

## **Can the Environment Survive China's Craze for Automobiles?**

Jimin Zhao\*

*School of Natural Resources and Environment, University of Michigan, 430 East University,  
Dana Building, Ann Arbor, MI 48109-1115*

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### **Abstract**

This article evaluates China's recent programs to reduce the environmental impacts of rapid vehicle development and makes recommendations on how China can follow a more sustainable path of vehicle development. These programs as well as efforts to control industrial and residential pollution have led to a slight improvement in China's air quality. However, without renewed efforts, China's rapid vehicle population growth threatens the environment. The article concludes that the government can play a central role in guiding the direction of motorization through regulation, partnerships between government and industry, and adoption of market-based incentives. In the short-term, there is great potential for China to reduce emissions from conventional vehicles, especially by improving fuel quality. Although limiting private ownership of vehicles is probably impractical, vehicle use can be reduced through the development of a convenient public transportation system, introduction of high parking fees, and better urban planning. Government policies should promote hybrid vehicles and encourage multinationals to turn China into a testing ground to promote hydrogen vehicles in the future.

*Keywords:* Clean vehicles; Emissions; Air quality; Sustainable transportation; China

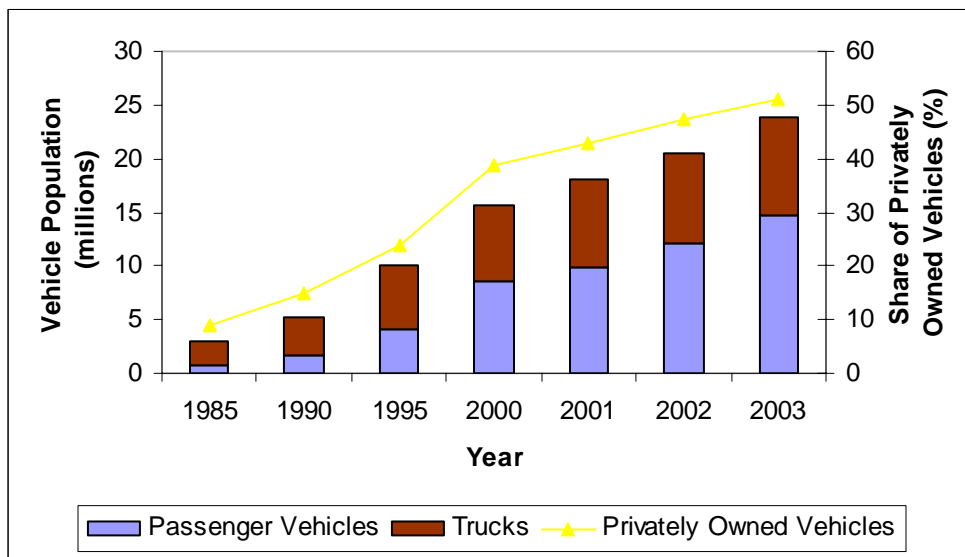
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\* Tel.: 1-734-6475952; fax: 1-734-6475841.

*Email address:* jmzhao@umich.edu

# 1. Introduction

China now desires the same vehicle systems that have given developed countries great mobility and convenience over the last century. Its vehicle population has been increasing rapidly and the auto industry has become an important sector in the country's overall economy. The motor vehicle population in 2003 reached 23.8 million, increasing by 332 percent since 1990, with an average annual growth rate of 12 percent (see Figure 1). The rate of growth is even faster in major cities, such as in Beijing and Shanghai, where the annual vehicle growth rate has been 17-20 percent. Much of the growth has occurred in privately owned vehicles, whose share of total vehicles increased from 8.9 percent in 1985 to 51 percent in 2003. The private share in large cities is even higher; of the 280,000 new vehicles registered in 2002 in Beijing, 90% were private cars.<sup>1</sup>



Source: CAAM & CATARC 2004.

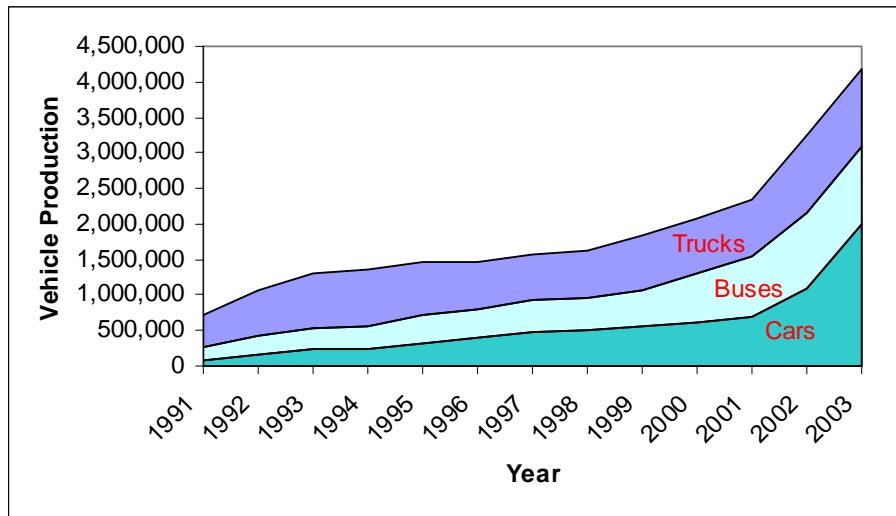
Fig. 1 China's Vehicle Population and Share of Privately Owned Vehicles

In 2003, over 4.4 million vehicles were made in China, making the country the 4<sup>th</sup> largest vehicle producer in the world, following the U.S., Japan, and Germany. This was a dramatic increase from its rank of 11<sup>th</sup> three years ago.<sup>2</sup> Most of the production increase was passenger cars, output of which increased by 84.4 percent in 2003, accounting for nearly 50 percent of the country's total vehicle production (See Figure 2). Due to the high profits in the auto sector, some companies in other sectors, such as the household electric appliance sector and the tobacco sector, have begun to invest in vehicle production. The Chinese government estimates that vehicle production will reach 8 million in 2010, and 12 million in 2020, when China will rank second in the world after

<sup>1</sup> *Beijing Youth Daily*, August 7, 2003.

<sup>2</sup> China Business Update, 2003: A Year of Record Growth for Car Output and Sales, January 15, 2004.

the United States and account for 20 percent of global output.<sup>3</sup> The auto sector's contribution to total GDP growth could be as high as 20 percent.<sup>4</sup>



Source: CAAM & CATARC 2004.

Fig. 2 Vehicle Production in China

Even though China has experienced rapid growth in her vehicle population, the total number of vehicles per person remains a mere fraction of those in the United States or even other developing countries. China had 12 vehicles per 1,000 people in 2003, compared to 100 in Brazil and 940 in the United States. The vehicle population is likely to continue to grow rapidly with increasing purchasing power and falling vehicle prices. China's GDP is predicted to maintain a growth rate of 7-8 percent annually over the next decade. Automobile prices fell by 15-20 percent in 2003 and are likely to continue falling with intensified competition and scheduled tariff reductions.<sup>5</sup> Based on a survey conducted by the National Statistical Bureau's Urban Survey Team, about 150 million families in China, comprising a population of 500 million, are expected to buy automobiles in the coming 10 to 15 years.<sup>6</sup>

However, the rapid and continuous growth of a transportation system based on gasoline and diesel fuels could dramatically increase China's dependence on oil imports, and also threaten local air quality and global climate change. Were China to have as many vehicles per capita as the United States, over 900 million vehicles would be traveling its roads, or 40 percent more than today's world total. And if China's per capita oil consumption matched the current U.S. rate, Chinese oil demand would exceed today's worldwide oil production by 18 percent.

Can the already seriously polluted environment survive the Chinese craze for automobiles? China is still in an early stage in structuring its automobile industry and

<sup>3</sup> China Development Forum, November 17, 2003, Beijing.

<sup>4</sup> Asia: Economic Analysis, *Emerging Markets Monthly*, August 7, 2003, Deutsche Bank.

<sup>5</sup> Editor's Note, "2003: The Year of Falling Prices," *CBU-Auto*, Vol.9, No. 41, December 18, 2003.

<sup>6</sup> *Beijing Times*, March 12, 2003.

transportation system. Can China follow a more sustainable path by addressing the needs of its people while promoting energy security and environmental well-being? China's decisions about the automobile industry will affect not only China but the rest of the world with respect to energy security, environmental protection, economic competitiveness, and climate change. Drawing upon field research conducted from 2001 to 2004, this paper analyzes the environmental impacts of vehicle emissions in China, evaluates government efforts to reduce vehicle emissions, and finally discusses policy implications.

## **2. Environmental Impacts of Vehicle Emissions**

China's rapid industrialization, urbanization, and motorization have contributed greatly to China's urban air pollution. A report released in 1998 by the World Health Organization noted that of the ten most polluted cities in the world, seven can be found in China.<sup>7</sup> The main sources of urban air pollution have changed over time—coal smoke pollution due to industrialization during the 1970s, serious acid rain pollution in the 1980s, and vehicle pollution or a mix of vehicle pollution and coal smoke since the late 1990s (He, Huo, and Zhang 2002).

Air quality in China has recently improved slightly with a recent increase in the percentage of cities meeting national air quality standards (level II) from 27% in 1998 to 41.7% in 2003 (see Table 1). Among major air pollutants in China, SO<sub>2</sub> and Total Suspended Particulates (TSP)<sup>8</sup> pollution have fallen or stabilized but nitrous oxides (NO<sub>x</sub>) pollution has become more serious in large cities. The pollution reduction occurred due to smoke abatement and dust removal, after regulations requiring the use of briquettes and greater residential use of gas, electricity, and oil instead of coal in the late 1990s. Vehicle pollution has led to significant urban air pollution problems related to NO<sub>x</sub>, particulate matters, and ozone. NO<sub>x</sub> concentration in some large cities such as Beijing and Shanghai, has increased gradually in the 1990s and some even exceeded national air quality standard level III (He, Huo and Zhang 2002). For example, NO<sub>x</sub> emission in Beijing fell by 17% from 1988 to 2000, but increased by 7.1% in 2002 and increased again in 2003.<sup>9</sup> After five years of consistent improvement, Beijing's air quality deteriorated slightly in the first half of 2004 as compared to 2003.<sup>10</sup> One of the factors causing this air quality drop is the rapid increase in vehicles on the road; about 1000 new cars are added to Beijing's roads each day.

Motor vehicles have become China's major source of air pollution, replacing industrial pollution. In a 2001 report, the World Bank noted that China had made strides in lowering industrial pollutants and coal-burning, but cautioned that vehicle-related pollution was rising (He, Huo, and Zhang 2002). On average, vehicles are currently contributing approximately 45 to 70 percent of the NO<sub>x</sub> emissions and about 50-80 percent of CO emissions in typical Chinese cities (see Table 2). These contributions have increased over time. In 1996, in the downtown area of Shanghai, about 86% of carbon

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<sup>7</sup> China: Environmental Issues, available at <http://www.eia.doe.gov/cabs/chinaenv.html>, July 2003.

<sup>8</sup> The indicator TSP was changed to PM<sub>10</sub> in late 1990s due to concern over PM<sub>10</sub>'s impact on human health.

<sup>9</sup> Available at the website of the Beijing Environmental Protection Bureau, <http://www.bjepb.gov.cn>, September 26, 2003.

<sup>10</sup> Beijing Environment, Science and Technology Update, July 30, 2004.

monoxide, 96% of HC, and 56% of NO<sub>x</sub> in the air were from automobile exhaust; the shares increased to 87%, 97%, and 74% in 2002 (Lu and Qi 1999; CATARC 2003). Although the number of automobiles is not great compared to developed countries, because of old manufacturing technology, the long duration of vehicle use, less stringent emission control laws, serious traffic congestion, poor road infrastructure, and bad maintenance of vehicles, pollution from automobile exhaust in China is very serious.<sup>11</sup>

Table 1

China Urban Air Quality in 1998~2003 (mg/m<sup>3</sup>)

Year	1998	1999	2000	2001	2002	2003
Total number of cities investigated	322	338	332	341	343	340
Share of cities meeting National Standard Level II (%)	27.6	33.1	34.9	33.4	34.1	41.7
Share of cities meeting Standard Level III but not Level II (%)	28.9	26.3	30.1	33.4	34.7	31.8
Share of cities not meeting Standard Level III (%)	43.5	40.6	34.9	33.1	31.2	26.5
Average SO <sub>2</sub> Concentration	0.057	0.054	0.053	0.052	0.047	
Average TSP Concentration	0.045	0.046	0.044	0.035	0.033	
Average NO <sub>x</sub> Concentration	0.284	0.264	0.263	0.272	0.254	
Average PM <sub>10</sub> Concentration				0.113	0.12	

Sources: SEPA 2003, 2004a, and 2004b.

Table 2

Contribution of Vehicle Emissions to Air Pollution in Some Cities (2002)

City	Vehicle Contribution Rate (%)		
	CO	HC	NO <sub>x</sub>
Beijing	63.4	73.5	46
Shanghai	87	97	74
Chongqing	85.8	36.6	86.3
Wulumuqi	88.7	--	48.5
Tianjin	83	81	55
Chengdu	62	70	45
Guangzhou	84.1	--	25.7

Source: CATARC, 2003.

Note: This table is based on a survey conducted by the National Clean Vehicle Office at the end of 2002.

<sup>11</sup> Interviews with experts in Beijing and Shanghai, June 2001 and 2002.

Traffic congestion in large cities exacerbates the pollution from vehicle emissions. While the number of vehicles is increasing by 20 percent per year in Beijing, the road network is expanding by only 3-4 percent per year. The average driving speed on 11 main roads in Beijing is estimated to be only 12 km/h, roughly the same as riding a bicycle.<sup>12</sup> The generally lower traffic speeds and stop-go driving patterns not only increase the amount of fuel consumed, but also result in higher emissions per unit of distance traveled.

The resulting air pollution affects public health. Respiratory disease now accounts for one in four deaths in China, and the World Bank estimates that air pollution costs about 5 percent of China's GDP if one considers the health-care costs and lost productivity from those too ill to work.<sup>13</sup> Because of increased vehicle emissions, coughs and common colds in Shanghai have become more severe and it takes a longer time for people to recover.

Rapid vehicle growth could also dramatically increase the threat of global climate change. China is the world's second largest emitter of greenhouse gases, after the United States. Even though China's energy use and greenhouse gas emissions per capita remain far below the levels found in richer countries, the increase in vehicle population will make the total emissions from China rise quickly. The International Energy Agency predicts that the increase in greenhouse gas emission from 2000 to 2030 in China alone will nearly equal the increase in the rest of the world.<sup>14</sup>

### **3. Efforts Adopted to Reduce Vehicle Emission Impacts**

The great efforts to control vehicle emissions in China have been made since the late 1990s, even though the first national vehicle emission standards were issued in 1983.<sup>15</sup> The government reform in 1998 gave the State Environmental Protection Administration (SEPA) the exclusive responsibility for vehicle emission control and monitoring. The 2000 revision to the Air Pollution Prevention and Control Law added a new chapter on vehicle emission control, including specific penalty measures. This led to the phaseout of leaded gasoline, the introduction of European emission standards, the promotion of alternative fuel vehicles, the implementation of fuel economy standards, and the development of an R&D program for advanced clean vehicle technologies, such as electric battery vehicles, hybrid vehicles, and fuel cell vehicles.

#### **3.1. Lead-free Gasoline Program**

China's lead-free gasoline program was directed by the central government and supported by local governments. The unleaded gasoline program was implemented in three steps: a pilot program in Beijing, Shanghai, and Guangzhou; implementation in 47 cities in special economic zones and several important tourist cities; and a nationwide production phaseout

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<sup>12</sup> *Beijing Youth Daily*, August 7, 2003.

<sup>13</sup> Ben Dolven, *The Great Car Crush*, Nov. 27, 2003.

<sup>14</sup> Keith Bradsher, *China's Boom Adds to Global Warming Problem*, *The New York Times*, October 22, 2003.

<sup>15</sup> Zhou Yangsheng, *Evaluation of China's Vehicle Emission Control Policies and Systems*, September 2003.

by January 1, 2000.<sup>16</sup> By the end of June 2000, China had phased out leaded gasoline use by all vehicles (SEPA, 2001).

China did this quickly, unlike many other countries. For example, it took the U.S. Environmental Protection Agency from 1970 to 1996 to phase out lead in gasoline (Lovei, 1996). The rapid move to unleaded gasoline demonstrates the strong leadership role the central government can play in pollution control. In contrast to governments in other market economies, the Chinese central government still retains relatively strong administrative power due to the long history of central planning and China's authoritarian political system. China's national government can still play an important role in promoting issues that carry social and environmental benefits. The rapid move to unleaded gasoline was also made possible by the strong support of local governments. Great public pressure to deal with heavy air pollution in Beijing and Shanghai has provided political and economic incentives for local governments to move forward quickly.

### **3.2. Vehicle Emission Control Programs**

China adopted the European system for controlling emissions from new vehicles during the late 1990s. Beginning January 1, 2000, China required all new light duty vehicles to meet the Euro I emission standards, and beginning July 1, 2004, the Euro II emission standards.<sup>17</sup> China's third phase emission standards for passenger and light vehicles, based on Euro III and IV emission standards, has been released to government departments and automakers for comments and suggestions.<sup>18</sup> It is expected that China will implement Euro III in 2008. China has an ambitious plan to catch up with vehicle emission standards in developed countries by 2010.

Some local government agencies, in particular in Beijing and Shanghai, have been proactive in controlling vehicle emissions. Beijing advanced the deadline for enforcing Euro I standards one year ahead of the national schedule and two years ahead for Euro II standards. Shanghai followed by implementing Euro II standards in 2003, one year earlier than national standards. Beijing is likely to implement Euro III in 2005 and Euro IV in 2008, and Shanghai may also advance its Euro III schedule.<sup>19</sup> These decisions came in the wake of public appeals for clean air amidst the soaring number of vehicles, and the environmental requirements for the 2008 Beijing Olympic Games and for the World Trade Expo in Shanghai in 2010.

Tax refund policies helped motivate auto manufacturers to comply with national standards ahead of national regulations. The State Administration of Taxation and the Ministry of Finance announced in July 2000 that the consumption tax for automobile manufacturers whose products satisfied the Euro II emission standards before 2004 would be decreased by 30 percent. The affected vehicles included sedans, sports utility vehicles, and mini-buses. In contrast to many countries, the consumption tax in China is

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<sup>16</sup> Interviews with an official in SEPA, July 2002, Beijing.

<sup>17</sup>For gasoline passenger cars, Euro I CO: 2.72 g/km, HC+NO<sub>x</sub>: 0.97. Euro II CO: 2.2, HC+NO<sub>x</sub>: 0.5. European is now at Euro III (CO: 2.30, HC: 0.20, and NO<sub>x</sub>: 0.15). By 2005, they have to be at Euro IV (CO: 1.00, HC: 0.1, and NO<sub>x</sub>:0.08).

<sup>18</sup> Available at the website of the State Environmental Protection Administration, <http://www.zhb.gov.cn>, October 2004.

<sup>19</sup> Beijing Morning News, September 11, 2003.

paid not by consumers but by manufacturers based on vehicle type and sale quantity. The major auto companies, such as First Auto Works, Dongfeng Motor Corp., and Shanghai Automotive Industry Corp., all received tax refunds for some of their vehicle models that met Euro II standards.<sup>20</sup>

Even though the central and some local governments have been very proactive in promoting new emission standards, inconsistency in policy implementation and a lack of supporting policies have created barriers to the implementation of vehicle emission standards. Probably due to concern over vehicle stocks, in September 2004, SEPA extended the original July 2004 deadline and allowed new vehicles manufactured before September 1, 2004 that were able to meet Euro I standards to be sold until the end of 2004.<sup>21</sup> This inconsistency allowed firms who did not follow regulations to gain market advantage by continuing to sell high emission (low cost) vehicles. In 2004, the government cancelled the tax refund policies for vehicles meeting Euro II but issued a similar tax refund policy for vehicles meeting Euro III by July 1, 2004. However, because China had not completed issuing national emission standards based on Euro III standards, and the country still had insufficient amount of fuel capable of meeting Euro III standards, SEPA postponed the implementation of the new tax refund policy in September 2004.<sup>22</sup> Without standards and high quality fuel, the good intention to achieve early implementation of Euro III standards in Beijing and Shanghai faced difficulty in being realized.

Inspection and maintenance (I/M) programs such as annual emissions testing, roadside inspection, scrapping of old vehicles, and refitting of in-use vehicles have been adopted to reduce the emissions of in-use vehicles. Inspections are conducted by agencies authorized by local public security bureaus and environmental protection bureaus (Li, 2002). A car that is not in compliance with emission standards in an annual or roadside inspection is not permitted to be driven on the road and the owner must install emission reduction equipment in the car. Beijing started to use environmental labels (green and yellow) in 1999 to distinguish vehicles meeting different emission standards and did not allow vehicles with yellow labels to run within the central city areas during certain time periods.<sup>23</sup>

Another major aspect of pollution from vehicle emissions is the use of vehicles beyond their service life. In 2000, SEPA issued a notice concerning the 1997 Amended Vehicle Elimination Standards on Scrapping Old Vehicles. Non-commercial vehicles with 9 or fewer seats, including cars and sport utility vehicles, can be operated for 15 years and commercial vehicles with more than 9 seats can be operated for 10 years. The notice stipulates that vehicles that exceed these limits should be scrapped if their emissions exceed the national emission standards even after repairs or the installation of a filtering device. However, it is difficult to enforce this regulation because of the lack of monitoring. In addition, due to different regional emission requirements, some vehicles

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<sup>20</sup> Interviews with managers and technicians at big 3 companies, July and August 2002, Changchun, Shanghai, and Beijing.

<sup>21</sup> *Car Weekly*, September 9, 2004.

<sup>22</sup> *Nanfang Daily*, September 17, 2004. There are also arguments that the government to do so to increase national taxation.

<sup>23</sup> <http://www.bjepb.gov.cn>, Explanation of restricting driving of high emission vehicles in central city areas, Beijing Auto Daily.

which were supposed to be scrapped in big cities were instead sold to other cities or rural areas for substantial profit.<sup>24</sup>

Emission control in both new and in-use vehicles helped slow emissions increases, but many problems remained. China's vehicle-emissions standards are comparable to those in India, the Philippines, and Indonesia, but lag behind those of most developed nations by nearly a decade.<sup>25</sup> Compared with the United States, China's current limits (Euro II) are 26 percent higher for carbon monoxide, and more than twice as high for hydrocarbons. Enforcement of emission standards in China also has been poor. It is often easy for vehicles to pass inspections because inspections are not very strict and some drivers just pay for an inspection license.<sup>26</sup>

### 3.3. Alternative Fuel Vehicle Program

In order to significantly lower pollution from vehicles and reduce oil dependency, in April 1999, twelve Chinese cities began participating in the program "National Clean Vehicle Action" that introduced alternative fuels, in particular compressed natural gas (CNG) and liquefied petroleum gas (LPG). By 2002, the Ministry of Science and Technology had invested 50 million RMB (US\$6.1 million), and local governments and enterprises had invested billions more RMB in the program (Zhang, 2002).

CNG and LPG vehicles and stations increased rapidly in some demonstration cities (see Figure 3). By the end of 2002, the number of CNG and LPG vehicles increased to 153,000 and refueling stations reached 486 in 12 demonstration cities (CATARC, 2003). Eight other cities joined the program and had 12,500 CNG and LPG vehicles by 2002. More than 80 percent of taxis in Shanghai and 50 percent of buses in Beijing can use CNG/LPG (Hou, et al, 2002). However, the CNG/LPG technology is relatively primitive. The majority of China's alternative vehicles are retrofitted; in 2002 only 16 percent were new vehicles (Zhang, 2002).

China also has promoted ethanol-based and methanol-based fuel vehicles on a pilot basis in several cities.<sup>27</sup> China is demonstrating ethanol-based fuel vehicles in five cities in Henan, Jilin, and Heilongjiang, areas rich in corn production, a move designed to create a new market for surplus grain and to reduce consumption of petroleum. Three plants producing denatured fuel ethanol from corn are being constructed. The demonstration of methanol-fueled vehicles is occurring in Taiyuan, the capital city of Shanxi Province, which is rich in coal resources. Ninety-two methanol-fueled mini-buses have been used for several years in Taiyuan, and one methanol engine was approved for production. Shanxi plans to have as many as 5,000 methanol-fueled buses on the roads by 2006.<sup>28</sup>

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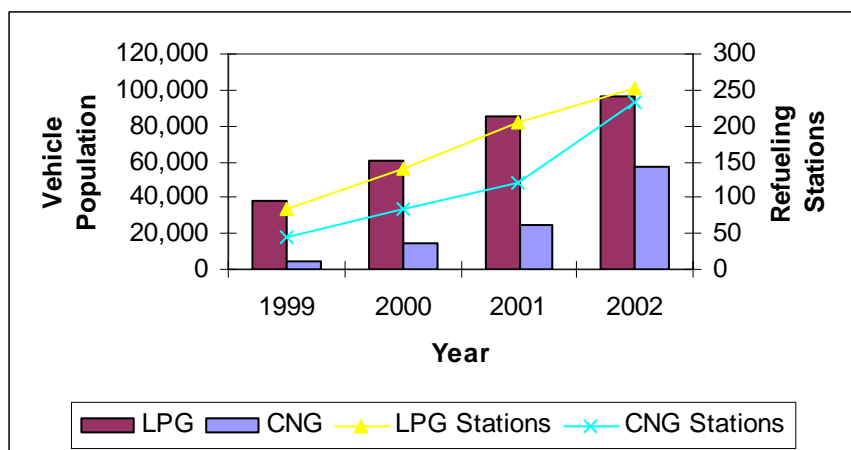
<sup>24</sup> XingCai, October 11, 2004. see [www.qiche.com.cn](http://www.qiche.com.cn).

<sup>25</sup> In compared, Euro I was put into effect in Europe in 1992, Euro II in 1996, Euro III in 2000, and Euro IV is planned to be implemented in 2005.

<sup>26</sup> Interview with a SEPA official, July 2002, Beijing.

<sup>27</sup> Ethanol is an alcohol-based alternative fuel produced by fermenting and distilling starch crops that have been converted into simple sugars. Methanol can also be used to make MTBE, an oxygenate which is blended with gasoline to enhance octane and create cleaner burning fuel.

<sup>28</sup> China uses methanol for cleaner fuel, *People's Daily*, October 11, 2001.



Source: CATAC 2003.

Fig. 3 Alternative Fuel Vehicles and Refueling Stations in China

Problems have arisen in the process of moving to alternative fuel vehicles. First, progress in promoting alternative fuel use has been limited. AFVs accounted for only 0.65 percent of the total vehicle population in China in 2002. The current Clean Vehicle Action Program focuses on niche markets for taxis and buses; there is no AFV market for individual consumers. The ethanol demonstration has not been effective because of the high cost of ethanol fuel, low fuel efficiency, and insufficient availability of fuel refueling stations.<sup>29</sup> In addition, the AFV program has focused on the number of clean vehicles rather than the actual use of alternative fuels. This has led cities to pay attention to the number of vehicles retrofitted to use LPG or CNG, but ignore whether the changed vehicles actually used LPG or CNG. Even though in 2002 there were 32,000 and 37,000 taxis capable of using LPG in Beijing and Shanghai, respectively, less than 10 percent of them actually did so (CATAC 2003).<sup>30</sup>

Second, the experience of demonstration cities shows that simple conversion to LPG or CNG does not necessarily mean “cleaner” vehicles. The cleanness of vehicles depends on emission levels, which are not only influenced by what kind of fuel vehicles use but also the emission control technology.<sup>31</sup> Currently around 84 percent of LPG and CNG vehicles (in particular taxis) are retrofitted with low emission control technology; some cannot even meet Euro I emission standards. Research conducted by Tsinghua University and SEPA on motor vehicle pollution control in Beijing found that the

<sup>29</sup> Interview with an official from MOST, July 2002, Beijing.

<sup>30</sup> Author’s own investigation with taxi drivers in Beijing and Shanghai, June 2002 and October 2003.

<sup>31</sup>LPG or CNG fueled vehicles have three levels of technology. The first generation technology can improve emission levels compared to the same technology in traditional gasoline vehicles, but cannot meet Euro I standards. The 2<sup>nd</sup> generation technology uses electronic control-mixing chambers, closed loop control, and three-way catalyst (TWC) equipment, and can meet Euro II emission standards. The 3<sup>rd</sup> generation technology adopts electronic injection (EPI), matching closed loop control, and dedicated TWC equipment. Almost all are dedicated vehicles that can meet Euro III or Euro IV standards.

environmental improvements from alternative fuel programs is not obvious (Fu and Yuan, 2001).

Third, insufficient availability of refueling infrastructure for AFVs slowed down AFV development. The program did not pay attention to the availability of high-quality alternative fuels and the construction of refueling stations at the early stage of program implementation.<sup>32</sup> The high cost of building LPG or CNG stations is a barrier to infrastructure development. The government provided subsidies for initial AFV retrofitting and infrastructure construction, but there are no tax benefits or other economic incentives for consumers to use AFVs.

### **3.4. Electric Vehicle R&D Program**

The Chinese government started to support R&D on electric vehicles in the early 1990s, and initiated a comprehensive electric vehicle program under the National High-Tech R&D Program for China's Tenth Five-Year Plan period (2001-2005). Through this program, the Chinese government hopes China could leapfrog over conventional vehicle technology and enhance the ability of China's auto industry to compete internationally.<sup>33</sup> The national government has provided 880 million yuan, or U.S.\$106 million (Cropper, 2002). Including investments made by local governments and enterprises, the total investment was RMB2.5 billion. The program focuses on promoting three kinds of clean vehicle technologies: commercialization of battery electric vehicles, large-scale production of hybrid vehicles, and R&D on fuel cell prototypes.

Major auto producers are leading R&D on electric vehicles. The Shanghai Automotive Industry Corp. plans to have its third-generation prototype of a fuel cell Start car by 2005 based on its Santana 2000 model.<sup>34</sup> Beijing, Wuhan, Weihai, and Tianjin are listed as demonstration cities for battery electric vehicles and Beijing will test 20 battery electric buses in 2004 and will establish a 1,000 battery electric bus fleet for the 2008 Olympic Games.<sup>35</sup> Tsinghua University and Beijing Green Energy Corporation are working on hybrid buses.

The move to clean vehicle technology has also generated interest among international auto giants and international funding organizations. A fuel cell concept vehicle, the Phoenix, was developed in 2002 by the Pan Asia Automotive Technology Center, a joint venture of GM and Shanghai Automotive Industry Corporation.<sup>36</sup> With U.S.\$12 million from the Global Environmental Fund and the United Nation Development Program and other funds from Chinese national and municipal governments and the private sectors, Beijing and Shanghai will purchase and operate six fuel cell buses each and build hydrogen fuel stations in 2006-2007. This project aims to demonstrate the technical and commercial viability of a small fleet of fuel cell buses and accumulate knowledge and experience to allow for cost-reduction and the introduction of fuel cell buses to ten cities from 2007 to 2015.

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<sup>32</sup> Interviews with officials in the Clean Vehicle Action Office, Beijing, July 2002.

<sup>33</sup> Xu Guanhua, Minister of the MOST, speech at the National 863 High-Tech R&D Program for Electric Vehicles, September 21, 2001.

<sup>34</sup> See <http://www.automarket.net>, August 12, 2002.

<sup>35</sup> See <http://www.chinafcv.org>.

<sup>36</sup> See <http://www.chnaev.org>, May 26, 2004.

Some are skeptical about the program and are not sure whether China can really catch up to the world-level advanced technology, because China still faces a large gap with industrialized countries in R&D on advanced clean vehicle technology.<sup>37</sup> Some developed countries and auto giants already have spent billions of dollars in R&D on fuel cell vehicle technology. About 150,000 hybrid vehicles have been sold worldwide since Toyota and Honda introduced hybrids in the late 1990s.<sup>38</sup> The huge production cost of electric vehicles and low R&D capability in auto technology are significant barriers to the development of fuel cell vehicles in China.

### **3.5. Fuel Economy Standards**

China's State Council approved the country's first automobile fuel efficiency standards in October 2004 in a move to keep soaring oil consumption in check, reduce vehicle emissions, and ensure that foreign car makers bring their latest technology to China. The new fuel efficiency standards apply to all new cars, vans, and sport utility vehicles. The first phase will take effect in July 2005, with a stricter second phase starting in 2008. The fuel economy standards require 32 different car and truck weight-based classes to achieve between 19 and 38 miles per gallon (mpg) by 2005, and between 21 and 43 miles per gallon by 2008.

The new standards are more stringent than the U.S. standards, but less strict than the voluntary standards in Europe. China's standards require the national car fleet by 2008 to be 15-20 percent more fuel-efficient than the current U.S. fleet—with particularly tough restrictions on sports utility vehicles. Only 79 percent of U.S. car sales and 27 percent of U.S. light truck sales currently meet China's 2005 standards, and only 19 percent of car sales and 14 percent of truck sales currently meet China's 2008 standard.<sup>39</sup> In addition, the American standards are fleet averages while the Chinese standards are minimums for each vehicle.

While smaller vehicles can meet the first phase standards with few or no changes, standards for heavier vehicles may require firms to invest in research and development. Even though there may be no problem for joint ventures to meet the first phase standards, the new standards could encourage foreign car manufacturers to bring better technology into China, including hybrid technology.

## **4. Policy Analysis**

### **4.1. Limiting privately-owned vehicles is not a practical approach, but vehicle use can be reduced**

It is argued that China should limit the privately owned vehicle population in order to avoid going down the same path as developed countries in vehicle development. However, the growing importance of the booming automotive industry to the national economy, as well as to local governments' fiscal revenues and employment, naturally

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<sup>37</sup> Interviews with auto manufacturers, June-August, 2002, China.

<sup>38</sup> Hakim, D., "Hybrid Cars Are Catching On," *New York Times*, January 28, 2003.

<sup>39</sup> China's Fuel Efficiency Rules will Exceed America's, *Quickchange*, October 13, 2004.

lead policy-makers to think twice before adopting such an approach. There is little sign that the Chinese government is ready to limit the growth of its car market. In fact, the nation has invested enormous amounts of capital and designed national policies for this sector in order to stimulate demand and promote economic growth. Driving has become a middle-class status symbol, and demand for vehicles has increased significantly as noted earlier. As General Motors Chairman and CEO Rick Wagoner put it in November 2003: "The Chinese are car crazy."<sup>40</sup>

Shanghai is the only city in China that limits the use of vehicles by restricting the number of registered vehicles, which it has done since 2000. The city limits the number of license plates it issues and prices them at auction. In 2003 Shanghai issued 53,068 licenses at a price of 35,000-40,000 yuan each (\$4,225-\$4,830).<sup>41</sup> As a result, the number of locally registered cars in Shanghai is less than in Beijing; vehicle numbers remain below 1.4 million although some residents may go to nearby cities to buy their cars. Even with limits on licensing, Shanghai's privately owned vehicles increased from 7,000 to 200,000 over the past 4 years.<sup>42</sup> Shanghai's mayor announced in July 2003 that Shanghai would gradually loosen restrictions on the purchase of private vehicles in the long run but further restrict the use of cars in downtown areas.

Beijing failed to follow such model due to strong opposition from industry and consumers. In September of 2003, the Beijing municipal government proposed to limit privately owned vehicles by charging license fees as one of ten measures to deal with serious traffic congestion in Beijing.<sup>43</sup> This proposal met strong opposition from the automobile industry and consumers, leading to heated debates on websites and in newspapers. In late October, the Beijing municipal government cancelled the proposal and promised to continue to encourage private vehicle consumption. Similar discussions also occurred in other cities, such as in Guanzhou and Chengdu, but none have moved forward.

Limiting personal ownership of private vehicles is not a practical approach at this moment, but vehicle use can still be reduced. Compared to other large cities in the world, the central problem in Chinese cities is not the number of vehicles but the number of vehicles in use everyday. I conducted a simple calculation comparing the vehicle population and the number of vehicles in use based on fuel consumption. Assuming comparable fuel efficiencies, in 2001, the usage of China's vehicles was 5.15 times greater than in the U.S., 1.49 times greater than in Japan, and 2.31 times greater than in France. The number of vehicles on the road in Beijing is almost the same as in New York and more than in Tokyo, even though New York and Tokyo have much higher vehicle populations. The major reasons for such differences include better and more convenient public transportation systems and high parking fees for downtown areas in Tokyo and New York. Beijing and Shenzhen have recently proposed charging higher fees for downtown parking.<sup>44</sup>

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<sup>40</sup> Ben Dolven, *The Great Car Crush*, Nov. 27, 2003

<sup>41</sup> Beijingers Go Car Crazy, *China Daily*, August 6, 2003.

<sup>42</sup> *Jiefang Daily*, Feb 11, 2004.

<sup>43</sup> Ten Measures for Beijing's Traffic Congestion, available at Beijing Environmental Protection Bureau website, <http://>, September 24, 2003.

<sup>44</sup> *Nanfang Urban Daily*, January 19, 2004.

## 4.2. Public Transportation

Most large cities depend on the public transit system to restrict car use, for example, 90 and 80 percent of people in Hong Kong and Washington, D.C. take public transit for working and shopping. For a long time, China's city transportation heavily relied on buses and bicycles. However, due to the rise in automobiles, commuters in large cities such as Beijing and Shanghai have increasingly depended on taxis and private cars. The share of individuals using the public transit system in Beijing fell to 24 percent in the 2000s from 70 percent in the 1970s.<sup>45</sup> The bicycle population in urban China decreased from 182.1 per hundred households in 1998 to 142.7 in 2002.<sup>46</sup> The percentage of people who bike to work in Beijing has decreased to 20 percent from 60 percent ten years ago.

The inconvenience and slowness of the public transit system is a barrier to greater use of public transportation systems. Beijing has three metro lines, with a total length of 100 km and fewer than 100 stations, while New York has 30 metro lines, with a total length of 411 km and 468 stations.<sup>47</sup> Beijing's public transit is highly dependent on ground buses. By the end of 2002, Beijing had 21,049 buses with 739 routes, accounting for 75% of Beijing's public transit system. Due to bad urban planning and because there is no right of way for public transit vehicles, public buses are among the slowest traffic vehicles and even contribute to traffic congestion.

Major cities such as Beijing and Shanghai made great efforts to build elevated ring roads and urban expressways and metro systems to enhance public transit capacity and to reduce traffic congestion. Beijing proposed selecting private investors for urban road infrastructure through a bidding format, in return for 25 years of operating rights. Beijing's 2008 Olympics and Shanghai's 2010 World Exposition are creating high pressure for Beijing and Shanghai to build better public transit systems. Beijing will invest 35 billion yuan (US\$4.2 billion) in 2004 and build a 130km-length new highway, 11 rapid road projects, 28 projects for urban road construction and 2 transfer stations.<sup>48</sup> It also will invest 180 billion yuan (US\$21.7 billion) on traffic improvement before 2008. In addition, local governments began to encourage private investment in transportation infrastructure as a means of financing operations and expanding new and existing facilities.

Bus rapid transit (BRT) was developed in the United States and is viewed as an important transportation innovation because it can achieve the capacity and economic development potential of rail, but at a fraction of the cost and with low emissions (e.g., Sperling and Clausen 2002; Vincent 2003). Rail lines in urban areas cost over \$100 million per mile in developing countries, whereas BRT costs less than one-tenth as much (Sperling and Clausen 2002). BRT achieves high speed by operating with exclusive rights-of-way, fast loading and unloading by elevating platforms to the same level as the bus floor, and collecting fares off board. BRT also has frequent and all day service with intelligent transportation system technology, and a cost-effective transit alternative that can help improve air quality and reduce congestion. A successful example of bus rapid transit in a developing country is in Curitiba, Brazil (Sperling and Clausen 2002). A growing number of cities around the world, such as Quito, San Paulo, Nagoya, Ottawa,

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<sup>45</sup> <http://house.sina.com.cn>, January 16, 2004.

<sup>46</sup> Disappearing Bicycles, *Xinhua Net*, Dec. 9, 2003,

<sup>47</sup> Chong Gang, <http://www.qiche.com.cn>, April 11, 2003.

<sup>48</sup> *China News Network*, <http://finance.sina.com.cn>, Feb 3, 2004.

and Pittsburgh, are now using BRT. With the support from the Energy Foundation and local governments, Beijing, Shanghai, Xian, Chengdu, Kunming are conducting a pilot BRT program.

### **4.3. Great Potential to Reduce Emissions from Conventional Vehicles**

Reducing emissions from each individual vehicle is another way to reduce total vehicle emissions. America's experience with vehicle emission control over the past decades shows that an effort to control conventional vehicle emissions can be cost-effective. With Federal standards for exhaust emissions in effect for decades in the U.S., both HC and CO have been reduced by 96 percent in passenger cars since the 1960s, and NOx emissions have been cut by 76 percent in cars over the same period (Ross et al 1995). Similar reductions have occurred for light trucks. Even though vehicle miles traveled increased by about a factor of 2, total automotive emissions declined by roughly 50 percent nationwide.

Powerful new technologies made these reductions possible. Most noteworthy are the catalytic converter and closed-loop engine controls; the latter includes sensors before and after the engine proper, and computer analysis of the information leading to real-time control of fuel injection, with the principal objective being to maintain the right chemical balance of fuel and air. Thus, cleaner vehicle technologies do exist that can reduce vehicle emissions substantially. The challenge for China is to get those technologies in place in vehicles as quickly as possible (Walsh 2003).

China is behind in conventional vehicle emission control and there is great potential to reduce emissions from conventional vehicles given the U.S. experience. An MIT study concluded that in the next decade, improved conventional technologies will be a cost-effective choice for China (Drake 2002). Technologies that can meet international emission standards are available to multinational companies, which are the technology providers for China's joint ventures. Ford believes that there is no technological difficulty for it to meet high emission standards even approaching "zero" emissions.<sup>49</sup> Given current high profit margins, joint venture companies have the capability to produce cleaner vehicles even while maintaining or lowering current price levels. In addition, it is much more effective to control producers than consumers due to their huge difference in numbers.

### **4. 4. Fuel quality is the key to meeting emission standards**

Meeting emissions regulations requires both vehicle emission control technologies and high quality fuel (Walsh 2003; He 2003). Current gasoline quality in China cannot meet the requirements of strict emission control, due to relatively high benzene, olefin and sulfur content. Sulfur in fuels damages the pollutant discharge control system and electronic sensor system in automotive vehicles. With regard to diesel vehicles, the problem may be even more severe as high sulfur fuels can preclude the use of advanced PM and NOx control technologies. Even though Beijing is making great efforts to implement Euro III standards by 2005, the availability of high quality fuel is a challenge. In rural areas, the fuel quality is even worse.

In China, the current standard sulfur level for gasoline is 800 ppm, compared to 500 ppm required by Euro II, and 150 ppm for Euro III. In Europe, sulfur content will be

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<sup>49</sup> Interview with Ford researchers, January 23, 2004, Ford Headquarter, Dearborn.

reduced to 50 ppm by 2005, and further reduced to 10 ppm in the future; in the United States, it will soon reach 30 ppm (Walsh 2003). China's sulfur content standard in diesel oil is 2,000ppm, while Euro III requires 350 ppm and Euro V 10 ppm.

High olefin content reflects the fact that China's refineries use catalytic cracking in their secondary processing equipment. More than 80 percent of the country's gasoline is made through this process. Given the limited ability of China's refining infrastructure to handle and process high-sulfur crude oil from countries in the Middle East, China will increase its imports of lower sulfur crude oils from countries such as Indonesia, Malaysia, Libya or from the North Sea.

The Energy Foundation recently funded a study to examine what needs to be done with China's refineries to increase fuel quality. The study showed that refinery modifications are possible at reasonable cost. Converting fuels to meet Euro II standards across the country by 2005 is feasible at a relatively low cost of less than \$0.01 per gallon for gasoline and less than \$0.02 per gallon for diesel. The incremental cost per gallon of converting to Euro III beyond Euro II is \$0.0029 and \$0.0012 (Walsh 2003).

Government policy is necessary to encourage industries to improve transportation fuel quality. First, fuel quality standards and a monitoring system coordinated by relevant agencies are required. Second, the government can set up a schedule for fuel quality improvement and standards, which can provide a clear timetable for enterprises to formulate their technology development strategies. Third, some economic incentive policies such as taxation policies can be established to give enterprises additional motivation to improve fuel quality. Germany and Hong Kong both used taxation policy to improve their fuel quality within a short time (He 2003). Finally, enforcement of standards can be strengthened to verify fuel quality during the fuel distribution process.

#### **4.5. Farm Vehicles—weak point in China's vehicle emission control**

China's output of farm vehicles in 2002 reached 2.59 million units, according to statistics from the Farm Vehicle Industry Association.<sup>50</sup> In Beijing, there are about 200,000 farm vehicles, accounting for one-tenth of all vehicles. Beijing had 4,731 registered tri-cars (small three-wheeled cargo vehicles used in rural areas) in 1996, and this figure jumped nearly 10 times by 2002 to 44,945 tri-cars.<sup>51</sup> These vehicles are used by millions of small businesses that transport farm products, construction materials, and locally manufactured products; and are the principal mode of motorized travel in rural areas.

In 2001, the then State Economic and Trade Commission, State Development and Planning Commission, and the State Environmental Protection Administration (SEPA), issued a notice on Farmer Vehicle Standards in Scrapping Old Vehicles,<sup>52</sup> which specified that the maximum lifetime of farm vehicles to be from 6 to 9 years. In January 2002, SEPA issued the first phase standards for new farm vehicles manufactured after October 2002 and in December 2003 SEPA issued the second phase standards for new farm vehicles manufactured after January 2004. Vehicles that cannot meet standards are not allowed to produce.

Even though SEPA issued emission standards for new agricultural vehicles, for most standards, there are no emission control measures. Many farm vehicles are old; for

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<sup>50</sup> *CBU-Auto*, Vol. 4, No. 8, March 6, 2003.

<sup>51</sup> *Beijing Environment, Science and Technology Update*, March 21, 2003.

<sup>52</sup> State Economic Trade and Resource (Guojingmao ziyuan) document, No. 234, 2001.

example, over 81% of tractors have been used for 10 years or more and less than 10% have regular maintenance for air, fuel and oil filters. It is estimated that only 18% of the 200,000 agricultural vehicles and tractors in rural Beijing meet the municipality's emission standards.<sup>53</sup> Particulate emissions from farm vehicles, many of which have only single-cylinder diesel motors, are 6 to 10 times the level of a gasoline automobile. This suggests that particulates emitted from farm vehicles equal the emissions from all other vehicles driving in Beijing (Beijing has 2 million vehicles).

It will be much more difficult to control farm vehicle emissions than car emissions, given lower farmer income levels and limited awareness of emission controls. Vehicle emissions from farm vehicles are not highly visible to high level leaders, but their effects on air quality are huge. Developing innovative cleaner vehicles for rural use should be given high priority.

#### **4.6. Hybrid vehicles merit promotion**

Although China has begun research and development on the use of hydrogen as a transportation fuel, the transition to hydrogen cannot occur quickly. Conventional gasoline vehicle technology is very difficult to replace because of large sunk investments in vehicle production facilities and an extensive gasoline infrastructure. The incremental benefits of hydrogen to consumers will likely be small relative to “conventional technology” vehicles and fuels, even if the public good benefits such as cleaner air and energy security are much greater. Hydrogen is inherently expensive to transport, store, and distribute—all significant disadvantages for a transportation fuel. Furthermore, the introduction of hydrogen requires the simultaneous deployment of hydrogen vehicles and development of a hydrogen infrastructure (Melaina 2003). A hydrogen refueling infrastructure would be capital intensive in absolute terms, although estimates have suggested that per vehicle costs could be as low as \$300-\$700 per vehicle once economies of scale and production have been attained (Ogden et al, 1999). The cars themselves will most likely be expensive, at least initially, and especially if they are fuel cell vehicles. For these and other reasons, it is not reasonable to expect significant commercialization of hydrogen vehicles in the near future in China.

Hybrid electric vehicles (HEVs) combine the internal combustion engine of a conventional vehicle with the battery and electric motor of an electric vehicle, resulting in twice the fuel economy of conventional vehicles and lower emissions compared to conventional vehicles. This combination offers the extended range and rapid refueling that consumers expect from a conventional vehicle, with a significant portion of the energy and environmental benefits of an electric vehicle. There is no need for new infrastructure and it is relatively inexpensive. The inherent flexibility of HEVs enables them to be used in a wide range of applications, from personal transportation to commercial hauling. The recharging system from braking energy during stop-and-go low speed urban driving saves energy; this makes hybrids or partial hybrids of great value for fuel economy.

Some multinational companies have begun testing hybrid vehicles in China. Toyota Motor, the world's largest producer of gasoline-electric hybrid vehicles, will work with China's First Auto Work Group to assemble its Prius hybrid cars in China by the end of

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<sup>53</sup> *Beijing Youth Daily*, February 10, 2003.

2005, the first time Toyota will manufacture hybrid cars outside of Japan.<sup>54</sup> General Motors Corp. will build a hybrid bus in China with its partner, Shanghai Auto Industry Corps, and study the feasibility of mass-producing the vehicles in China.<sup>55</sup> China has buses eight times more than the number in the United States. If these fleets were converted to hybrid vehicles, it would be a great contribution to energy saving and emissions reduction. DaimlerChrysler AG plans to test three hydrogen fuel-cell buses in Beijing in 2005.<sup>56</sup> Whether these expensive hybrid buses or cars will gain a market in China remains to be seen to producers and consumers. The Chinese government can provide appropriate incentive policies to encourage the introduction of hybrid and hydrogen technologies.

#### **4.7. Economic incentive policies for both consumers and manufacturers**

The high cost of advanced cleaner vehicles makes it difficult for these vehicles to be competitive with traditional automobiles. At the same time, solely relying on regulatory measures cannot resolve all enforcement problems. Partnership between government and industry, along with market-based incentive policies, are necessary measures to get auto manufacturers to become actively involved in moving to cleaner vehicles instead of passively following national regulations. The consumption tax reduction policy for vehicles that meet environmental standards ahead of national regulations and the partnership of government and industry in R&D on advanced vehicle technologies are good initial examples of such cooperation. However, such policies are still rare in China. For example, there are no preferential tax incentives for alternative fuel vehicles or infrastructure construction. Competitive pressure due to WTO accession and the opportunity to “leapfrog” technologically in the auto industry are motivations for auto manufacturers to move to cleaner vehicle technology. The Chinese government could establish incentives for such companies, and help China become a testing ground for new vehicles.

China’s price for transportation fuel is among the lowest in the world, about 30 percent of the gasoline price in France. China still has no taxes on transportation fuel, while more than seventy percent of the cost of gasoline in France, Germany, and the United Kingdom are in the form of taxes (Davis and Diegel 2003). Consumers in China are very sensitive to fuel economy. Qixue Institute conducted a survey on factors affecting car purchasing behavior in Beijing, Shanghai, and Shenzhen.<sup>57</sup> The survey finds that most buyers in China list vehicle price and fuel economy as the major factors affecting their decisions on which kind of cars to purchase. A fuel tax seems an obvious first step in reducing gasoline and diesel use. It is more effective than standards in controlling fuel consumption because it affects the miles driven by both new and in-use vehicles.

However, political factors can be a large barrier to implement the fuel tax. For example, China’s efforts to levy a tax on fuel consumption to replace road tolls and fees were not successful. A tax on fuel was included in the Amendments to the Highway Law,

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<sup>54</sup> Toyota in joint venture to build hybrid cars in China, *Bloomberg News*, September 16, 2004.

<sup>55</sup> Michelle Krebs, GM to build hybrid bus that will be studied in Shanghai, *Detroit Free Press*, October 11, 2004.

<sup>56</sup> *People’s Daily*, see <http://www.chinaev.org>, May 26, 2004.

<sup>57</sup> The survey report was available at <http://www.sina.com.cn>, September 22, 2003.

which was passed by the National People's Congress in November 1999. The fuel tax was viewed as the key element of the central government's revenue reform policy because it could transform the myriad of locally collected fees into centrally controlled tax revenues, and was therefore opposed by local governments.<sup>58</sup> Conflicting interests also occurred in different ministries regarding how the tax should be fine-tuned to reduce unexpected and undesirable financial burdens on users, especially those who frequently use vehicles, e.g., taxi drivers, and farmers who use gasoline or diesel for pumping water for crop irrigation.

Most Chinese consumers are first-time buyers of vehicles. Consumer education and training in advance are critical since many Chinese consumers have not formed habits of using traditional vehicles. This provides a great opportunity for China to establish a market for cleaner vehicles since the private vehicle market is not well established.

## 5. Conclusions

China will continue to motorize rapidly but measures must be taken to reduce the environmental impacts posed by motorization. The government can play a central role in guiding the direction of motorization through regulation, partnerships between government and industry, and adoption of market-based incentives. A consistent and integrated sustainable transportation policy should be adopted to balance short- and long-term goals to move towards cleaner vehicles.

In the short-term, efforts to control conventional vehicle emissions are necessary and can be cost-effective based on the U.S. experience with vehicle emission control. Controlling vehicle emissions at the production stage is an easier approach than managing the activities of millions of consumers. Although it is important to issue stricter emission standards to encourage industries to move quickly to catch up with European and American standards, it is more cost-effective and critical to ensure that vehicles comply with emission standards by improving effective enforcement, in particular for farm vehicles and motorcycles, and improving fuel quality. Fuel quality presents a great challenge to the effectiveness of the implementation of emission standards due to high sulfur content. It is economically feasible for China's refineries to provide higher quality fuel. Government should support efforts to increase fuel quality by advancing fuel regulations and economic incentives.

The growth of privately owned vehicles is inevitable along with income increases and falling car prices. Even though restricting privately owned vehicles is not a practical approach, vehicle use can be reduced. A convenient and fast public transportation system, high parking fees, a fuel tax, and better urban planning, can help reduce the use of cars. A bus rapid transit system should be promoted because it can meet the capacity and economic development potential of rail, but at a fraction of the cost and with low emissions.

There is high expectation for China to leapfrog to hydrogen vehicles to avoid the model of motorization of industrialized countries. However, a transition to hydrogen vehicles will not occur quickly and its development should be viewed as a long-term goal due to the huge cost and infrastructure requirements. Government policies and

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<sup>58</sup> "China will not start Fuel Tax in Near Future," *People's Daily*, May 3, 2002,

regulations should promote hybrid vehicles as a transitional technology because there is no need for new infrastructure and it is relatively less expensive. Economic incentive policies for both consumers and manufacturers are necessary to promote cleaner vehicles. This could also attract multinationals to use China as a testing ground for innovative cleaner vehicles. A new and thriving market for cleaner vehicles can be established through education and training of consumers before they form the same habits as in developed countries. A holistic approach, considering vehicle technology, fuel availability, and customer acceptance is critical for accelerating the transition to hydrogen vehicles.

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