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Fuel Efficiency Strategies for Chinese Automotive Industry

CHINA
SOCIETY OF AUTOMOTIVE ENGINEERS

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INTERNATIONAL CENTER FOR ECONOMIC AND TECHNICAL EXCHANGES

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Preface

China's automotive industry has enjoyed buoyant development since the beginning of the new century. In 2012, China produced a little over 19 billion vehicles. By the end of 2012, the total societal automobile ownership amounted to nearly 121 million (including 11.45 million three-wheel vehicles and low-speed trucks) and there were 89 vehicles for every thousand people (including three-wheel vehicles and low-speed trucks).

In 2011, vehicles across the nation consumed 144 million tons of gasoline and diesel, making up 59% of the total societal apparent consumption. China's imports of petroleum experienced an annual growth of 58% in 2012, posing big challenges for energy conservation. With the increasingly exposed conflict between automotive demand and energy conservation, the State Council issued the *Energy-saving and New-energy Auto Industry Development Plan (2012-2020)* as a guideline for the development of energy conservation and the new-energy auto industry for the next decade. The Plan sets a goal of lowering the average fuel consumption of passenger vehicles to 6.9 liters per one hundred kilometers by 2015 and 5.0 liters per one hundred kilometers by 2020[1]. Although the Plan also proposes major tasks to be performed and the methods for assuring this, specific and detailed measures were still needed to identify and implement these broad goals.

Traditional fuel powered vehicles have a wide coverage and a large customer base. Hybrid vehicles come in two forms: the conventional hybrid vehicles, classified as energy saving vehicles, and the plug-in vehicles, classified as new-energy vehicles. Compared with other new-energy vehicles, hybrid vehicles enjoy a more promising market prospect in the near to mid-term and rely on more mature technology. Therefore these two categories are the priority for the near-term and mid-term energy saving strategies. This report summarizes the research for the project *Fuel Efficiency Strategies for Chinese Automotive Industry*, which was sponsored by the United Nations Industrial Development Organization, the China International Center for Economic and Technical Exchanges (CICETE), the Society of Automotive Engineers of China (SAE-China), and the China Automotive Technology & Research Center (CATARC). Targeting the above vehicle categories, this project adapted global development experiences to China's realities. The researchers assessed the development goals for 2015 and 2020, the existing problems in reaching these goals and proposed technical approaches for resolving these problems; and proposed measures and policy recommendations for the promotion of energy conservation and development. This report will serve as a valuable technical reference for the government and enterprises.

The research project mainly targets the energy saving issues of traditional fuel vehicles (excluding vehicles powered by alternative fuels like CNG) and common hybrid vehicles, with a focus on realizing energy conservation through technologies

and product structure. The scope of this report therefore does not include issues concerning fuel quality, energy-saving driving, improving traffic flow and an energy conservation culture, alternative energy, new-energy automobiles, etc. Furthermore, it takes account of but does not elaborate on technical issues closely related to the application of energy-saving technologies such as fuel quality.

The project covered five key research areas:

1. Current situation and trends in overseas automobile energy conservation efforts;
2. Current situation of China's automobile energy conservation efforts;
3. A comparison between overseas and China's automobile energy conservation, and China's major problems;
4. The 2015 and 2020 development goals for China's automobile energy conservation efforts, technical approaches and potential;
5. Recommendations on policy measures to promote China's automobile energy conservation efforts.

The project first produced the following three sub-reports:
Sub-report 1: Current Situation and Trends in Overseas Automobile Energy Conservation Efforts;
Sub-report 2: Current Situation, Goals, Approaches and Suggested Policy Measures for China's Automobile Energy Conservation Efforts; and
Sub-report 3: A Comparison between Overseas and China's Automobile Energy Conservation Efforts, and China's Major Problems.

This main report builds on these three sub-reports. It is not simply the integration and summary of the findings of these three sub-reports. It also draws on the International Energy Agency (IEA) Technology roadmap approach[2], following the research methodology of “Targets - Target decomposition - Barriers - Roadmap - Actions”.

The project adopted a variety of research methods, which are complementary and aim to reach accurate, in-depth and scientific conclusions. The methods are as follows:

Material collection and data analysis: Researchers collected data on and analyzed relevant domestic and overseas policies, laws and regulations[3]. Based on multi-dimensional data, a comparative study was conducted on the current situations and trends between overseas and domestic energy conservation efforts.

Corporate research and overseas investigations: The research team visited a number of international automotive companies including Toyota, Nissan and GM, and communicated with their technical teams. They also investigated major domestic auto companies including FAW, SAIC Motor, BAIC Motor, Changan, Geely and Great Wall, and had discussions with renowned experts and scholars in the auto industry. From August 5th to 10th, 2012, researchers visited Japan to explore its energy

conservation efforts in the automotive industry. In March 2013, principal researchers visited the US and Mexico for the same purpose.
Survey: From April to June 2012, eleven experts from China's automotive industry responded to a questionnaire about key energy conservation issues. From November 2012 to January 2013, representatives from various countries who attended the 2012 FISITA Meeting also submitted their responses to the questionnaire.

Technical discussions: From August 2012 to May 2013, four expert seminars were held in Beijing, with the third and the fourth seminars being held for the whole industry. 65 representatives attended the third seminar and 101 attended the fourth seminar, including experts from four government departments. Through in-depth communication, the project quality has been greatly improved and influences in the industry have been expanded.

On the basis of these research methods, the final report was prepared.

1 Rationale for Chinese automotive fuel efficiency

Energy saving and low carbon development in the automotive sector, whether in China or overseas, is dependent of four key parameter and their relationships, namely, vehicle, fuel, road and users.

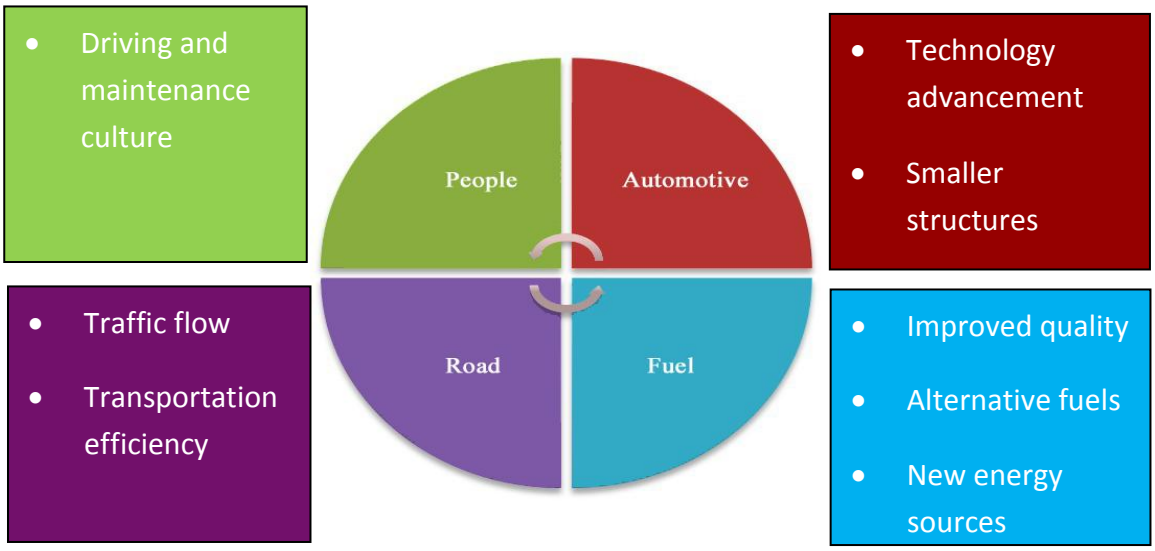

Figure 1-1 Four factors of automotive fuel efficiency and low carbon development

"Vehicle" refers to improving automotive fuel efficiency mainly through energy saving technology and the development of miniaturized product structure.

"Fuel" refers to the improvement in the quality of oil products and the diversification of fuels, including the development of alternative fuels and use of renewable energy sources.

"Road" refers to improving traffic flow and transportation efficiency, including intelligent traffic.

"People" refers to the driver, who is responsible for energy-efficient driving, green maintenance, and having an energy saving culture.

This project mainly focuses on studying the **"vehicle"** factor.

The development of fuel efficient vehicles requires the joint involvement of government, industry, the public and the media, and concerted efforts from the entire society. Different stakeholders have specific roles in promoting energy conservation in vehicles. For example, the government is the leader and promoter of the energy saving targets while the manufacturers and consumers are action takers to achieve those targets.

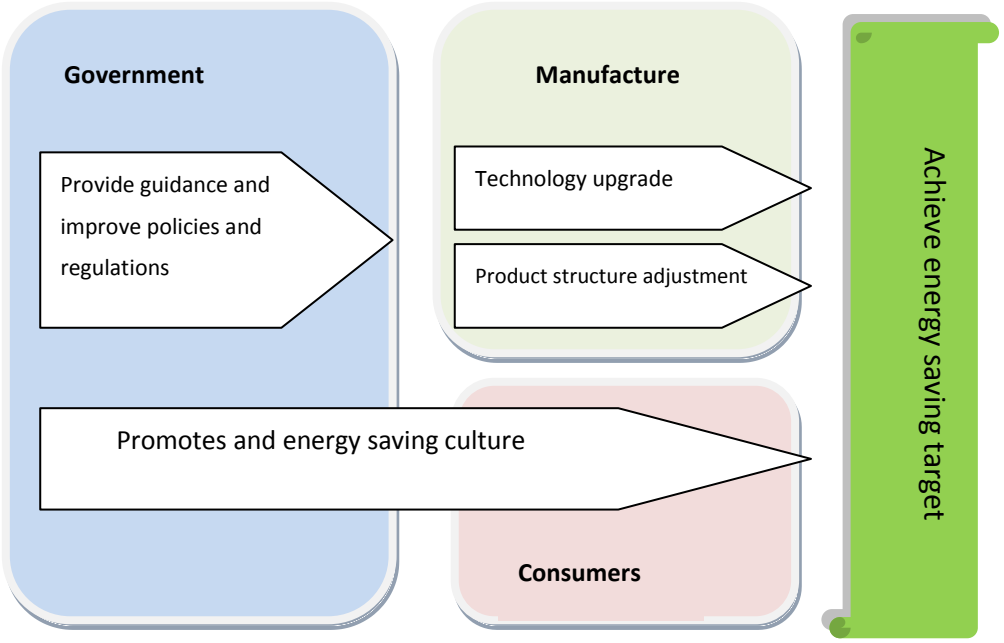

Figure 1-2 Roadmap for automotive fuel efficiency in China

The government can promote and guide industry energy conservation through industry management, development of standards, and guidance of fiscal and taxation policies. While actively guiding the enterprises to achieve higher fuel efficiency, the government also needs to focus on cultivating a culture of automotive energy conservation and to promote energy conservation in consumption sectors. In China, there are a number of government departments involved in the management of vehicle energy conservation. The Ministry of Industry and Information Technologies, the National Development and Reform Commission, the Ministry of Science and Technology, the Ministry of Commerce, the General Administration of Customs, the General Administration of Quality Supervision, Inspection and Quarantine, the Ministry of Transportation, the Ministry of Environmental Protection and other departments are involved in the management. The Ministry of Finance, State Administration of Taxation and other departments develop fiscal and taxation policies to promote energy-saving vehicles.

In the case of manufacturers, they should factor in the cost-efficiency of energy-saving technologies in response to the requirements and under the guidance of policies. Their goal is to achieve energy conservation by upgrading technology and product structure adjustment. Furthermore, manufactures should play an active role in the promotion of energy-saving technologies, energy-saving driving and maintenance.

In the case of industry associations, they have a role to play when supporting the formulation of sectoral standards, technology research and knowledge sharing.

For their part, consumers have the ultimate choice when selecting vehicles. The creation of an energy-saving culture, energy-saving driving and maintenance will influence the actual fuel consumption levels. The influence of the consumers was considered out of the scope of this research project, and therefore is not discussed in details here.

2 The development goals for China’s automotive fuel efficiency

The ever growing automobile ownership in China is aggravating the energy supply situation. Against such a backdrop, the government continues to mandate controls over automobile energy conservation. The efforts have proven to be effective, with the main measures including:

1) Standards for vehicle fuel consumption limits, including GB19578-2004 *Fuel Consumption Limit Standards for Passenger Vehicles in China*, followed later by standards for vehicle fuel consumption limits for lightweight commercial vehicles and heavy weight commercial vehicles. The implementation of these standards is led by the Ministry of Industries and Information Technology (MIIT);
2) *Promotion and enforcement regulations for energy-saving vehicles (passenger vehicles with engine displacement of up to 1.6 L) under the “Project to Promote Energy-efficient Products for the Benefit of the People”.* It was jointly carried out by the Ministry of Finance (MOF), the National Development and Reform Commission (NDRC), and MIIT in June 2010;
3) *Interim Management Measures for Demonstration and Promotion of Energy-saving and New Energy Vehicles* and *Interim Management Measures for Pilot Fiscal Subsidy for Purchasing Private New Energy Vehicles*. These programs were jointly carried out by MOF, the Ministry of Science and Technology (MOST), MIIT and NDRC in 2009;
4) *Vehicle and Vessel Tax Law of the People's Republic of China* and policies of vehicle and vessel tax reduction and exemption for energy-saving and new energy vehicles. These were jointly elaborated by MOF, the State Administration of Taxation and MIIT in 2012;
5) *Development Plan of Energy-Saving and New Energy Automotive Industry (2012-2020)*, issued by the State Council in 2012;
6) *Measurement Methods for Corporate Average Fuel Consumption of Passenger Vehicles*, which was jointly issued by MIIT, NDRC, the Ministry of Commerce (MOFCOM), the General Administration of Customs and the AQSIQ in March 2012.

Currently, China has established a relatively comprehensive management system for energy conservation in individual passenger vehicles. With the issuance of the *Measures for Computing the Average Fuel Consumption of Passenger Car Manufacturers*, China is making the transition from targeting individual vehicles' fuel efficiency to meet individual targets to targeting fuel efficiency at an enterprise level to meet overall targets. China’s automotive fuel efficiency is getting in line with international best practice. Despite these accomplishments, China is also confronted with many challenges and requires detailed strategies to promote automobile energy conservation.

2.1 China’s targets for the fuel efficiency and curb weight of passenger vehicles

Recent years have seen progress in terms of energy consumption for China's passenger vehicles. At the end of 2012, domestic passenger vehicles on average consumed 7.4 liters per one hundred kilometers (L/100km), i.e. they emitted 173 g of CO_{2eq}/km. This compares to a consumption of 7.8L/100km in 2009 (see fig. 2-1).

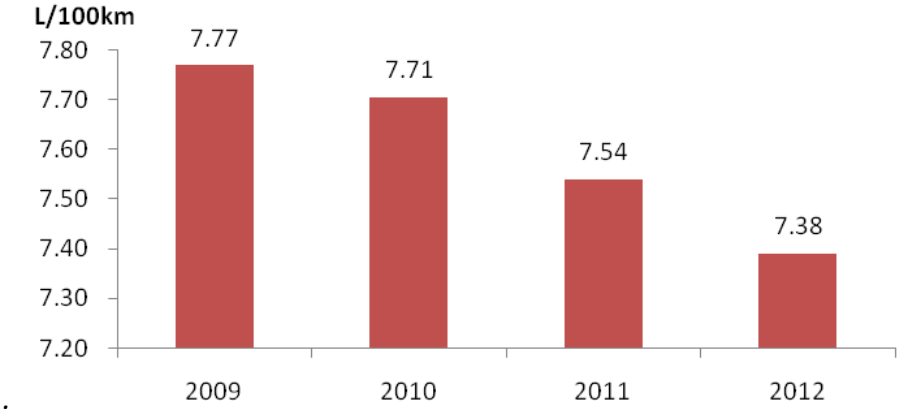

Figure 2-1 Average fuel consumption by domestic passenger vehicles from 2009 to 2012

Source: CATARC-ADC

Note: These figures are weighted averages from several different mathematical models. According to the *Measures for Computing the Average Fuel Consumption of Passenger Car Manufacturers*, in cases where several values for energy consumption were obtained from a single model, the figure obtained under the most unfavorable conditions must be adopted

Figure 2-2 shows how China's current levels of vehicle fuel consumption and future targets for consumption compare with those of various other countries.

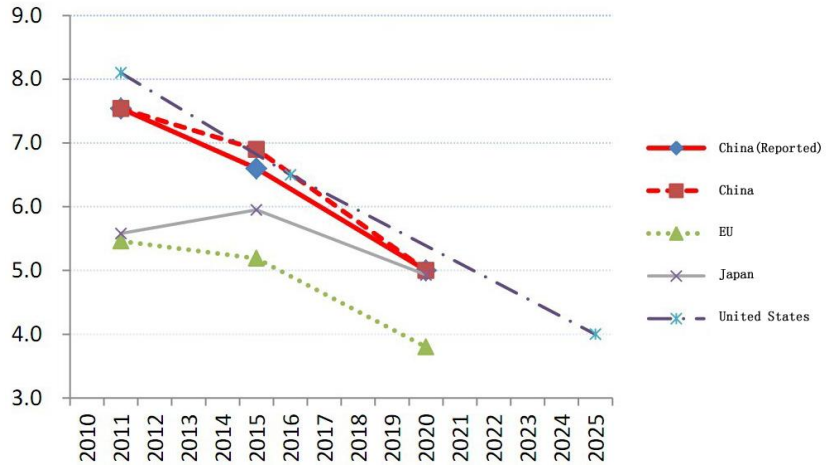

Figure 2-2 A comparison between the current passenger vehicle fuel consumption and future targets

Source: CATARC-ADC, ACEA[4-5], JAMA[6-7], EPA[8-10], NHTSA, ICCT

Note: The figures are adjusted according to NEDC conditions. The vertical ordinate unit is L/100km.

China's 2020 target for average passenger vehicle fuel consumption is 5.0L/100km, i.e. 119.2 g/km emissions of CO_{2eq}; and shall be achieved through technological progress and product structure adjustment.

In January 2012, the third phase of fuel consumption standards took effect, while June 2012 marked the publication of the *Energy-saving and New-energy Auto Industry Development Plan (2012-2020)*. In July 2012 the "Data Management System for Automobile Fuel Consumption" was launched. Therefore, 2011 was identified as the benchmark year for the target.

Based on the current situation and general demand of energy conservation in China's automotive industry, and the international experience and feasibility of adopting technologies, the year 2020 was set as the year when the target passenger vehicle fuel efficiency would meet the global advanced level.

The main projection assumptions are the following:

- In 2020 the overall adoption of low emission vehicles is 25% higher than that of 2011;
- Vehicles with small displacement and light weight would consume 5.5% less fuel;
- The increased share of diesel passenger vehicles would save 2% fuel; and
- The increased share of hybrid passenger vehicles would save 4% fuel.

The combined savings of these measures would be 36.5%. However, when adjusting this amount to account for the double-counting of the effects of certain technologies, the percentage improvement in fuel efficiency is 34% (compared to 2011 values). The equation for the 2020 target fuel efficiency derives in the 5L/100km; which is equivalent to 119.2g/km emissions of CO_{2eq}[1].

China's 2020 target for the curb weight of passenger vehicles is 1,250kg. In recent years, the average curb weight of Chinese passenger vehicles has grown relatively quickly from 1,228 kg in 2009 to 1,295 kg in 2012. The average annual growth rate is 1.8% with an average annual growth of 22.4 kg, as shown in Figure2-3.

[1] in this calculation, the share of diesel passenger vehicles in 2020 is taken to be 10%. 1 L of gasoline = 2.35kg CO_2. 1 L of diesel = 2.69kg CO_2

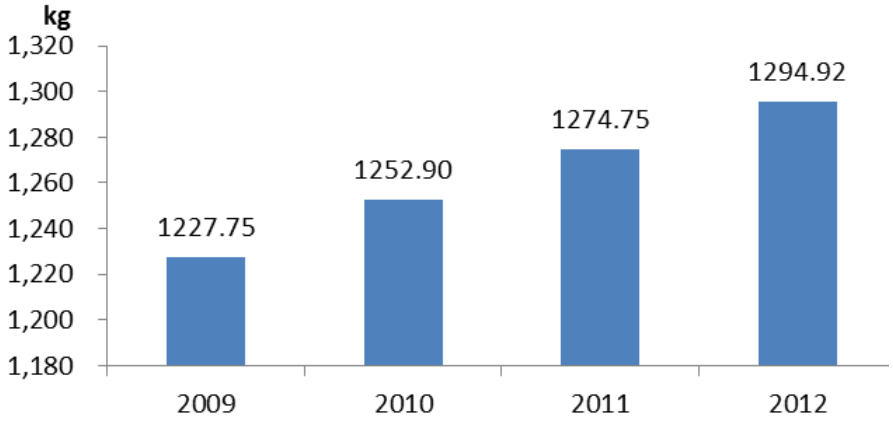

Figure 2-3 Average curb weight of domestic passenger vehicles from 2009 to 2012
Source: CATARC-ADC

According to ICCT[11], in the 27 EU countries, the average curb weight of passenger vehicles (mass when in use, i.e. the curb weight plus the driver's mass) was 1,393 kg in 2011 and 1,268 kg in 2001. The average annual growth rate was 0.94% with an average annual growth of 12.5 kg. This may be considered to be 1% when the impact of the 2008 financial crisis is deducted. In 2009, the EU issued regulations to cap CO_2 emissions of passenger vehicles. The growth of curb weight will then be restrained, and the expectation is of a halving in the growth rate to 0.5%.

In the US, in the recent decades the SUV market share has seen a remarkable expansion. In addition, the curb weight of light vehicles has been generally increasing with the constant improvement in the performance of vehicles and in response to the increasingly stringent laws and regulations on safety and emissions. According to EPA data[10], the average curb weight of cars in the US in 2011 is of 3,617 pounds, showing an average annual increase from 1982 to 2011 of 0.59% or 19.45 pounds.

China is now at the stage where a large increase in the sale of passenger vehicles to household users and the share of SUVs will grow. With 2011 taken as the benchmark year for curb weight, the average annual growth rate was defined as "30% of EU annual increase of over 70% of China's annual increase", multiplied by a factor of 40% considering China's national goal of energy conservation and policy for developing miniaturized products. This results in an average annual growth rate of 0.66%. Therefore, the projected 2020 average curb weight for Chinese vehicles will be 1,353kg. The reduction target for the period 2011-2020 is 10%, hence the net average curb weight in 2020 will be 1,220kg. Factoring in imported models, the weight should be increased by another 2%. Therefore, the resulting China's 2020 target for domestic passenger vehicle curb weight is 1,250kg, excluding pure electric and battery passenger vehicles.

2.2 The target for fuel efficiency of commercial vehicles

In 2011, new light-weight commercial vehicles in China had an average fuel consumption of 8.16L/100 km. To meet the global targets of fuel efficiency in 2020, i.e. 6.5L/100km, the average consumption should decrease by 2.5% annually, down by 9.6% in 2015 to 7.4L/100km, and again down by 12.2% in 2020 to 6.5L/100km.

For medium and heavy weight commercial vehicles, based on findings of *Policies for Energy-saving and New-energy Technologies*[3], if passenger vehicles and wagons are grouped together, the average fuel consumption in 2009 was 35L/100 km. To meet the goal of matching international level of fuel efficiency in 2020, i.e. 25L/100km, the average consumption should drop by 3% annually, down by 16.7% in 2015 to be 29.2L/100km, and again down by 14.1% in 2020 to be 25L/100km.

Using the generalized logical model with variable parameters and multivariate linear model, it is predicted that in 2020, automobile ownership will be 240 million, with an annual demand of 27.36 million.

By 2020 the average fuel consumption per vehicle per year will be 1 ton. The automobile ownership will be up by 150% compared with that of 2011, while the fuel consumption will increase less than 75%.

It has been calculated that in 2011, gasoline consumption in vehicles was 68.6 million tons, making up 88.7% of the total national gasoline consumption of 77.4 million tons; diesel consumption in vehicles was 75.5 million tons, making up 45.1% of the total diesel consumption of 167 million tons. In 2011, the ratio of fuel consumption by passenger vehicles against commercial vehicles was 44:56.

In 2011, China's automobile ownership was 93.50 million (excluding 12.28 million three-wheel drives and low-speed trucks). Total consumption of gasoline and diesel was 144 million tons, i.e. 1.54 tons per vehicle per year.

Factoring in energy conservation measures realized by adopting energy efficient technologies, market structure and driving habits, it is calculated that in 2020, the 240 million vehicles will consume about 240 million tons of gasoline and diesel, i.e. one ton per vehicle per year.

In other terms, the automobile ownership will be up by 150% compared with that of 2011, while the fuel consumption will increase less than 75%.

3. Understanding China's automotive energy conservation targets

3.1 The 2015 passenger vehicle fuel efficiency target and the 2020 annual rate of decrease target

The targeted average fuel consumption of passenger vehicles in 2015 is 6.6L/100km, which requires an annual decrease of 3.27% from 2011. From 2015 to 2020 an annual decrease of 5.4% is required.

The 2020 fuel efficiency target for passenger vehicles is 5.0L/100km. From 2011 to 2020, the average annual decrease rate is 4.46%.

This target is based on the principle that 2015 should be the tipping point on the two linearly decreasing trends from 2011 to 2020, with that before 2015 slower and that after 2015 faster.

This principle is based on the following four factors:

1) The energy conservation plan took effect only in 2012, and requires more detailed measures to promote its implementation. The measures to manage the computation of average fuel consumption of passenger vehicles are still on the way. This certainly will influence the decrease rate of the first period of time.
2) The third phase fuel consumption standards will expire in 2015. Follow-up standards and policies are likely to further promote small vehicles.
3) After 2015, the development of hybrid and diesel passenger vehicles may speed up.
4) Currently, China's overall energy conservation technology level is relatively low. In the early stage, technological measures will jumpstart the decrease. As technologies advance, in the later stage, it will become harder to accelerate the decrease. The slope will therefore become less steep.

Considering these four factors, the decrease of passenger vehicles will go from slow to fast. Based on an equal annual decrease rate of 4.46% for 2011 to 2020, the fuel consumption targets for 2015 is 6.28L/100km.

Considering a slope of 70%, with an accelerated decrease after 2015, the decrease rate for the period until 2015 is 4.46% * 70% = 3.12% and the 2015 target is accordingly adjusted to 6.6L/100km.

Table 3-1 Breakdown of China's passenger vehicle fuel efficiency targets

Year	Item	Value
2011	Fuel Consumption (L/100km)	7.54
2015	Fuel Consumption (L/100km)	6.6
	Annual Decrease	3.27 % (From 2011)
2020	Fuel Consumption (L/100km)	5.0
	Annual Decrease	4.46% (From 2011) 5.40% (From 2015)

3.2 Targets for small passenger vehicles

By 2020, the share of passenger vehicles with 1.6L and lower displacement will be increased from the current 65% to 80%. The market share of small passenger vehicles will increase from the current 8% to 18%. At present, small vehicles are defined by displacement and curb weight:

1) Displacement, the first standard defines small vehicles as those with a displacement below 1,000mL. In 2012, China had 1,496,211 passenger vehicles that met this standard, making up 10.3% of the total passenger vehicles. The distribution of curb weights is shown in table 3-2.

Table 3-2 Curb weights of the passenger vehicles with displacements of 1.0L or less

Curb Weight, kg	Production	Share
CM≤700	7,543	0.5%
800<CM≤900	384,618	25.7%
900<CM≤1000	797,345	53.3%
1000<CM≤1100	260,920	17.4%
1100<CM	45,785	3.1%
Total	1,496,211	100%

Source: CATARC-ADC

2) Curb weight, the second standard is weight below 1,000kg. In 2010, there were 1,189,506 passenger vehicles with a displacement below 1 L and a curb weight below 1,000kg, accounting for 79.5% of all the passenger vehicles with a displacement under 1 L and 8.2% of the total passenger vehicles.

The final definition of a small passenger vehicle is a passenger vehicle with a displacement of 1 L or lower and curb weight of 1,000kg or lower. By 2020, the market share of small passenger vehicles will increase from the current 8% to 18%.

3.3 Targets for the application of fuel efficient technologies

Advanced energy saving technologies are being applied in a wide range of fields. The year 2020 will see the universal application of energy saving technologies and products such as the start-stop system, variable valve timing, efficient transmission with six or more gears, electric power steering, low rolling resistance tier, monitoring and warning system, as well as a fairly large-scale application of the GDI engine, TC engines, low friction engine design, auto accessories with improved performance, Atkinson cycle hybrid engine, etc. The weight of individual vehicles is expected to drop by more than 10%.

For other vehicles market share the targets for 2020 are as follows

- For diesel passenger vehicles will be increased from the current value of less than 0.8% to 10%.
- For hybrid vehicles should be increased from the current share of less than 0.1% to 15%.

4 Gaps and barriers for the adoption of fuel efficiency measures

4.1 Comparison with international automotive fuel efficiency data

The average fuel efficiency of China in 2011 was 7.54L/100 km, equivalent to emissions of CO_2 of 178.2g/km. In the same year the average fuel efficiency: for other regions studied were: for the EU 5.46L/100 km and the respective CO2 emissions were 136.6g/km; for Japan was 5.58L/100 km; and the for light-duty vehicles in US was 32.3 miles/gallon, equivalent to 8.10L/100 km under the conditions of the New European Driving Cycle (NEDC).

This data and the national targets are presented in the table below. The table shows that the annual rates of decrease for China, the EU and Japan from 2015 to 2020 and for the US from 2017 to 2025 are significant, with over 5% for the US and over 6% for China and the EU.

Table 4-1 Present and target values of fuel consumption in passenger vehicles - China, the EU, Japan and the US

Unit: L/100km, all converted to equivalence in New European Driving Cycle (NEDC) conditions

Year	China	EU	Japan	US
2011	7.54	5.46 (136.6g/km)	5.58 (19.9km/L, JC10-15)	8.1 (32.3 mpg)
2012	7.38	5.28 (132.2g/km)	5.14 (21.6km/L, JC10-15)	7.6 (34.3mpg)
2015	6.9 (plan): Annually -2.19%(than 2011) 6.6(report) annually -3.27%(than 2011)	5.19 (130g/km) annually -1.23%(than 2011)	5.95 (16.8km/L, JC08) annually -1.94%(than 2004)	
2016				6.5 (225g/mi) annually -4.31%(than 2011)
2020	5.0 annually -6.24%(than 6.9) annually -5.40%(than 6.6)	3.80 (95g/km) annually -6.08%(than 2015)	4.93 (20.3km/L,JC08) annually -3.61%(than 2015)	
2025				4.0(143g/mi) annually -5.25%(than 2016)

Sources: CATARC-ADC, ACEA, JAMA, EPA, NHTSA, ICCT

Notes:

1. For EU, assumptions are that 45% of passenger vehicles are using diesel engines, and emission factor are for 1L gasoline =2.35 kg CO_2, 1L diesel =2.69 kg CO_2;
2. Data in JC10-15 and JC08 conditions is converted to data in NEDC condition through JAMA formula;
3. Data in American condition is converted to data in NEDC condition through ICCT formula.

The EU and Japan are leading in automotive energy saving and low-carbon emission development. In 2012, the average fuel consumption of individual passenger cars in China was 39% higher than in the EU, and 44% higher than in Japan. Hence, there is a significant gap between China and the advanced level in the world in terms of fuel efficiency and CO_2 emissions.

Based on the targets for 2015, the planned value for the average fuel consumption in China (6.9L/100km) is 33% higher than that of the EU, and 16% higher than that of Japan. The reported fuel consumption of 6.6L/100km is 27% higher than in the EU, and 11% higher than in Japan. With regards to the target values in 2020, the average fuel consumption of individual passenger car in China is 32% higher than in the EU, and 1% higher than in Japan.

In 2011, the average automotive performance indices of passenger vehicles in China, such as engine displacement and curb-weight, were lower than the average level of passenger vehicles in the EU and US, and higher than in Japan, as presented in Table 4-2. As for curb weight, on average passenger vehicles in China were 8.5% lighter than those of the EU, 23.7% lighter than those of the US, and 19.3% heavier than those of Japan. As for the proportion of diesel-powered vehicles, diesel-powered passenger vehicles in the EU accounted for 56% of the total sales volume of passenger cars in 2011, which was much higher than in other countries. Japan is taking the lead in new-energy vehicles, particularly in HEV, the sales volume of which accounts for 16% of the total sales of passenger vehicles. However, in China the market share of both diesel powered and new-energy vehicles is quite small.

Table 4-2 Comparison of average product structure of passenger vehicles – Data for China, the EU, Japan and the US

	China	EU	Japan	US
Curb-weight kg	1,275	1,393	1,168	1,641
Engine capacity mL	1,608	1,644	Sales volume of mini vehicles accounts for ⅓	2,638
Proportion of diesel powered vehicles	0.56%	56%	0.1%	0.9%
Proportion of hybrid vehicles	0.05%	0.7%	16% (new-energy vehicles, most of which are hybrid vehicles)	3.4%

Sources: CATARC-ADC, ACEA, JAMA, EPA, NHTSA, ICCT

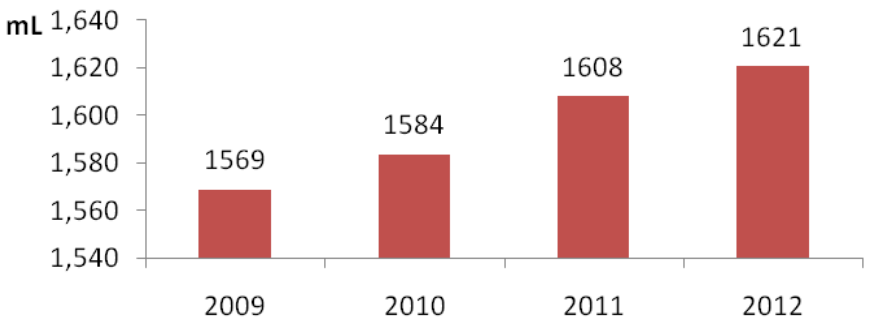

Figure 4-1 The average engine displacement of domestic passenger vehicles 2009-2012
Source: CATARC-ADC

As shown in table 4-3, there is a gap between China and the EU and US in the adoption of fuel-efficiency technologies for passenger vehicles. When considering the penetration of the most common technologies, such as reducing engine friction losses, the use of hybrid powered vehicles, and of electric power steering, China lags behind Europe and the US. On the other hand, the levels of adoption of turbo charging in gasoline engines and direct injection are close to those in the EU and US. Overall, when compared to the EU and US, China has a long way to go in disseminating key technologies.

Table 4-3 Comparison on the application of energy saving technologies in selected countries

Main technical measures		US light-duty vehicles (2011)	EU (2010)	China (2012)
Advanced engine technology	Turbo charging gasoline engine	7.2%	–	11%
	Gasoline (engine) Direct Injection	15.4%	14%	10%
	Variable valve timing	93.1%	–	35%
	Variable valve lift	12.8% (2008)	–	
	Engine friction loss reduction	15% (2008)	–	Very low
	Idle start-stop	–	–	Very low
	Cylinder deactivation	9.5%	–	0%
	Attachments performance improving	–	–	Very low
Advanced transmission technology	Gears multiplication	6-speed transmission 53.8% 7+-speed transmission 5.5%	6+,38%	6MT,1% 6, 7, 8AT12%
	Dual clutch transmission	0.8% (2008)	3%	5.8%
	Continuously variable transmission	11.9%	2%	5.2%
Light weight materials		–	–	Very low
Hybrid power		4.0%	1%	0.05%
Other advanced technologies	Electric power steering	12.6% (2008)	–	Very low
	Air resistance reduction	9% (2008)	–	Very low
	Monitor reminder	–	–	Very low
	Low rolling resistance tires	7% (2008)	–	Very low

Sources: CATARC-ADC, ACEA, JAMA, EPA, NHTSA, ICCT[11]

4.2 International fuel efficiency standards and regulations

In recent years, standards and regulations have been successively issued in China, Europe, the US and Japan regarding fuel consumption and CO_2 emissions of both passenger and commercial vehicles. For heavy-duty commercial vehicles there are still no relevant regulations in the EU, and they are also limited in China.

China adopted the first phase of its fuel consumption limit standards in July 2005, the second phase in January 2008 and the third phase in January 2012. According to the standards, vehicles are classified into 16 groups based on their curb weights, each subject to corresponding limits or target requirements. Phases I and II focused on the management of fuel consumption limits of individual vehicles, while the concept of “average enterprise fuel consumption” was introduced in phase III, which

is much more similar to the fuel consumption management for vehicles in the US, the EU and Japan. However, there are many differences in fuel consumption and CO_2 emission standards and regulations among different countries and areas.

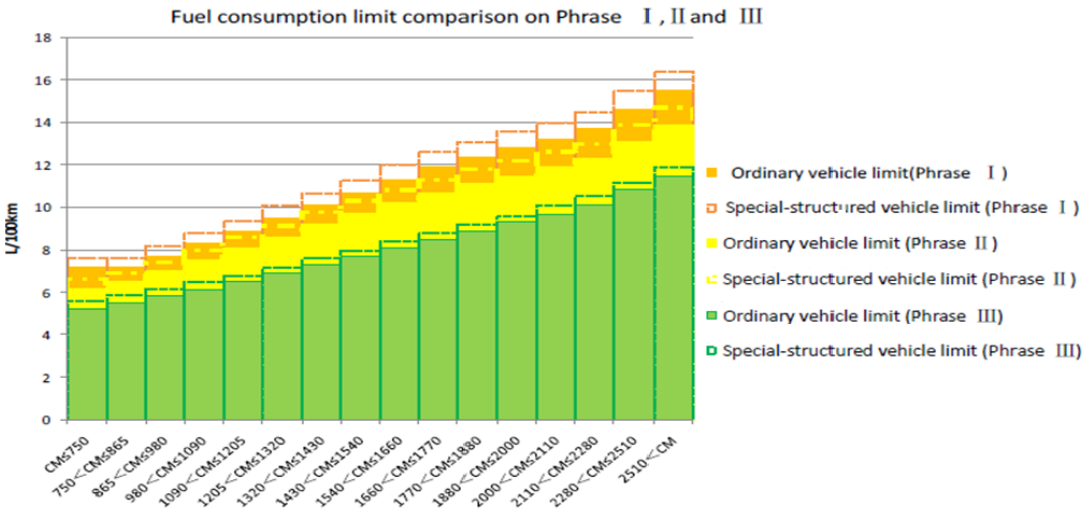

Figure 4-2 Comparison of Phases I, II, III fuel consumption limit standards for passenger vehicles in China

The CO_2 emission limit for passenger vehicles in the EU can be estimated using the following formulae:

Formula 4.1) CO_2 emissions = 130 + a × (M-M0)

where
a = slope of the curve
M = vehicle weight (kg);
Mo= baseline weigh (kg)

Table 4-4 gradient and baseline curve weight for Phases I, II, III

Variables	Phase II 2010 to 2015	Phase III 2016 and future years
Mo= baseline weight (kg)	1372	To be established
a = slope of the curve	0.0457	0.0457

In the case of the EU, figure 4.3 reflects the different percentages of CO_2 emission decrease required for the vehicles with different weights, showing a linear relationship between vehicle with and CO2 emissions

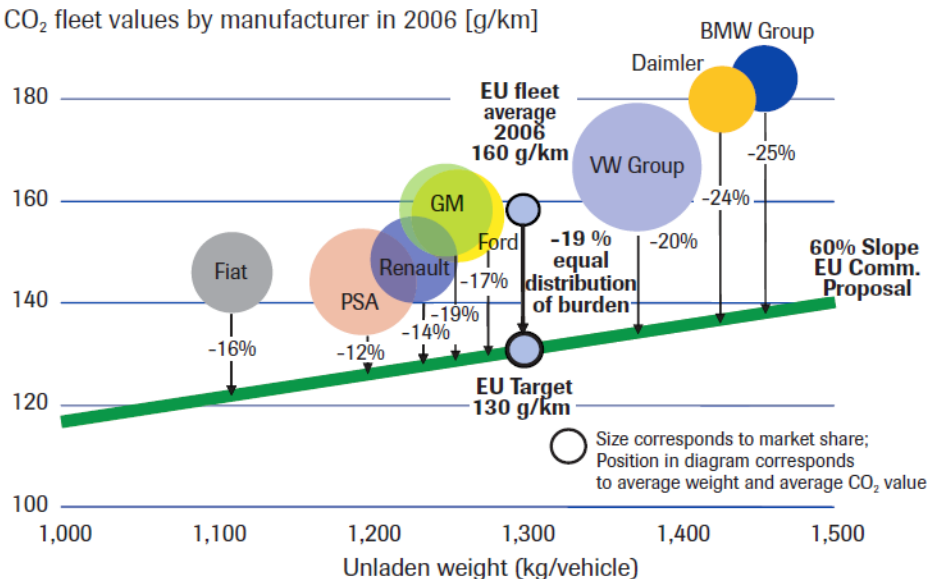

Figure 4-3 CO_2 Emission limit regulations for passenger vehicles in the EU

Source：VDA[12]

The gradient for the EU curve “a” is 0.0457. It reflects the variation of CO_2 emissions with curb weight and is a core element of the regulation. The EU’s new proposal for CO_2 emissions from passenger vehicles after 2020, the value of “a” should be reduced from 0.0457 to 0.0333.

Figure 4-4 shows the curves in the US’s Corporate Average Fuel Economy (CAFE) regulation for passenger vehicles (2011-2016). The horizontal axis is the footprint area (wheelbase multiplied by the average track). The curve for 2011 is S-shaped while those for 2012 -2016 are horizontal lines at the two ends plus an oblique line in the middle, indicating gradually increased requirements.

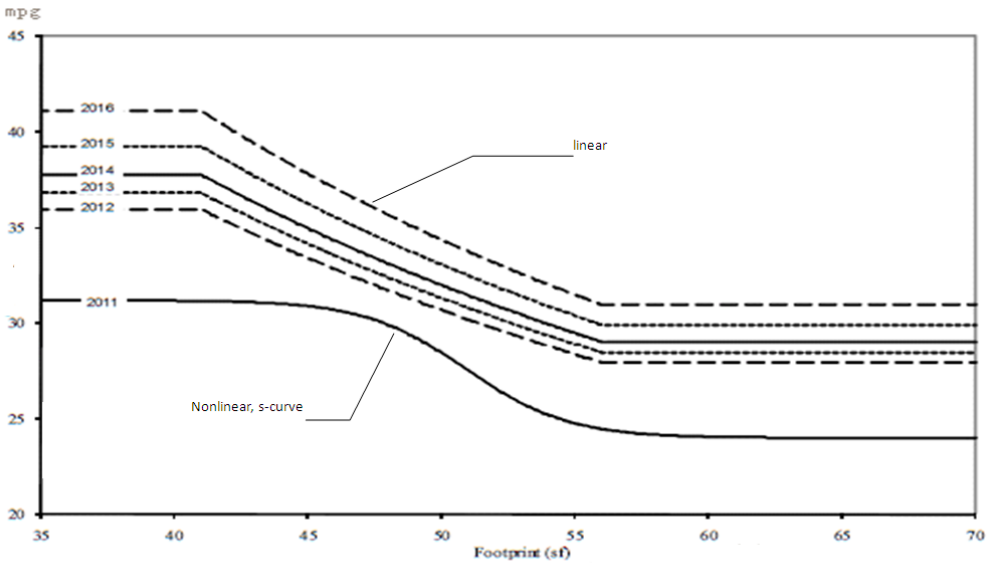

Figure 4-4 Fuel efficiency targets for passenger vehicles under Car Fuel Economy (CAFE) regulations in the US (2011-2016)

Sources: EPA, NHTSA

Figure 4-5 shows the standards for the fuel consumption of passenger vehicles in Japan for 2015 and 2020. While CAFE is implemented overall, in Japan progressive requirements are imposed on different category of vehicles classified by curb weight.

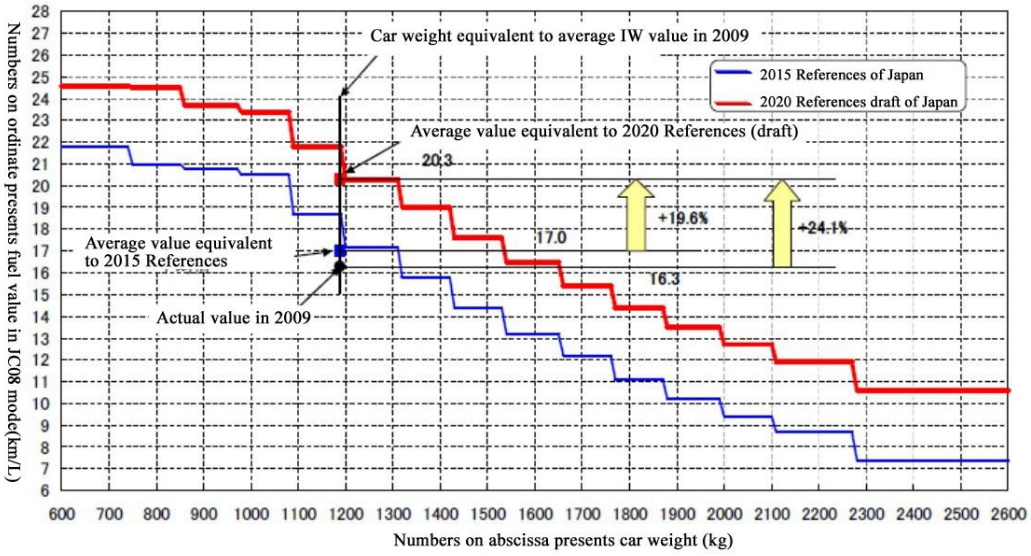

Figure 4-5 Fuel consumption targets in Japan in2015 and 2020

Source: JAMA

Table 4-4 compares the fuel consumption regulations in the selected regions and its effects on emissions

Table 4-5 Fuel consumption and CO_2 emission standards and regulations in selected regions

Items		China	US	Europe	Japan
Indicator	**Contents**	**Fuel consumption (L/100 km)**	**Greenhouse gas emission(g/mi) Fuel consumption (miles/gallon)**	**CO_2 emissions (g/km)**	**Fuel consumption (km/L)**
	Comments	***Consider the different testing conditions in different countries and regions when comparing data.***			
Independent variable to be monitored	Contents	Curb-weight	Footprint area (wheelbase average tread span)	Mass in running order	Curb-weight
	Comments	• The relationship between footprint area and fuel consumption and CO_2 emissions are quite indirect; as a variable, it is conducive to lightening weight and achieving energy savings and low-carbon emissions, but not conducive to reducing the size (large vehicles are unfavorable for fuel savings). • The relationship between curb weight and fuel consumption and CO_2 emission are much closer and more sensitive; as a variable, the reasonable matching of the limit value curves is needed; if the slope is too steep, it will be very unfavorable for lightening weight or structural energy saving and low-carbon emissions, as it is easier for heavier vehicles to meet the requirements compared with the lighter ones; if the slope is too flat, it will be too conducive to lightening weight and achieving structural energy saving and low-carbon emission.			
Curve shape for limit on fuel consumption and CO_2 emissions	Contents	Type A Divided into groups according to curb-weight, and stair-shaped.	Type B Take footprint area for reference, with horizontal line at the two ends and an oblique line in the middle.	Type C A single oblique line.	Type A Divided into groups according to curb-weight, and stair-shaped.
	Comments	• The advantages of Type A are to limit the fuel consumption of big vehicles, on the one hand, as the limit will not go up for larger cars, and encourage small vehicles, on the other hand, as the limit will not go down for smaller vehicles. • Type C is better than Type A because it transitions smoothly and avoids sudden change. • Only judging from the period of one year, Type B is the most scientific because it has longer horizontal lines at the two ends and there is a continuous line connecting the two ends. • The weaknesses of Type C If there is only modification on "M_0"but not "a" during the three-year review, when M_0 becomes larger, the horizontal line has to be paralleled down to keep 130g/km unchanged, which is further unfavorable to small vehicles as the required reduction rate for lightweight vehicles is much larger than that for heavyweight vehicles.			
Quotas for indirect energy saving technology which do not affect the car's working conditions	Contents	There is no corresponding measure. Efficient air conditioning units and tire pressure monitoring will be considered after 2016.	To set special quotas for air conditioner and other indirect energy saving technologies that are irrelevant to working conditions.	To set special quotas for indirect energy saving technologies that are irrelevant to working conditions.	Non
	Comments	Special quotas are conducive to energy saving.			

Items		China	US	Europe	Japan
Combination of enterprises and trading	Contents	Conditional combination of enterprises is allowed. Credits can be carried over. Whether trading is permitted is not clear.	It is forbidden to combine, but trading is allowed (excluding those below minimum value).	Combination is allowed but trade is prohibited.	
	Comments	There are pros and cons for each.			
Preferential terms for small enterprises	Contents	Currently, there are no preferential terms for small enterprises.	There are preferential terms for small enterprises.	There are preferential terms for small enterprises.	Enterprises with output lower than 2000 are not in the limiting range of the regulations.

Sources: CATARC-ADC, ACEA, JAMA, EPA, NHTSA, ICCT

4.3 Barriers preventing the improvement of fuel efficiency in China

Lack of a rewards and punishment system for fuel consumption and lack of consistency between enterprise and national level targets

The *Development Plan of Energy-Saving and New Energy Automotive Industry (2012-2020)* lays down the national targets for passenger vehicles' fuel consumption in 2015 and 2020, which are to lower the fuel consumption to 6.9L/100km and 5.0L/100km respectively. The development plan also states the need to:

- Establish a comprehensive management system for energy conservation in vehicles;
- Promote research into, and the application of, various advanced energy-saving technologies such as hybrid power;
- Accelerate and promote the wide usage of energy saving vehicles;
- Launch the management regulations on fuel consumption of vehicles based on corporate average fuel consumption and phased targets;
- Progressively implement fuel consumption management for both domestically manufactured and imported vehicles in 2012;
- Conduct research on reward and punishment policies based on the fuel consumption level of vehicles; and
- Formulate new, and improve existing, laws and regulations.

In late 2011, the Chinese government released the national standard GB27999-2011 "*Methods and Indicators for Evaluation on Fuel Consumption of Passenger Vehicles*". On March 14, 2013, the "*Measurement Method for Corporate Average Fuel Consumption of Passenger Vehicles"* was jointly issued by the Ministry of Industry and Information Technology (MIIT), the National Development and Reform Commission (NDRC), the Ministry of Commerce (MOFCOM), the General

Administration of Customs, and the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ). *The Measurement Method* calculates the actual and target values of the average fuel consumption for enterprises.

Reward and punishment mechanisms must be formulated in the near term to promote greater fuel efficiency in vehicles.

Some incentives, both positive and negative, already exist. For instance, companies are required to disclose to the public information about the fuel efficiency of their vehicles.

On the other hand, a negative incentive is incorporated into the measuring technique for corporate-level targets. If curb weight increases, corporate-level targets will increase as well, allowing an enterprise to achieve its target even though the actual fuel efficiency grows. This result does not make a positive contribution to the achievement of the national targets. Consistency between corporate-level targets and the national target can be realized by one of the two ways. One is to adjust the slope and intercept (high and low positions) of the oblique line in the CAFE overall limit in a timely manner. The other is to establish reward and punishment mechanisms based on the relationship between the two targets. In this regard the mechanism of a minimum CAFE value in the US worth studying.

The rate of decrease of fuel efficiency is nearly double of that from the EU and it does not lead to vehicle miniaturization

In the EU, passenger vehicles' CO_2 emissions must conform to limits defined by a linear curve which follows the formula 4.1; as shown is Figure 4.3

The gradient for the EU curve "a" is 0.0457. It reflects the variation of CO_2 emissions with curb weight and is a core element of the regulation. When comparing this emission curve with that of China, the equation needs to be converted to L/100km.

After such conversion, the equation becomes

Formula 4.2) **y = 0.00183 x +2.6888**
where
y: is fuel use L/100km
x: curb weight in kg

The gradient of 0.00183 results from an artificial increase of 60%, to encourage lighter weight vehicles. Normally, the slope should be 0.00305).

Japan and China's fuel consumption standards are stair-shaped according to curb-weight. Nevertheless, each can be fitted to a continuous line to allow a comparison with the EU limits, as presented in figure 4-6:

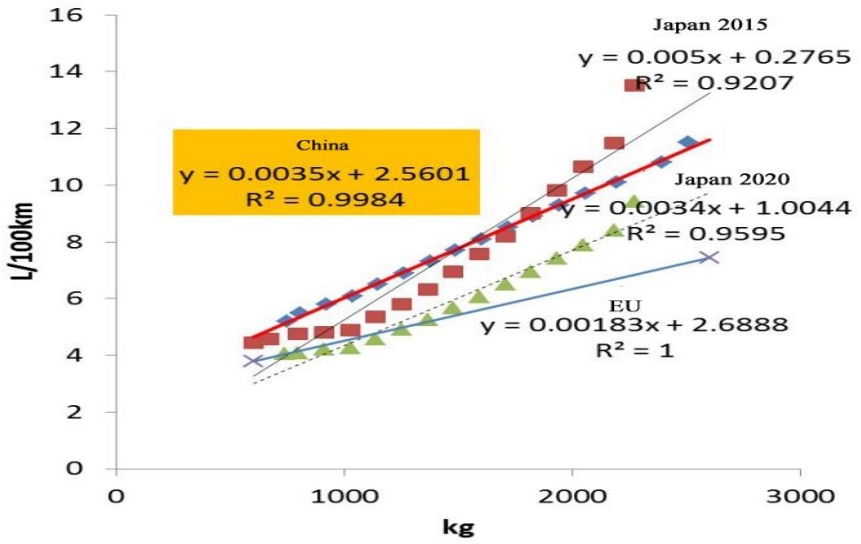

Figure 4-6 Fuel consumption adjusted curves for China, the EU, and Japan

Figure 4-6 shows that the gradient of the adjusted curve for China's standard is close to that of Japan's regulation for 2020, and is much lower than Japan's regulation for 2015. However, it is twice as high as the slope of the EU's regulation for the period before 2020.

Compared to the EU, China's standard is very unfavorable to vehicle miniaturization and increasing fuel efficiency, and will encourage companies to increase the weight of the vehicles. This works against the goal of energy conservation.

Incentive policies for small displacement vehicles and small passenger vehicles need to be further strengthened

In China, there is no clear definition of what constitutes small vehicles and a lack of incentives directly linked to vehicle size. Currently, the incentives focus on displacement. In recent years, the market share of passenger vehicles with displacement of 1.6L and below was 60% to 70% in China, which is similar to France. In China, the market share of these vehicles showed a decreasing trend in the last decade, until 2009 when their share increased significantly due to fiscal and tax policies such as the national vehicle purchase tax reduction and the "Project to Promote Energy-efficient Products for the Benefit of the People" which provides a subsidy of RMB 3,000 to each buyer of a fuel efficient car. So far, the technical level of most Chinese small vehicles is still relatively backward, and it needs to be constantly improved for medium- and long-term development.

At present, China's automotive consumption taxes are as follows:

- Displacement of 1.0 liter and below: 1%;
- Displacement of 1.0-1.5 liters: 3%;
- Displacement of 1.5-2.0 liters: 5%;
- Displacement of 2.0-2.5 liters: 9%;
- Vehicles with bigger displacement are subject to higher tax rates.

The rates of the “vehicle and vessel tax” are as follows, on an annual basis:

- Passenger vehicles with displacement lower than 1.0 liter: RMB 60-360;
- 1-1.6 liters: RMB 300-540;
- 1.6-2.0 liters: RMB 360-660;
- 2.0-2.5 liters: RMB 660-1,200;
- Vehicles or vessels with bigger displacements are subject to higher tax rates.

Note that the consumption tax and vehicle and tax rates for vehicles with a displacement below 2.0 L the differences are not big.

Taking Japan as a comparison[13], where micro-motor vehicles (formerly known as light four-wheeled vehicles) are defined as those with a displacement below 660mL and meet the relevant requirements on size. In recent years, with the support of *Light Four Wheel Policy*, micro-motor vehicles have accounted for about one third of the new car registrations. At purchase, there is a 2% tax rate difference; moreover, a tax exemption is offered to the purchaser of a car priced under 500,000 Japanese Yen (equivalent to RMB 32,500). There are also benefits with regard to the so-called tonnage tax during the period of ownership, especially for micro motor vehicles. The tonnage tax for micro motor vehicles for household use is 7,200 Yen per year (equivalent to RMB 468 per year), and is increased as the displacement increases. For those with 1.0 L displacement, the tax rises to 29,500 Yen per year (equivalent to RMB 1,918 per year). Such tax policies have played a large role in the development of micro-motor vehicle.

Using Japan’s system as a reference, China should increase the incentives policies for small vehicles.

Fuel efficient technologies are underdeveloped, and more support to R&D is required

Due to the late start of China's automobile industry, there is a technology gap compared with Europe, the US, Japan, and other countries. The application of energy saving technologies is the key to achieving higher vehicle fuel efficiency. Currently, the use of many key energy-saving and emission-reducing technologies, such as gasoline direct injection, dual-clutch transmission, and continuously variable transmission, have been progressively extended by non-Chinese automotive companies. Although there are some market applications in China, it is not easy to promote energy saving technologies since there is a limit in core technology and a lack of related technology standards.

Small engine technology has become the global trend, with European car companies, for instance, developing three-cylinder engines. Currently, the technology level of the majority of Chinese domestic small displacement vehicles has fallen behind, and there is need to constantly improve the technical level for the medium-and long-term development.

Tax reforms for fuel efficient vehicles needs to be further strengthened

As of March 2013, 19 countries in the EU, including Germany, France, and the UK, had implemented a tax system based on vehicle's CO_2 emissions[14]. In the US, there is the "gas-guzzlers tax" for passenger vehicles with fuel efficiency below than 22.5 miles per gallon (excluding van-type passenger car, SUVs, or pickups). In Japan, there is an exemption from the "motor vehicle purchase tax" and the "motor vehicle tonnage tax" for energy-saving vehicles.

Currently, China's vehicle purchase tax is levied in accordance with the price of the vehicle. This has basically deterred the development of energy-saving technologies because in normal circumstances, the application of energy-saving technologies will increase the vehicle costs. The consumption tax and the vehicle and vessel tax are levied in accordance with the displacement of the car, and there is tax exemption on energy-saving and new-energy products. But the overall tax system is not directly related to fuel efficiency. It is implemented with limited intensity and has not been fully leveraged to maximize fuel efficiency.

Moreover, there is no defined time limit linked to the tax policies for energy-saving and new-energy vehicles. The risk for manufacturers is that the policies would be rescinded at any moment as conditions change. In Japan, in contrast, the tax policies are more stable. Certain fuel-efficient vehicles, for instance, enjoy the privilege of complete exemption from the tonnage tax for the first three years of ownership and a reduction of 50% in the tax for the fourth and fifth year of ownership.

Finally, China's consumption tax (equivalent to the fuel tax in other countries) is much lower than the fuel taxes in the EU and Japan. This tax amounts to RMB1.0/L for unleaded petrol and RMB0.8/L for diesel in China. In comparison, in 2012 the fuel tax on petrol in Germany was €0.65/L (or RMB5.5/L) for unleaded petrol and €0.47/L (or RMB4.0/L) for diesel.[15]

Insufficient attention paid to the fuel efficiency of commercial vehicles

In spite of having set standards with fuel consumption limits for light-duty commercial vehicles early on, the limits are not that strict and the structure of the standards needs to be improved. The current standards have had an effect, but the effect is not big enough. Having just been launched as part of the automotive industry standards, the equivalent standard for heavy commercial vehicles covers only a limited number of products and will only be applicable to future models. It will therefore have positive but limited effect.

Domestically, commercial vehicles are regarded as work-related piece of equipment, often purchased at very low prices. The application of light-weight technology would increase the cost, thus it has not been well promoted in the market. In addition, overloading is common among commercial vehicles, which has affected the promotion of energy efficient technologies indirectly. Due to overloading, Chinese manufacturers have always focused on durability and neglected light-weight technologies. As has already been mentioned, as part of the "Project to Promote

Energy-efficient Products for the Benefit of the People", passenger vehicles can enjoy a fiscal subsidy of RMB 3,000 per vehicle at the purchase stage, but there is no related policy for commercial vehicles. Commercial vehicles are responsible for a high percentage of total vehicle fuel consumption in China, and fuel efficient technologies for commercial vehicles are not well developed. The attention paid to the energy savings of commercial vehicles is far from enough.

Hybrid vehicles have low market penetration

Between 2009 and 2012, in order to promote the development of new energy vehicles, the state introduced two new policies: the *Interim Management Measures for Demonstration and Promotion of Energy-saving* and the *New Energy Vehicles* and the *Interim Management Measures for Pilot Fiscal Subsidy for Purchasing Private New Energy Vehicles*. The first of these policies focuses mainly on taxis, buses and other official business vehicle fleets and covers all the technical categories. It was implemented in 25 large and medium-sized cities in batches. In September 2012, the promotion of hybrid buses (including plug-in hybrid electric buses) was extended to all cities in China, with an overall goal of 3,000-5,000 vehicles. The second of these policies focuses mainly on the purchases of private passenger vehicles and covers only plug-in hybrid electric vehicles and pure electric vehicles. In 2012, the production of hybrid vehicles falling within the *Recommended Vehicle Models Catalogue for the Projects of Energy Saving and Promotion of New Energy Automobiles* reached 11,514, of which 10,421 were ordinary hybrid vehicles and 1,093 were plug-in hybrid vehicles. The production of large hybrid passenger vehicles reached 6,365, of which 5,534 were ordinary hybrid and 831 plug-in hybrid vehicles.

Currently the hybrid vehicles have a small market share in China, totaling 0.06% in 2012. The previous key promotion policies will all expire in the first half of 2013, and the market is waiting to see what will happen. A new round of policies is needed to ensure the continuity of the promotion measures.

Currently, the common hybrid vehicles are not included in the category of new energy vehicles and can only be treated as energy-saving vehicles of fossil sourced energy in its narrow sense. Therefore more encouragement is needed. Common hybrid vehicles, as the priority in the current development of energy-saving vehicles both in China and abroad, deserve more support.

Moreover, it is necessary to consider technology research and development in new models when promoting hybrid vehicles. It is also necessary to take into account the production output in order to avoid problems such as the low production and imbalanced utilization of policy benefits.

Diesel-powered passenger vehicles represent less than 1% of the market share

As of today, diesel-powered passenger vehicles account for nearly 0.8% of all the passenger vehicles. In Western Europe, the percentage is about 50%. Since

diesel-powered vehicles save up to 20-30% of fuel compared to petrol-powered vehicles in similar categories, priority should be given to promote the development of advanced diesel-powered passenger vehicles.

Coordination and development of the fuel industry and fuel products

High-quality fuel and lubricating oil are the foundation of energy-saving vehicles, and the quality of oil products for vehicles in China needs to be improved. The low quality of fuel and lubricating oil will not only affect energy savings, but also cause other negative effects. Therefore, in order to achieve energy savings and emission reduction, the quality of oil products has to be improved.

The European driving cycle is used but it does not match the local conditions

The European Driving Cycle, which has been adopted as the test cycle in China, has been developed on the basis of traffic conditions and the urban structure in European countries. But there are significant differences between China and European countries not only in urban structure, but also in road conditions, vehicle types, traffic conditions and even driving habits of the drivers.

For example, the settings used on stop signs and traffic lights directly influence idling and pausing. Many roads in China are still used for mixed transportation, including both motorized and non-motorized vehicles. Poor road maintenance results in poor traffic conditions. Privately owned vehicles do not have a long history in China and many consumers prefer vehicles with a capacity to carry three generations of family members, thus they opt for large vehicles.

To save cost, people will buy vehicles with poor vehicle dynamics. Commuting distances also have direct impacts on the design of indicators such as driving range of the electric vehicles. In addition, as opposed to many foreign vehicle markets which are mature, the market for privately owned vehicles in China, both in urban and rural areas, is not saturated and the driving conditions are changing continuously. Thus, as of today, the European conditions cannot properly reflect vehicles' actual driving conditions in China. The design of vehicles needs to be matched with the actual driving conditions, and appropriate power chosen accordingly. Since different driving conditions will lead to big differences in vehicle performance and fuel consumption, a standardized driving cycle that is tailored to the specific traffic situations and characteristics in China needs to be developed.

5 Roadmap to Adopt Fuel efficiency Measures

5.1 Technological roadmap for Chinese automotive fuel efficiency

Achieving the medium and long-term goals of automotive fuel efficiency in China mainly depends on the efforts made in introducing energy saving technology and a fuel-efficient product structure. The gap between China's current level of fuel efficiency and the international advanced level is around 30%. Over the next few years, adopting advanced energy saving technology will be the main method to improve automotive fuel efficiency in China. In addition, the development of small vehicles, hybrid vehicles and diesel passenger vehicles will be important for ensuring a diverse product structure.

This study performed technical and economic analyses on the main energy saving technologies and measures for promoting automotive fuel efficiency based on the domestic and foreign literature, reports, and research results of domestic vehicle models.

The results of these efforts were first laid out in the following three sub-reports:
Sub-report 1: Current Situation and Trends in Overseas Automobile Energy Conservation Efforts;
Sub-report 2: Current Situation, Goals, Approaches and Suggested Policy Measures for China's Automobile Energy Conservation Efforts; and
Sub-report 3: A Comparison between Overseas and China's Automobile Energy Conservation Efforts, and China's Major Problems.

Sub-reports 1 and 2 show the fuel-saving effects of specific technologies and the increase in the cost of a single car which incorporates these technologies. When choosing a specific technology, manufacturers will give priority to those giving rise to lower production costs and less fuel consumption. Therefore, the technologies which manufacturers will prefer to adopt include turbocharged vehicles, gasoline direct injection (GDI), stop-start, dual-clutch transmission (DCT), continuously variable transmission (CVT), multiple gears, and electric power steering (EPS).

In addition to the adoption of advanced energy saving technologies, optimized product structure is a priority in energy saving. The two are closely related to each other. Energy savings by optimizing product structure mainly include increasing the share of smaller vehicles and diesel-powered vehicles. Comparing China's average automotive displacement and average vehicle weight with those in developed countries, there is a great potential for the development of small volume vehicles in China, which requires a range of sound government policies to guide the development of the market. With respect to the market applicability of technologies, the project team conducted a survey of experts, inviting them to prioritize energy saving technologies in the order of their importance in 2015 and 2020. The results are presented in table 5-1.

Table 5-1 Expert survey results of China's s energy saving technology pathways in 2015 and 2020

No.	Pathway choices in 2015 (with no sequence or reference rate)	Prior technology to be developed in 2015 (weighted by sequence)	Pathway choices in 2020 (with no sequence or reference rate)	Prior technology to be developed in 2020 (weighted by sequence)
1	Idling Stop-Start	Idling Stop-Start	Plug-in Hybrid Electric Vehicle	Plug-In Hybrid Electric Vehicle
2	Gasoline Turbo-charged Direct Injection	Gasoline Direct Injection	Variable Valve Actuation (Variable Valve Timing (Coupled Cam Phasing) + Variable Valve Lift)	Gasoline Turbo-charged Direct Injection
3	Electric Power Steering	Gasoline Turbo-charged Direct Injection	Lightweight-aluminum body	Variable Valve Actuation (Variable Valve Timing (Coupled Cam Phasing) + Variable Valve Lift)
4	Turbocharged	Electric Power Steering	Gasoline Turbo-charged Direct Injection	Dual Clutch Transmission
5	Variable Valve Timing (Coupled Cam Phasing)	Turbocharged	Cylinder Deactivation	Diesel passenger vehicles
6	Lightweight high-strength steel body	Variable Valve Timing (Intake Cam Phasing)	Dual Clutch Transmission	Tire Pressure Monitoring System
7	Gasoline Direct Injection	Lightweight-plastic air intake manifold	6+ Automatic Transmission	Lightweight-high strength steel body
8	Dual Clutch Transmission	Plug-in Hybrid Electric Vehicle	Low rolling resistance tires	Lightweight-aluminum body
9	Continuously Variable Transmission		Hybrid Electric Vehicle	
10	6+ Automatic Transmission		Diesel passenger vehicles	
11	6 Manual Transmission		Variable Valve Lift	
12	Lightweight-plastic air intake manifold		Lightweight-high strength steel body	
13	Variable Valve Timing (Intake Cam Phasing)		Gasoline Direct Injection	
14	Electric water pump		Variable Valve Timing (Coupled Cam Phasing)	
15	Hybrid Energy Vehicle		Stop-Start	
16	Automated Manual Transmission		Air inlet grille active closed system	
17	Plug-In Hybrid Electric Vehicle (PHEV)		Tire Pressure Monitoring System	
18	Diesel passenger vehicles			

Considering these results, this study concluded that China's technical pathway for automotive energy saving could be the following:

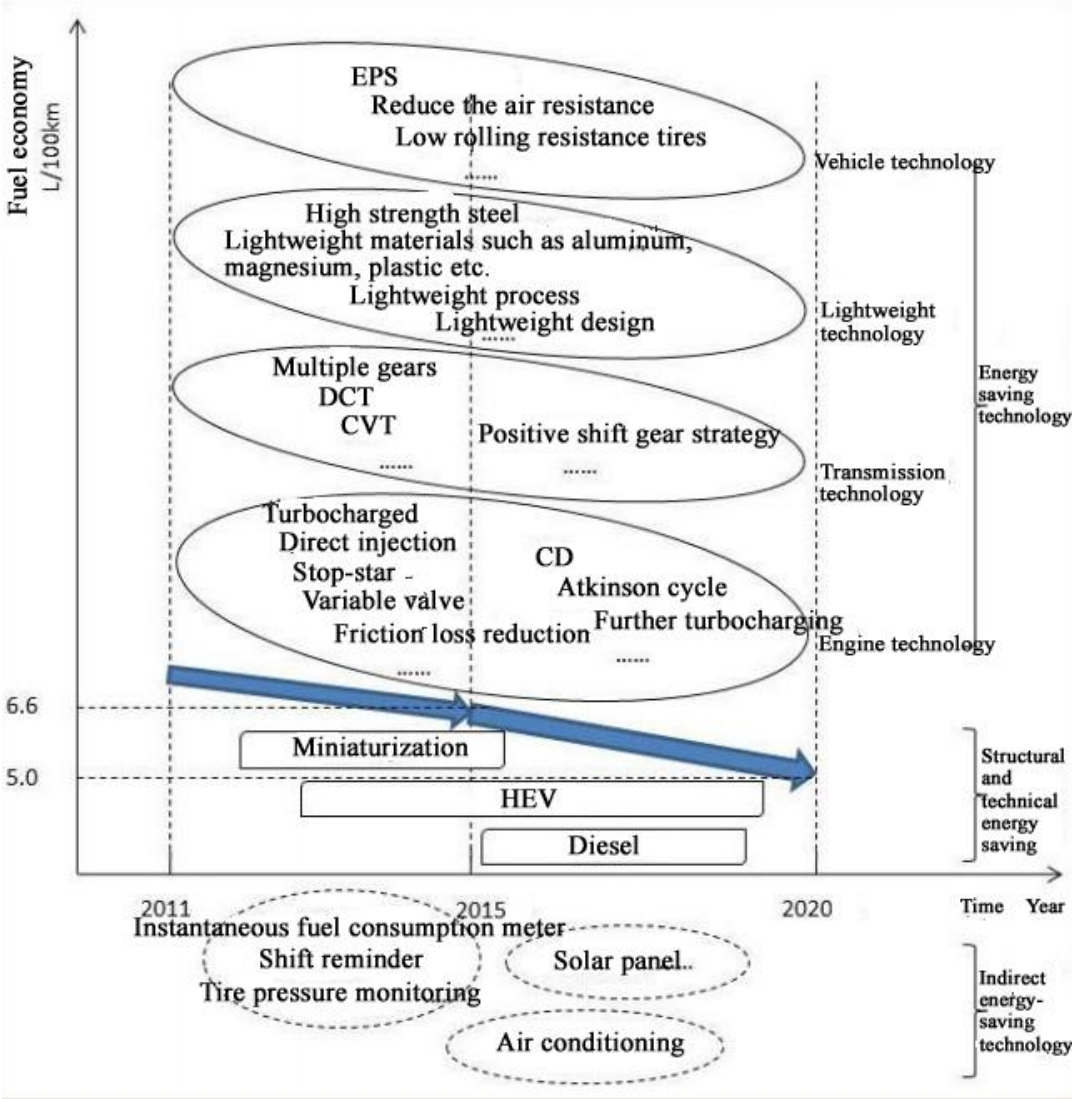

Figure 5-1 Technical pathways for energy saving

The key energy-saving technologies that need to be adopted are related to advanced engines and transmission technology, lightweight designs technology and vehicle technology. All four categories of technologies should be vigorously developed throughout the process of achieving the energy-saving goals. According to the chronological sequence for the promotion of energy-saving technologies, each of the four major fuel-efficient categories has its own internal order of development.

In addition, indirect energy-saving technologies not reflected in the test driving cycle also need to be adopted. The technologies to be used prior to 2015 are instantaneous fuel consumption meter, gear shift prompt controller, tire pressure monitoring, energy-saving air conditioning units, etc.; the technologies to be promoted from 2015 to 2020 are energy-saving air conditioning, solar panels for battery recharging, etc.

5.2 Analysis of the effect of fuel efficient technologies in China's automotive industry

Based on the fuel-saving targets, actual service mileage, and the forecast of the future demand of various types of vehicles, the fuel conservation results of new vehicles in 2015 and 2020 are shown in table 5-2.

Table 5-2 Projected fuel conservation results by vehicle type

Vehicle types	Fuel savings 10^4 tons	
	2015	2020
Passenger vehicles	367.5	803.8
Light commercial vehicles (incl. mini trucks)	77.2	169.9
Heavy commercial vehicles	288.4	681.6
Total	733.0	1655.2

The above estimations of fuel savings were made taking 2011 as the baseline year in which the implementation of energy-saving measures began, showing the amount of fuel saved in the period 2015 and 2020. These are the fuel savings from structural and technical changes, over and above the fuel-saving effects from changes in the market. The total projected fuel savings are the basis on which further efforts can be made on energy savings from the consumer side, such as green driving, green maintenance, and smart traffic. The fuel saved in this way in 2015 and 2020 will account for 2.5% and 7.5% respectively of the total fuel consumption after structural and technical fuel-saving measures have been adopted. Finally, by totaling up the expected effects of the three kinds of fuel-saving measures, the conclusion can be drawn that 119.605 million tons of fuel in total will be saved by Chinese vehicles in 2020, which will make up for 70% of the expected fuel gap in the same year.

Table 5-3 Fuel-saving effects combining fuel-saving measures for 2015-2020

		Fuel savings 10^4 tons	
	Vehicles types	2015	2020
Effects of technical fuel-saving measures (with the changes in market structure considered)	Passenger vehicles	1,246.4	4,787.4
	Light commercial vehicles (incl. mini trucks)	268.4	1,120.9
	Heavy commercial vehicles	923.7	3,527.3
	Subtotal	2,438.5	9,435.6
Projected fuel savings during vehicle use, such as from green driving, green maintenance, etc.		672.5	2,524.9
Total		3,111.0	11,960.5

6 Recommendations for implementing automotive fuel efficiency measures in China

The development of energy saving measures for China's automotive industry needs to be propelled by mandatory standards and regulations, while the market also needs to be oriented to increasing fuel efficiency through the use of incentive policies. Therefore, the government needs to adopt both regulatory and incentive measures in governance for the development of energy savings for the automotive industry. As stated in the official Interpretation of the "Measurement Methods for Corporate Average Fuel Consumption of Passenger Vehicles"[17], an integrated management system for energy saving in the automotive sector that includes technical standards, an energy management system, and fiscal and tax measures is to be established.

Figure 6-1 The Integrated function of the Chinese Government in promoting fuel efficiency measures

6.1 Recommended measures

6.1.1 Regulate the overall energy savings of the enterprises by establishing a management system for average fuel consumption of automotive enterprises; and enhance the performance review related to the "National Targets"

The regulation *Measurement Methods for Corporate Average Fuel Consumption of Passenger Vehicles*, launched officially in March 2013, establishes that China's automotive fuel efficiency efforts are experiencing a significant transformation from a focus on single vehicle ownership to a focus on enterprise managed fleets and from single target management to an overall fuel efficiency target. The methods given in the regulation can calculate the actual value, the target value, and the credit balance of the average fleet fuel consumption of both domestic and imported passenger

vehicles. However, data analysis is not enough. It should be matched with a reward and punishment mechanism, and the necessary administrative measures should be formulated. In formulating these measures, the connections between the "corporate targets" and "national targets" should be taken into consideration. To strengthen the role of "national targets", it is feasible to draw upon the system of minimum CAFE value used in the United States and set the upper limit of fuel consumption related to the "national targets". The companies that break the limit can be prohibited from trading or companies above or below the limit can be given different rights (e.g., rights of energy quota trade, eligibility for preferential policies, etc.) or weights of tradable energy quota. In addition, contributions from the companies to energy savings can also be considered. Such contributions could be that the company has a more stringent target of fuel efficiency than the national target, and that the rate of decrease of the company is higher than the national value.

There are several core issues that need to be resolved in "corporate management measures". The first is a rewards-punishment system that measures degree of achievement of "corporate targets", the second is the relation between "corporate targets" and "national targets", and the third is verification of enterprise report data to ensure that it is real and verifiable.

In addition, in the medium to long-term, the "management measures" can also regulate the energy savings of new energy vehicles.

6.1.2 Support small displacement vehicles by defining a small vehicles category

This initiative may be led by the Ministry of Industry and Information Technology, the National Development and Reform Commission, and the Ministry of Finance, with the participation of other government departments, enterprises, industry organizations, and agencies.

Embodied energy efficiency is one of the important ways to meet China's energy saving targets and also one of the significant measures to reduce the industry's overall fuel consumption. Therefore, the government should continue to promote the development of small-displacement passenger vehicles.

At present, China's automotive consumption tax rate and vehicle and vessel tax rate are linked to engine displacement, but the differences are not large enough for displacements of 2.0 L and below. It is proposed to more strongly differentiate the tax rates for the vehicles with different engine displacements and to consider tax exemptions for small-displacement vehicles.

The definition of small vehicle is not clear in China. It is suggested that small vehicles be defined by engine displacement less than or equal to 1,000 mL and a curb weight of less than or equal to 1,000 kg. In 2012, the total number of passenger vehicles within these limits were 1,189,506, accounting for 8.2% of total passenger vehicles.

Considering the positive experience from Japan, more policies should be formulated to further promote the development of small vehicles. Tax reductions and

exemptions in the purchase and ownership phases should be implemented so as to promote the embodied energy savings in passenger vehicles.

6.1.3 Promote the development of fuel efficiency measures by improving tax policies

This initiative can be led by the Ministry of Finance, the State Administration for Taxation, the Ministry of Industry and Information Technology, and the National Development and Reform Commission.

1) It is recommended to add limitations to ensure that vehicles with displacements smaller than 1.6 L and curb weights less than 1,300kg are eligible for tax benefits, such as 50% reduction of vehicle tax.

In recent years, the average curb weight of passenger vehicles in the country has increased annually and had exceeded 1,300kg by the second half of 2012. It is suggested to add a limit of curb weight to the tax policy.

2) It is recommended to give consumers stable expectations about the time period over which the vehicle tax benefits apply.

Currently, two lists have been published of enterprises and vehicle models eligible for the preferential tax, but with no time period for their eligibility. Because the energy saving technologies are developing all the time, enterprises are aware that the new conditions for giving preferential treatment and the new lists which follow from this will be published soon. This provides a challenge to them, because they have no stable expectations about the timeline of the preferential policies. This is not conducive to them marketing models on the current list.

According to information received from the Japan Automobile Manufacturers Association (JAMA), as of 2012 Japan's new implementation of duty exemption and reduction of the "motor vehicle purchase tax" and "motor vehicle tonnage tax" for energy-saving and environmentally-friendly vehicles will totally exempt eligible consumers from the "motor vehicle tonnage tax" during the first three years of the levy, and will exempt them from 50% of the tax in the next two years of the levy; for new vehicles. This system provides consumers with a stable expectation of the timeline of the exemptions and is a worthy reference for China.

3) It is recommended to add the factors of vehicle weight and fuel consumption during the reform of the consumption duty, vehicle tax and motor vehicle purchase tax.

The EU has tax categories linked to CO_2 emissions. Japan utilizes the motor vehicle tonnage tax. In China, the factors of vehicle weight and fuel efficiency must be taken into account during the reform of the consumption duty, vehicle tax and motor vehicle purchase tax. Moreover, measures taken in Japan and France include preferential tax rates given to vehicles with much lower fuel economies than a given

target value. It is also suggested that an appropriate tax rate is given to hybrid vehicles.

4) It is recommended to gradually increase the fuel duty.

The fuel duty is reflected directly in the retail price of gasoline and diesel, so an increase in fuel duty will have immediate effects on fuel conservation. But a portion of passenger car owners in China, especially luxury car owners, are not sensitive to fuel prices. This portion can be quantified at about 2% - in 20102, 1.61% of all domestic passenger vehicles had a displacement of over 2.5 L. In these cases, supplementary measures should be taken to promote the development of automotive energy-saving actions.

6.1.4 Increase the support for the R&D process

This initiative can be led by the Ministry of Science and Technology, the National Development and Reform Commission, the Ministry of Industry and Information Technology, and the Ministry of Finance, with the participation of other government departments, trade organizations, enterprises and intermediary agencies.

1) The government should take the lead in setting up a special fund dedicated to supporting research and development of technology projects. Also, it should take measures to support and disseminate the application of key technologies. Meanwhile, the government should promote cooperation between enterprises and government agencies and academia in research and development, to reduce costs and the associated risks.

2) With support from the government, third-party institutions such as SAE-China and CATARC should coordinate resources within the industry sector to carry out regular and rolling research into the technical pathways for the medium and long-term development of China's automotive fuel efficiency, along with the related technical and economic research. They should also prepare a catalogue of the high-efficiency technologies whose adoption should be encouraged for China's medium and long-term development, so as to support the launch of government projects The popularization of major energy saving technologies, such as supercharged gasoline engines, direct injection, energy-saving transmission, use of lightweight materials, hybrid energy, Atkinson cycle engines, low-friction lubricants and reduction in air resistance, should be promoted, while indirect energy saving technologies such as tire pressure monitoring, fuel-saving gear shift prompt controllers, should also be included in the catalogue.

3) Statistical analysis of the data on the market application of energy-saving technologies should be further strengthened. At present, the database derived from the *Notification on Automotive Manufacturers and Products* contains many production parameters, but few of these are directly related to energy conservation parameters such as the steering mode, supercharger type, or transmission type. Parameters for many energy-saving technologies, such as variable valve and low

rolling resistance tires, are considered independent information and belong to enterprises' optional fields. Since actual market data is difficult to obtain, statistical analysis of specific market applications is difficult. The government should lead the effort in setting up a large public industry database to support technology research and development.

6.1.5 Promote the development of fuel efficient commercial vehicles

This initiative can be led by the National Development and Reform Commission, the Ministry of Industry and Information Technology, and the Ministry of Finance, with the participation of other government departments, trade organizations, enterprises, and intermediary agencies.

1) The existing industry standard on commercial vehicles should be improved, and the limit on fuel consumption for heavy commercial vehicles should be upgraded from an industry standard to a national standard. Also, the scope of the limit should be expanded to cover more vehicle types and the threshold should be improved. The industry standard only involves ordinary trucks, tractor-trailers, and passenger cars with seats, while a national standard should also cover dump trucks and urban buses and impose more stringent limits on the vehicles in similar categories compared to the industry standard.

2) Research should be accelerated and subsidy policies should be formulated for commercial vehicles under the "Project to Promote Energy-Efficient Products for the Benefit of the People".

Commercial vehicles have high emissions and high fuel consumption, thus there is much space for improvement. The application of energy-saving technologies could effectively reduce their fuel consumption, but almost every measure means increased costs. The Chinese market is characterized by consumers being very sensitive to vehicle prices. Therefore, it is necessary for the government to roll out fiscal subsidies to promote energy-efficient products and to promote the application of energy-saving technologies. It is suggested that subsidy policies for commercial vehicles under the "Project to Promote Energy-Efficient Products for the Benefit of the People" should be formulated.

To promote further uptake of energy-saving technologies, it is suggested that higher subsidies be given for vehicles with higher fuel efficiencies. In addition to a fuel consumption indicator, it is proposed that an indicator of the minimal capacity utilization factor be added (this is equivalent to the maximum permissible load capacity, including the mass of the driver and passengers, divided by the curb weight). The amount of subsidy to be set could range from RMB 10,000 upwards (for the analysis on the cost-efficiency of the relevant technologies, see sub-report 2).

3) Drawing on the experiences of the EU and the US, the fuel consumption unit should be changed from L/100 km to L/100 t-km and the unit for buses should be

changed to L/100 person-km, making the indicator relevant to the design load capacity.

4) In order to promote the technology development of light commercial vehicles, it is recommended to better manage the “overload” issue.

The improvement of the utilization factor of the curb weight is an important aspect of technology advances in modern truck manufacturing. Light-weight technologies can improve the capacity utilization factor. The lighter weight of commercial vehicles can be achieved just by relying on light materials. It is suggested that research institutes and universities jointly push the necessary advances in light-weight technology. The state-level Lightweight Automobile Technology Innovation Strategic Alliance led by the Society of Automotive Engineers of China can also play an active role.

There are also many other social and technological problems to be solved. In particular, more efforts should be made to solve the overload issue of commercial vehicles. In terms of policies, it is suggested that the government take the lead, with many departments, such as the Ministry of Transportation, the Ministry of Public Security, NDRC, MIIT, and AQSIQ, working together.

6.1.6 Continuously increase the support given to hybrid vehicles

This initiative can be led by the government with the participation of trade organizations, enterprises and intermediary agencies. The government departments to be involved are mainly the Ministry of Science and Technology, the Ministry of Finance, the Ministry of Industry and Information Technology, the National Development and Reform Commission, etc.

First, the promotion policies from 2009 to 2012 should be continued. This requires drafting new polices, which should be able to motivate local initiatives and prevent local protectionism. An example is to implement moderate and nationally unified fiscal subsidy policies.

Second, manufacturers should be encouraged to develop hybrid technologies, which include plug-in hybrid technologies and common hybrid technologies. Fiscal and tax subsidy policies for hybrid passenger vehicles should be launched and adopted nationwide. In particular, given the cost and difficulty of policy implementation, the fiscal and tax subsidy policies could be simplified to cover all types of hybrids, without further division, such as providing RMB 10,000 for each hybrid car (total price not exceeding RMB 100,000) or 20,000 RMB subsidies for each hybrid car (total price exceeding RMB 100,000). To allow more manufacturers to benefit from the policy, it is recommended to enforce a subsidy limit, for example a maximum of 60,000 vehicles of an individual manufacturer can receive the subsidies. In addition, the geographic choice for promotion should be given attention. For instance, very low temperatures will greatly reduce the battery discharge efficiency, thus affecting usage, so areas with such temperatures might need more promotion.

6.1.7 Encourage the development of diesel vehicles

This initiative involves the joint participation of government, industry and enterprises.

By moderately increasing the difference between the diesel consumption tax and the gasoline consumption tax, the development of advanced diesel passenger vehicles will be promoted within a period of time and scope. At the same time, in order to speed up the independent innovation of China's advanced diesel technologies, petrochemical enterprises should be encouraged to produce high quality diesel through measures like appropriate pricing and tax incentives.

6.1.8 Improve the automotive energy saving standard system

This initiative can be led by the Ministry of Industry and Information Technology, the National Development and Reform Commission, and the General Administration of Quality Supervision, Inspection and Quarantine, coordinated by SAE-China and CATARC, with the participation of enterprises.

1) In 2020, the fourth phase of the fuel consumption standard for passenger vehicles should draw lessons from international best practices in the US, the EU and other countries. Incentives should be given to promote indirect energy saving technologies other than the energy-saving air conditioning technologies mentioned early or which are not covered by the test driving cycle, and different treatment should be given to research by small-scale manufacturers. The vehicle categories should include unconventional fuel trains, such as vehicles driven by compressed natural gas (CNG) and other alternative fuels and those driven purely by electricity.

2) In the near term, standards should be formulated for devices such as instantaneous fuel consumption meters, gear shift timing prompt controllers, tire pressure monitoring devices, etc.

3) Information Fiches on Automotive Fuel Consumption should be further improved. The information fiches published in the US on automotive fuel efficiency contain not only a particular model's fuel efficiency data, but also fuel consumption economy data of similar vehicles and the fuel efficiency conditions of the same model year. The US experience may provide us something to learn.

4) In the near term, the implementation of high quality fuel standards should be promoted, to effectively solve the situation in China where fuel quality standards have lagged behind the vehicle emission standards for a long time.

5) In the near term, basic standards suitable for the Chinese context, such as vehicle driving cycles, should be formulated. Currently, the EU, the US and Japan all have driving cycles suitable for their own national conditions. US light-weight vehicles used to have to go through fuel consumption tests under only two conditions, city and highway conditions, but now they have to be tested under more conditions including

abrupt acceleration and deceleration, driving with the air conditioning on, and cold start. In Japan, the driving cycles for passenger vehicles have been changed from the stable JC10-15 to the transient JC08 conditions. The current Chinese driving cycle mainly refers to EU conditions, which can no longer be considered an appropriate reference for vehicles' actual fuel consumption and displacement levels in China. It is necessary to conduct relevant research on a standardized driving cycle that would be suitable for China and formulate related standards. It is the core and basic work of the automotive industry, and is critical to vehicles driven by both traditional and new energies. In China, lessons should be learned from the research methodologies and conclusions of Worldwide harmonized Light vehicles Test Procedure (WLTP) to conduct research to form vehicle driving conditions suitable to China's conditions.

6.2 Priorities and their timeframe

In the near-term, formulate a reward and punishment system for enterprises dealing with passenger vehicles based on measurement methods for average fuel consumption regulation

The reward and punishment system for passenger and lightweight commercial vehicles is based on the average corporate fuel consumption or CO_2 emissions, which is a common practice globally. Since July 1st, 2012, China has set up a data platform for passenger vehicles – the Vehicle Fuel Consumption Data Management System. The regulation *Measurement Methods for Corporate Average Fuel Consumption of Passenger Vehicles* took effect on May 1st, 2013. However, except for disclosing to the public the results of the measurements and comparing the results among enterprises as a way of encouraging them, it lacks a reward and punishment mechanism. The reward and punishment mechanism should be based on scientific research. The strength of a reward and punishment mechanism is that it can have a direct impact on the decision-making process of manufacturers: they can accept the punishment, or they can invest in the necessary R&D on energy-saving products. In China, lesson should be learned from the best practices abroad, such as progressive penalties for products exceeding the standards in the EU, or the punishment for high fuel-consuming vehicles that exceed Environmental Protection Agency limits in the U.S. The level of the punishment should be calculated in a scientific manner and an assessment of its influence on industry should be conducted.

The reward and punishment mechanism should be formulated and published in the near term. It is suggested that the formulation be finished before2014.

According to initial measurements undertaken by CATARC-ADC, the penalty for part of the enterprises manufacturing passenger cars would reach hundreds of millions of RMB for the second half of 2012 if the EU model were used.

Improve the subsidy policy for energy-saving passenger vehicles under the "project to promote energy-efficient products for the benefit of the people", and formulate a subsidy policy for heavy-weight commercial vehicles

1) Passenger vehicles

There are two problems for passenger vehicles. First, after the 7th and 8th catalogues for energy-saving subsidies issued in October 2001 when the conditions for the subsidies became stricter, no new catalogue has been published. Without new vehicle models listed for receipt of subsidies, the role of the policy has been progressively weakened. It is suggested that first, the standard should be stricter and a new catalogue of vehicle models should be published in time to guide future developments in energy-saving efforts by vehicle manufacturers. Specifically, it is recommended that the new catalogue should be rolled out in 2014.

Second, the "progressive factor" used in the consistency evaluation of fuel consumption data has been shown to be too low. According to the provisions of the fuel consumption test for certification of new vehicle models, the vehicle to be tested should have travelled at least 3,000 km but not more than 15,000 km. By this time the fuel consumption of the vehicle is lower than that of a new vehicle. But in the test for consistency of fuel consumption, a new vehicle with no mileage can be used for the test. As a result, the concept of a "progressive factor" came into being: the result of the test for consistency of fuel consumption is multiplied by this progressive factor to determine if the new, untraveled vehicle being tested meets the standard. The value of the progressive factor, which is currently fixed at 0.92, is too low. According to experimental analysis, the "progressive factor" should be increased to 0.94 or 0.95.

2) Heavy-weight commercial vehicles

It is suggested that the energy-saving subsidy policies should be issued for heavy-weight commercial vehicles in the near term.

In the commercial vehicle market, the share of vehicles for carrying freight is much higher than that of passenger vehicles. Therefore, the feasibility of subsidy policies for energy-saving trucks can be assessed before implementing the policy.

In terms of energy-saving indicators, besides the fuel consumption indicator, it is suggested that a minimum limit on the payload utilization factor be added.

It is suggested that the relative incentive policies should be issued in 2014.

Formulate energy saving policies for energy saving vehicles

The years between 2009 and 2012 were the main period when subsidy policies for new energy vehicles in China were promoted. In early 2013, the previous round of main promotion policies began to expire and manufacturers and the market are currently in an atmosphere of wait-and-see. The promotion policies should be continued. It is suggested that the relative incentive policies should be issued in 2013.

Improve the target value curve of the fuel consumption standard to promote structural energy saving development.

While the area of footprint (wheelbase multiplied by the average track) is taken as the basic parameter in the U.S., the curb weight is used in China, the EU, and Japan. The curb weight has a more direct and obvious influence on fuel consumption and hence, it is more difficult to set.

When the gradient of the curve (that defines the distribution of fuel consumption limits for vehicles with different curb weights) deviates from the theoretical value, then the energy saving structure will be pushed to reduce fuel use.

Currently, the slope of the third phase fuel consumption standard for passenger vehicles in China is close to the standard limit slope of 2020 of Japan, but it is double that of the EU. More research should be conducted for improvement.

It is suggested that the fuel consumption standard for passenger vehicles of the 4th phase be released before 2015 and the curve be taken as a core content of the standard.

6.2.5 Promote the dissemination of energy-saving technologies and knowledge

This initiative can be jointly promoted by industry organizations, intermediary organizations governments and enterprises.

To enhance the exchange of automotive energy saving technologies, industry organizations and agencies can hold technology exchange conferences or seminars on a regular basis. To scale up the dissemination of knowledge, an awareness campaign on automotive energy-saving knowledge can be launched by taking advantage of the “National Energy-Saving Week”. The campaign can cover the concept, rationale, roles, effects, market application, and usage of energy-efficient technologies.

It is suggested that obvious effects be achieved in 2014.

7 Conclusions

- In 2012, the average fuel consumption of domestic passenger vehicles was 7.38L/100 km, equivalent to 173 g/km of CO_2 emissions. The average curb weight was 1,294.92 kg and the average displacement was 1.621 L. Diesel passenger vehicles' share of the market was less than 0.8%. The production of hybrid energy vehicles reached 10,421, and that of plug-in hybrid energy vehicles, 1,093. In 2012, the average fuel consumption of passenger vehicles in China was 39% higher than that of the EU and 44% higher than that of Japan.

- The target for the average fuel consumption of passenger vehicles in China is 6.6L/100km in 2015; and 5.0L/100km in 2020, equivalent to 119.2g/km of CO_2 emissions. The 2015 target is lower than the goal of 6.9L/100km set in the *Development Plan for Energy Saving and New Energy Automotive Industry* (2012-2020). The target for the average curb weight of the passenger vehicles in 2020 is 1,250kg.

- The total gasoline and diesel consumption in China in 2011 was 144 million tons, equivalent to 1.54 tons/vehicle-year. It is projected that in 2020, the 240 million vehicles will consume 240 million tons of fuel, equivalent to 1 ton/vehicle-year.

- China, the EU and Japan take vehicle weight as the parameter, while the U.S. takes the footprint area. Fuel consumption is more directly related and sensitive to curb weight than to the footprint area. The footprint area system is conducive to lightening weight and easy for user perception. But it also has its disadvantages, that is, that inappropriate constraints will lead to big vehicle size.

- The gradient of the fuel efficiency vs weight curve of the phase 3 fuel consumption standard in China is slightly higher than the value for 2020 in Japan, but it is nearly double the value for EU before 2020. This condition is unfavorable for lightening weight and optimizing product structure to give energy savings. Therefore, the fuel efficiency curve needs further research and revision.

- The automotive energy saving technology pathway in China includes technical and product structure aspects. The technical aspects include engines, transmissions, the use of lightweight materials, vehicle technologies, along with gear shift prompt controllers, tire pressure monitoring, energy-saving air conditioning and other indirect energy-saving technologies. The design aspect includes the adoption of more compact structures, and increasing hybrid and diesel-driven technology.

- The reward and punishment methods for enterprises manufacturing passenger vehicles should be based on the measurement of the average fuel consumption, and be set up in the near term. The examination of the "National Targets" should

be enhanced and the overall corporate energy efficiency improvements should be regulated with reference to the minimum CAFE requirement in the US. It is feasible to consider setting policy rights or energy quota trade rights for companies above the limit which differ from those below it.

- Predictable and stable timelines for preferential vehicle and vessel taxes should be published. It is also suggested that the constraining conditions of engine displacement not exceeding 1.6 L and curb weight not exceeding 1300kg should be added to the set of conditions of the preferential vehicle and vessel taxes. It is suggested that in the reform of consumption taxation, vehicle and vessel taxation, and vehicle procurement taxation, factors such as curb weight and fuel consumption should be introduced to the system.

- The “Project to Promote Energy-Efficient Products for the Benefit of the People” should be improved and subsidy policies should be formulated to encourage the adoption of energy-saving measures in heavy-weight commercial vehicles. For passenger vehicles, first, the standards should be made stricter and the new catalogue of vehicle models to be subsidized should be released in a timely manner. Second, the “progressive factor” in the test for fuel consumption consistency should be increased moderately. For example, it should be increased from the current 0.92 to 0.94 or 0.95.

- A new cycle of promotion policies for energy-saving vehicles should be rolled out in the near term.

- The general idea of energy saving and low carbon development in the automotive sector, whether in China or overseas, can be summarized as the progress in and coordination between technological and social and economic factors, including: vehicle, fuel, road and people. This research focuses on the aspect of vehicle. In any future research, other key factors such as “fuel”, “driver behavior” and “road management” should be studied, to investigate issues such as the diversification in vehicle fuels, energy-saving driving habits, green vehicle maintenance, energy-saving consumption and culture, and the improvement of traffic flow.

References

[1] State Council. *Energy-saving and New-energy Auto Industry Development Plan (2012-2020), Guo Fa* (2012) No.22. 2012-06-28.

[2] IEA. *Guidelines on Development and Implementation of Energy Technology Roadmap*. 2010.

[3] Department of Industry Coordination, National Development and Reform Commission. *Compilation of Research Results in Policies on Energy-saving and New Energy Automotive Technologies*. 2009-06.

[4] Regulation (EC) No 443/2009 of the European Parliament and of the Council. *Setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles*. 2009-04-23.

[5] European Environment Agency. *CO_2 emissions performance of car manufacturers in 2012*. 2013-10.

[6] Japan Automobile Manufacturers Association. *Environment Report 2013*. 2013-11.

[7] Ministry of Economy, Trade and Industry, Ministry of Ministry of Land, Infrastructure, Transport and Tourism. *Standards of evaluation of manufacturers, etc. related to improving the performance of passenger cars*. 2013-03-01.

[8] Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA). *Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule*. 2010-05-07.

[9] Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA). *2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, Final Rule*. 2012-10-15.

[10] Environmental Protection Agency (EPA). *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends:1975 Through 2012*. 2013-03.

[11] International Council on Clean Transportation (ICCT). *European Vehicle Market Statistics*. 2011 Edition.

[12] VDA. *Annual Report 2008*:20-21.

[13] JAMA. *Automobile and Taxation*. http://www.jamabj.cn/tax/index.asp.

[14] ACEA. *Overview of CO_2-Based Motor Vehicle Taxes in the EU.* 2013-04-04.

[15] VDA. *Annual Report 2013*:115.

[16] Department of Equipment Industry, Ministry of Industry and Information Technology. *Monthly Report on Promotion of Energy-saving and New Energy Vehicles*. 2013-01.

Department of Equipment Industry, Ministry of Industry and Information Technology. *Interpretation of the "Measurement Methods for Corporate Average Fuel Consumption of Passenger Vehicles"*. 2013-03-20.

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