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China's Fuel Economy Standards for Passenger Vehicles

Rationale, Policy Process, and Impacts

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Energy Technology Innovation Policy (ETIP)

The overarching objective of the Energy Technology Innovation Policy (ETIP) research group is to determine and then seek to promote adoption of effective strategies for developing and deploying cleaner and more efficient energy technologies, primarily in three of the biggest energy-consuming nations in the world: the United States, China, and India. These three countries have enormous influence on local, regional, and global environmental conditions through their energy production and consumption.

ETIP researchers seek to identify and promote strategies that these countries can pursue, separately and collaboratively, for accelerating the development and deployment of advanced energy options that can reduce conventional air pollution, minimize future greenhouse-gas emissions, reduce dependence on oil, facilitate poverty alleviation, and promote economic development. ETIP's focus on three crucial countries rather than only one not only multiplies directly our leverage on the world scale and facilitates the pursuit of cooperative efforts, but also allows for the development of new insights from comparisons and contrasts among conditions and strategies in the three cases.

Summary

China became the pioneer in the developing world in adopting fuel economy standards (FES) for vehicles, driven by its concern regarding increasing oil imports due to a rapid growing transportation sector, its desire to push international auto companies to bring advanced and efficient technologies to China, and its wish to spur its own auto companies to improve its product offerings and compete with international companies. After a rather swift policy-making process, China issued its FES for light-duty passenger vehicles (LDPV) in September 2004. The first phase took effect on July 1, 2005, and the second phase entered force on January 1, 2008. The stringency of the Chinese FES ranks third globally, following the Japanese and European standards. The Chinese standard was successful in reducing the average fuel consumption (measured as liter/100km) of the new national LDPV fleet (by 11.5%) and stimulating broader deployment of more advanced vehicle technologies. The Chinese experience is highly relevant for countries that are also experiencing or anticipating rapid growth in personal vehicles, those wishing to moderate an increase in oil demand, or those desirous of vehicle technology upgrades.

In this paper, we first review the policy-making background of the Chinese FES for LDPVs, including the motivations, key players, and the process; and then explain the contents and the features of the FES, and why there was no compliance flexibility built into it. Next, we assess the various aspects of the standard's impacts, such as fuel economy improvement, technology changes, shift of market composition, and overall fuel savings. Lastly, we comment on the prospect of tightening the existing FES and summarize the complimentary policies that have been adopted and contemplated by the Chinese government for further promoting efficient vehicles and reducing gasoline consumption.

1. Major Motivations for Vehicle Fuel Economy Standards

a. Oil security concerns associated with rapid vehicle population growth

China has always believed that a strong auto industry can be one of its powerhouses to propel economic growth.[1] With its policies which encourage both domestic and international investment in auto industry and strong domestic demand for road transport vehicles, the China auto industry has undergone rapid growth since the early 1990s. Total vehicle production grew from about 700,000 units in 1991 to 4.44 million in 2003 (the total production reached 8.88 million in 2007).[2] The annual light-duty passenger vehicles[3] production grew even faster during the same period: it grew from less than 100,000 units to 2.85 million units (6.73 million in 2008) during the same period. The growth of LDPVs production was particularly shocking in 2002 and 2003, growing at a rate of 48 percent and 52 percent respectively (China Automotive Technology and Research Center, 2007a, 2001).

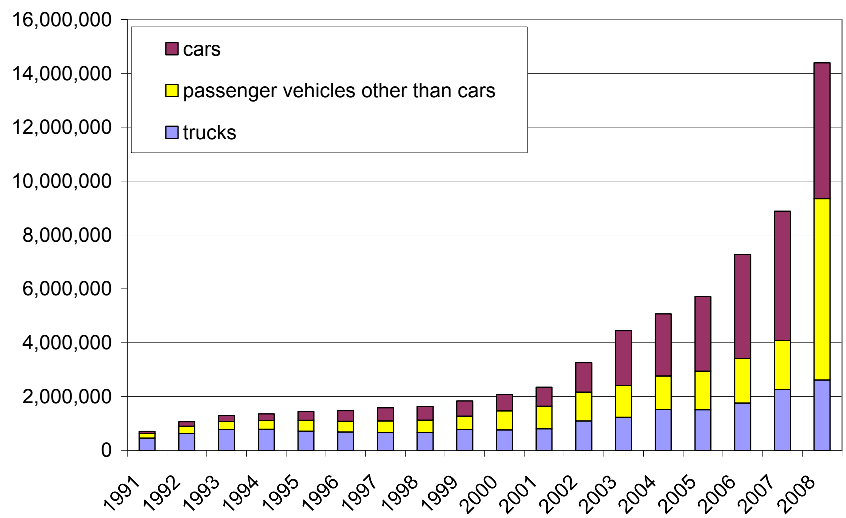

Figure 1 Vehicle Production in China (1991-2007)
Source: CATARC 2007; and China Auto Industry Association 2009.

[1] Indeed, the auto industry contribution to China's total GDP has grown from less than 4% in 2000 to 7.3% in 2006.

[2] Over 95% of vehicles manufactured in China are sold in the domestic market, despite the rapid growth of Chinese automobile export since the early 2000s. About half of these exported vehicles are trucks made by Chinese companies.

[3] According to Chinese classification, a light-duty passenger vehicle (M1 vehicles) is a vehicle whose major function is to carry people, have no more than 8 seats (other than the driver seat) and weigh less than 3,500 kg. Cars, multi-purpose vehicles (vans), SUVs and mini buses all belong to this category.

Partially driven by growing energy demand from the transportation sector, China's oil consumption has risen steadily beginning in the early 1990s. It became a net oil importer in 1993, and since then its dependency on imported oil has kept worsening (see Figure 2). In 2005, about 46 percent of China's oil demand was met by imports.[4] The transportation sector accounted for 37 percent of China's oil consumption (121 out of 327 million tons), and road transport utilized 24 percent of total oil consumption (International Energy Agency 2007). The IEA has forecasted that without aggressive policies and measures to reduce oil demand in the next two decades, Chinese oil demand will reach 808 million tons per year (the transportation sector will require 460 million tons), while road transport will account for 43 percent of its total oil consumption in 2030. By then, China would have to import more than 80 percent of the oil that it will need.

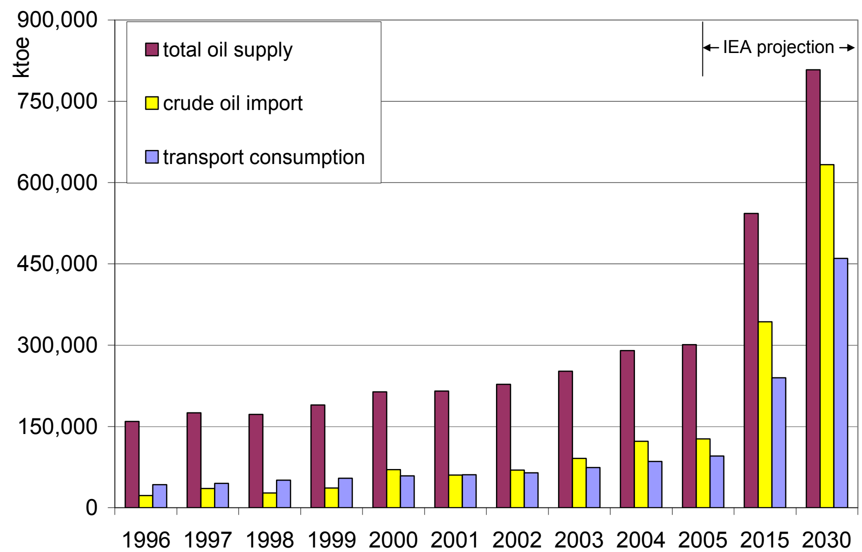

Figure 2 China's Total Oil Supply, Import, and Transportation Consumption
Data: International Energy Agency, World Energy Outlook 2007, and its online database.

Such trends and projections have received increasing attention within the Chinese government. Pushing automakers to bring more efficient vehicles to Chinese market through compulsory fuel-economy standards (FES) seemed to be a good way to alleviate the growing conflict between China's desire for a strong auto industry and a

[4] This ratio reached 51.5% in 2007, according to BP Statistics Review of World Energy 2008.

vast domestic auto market and its concern for oil security (Huo 2004). In the 2004 Policies for Automotive Industry Development (National Development and Reform Commission 2004), the Chinese government set forth its goal of reducing the average fuel economy of new vehicles by 15 percent in 2010 (2003 as the baseline).

b. Force foreign companies to bring in more modern and fuel-efficient energy technologies

Before the 1980s, China had not put much emphasis on light-duty passenger vehicles and therefore had little indigenous R&D capacity. Production of light-duty passenger vehicles was completely stopped during the Cultural Revolution. Starting in the mid 1980s, China opened up the sector to allow foreign automakers to form joint ventures with Chinese auto companies, expecting that the foreign companies would bring in needed technologies, managerial experience, and R&D capabilities. During the same period, some China auto companies also licensed technologies from a few foreign companies to start their own production lines. Despite the Chinese government's wishes, there were insufficient incentives for foreign auto companies to transfer their clean and efficient technologies to their products made in China, let alone assist Chinese companies to enhance their indigenous R&D capacity for clean vehicle production (Gallagher 2006).

Until the mid-1990s, only nine car models were made and sold in China, and the technologies used were often at least ten to fifteen years old. The situation started changing in the late 1990s, as the major auto makers realized that the Chinese market was expanding rapidly and was very likely to become one of the largest ones in the immediate future. Meanwhile, the Chinese government gradually removed its policy barriers for foreign companies to enter the auto industry after 2001, mainly as the result of its admission to the WTO. The competition among international auto makers further intensified. They then brought in more diversified and newer models. The technology gap between the models launched by foreign makers in China and those in their home markets has narrowed, and the newest models are now introduced to China and advanced markets almost simultaneously, although the technology embedded in the vehicle models may not be the same. (See Figure 3 for reduced time gap of selected models introduced in China and in advanced markets.)

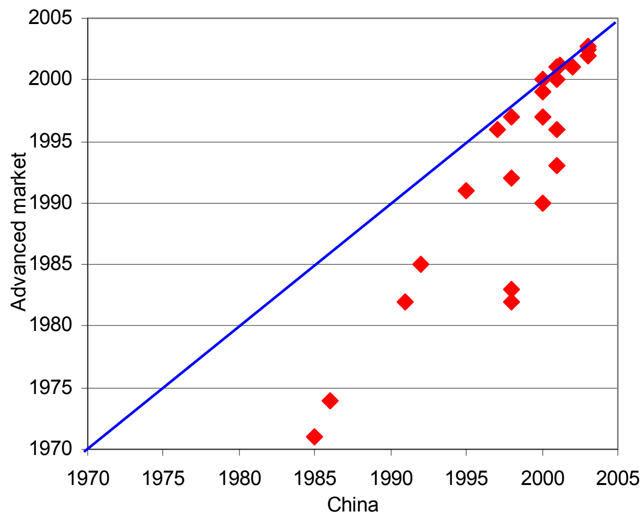

Figure 3 Time Gap of Model Introduction in Chinese and Advanced Markets
Source: Presentation by CATARC vice president (Zhang, 2004).

The average fuel economy of the Chinese new fleet, however, significantly lagged behind that of the most efficient national fleet as late as the early 2000s. Chinese experts estimated that in comparison with the new Japanese and German LDPV fleets, the average curb weight and engine displacement of Chinese new LDPV fleet was almost 11 percent and 15 percent less, but the average fuel economy was 10 percent worse (China Automotive Research and Technology Center 2003).

The Chinese government strongly felt that a national FES could help to reduce the efficiency and technological gaps between vehicles sold in China and those sold in advanced markets. This was particularly relevant for the joint ventures that had access to international technology. These joint ventures accounted for more than 80 percent of the light-duty passenger vehicle sales in China in 2003 (derived from model sales data in the China Automotive Yearbook 2004). The government felt that with the FES in place, Chinese companies would have more leverage when negotiating with their foreign counterparts regarding the technologies that foreign companies ought to bring to joint-ventures (Huo 2004).

c. Push domestic manufacturers to improve

Lacking product development capabilities made the domestic passenger vehicle makers to concentrate at the lower end of LDPV markets. They have mainly focused on cars and minivans with smaller engines (mostly within the range of 0.8 to 1.3 liters), less weight, and fewer features. In 2003, they together accounted for less than 20% of the Chinese car markets[5]. About 60 percent of their production was based on outdated designs purchased from global players, such as Daihatsu and Suzuki (CATARC 2004). Even the so-called "self-designed" models were largely modified versions of outdated foreign models. Despite their lower quality and fewer amenities, these domestic brands have attracted a large number of first-time vehicle purchasers in China because of their high affordability.

The government felt that the FES should not put the domestic auto makers out of business, and should not cause a sizable increase of production costs of small vehicles. As we will show in Section 3, the government's lenience toward domestic auto makers manifested itself in the less stringent requirements for very light vehicles. And yet, the government expected that the FES would provide some incentives for domestic companies to improve their products and overall competiveness (CATARC 2003). The government hoped that the Chinese auto companies would be able to not only secure their market niche and compete more broadly in the domestic market, but also sell their products internationally. To export, however, improvement of vehicle performance and quality is necessary.[6]

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[5] In the last couple of years, domestic auto makers added models with larger engine and more features. Chinese brand passenger vehicles actually expanded their market share to about 25% in 2007 (China Automotive Industry Association 2008).

[6] Indeed, China vehicle exports have grown rapidly since 2000. China only exported less than 21,000 vehicles (5,837 trucks, 3,644 buses and 3,075 cars) in 2000, while it exported more than 313,000 vehicles (about 170,000 trucks, 10,000 buses, and the 133,000 light-duty passenger vehicles) in 2006. Most of the exported vehicles are so-called "China brand," and made by Chinese companies. The targeted market of these vehicles includes African and southeastern Asian countries; and their current competitive advantage is low upfront purchasing costs.

2. Major players and the process of FES development

a. Players in FES development: state agencies, research institutes, industry and NGOs

State agencies

According to the Chinese law on standard-making, the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) has the ultimate authority for creating and managing national standards. The Standardization Administration of China (SAC), whose operation is under the supervision of AQSIQ, exercises the actual administrative responsibilities of standard-making by undertaking unified management, supervision and overall coordination of standardization works in China.[7] Meanwhile, other ministries (and related industrial departments) that are in charge of particular economic activities or sectors have corresponding technical responsibility for standard making and enforcement within their respective jurisdictions. During the process of formulating the FES, the former State Economic and Trade Commission (SETC)[8] and the National Development and Reform Commission (NDRC) were in charge of the development of auto industry in China successively, so they both played a critical role in pushing out the FES.

The SAC periodically creates work plans for national standard-making in the immediate future, and only anticipated standards included in such a plan will go through formal procedures and are likely to be promulgated at the end of the plan period. Ministries must put forward proposals for new standards in advance so that the SAC may include their proposals in its work plans. In most cases, the time between when the SAC announces a standard-making intention and the issuance of final standards is very pressing (it can be from 1 to 3 years. In the case of the FES, it took two years; in the case of unleaded gasoline, one and half years). Thus, a ministry usually has already commissioned a feasibility study for a future standard and

[7] The SAC itself is mainly responsible for presiding and supervising the procedures of standard making. It also has many technical committees which comprise of top experts of particular fields to take care of the technical aspects of standard making.

[8] SETC was disbanded during the central government's reorganization in 2003, and the responsibility of industrial development was transferred to NDRC.

sometimes even has had a draft in its hands before it proposes a standard-making intention to SAC.

Research institutes

The China Automotive Technology and Research Center (CATARC) was the key technical player in the process of drafting FES. They were commissioned to conduct the feasibility study, to create the testing procedure for vehicle fuel economy, and to propose the scheme and desired stringency levels of FES. As the hosting organization for the secretariat of the Automobile Technical Committee of SAC,[9] it also carried out most of the organizing and coordinating effort during the official standard making procedures, such as soliciting inputs and comments from auto companies, relevant government agencies, research communities and the public. CATARC's critical role during the FES making was warranted by its unique position: a semi-government organization whose core competence is in automobile testing, certification, and automobile-related policy research. Because CATARC was originally established with Central Government funding, it once belonged to the China National Automobile Industry Corporation and later the Ministry of Machinery. It is currently under the supervision of the State-owned Assets Supervision and Administration Commission (SASAC, which appoints the members of high management of CATARC), and yet it enjoys great financial independence and managerial autonomy. It is not surprising that over the years, CATARC has developed close ties with key national agencies and has assisted these agencies with technical knowledge concerning all aspects of the auto industry.

Auto companies

The influence and the participation of auto companies during the FES process appears to have been rather limited, given the circumstance of the industry and the Chinese government's procedures for policy-making in the early 2000s. It was estimated that the Chinese annual demand for new vehicles would reach at least 10

[9] More specifically, the Auto Standardization Research Institute (ASRI) under CATARC serves as the secretariat for the Technical Committee of Auto Industry under SAC and the secretariat for the Auto Division of the China Standardization Association.

million by 2010; and all major international companies wanted to take a share in this rapidly growing market. International investment in the Chinese auto industry rode a rising tide in the early 2000s. From 2000 to 2003, 112 joint ventures were created and 22 of them were formed to manufacture whole vehicles (CATARC 2001, 2002, 2003, 2004). Auto companies were experiencing great investment anxiety and pressure in China. Naturally, most of their attention was directed at how to get their foot in the Chinese market and build up their production capacity quickly. They were occupied with developing their long-term strategies in China, identifying their Chinese business partners, and negotiating terms of their joint ventures. The auto companies did not allocate significant resources to scrutinize (not to mention influence) the wide range of regulatory ideas that were being contemplated by various central agencies. In addition, in the early 2000s, policy making in China was hardly a transparent process that welcomed and openly engaged various stakeholders at the early stage of policy formulation. Even if they had intended to, the international companies new to China would not have found effective channels to be an influential participant to the FES process. As of mid-2002, the CEO of a major foreign auto company producing cars in China had no idea that the FES was seriously under development, saying he thought it was on hold indefinitely.[10]

China Energy Sustainable Program of the Energy Foundation

Created by the Energy Foundation in 1999, the China Energy Sustainable Program (CESP) has aimed to assist in China's transition to a sustainable energy future by promoting energy efficiency and renewable energy. Improving vehicle fuel economy in China was chosen to be one of its targeted policy areas.

In 2001, CESP brought salience and added details to the fuel economy concept in China by commissioning a landscape study to four Chinese institutes that were influential in policy making concerning auto industry and energy.[11] The study introduced fuel economy policies in developed countries and disclosed the difference between the estimated average fuel economy of the Chinese LDPV fleet and that of

[10] Interview with CEO of U.S. automobile company in Shanghai, July 10, 2002.
[11] This study was jointed carried out by the Development Research Center of State Council, Tsinghua University, CATARC, and China Academy of Environmental Sciences.

western ones. At the same time, through intensive dialogue, CESP secured the formal State Economic and Trade Commission (SETC)'s full embracement of the idea of creating Chinese FES. With the official backing of SETC, CESP funded CATARC to carry out a much more detailed technical study on possible Chinese FES which eventually became the foundation for three Chinese fuel economy-related documents: the Testing Procedure for the Fuel Consumption of Light-duty Vehicles, the Limits for the Fuel Consumption of Passenger Vehicles, and the Labeling System for Fuel Consumption of Light-duty Vehicles.[12]

In addition to funding and guiding studies on policy options for improving vehicle fuel economy,[13] CESP also brought leading international experts and practitioners to China so that Chinese policy makers can learn from worldwide experiences. Notably, the Chinese marveled at Japan's highly efficient fleet and its continued pursuit for efficiency, and they were surprised and alarmed by the stagnancy of the fuel economy of the American passenger vehicle fleet since the mid 1980s and by the dominance of SUV in the U.S. private vehicle market.

b. The process

- In summer 2001, after seeing a 90 percent increase of oil import during 2000, the former State Economic and Trade Commission (SETC) initiated the *Study on Fuel Economy Standards and Policies for Vehicles in China*, with financial support from China Energy Sustainable Program. This study intended to investigate technical and policy approaches to improve vehicle fuel efficiency appropriate for China. To maximize the official recognition of the study, a steering committee was formed among key departments from six central agencies: SETC, the formal National Development and Planning Commission (the current NDRC), the General Administration of Quality Inspection, Supervision and Quarantine, the State Environmental Protection

[12] Starting July 2008, all manufactures are required to display fuel economy on their LDPVs, including performance in urban and highway conditions.
[13] For the purposes of full disclosure, the Energy Technology Innovation Project at the Harvard Kennedy School received a grant during this period from CSEP, in part to work together with CATARC on the development of policy options for improving vehicle fuel economy.

Administration, the Ministry of Finance, and the National Taxation Bureau. CATARC was selected to carry out the technical work of study.

- In 2002, the Standardization Administration of China (SAC) formally announced the Central Government's intention to formulate the *Limits of Fuel Consumption for Passenger Vehicles* in its work plan. CATARC was again chosen to lead the drafting effort, building up the study commissioned by SETC the year before. The drafting group also involved some consultation from experts from as many as ten auto companies. [14]
- Through 2002 and 2003, the standards drafting group met on regular basis to draft the standards. They collected fuel-consumption data of all LDPV models made and sold in China via two different sources: the auto makers[15] and the state vehicle test centers.[16] At the same time, the drafting group also obtained fuel-consumption data for passenger vehicles and information on fuel-economy approaches for other countries. The group then compared these three sets of data (those reported by the automakers, those obtained by test centers, and international information) to get a sense on the fuel efficiency gaps between Chinese LDPVs and the global state-of-the-art. They also carried out an economic analysis of various fuel-consumption-reduction approaches (i.e., the costs associated with specific technologies to

[14] These companies included Guangzhou Honda, Shanghai Volkswagen, Shanghai GM, Dongfeng Peugeot Citroen, FAW-Volkswagen, Hafei Automobile, ChangAn Automobile, Pan Asia Technical Automotive Center and China FAW. The involvement of auto companies here mainly was to supply the information on the fuel economy and sales of their models for the analysis.

[15] In early 2003, SETC directed all automakers to collect and submit fuel-consumption data of their models based on the GB/T 19233-2003 testing method. In order to obtain information on emissions and fuel consumption simultaneously during a test, the driving cycle for determining fuel consumption (GB/19233-2003) was set the same as the one specified for the Chinese National Emissions Standards Phase II (GB 18352.1-2001). In 2005, a modified driving cycle was adopted for the Chinese National Emissions Standards Phase III and IV (GB 18352.2-2005). Companies are allowed to use the modified cycle to calculate the fuel consumption levels of their vehicles, because Phase III emission standards took effect first in Beijing at the end of 2005 and then nationwide in July 2007. The difference of the fuel consumption during the old driving cycle and that during the new cycle was considered negligible, because the two cycles differ in a 40-second waiting time for an engine to warm up (the new cycle starts from a cold start), which has considerable impacts on conventional emissions from vehicles with three-way catalytic converters but only has very limited impacts on fuel consumption.

[16] Auto makers must have their new models tested at a state vehicle test center to prove the performance of the model met Chinese requirements before the models can be sold in the Chinese market. Therefore, the state test centers have fuel-consumption data of all models through their tests.

improve fuel economy) based on existing western literature, especially the 2003 National Academy Press' publication on the effectiveness and impact of the U.S. CAFE Standards.

- In second half of 2003, the drafting group convened a couple of meetings to solicit comments from auto companies and relevant research and test institutes. Technical experts from various automakers participated in discussions over the draft standards, offered their comments and voiced their concerns. It is not clear how thoroughly the experts commented on the standards, and to what extent their concerns were addressed and incorporated into the final version of the draft.[17]

The final standards were approved and issued on September 2, 2004.

3. Details of the standards

The Chinese Fuel Economy Standards limit fuel consumption by weight category, and do not differentiate between diesel and gasoline vehicles.[18] Alongside the weight classification, the Chinese standards also divided vehicles into two big categories: "normal structure" vehicles, i.e., vehicles with manual transmission (MT) and less than 3 rows of seat; "special structure" vehicles, i.e., vehicles with automatic transmission (AT), or with at least three rows of seats. Requirements for "special structure" LDPVs are 6 percent less stringent than those for "normal structure" vehicles of the same weight class.

The standards were implemented in two steps: Phase 1 introduced standards for light-duty passenger vehicles (the Chinese "M1" category of vehicles) under the weights of 3,500 kg and with no more than 9 seats (including driver's seat) in sixteen steps (in comparison, the Japanese 2000 and 2010 standards had 6 and 9 steps respectively); the standards for new models came into effect from July 1, 2005 and for

[17] It should be noted that many automakers were somewhat caught in surprise when the final standard was released, maybe because they were not expecting the standard to actually be finalized so quickly.

[18] Standards do not apply to alternative fuel vehicles (e.g., ethanol or natural-gas fueled vehicles). Unlike CAFE in the United States, auto companies can't claim any credits for their sales of flexible fuel vehicles.

continued models from July 1, 2006. Phase 2, which further tightened the standards by 10 percent in general (but reduced the number of steps to fifteen), took effect for new models on January 1, 2008 and will take effect for continued models from January 1, 2009. Figure 4 shows the two phases of Chinese FES limits for "normal structure" (and also shows the Japanese standards for 2000 and 2010 for comparison purpose).[19]

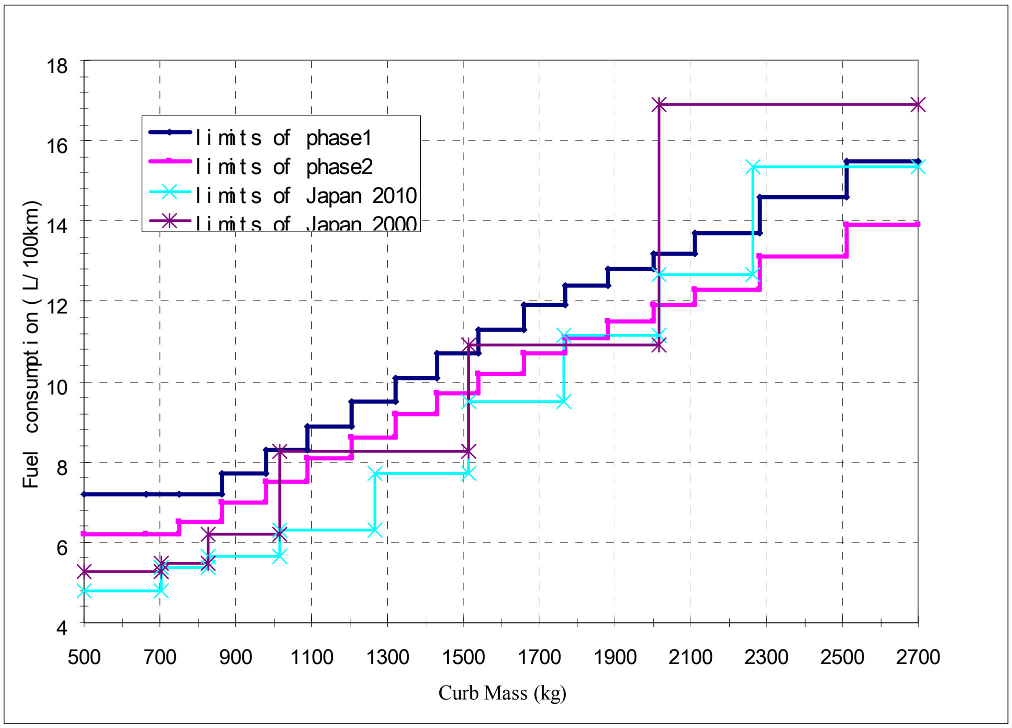

Figure 4: Fuel Consumption Limits for Passenger vehicles in China and Japan
Source: CATARC 2007c.
(Note that Chinese standards are based on the European driving cycle while the Japanese standard are based on their own driving cycle)

The rationale for adoption of the weight-based standards derives from the structure of the Chinese automobile industry. With 28 companies all together rolling out only 1.9 million LDPVs per year in 2002, the industry was highly-fragmented. Most manufacturers offered a very narrow range of vehicles. A CAFE-style approach would have been problematic for manufacturers that made primarily large vehicles by putting them at a disadvantage. Conversely, a CAFE structure would hardly give any incentive to those manufacturing primarily smaller vehicles to move towards more fuel-

[19] The Japanese standards will be further tightened in 2015.

efficient vehicles. Thus, the weight-based approach was adopted to provide incentives for all manufacturers.

The Chinese standards are also different from the Japanese approach in that under the Chinese system, the fuel economy value of every model needs to satisfy the standard for that weight category. The Japanese standards, in contrast, allow a manufacturer to meet the standard for each weight group through weighted average value of its vehicles sales within that category.[20] As of 2003, even international auto makers in China were making only a handful of models each, and the domestic ones often were only offering one or two models, so the Japanese credit trading system would not have worked well for China either (CATARC 2003). Thus, the Chinese system does not have any built-in compliance flexibility; it was designed to improve the fuel economy of every vehicle model.

Chinese policy makers decided that the Phase I fuel economy requirements should be the average fuel economy of 2002 LDPV models. In fact, as of 2003, about half of 2002 models could not meet Phase I standards. Many of these highly inefficient models were based on technologies popular in the western markets in the 1980s and were about to be replaced by newer models. The policy makers felt that Phase I requirements would accelerate the phasing-out process of these obsolete models and would not be too difficult for auto companies to meet. They believed that the pressure should be different for Phase II requirements whereby auto companies would have to make technological reconfiguration and/or improvements on some newly introduced models. The standards drafting group felt that a period of five years (2004-09) would be consistent with the general cycle for auto companies to launch new models and bring about new technologies, and thus should give these companies enough time to modify their product offerings in accordance with more stringent fuel economy requirements (CATARC 2003).

[20] The Japanese system also allows auto companies to use extra credits earned for one weight class to compensate for the shortfall of another weight class, but at a 50% discount.

Figure 4 also shows that Japan's fuel consumption standards in the lower weight groups in general are much tighter than China's, except for vehicles above ~ 2,000 kg where the Chinese standards are clearly more stringent (it is true for both the comparison of Japanese 2000 standards with Chinese 2005 standards and the comparison of Japanese 2010 standards with Chinese 2008 standards).

The Chinese standards for heavier passenger vehicles were set particularly tight because Chinese policy makers were alarmed by the high popularity of SUVs in the United States and the resulting low average fuel economy of the American fleet. To try to prevent SUVs from dominating the market in the future, Chinese policy makers intentionally made it very challenging for heavy LDPVs to meet the standards for their weight classes. (As we show in the Section 5, to further restrain the demand for SUVs and luxury cars, the Chinese government has also imposed very high excise taxes on large passenger vehicles). In contrast, the standards for vehicles with curb weight less than 1,090 kg were rather loose because the government did not want to put too much stress on domestic auto makers whose major product offerings were several models of very small, low-end multipurpose vans, which were then popular among Chinese consumers. This demonstrates that the standards allowed greater leeway for manufacturers of primarily smaller vehicles (i.e., most of the domestic firms) while putting significant pressure on the manufacturers of luxury and sport-utility vehicles (which mostly turn out to be JVs).

4. Outcomes / Impacts of China's FES

New LDPVs available in the Chinese market in 2002 and 2006 were used to analyze the overall changes in LDPV technology and performance in China. The 2002 data set includes 394 models, among which, 319 were equipped with manual transmission and the rest with automatic transmission. Information regarding the 2002 vehicles relies on companies' reports (recall that SETC required all car companies to report fuel consumption of their models in 2003), and original data from national vehicle testing centers. The 2006 data set includes 865 models, among which, 542 models (including all 20 diesel models) were equipped with manual transmission, and the rest with automatic transmission. Information regarding the 2006 vehicles relies mainly on the two bulletins on passenger vehicle fuel consumption issued by NDRC in 2006 and 2007, and to much less extent, on data from testing centers and auto companies.

a. Improved fuel economy

Overall Compliance

"Before" and "after" snapshots of vehicles sold in China indicate a clear shift in the fuel efficiency of vehicles as a result of the implementation of the FES. Figures 5a and 5c show the fuel economy of new "normal" and "special" structure vehicles produced in China in 2002, i.e., when the Standardization Administration of China (SAC) formally announced its plan to promulgate FES in two years; and Figures 5b and 5d show the fuel economy of these two types of vehicles produced in China in 2006, when Phase I requirements took full effects.

In 2002, nearly 40 percent of normal structure LDPVs on the market failed to meet the Phase I standards and 82 percent of these vehicles failed the Phase II standards. By the end of 2006, all of the new normal structure LDPVs met Phase I standards and about two thirds of them met the Phase II standards. The overall compliance record of special structure LDPVs was even more impressive. More than a quarter of these vehicle models in 2006 already met Phase II requirements, some of them even consumed gasoline at a level way below the standards. The reason for this good performance is that most special structure LDPV models were brought by international auto companies to China only after 2003. In anticipation of the Phase II requirements, these companies typically introduced efficient models that could meet more stringent standards in the future.[21]

Note that while many of the vehicles on the market in 2006 just met the Phase I standards, the auto manufacturers were looking ahead to the Phase II standards and

[21] Since compliance flexibility is not a component of the Chinese fuel economy standards, models that can not meet their corresponding fuel economy limits are not allowed to be produced. NDRC has required auto companies to report fuel economy of their LDPVs; it then publicizes the results in its special bulletins. To date, two bulletins on LDPV fuel economy have been published: one in July, 2006 and the other in July, 2007. The 2007 bulletins included 2,350 qualified models sold in China and 444 disqualified models that are no longer produced.

therefore had already introduced a number of vehicles that would meet these future standards. This indicates that the government's clear roadmap may have had an immediate influence on the choice of technology and product introduction by the manufacturers.

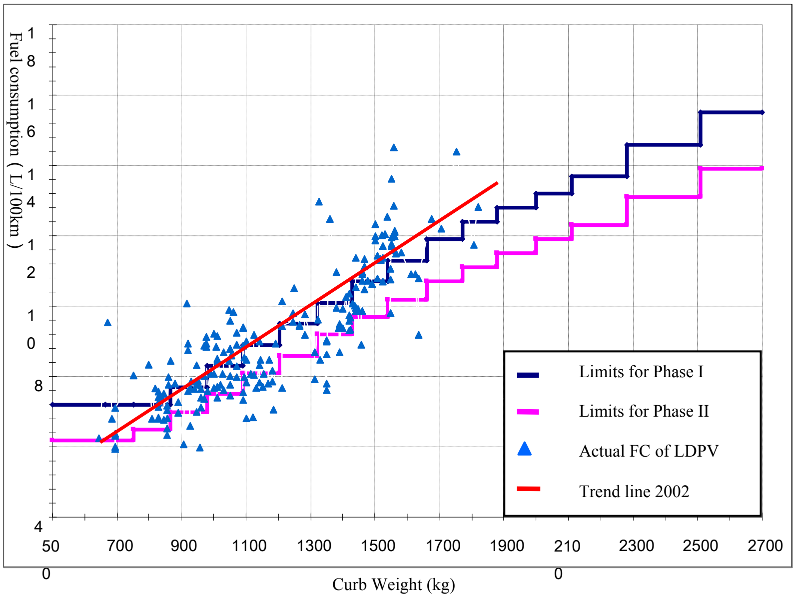

Figure 5a: Fuel Consumption of "normal structure" passenger vehicles in 2002
Source: CATARC 2007c.

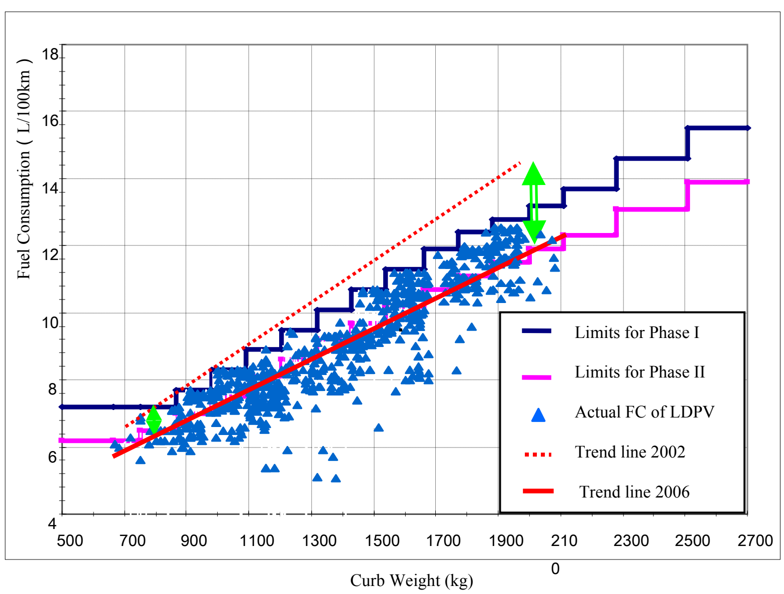

Figure 5b: Fuel Consumption of "normal structure" passenger vehicles in 2006
Source: CATARC 2007c.

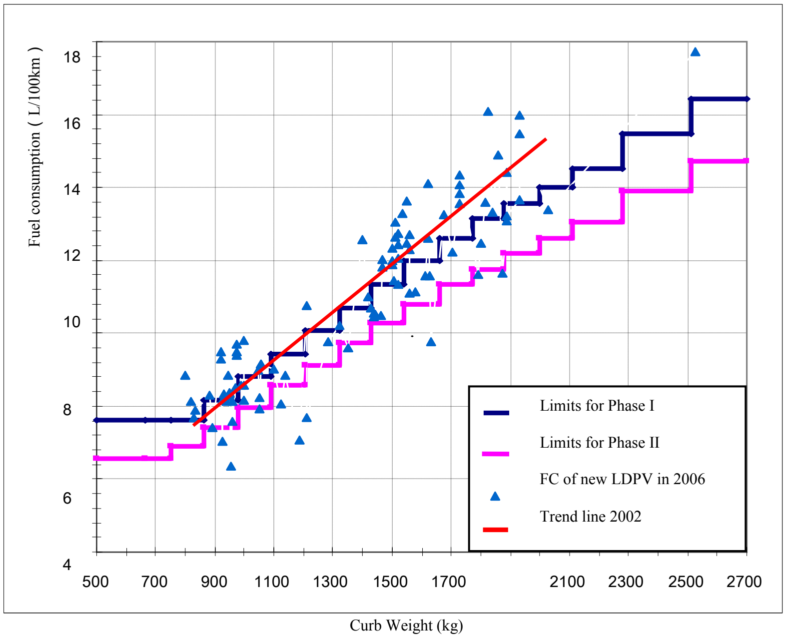

Figure 5c: Fuel Consumption of “special structure” passenger vehicles in 2002
Source: CATARC 2007c.

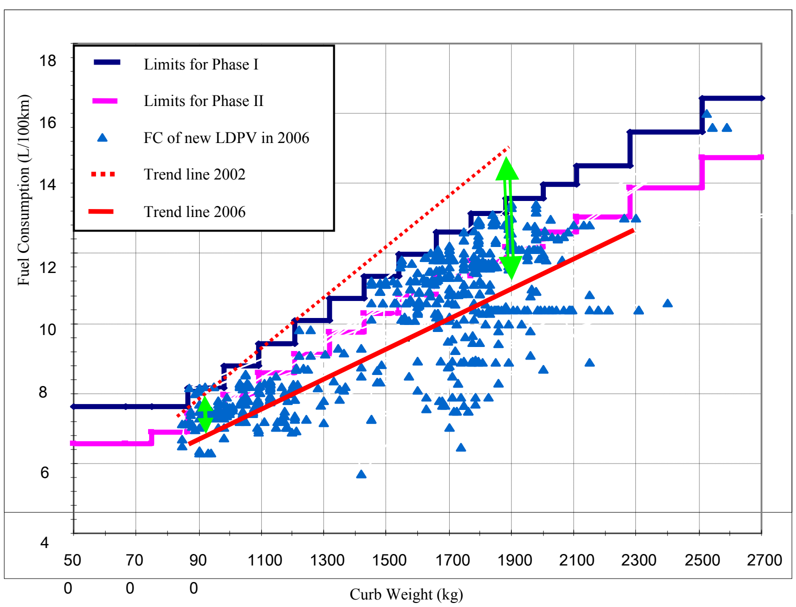

Figure 5d: Fuel Consumption of “special structure” passenger vehicles in 2006.
Source: CATARC 2007c.

Fuel Economy Improvements for Different Weight Classes

Comparing the average fuel economy of the new LDPVs of one weight class in 2002 and that of the new LDPVs in the same weight class in 2006, one can see that the improvement of average fuel economy is prevalent for all LDPV weight classes. Normal structure vehicles reduced their average fuel consumption per 100 km by 7 to 17 percent while special structure vehicles reduced their fuel consumption even further, by 10 to 20 percent. Comparing the trend line in Figure 5a with that in 5b, and the trend line in figure 5c with that in figure 5d, one can see that in general, the average fuel economy of heavier LDPVs improved more than lighter LDPVs in both absolute and relative terms. Thus, the discrimination of the Chinese FES against heavy LDPVs seemed to have worked very well to force the fuel economy improvement of these vehicles.

Sales-Weighted Fleet Average Fuel Economy (L/100 km)

Corporate average fuel economy (sales-weighted) levels were calculated for 34 companies that accounted for 90 percent of total LDPVs production in China in 2006. Twenty-two of them had been producing LDPVs in 2002 (the rest 12 started production between 2003 and 2006), so their corporate average fuel economy levels in 2002 were also calculated for comparison purposes. The results are shown in Figure 6.

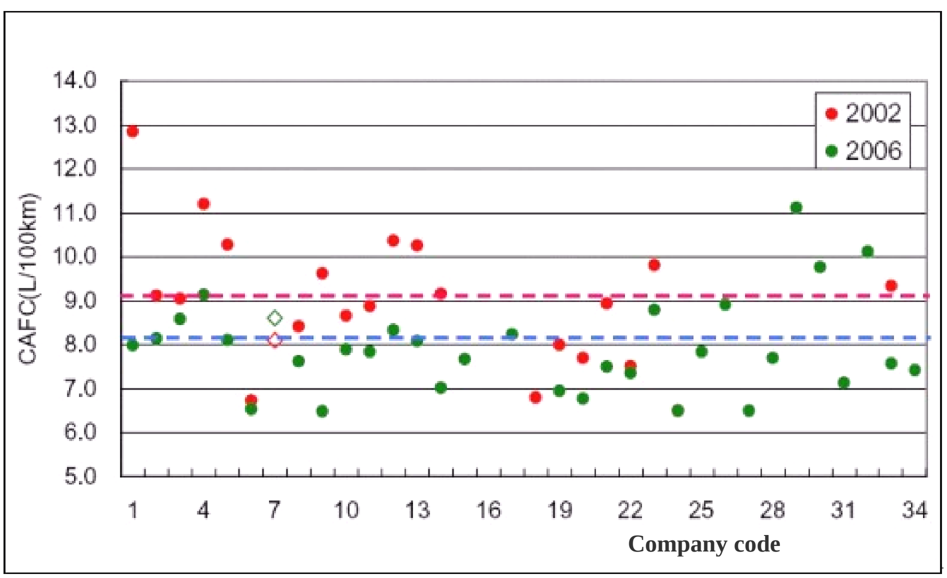

Figure 6 Corporate Average Fuel Consumption of 34 Automakers in China

Source: CATARC 2007b.

In 2002, the corporate average fuel economy varied significantly, from 12.9 L/100 km (18.2 mpg) to 6.7 L/100 km (35.1 mpg). The difference among companies dropped somewhat in 2006. The company producing the least efficient fleet had a corporate fuel economy of 11.1 L/100 km (21.4 mpg) while the one producing the most efficient fleet had a corporate fuel economy of 6.5 L/100 km (36.2 mpg). 21 out of the 22 companies that had been producing passenger vehicles in 2002 improved their corporate average fuel economy from 2002 to 2006; they accomplished this by increasing the share of smaller-engine models in their product mix and adopting better and more efficient technologies. The most significant improvement at the company level was a drop of average fuel consumption per 100 km from 12.9 liters to 7.9 liters (from 18.2 mpg to 29.4 mpg).

At the national level, the sales-weighted average fuel consumption per 100 km of all passenger vehicles was 9.11L (25.4 mpg) in 2002 (the upper dotted line in figure 7) and dropped to 8.27 L/100km (29.2 mpg) in 2006 (the lower dotted line in figure 7), a reduction of about 11.5 percent. Eight out of the 22 companies had their corporate average fuel economy lower than the national average in 2002; and 14 out of 34 companies had their corporate average fuel economy lower than the national average (CATARC 2007b).

b. Technology advancement

This section examines the changes in the deployment of efficiency-relevant vehicle technologies by 12 largest auto companies from 2002 to 2006. These companies accounted for 75 percent of all passenger vehicle sales in China in 2006 (CATARC 2007a). Eight of them are joint ventures among Chinese auto companies and major international auto companies based in Europe, the United States, Japan, and Korea, and the remainders are domestic companies.

Before the introduction of the FES, many of the JVs had paid little attention to fuel economy when introducing new models, often introducing obsolete models. As shown in Figure 3, most models introduced to China before 2000 had been sold in western markets for at least 5-15 years. In addition to the stimulation provided by the intensified competition among international companies in the China since the late 1990s, the issuance of FES has also apparently motivated these companies to introduce diversified and modern models to the Chinese market and to apply newer and more efficient technologies to their products (see Figure 7.a and 7.b).

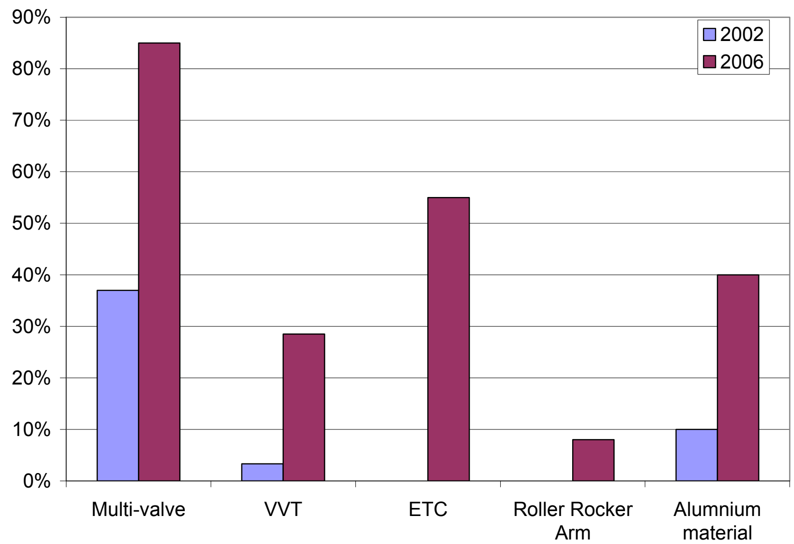

Figure 7.a Popularity of Selected Fuel-saving Technologies

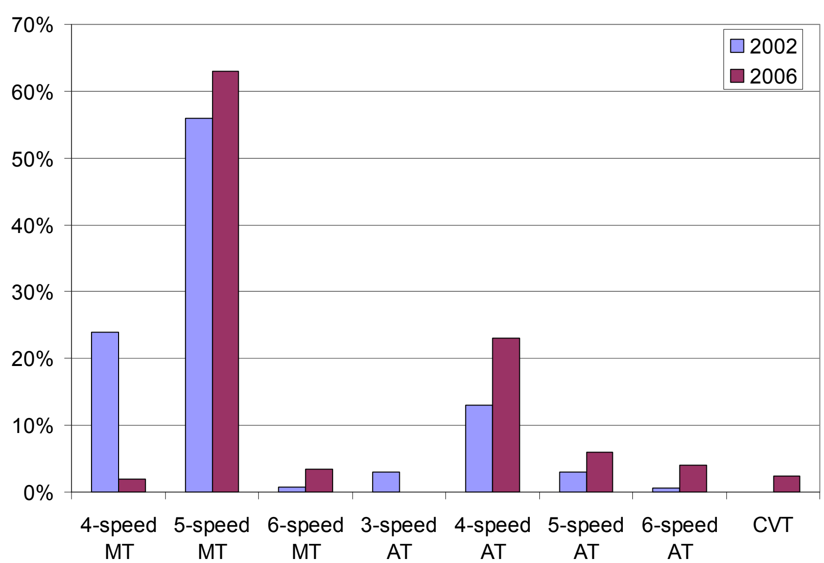

Figure 7.b Popularity of Various Transmission Designs
Source: CATARC 2007c.

Multivalve, overhead camshaft valve train

The application of the single and double overhead cam (SOHC or DOHC) designs, with two to five valves per cylinder, has the potential to improve fuel economy by 2 to 5 percent through reduced friction loss, boosted specific power (hp/liter), downed sized engine, and increased compression ratio (Chon and Heywood 2000). In 2006, almost all new passenger vehicle models adopted either SOHC or DOHC design. Meanwhile, the adoption rate of 4 valve technology grew from 57 percent in 2002 to 81 percent in 2006, at the expense of 2 valve technology (which dropped from 39 percent to 15 percent). There was also a slight increase of the popularity of 5 valve technology (from 2.5 percent to 4.6 percent, CATAR 2007b).

Variable valve timing (VVT)

This technology allows the lift or duration or timing (some or all) of the intake or exhaust valves (or both) to be changed while the engine is in operation. Under high-load, high-speed conditions, variations in cam phasing can improve volumetric efficiency and reduce residual gases. It can lead to 2 to 3 percent increase of fuel economy (Chon and Heywood 2000). The rate of VVT penetration among all passenger vehicle models offered by the 12 largest auto companies increased from 3.3 percent in 2002 to 28.5 percent in 2006 (CATARC 2007b). Eight of the 12 companies used VVT in their passenger vehicles. Among which, one company applied this technology to all of its models while the other seven used it only on some of their models (varying from 15 to 50 percent).

Multi-speed Transmission Technology[22]

In 2006, very few models were using four-speed manual transmission (MT) and more were using five- and six-speed MT. For vehicles with automatic transmission (AT) technology, 3-speed became obsolete and 4- and 5-speed gained more popularity

[22] It should be noted automatic transmission (AT) has gained more popularity in the Chinese passenger vehicle market, despite that it is less efficient than manual transmission (MT). The penetration of AT technology among vehicle models weighing less than 2,000 kg increased during 2002 to 2006. In particular, for the vehicle classes weighing between 1,540 to 2,000 kg, only 20% models employed AT, while the number increased to 52% in 2006. The penetration rate of AT among vehicles weighing less than 1,090 kg increased from 11% to 23%.

in 2006 (CATARC 2007b). A slightly higher share of passenger vehicles (from 1.3 percent in 2002 to 7.5 percent in 2006) even had six-speed transmission.[23] Continuous variable transmission (CVT) was also applied to a few more models (its share increased from 0.4 percent to 2.4 percent), which can bring 4 to 8 percent fuel economy gains.

Electronic Throttle Control (ETC)

Using an electronic unit to determining required throttle position by calculations from data measured by multiple sensors such as the accelerator pedal position sensor, engine speed sensor and vehicle speed sensor, ETC provides more precise control of air-fuel ratio and better torque management, and thus provides somewhat reduction in fuel consumption.[24] None of the passenger vehicle models made in 2002 utilized this technology, while about 56 percent of models were equipped with ETC in 2006.

Other Improvements

Compared with 2002 models, a significantly higher share of 2006 models (40 percent vs. 10 percent) used aluminum alloys for engines and other parts to reduce weight. Also, 2006 models in general tended to have more streamlined bodies to reduce aerodynamic drags and better tires to reduce rolling resistance. Rocket roller arm oil tappets and advanced lubricants which help to reduce engine friction losses were also applied to some models.

c. Other attribute changes

While auto makers improved the fuel economy of their vehicles, they also improved other attributes such as power, amenity, and safety which are highly valued

[23] According to the National Academy Press report on Effectiveness and Impact of Corporate Average Fuel Economy Standards (2003), five-speed transmission can lead to 2-3% fuel economy gain in comparison with 4-speed transmission, while six-speed transmission has 1-2% fuel economy gain over 5-speed transmission.

[24] Delphi claims that their electronic throttle control system can provide up to 10 to 15% of fuel economy gains, in comparison with mechanical control system, depending on application. See "Delphi Electronic Throttle Controls and Control Bodies for Small Engines" at https://delphi.com/shared/pdf/ppd/pwrtrn/se_tb.pdf. The major benefit of ETC is to makes it much easier to integrate features such as cruise control, traction control, stability control and others that require torque management, since the throttle can be moved irrespective of the position of the driver's accelerator pedal.

by more mature consumers. As a result, the average curb weight of LDPVs in China grew by 10 percent from 2002 and 2006.

Increased Weight

The average curb weight of new LPDV models in China increased from 1,230 kg to 1,356 kg from 2002 to 2006. This indicates that auto companies did not simply reduce the weight of their vehicles to meet the FES. On the contrary, to meet the expectations of the maturing Chinese car buyers, companies offered models with more features and larger interior space. As shown in Figure 8, the share of LPDVs with curb weight less than 1,090 kg to all LPDVs dropped from 44 percent to 27 percent while the share of LPDVs weighing more than 1,540 kg grew from 24 percent to 36 percent in those five years. Vehicles with automatic transmission tend to become particularly heavier. Almost half of the vehicles with automatic transmission weigh over 1,540 kg.

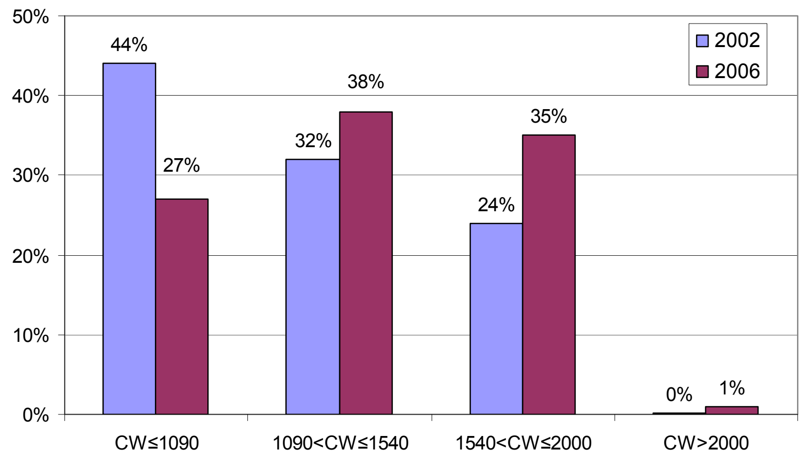

Figure 8 Distribution of LDPV Models by Curb Weight (2002 vs. 2006)
Source: CATARC, 2007b.

Despite the considerable weight gain from 2002 to 2006, the new LPDV models in China on average weighed about 10 percent less than those in Japan (1,356 kg vs. 1,369 kg), and weighed about 27 percent less than those in the United States (1,848 kg) in 2006.

Increased maximum velocity

The average maximum velocity of new LPDV models in China increased from 150 km/hr (93.7 miles/hr) in 2002 to 160 km/hr (100 miles/hr) in 2006. Only 35 percent of all 2002 LDPV models could achieve a speed higher than 160 km/hr while 58 percent of all 2006 LDPV models could achieve it.

Boosted power-to-weight ratio

The power-to-weight ratio (specific power) measures the actual performance of an engine, especially acceleration when vehicle curb weight is used as the denominator. From 2002 to 2006, the average power-to-weight ratio of LDPV models in China increased by more than 10 percent. The average power-to-weight ratio of vehicles with manual transmission grew from 55.9 w/kg to 61.6 w/kg while that of vehicles with automatic transmission grew from 65.7 w/kg to 73.7 w/kg (engine weight is used here). In 2002, among vehicle models with automatic transmission, only 10 percent of them had a power-to-weigh ratio higher than 60 w/kg; while in 2006 the ratio was 80 percent. The shift was less dramatic (an increase of 18 percentage points) for vehicle models with manual transmission.

Improved safety

It does not appear that the fuel economy improvement of the Chinese LDPV fleet during the 2002-2006 period occurred at the expense of vehicle safety. China issued the Chinese New Car Assessment Program and a series of detailed safety standards to improve vehicle safety during the same period. These safety standards concerned a wide range of aspects that are commonly addressed in western vehicle safety regulations, such as occupant crash protection (for both head-on and side collision), safety belt and head restraints, airbag, braking system, post-crash fuel system integrity, flammability of interior materials, door locks and door retention components. Auto companies were required to meet these safety standards as well as fuel economy standards, and thus, 2006 passenger vehicle models in general had both better fuel economy and better safety features than 2002 models.

d. Vehicle sales

In comparison to the clear evolution in product offerings, the consumer response to the introduction of standards is not clear. Figure 9 shows the market shares of passenger vehicles by the size of engine displacement from 2002 to 2007. Despite the fact that the Chinese FES is rather lenient on very small passenger vehicles (i.e., vehicles with engine displacement less than 1.0 liter and curb weigh less than 1,090 kg,) this segment of vehicles actually lost its dominance in the Chinese market. Its market share has been gliding rapidly since 2003. Instead, vehicles with 1.0-1.6L and 1.6-2.0L engine size have steadily gained their market shares. The 1.0-1.6L segment became the most popular one with a market share of 48 percent, while 1.6-2.0L segment showed very strong growth in the last couple of years. The market share of vehicles with engines larger than 2.0 liters remained relatively flat.

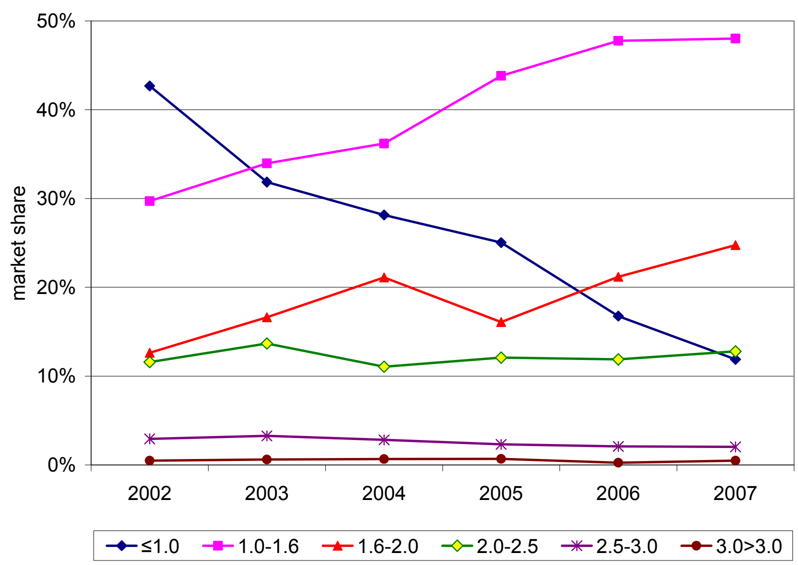

Figure 8: Passenger vehicles sales by engine size, 2001-2006
Source: CATARC 2007a, 2005, 2004 and 2003; On-line news briefings from China Automotive Industrial Association 2008.

There could be a number of possible explanations for the growth of vehicles with 1.0-2.0L engine size, such as the road-use discrimination against mini-passenger vehicles by local governments (intended to avoid congestion);[25] a lack of a tax advantage for very small cars (all cars until 1.5L engine size had a 3 percent tax until

[25] The Central Government has ordered local governments to abolish such local policies.

the most recent tax rate adjustment in 2008, see Box 1 for details); the introduction of a number of attractive compact cars (~1.4-1.6L); no increased fuel taxes, and, that wealthier and increasingly maturing Chinese car buyers were moving toward higher-quality products that provided better overall performance and more amenities.

In 2007, cars dominated the Chinese passenger vehicle market with total sales of 4.73 million, at an annual growth rate of 24.5 percent. Within this segment, cars with 1.0-1.6 L engine size accounted for about 50 percent and those with 1.6-2.0 L engine accounted for 30 percent. The total sales of mini-MPVs reached 988 thousand, a moderate 7.6 percent increase. Even within this very low-end LDPC segment, vehicles with 1.0-1.6 engine size gained much popularity. Regular MPV sales totaled 226 thousand (an 18 percent annual increase). SUV sales had the most astonishing growth (about 51 percent), up to 359,000. Both MPV and SUV segments are mainly comprised of vehicles with 1.6-2.5 L engines, which are significantly smaller than their western counterparts. The relatively humble size of MPVs and SUVs in China is partially due to the harsh requirements of the Chinese FES for heavy vehicles, and partially due to the progressively higher excise taxation on vehicles with very large engines.

e. Fuel saving and GHG reduction benefit

Setting 2002 as the base year, and assuming that companies started improving fuel economy of their products in 2002, the annual LDPV sales in China were 2.8, 3.2, 3.8 and 5.2 million respectively from 2003 to 2006. We estimate that during those four years, the improved average fuel economy of the Chinese LDPV fleet led to:

- Conservation of about 1.3 billion liters (equivalent of 8.3 million barrels, or 1 million tons) of gasoline (see Figure 9).[26] In 2006, avoided gasoline consumption was about 0.5 million tons (about 600 million liters in Figure 9). The actual annual total gasoline consumption was 52 million tons, so the gasoline demand was cut by almost 1 percent.

[26] The calculation is based on the following assumptions: 1) the 1.05 L/100km improvement of fuel economy (new LDPVs) was evenly spread over four years (2003-06), i.e. each year, the average fuel consumption of the new LDPV fleet improved by 0.2624 L/100km, and 2) all vehicles were driven for 15,000 km per year.

- Expense savings (avoided gasoline purchase) of about 6 billion *yuan* (equivalent of about USD 1 billion).[27]
- Avoidance of about 3 million tons of CO_2 emissions. About 1.4 million tons of emissions were avoided in 2006.[28] For comparison, China emitted about 6.2 billion tons of CO_2 in 2006 (Netherlands Environmental Assessment Agency, 2007), and the improved fuel economy of LDPVs only led to less than 0.02 percent of the CO_2 emission avoidance that year.

Figure 9 Fuel Savings due to Improved LDPV Fuel Economy over Years

5. Looking forward

The factors that led to the issuance of vehicle fuel-economy standards have continued to provide impetus for the Chinese government to create new standards for other types of vehicles (i.e., light-duty trucks, heavy-duty commercial vehicles, and agricultural vehicles), and to tighten the existing standards for LDPVs. In particular, tighter fuel-economy standards are in line with Chinese national policies for energy

[27] We assume 1) reduced gasoline demand did not have an impact on its price; and 2) gasoline was priced at a constant 6,000 *yuan* per ton.
[28] The combustion of 1 liter of gasoline leads to 2.38 kg CO_2 emissions.

efficiency and oil security. This includes the 2004 Medium & Long-term Special Plan for Energy Saving.

Encouraged by the apparent oil-saving and technology-pushing effects of the existing FES for LDPVs, China promulgated its first FES for light-duty trucks (Standardization Administration of China, 2007) in July 2007, and the standards took effect on February 1, 2008.[29] China is also seriously considering tightening the LDPV standards in the coming years. A recent CATARC's study shows that the average fuel consumption per 100 km of the Chinese LDPV fleet was about 12 percent and 30 percent higher than those of the European and Japanese fleets, respectively (see Figure 10). China is determined to emulate Europe and Japan in pushing for a highly efficient national LDPV fleet. It is expected that the third phase of FES for LDPVs will take effect around 2012.[30]

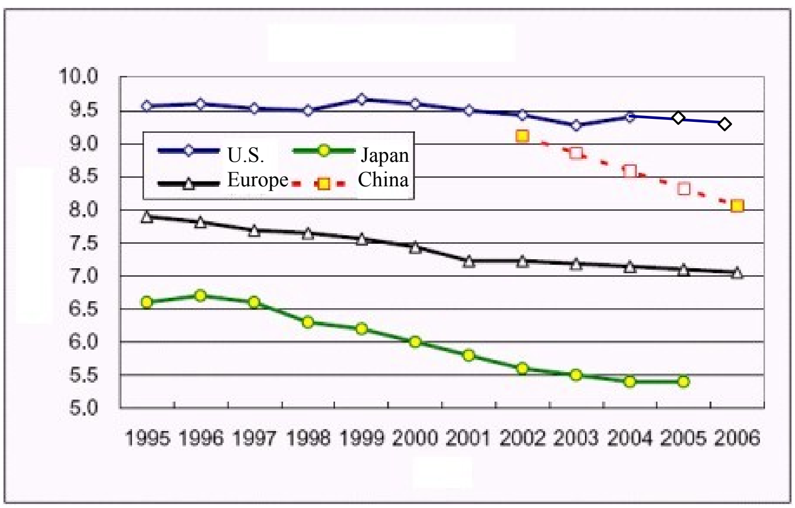

Figure 10 Comparing Sales-weighted National Average Fuel Consumption of LDPV
Source: CATARC, 2007b.

[29] Similar to the FES for LDPVs, the FES for light-duty trucks (defined as trucks weighing less than 3,500 kg) also has two phases: the first phase took effect on February 1, 2008 (existing models has a grace period of 11 months) while the second phase took effect on January 1, 2011. The first phase doesn't have much direct impact on light-duty trucks in the market; but the second phase requires an improvement of 5-10%.

[30] It has not been determined whether the new FES will keep the same weight-based (similarly, footprint) structure or take the corporate-average approach, whether it will be based on fuel consumption or CO_2 emissions.

At the same time, complementary policies are also being considered and some of them have been implemented. These include reducing subsidies for mobile fuels,[31] converting road maintenance fees to fuel taxes,[32] fuel economy labeling systems, and incentive measures (such as preferential tax measures – see Box 1 below), improving inspection and maintenance systems,[33] and setting standards for alternative fuels and alternative fuel vehicles.[34]

Box 1. Excise tax structures

In March 2006, the Chinese central government modified the excise tax on vehicles to provide a stimulus for sales of small-engine vehicles. Thus, the tax rate on small-engine (1.0-1.5 liter) vehicles was reduced from 5 to 3 percent, while the tax rate on vehicles with larger-engines (more than 2.0 liters) was raised from 8 to 9-20 percent, depending on the size of the engine, as can be seen in Table 1. Also, the preferential 5 percent tax rate that applied to SUVs was eliminated. (This preferential tax rate had earlier been out in place because it was felt that SUVs would be used only in rural areas or rough terrain.) The surge of oil prices in the last couple of years, the continued rising oil imports, and the rapid growth of SUV sales made the central government decide to partially modify the rate again in August 2008. The tax rate for vehicles with engine displacement no larger than 1 liters dropped to 1 percent while that for vehicles with engine displacement between 3 and 4 liters and larger than 4 increased to 25 percent and 40 percent respectively.

[31] The Central Government still controls the prices of wholesale fuels, which have been set lower than the international trading prices. Oil refineries have claimed that they were running in deficit for years.

[32] The intention is to make drivers more aware of the cost of driving, and to create a direct linkage between the cost and the amount of road use. After 15 years of contemplation and balancing of interest conflicts, the Central Government finally announced on December 18, 2008 to increase the excise tax on gasoline from 0.2 yuan/liter to 1.0 yuan/liter and that on diesel from 0.1 yuan/liter to 0.8 yuan/liter and to eliminate road maintenance fees and charges, starting from January 1, 2009. At the same time, because of the drop of international crude oil price, the government decided to reduce wholesale prices of gasoline, diesel, and kerosene by 900, 1100, and 2400 yuan per ton. As a result, the retail prices of gasoline and diesel (excise taxes are embedded in retail prices) were actually reduced by about 1 yuan/liter.

[33] Vehicles with engines and sensors that don't work properly often consume too much fuel and emit significantly high level of pollutants.

[34] Standards for entering alternate-fuel vehicle production were issued by the NDRC in October 2007. Technical standards for hybrid and electric vehicles are currently in the final stage of review (the solicitation of public comments during the period of Sept. 08-Oct.15, 2008). As of September 2008, the production of 5 gasoline/diesel hybrid, 1 fuel-cell, and 1 fuel-cell hybrid vehicle models were approved by NDRC (Liu, 2008). Standards for bio-diesel and methanol are in the drafting process.

Table 1. Changes in Excise Tax Rates for Light Duty Passenger Vehicles in China

Vehicle group (based on engine size, liter)	Tax rate (from Sept 1, 2008)	Tax rate (Apr. 1, 2006 to Aug. 31, 2008)	Tax rate (Jan. 1, 1994-Apr. 1, 2006)
engine size ≤1.0	*1*	3	3
1.0 < engine size ≤ 1.5	3	3	5
1.5 < engine size ≤ 2.0	5	5	5
2.0 < engine size ≤ 2.5	9	9	5 if ≤2.2; 8 if >2.2
2.5 < engine size ≤ 3	12	12	8
3.0 < engine size ≤ 4.0	*25*	15	8
engine size > 4.0	*40*	20	8

Note: under the 1994 excise tax scheme, SUVs were only classified into two groups based on their engine size (2.4 liters is the limit); SUV buyers needed to pay excise tax at a rate of 3 percent or 5 percent. Similarly, car were classified into three groups (<1.0, 1.0-2.2, and >2.2 liters); the excise tax rate for the three groups are 3 percent; 5 percent, and 8 percent.
Source: Ministry of Finance and State Administration of Taxation (2008, 2006).

Appendix I: Comparison to other major countries

The table and chart below show the basis of fuel economy standards from different parts of the world as well as the fuel-economy (current and projected) of new passenger vehicles in various countries. The fuel-efficiency performance of vehicles in China is higher than other major countries other than Europe and Japan.

Table 2: Approach to fuel-economy standards in different countries/regions

COUNTRY/ REGION	STANDARD	MEASURE	STRUCTURE	TARGETED FLEET	TEST CYCLE	IMPLEMENTATION
Japan	Fuel	km/l	Weight-based	New	JC08	Mandatory
European Union*	CO_2	g/km	Single standard	New	NEDC	Voluntary
China	Fuel	l/100-km	Weight-based	New	NEDC	Mandatory
Canada*	GHG (CO_2, CH_4, N_2O, HFCs)	5.3 Mt reduction	Vehicle class-based	In-use and new	U.S. CAFE	Voluntary
California	GHG (CO_2, CH_4, N_2O, HFCs)	g/mile	Vehicle class-based	New	U.S. CAFE	Mandatory
United States	Fuel	mpg	Single standard for cars and size-based standards for light trucks	New	U.S. CAFE	Mandatory
Australia	Fuel	l/100-km	Single standard	New	NEDC	Voluntary
South Korea	Fuel	km/l	Engine size-based	New	U.S. EPA City	Mandatory
Taiwan, China	Fuel	km/l	Engine size-based	New	U.S. CAFE	Mandatory

*Europe and Canada are shifting to mandatory regulatory programs.

Source: The International Council on Clean Transportation, 2007.

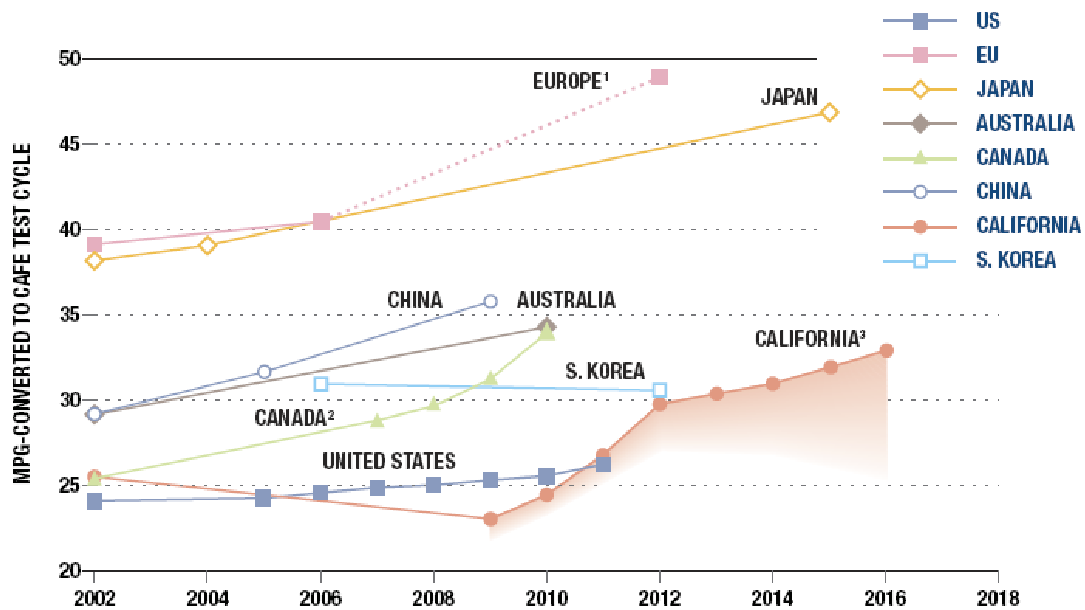

Figure 11: Actual and Projected Fuel Economy for New Passenger Vehicles by Country, 2002-2018
Source: The International Council on Clean Transportation, 2007

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Acronyms

AQSIQ	Administration of Quality Supervision, Inspection and Quarantine
AT	Automatic Transmission
CAFE	Corporate Average Fuel Economy
CARTAC	China Automotive Technology and Research Center
CESP	China Energy Sustainable Program (of the Energy Foundation)
CVT	Continuous Variation Transmission
DOHC	Double Overhead Cam
ETC	Electronic Throttle Control
FES	Fuel Economy Standards
JV	Joint Venture
LDPV	Light-duty Passenger Vehicle
LDT	Light-duty Trucks
MPV	Multi-purpose Vehicles
MT	Manual Transmission
NDRC	National Development and Reform Commission
SAC	Standardization Administration of China
SASAC	State-owned Asset Supervision and Assessment Commission
SEPA	State Environmental Protection Administration
SETC	State Economic and Trade Commission
SOHC	Single Overhead Cam
SUV	Sport Utility Vehicles
VVT	Variable Valve Timing

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