peak hour is able to fully recover its costs. This limits the prospects of approval of the CDM applications of BRT systems by the UNFCCC.

No other ADB developing member country has a broader CDM implementation experience than the PRC, although this experience is in sectors other than urban transport. Given the availability in the Chinese language of a very detailed CDM operational manual for preparing urban transport CDM projects in accordance with the approved CDM urban transport project methodology, which has been used for training of Chinese urban planners, no other developing member country is better placed to develop and submit urban transport projects for CDM approval. This competence notwithstanding, the CDM approval requirements are very demanding in terms of methodological and data requirements. Considerable simplification and speeding up of CDM procedures and requirements, combined with broadened eligibility criteria for CDM applications in the urban transport sector, would be needed to make the CDM an effective financing modality to support GHG-reducing urban transport initiatives.

In practice, engaging in developing and making use of an approach for a CDM methodology for a transport project has so far proven to be a very time-consuming, costly exercise with only very limited prospects of success.

In conclusion, the CDM, as currently designed, is unlikely to be effective for bringing about large-scale changes in urban transport. The new idea of nationally appropriate mitigation actions (NAMAs) may, however, be more promising. NAMAs include three categories, namely (i) autonomous actions by developing countries without outside support; (ii) actions undertaken with support from developed country parties; and (iii) actions that could be partially or fully credited for sale in the global carbon market. There can be little doubt that determining the type and level of developing country actions (NAMAs) will be a key element for the post-2012 climate framework. This should give the PRC and other developing countries new opportunities for obtaining support for their actions in the urban transport sector to mitigate climate change.

Global Environment Facility and Urban Transport Financing

Considering the limited potential for using the CDM to stimulate initiatives to reduce GHG emissions from urban transport, there is a need to look at other potential financing mechanisms. The most obvious alternative is the Global Environment Facility (GEF). It provides funding to pay for the incremental costs of designing a project or program to achieve domestic and global emission reduction.
Through the GEF, cities in the PRC can mobilize additional funding for implementation of their urban transport projects (e.g., to improve urban public transport or promote nonmotorized transport). One feature that has potential to make GEF financing more effective than the CDM for PRC cities is a new strategic GEF program, which will give more emphasis to non-technology options such as planning, modal shift, and the promotion of better-managed public transport systems. GEF support can be given to promote transport modes with lower carbon intensity, such as BRT and public rapid transit more generally. Unlike the CDM, there are a number of approved GEF medium- and large-scale urban transport projects around the world with various GEF-implementing and executing agencies, including various fuel-cell bus commercialization projects in the PRC.
Reform Strategies to Mitigate Emissions from Transport in the People’s Republic of China

Strategic Reform Approach

The strategic objective in urban transportation is to establish a safe, accessible, efficient, economic, harmonious, and environmentally friendly urban transport system that will meet the needs of socially, environmentally, and economically sustainable development and reduce GHG emissions from urban transport.

Strategies for reduction of CO₂ emissions require an integrated approach. The current institutional and regulatory framework in the transport sector in the PRC is the result of incremental development over many years. This has led to the absence of a comprehensive, integrated policy for sustainable urban transport that adopts a holistic approach to meeting transport demands. An integrated sustainable urban transport policy should have the following features:

- Extensive focus: It looks at transport in relation to other dimensions needed to meet transport challenges.
- Dynamic: It provides a framework for a continuing and adaptive process of strategic, integrated, and coordinated action at all levels.
- Holistic: Problems, solutions, and effects are simulated and discussed together with the view of effects to society as a whole.
- Multi-stakeholder participation: It includes government agencies, nongovernment organizations, the private sector, academe, and other organizations working in the areas of transport, environment, energy, climate change, safety, health, finance, and education.

Several priorities are recommended within this strategic reform approach. These are discussed in the succeeding pages.
First Priority: Identification and Selection of “Win–Win” Options

Both energy conservation and associated emission reductions should be an integral element of a sustainable urban transportation strategy for the PRC. The focus should first be on identifying and implementing “win–win” solutions where there would be no obvious losers. These cover areas and actions that would improve both the urban environment and the traffic situation at the same time, and would have no added budgetary burden, perhaps even freeing up budget monies to be available to support improved transport and environment solutions. These options are mostly focused on removing past distortions, (e.g. certain kinds of subsidies and taxes, free parking), that are no longer suited to the needs of a well-functioning urban economy. Many such distortions have become outdated as a result of technological and societal change, but remain costly in terms of both budget transfers and perverse incentives to travelers. With certain compensatory measures in place, these should be dealt with quickly at administrative levels.

Actions under this heading include providing information to travelers on how to become an eco-driver, introducing special incentives for car pooling, switching from flat-rate tolls to those adjusted for peak periods, reducing the supply of curbside parking and off-street parking, increasing parking charges, and providing employer incentives for use of nonmotorized transport.

Second Priority: Removal of Administrative Barriers and Distortions

The next priority is administrative reforms that remove barriers and distortions to urban efficiency and effectiveness. From a societal perspective, these may also be labeled “win–win” options because they improve transport sector efficiency and effectiveness without a need for physical investments. However, those who have enjoyed protection and profits from the distortions are likely to mobilize lobby group protests and try to delay or abort the reform process.

Examples of such reforms include removal of monopoly privileges of transport service providers, cordon pricing for entry into the central business district by car (flat fare or variable with traffic levels), giving preferential treatment to buses and nonmotorized transport modes over cars on urban streets and at intersections, provision of safe and inexpensive parking for both cars and nonmotorized vehicles at suburban bus and metro stations, and establishing improved enforcement of vehicle emissions inspections. Where full-cost pricing of car use on congested streets is not politically possible, the distortions from the implicit subsidy of such car use can be dampened by increased subsidies to make public transport more price-competitive, based on transfer of revenues obtained from car use and car ownership taxes.

The “win–win” nature of such strategies is strengthened when taking into account the co-benefits of reduced emissions of other harmful local pollutants. These co-benefits could be of substantial value to the local and provincial economy and to people’s well-being, and a focus on such co-benefits could facilitate accelerated policy approval and implementation.
There are also potential co-benefits in the form of improved urban population health from more physical activity related to increased use of nonmotorized transport and restricted car use.

**Third Priority: Legislative Changes and Physical Investments**

Once the feasible “win–win” possibilities have been exhausted, the CO₂-reducing policy options requiring either time-consuming change in legislation and/or physical infrastructure investments should be considered. These require considerable preparatory work and lobbying among affected stakeholders before they can be presented to decision makers.

The best alternatives are those that jointly provide for the largest net present value of overall strategy benefits, subject to budget constraints, and include the transaction costs of the initiative. Elements of such a strategy would include both policy reforms and investments in urban land use and transport. When interdependencies between strategy elements are at play, simply ranking them by individual benefit–cost ratios may not yield the maximum net present value of the strategic package. Such interdependencies may imply considerable synergies of joint implementation (i.e., total benefits of coordinated joint implementation exceed those of the components taken individually), and it is therefore a “package” approach that should be pursued. Typical examples in this category include joint implementation measures to reduce access of cars to congested central business districts and make access more costly (e.g., congestion pricing and time-of-day variations in parking fees combined with reduced supply of off- and on-street parking space), and large investments in a comprehensive public transport system offering wide commuter coverage and high-quality services (as in Singapore).

If the various GHG-reducing investments can be handled independently of each other, the urban transport strategic approach of combating climate change would be to rank the proposed actions according to how much CO₂ emission reductions each activity is expected to yield per annual yuan spent, given that any quantifiable negative side effects of a social or environmental character should be included in the benefit–cost estimation.

In practice, initiatives to institute reforms and undertake GHG-reducing urban transport investments will come from city, provincial, and national levels. While city-level initiatives will be dominated by city-specific characteristics and needs, national initiatives will be more generic and apply to situations across many cities. In most cases, a good dialogue between local and national authorities—at least with the provincial transport departments and other ministries involved in urban planning—is needed to facilitate the approval and implementation process. The government should consider undertaking a nationwide capacity and competence building technical assistance program for urban decision makers and transport planners and operators, where the focus should be not only on the techniques of project preparation, but equally on providing objective information about the potential, limitations, and institutional and organizational barriers to change and reforms along the lines described above, and on techniques available to facilitate consensus building for approval and implementation.
Implementing a Strategic Reform Agenda

Removing Distortions and Externalities

The PRC has extensive experience in applying command and control measures in different sectors of the economy. Many PRC cities have already demonstrated a willingness and ability to combat traffic congestion by means of various regulatory policy instruments. Impressive results have been achieved with effective monitoring and enforcement, and much of this experience is transferable to other growing cities that have yet to make such policy decisions. Such policy measures include making idling of engines illegal, introducing flexible work hours, restricting vehicle emissions (as also adopted by several German cities), making modes of nonmotorized transport safer and more convenient, and imposing car-free days based on license plate numbers.

However, the active use of pricing instruments to influence how individuals choose whether and how to travel has not yet been established as mainstream practice in the PRC. People are more used to obeying regulatory measures than to making their own choices based on relative costs and prices of competing alternatives. There remains considerable skepticism and reluctance to use market-based instruments to manage public goods such as scarce road and street space.

With market-based policy instruments becoming increasingly accepted and adopted by cities in other countries, and with PRC becoming more and more open to management ideas and practices that have been proven efficient and effective internationally, a sustainable urban transport strategy for the coming decade in the PRC should seriously consider the adoption of economic policy instruments as key strategic components for bringing about low-carbon urban transport.

Among these, the most effective and efficient remedy would be one of several practical methods of congestion pricing of urban transport, as successfully implemented in many cities internationally, including London, Singapore, and Stockholm. It would be helpful if the initiative to facilitate and encourage congestion pricing could come from the National Development and Reform Commission and MOT jointly so that provincial authorities can inform central cities to move ahead with preparations for reforms to road user charges.

Since congestion pricing is a city-specific measure, it does not involve revenue leakages like those associated with license plate quota systems or local fuel price variations where registration and fuel purchases can be conducted in a neighboring jurisdiction (e.g., as experienced in Shanghai).

To further stimulate such initiatives and combat local resistance at the city level, the national and provincial governments should provide the necessary technical assistance for training local staff to understand the merits of establishing and operating congestion pricing systems. The government may also consider offering subsidies toward the investment and operation and maintenance of modern, effective citywide public
transport networks and safe nonmotorized transport networks. These need to be enforced significantly in order to convince reluctant stakeholders to adapt to congestion pricing.

It can be expected that car owners will raise considerable opposition to congestion charging schemes. It is, therefore, important to make it clear to decision makers that car owners can best afford to pay for the congestion and associated adverse effect of their behavior and choices. The relevant authorities should prepare easily understood analyses that clearly show the external costs to the local economy over and above what car users actually pay for their use of the limited road space and parking facilities.

It should, at the same time, be made clear to all stakeholders that those who are captive to public transport and nonmotorized transport systems are the middle-income and poorer residents, and they are subsidizing car users as long as the latter pay less than the true cost of travel on congested urban streets. Opposition from car owners and downtown shop owners was an initial concern when Singapore first introduced congestion pricing in the early 1970s, but these fears soon proved to be unfounded. The outcomes of congestion pricing were carefully and transparently presented to stakeholders to increase its acceptance.

Singapore’s success with congestion pricing (as in Stockholm and London more recently) is very much a result of the authorities’ determination to simultaneously upgrade and integrate the public transport system so that all travelers have an attractive alternative to using their cars to go to the city center.

At the same time, each city has to tailor such a system to match its unique city characteristics—for example, exempting car pool vehicles from paying the congestion charge or compensating certain minority groups of travelers who can document that they cannot afford to pay the daily congestion charge.

Singapore did not face the opposition of a car-manufacturing lobby when introducing congestion pricing. In PRC provinces where the auto industry has a strong presence, actions to combat such opposition and gain the support of the industry will be a key strategic initiative in need of high-level government support. Media mobilization will also be a key input.

Through the recently implemented fuel tax reform, the PRC authorities have already demonstrated a willingness to raise fuel prices and also to increase vehicle purchase taxes in line with engine size. This willingness to apply the principles of graduated fees and taxes will make it easier to change and differentiate the tax and fee levels to better reflect the costs of the externalities caused by different types of vehicles and the choices of when and where to use the car.

Individual cities have the authority to determine how much they will charge for curbside parking. They can also decide how many such parking spaces they will provide and how many off-street parking spaces they will allow in the central business districts. Active local parking policies should be relatively easy to implement, and should work in
tandem with congestion pricing and increased national fuel and vehicle taxes and fees to divert an increasing number of travelers to public transport and nonmotorized transport (assuming that facilities for such modes are upgraded to satisfactory standards).

Based on the experience with the license plate auctioning system in Shanghai, one can conclude that such a system can be an efficient GHG-reducing policy measure in the PRC but there are risks of city-level leakages in the form of vehicle registrations in neighboring jurisdictions with lower taxes and fees.

As part of an integrated, comprehensive, and sustainable urban transport policy package, the PRC authorities should make provisions for the use of increased tax and fee revenues from the purchase and use of cars to build and improve public transport and nonmotorized transport facilities.

**Building Capacity and Capability**

There is a need to raise awareness and train decision makers to take genuine ownership of the proposed GHG-reduction reforms, especially those focused on removing externalities and distortions. This helps them to be effective at making sound decisions about GHG-reducing urban transport operating conditions and associated investments.

Managers and decision makers at all levels must receive systematic training on the linkages between energy, environment, and the economy in order to strengthen the capacity to mainstream energy conservation and GHG reduction across and throughout the entire production process. To further stimulate such participation, it is suggested that the operational performance of energy conservation and reduction of the GHG emission policies be included as criteria to evaluate the performance of managers and decision makers at all levels.

To implement the capacity and competence building for decision makers and managers, the following actions are recommended:

- Develop long-term mechanisms for training managers and decision makers on mainstreaming transport energy conservation and reduction of GHG emissions. All the national and local urban transport managers and decision makers should be notified and updated regularly through a network on the most recent information and policies on effective energy savings and GHG reduction.

- At all relevant local, provincial, and national levels, employee training should be updated annually to ensure competency. Urban transport managers and decision makers should be required to take an examination on energy efficiency and GHG emission reduction subjects.

- As part of the training, staff should analyze the merits and obstacles for gradually increasing the use of economic policy instruments such as congestion pricing, progressive purchase and annual vehicle taxes and fees, and differentiated
parking fees. The complementarity between regulatory instruments and economic instruments should be emphasized.

- Commensurate budget for capacity building must be provided by the local, provincial, and national governments. To speed up this awareness-raising and training process—so that the scope for selecting GHG-reducing urban transport investments and policies is quickly expanded—there should initially be a national allocation for such capacity building to be channeled to provinces and cities through the provincial transportation departments. This could be financed with revenues from fuel and vehicle sales and annual license fees.

Addressing Auto Industry and Fuel Refinery Challenges

**Eco-vehicles**

There is considerable potential for using clean-technology cars and light duty vehicles, including e-bikes, and even greater potential for doing so with heavy vehicles. As a means to promote accelerated adoption of small, fuel-efficient cars, the PRC should continue to develop and strengthen the nationwide graduated vehicle purchase and annual license plate tax schemes that are progressive with factory-declared emission standard of the vehicle’s engine. To prevent leakages, inter-provincial or intra-provincial variations in such taxes should not be allowed. For commercial vehicles (trucks and buses), a corresponding action plan should be designed and adopted to be able to implement the newly released PRC guidelines that limit fuel consumption for commercial vehicles.

**Engine technology**

Developing more fuel-efficient engines in the PRC is a key strategic element in promoting eco-vehicles among car users. However, this is a complex challenge because of (i) the engine manufacturers’ mutual dependence on the availability of competitively priced clean fuels suitable for highly efficient clean fuel engines; (ii) the dependence of oil refineries on the availability of vehicles equipped with clean engines; and (iii) the refineries’ dependence on government-determined fuel prices, which so far have made it unprofitable to refine low-sulfur, high-quality liquid fuels.

Since the 9th Five-Year Plan, the government has been making great efforts to develop clean energy-saving electricity-powered vehicles. In the 10th Five-Year Plan, under the leadership of the Ministry of Science and Technology, the government has mobilized a number of local governments, enterprises, and research institutions in a collaborative effort to systematically carry out the Special Key Program for Electricity-Powered Automobile Research and Development. This involves a total investment of CNY2.4 billion ($366 million), which includes CNY800 million ($12 million) financed by the central government. Four years of efforts have laid a good foundation for the development of electricity-powered vehicles in the PRC. But there remain major challenges with this program:

- Most of the research work has focused on the technological aspects without addressing the policy and regulation-related issues associated with the process of industrializing and commercializing the technologies.
• The technological process and funding must have a long-term orientation. It may take 2 decades for some of the technologies to be available in the market, such as the technology for fuel cells and hydrogen use. Insufficient support has been given to the development of technologies that can bring benefits in the next 10–20 years, such as hybrid plug-in vehicles.

• The research process has so far largely depended on domestic technologies without fully incorporating international developments and absorbing the international best experience. This means that the PRC is not taking full advantage of the huge potential of its domestic market to attract and utilize state-of-the-art international technologies.

• As a result, the PRC is behind other car-producing countries in development of both conventional vehicle and hybrid electric technologies. It has also been slow to expand its capacity to reduce pollution and energy consumption by developing advanced vehicle technologies.

The strategic challenge is to provide vehicle manufacturers with the necessary incentives to innovate and adopt proven fuel-saving and clean fuel technologies.

**Eco-fuels**

The challenge of introducing clean diesel fuels for trucks is politically complex and is linked in a two-way relationship to the incentives for developing and producing fuel-efficient clean fuel engines. The government has been hesitant to allow the international increase in oil costs to be fully reflected in the fuel prices that refineries are allowed to charge for fuel sales. As a result, oil companies such as Sinopec at times lose on every gallon of diesel sold, and therefore seek to buy the cheapest crude they can find on the market, which contains high sulfur content.

Given the current trucking industry structure, introducing and enforcing adherence to top emission standards for diesel-engine trucks, buses, and agricultural vehicles (which often operate as local short-distance trucks) will be costly for the transport services industry and those dependent on transport services. Individual truck operators dominate the market. With few market entry barriers, there is cutthroat competition and operators earn very low margins. To survive, truck operators practice widespread overloading, which damages both the trucks and the roads. If truck operators had to pay the full costs of both fuel and vehicle upgrading to meet top emission standards, the authorities fear there would be a massive closure of small trucking companies and widespread dissatisfaction and unease among a segment of the transport sector that plays a vital role in supporting the construction industry.

Phasing out old polluting taxis and buses in Beijing and providing financing to facilitate large-scale replacement with new fuel-efficient vehicles (many of them running on natural gas) may have been a relatively easy task in the country’s most visitor-exposed city. However, to ban highly polluting old trucks is a much more sensitive task. There is a huge number of smaller operators and, due to competition, they have so far not been able to pass on the increasing fuel costs to customers, and many operate on the verge of bankruptcy.
The PRC therefore needs a national oil price regime that taxes the sulfur content of oils. This way, the refineries will seek to import clean crude to refine into clean diesel fuels compatible with the low-emission, high-performance car engines to which the PRC is committing itself. Similarly, the PRC should also be committed to the use of clean diesel fuels for heavy diesel-operated vehicles.

On 18 May 2009, the State Council announced the Petrochemical Industry Restructuring and Revitalization Plan. This mandates nationwide “China III” quality gasoline motor fuel (150 parts per million [ppm] sulfur) by 2009 and nationwide “China III” quality diesel motor fuel (350 ppm sulfur) by 2010. The announcement also says that any fuels not meeting these standards may not be sold into the market after the implementation dates. The announcement represents a key step by the PRC toward fuel desulfurization. It establishes, for the first time, a definitive timetable for nationwide implementation of 350 ppm sulfur diesel. The authorities should encourage the oil and gas refineries to reduce sulfur content and enhance fuel qualities to the standards that modern clean and fuel-efficient engines require for efficient operation. In doing so, the authorities will have to address issues of conflict between the auto industry, fuel refinery development, and sustainable natural resources and environment management, and between human consumption of finite resources and the goal of sustainable development. These conflicts include how to deal with (i) the environmental and health damages caused by the high sulfur and particulate matter emissions from poor quality fuels, and (ii) the adverse short-term income impacts on transport operators from higher prices for clean fuels as well as from additional taxes to be charged on polluting fuels to encourage switching to modern fuel-efficient engines that require clean fuels.

Reinforcing the Development of Integrated Urban Transport

Prioritizing public transport has become a major strategic element of urban transport development in the PRC. Central cities should take initiative to strengthen their public transport development planning and to build a high-capacity, high-quality public transport system. With growing awareness that urban travelers pay attention to the convenience of quick and smooth transfer between modes (e.g., from bus to subway), integrated planning of investments and operation of the different components of urban transport systems is becoming increasingly important for the reduction of GHG emissions from urban travel.

With the rapid proliferation of e-bikes in PRC cities, urban authorities should mobilize to prepare travel and commuting options so that e-bikes are effectively integrated with, and become complementary to, conventional public transport such as BRT, light rail, and subways. In the interest of resource savings and emissions reduction, the central city authorities should adopt and apply policy instruments and regulations that will lead to the delivery and use of vehicles with high fuel efficiency and low pollution. In this context, the tax policies should be designed so as to stimulate the acquisition and use of bicycles and e-bikes along with much improved, harmonized, and affordable urban public transport.
Before considering construction of subways, these cities should try to fulfill their travel demands by means of conventional public transport, and should consider BRT and priority bus lanes before deciding to invest in subways or light railways. Due to the high cost, rail-based systems should only be considered if transport demand in key corridors reaches levels that exceed the capacity of what BRT can handle effectively. In all cases, the feasibility of public transport investment options must be carefully studied.

**Integrate urban and suburban transport**

There remains a growing gap in income and social welfare between urban and suburban residents in the central cities. Until the recent government reform requiring MOT to take over the responsibility for both inter-urban, rural, and urban transport and the integration of these roles, there was virtually no integration between urban and suburban transport. This made it more difficult for suburban dwellers to access markets and social services.

MOT should assist the provinces and central cities to speed up the integration of urban and rural transport development to provide suburban residents with good-quality roads and public transport services. This is essential for building a well-functioning society in and around the cities. Such integration will become a key component in a long-term strategy to stop the growing gap between economic and social indicators of urban and suburban areas.

**Integrate land use and transport planning**

The strategic recommendations for successful integrated implementation of transportation and land use planning measures that emerge from the above analysis, are complementary to those presented in the sourcebooks and guidelines for integrated urban transport planning published by GTZ (2008b). These include the following:

- Ensure that new developments include mixed land uses throughout the urban area to reduce the need for travel.
- Ensure that nonmotorized transport facilities (sidewalks, pedestrian crossings, bicycle and e-bike lanes, and safe parking spaces for e-bikes and bicycles) are attractive to existing and potential users from a safety, convenience, and accessibility perspective.
- Create partnerships with local employers and businesses for the creation of ancillary nonmotorized transport facilities at workplaces (e.g., lockers, storage facilities, showers, bicycle racks).
- Secure effective integration with other modes (between rail and buses) in terms of common thoroughfares; corresponding timetables; and provision of park and ride facilities for cars, scooters, e-bikes, and bicycles so as to encourage their use.
- Ensure that public transport vehicles and associated infrastructure (station platforms and hubs) are easily accessible, with low-floor vehicles, step-free entry and exit, good illumination, safe and comfortable waiting and transfer areas, and good updated information about routes, schedules, delays, etc.
• Ensure that public transport provision has the appropriate level of service and coverage to meet the potential user demand.
• Use appropriate fare structures to ensure adequate levels of patronage.
• Ensure easily accessible and updated provision of relevant passenger travel information (timetables, format of information, advertising).
• Integrate public stakeholders from early preparatory project planning and design stages to increase awareness and acceptance of the measures.

Strengthening Urban Transport Technology Development

\textit{Information technology in urban transport}

The PRC needs to strengthen the role of technology in cities’ comprehensive transport systems in the aspects of planning, construction, operation management, and transport service. Technology can be used for improving the overall service level through provision of urban transport, intelligent transport management, and real-time transport information services.

Information technology can control vehicle entry and exit from major roads to optimize traffic flows. It can be used to monitor traffic lights and optimize traffic flows per street. Computers installed in vehicles can inform drivers of the best route to take.

Information technology can be used efficiently to monitor and minimize violation of traffic laws and vehicle restrictions. Such command and control measures are currently more popular with the PRC authorities than market-based congestion and pollution monitoring instruments, and have been proven to reduce traffic, congestion, and associated pollution considerably and with immediate effect. With information technology controls in place, such traffic-reducing measures can relieve the urban transport systems until the political support has been established for congestion pricing.

\textit{E-bikes}

Assuming that the various hazardous emissions related to power production and battery production and recycling can be safely controlled, e-bikes can meet much of the future demand for mobility from residents in an environment friendly way.

To realize the full potential of e-bikes, the government should first prepare nationwide regulations to prevent cities from banning or discouraging the purchase and use of e-bikes, combined with information and awareness raising to alert city authorities to the great environmental merits of e-bikes. Cities should also actively promote e-bike use between residential areas and public transport stations by providing safe e-bike (and bicycle) parking spaces.

If the aim of e-bikes is to reduce car travel and local pollution from car emissions in congested urban areas, the attractiveness of e-bikes can be improved by charging significantly higher taxes on car ownership, car use (especially during congestion periods), and parking.
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Urban Transport Strategy to Combat Climate Change in the People’s Republic of China

This publication examines the problems and issues of urban transport in relation to climate change in the People’s Republic of China. It reviews international and local best practices for addressing such challenges. It also identifies policies, strategies, and measures to reduce CO₂ emissions from the transport sector and recommends applicable options for implementation in the People’s Republic of China.

Possible strategic measures to reduce CO₂ emissions include (i) identification, selection, and implementation of “win–win” travel demand management measures that improve both the urban environment and the traffic situation with no budgetary burdens; (ii) removal of administrative barriers and distortions to urban efficiency and effectiveness that require administrative changes and reforms; (iii) legislative changes and physical investments to be considered after the “win–win” options have been exhausted; and (iv) strengthening of knowledge management and building of capacity for integrated sustainable transport management to mainstream transport energy conservation and greenhouse gas reduction.

About the Asian Development Bank

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Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.