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POLICY OUTLOOK

Driving Force

Energy and Climate Strategies for China's Motorization

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Deborah Gordon and Yuhan Zhang

SUMMARY

Just five years ago, no one anticipated China's phenomenal rate of motorization. While all signs had been pointing to significant growth in the country's vehicle fleet, recent projections are already out of date. Today, China is a driving force in global motorization. Future harmonious growth will depend on equitable and efficient measures that minimize the energy and environmental effects of China's burgeoning transportation sector.

The number of cars in China was projected to increase six-fold in the first decade of the new millennium. Analysts estimated that it would take at least two decades for China's automobile fleet to catch up to today's U.S. fleet.[1] And if *fast-paced* growth continued, China's total motor vehicle fleet was expected to be on par with America's fleet by 2030.

This reality did not materialize. Instead, China's motorization vastly exceeded all expectations. Between 2000 and 2010, the nation's car fleet grew by a factor of 20.

The total number of motor vehicles—cars, trucks, motorcycles, rural vehicles, and buses—ballooned from a projected 170 million to an estimated 270 million. Today, with its current vehicle fleet likely 60 percent larger than forecast just a few years ago, China has zoomed ahead of Japan and the EU nations and is poised to overtake the United States with its 250 million vehicles.[2]

China's vehicle growth is expected to continue, and possibly accelerate. Even if its annual gross domestic product growth rate declines from 10 to 7 percent, as projected by the International Monetary Fund and laid out in China's 12th Five-Year Plan, some 600 million vehicles could fill China's roads by 2030.[3]

China's unprecedented rate of motorization is a driving force of global proportions—one that has come to pass much sooner than expected. To consider the policy outlook vis-à-vis the surging size of China's vehicle fleet, it is helpful to recall China's transportation situation at the turn of the century, to look at a snapshot of where China's motorization is today, and to consider potential fleet growth by 2020 and 2030, tracing the boundaries for both slower and rapid economic expansion.

The sheer numbers of and future projections for China's vehicle fleet illuminate the energy and climate implications of China's on-road transportation, both at home and abroad. Oil consumption, climate change, and air pollution will be pervasive concerns that China must reconcile as it motorizes.

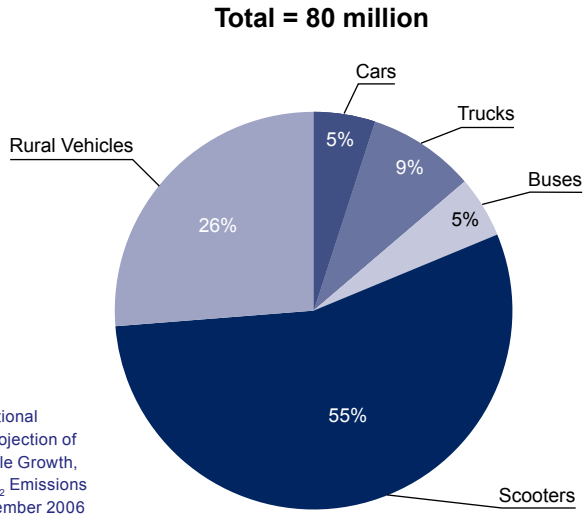
Effective policy tools will be critical for China to manage its burgeoning motor vehicle fleet. In this respect, many opportunities for advancing new transportation technologies and strategies hold great promise:

- Advance clean fuel technologies through research, demonstration, and deployment; more effective regulatory standards; and financial incentives. Targets of opportunity include low-emission petroleum refineries, sustainable biofuels, and renewable hydrogen fuels.
- Commercialize and deploy clean and efficient electric vehicles (EVs) that pair battery development with smart grid advances. Targets of opportunity include light-weight EVs to maximize efficiency and vehicle range, fuel cell technologies, and carbon capture and storage for cleaner coal-fired power generation for a growing EV fleet.
- Tighten fuel economy and vehicle tailpipe standards and enhance monitoring and enforcement mechanisms. Targets of opportunity include vehicles with near-zero greenhouse gas emissions, improvements in light- and heavy-duty vehicle energy efficiency, and uniform fuel quality standards.
- Implement fiscal transportation policies that promote clean, efficient transportation choices. Targets of opportunity include new fuel taxes, pay-as-you-go user transportation fees, private vehicle taxation, and clean vehicle incentive programs.
- Implement transit-oriented land use policies and invest in public transit. Targets of opportunity include investments to strategically expand public transit, road pricing, prioritization of non-motorized transportation, and integrated transportation and land use development.

Where China Was Headed: Vehicle Population Estimates From the 2000s

Of the 80 million motor vehicles on China's roads in 2000, just over half were motorized scooters and other two-wheeled vehicles (figure 1). Rural vehicles (RVs) accounted for a quarter of China's vehicle fleet. In 2000, cars and buses were an oddity, with each accounting for only 1 in 20 vehicles.[4] *Nonmotorized* transportation modes—walking and biking—which are not included in these counts or addressed in this report, were still the primary means of mobility in China into the early 2000s.

Figure 1. SNAPSHOT OF CHINA'S VEHICLE FLEET IN 2000



Source: Argonne National Laboratory et al., "Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO_2 Emissions Through 2050," December 2006

Ownership of private cars in China exploded from a scant 4 million to 19 million between 2000 and 2005. Still, motorized two-wheelers (scooters and motorcycles) outnumbered cars by nearly 4 to 1.[5] RVs—an estimated 100 million in all sizes, shapes, and conditions—continued to significantly outnumber cars (figure 2).

Figure 2. EXAMPLES OF RURAL VEHICLES IN CHINA

Source: Wikimedia Commons, http://commons.wikimedia.org/w/index.php?title=Special%3ASearch&redirs=1&search=china+rural+vehicles&fulltext=Search&ns0=1&ns6=1&ns12=1&ns14=1&ns100=1&ns106=1&uselang=en

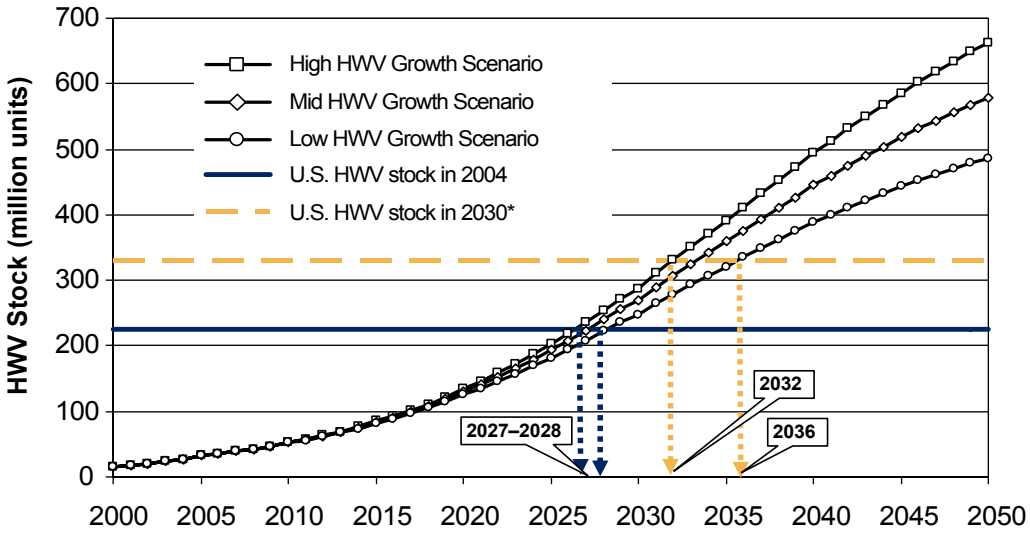
The production of RVs in China increased annually by 38 percent between 1985 and 2000.[6] This rapid RV growth, which outpaced that of urban cars, was partly the result of the much more lenient requirements and regulations for RVs compared with cars. The growth of RV production in China slowed after 2000, probably as a result of the slower growth in the incomes of rural families and new stringent regulatory conditions for using RVs.[7]

A pronounced shift from two-wheelers to four-wheeled cars occurred as markets opened up, people moved from rural to urban areas, and incomes rose. Motorcycles and RVs offered transitional transportation because of their much lower prices. Increasing numbers of households turned to conventional cars as per capita income increased. Moreover, the government employed policies to encourage citizens to buy cars. Notably, in 2004, the National Development and Reform Commission (NDRC) issued the Policy on Development of the Automobile Industry, which encouraged private purchases of cars.[8]

In 2000, no one could fully anticipate the imminent and dramatic rate of motorization that lay ahead.

Although analysts anticipated an uptick in China's motorization, none could fully anticipate the imminent and dramatic rate of change that lay ahead. A report by the U.S. Argonne National Laboratory (ANL) in 2006 predicted China's vehicle fleet would more than double by 2010 (figure 3). ANL's intermediate growth projections included the addition of 22 million cars, 15 million buses and heavy trucks, 33 million scooters and motorcycles, and 20 million RVs on China's roadways.[9] ANL predicted that China's highway vehicle fleet would be on par with the U.S. highway vehicle fleet by 2030.[10]

Figure 3. PROJECTED HIGHWAY VEHICLE (HWV) STOCK IN CHINA, 2000–2050



* U.S. Energy Information Administration (EIA), 2006

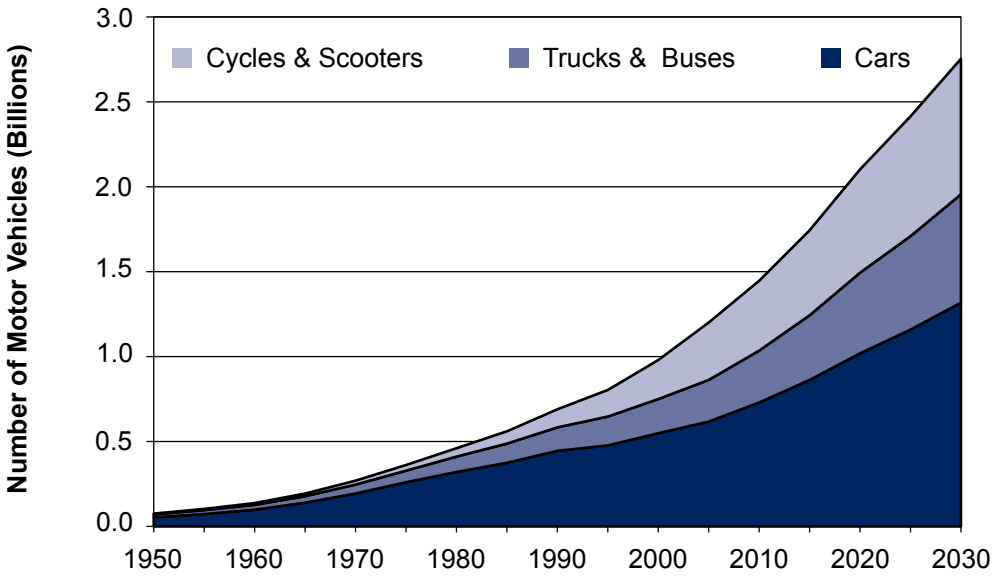
Source: Argonne National Laboratory et al., "Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO_2 Emissions Through 2050," December 2006

China's Energy Research Institute (ERI) of the NDRC likewise forecast vehicle growth using mid-2000 data and estimated that there would be more than 500 million total vehicles on China's roads by 2040. Still other estimates predicted that cars alone would reach 146 million as early as 2020.[11]

In *Two Billion Cars,* Sperling and Gordon charted the exponential ramping up of global vehicle ownership. China's rapid motorization was the primary factor in the predicted doubling of the world's number of vehicles, from 1 billion to 2 billion, in the 2020s (figure 4).[12] India, Brazil, and other large, fast-growing countries were also expected to experience rapid motorization. But China was to lead the way.

Rapid and extensive motorization will have a profound effect both within China and on the rest of the world.

Figure 4. GLOBAL VEHICLE MOTORIZATION, ACTUAL TO 2005 AND PROJECTED TO 2030



Source: Adapted from Daniel Sperling and Deborah Gordon, *Two Billion Cars: Driving Toward Sustainability* (New York: Oxford University Press, 2009)

These reports of China's unprecedented growth in number of vehicles have captured attention on the world stage. Experts agree that this rapid and extensive motorization will have a profound effect both within China and on the rest of the world.[13]

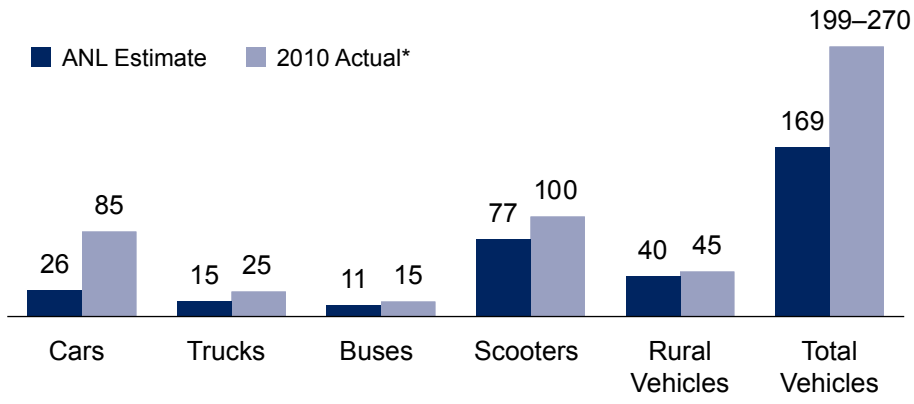
A Snapshot of China's Vehicle Population in 2010

Projections of the rapid growth in China's motor vehicle fleet could not have been more accurate—and yet further from the truth. The country's red-hot economy transformed its anticipated growth in motorization to a much steeper

rise by 2008, putting its vehicle fleet on a new trajectory by 2010. As a result, the actual situation today on its roads is far beyond where the experts expected it would be just five years ago.

At the close of the first decade of the new millennium, the size of China's motor vehicle fleet had soared beyond projections. The growth in private auto ownership was primarily responsible for pushing the country's vehicle fleet to a reported 200 million in 2010 (figure 5).[14] Although precise numbers are difficult to ascertain—especially for trucks, scooters, and motorcycles—China's actual vehicle fleet may exceed official counts. We put the 2010 figure at closer to 270 million when all motor vehicles are tallied.

Figure 5. CHINA'S MOTOR VEHICLE FLEET, 2010 (IN MILLIONS)



Note: ANL = Argonne National Laboratory.

• Actual 2010 figures were unavailable for trucks and scooters, so these figures have been estimated.

Source: ANL estimates—ANL 2006 and 2010 Actual—Traffic Management Bureau of the Ministry of Public Security

The sheer growth of vehicle ownership and use is a driving force for air pollution, climate change, oil consumption, and traffic congestion.

Related statistics for drivers and highways are keeping up with China's fast-paced motorization. In October 2010, the Ministry of Public Security disclosed that the number of legal drivers had reached 205 million, including 144 million automobile drivers. In 1999, the country had only 6,258 kilometers of highways; now it has 65,000 kilometers (and 3.7 million kilometers of paved roads). Its road system is poised to grow, whereas that of the United States has been largely built out. In 2009, the United States had 75,000 kilometers of highways and 6.5 million kilometers of paved roads. China is expected to surpass the United States with the world's most extensive highway system by 2012.[15]

The Future Growth of China's Vehicle Fleet

China faces an environmental dilemma. The sheer growth of vehicle ownership and use is a driving force for air pollution, climate change, oil consumption, and traffic congestion. Economic growth and public policies will be major factors in

determining how China's motorization evolves. Different nations subscribe to different motorization patterns (figure 6). The question is, which trajectory might China follow?

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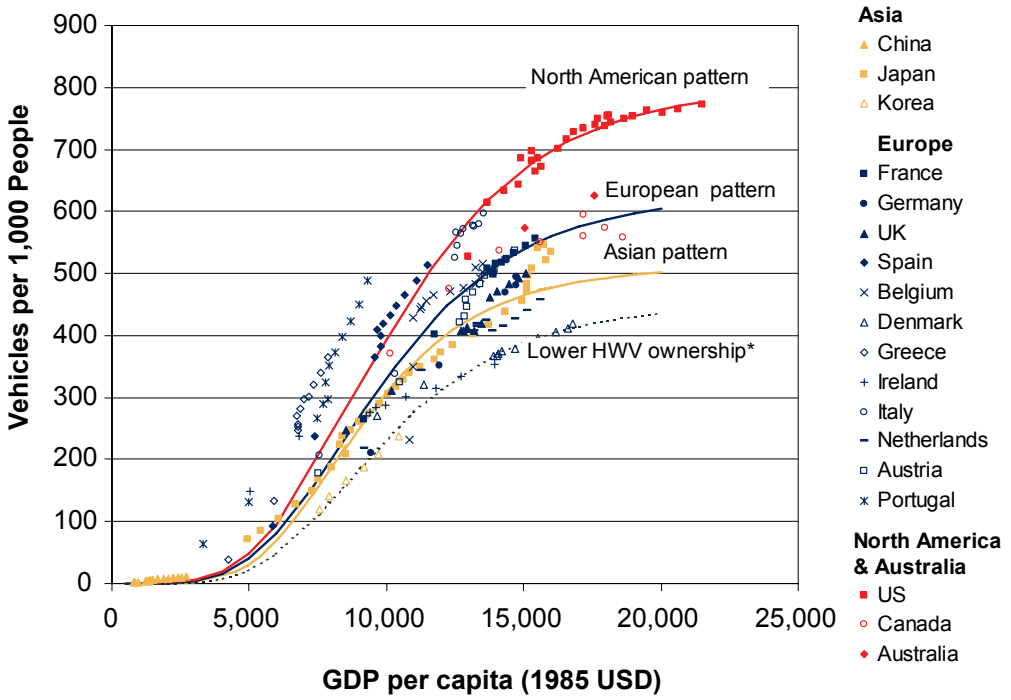
In 2010, China overtook Japan as the world's second-largest economy with the world's second-largest motor vehicle fleet. On a per capita level, China's current annual gross domestic product is reported at $4,200.[16] Though still low by global standards, it is significantly higher than the estimated $2,400 at which motorcycle ownership becomes common or the $3,600 at which car ownership becomes common.[17] Looking ahead, if China's economy expands by 7 percent annually, it is projected to overtake the United States as the world's largest economy in the 2030s, according to the International Monetary Fund.[18]

Figure 6. GROWTH TREND OF VEHICLE OWNERSHIP IN SELECTED COUNTRIES



* Lower highway vehicle (HWV) ownership is expected in countries with lower incomes, early stages of development, higher population densities, geographic constraints, and policies constraining vehicle ownership. China, as recently as 2005, had been located on this lower curve but is now between the Asian and European curves.

Source: Argonne National Laboratory et al., "Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO_2 Emissions Through 2050," December 2006

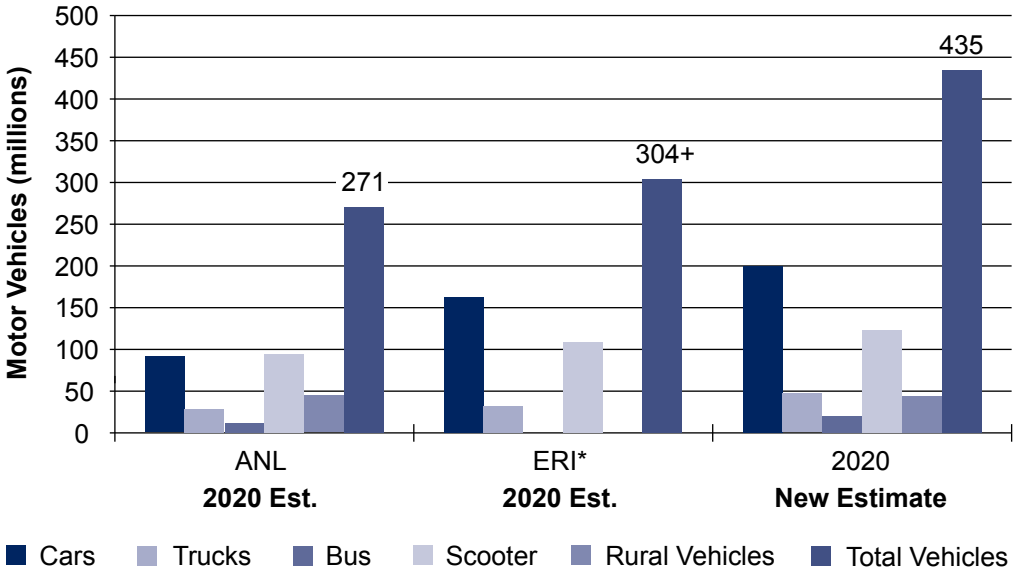
Another pressing factor influencing motorization is how rapidly China's cities will grow. At present, 45 percent of China's residents live in urban areas.[19] A 2008 McKinsey & Company report estimated that an additional 350 million people—more than the population of the United States—would move from China's rural areas to its cities by 2030.[20] Such a shift would mean that 219 cities in China would each have more than 1 million people by 2025.[21] Such migrations from rural to urban areas usually translate into higher household incomes,

which in turn encourage motor vehicle ownership and use. In Beijing, for example, residents bought 4.7 million cars in 2010—almost double the figure five years ago.

Although rural areas are losing residents, the number of autos in these areas has still been growing. The Chinese government has been promoting consumer spending on new cars. In 2010, a total of 18 million purchases of new cars and motorcycles were subsidized under the Sales of Autos and Motorcycles in Rural China Policy. RV purchase subsidies were discontinued as of January 2011.[22] This decision ends a policy started in 2009 to bolster RV demand at the height of the global recession.

China's current vehicle fleet is about as large as experts thought it would be in the early to middle 2020s. Double-digit economic growth, financial incentives to spur auto ownership, national policies supporting auto making as a pillar industry, and urbanization all played a role. New estimates for 2020 have accelerated growth by a decade, putting China's car ownership at 200 million by 2020 and the total vehicle fleet at more than 400 million (figure 7).

Figure 7. OLD AND NEW ESTIMATES OF CHINA'S NUMBER OF MOTOR VEHICLES, 2020



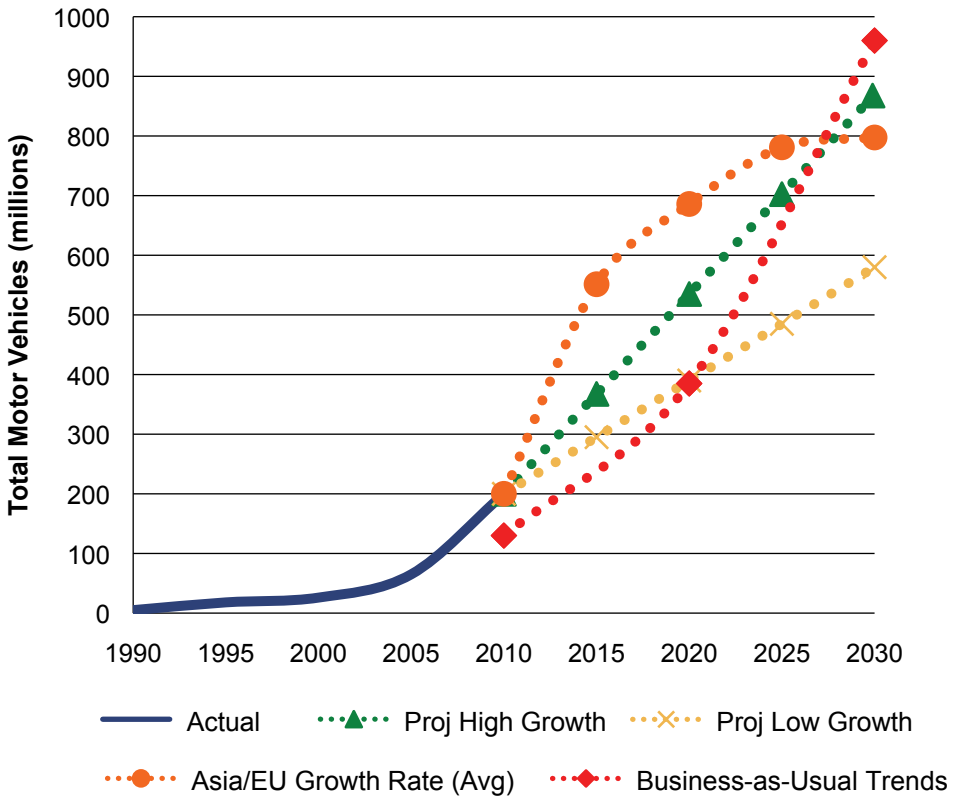
ANL = Argonne National Laboratory ERI = Energy Research Institute

* Business-as-usual estimates do not include rural vehicles and scooters and/or motorcycles in their projections.

Source: Development Research Center (State Council), Energy Research Institute (NDRC), and Institute of Nuclear and New Energy Technology (Tsinghua University), 2050 China Energy and CO_2 Emissions Report (Beijing: Science Press, 2009)

By 2030, motor vehicle projections diverge widely: China could see its vehicle fleet rise to 600 million or balloon to nearly 1 billion (figure 8). Vehicle growth will be determined by local and national policies, economic growth, and local conditions.

Figure 8. NUMBER OF MOTOR VEHICLES IN CHINA, ACTUAL TO 2010 AND PROJECTED TO 2030



Sources: Energy Research Institute projections, 2009, business-as-usual estimates; authors' estimates.

Strategic policies and sound transportation investments will be necessary to balance China's future urban mobility. Public transportation investments supported by transit-friendly development will play an important role in determining how urbanization affects motorization. In the next five years, 45,000 kilometers of new rapid rail is expected to connect every Chinese city with a population greater than 500,000 people. There are also targets to improve subway and light rail systems in cities that already have urban public transit systems. New transit systems are planned for at least ten cities, and planning is under way for six or more additional cities.[23]

Such mobility alternatives can moderate ownership and use of personal motor vehicles. A typical urban subway system in China can remove as many as 4 million autos and motorcycles from the road, whereas buses—including bus rapid transit systems—may obviate the need for 19 million more vehicles.[24] At a time when the number of personal vehicles in China is expected to nearly double, greater investment and reliance on public transit will be more important than ever to ensure growing urban mobility without auto-related congestion and pollution.

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What China's Phenomenal Motorization Means for Energy and Climate

Booming motorization in China has implications for energy security, climate change, air quality, and urban environments both at home and abroad. China's economy already depends more on oil imports from unstable sources than either America or Europe, with nearly 60 percent of its oil imported from regions such as the Middle East and North Africa.[25] China's oil demand is expected to increase in the foreseeable future, driven by its phenomenal vehicle fleet growth. Unrest in oil-producing nations raises the prospect of serious energy security concerns for nations with highly oil-dependent transportation systems. Increasing world oil prices—the price had topped $100 a barrel as of early 2011—also raise economic concerns about affordability for China's citizens and their demands for increasing motorization. With less than 2 percent of proven world oil reserves, China will want to think strategically about its dependence on oil imports from unstable sources.[26]

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Climate change and regional air quality are related issues that will concern China as its motor vehicle fleet grows. Already, Beijing and other Chinese cities are combating serious air pollution. Hazy cities, increased morbidity and mortality from air toxins, and reduced crop yields from air pollutants will be exacerbated by rising fuel production and vehicle tailpipe emissions. On a national scale, climate change is expected to bring damage due to rising sea levels, more frequent droughts and effects on food production, increasingly severe storms that may damage newly built infrastructure, more outbreaks of disease, and a host of other hardships to which the country may or may not easily adapt. Reducing emissions will be important, but even the cleanest conventional vehicle fleets that meet tailpipe standards still contribute more than half of total air pollutant and climate change emissions.

Urban forms will change as China's cities grow. Although American-style suburbanization may not be replicated exactly—given high population densities and strict boundaries between urban and rural areas—China's urban areas themselves are expected to keep expanding outward. As witnessed in the world's megacities, cities and cars are incompatible, causing disabling congestion, pollution, illness, and accidents.

Alternatives to cars and other motor vehicles—bus rapid transit, rail mass transit, bicycling, walking, and intermodal freight movement—will be key. These mobility options must be central in urban development to combat the predominance of cars and trucks.[27]

Strategies for Managing China's Burgeoning Vehicle Fleet

Strategic planning and policy directives are crucial for dealing with China's expanding motor vehicle fleet. In particular, China would benefit from the development of a less oil-dependent transportation system. The United States, Japan, and the EU member states are severely constrained by the fact that their inefficient, oil-dependent transportation systems are mature and only able to change very slowly. The United States and other developed countries have not made smart technology and policy choices during the past three decades, enticed by cheap oil that locked in gas-guzzling vehicle fleets. Thus, when oil prices spike or as conventional oil supplies dwindle, the Western economies stand in harm's way, economically and physically.

China is in a much more fortunate position. As the country grows, it stands at the crossroads of burgeoning motorization. What form this motorization takes will have everything to do with the policies China adopts. In these times of constrained, expensive, and unstable oil supplies, safety concerns about nuclear power, and foreboding climate disruptions, China would benefit tremendously from technological and policy innovations that move it beyond conventional vehicles, fuels, and mobility.

Avoiding the mistakes of the West will be paramount for China's equitable and efficient growth and security. Thus, policy makers with keen eyes toward the energy and environmental sustainability of vehicle, fuel, and land use decisions could avert the difficult resource and economic situations its global neighbors will continue to deal with for decades to come.

China is well-positioned to chart a different course. Policy tools are available to manage China's motor vehicle fleet. Opportunities for advancing new transportation strategies include the five approaches outlined below.

First, China needs to spur innovation on clean vehicle and fuel technologies. Conventional internal combustion engine vehicles and petroleum fuels have dominated transportation for more than one-hundred years. Despite their widespread appeal, today's cars pose tremendous risks for national and global security. There will be handsome rewards in international markets for the development of ultraclean and efficient vehicle and fuel technologies. Efficiency gains and emissions reductions will be key in all transportation-related industries. A little waste and environmental damage will add up quickly as China's motor vehicle fleet grows. Examples of priority policies that could help China make progress include (1) the adoption and enforcement of Euro VI emission standards for cars, trucks, and buses[28] (these standards are due to be implemented in Europe in 2014); (2) the best available control technologies on new and exist-

ing petroleum refineries through the use and enforcement of stationary source pollution regulations.

Second, China needs to rapidly commercialize EVs and advance smart electric grids. It will be crucial to maintain progress on rapid EV commercialization and deployment. These breakthroughs pair battery development with smart grid advances. The development of light-weight vehicle materials—another breakthrough—will be beneficial to maximize EV efficiency and range. China may also want to venture into vehicle fuel cell development. And it will need to undertake demonstrations to test the efficacy and secure containment from carbon capture and storage. This will facilitate cleaner coal-fired power generation to fuel a growing EV fleet and protect against major climate and air pollution ramifications from future coal-to-liquids processes.

China needs to develop policies to promote vehicles that have near-zero greenhouse gas emissions.

Third, China needs to develop policies to promote vehicles that have near-zero greenhouse gas emissions. Enforceable fuel economy standards are a cornerstone of any policy portfolio related to motor vehicles. They offer guidance for planned, safe vehicle operation in a well-functioning economy. China's standards are some of the strongest in the world. Still, continuous improvements to these standards for cars, trucks, buses, and motorcycles will bring up fuel efficiency levels over time, spurring vehicle innovations. Likewise, fuel quality standards are an important part of managing transportation emissions. China should hasten the pace to bring the fuel quality of gasoline and diesel up to EU and U.S. standards. Dirty fuels jeopardize optimal engine operation and emission control systems. All facilities must abide by routinely tightened fuel standards that require continuing control of sulfur content and other impurities that can foul engines and harm public health. Standards by themselves, however, are not enough. There also need to be strict enforcement mechanisms to verify that goals, once set, are being met. In addition, the implementation of carbon taxes in China could drive the development of vehicle innovation. In 2014, China plans several pilot zones for the implementation of these taxes.

Fourth, China needs to create a robust economic and fiscal framework for transportation. Perhaps America's worst failure regarding transportation has been its refusal to institute market mechanisms to balance overall supply and demand, along with pricing externalities to minimize undesirable social effects. Without these economic safeguards, unsustainable usage patterns are promoted. Prices are the best form of information in a market system. When goods and services are kept artificially cheap, they tend to be over consumed. Failures to accurately price the external effects of consumption lead to undesirable outcomes. Maintaining sufficiently high fuel taxes that cover total system costs, for example, will be important as China's vehicle fleet continues to grow. Moreover, employing financial incentives, such as vehicle feebates, a mechanism that raises fees on high-emission vehicles and provides rebates on low-emitting vehicles, will induce the

production of clean vehicles. Such polluter-pay principles[29] will be key in helping to shift the production and purchase costs of improved vehicle models.

Fifth, China needs to implement smart, location-efficient land use policies. The zones between China's urban and rural areas may appear stark today, but they are prime for development over time as cities spread outward and incomes grow. How China continues to urbanize will be crucial in determining its motorization patterns. Sprawling development is not easily accessed by auto alternatives. As a result, residents and businesses tend to be wedded to private cars and trucks. And once land is developed, it is very difficult to reverse course and reintroduce more efficient transportation options. Designing development patterns around interconnected, seamless, plentiful transit services and other auto alternatives will be key. Sound transit infrastructure investments and integrated transportation and land use planning provide opportunities for smart growth, especially when designed at the outset as urban areas grow.

Designing development patterns around interconnected, seamless, plentiful transit services and other auto alternatives will be key.

In addition to integrated development, real-time information technologies should be employed to create seamless transit services and foster new mobility options. Pricing mechanisms that influence urban forms should be utilized, and subsidies that enable auto ownership and use should be avoided. As such, road pricing, parking fees, private vehicle taxation, transit investments, transit-oriented development, intelligent transit systems, and the prioritization of public and nonmotorized transportation can be used to effectively manage auto use during times of growth to maintain location-efficient land use over the long term.

• • •

China is a driving force for worldwide motorization. Along with the United States, China will influence energy and environmental outcomes on a global scale. Along the way, China will also experience local and national effects borne by its motorization choices. Still, at this point in its development and growth, China remains in the driver's seat regarding its motorization. Just how fast will China's fleet continue to grow? It has the most to gain—or lose—in answering this question.

China has at its fingertips an array of policy options to manage the driving force of motor vehicles. A secure, healthful, and equitable future depends on China's ability to successfully minimize the energy and environmental impacts of its burgeoning motor vehicle fleet.

Notes

1 Argonne National Laboratory (ANL) and M. Wang, H. Huo, L. Johnson, and D. He (Energy Foundation), "Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO_2 Emissions Through 2050," ANL/ESD/06-6, December 2006, www.transportation.anl.gov/pdfs/TA/398.pdf.

2 Oak Ridge National Laboratory, *Transportation Energy Databook: Edition 29*, 2010, http://cta.ornl.gov/data/download29.shtml.

3 The IMF projections were reported in China's Way to the Top," *Washington Post,* February 15, 2011, www.washingtonpost.com/wp-srv/special/business/china-growth; for the Twelfth Five-Year Plan figures, see http://europe.chinadaily.com.cn/business/economy_6.html.

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5 Development Research Center (State Council), Energy Research Institute (NDRC), and Institute of Nuclear and New Energy Technology (Tsinghua University), *2050 China Energy and CO_2 Emissions Report* (Beijing: Science Press, 2009).

6 G. Tang, "Review and Prospects of Rural Vehicle Market" (in Chinese), *Rural Machinery Market,* vol. 1 (2003): 44–45.

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8 NDRC, 2005, www.ndrc.gov.cn/gyfz/zcfg/t20050707_27861.htm.

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10 Ibid.

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12 Daniel Sperling and Deborah Gordon, *Two Billion Cars: Driving Toward Sustainability* (New York: Oxford University Press, 2009).

13 Lee Schipper and Wei-Shiuen Ng, "Rapid Motorization in China," World Resources Institute, October 18, 2004, www.transportroundtable.com.au/courses/201008_hsst/references/schipper-bank-China_Motorization.pdf.

14 Numbers of vehicles are according to the Traffic Management Bureau of the Ministry of Public Security; see "New-Energy Cars Take Off in China with Government Support," *China Daily,* December 10, 2010, www.chinadaily.com.cn/business/greenchina/2010-12/10/content_11683177.htm.

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16 International Monetary Fund, cited in www.washingtonpost.com/wp-srv/special/business/china-growth; U.S. Central Intelligence Agency, *CIA World Fact Book,* www.cia.gov/library/publications/the-world-factbook/geos/ch.html.

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19 United Nations, "World Urbanization Prospects: 2007 Revision," 2008, http://data.worldbank.org/data-catalog/world-development-indicators.

20 McKinsey & Company, "Preparing for China's Urban Billion," March 2008, www.mckinsey.com/mgi/publications/china_urban_summary_of_findings.asp.

21 See Bettina Wassener and Andrea Deng, "'Straddling Bus' Offered as a Traffic Fix in China," *New York Times,* August 17, 2010, www.nytimes.com/2010/08/18/business/global/18bus.html.

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23 "China's Twelfth Five-Year Plan," approved by China's National People's Congress on March 14, 2011, www.gov.cn/2011lh/content_1825838_4.htm.

24 See www.bushome.net.

25 Trevor Houser, "Oil-Hungry China Needs an Energy Security Rethink," Financial Times, March 18, 2011; "China's Dependence Level on Imported Oil Surpassed the Alert Line," Xinhua, March 29, 2010, http://news.xinhuanet.com/fortune/2010-03/29/content_13265670.htm.

26 The United States only has about 2 percent of world proven oil reserves; see U.S. Energy Information Administration, "World's Proven Oil Reserves," March 3, 2009, www.eia.doe.gov/international/reserves.html.

27 Wei-Shiuen Ng, Lee Schipper, and Yang Chen, "China Motorization Trends," *Journal of Transport and Land Use,* vol. 3, no. 3, Winter 2010.

28 Foton Motor, for example, is striving to beat Euro VI emissions standards for heavy-duty bus engines. Euro VI standards require all vehicles equipped with a diesel engine to substantially reduce their emissions of nitrogen oxides. For example, emissions from cars and other vehicles intended to be used for transport will be capped at 80 mg/km (an additional reduction of more than 50 percent compared to the Euro 5 standard). Combined emissions of hydrocarbons and nitrogen oxides from diesel vehicles will also be reduced. These will be capped at, for example, 170 mg/km for cars and other vehicles intended to be used for transport. Similar innovations are needed in cars and motorcycles. See www.chinabuses.org/news/2010/0621/article_3343.html.

29 For more information, see www.arb.ca.gov/research/apr/past/08-312main.pdf; www.theicct.org/pubs/feebate_may10.pdf; and http://cta.ornl.gov/cta/Publications/Reports/FeebateEnergyPolicy_FINAL.pdf.

DEBORAH GORDON is a nonresident senior associate in Carnegie's Energy and Climate Program, where her research focuses on climate, energy, and transportation issues in the United States and China.

Since 1996, she has been an author and policy consultant specializing in transportation, energy, and environmental policy for non-profit, foundation, academic, public, and private-sector clients.

YUHAN ZHANG is a research assistant in Carnegie's Energy and Climate Program. His research focuses on U.S.-China strategic relations, clean technology trade and investment, and China's economic and political development.

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