China Passenger Vehicle Fuel Consumption

2015 Development Annual Report

The Innovation Center for Energy and Transportation

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Authors

Liping Kang, Maya Ben Dror, Lanzhi Qin, Feng An

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Innovation Center for Energy and Transportation (*i*CET)

Address: Beijing Fortune Plaza Apartments A Room 7H No.7 DongSanHuan Middle Rd., Chaoyang District, Beijing, 100020, P. R. China

Phone: +86.10.65857324
info@icet.org.cn
www.icet.org.cn

Content

Figures

Tables

Executive summary

In 2014, China's passenger car production maintained a steady growth of nearly 20 million units, while the volume of imported cars saw a rapid increase of more than 1.4 million units. In the last ten years, the rapid development of the passenger car has become one of the main drivers of China's oil consumption, greenhouse gas, and pollutant emissions. International experiences demonstrate that fuel economy standards are one of the most effective policy pathways for improving vehicle fuel efficiency, promoting technological upgrading, and reducing greenhouse gas emissions.

China started implementing the first phase of its fuel economy standards in July 2005. Since then, it has introduced three more phases: extending the standard to include fuel consumption targets, corporate average fuel consumption targets and limits, and imported vehicles management (in preparation to include imported cars under the standard). In the very beginning, it just set fuel consumption limit values, yet later on, the combined system of model limits and the corporate average fuel consumption (CAFC) has been adopted. In 2012, the management of passenger cars was incorporated, adding teeth to the standard.

China is gradually forming a standard management system for advancing an effective fuel consumption standards implementation. This report utilizes key indicators, in alignment with the standard, as detailed in the below table. It has been 9 years since China's fuel consumption standards went into their implementation phase. During this period, China's domestic average fuel consumption improved from 8.16L/100km to 7.12L/100km (if incorporating the contributions brought by new energy vehicles). China's overall per-km fuel consumption was reduced by 12.7% during this period, with an average annual decrease of about 3%.

Explanation of Terminologies in China's Fuel Consumption Regulatory System

Measurement Index	Acronyms	Explanation	Reference Standard and timeframe
Fuel Consumption Limit	FC	Every individual vehicle models have to meet their corresponding weight-bin limit. The limit value of the fourth phase is about 20% lower than that of the third phase, equal to the target value in the third phase;	***Starting 2005:*** **GB19578-2004 (Phase I)** ***Starting 2016:*** **GB19578-2014 (Phase IV)**
Target Fuel Consumption	T_{FC}	Phase III was implemented in 2012, and also introduced a FC target value associated with each vehicle model (according to its weight-bin classification). There is no requirement for meeting the individual vehicle model FC target, however T_{FC} is used to calculate the target value of average fuel consumption (TCAFC) of auto companies.	***Starting 2012:*** **GB27999-2011 (Phase III)** ***Starting 2016:*** **GB27999-2014 (Phase IV)**

Actual Average Fuel Consumption of Auto Manufacturers	CAFC	Targeting auto companies, the CAFC is calculated according to the annual vehicle model type and volume output and the model's actual fuel consumption (see section 1.1 for details). CAFCxxxx means CAFC for specific year, for example $CAFC_{2014}$.	
Target Average Fuel Consumption of Auto Manufacturers	$T_{CAFC-III}$ $T_{CAFC-IV}$	Target CAFC for the current phase period; Automakers have to meet their corporate average fuel consumption (CAFCxxxx) target ($T_{CAFC-xxxx}$) in each model year (xxx).	***Starting 2011:*** **GB27999-2011** **(Phase III)** ***Starting 2016:*** **GB27999-2014** **(Phase IV)**
Actual and Target FC Ratio	$CAFC_{2014}$ /$T_{CAFC-III}$ $CAFC_{2014}$ /$T_{CAFC-IV}$	CAFC actual annual value/ Target CAFC value; By using this calculation method, one can track the annual CAFC % gap from meeting the ultimate target: $T_{CAFC-III}$ represents Phase III (6.9L/100km by 2015) while $T_{CAFC-IV}$ represents Phase IV (5L/100km by 2020).	***Starting 2011:*** **GB27999-2011** **(Phase III)** ***Starting 2016:*** **GB27999-2014** **(Phase IV)**
CAFC Credits	---	Auto manufacturers can earn credits if their CAFC is above the annual target (CAFC/T_{CAFC} value is less than 100%). Otherwise, they will be penalized – details of this regulation are still under discussion.	**The accounting method for average fuel consumption of passenger car enterprises**

Note: * It is planned to begin implementation in 2016, belonging to the standard for the 4th phase;

** The credits trading system has not been adopted.

In order to reach the passenger car fuel consumption target of 5L/100km by 2020, announced in the "energy-saving and new energy automobile industry development plan (2012-2020)", passenger car fuel economy standards were improved in 2014 (namely, "Phase IV") and will be officially implemented as of 2016. Compared with Phase III, single vehicle limits were tightened by some 20% on average (greater reduction is required from higher-weight cars), and the target FC value decreased by 30-40%. In addition, the new standard encourages advanced energy-saving technologies and suggests flexibility mechanism which includes credits trading towards sound and effective implementation.

As the only domestic non-governmental organization to participate in China's passenger car fuel economy standards system development, the Innovation Center for Energy and Transportation (*i*CET) has been continuously tracking and analyzing the state and development of China's passenger car fuel consumption standard implementation. These efforts were primarily aimed at advising policy-makers towards the design and enforcement of a robust and effective standard. "China Passenger Vehicle Fuel Consumption Development Annual Report 2015" is the fifth report produced by iCET. This report has analyzed the development of the Phase III and IV of China's fuel consumption standard, introduces auto manufacturers' individual FC performance, evaluates the contribution of New Energy Vehicle (NEV's) to corporate and overall performance, and proposes recommendations towards the 2020 target. The highlights of this report are as follows:

1. In 2014, importing and JV auto manufacturers' CAFC improvement rate slowed from last year; If NEVs contribution to FC reduction are excluded, then independent companies' CAFC further worsened.

Without considering the impact of New Energy Vehicles (NEVs) on the average fuel consumption of China's passenger cars in 2014, domestic enterprises reduced their annual FC by 1.4% points from last year to 7.22L/100km, while independent brand enterprises' increased their CAFC by 3%, and joint ventures and importing enterprise maintained an annual decline of 3% as shown in the below table.

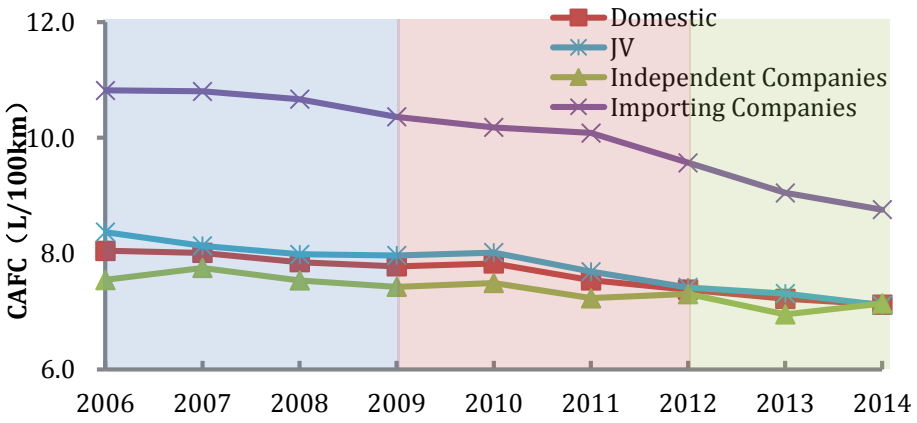
2014 Actual to Target FC by Enterprise Types

Enterprise Type	Actual CAFC 2014 (L/100km)	Actual CAFC 2013 (L/100km)	CAFC 2014/2013
Domestic passenger cars enterprises (JVs and Independent combined)	7.22	7.33	**-1.5%**
- Joint ventures	7.12	7.22	**-1.4%**
- Independent enterprises	7.10	7.31	**-2.8%**
Importing enterprises	7.14*	6.95	**+2.9%**
National average	8.76	9.05	**-3.2%**

Note: Excluding NEVs; * if including NEVs, independent auto makers CAFC reached 6.77L/100km in 2014.

Between 2006 and 2014, the CAFC of domestic car auto companies (JVs and independent brands) and importing companies were declining annually, falling by some 0.1-0.25L/100km every year. Imported cars, mainly comprised of luxury or sports cars with rather high FC levels, were faced with increasing pressure to meet the standards. The CAFC of JVs has been falling yet gradually slowing-down its improvement pace. If keeping the existing fuel consumption decline pace, it will be difficult to achieve the 2020 CAFC goal of 5L/100 km.

2006-2014 by-Brand Type CAFC Decline

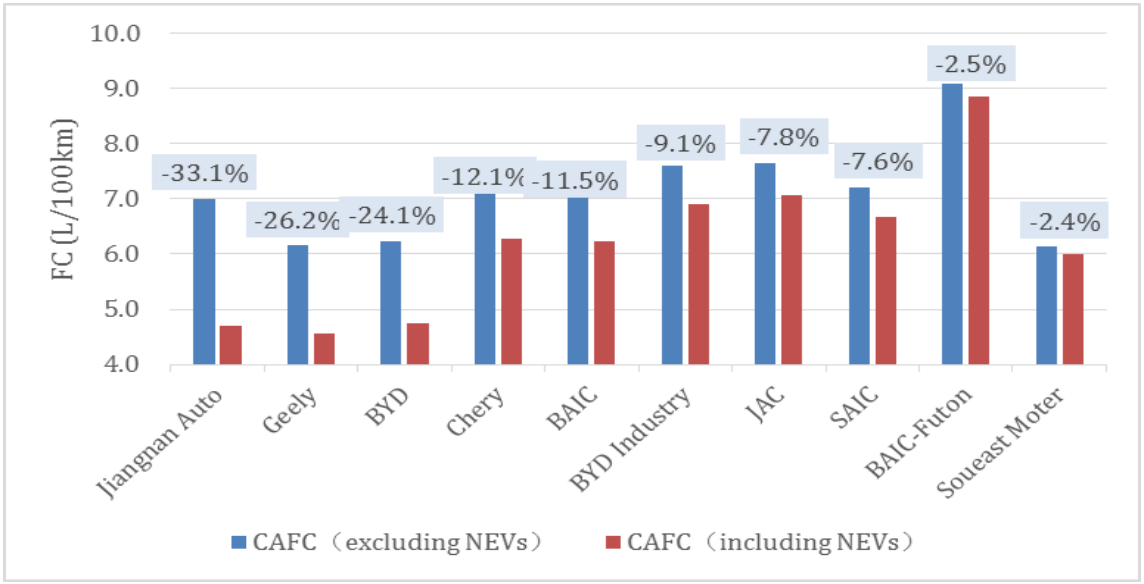


Note: Domestic companies are comprised of JV brands and Independent brands.

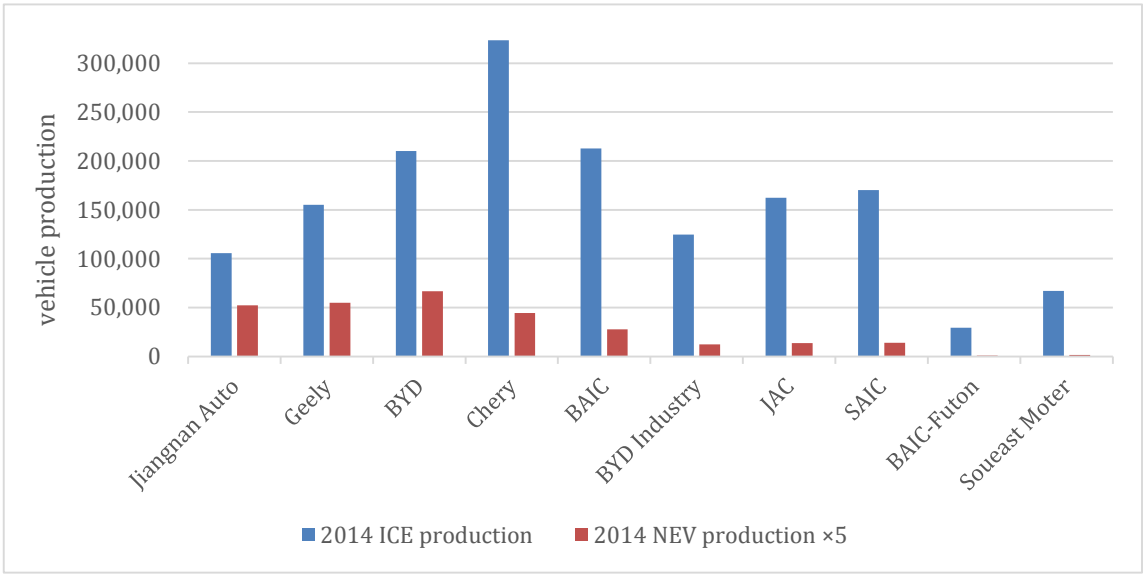
2. New Energy Vehicles (NEVs) will help achieve China's Phase III's (2015) target of 6.9 L/100km.

The total production of passenger NEVs in 2014 was 4 times that of 2013, amounting to 54,500 total NEVs, among which the production of pure electric and hybrid passenger cars was 37,800 and 16,700 respectively. In 2014, the incorporation of NEVs in the annual corporate average fuel consumption (CAFC) led to a decrease of nearly 0.1L/100km in national average fuel consumption (from 7.22L/100km to 7.12L/100km), as well as the independent brands average FC (from 7.33L/100km to 7.22L/100km). At present, NEVs are still mainly produced by independent brands, decreasing their CAFC from 7.15L/100km to 6.77L/100km. NEVs contributed as much as 20-30% to the decrease of CAFC of local brands, such as Jiangnan Automobile, Geely Automobile, and BYD automobile. NEVs could clearly help achieve the national fuel consumption target of 6.9L/100km by 2015, which requires a reduction of 0.3L/100km in the Phase III final implementation year (2015) and will be challenging if only relying on traditional cars' technology improvements.

The impact of NEVs on selected auto companies' CAFC



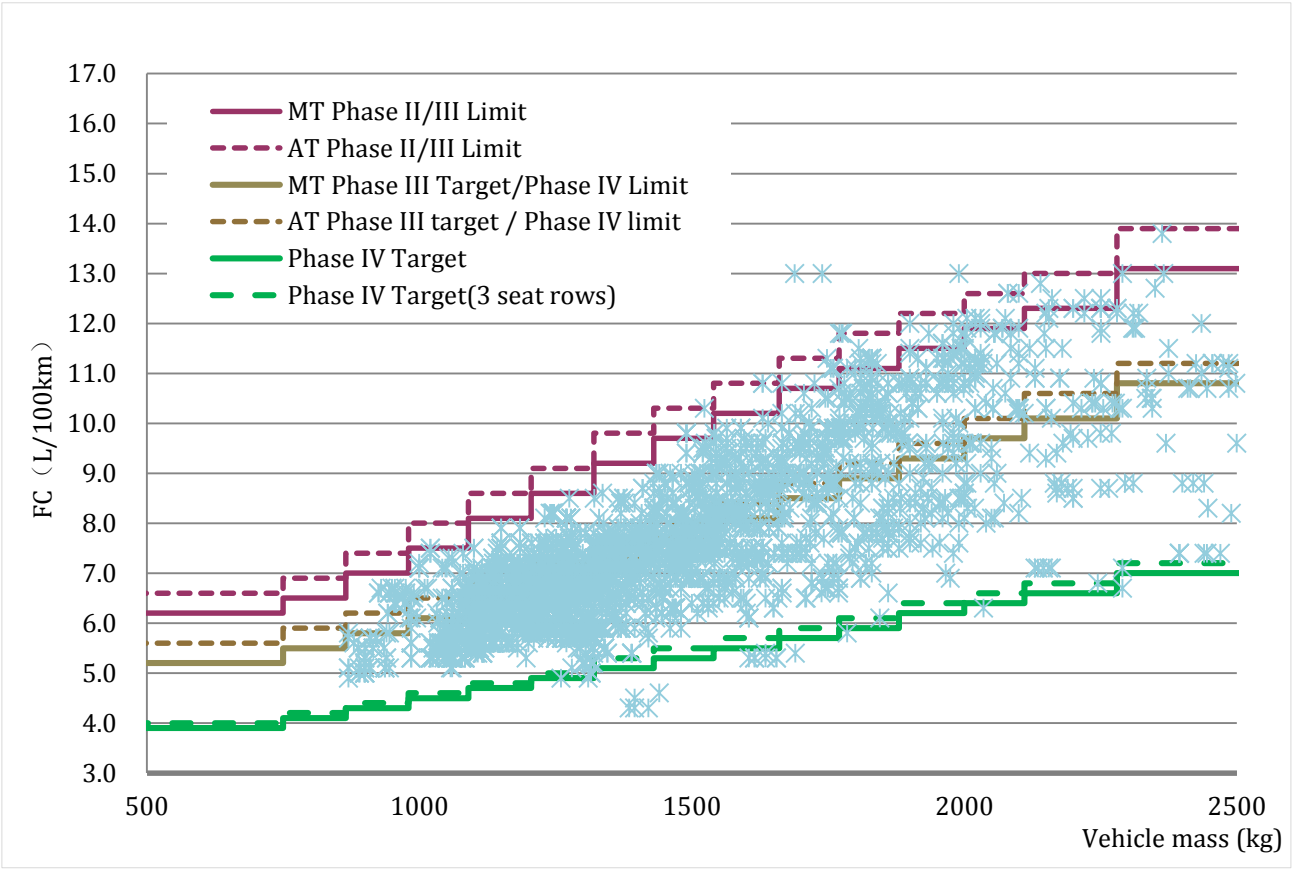
ICE and NEV production by selected companies



3. Over 75% of 2014 new models' fuel consumption reached the limit value requirements of the China's Phase III Target, indicating 25% have only 2 years to meet the Phase IV limit.

Among the models published on the Ministry of Industry and Information Technology (MMIT) China Fuel Consumption Website in 2014, China's passenger vehicle average fuel consumption was between Phase III and Phase IV limit values. 74.3% of models reached the limit value of Phase IV (the target value of the Phase III), bringing significant FC reductions from last year.[1] A small number of hybrid, plug-in hybrid and diesel models demonstrated an ability to achieve a fuel consumption level that is below the target of Phase IV. The remaining 25% have only two years to improve their fuel consumption before Phase IV enters force. Only four imported models failed to meet the annual FC requirement of 2014 (however better than last year's imported models' performance).[2]

China's 2014 Passenger Cars FC Distribution



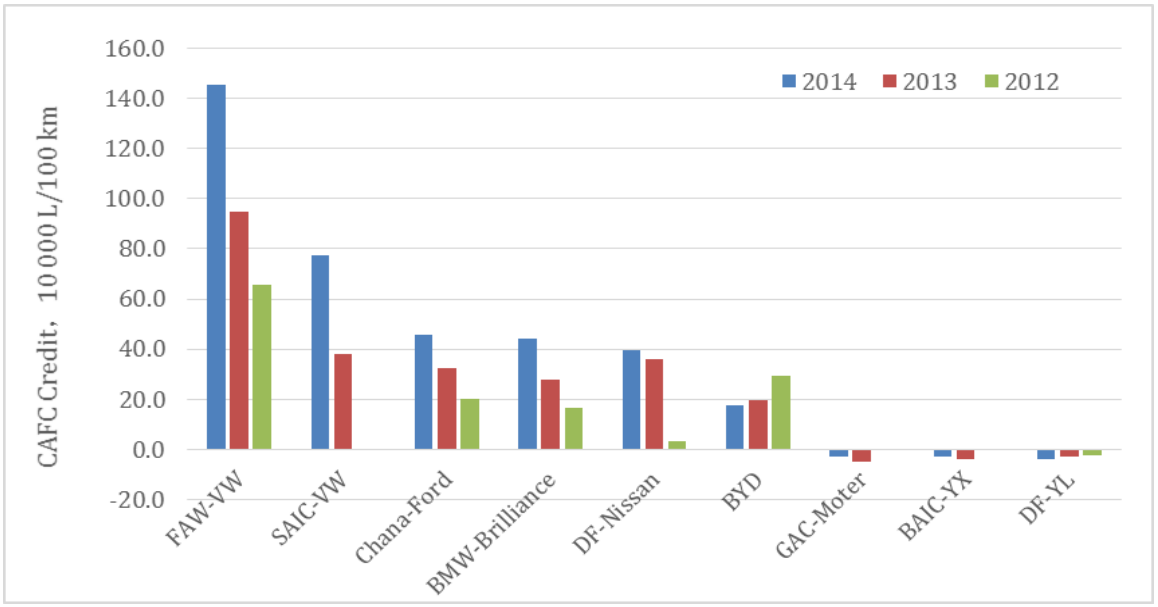
4. CAFC credits mechanism will assist in meeting Phase IV fuel consumption target.

Based on an experimental calculation of potential credits accumulation over the past three years (2012-2014), a total of 12,140,000L/100km CAFC credit and 780,000 L/100km CAFC debts have been produced (section 1.1.3 elaborates on CAFC credit and debts calculation), demonstrating an imbalance. The

[1] Half of models had reached the limit value of the 4th phase (the target value of the Phase III) in 2013.
[2] 10% of models did not meet the limit value of the 2nd and Phase III, mainly the middle and large luxury car, SUV and sports car in high-quality range.

concentration of credits is in rather limited auto brands, indicating that technology and credits transfer should be created for enabling improvements without compromising China's auto sector competitiveness.

2012-2014 Domestic enterprises with credits above/below target performance

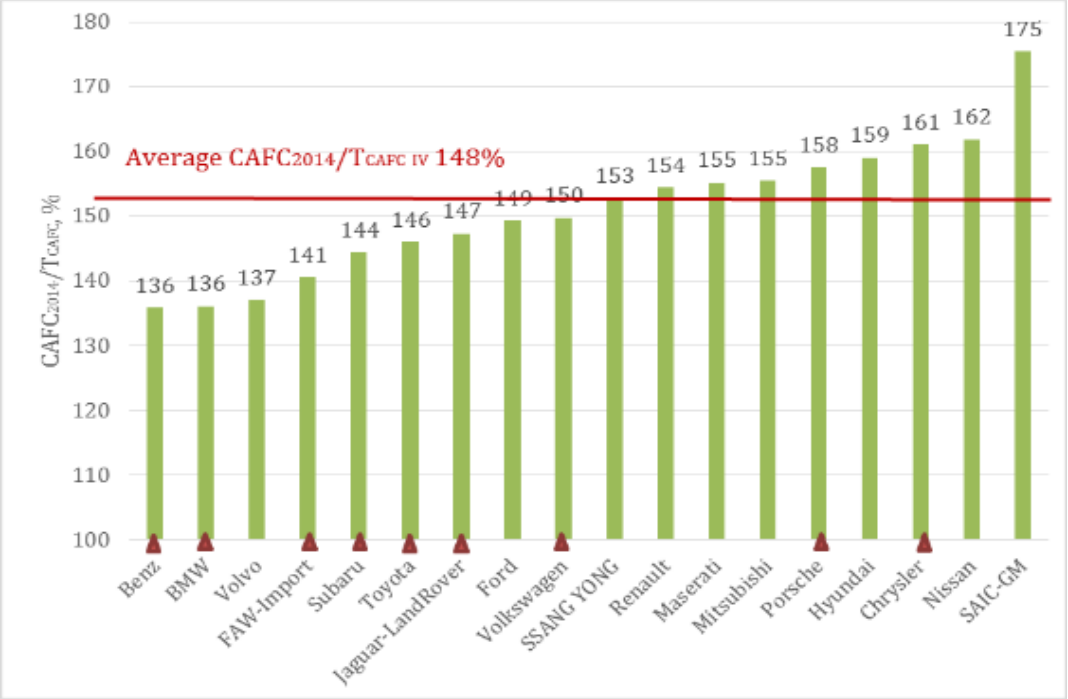


5. While domestic cars are largely assisted by NEVs in meeting their CAFC/$T_{CAFC2020}$, importing auto makers are faced with great pressure to reduce their average FC.

Domestic auto companies' $CAFC_{2014}/T_{CAFC\ IV}$ was 138% (including NEVs), indicating a fall of 6 percentage points from the previous year and 134% of Phase IV target. However, if NEVs are excluded, manufacturers with annual production capacity of over 10k cars would be faced with a CAFC target range of between 4.5 and 5.9 L/100km, therefore the $CAFC_{2014}/T_{CAFC}$ could be as high as 150%. When NEVs are included, domestic manufacturers such as Geely Automobile, Jiangnan Automobile, and BYD Auto have already reached their Phase IV requirement. In general, manufacturers of small car models face low implementation pressure, while manufacturers of medium and large models are faced with relatively high standards implementation pressure.

Importing auto companies' $CAFC_{2014}/T_{CAFC\ IV}$ was 148%, falling by 7% from last year, and some 10% higher than that of the domestic passenger cars. As of Phase III, importing auto companies are included in the national light vehicle fuel consumption management standard system, and its required $CAFC_{2016}/T_{CAFCIV}$ is 134%. Importing auto companies need to decline their average FC by 15% during the two-year transition period of 2015-2016, thus facing greater pressures than domestic enterprises.

The ratio of importing enterprises' actual to Phase IV target CAFC



Note: The figure includes auto companies with import volume of over 10,000; ▲ marks the enterprises with import volume of over 50,000 in 2014.

Domestic and Importing auto companies' average $CAFC_{2014}/T_{CAFC\ IV}$ reached 138.7%, indicating potential smooth transition to the 2016 target of 134%.

2014 CAFC gap from Phase IV Target

	2014 CAFC * (L/100km)	$T_{CAFC-IV}$ (L/100km)	$CAFC/T_{CAFC-IV}$	$CAFC/T_{CAFC-IV}$*
National Average	7.12	5.13	140.6%	**138.7%**
Domestic companies	7.01	5.08	139.8%	**138.0%**
JVs	7.11	5.09	139.7%	**139.5%**
Independent	6.77	5.08	138.0%	**133.3%**
Importing companies	8.76	5.93	147.7%	**147.7%**

* Including NEVs

6. New energy vehicles (NEVs), Energy-saving technologies, and a credits trading mechanism are key for achieving Phase IV 2020 5.0L/100km target

Phase IV $CAFC/T_{CAFC-IV}$ implementation plan, the increasing in stringency phase, is described in the table below. It requires an overall decline of 10% in CAFC/ $T_{CAFC-IV}$ ratio between 2018 and 2020, translating to an annual decline of 0.5L/100km or 9%. During Phase IV (2016-2020), CAFC should fall by 6.2% per year on average. Compared with an average annual decline of less than 2% in the past seven years (2006-2014) the 2020 goal seems challenging. Not only are advanced energy saving technologies required, but also new energy vehicles (NEVs) as well as credits trading mechanism for speeding China's average FC reduction will be needed.

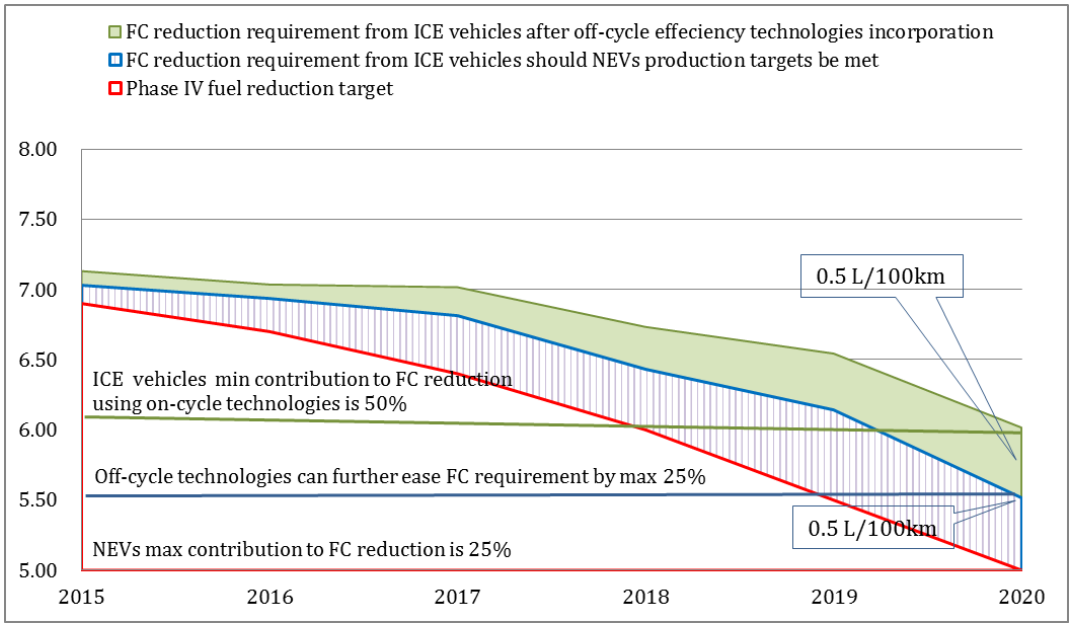
Phase IV CAFC/$T_{CAFC\ IV}$ Plan

Year	CAFC/ $T_{CAFC2020}$	Annual *percentage point* reduction (improvement)	CAFC *L/100km*	CAFC Annual *L/100km* reduction (improvement)	Annual *percentage* reduction (improvement)
2014	140%	3	7.12	0.21	**-2.8%**
2015	138%	3	6.90	0.22	**-3.1%**
2016	134%	4	6.70	0.20	**-2.9%**
2017	128%	6	6.40	0.30	**-4.5%**
2018	120%	8	6.00	0.40	**-6.3%**
2019	110%	10	5.50	0.50	**-8.3%**
2020	100%	10	5.00	0.50	**-9.1%**
Annual average improvement percentage between 2016 and 2020					**-6.2%**

Note: Data for 2014 is actual data, while 2015-2020 data is based on announced national targets.

In Phase IV, advanced energy-saving technologies will be entitled for CAFC credits. Kinetic energy recovery systems (KERS), high efficiency air conditioning, idle start and stop device, and shift reminder device would each enable a reduction of 0.5L/100km in the FC of models in which they are integrated. Accounting of new energy vehicles (NEVs) will enable a decline of 0.5L/100km at most from the corporate average fuel consumption (CAFC) value. By achieving the maximum amount of two credits, a corporate average fuel consumption would be reduced by 1L/100km, accounting for half of Phase IV's (2016-2020) total target (6.9 L/100km down to 5 L/100km). In this case, the average fuel consumption reduction of traditional vehicles only needs to be 0.9L/km, thus maintaining an average annual decline of about 3.3%, instead of 6.2%.

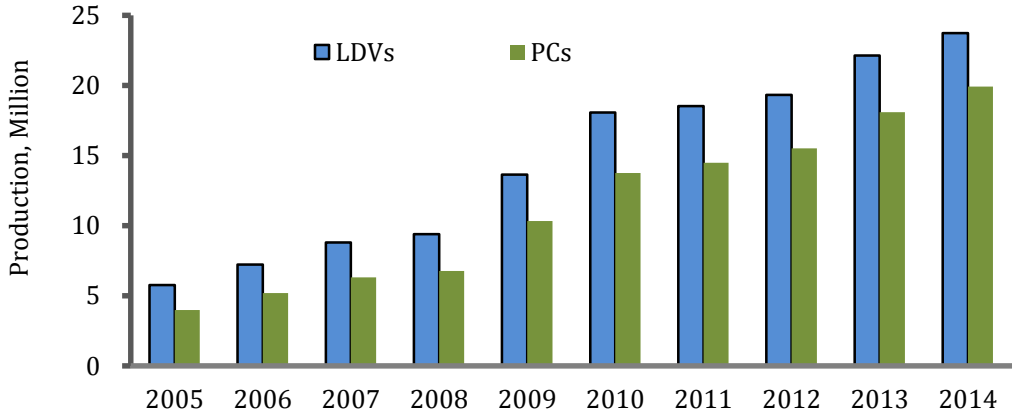
NEVs and Energy Saving Technologies Impact on Phase IV FC Targets



1. Introduction

In 2014, China's auto production continued to maintain steady growth and performs as the world's largest auto market for the sixth consecutive year (Figure 1).[3] China's market share in the global automotive industry increased from 3.5% in 2000 to 27.4% in 2014. Meanwhile, in 2014, China's overall vehicle production surpassed 23 million. Passenger cars account for as much as 84% of the total vehicle production, and the growth rate of passenger cars is three percentage points higher than that of the total auto market (10% and 7% respectively)[4]. Nevertheless, China's car ownership is still below developed countries' average ownership levels, signaling that auto production and sales volumes will continue to grow in the near future.[5] Therefore, passenger car emissions and energy management have become an important strategic issue pursued by the national and local governments.

Figure 1: 2005-2014 China's light-duty vehicles (LDVs) and passenger cars (PC) Production



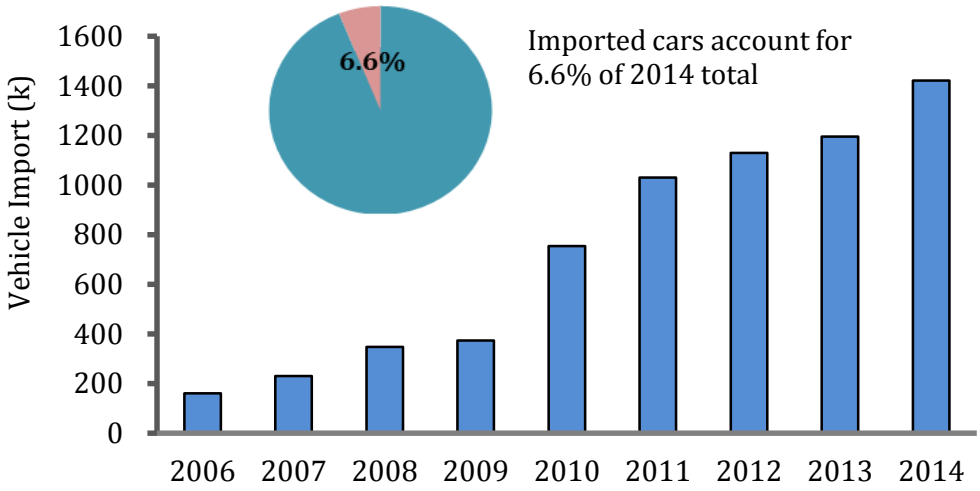
As of 2012, the imported cars' fuel consumption (FC) management has been strengthened. The total volume and growth rate of imported passenger cars are significant: in 2014, imported vehicle sales increased by 21.6% from the previous year, amounting to an annual total sales volume of 1.421 million cars, which accounted for 6.6% of China's total annual new passenger cars fleet (Figure 2). Imported passenger cars market growth is still led by the SUV segment, accounting for 63.3%.[6]

In recent years, China's dependence on foreign oil rises constantly, and has reached

[3] China Automobile Industry Association, China Automotive Technology Research Center, TOYOTA (China) Investment Co., Ltd., China's auto industry development annual report (2015). Beijing. 2015.04.
[4] In 2014, growth rate of cars was about 7%, and that of passenger car was about 10%.
[5] http://auto.people.com.cn/n/2015/0128/c1005-26463124.html
[6] China automobile import and export trading company. Annual report of the China import & export automobile market in 2014. Beijing. 2015.02
2014 http://auto.sohu.com/20150127/n408104195.shtml

60% in 2014.[7] Gasoline and diesel consumed by the auto sector amount to over 150 million tons annually, accounting for about 60% of refined oil products consumption.[8] As China's car ownership continues to grow, the demand for refined oil to power vehicles continues to grow. In addition, the vehicle transport sector has been officially announced as one of the prominent sources of urban air pollution.[9] With the increase in car ownership and travel activity, problems concerning energy use and the environment (air quality in particular) have become increasingly more prominent. In order to reduce the level of the auto sector fuel consumption and improve the energy efficiency of cars, the State Council, in its current "energy-saving and new energy automotive industry development plan (2012-2020)," has already set clear objectives for China's average passenger car fuel consumption reduction. It has set to reach 6.9 L/100km by 2015 and 5.0L/100km by 2020.[10] In the recent national "Made in China 2025" plan, it was proposed that the average fuel consumption of passenger cars (including new energy vehicles) would drop to 4L/100km by 2025.[11]

Figure 2: 2006-2014 China's imported cars development



International and domestic experiences prove that the implementation of fuel consumption standards is instrumental for promoting technological improvements that can deliver significant vehicle efficiency. China began the implementation of the first phase of its fuel economy standards in July 2005. During the nine years since then, China's passenger car average fuel consumption has declined from 8.05L/100km to 7.01L/100km, marking a

[7] http://news.xinhuanet.com/finance/2015-01/28/c_1114168854.htm
[8] The national standard for the fuel consumption of passenger car.2014.01 http://www.miit.gov.cn/n11293472/n11293832/n12845605/n13916913/n15852446.files/n15851861.pdf
[9] Ministry of environmental protection. China motor vehicle pollution prevention and control annual report. http://www.zhb.gov.cn/gkml/hbb/qt/201112/t20111219_221495.htm
[10] Notice of the State Council on the issuance of energy conservation and the development of new energy automotive industry (2012 - 2020), 2012.06. http://www.nea.gov.cn/2012-07/10/c_131705726.htm
[11] MIIT. the promotion of energy saving and new energy automotive development in "China made 2025" planning series interpretation.2015.05.22. http://zbs.miit.gov.cn/n11293472/n11295142/n11299123/16604739.html

decrease of 12.9% (however the average annual decrease is just 3%),[12] China's fuel consumptions' third phase, which began in 2012, includes fuel consumption management of imported cars. This segment saw an outstanding annual average decrease of about 5% since the phase began. China is gradually shaping its fuel consumption targets and management system and the implementation of the standard continues to improve.

The Innovation Center for Energy and Transportation (*i*CET) is among the key initiators and supporter of China's passenger car fuel consumption standards. Its founder and president, Dr. An Feng, has been involved in the promotion of China's first fuel consumption limits since 2002, and since 2006 *i*CET is devoted to the important task of delivering an annual tracking of the standard's implementation and design development through analyses, study reports, and experts panel discussions. In recent years, great emphasis has been placed on the corporate average fuel consumption standard and the development of a management mechanism.

[12] The results of this report and the annual report of China passenger car fuel consumption by *i*CET.

1. China passenger car fuel consumption management system

This chapter introduces the management practices of China's passenger car fuel consumption standards and the involved organizations. The chapter also compares China's management system with that of other major regimes.

1.1. China's Fuel Consumption Standards

1.1.1. Introduction to China's fuel consumption standards system

China's passenger car fuel consumption management system includes testing standards, labeling standards, limit standards, and targets – listed in Table 1.

Table 1: China's passenger car fuel economy standards system

Standard type	Standard title
Testing standards	Measurement methods of fuel consumption for light duty vehicles (GB/T 19233-2003)
	Fuel consumption limits for passenger cars (GB19578-2004)
Standard introduction	Light vehicle fuel consumption classification (GB 22757-2008)[13]
Limits Standards	Fuel consumption limits for passenger cars (GB19578-2014)
	Fuel consumption evaluation methods and targets for passenger cars (GB 27999-2014)

The limit standards are mandatory standards meant to improve China's passenger car fuel economy. It is comprised of two sections: the first, namely GB19578, sets the limit of FC per vehicle weight bin (per model) which needs to be met for certified production and sale; the second, GB27999, targets an average fuel consumption level for each passenger car corporation based on its fleet composition, namely the Corporate Average Fuel Consumption (CAFC). The ratio of corporate actual to target fuel consumption value(CAFC/TCAFC) is an annual measurement of conformity with the standard. Auto companies can change their fleet composition; for example, by increasing small vehicle volumes to allow for heavy vehicles production without compromising adherence to the standard. The core standards and their measurements used in this report are specified in Table 2.

[13] 修订版的《轻型汽车燃料消耗量标识》标准目前正在征求意见.
http://www.catarc.org.cn/NewsDetails.aspx?ID=2505

Table 2: Explanation of Terminologies in China's Fuel Consumption Regulatory System

Measurement Index	Acronyms	Explanation	Reference Standard and timeframe
Fuel Consumption Limit	FC	Every individual vehicle models have to meet their corresponding weight-bin limit. The limit value of the fourth phase is about 20% lower than that of the third phase, equal to the target value in the third phase;	***Starting 2005:*** **GB19578-2004 (Phase I)** ***Starting 2016:*** **GB19578-2014 (Phase IV)**
Target Fuel Consumption	T_{FC}	Phase III implemented in 2012, also introduced a FC target value associated with each vehicle model (according to its weight-bin classification). There is no requirement for meeting the individual vehicle model FC target, however T_{FC} is used to calculate the target value of average fuel consumption (TCAFC) of auto companies.	***Starting 2012:*** **GB27999-2011 (Phase III)** ***Starting 2016:*** **GB27999-2014 (Phase IV**
Actual Average Fuel Consumption of Auto Manufacturers	CAFC	Targeting auto companies, the CAFC is calculated according to the annual vehicle model type and volume output and the model's actual fuel consumption. CAFCxxxx means CAFC for specific year, for example $CAFC_{2014}$.	
Target Average Fuel Consumption of Auto Manufacturers	$T_{CAFC-III}$ $T_{CAFC-IV}$	Target CAFC for the current phase period; Automakers have to meet their corporate average fuel consumption (CAFCxxxx) target ($T_{CAFC-xxxx}$) is each model year (xxx).	***Starting 2011:*** **GB27999-2011 (Phase III)** ***Starting 2016:*** **GB27999-2014 (Phase IV)**
Actual and Target FC Ratio	$CAFC_{2014}$ /$T_{CAFC-III}$ $CAFC_{2014}$/ $T_{CAFC-IV}$	CAFC actual annual value/ Target CAFC value; By using this calculation method, one can track the annual CAFC % gap from meeting the ultimate target: $T_{CAFC-III}$ represents Phase III (6.9L/100km by 2015) while $T_{CAFC-IV}$ represents Phase IV (5L/100km by 2020).	***Starting 2011:*** **GB27999-2011 (Phase III)** ***Starting 2016:*** **GB27999-2014 (Phase IV)**
CAFC Credits	---	Auto manufacturers can earn credits if their CAFC is above the annual target (CAFC/T_{CAFC} value is less than 100%). Otherwise, they will be penalized – details of this regulation are still under discussion.	**The accounting method for average fuel consumption of passenger car enterprises**

China's fuel consumption standards has already undergone three phases and has recently entered its forth phase. The "vehicle fuel consumption limit" (GB19578-2004)," is China's first mandatory vehicle fuel consumption management standard, which was implemented in two phases: the first phase ran from July 1st, 2005 to July 1st, 2006, steering the production of new vehicles and existing vehicles respectively, while the second phase commenced in January 1st. 2008 to January 1st, 2009, steering the new vehicles and existing brands production respectively. The two phases grouped vehicles into 16 weight-bins according to each car's curb weight, therefore fuel consumption limits and requirements are less for lower curb-weight vehicles.

By the end of 2011, China issued the "passenger car fuel consumption evaluation methods and indicators" (GB27999-2011), which included the first-ever introduction of corporate average fuel consumption (CAFC) standards. Again, according to a car's curb weight-bin, a 2015 target was set and subsequently, the first-ever CAFC accounting methods and indicators were outlined. The CAFC targets all manufacturing enterprises (including domestic and imported) and sets a corporate target as well as an annual gap from the target. These are determined and calculated according to the manufacturer's vehicles actual fuel consumption and corresponding production volume. Manufacturers can therefore flexibly adjust their vehicles technologies (and weight) and vehicles' production volume in order to meet the required annual CAFC. China's Phase III sets the implementation requirements for 2015 CAFC at 6.9 L/100km. Table 1 outlines China's passenger car fuel economy standards development.

In December 2014, the State Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) and the State Standardization Committee jointly issued the forth phase of the "vehicle fuel consumption limit standard" (GB19578-2014) and "passenger car fuel consumption evaluation methods and indicators" (GB27999-2014). It is aimed at setting a more stringent China's Phase IV fuel consumption standard: by 2020, a CAFC of 5.0 L/100km is set forth. The new phase will enter force as of January 1st, 2016 and January 1st, 2018 for new and used cars respectively. Phase IV is designed to increase cars' fuel consumption limits by about 20% and fuel consumption targets by 30%-40%. The new standard provides more detailed technology pathways for reducing fuel consumption and further promotes new energy vehicles by detailing their relative fuel consumption calculation. The new standard requires an accelerated annual corporate average reduction rate of roughly 3% in the first year (2016) to about 9% in the last two years (2019 and 2020).

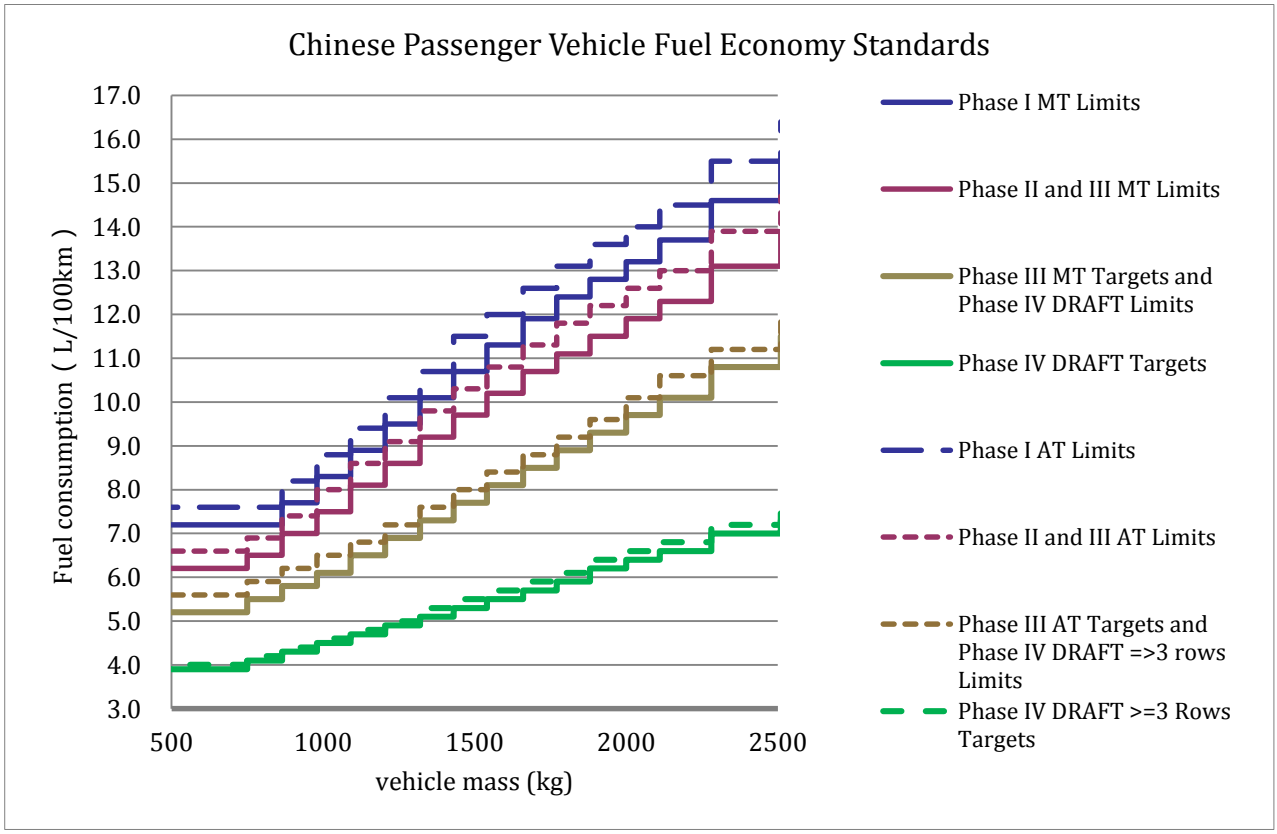
Table 3: China's by-phase fuel consumption standard system

Phase	Timeframe	Title	Comments
Phase I	2005.07-2008.01 New cars 2006.07-2009.01 Used cars	GB19578-2004	Single vehicle FC limit
Phase II	2008.01-2012.07 New cars	GB19578-2004	

	2009.01-2012.07 Used cars		
Phase III	2012.07-2015.12	GB19578-2004 GB27999-2011	Single vehicle FC limit and corporate average FC target; includes imported vehicles targets.
Phase IV	2016.01-2020.12	GB19578-2014 GB27999-2014	Single vehicle FC limit and corporate average FC target; includes imported vehicles targets.

China's passenger vehicle fuel economy standards have quickly evolved over the past decade and continue to advance vehicle efficiency technology improvements by aligning China's vehicle market with global fuel economy standards by 2020. **Figure 3** shows the four current phases of the governing framework of fuel economy (more details can be found in **Appendix II**).

Figure 3: China's by-Phase Fuel Consumption Limits and Targets



1.1.2. Corporate Average Fuel Consumption (CAFC) calculation method

The CAFC uses vehicle model (annual serial model details) and annual production (or importation) to calculate weighted average company fuel consumption based on the New European Driving Cycle (NEDC), as shown in the formula below:

$$CAFC = \frac{\sum_{i=1}^{N} FC_i \times V_i}{\sum_{i=1}^{N} V_i \times W_i}$$

***N**: the vehicle model serial number*
***FC**i: fuel consumption of the "i"th model*
***V**i: annual production or importation of the "i"th model*
***W**i: value of "i"th model; New Energy Vehicles (NEVs) and Energy Saving Vehicles (ESVs) accounted for larger volumes that the actual production or importation, as detailed in **Table 4**.*

The CAFC Target is based on individual vehicle fuel consumption target, and then uses the quantity of annual production or importation of each model to calculate a weighted average for the entire corporate fleet. See the formula below:

$$T_{CAFC} = \frac{\sum_{i=1}^{N} T_i \times V_i}{\sum_{i=1}^{N} V_i}$$

***N**: the vehicle model serial number*
T**i: Target value of the specific "i"th model (calculated by weight-bins,* **GB27999)*
***V**i: annual production or import volume of the "i"th model*

These fuel consumption targets generally account for the time that a typical vehicle manufacturer needs for product planning, technology upgrades, and developing new vehicle models. The CAFC requirement was enacted in 2012 and allows automotive manufacturers until 2015 to gradually reduce their fuel consumption levels and meet their target. Phase IV continues the trend, reducing CAFC/T_{CAFC} gradually from 2016 to 2020.

Table 4: New Energy and Energy Saving Vehicles' Preferential Policies (each unit multiplier for CAFC calculation)

	EV	Full Cell EV	Plug-in EV (PHEV)*	ESV**
~2015	5	5	5	**3**
2016-2017	5	5	5	**3.5**
2018-2019	3	3	3	**2.5**
2020	2	2	2	**1.5**

* Plug-in electric vehicles (PHEVs) are defined as vehicles that have electric range of at least 50km.

** Energy Saving Vehicles are defined as cars with fuel consumption lower than 2.8L/100km.

1.1.3. Corporate Average Fuel Consumption Credits Calculation Method

The "passenger car corporate average fuel consumption calculation method" proposed the concept of credits. A company can earn or be in a deficit of credits dependent on whether its CAFC/T_{CAFC} value is below 100% or above the annually stated requirement (e.g. for 2014 the CAFC/T_{CAFC} requirement was 103%; the annual requirement is specific in GB27999), respectively.

Credits calculation is the multiplication of by-model production volume and by-model FC distance from target:

$$\text{Calculation of credits should } \mathrm{CAFC/T_{CAFC}} < 100\%: = (CAFC - T_{CAFC}) \times \sum_{i=1}^{N} V_i$$

$$\text{Calculation debt should } \mathrm{CAFC/T_{CAFC}} > Ri = (T_{CAFC} \times Ri - CAFC) \times \sum_{i=1}^{N} V_i$$

***V_i**: The production or import volume of the "i"th model*

***R_i**: Permitted gap between actual and target average FC of the "i"th year*

In 2014 and in accordance to **GB27999**, the R_i was 103%, making the range between 100%-103% ineligible for credits. If a company would achieve CAFC/T_{CAFC}<100%, it would earn credits if achieved CAFC/T_{CAFC} below 100% (credits value was not yet determined); if CAFC/T_{CAFC} > 103%, it fails to meet the annual requirement and produce credits for bellow target performance and is in debt.

The Ministry of Industry and Information Technology (MIIT) and China's Automotive

Technology Research Center (CATARC), along with experts from the third and auto sector, are studying China's credits management mechanism in order to create an effective fuel consumption standard flexibility mechanism.

1.1.4. China's fuel consumption standard Phase IV

In December 2014, the State Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) and the State Committee for Standardization jointly issued the fourth phase standard "Passenger car fuel consumption limits" (GB19578-2014) [14] and "Passenger car fuel consumption evaluation methods and indicators" (GB27999-2014).[15]

The fourth stage continues to set FC limitations by curb weight bins, and set corporate average FC targets based on the same weight classification rather than footprint (recently adopted in the US). The limits' weight bins remain similar to those of previous phases. Several of these limits are some 20% stricter than the second phase standard. The standard will come into effect in January 1st, 2016 for new production models and January 1st, 2018 for all vehicle models.

The new "Passenger car fuel consumption evaluation methods and indicators" (GB27999-2014) sets fuel consumption target requirement higher by 30% (in other words, FC target is lowered by 30%) for most vehicles and over 35% higher requirements for vehicles exceeding the 1660kg curb-weight. The new draft differs from the previous GB27999-2011 standard mainly through the following additions and updates:

1) Expanding the scope of the standard to include electric vehicles, plug-in hybrid vehicles, and gas-powered vehicles.
2) Encouraging the use of off-cycle energy-saving technologies such as Kinetic Energy Recovery Systems (KERS), efficient air conditioning, idle start-stop system, and shift reminder, by rewarding vehicles that implemented one or more of these technologies with a fuel saving credits of up to 0.5 L/100km from their Test-Approval FC value.
3) Although the new standards draft is not differentiating between automatic or manual models, it provides 3-5% reduction in fuel consumption for passenger cars with three seat rows and above.
4) In advancing the adoption of new-energy and energy-saving vehicles, production or import volumes are encouraged to be gradually reduced. However, power conversion solutions designed for diesel and gasoline passenger cars are not addressed in the new standards draft.
5) In advancing the adoption of new-energy and energy-saving vehicles, each unit produced is equivalent to more units using a gradually decreasing multiplier over the standard period, as detailed in **Table 4**.
6) Continuing the vehicle fuel consumption target value incorporation plan, getting the CAFC requirements stricter every year, reaching the requirements of CAFC target by

[14] 《乘用车燃料消耗量限值》 http://www.miit.gov.cn/n11293472/n11293832/n11293907/n11368223/n16423595.files/n16423009.pdf

[15] 《乘用车燃料消耗量评价方法及指标》 http://www.miit.gov.cn/n11293472/n11293832/n11293907/n11368223/n16423595.files/n16423010.pdf

2020, as shown in **Table 5**.

Table 5: CAFC target value incorporation plan in the Phase IV

Year	Required ratio ($CAFC/T_{CAFC\text{-}IV}$)
2016	**134%**
2017	**128%**
2018	**120%**
2019	**110%**
2020	**100%**

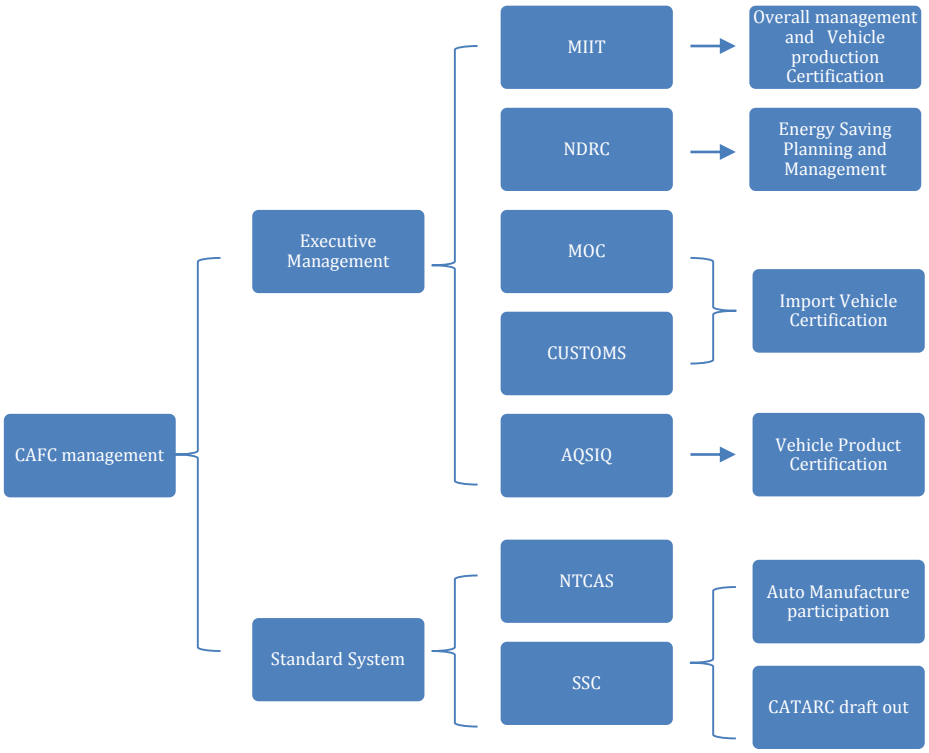
1.2. China's Fuel Consumption Management Framework

1.2.1. Institutional management

Currently, China's average corporate fuel consumption standard implementation for passenger car is jointly governed by several ministries: Ministry of Industry and information Technology (MIIT), the National Development and Reform Commission (NDRC), Ministry of Commerce (MOFCOM), General Administration of Customs, and the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), as illustrated in **Figure 4**. MIIT governs motor vehicles verification, such as domestic manufacturers' fuel consumption and manufacturing volume. The Customs Administration, AQSIQ, and MOFCOM are responsible for imported passenger car fuel consumption, import volumes, and importing entities verification, while NDRC is mainly responsible for the planning the dissemination and development of energy-saving and new energy cars.

The standards are co-published by the AQSIQ and the National Standards Committee (SSC), managed by the National Automotive Standardization Technical Committee supported by the China Automotive Technology and Research Center (CATARC).

Figure 4: Management organizations of China passenger cars fuel consumption



1.2.2. Governance methods

In order to improve vehicle management and in accordance with the 2012 "State Council's energy-saving and new energy automotive industry development plan (2012-2020)," a joint-ministerial effort comprised of the Ministry of Industry and Information Technology (MIIT), the National Development and Reform Commission (NDRC), the Ministry of Commerce (MOFCOM), and Customs General Administration (AQSIQ) developed an "Accounting Approach for Passenger Vehicle Corporate Average Fuel Consumption."[16] The accounting approach was announced in March 2013 and came into effect on May 1, 2013.

China's new accounting approach sets forth the following binding industry reporting requirements: vehicle manufacturers are obliged to report the Ministry of Industry and Information technology (MIIT) on their expected calendar year corporate annual average fuel consumption by December 20th of each year. By August 1st of each calendar year, the first year-half actual average corporate fuel consumption results should be reported; and by February 1st of each calendar year, the actual corporate average fuel consumption of the previous year should be reported. The approach does not specify penalties in case of lack of, inadequate, or false reporting, nor does it provide specific enforcement measurements. Auto companies that fail to provide inadequate reporting are subject to legal procedures as stated by the court of law. The enforcement authority is not specified.

[16] http://chinaafc.miit.gov.cn/n2257/n2783/c86525/content.html

Although management is rather toothless, joint ministerial efforts are being made for pulling compliance through 'shaming' methods using administrative tools instead of legal methods. On May 5, 2014, the MIIT published for the first time a list of auto manufacturers' average corporate fuel consumption scores for the year 2013.[17] On October 10, 2014, MIIT announced the "Strengthening of corporation passenger cars average fuel consumption management" method, which includes a series of reactions to non-compliance: publicizing FC results and gap from the standards' requirements, suspension of production, refusing government fund for supporting investment projects, strengthening of supervision over importation customs clearance, and inclusion of fuel consumption in the mandatory car production approval certification. The former statement includes the following procedure: by March 20th of each year, MIIT announces the CAFC calculation results and allows for comments; by June 1st of each year, five ministries jointly announce the final FC results of models and corporate average level through MIIT's fuel economy website (the results of 2014 were posted on the official website on June 12, 2015[18]).

1.3. International Comparison

1.3.1. Goals and implementation comparison

In the EU and the US, active measures for promoting the development of a national and regional automobile energy saving technologies are widespread. A new round of annual passenger car fuel consumption standards and regulations for 2020 and beyond was recently completed, posing stricter requirements on vehicle fuel consumption and its corresponding CO_2 emissions, as shown in **Table 6**.

Among these efforts, in 2009, the EU replaced the voluntary CO_2 emission reduction agreement with a mandatory system, simultaneously promoting vehicle fuel consumption and CO_2 emission limit requirements as well as labeling system. The announced 2015 target of CO_2 emissions is 130g/km (equivalent to 5.6 L/100km[19]) and the 2021 target is 95g/km (equivalent to 4.1L/100km).

Japan announced that its light-duty vehicles (LDVs) fuel economy target is 16.8km/L (6.1 L/100km) and 20.3km/L (5.2 L/100km) by 2015 and 2020 respectively.

In April 2010 and August 2012, the US released its LDV fuel economy and greenhouse gas (GHG) emissions requirements for 2012-2016 (phase I) and 2017-2025 (phase II), aiming at an average FC of 54.5mpg (4.3L/100km) and 56.2 mpg (4.2L/100km) for passenger cars by 2025.[20]

China's 2015 and 2020 targets are 6.9L/100km and 5L/100km respectively. In May 2015, the "Made in China 2025" plan proposed an overall passenger car fuel consumption target of 4L/100km by 2025.**Error! Bookmark not defined.**

[17] http://www.miit.gov.cn/n11293472/n11293832/n12845605/n13916913/15988846.html
[18] 关于 2014 年度中国乘用车企业平均燃料消耗量核算情况的公告.
http://www.miit.gov.cn/n11293472/n11293832/n12845605/n13916898/16646631.html
[19] In this paper, the fuel consumption (L/100km) is based on or transformed into the level under the EU's NEDC operating conditions.
[20] U.S. fuel economy target values include passenger cars and some light commercial vehicles.

Table 6: Comparison on FC standard targets of main countries and regions

Countries and regimes	2015		2020		2025	
	Target Requirement	NEDC operating conditions (L/100km*)	Target Requirement	NEDC operating conditions (L/100km*)	Target Requirement	NEDC operating conditions (L/100km*)
EU	130g/km	**5.6**	95g/km	**4.1**	N/A	**N/A**
US	36.2 mpg	**6.8**	44.8 mpg	**5.4**	56.2mpg	4.2
Japan	16.8km/L	**6.1**	20.3km/L	**5.2**	N/A	**N/A**
China	6.9L/100km	**6.9**	5.0L/100km	**5.0**	4.0L/100km**	4.0

* Converting the fuel economy level of various countries and regions into the value based on the EU NEDC operating level through ICCT conversion tool,[21] and the results are slightly different from that of "the interpretation of the passenger car fuel consumption in the Phase IV" published by MIIT[22] due to differences in factors used.

** The goal of 4.0L/100km was proposed for the first time in "China made 2025" plan.

Due to various test conditions of fuel consumption values and the various measurement units in different countries, this report utilizes the EU operating conditions (NEDC) and the value unit of L/100km, which are also used in China. Over the past ten years, various countries have improved vehicle fuel economy. In 2013, the United States passenger car fuel consumption reached 35.2MPG (about 7L/100km),[23] while Japan reached 127km/L (about 5.1L/100km),[24] the EU reached 127gCO_2/km (about 5.4L/100km), and China reached 7.22L/100km. By 2014, China reached 7.12L/km as marked in **Figure 5**.[25]

[21] ICCT. Converting Tool. http://www.theicct.org/info-tools/global-passenger-vehicle-standards. 2015.07.01

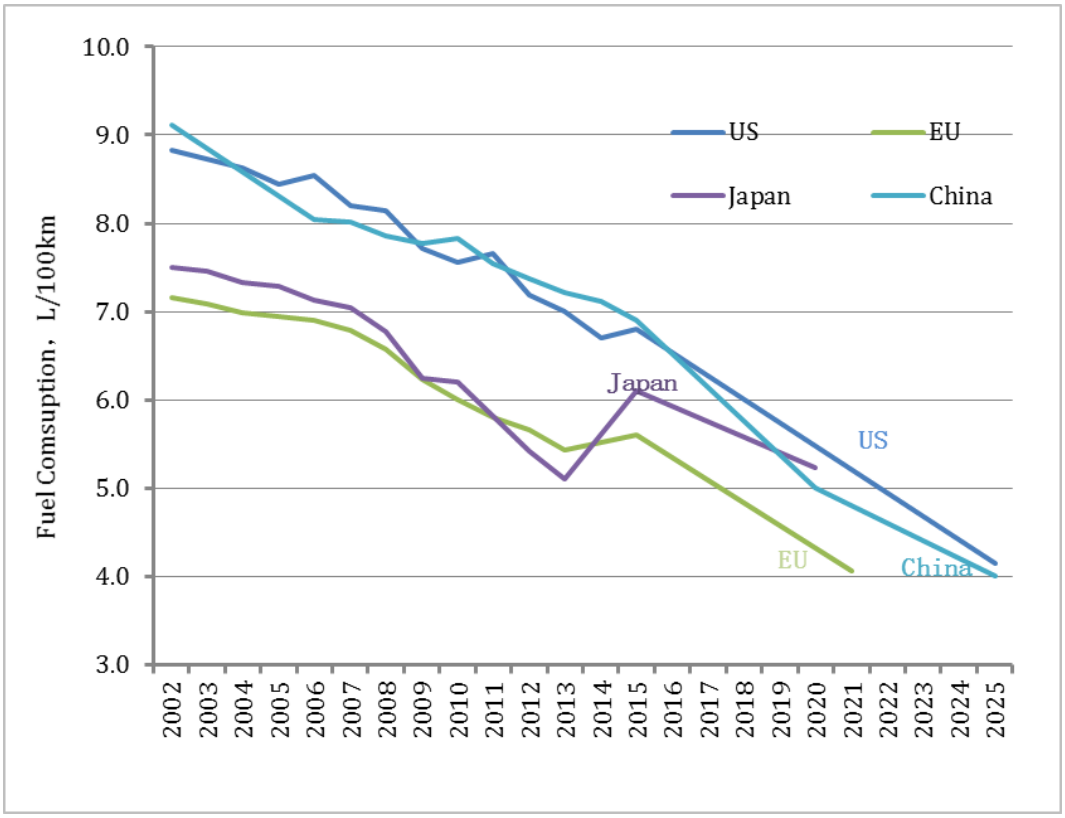
[22] "The interpretation of the passenger car fuel consumption in the fourth phase". http://www.miit.gov.cn/n11293472/n11293832/n11294042/n11481465/16423221.html

[23] US-EPA. Light-Duty Automotive Technology, Carbon Dioxide Emissions and Fuel Economy Trends Report :1975 Through 2014. 2014.10

[24] Japan Automobile Monthly Survey. 2014.05

[25] 2014 China passenger car enterprises CAFC accounting annual announcement. http://www.miit.gov.cn/n11293472/n11293832/n12845605/n13916898/16646631.html

Figure 5: Passenger car actual FC comparisons – China and abroad



Note: Converting the fuel economy level of various countries and regimes into the value based on the EU NEDC operating conditions by using the ICCT conversion tool (L/100km).

1.3.2. Comparison on management approach

All markets, besides China, manage their fuel consumption standard through penalties, as summarized in Table 8. Financial penalties are generally higher than the cost of technology integration. In the EU, for example, the penalty for the first 1 g/km exceeding the target value is 95 Euros/per vehicle, while the marginal cost of 1 g CO_2 per kilometer emissions reduction for most of fleet is about 25 euros, meaning that the penalty was set much higher than cost for technology improvement, encouraging manufactures to enhance their technology in order to meet the standard. In addition, several non-financial means are adopted, including product type certification and public shaming.

China's corporate average fuel consumption management model is mainly imitating the United States' model, enabling implementation flexibility and utilizing administrative penalties rather than financial ones, due to lack of an adequate management mechanism.

Table 7: Regional FC management approach comparison

Countries and Regions	Financial Penalty	Revoking product type certification, limit or stop production	Public shaming
US	√	√	
EU	√		
Japan	√		√
China		√	√

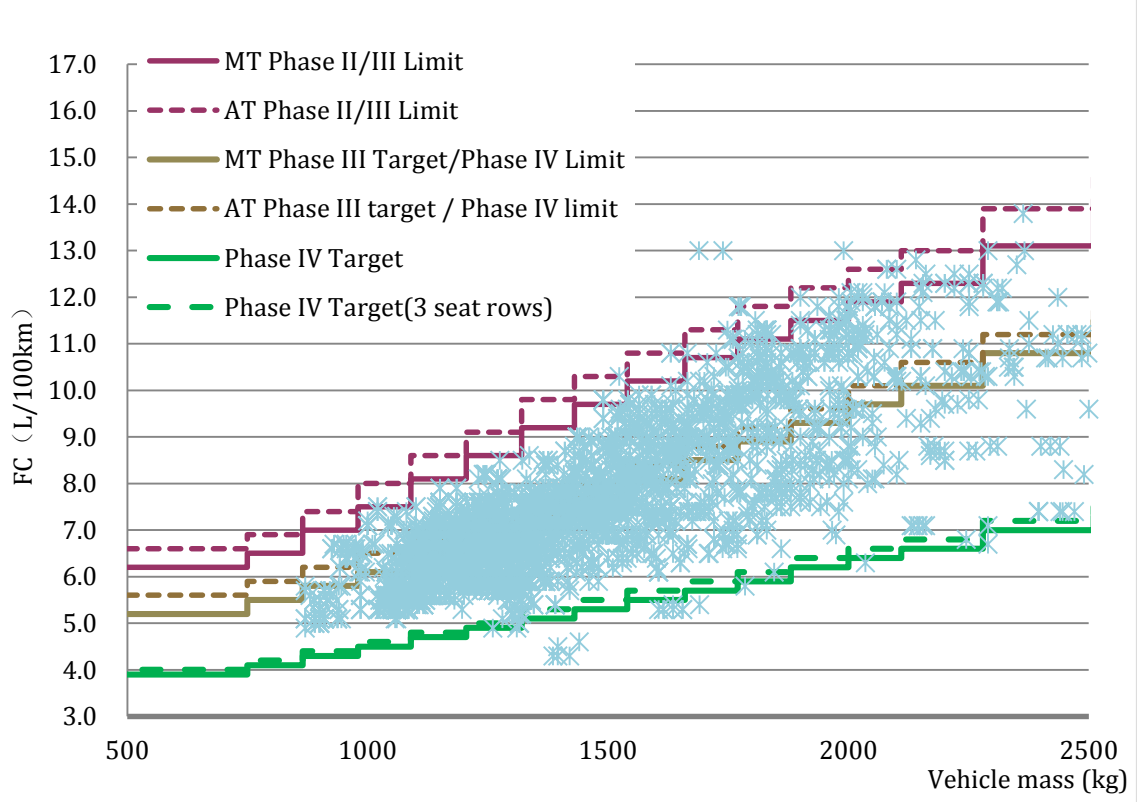
2. 2014 CAFC Overview

2.1. 2014 Vehicle fuel consumption distribution

In 2014, The MIIT's China Auto Fuel Consumption Website published a total of 4,784 light vehicle models' fuel consumption data, including 3,319 passenger car models (class M1) and 418 imported models,[26] as shown in **Figure 6**.

It can be seen that in 2014 China's passenger car fuel consumption was mostly spread between the limits of Phases II and III and the target value of Phase IV. 74.3% of models reached the Phase IV limit (equivalent to Phase III target value), a significant decrease compared to 2013 FC values.[27] The fuel consumption of several hybrid vehicle models (for example: the Toyota Camry, Prius and Lexus CT200h, Land Rover), electric vehicle models (such as BYD Qin, Chuan Qi hybrid, etc.), as well as some diesel cars (such as the BMW X5) can meet phase IV requirements. In 2014, only 4 imported cars did not meet their FC requirement, again, a significant improvement from last year.[28]

Figure 6: FC distribution of China's 2014 new passenger car models



[26] China Auto Fuel Consumption Website. http://chinaafc.miit.gov.cn/index.html
[27] In 2013, about 50% of models reached the fourth phase's limit (the target value of the third phase)
[28] In 2013, 10% of models did not reach the limit standards of the 2nd and Phase III, mainly the middle and large luxury car, SUV and sports car of high quality range.

2.2 Domestic passenger car auto companies

2.2.1 2014 CAFC of domestic auto companies

In June 2015, MIIT published the 2014 corporate average fuel consumption (CAFC) results of 88 domestic passenger car companies,[29] covering 19.01 million passenger cars. Independent brands accounted for 28% of the CAFC list while joint ventures (JVs) accounted for the remaining 72%. 27 companies failed to meet the annual corporate average limit,[30] however their vehicle production accounted for less than 5%.

Domestic CAFC reached 7.12L/100km (excluding new energy vehicles), marking a reduction of 1.4% from 2013. JVs average CAFC was 7.10L/100km, down 2.8% while independent brand CAFC was 7.15L/100km, an increase of 2.9% from the previous year. In 2014, the ratio of actual value of CAFC to target value was 96.1%, falling by 2% compared to 2013. If new energy vehicles (NEVs) were included, domestic passenger car CAFC could have reached 7L/100km, very close to the 2015 target of 6.9L/100km (0.2L/100km reduction).

In 2014, the target value of CAFC increased slightly, especially the target value of independent auto companies, which increased by 4% from 2013 levels. Independent and joint venture auto companies have both reached a CAFC/T_{CAFC} of below 100%, far below the annual target of 103%, as shown in **Table 8**. In 2014, the average curb weight of domestic vehicle was 1340kg, an increase of 13 kg from last year.

Table 8: The actual value and target value of China passenger car CAFC in 2014

Auto company type	CAFC target value (year-on-year) L/100km	CAFC actual value (year-on-year) L/100km	Ratio of actual value to target value CAFC/T_{CAFC}
Joint Ventures (JVs)[31]	7.40 (-0.8%)	7.10 (-2.8%)	**96.0%**
Independent[32]	7.29 (+4.0%)	7.15 (+2.9%)	**98.0%**
Total Domestic	7.40 (+0.7%)	7.12 (-1.4%)	**96.1%**

At the 2014 Top 3 CAFC performing domestic companies were Changan Suzuki, Geely Automobile, and BYD Auto, which achieved a CAFC of 5.77 L/100km, 5.16 L/100km, and 6.24 L/100km respectively.[33] These auto companies' production is focused on small cars with

[29] MIIT. Annual announcement on the declared average fuel consumption (CAFC) of passenger car companies in 2014. http://www.miit.gov.cn/n11293472/n11293832/n12845605/n13916898/16646631.html

[30] The standard value in 2014 was 103% of the target value of the Phase III.

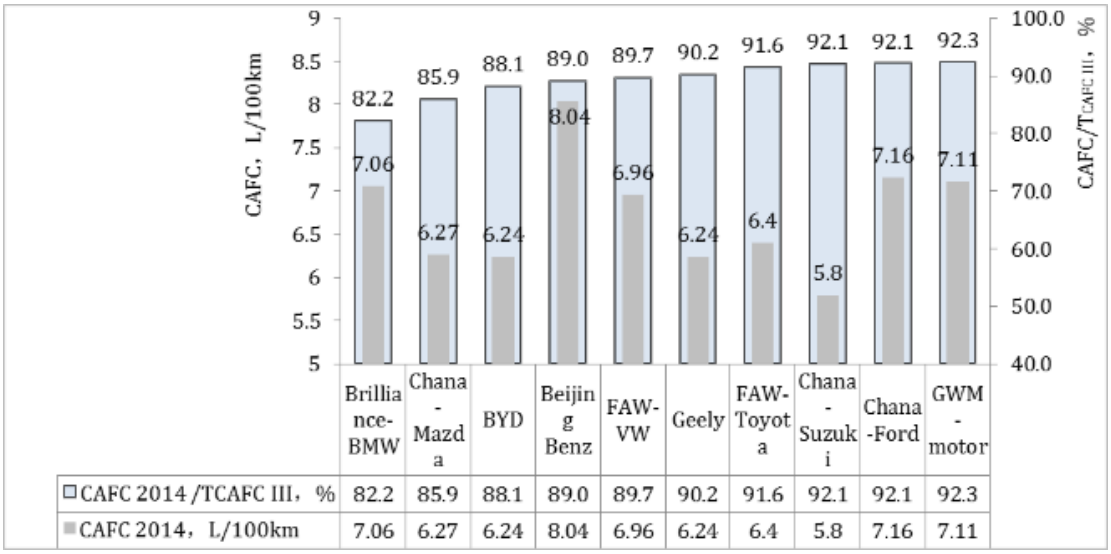
[31] The auto companies jointly funded by the Chinese side and the foreign side and producing locally manufactured foreign brands. If a corporation produces both joint venture cars and independent cars, it is considered as a joint venture.

[32] The corporation only funded by Chinese side and using Chinese brands.

[33] The ranking only takes those corporations with annual passenger car production more than 100000, the same below.

small displacement and low fuel consumption, naturally prone to low FC values.

Figure 7: 2014 CAFC Top performing domestic auto companies



All auto companies with annual production exceeding 100,000 cars reached the standard target, except for three auto companies: FAW Group, Beiqi Silver Cheung, and Guangzhou Automobile. The 2014 Top 3 CAFC/T_{CAFC} performing domestic auto manufacturers were BMW, Mazda, Changan and BYD, with CAFC/T_{CAFC} of 82.2%, 85.9%, and 88.1% respectively. Independent brands (BYD, Geely, Great Wall) were among the Top 10, as illustrated in **Figure 7**.

It can be observed that domestic auto companies with relatively good CAFC performances have been performing well during the past three years. Auto companies not reaching the standards are conducting technology upgrades and reducing the average fuel consumption of enterprises more quickly than other auto companies.

2.2.2 2014 CAFÉ credits of domestic auto companies

The "Accounting methods of corporate average fuel consumption of passenger cars" released by MIIT in March 2013 states CAFC credits would be incorporated into the fuel consumption management system. At present, the China Automotive Technology and Research Center (CATARC) is studying pathways for CAFC credits management; however no recommendations have been made public yet. A coalition of experts for CAFC credits consultation has been formed[34].

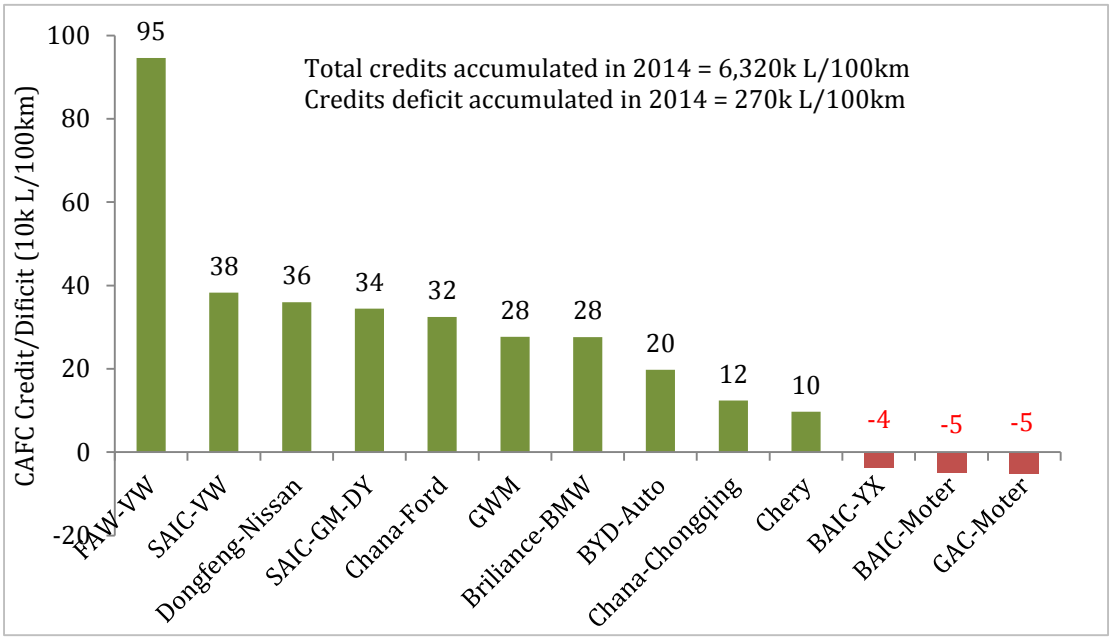
In 2014, 49 companies received credits for exceeding the annual target (a total of 6.32 million L/100km), marking an increase of 59% from last year. Among them, 25 joint ventures produces 5.127 million L/100km, accounting for 63% of the total, and independent auto

[34] CATARC Information Center Division is leading this research task under MIIT; http://www.catarc.info/

companies achieved 1.194 million L/100km, accounting for 37%. 15 companies produced credits of over 100000 L/100km. 2014 Top 3 CAFÉ-credits performing auto companies were FAW Volkswagen, Shanghai Volkswagen, Changan, Ford, with 1.453 million, 720k, and 457k L/100km respectively, as illustrated in **Figure 8**.

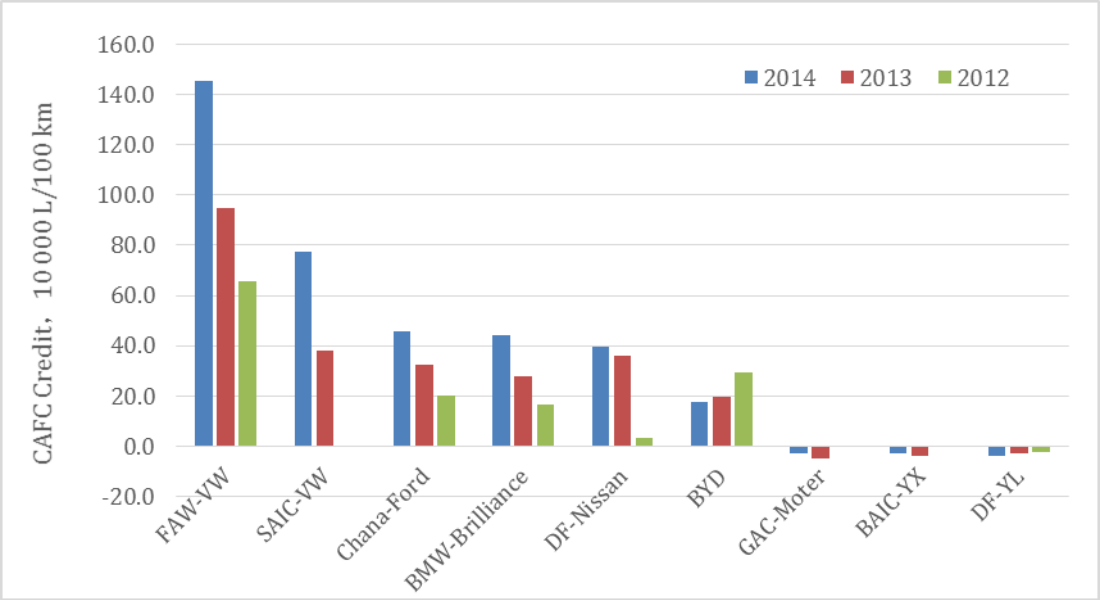
27 auto companies that have not complied with the standard received an accumulated credits shortage of 270,000L/100km, a decrease of 40,000L/km from last year. Among these auto companies, joint ventures produced 56,000L/100km, and independent auto companies produced 215,000L/100km. By-company deficit was less than 50k L/100km.

Figure 8: 2014 domestic auto companies' CAFÉ credits assessment



During the past three years (2012-2014), a total of 12.14 million L/100km credits have been produced (supply of credits), while total credits shortage was only 780000 L/100km (demand for credits). Credits supply is therefore exceeding credits demand, and is generally confined to a limited number of supply and demand companies. Therefore, the cost of credits is not likely to be significant under free market conditions and result in little impact to implement the relatively costly technology improvement. It is highly suggested that the cost of technology integration would be taken into consideration before determining credits value and a transfer and transaction mechanism.

Figure 9: 2012-2014 key domestic credits supply and demand companies



Between 2012 and 2014, domestic auto companies showed steady improvement in their CAFC/T_{CAFC} performance (except for BYD). Credits demand is dominated by key companies, such as GAC, BAIC YinXiang, Dongfeng YuLong, as illustrated in **Figure 9**.

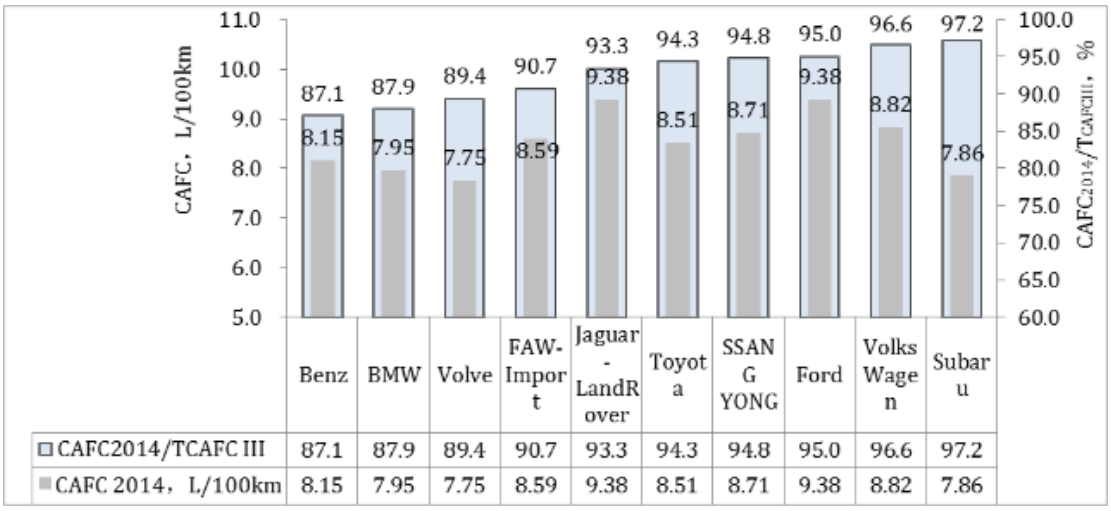
2.3 Importing auto companies

2.3.1 2014 CAFC of importing auto companies

In June 2015, MIIT announced the annual CAFC values of 28 passenger car importing auto companies, shown in **Figure 11**. The average CAFC value of importing auto companies was 8.76L/100km, 24.3% higher than that of domestic auto companies, but the gap between the two was reduced. The average CAFC fell by 3.2% from 2013, a greater decrease than that of domestic auto companies.

In 2014, the average CAFC target value of imported auto companies was 9.20L/100km, similar to that of 2013, and the average ratio of CAFC/T_{CAFC} was 95.2%, down 4% from 2013. 17 companies met the target value requirements and 11 failed to achieve the target. In 2014, among importing auto companies with annual sales exceeding 10,000, the 3 lowest credit gainers were Volvo, Subaru, and BMW, with 7.74L/100km, 7.86L/100km, 7.95L/100km respectively. Top performing importing auto companies were Mercedes Benz, BMW and Volvo, all below 90%, as shown in **Figure 10**.

Figure 10: 2014 actual CAFC of major importing auto companies

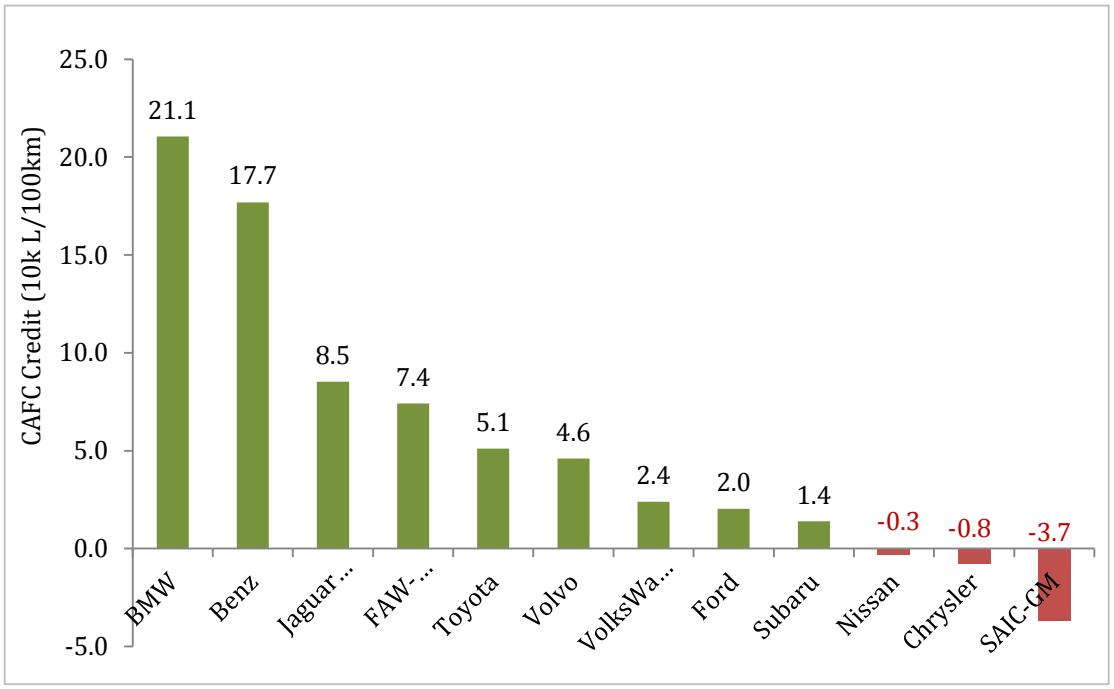


In recent years, importing auto companies steadily decreased their average engine displacement and improved their FC performance. According to "The strengthening of passenger car corporate average fuel consumption quantity management" released by MIIT in October 2014, stated penalties related to importing auto manufacturers focus on customs audit and imports inspection, translating to weak enforcement tools. This, as well as the relative low penalty as oppose to the vehicle sales margin, may explain the minor improvement of luxury importing auto companies.

2.3.2 2014 CAFÉ Credits of importing auto companies

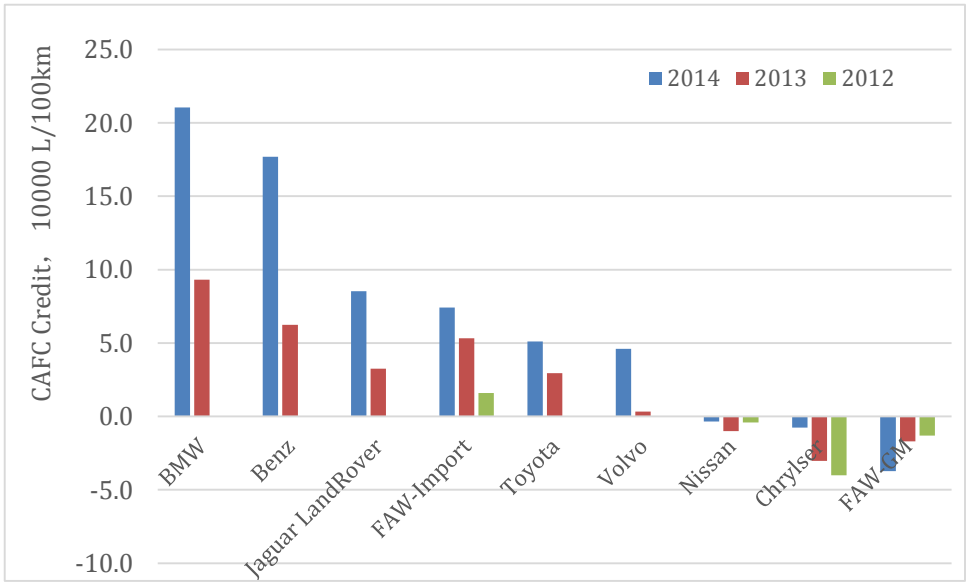
12 importing auto companies achieved the target value and accumulated a total of 704,000L/100km credits (credits supply), which is 2.3 times of 2013 value. Top performing were BMW (China) Auto Trade Co., Ltd., and Mercedes - Benz (China) Auto Sales Co., Ltd., which earned 177,000, 85,000, and 211,000 credit respectively. 17 companies failed to meet the target value in were in shortage of 57,000L/100km credits, as illustrated in **Figure 11**.

Figure 11: 2014 CAFE credits of importing auto companies



Between 2012 and 2014, a total of 1.026 million L/100km credits been produced by importing auto companies, while the shortage in credits was 220k L/100km. As demonstrated in **Figure 12**, BMW, Mercedes Benz, and Jaguar Land Rover led credits supply while Nissan, Chrysler, and SAIC GM led the demand for credits.

Figure 12: 2012-2014 key importing companies' credits supply and demand

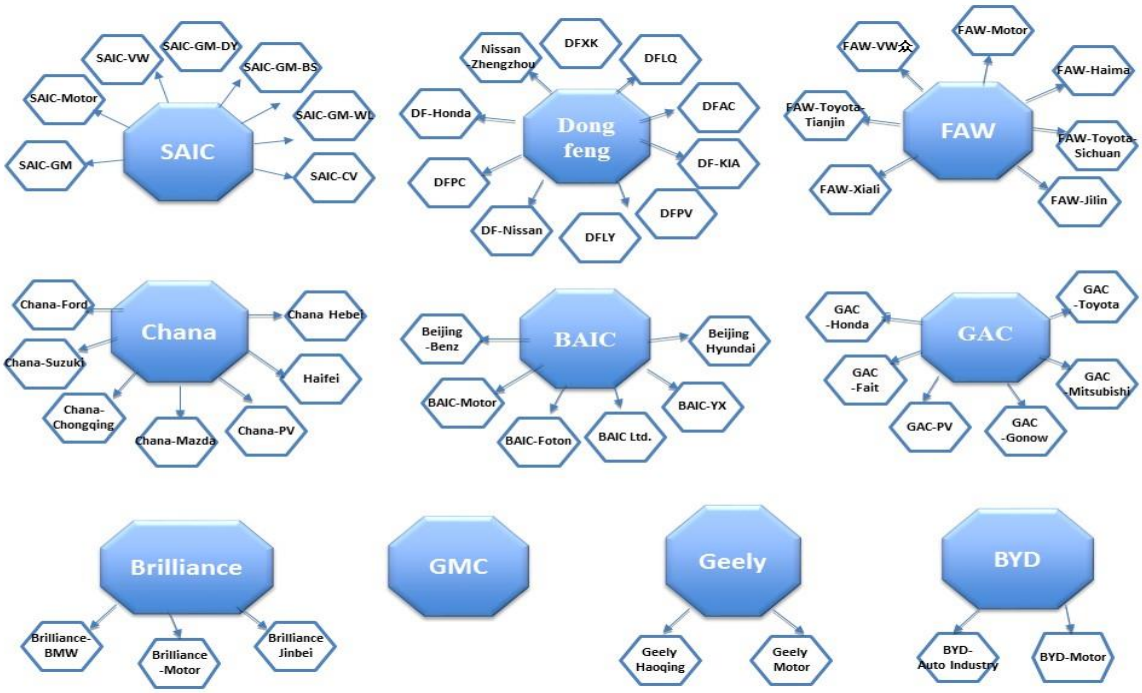


2.4 China's Top 10 automotive groups

2.4.2 Top 10 auto-groups structure

In addition to the CAFC analysis on passenger car enterprises and imported car dealers, this chapter will be accounting CAFC of China's top ten auto group; the group accounting refers to the organization structure as shown in Figure 13, including 52 independent companies.

Figure 13: China's Top 10 Automotive Groups



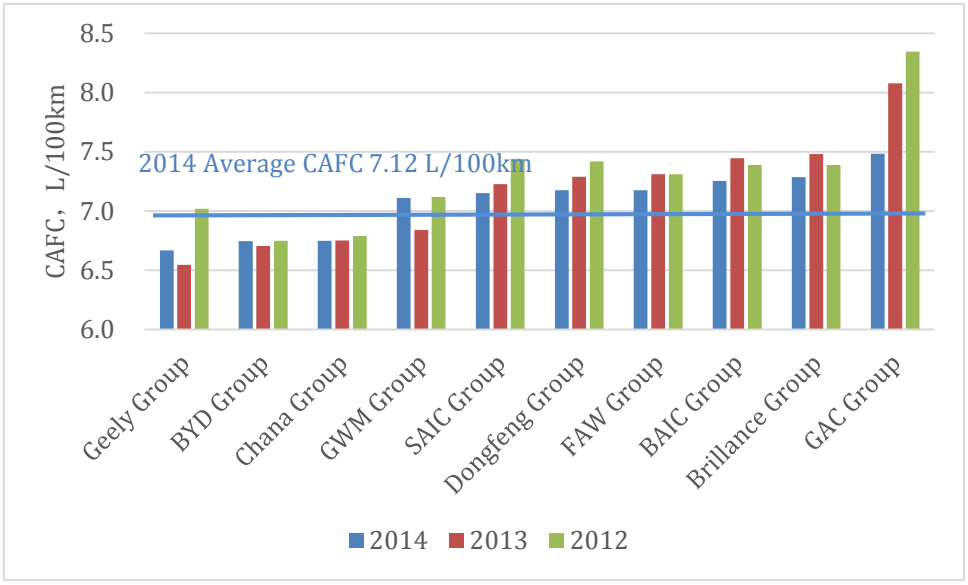
2.4.3 2014 Corporate CAFC

Passenger cars production of the Top 10 automobile groups accounts for about 94% of the China's total passenger car production. If taking the automobile groups as the fuel consumption standard accounting subject, China's 2014 CAFC will be about 8.0L/100km. The CAFC of Geely Automobile Group, BYD automobile group, and Changan Automotive Group is ranked best performing, with 6.67L/100km, 6.75L/100km and 6.75L/100km respectively, slightly higher than their 2013 CAFC as shown in Figure 14.

Between 2012 and 2014,[35] the Top 10 CAFC automobile groups except GreatWall all had varying degrees of; the largest decline was in Guangzhou Automobile Group, about 0.86 L/100km.

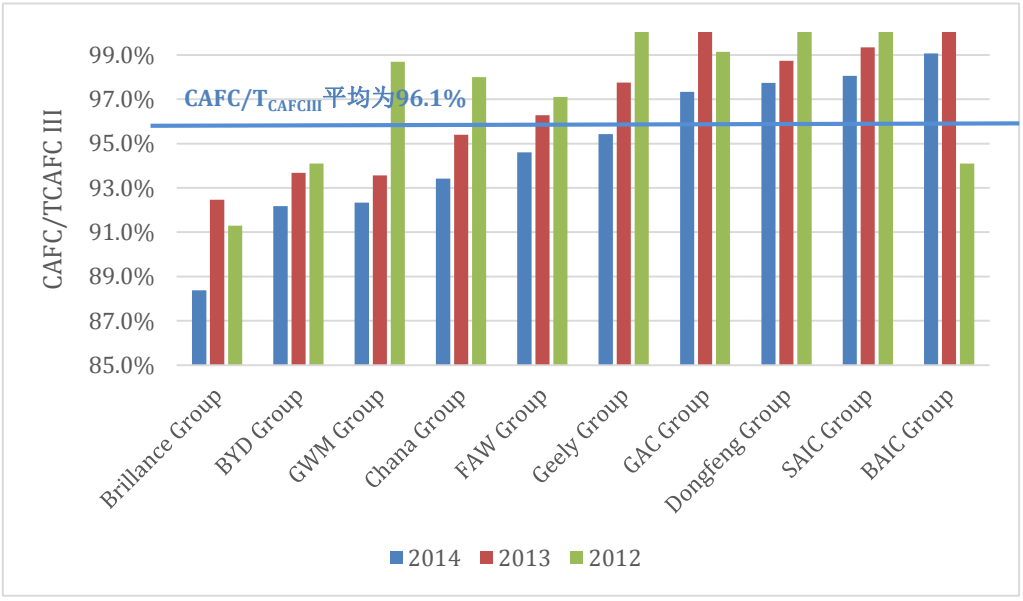
[35] In order to maintain the comparability of results, the calculation were all based on the data announced by MIIT, and the data for 2012 only include the data for the second half of 2012.

Figure 14: 2012-2014 CAFC of China's Top 10 automobile groups



During 2012-2014, the CAFC actual values and target values of those groups have both improved[36]. Brilliance Auto, BYD, and GreatWall, performed best in terms of their CAFC/T_{CAFC} score, as shown in **Figure 15**.

Figure 15: 2012-2014 actual vs. target CAFC of China's Top 10 automobile groups



[36] In order to maintain the comparability of results, the calculation were all based on the data announced by MIIT, and the data for 2012 only include the data for the second half of 2012.

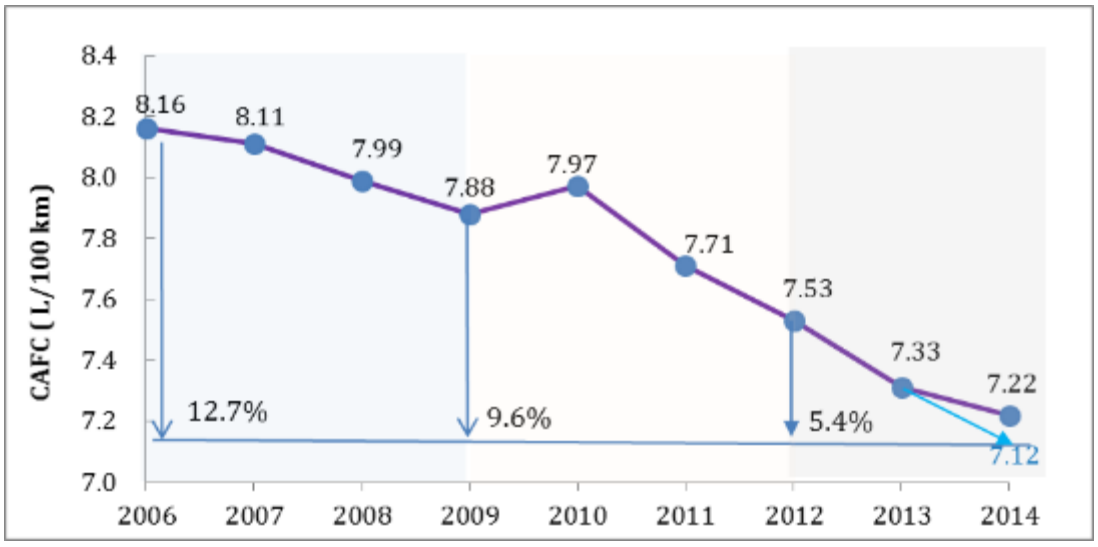
3 Developing trends and technical analysis of CAFC

3.1 Developing trends

3.1.2 National level

According to the *i*CET's China's Passenger Car Fuel Consumption Annual Report of 2014, during the 11th FYP period (2006-2010), the decline of average fuel consumption of passenger cars was not obvious, and the average annual decline rate was less than 1.7%. Since 2010, with the implementation of Phase II of the national fuel economy standard, significant CAFC improvements have been observed. Between 2010 and 2013, the annual improvement rate was of about 3%, getting closer to the periodic target. Should NEVs have been taking into account, the annual improvement in between 2013 and 2014 would double from 1.4% to about 2.8%.

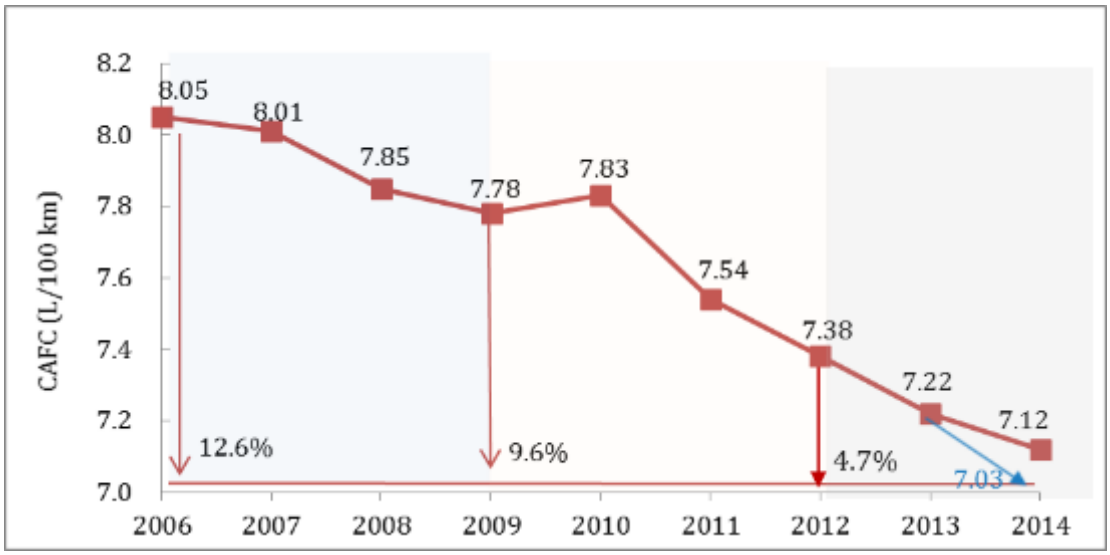
Figure 16: 2006-2014 China passenger car CAFC trends



3.1.2 Domestic auto companies

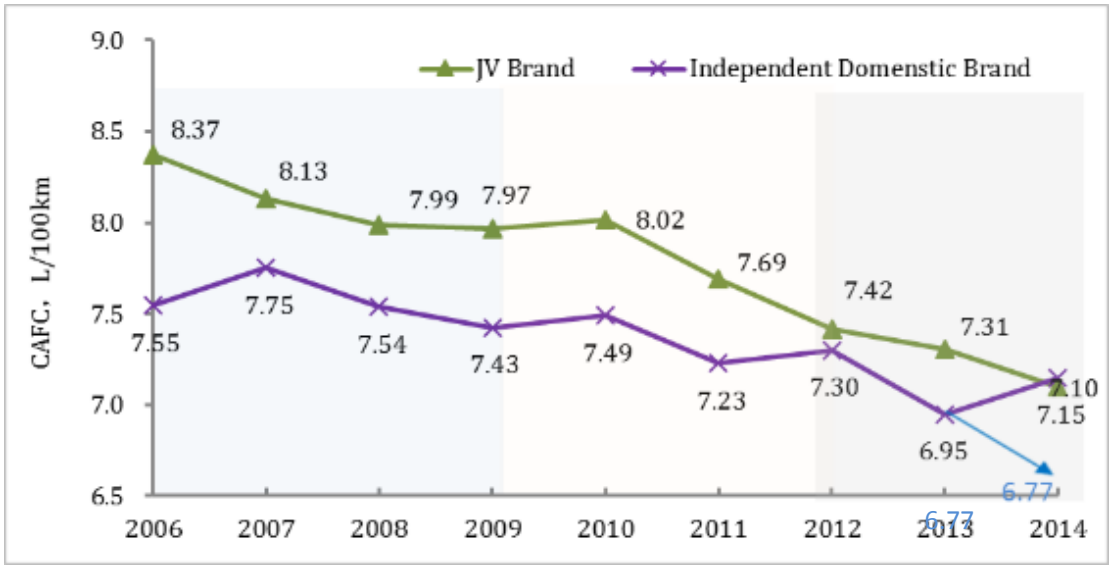
The CAFC level of domestic passenger car companies is very similar to the national level, as shown in Figure 17. Domestic auto companies' CAFC improved very quickly from 8.02L/100km in 2010 to 7.10L/100km in 2014 (average annual improvement of nearly 3%). However the CAFC trends of independent and joint venture auto companies vary, as illustrated in Figure 18.

Figure 17: 2006-2014 domestic passenger cars CAFC trends



Between 2006 and 2014, joint venture CAFC improved from 8.37L/100km to 7.10L/100km, marking an average annual decline rate of 2%. Influenced by Phase II of the standard, JVs' CAFC improved rapidly, by 7.5% between 2011 and 2012. Since 2012, amid the high FC performance relative to the target, CAFC improvement rate slowed down. While proven to have the capacity to perform, JVs are sensitive to national economic standards and policies, as demonstrated here. In 2014, new energy vehicles had no effect on joint venture CAFC.

Figure 18: 2006-2014 joint venture and independent auto companies' trends



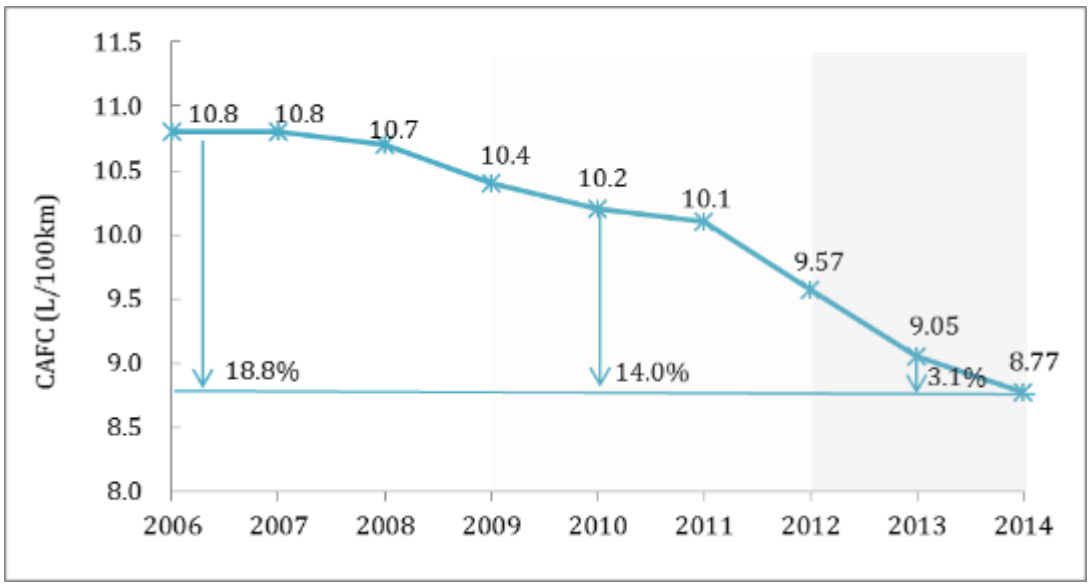
Independent auto companies mainly produce small cars and mini cars, therefore their CAFC benchmark is relatively good. In 2006, the average fuel consumption of independent auto companies producing passenger cars was only 7.55L/100km. However, due to a late start and weak technological capacities, reaching the target is still a challenge. Between 2006 and 2014, the average fuel consumption of independent auto companies improved from 7.55 L/100km to 7.01L/100km, 1% annual reduction on average. In 2014, independent auto

companies produced more than 50,000 new energy vehicles, which led to a CAFC decline of 2.6%. If excluding NEVs, CAFC in 2014 would have increased compared to 2013. It can be observed that the overall fuel consumption of independent auto companies is sensitive to policy yet reacts to new standard more slowly than joint venture companies. With the "Made in China 2025" plan proposed, independent brand enterprises are expected to gradually develop medium and compact car production lines, which will increase their requirement for technology upgrades for meeting the standard.

3.1.3 Import auto companies

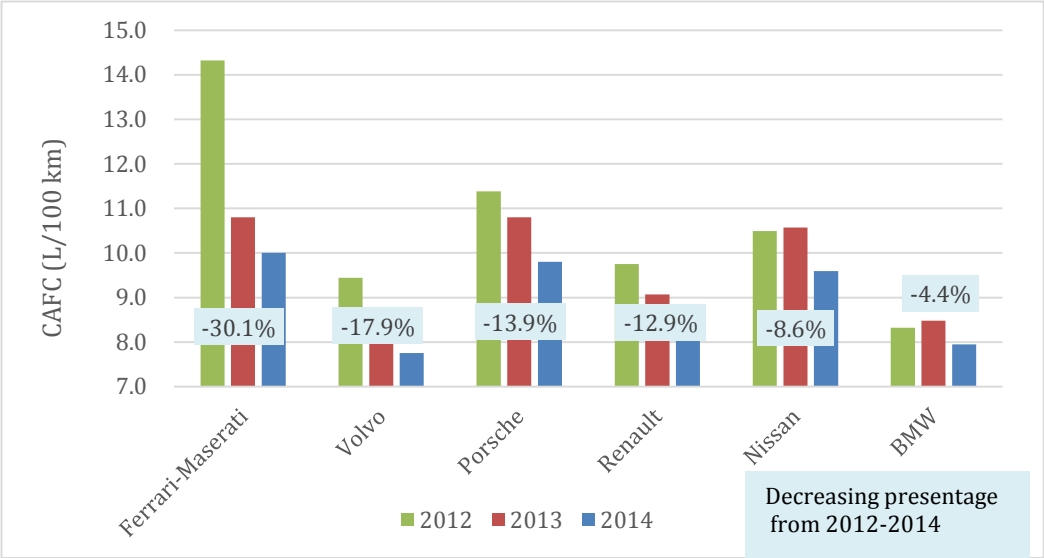
Imported cars are mainly luxury cars, sports cars, and SUV and large displacement and high fuel consumption models. Therefore, the overall CAFC level of imported cars is high, even before 2011, it maintained 10L/100km (Figure 23). However, the overall CAFC of imported cars has been declining since 2006. During 2006-2014, the average annual decline rate of imported car CAFC was about 2.6%, much higher than 1.4% of domestic car passenger car companies. In 2014, the imported car CAFC decreased by 3.1%, to 8.77 L/100km. Although the average fuel consumption of imported cars is high, compared to the domestic passenger car its annual import volume is so small that its effects on achieving national CAFC value target is not very significant.

Figure 19: 2006-2014 CAFC trends of imported auto companies



CAFC of import auto companies improved faster than that of domestic auto companies, among which sports car auto companies experienced the fastest improvement rate. Ferrari-Maserati CAFC fell by more than 30% from 14.3L/100km to 10L/100km, while Volvo and Porsche CAFC fell by 13.9% and 17.9% to 7.75L/100km 9.7L/100km respectively (Figure 20). The improvement of large luxury car was limited, therefore, imported auto companies seem to expand market shares of low-displacement vehicle while keeping their advantages in the high-end market in order to achieve the CAFC limits.

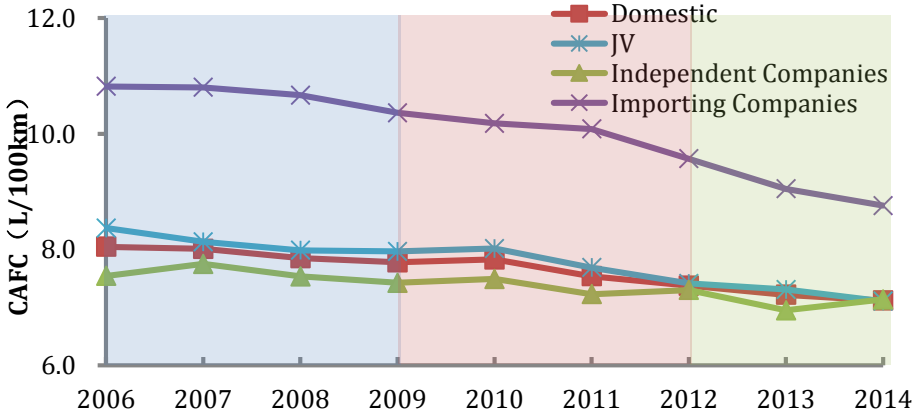
Figure 20: 2012-2014 CAFC trends of selected imported auto companies



3.1.4 Conclusions

The "Energy Saving and New Energy Vehicle Automotive Industry Development Plan" (2012-2020) stresses that an overall average fuel consumption target of 6.9L/100km by 2015 and 5L/100km by 2020 should be achieved. In order to achieve this goal, during 2006-2014, domestic (JVs and independent) and imported passenger car were required to improve their CAFC performance, as shown in **Figure 21**. Imported cars are mainly luxury car or sports car, whose average fuel consumption level is high. Their FC reduction pressure has been high in recent years, which may explain why their CAFC reduction was the fastest. The CAFC of joint ventures declined quickly and then slowed its reduction pace. Due to the increase in the curb weight of independent auto companies' vehicle fleet, their CAFC have actually increased. If existing fuel consumption improvement rate would maintain throughout the coming years, it would be difficult to achieve the CAFC goal of 5 L/100km by 2020.

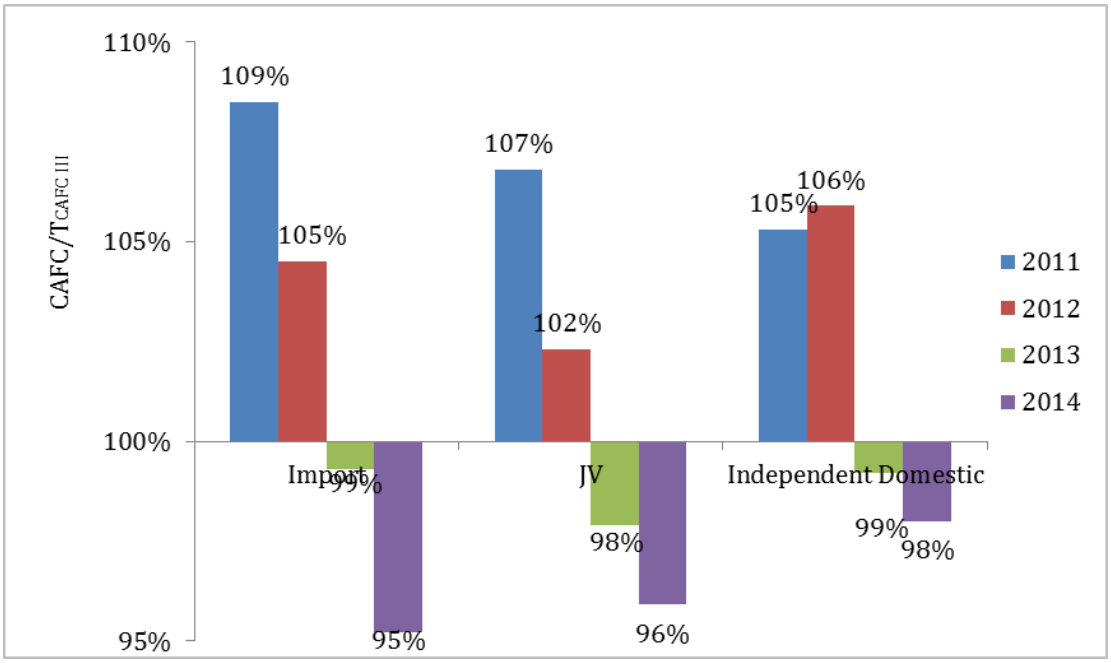
Figure 21: 2006-2014 CAFC trends of China auto companies by type



Note: Domestic companies are comprised of JV and independent brands.

The ratio of actual to target CAFC ($CAFC/T_{CAFC}$) is declining annually. Outstanding is the performance of importing auto companies that have achieved a 15% improvement in 3 years. While domestic auto companies have also dropped by nearly 10% during this period, there was no significant improvement in $CAFC/T_{CAFC}$ of domestic enterprises in 2014 (in NEVs were excluded, the improvement would be of 1.4%).

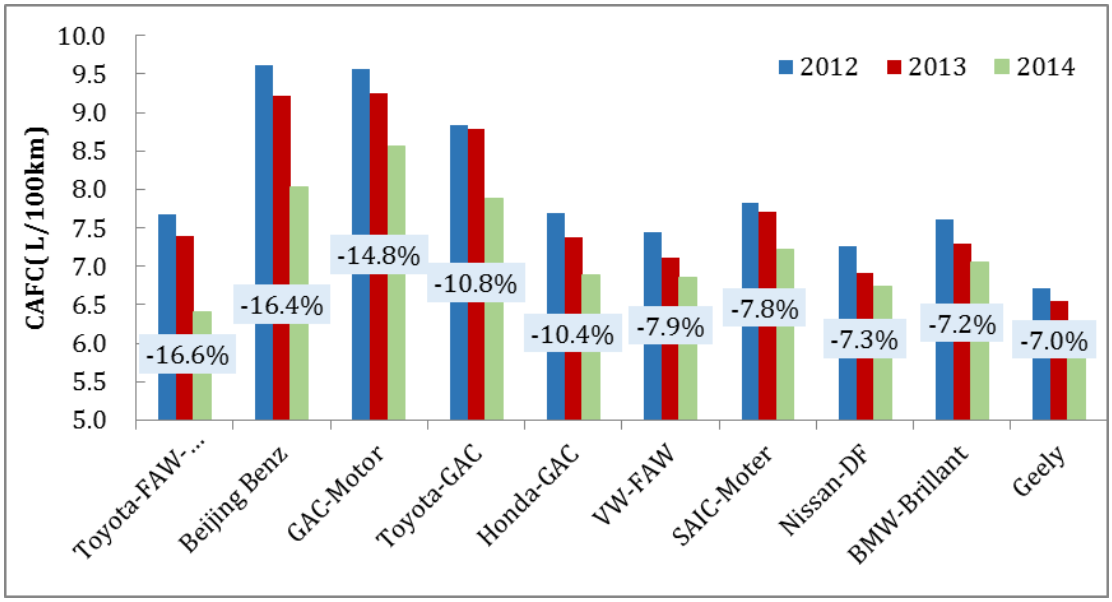
Figure 22: 2011-2014 $CAFC/T_{CAFC}$ trends by auto company type



3.2 Technical analysis of selected auto companies

Figure 23 shows the 10 auto companies that experienced the greatest CAFC improvement between 2012 and 2014. The Top five auto companies seem to have been faced with high pressure due to the production of high fuel consumption vehicles, especially since the implementation of Phase IV. Among these, the CAFC of Tianjin FAW Toyota saw a decline of 16.6%, and Beijing Benz saw a decline of 16.4%; their average annual decline exceeded 5%, far higher than the average decline level in the market. This high performance was enabled by the decrease of average fleet curb weight as well as fuel-saving technology integration.

Figure 23: 2012-2014 Top 10 performing auto companies in CAFC improvement



The auto companies that saw the largest CAFC decline between 2012 and 2014 are characterized by their large or middle luxury fleet composition. Amid pressures to meet Phase IV target going forward, this report attempts to assess the impact of fleet composition and technology integration towards meeting the new targets, which increases in stringency as it approaches 2020.

1# Tianjin FAW Toyota: During 2012-2014, CAFC decreased by 1.27 L / 100km, with a decline of 16.6%;

In the past three years, Tianjin FAW Toyota has made great progress on decreasing body weight, with an average body weight reduction of 160kg. At the same time, the enterprise's product structure has been adjusted, and the displacements of models produced in 2014 were all below 3.0L, which helped to reduce overall fuel consumption. Some models use the advanced S-CVT gearbox energy-saving technologies, which can reduce fuel consumption by more than 7%. In 2014, Tianjin FAW Toyota launched Lang Shi electric car in the domestic market; although the production amount is small, it has shown the company's efforts in promoting energy saving.

2# Beijing Benz: During 2012-2014, CAFC decreased by 1.58 L / 100km, with a decline of 16.4%;

Over the past three years, the average curb weight decline of Beijing Benz has not been obvious. However, light-alloy wheels are commonly used in its models, which can significantly help reduce rolling resistance and improve fuel economy. The average engine capacity of Beijing Benz models decreased from 2.4L in 2012 to 2.2L in 2014, which also helps to reduce fuel consumption. The CAFC decline of Beijing Benz is largely due to the application of advanced drive technology and automation technology; both of these technologies significantly reduce the driving loss, improving the fuel economy.

3# Guangzhou Automobile passenger cars: During 2012-2014, CAFC decreased by 1.42 L / 100km, with a decline rate of 14.8%

From 2012 to 2014, the average curb weight of Guangzhou Automobile Group passenger cars dropped by 92 kg, and the average power was reduced by 12%, which helped reduce overall fuel consumption levels. In 2014, Chuan Chi launch the first new energy vehicles—the hybrid GA5—with one hundred kilometers' fuel consumption at only 2.4L, which had a large effect on pulling down the overall average fuel consumption level. In addition, two types of GA6 turbo models equipped with "1.8T + 7G-DCT" dynamic control portfolio, which just consume less than 7L of fuel after driving for one hundred kilometers, will be helpful to achieve corporation compliance objectives.

4# GAC TOYOTA: During 2012-2014, CAFC fell by 0.95L/100km, with a decline rate of 10.8%

From 2012 to 2014, the average curb weight of GAC Toyota models decreased greatly, by 120kg, and the engine displacement was also reduced from 2.3L to 2.0L, significantly reducing fuel consumption level of the entire enterprise. Toyota also had excellent performance in the engine energy-saving technology; for example, models of the Zhi Xuan series adopted the 4NR type engine, making its fuel consumption fall to 5.4 L/100km. In the past two years, the expansion of the hybrid Camry market has greatly pulled down corporate average fuel consumption. In 2015, Toyota will launch four hybrid models, so its CAFC is expected to achieve a substantial reduction.

5# Honda: During 2012-2014, CAFC fell by 0.8L/100km, with a decline rate of 10.4%

Honda has outstanding performance in controlling fuel economy, and in 2014 the enterprise CAFC reached 6.89L/100km, achieving the target of Phase III early. In the past three years, Honda has only made little changes to average curb weight, power and displacement, but the application of advanced technology still has greatly reduced the corporate average fuel consumption values. The Fit III, launched in 2014, is equipped with the new 1.5L 4-cylinder DOHC i-vtec gasoline engine and CVT, using a high-intensity conveyor belt, making the speed ratio wider and leading to a decline of 1.5L/100km compared to the old version, a decline rate of 20%. In addition, Honda's variety of models will be replaced by a direct injection engine, which can further reduce the average fuel consumption for this enterprise.

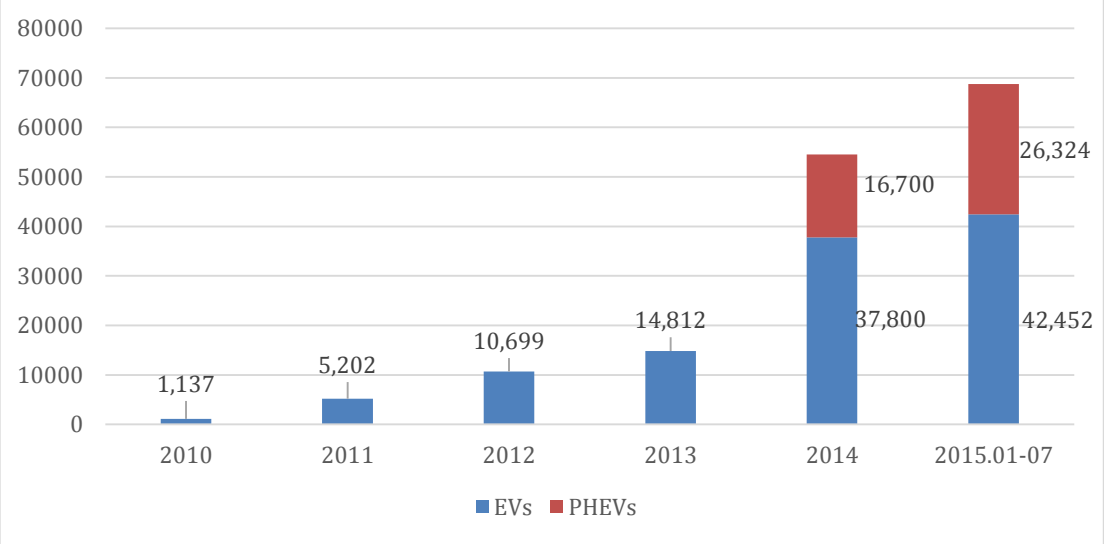
4 NEVs impact on CAFC performance

4.1 2014-2015 NEVs development

In 2014, the State Council issued the "Guiding opinions on accelerating the promotion and application of New Energy Vehicles (NEVs)", and other related government departments have taken a series of measures towards implementation, such as vehicle purchase tax exemption, charging facilities establishment incentives, government procurement, research funds, and released electric vehicle list which includes 78 models[37].

In 2014, there were over 300 types of NEVs, and the annual production was 83,900, four times that of the previous year (including passenger cars and commercial cars). The production of pure electric passenger cars amounted to 37,800, indicating an annual increase of three folds, while the production of plug-in hybrid vehicle was 16,700, marking an increase of nearly 22 folds. Stimulated by the NEVs purchase-tax reduction policy issued in October 2014, production and sales of new energy car was very high towards the end of the year. From October 2014 to July 2015, monthly production and sales of NEVs remained at around 15k-20k. From January to July 2015, the total production of NEVs was 98,900, three times that of the same period in 2014. Among these, the production of pure electric passenger vehicles was 43,000, with an increase of 2 folds, and plug-in hybrid vehicles' production was 26,100, 4 folds increase as shown in **Figure 24**[38]**.** China's NEV industry has developed in quality and variety, and NEVs sales have gradually shifted from the public to private sector.

Figure 24: 2010-2015 NEVs production



[37] MIIT. Auto industry economic operation situation in 2014. http://www.miit.gov.cn/n11293472/n11293832/n11294132/n12858417/n12858612/16418555.html

[38] MIIT. In July 2015, output of new energy vehicle reached 20000. http://zbs.miit.gov.cn/n11293472/n11295142/n11299183/16774275.html

4.2 NEVs contribution to CAFC

NEV models with high sales numbers include EVs such as Chery QQ3-EV, Conti Panda, Zotye E20, BAIC e-series, BYD E6, JAC EV, Zotye Yun 100, and hybrid vehicles (PHEVs) such as BYD Qin and Roewe 550. According to the accounting methods of energy-saving and NEVs determined in the "passenger car fuel consumption evaluation method and index," the accounting multiplier of pure electric vehicles, fuel cell passenger car and plug-in hybrid electric vehicle equipped with battery mileage exceeding 50km is 5, and the fuel consumption of these car types is calculated as 0. The incorporation of new energy vehicles has led to a decline of nearly 0.1 L/100km in the national average fuel consumption in 2014, reaching 7.12L/100km, while the traditional automotive technology upgrade reached decline of only 0.11 L/100km. Since new energy vehicles are mainly produced by independent auto companies in 2014, their average fuel consumption improved by 3.4%, from 7.14 L/100km to 6.77 L/100km.

In 2014, 30 enterprises produced NEVs, among which, there were 9 auto companies with output exceeding 1,000 car units. Since the sales of Zotye Yun 100 produced by Jiangnan Automobile exceeded 10,000 and its traditional cars sales was only 1 million, the NEV preferential accounting led to a CAFC decline of 2.32L/100km, reaching 33% annual improvement in CAFC. BYD Auto Qin led to a CAFC decline of 1.5 L/100km, 24%, and thanks to E6 and Denza CAFC of BYD also improved by 0.69 L/100km, down 9%. Chery's and other auto companies' NEV production impact on CAFC performance is detailed in **Table 9**.

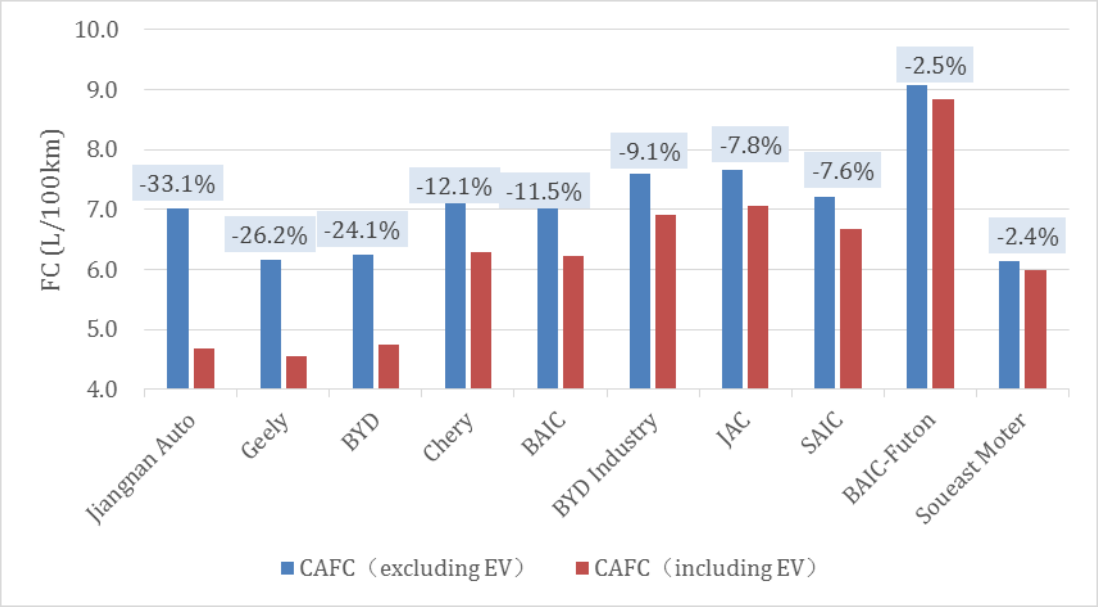
Table 9: NEV models impact on CAFC improvement in 2014

Enterprise	New energy model	Type	Production in 2014	Changes of CAFC L/100km	CAFC Improvement
BYD	Qin	PHEV	13328	-1.50	**-24.1%**
Geely	Kangdi EV	EV	11006	-1.61	**-26.2%**
Jiangnan	Zhongtai E20, Yun100	EV	10451	-2.32	**-33.1%**
Chery	QQ3 EV, EQ Electric	EV	8909	-0.87	**-12.1%**
BAIC	E150, E200	EV	5510	-0.81	**-11.5%**
Shangqi	Rongwei E50	PHEV	2812	-0.55	**-7.6%**
Jianghuai	Heyue IEV	EV	2735	-0.59	**-7.8%**
BYD	E6, Tengshi	EV	2490	-0.69	**-9.1%**
Dongfeng Nissan	Qichen Chenfeng	EV	1325	-0.05	**-0.7%**
Dongnan	EV3	EV	324	-0.15	**-2.4%**
Brilliance BMW	Zinoro, BMW 5 series	EV	344	-0.04	**-0.6%**
Beiqi Forton	EV Midi EV	EV	152	-0.23	**-2.5%**

Dongfeng Holdings	E30 Fengshen E30	EV	122	-0.05	**-0.7%**
GAC Car	Trumphchi	EV	177	-0.06	**-0.6%**

* Data source of NEV production volumes: CATARC

Figure 25: The impacts of NEVs on selected companies' CAFC



With the increase of NEVs production, the average fuel consumption of NEV manufacturers will continue to improve, leading to a decline in the overall national average fuel consumption. The total passenger vehicle NEVs production of 2015 is projected to exceed 120k, reducing the national CAFC by 0.2L/100km.

4.3 The contribution of NEVs to 2020 FC goal

According to "the energy-saving and new energy automotive industry development plan (2012 - 2020)," by 2020, pure electric vehicles and plug-in hybrid electric vehicle production capacity will reach 2 million, and the cumulative production and sales will exceed 5 million. To encourage the development of new energy vehicles, Phase IV provides accounting incentives to NEVs, but the preferential quota has been reduced compared with Phase III. By 2017, the accounting multiplier of NEVs is 5 but will be reduced to 3 in 2018 and to as little as 2 in 2020. By 2020, the fuel consumption of NEVs will be converted to energy consumption while that the fuel cell will be converted into 0. In order to evaluate the effect of energy saving and new energy vehicles on the CAFC target value, the scenario analysis was conducted under the following assumptions (**Table 10**):

Assumption I: new energy passenger cars will account for 80% of total new energy vehicles, and the cumulative sales will reach 4 million by 2020.

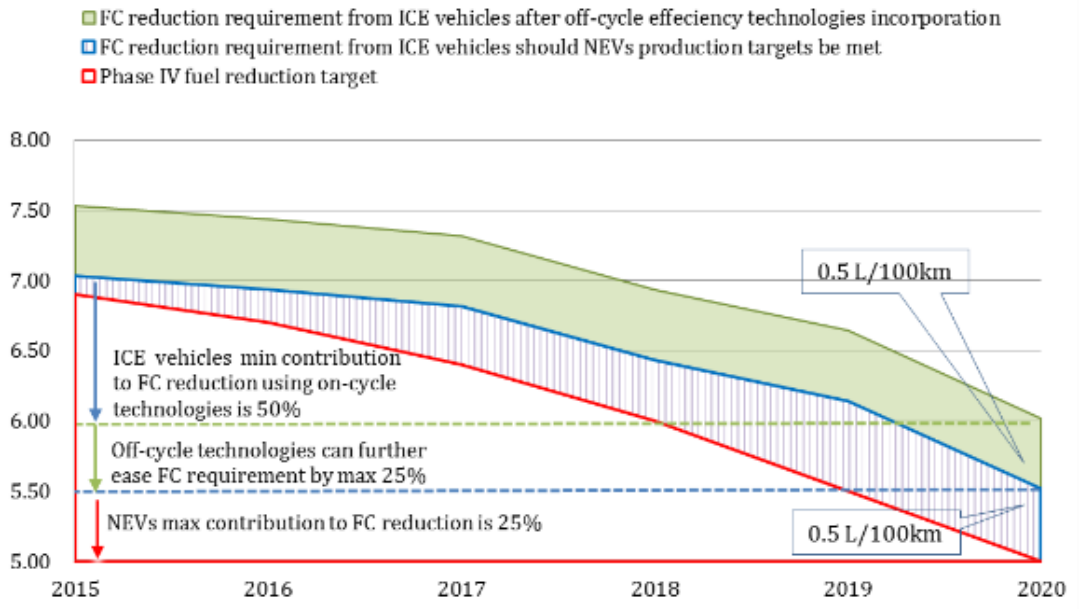
Assumption II: traditional passenger cars are assumed to grow at a rate of 8%, therefore traditional passenger car production will be 21 million in 2015 and 31 million in 2020.

Assumption III: in order to maximize the contribution of new energy vehicles to the average corporate fuel consumption, fuel consumption is still calculated as 0 for all NEVs.

Table 10: Annual NEVs relative production to ICE production – assumptions

Year	New energy passenger cars number (k)	Traditional cars number (k)
~2013	40	**18,090**
2014	60	**19,530**
2015	140	**21,100**
2016	240	**22,780**
2017	400	**24,610**
2018	680	**26,580**
2019	1,000	**28,700**
2020	1,440	**31,000**
Total	4,000	**192,410**

Figure 26: NEVs and Energy Saving Technologies Impact on Phase IV FC Targets



According to the above stated assumptions, if by 2020 the NEV goal of 2 million would be achieved of which passenger cars will comprise 1.6 million, and should NEVs account have a multiplier of 2 and their fuel consumption will accounted for zero, than the average fuel consumption would be improved by 0.5 L/100km, equivalent to 25% of the total Phase IV reduction from 6.9 L/100km to 5.0 L/ 100km. Therefore, the traditional passenger cars would only need to improve their FC to 5.5 L/100km, translating to technology improvements that account for 75% of the total CAFC decline. Of course, by 2020, whether the new energy

vehicles can achieve the goal is determined by technology breakthrough and consumer acceptance (**Figure 26**). Should NEVs reach the above stated contribution, the annual average FC improvement should be 4.8%; otherwise, the annual average FC improvement would be 6.2%.

5 Phase IV target implementation

"The evaluation method and index of passenger car fuel consumption" (GB27999-2014) of Phase IV fuel consumption standard sets forth fuel consumption target by vehicle weight class. This chapter will focus on analyzing the gap between the actual average fuel consumption (CAFC) and Phase IV target fuel consumption.

5.1 Methods and data

Although crucial for a corporate target calculation, vehicle fuel consumption and production data were not announced along with corporate CAFC in 2014. Therefore the target assessment analysis and comparison for Phase IV is based on the publically available data detailed in **Table 12**.

Table 11: The data source of target analysis on domestic passenger cars in the Phase IV

Type of data	Source of data
Vehicle FC	**中国汽车燃料消耗量网站**[39] **China automobile fuel consumption website**[40]
Vehicle production volume	**中国汽车技术研究中心*** **CATARC**
Other vehicle index	**中国汽车技术研究中心*** **CATARC**

* The output data of the China Automobile Technology Research Center (CATARC) is based on the data of the vehicle factory certification.

This reports' CAFC information is slightly different than that posted by MIIT, as shown in **Table 13 and 14**, due to the use of different sources of information. Therefore, when calculating the Phase IV target by using vehicle sales volume and fuel consumption data, the results are not of great differences.

Table 12: CAFC vs. T_{CAFC} analysis of domestic auto companies

	iCET calculation results*	MIIT posted information	Level of variation
2014 Actual CAFC *CAFC* (L/100km)	7.10	7.12	**99.4%**
2014 Target CAFC T_{CAFC} (L/100km)	7.37	7.40	**99.6%**
CAFC/T_{CAFC}	96.3%	96.2%	**100.1%**

***** iCET reached these results based on the data listed in Table 11.

[39] 中国汽车燃料消耗量网站.http://chinaafc.miit.gov.cn/index.html
[40] China automobile fuel consumption website. http://chinaafc.miit.gov.cn/index.html

Table 13: CAFC vs. T_{CAFC} analysis of importing auto companies

	iCET calculation results*	MIIT posted information	Level of variation
2014 Actual CAFC *CAFC* (L/100km)	9.22	9.20	**100.2%**
2014 Target CAFC T_{CAFC} (L/100km)	8.79	8.76	**100.3%**
CAFC/T_{CAFC}	104.9%	105.0%	**99.9%**

***** iCET reached these results based on the data listed in Table 11.

5.2 Phase IV T_{CAFC} of domestic auto companies

In 2014, the CAFC/T_{CAFC} ratio of domestic passenger car auto companies was 138%, a fall of 6% from 2013. If NEVs were excluded, the ratio would have been 140%. The CAFC/T_{CAFC} of JVs was about 139.5%, and that of independent auto companies was 133.3%. The Phase IV CAFC/T_{CAFC} ratio was relatively low thanks to independent auto companies' NEVs production volumes.

Table 14: The ratio of CAFC actual value to target value for the Phase IV in 2014

	2014 CAFC * *L/100km*	$T_{CAFC-IV}$ *L/100km*	CAFC/$T_{CAFC-IV}$	CAFC/$T_{CAFC-IV}$*
Joint ventures	7.11	5.09	139.7%	**139.5%**
Independent auto companies	6.77	5.08	138.0%	**133.3%**
Domestic passenger cars auto companies	7.01	5.08	139.8%	**138.0%**

* NEVs included. Table 11 details the figures on which the CAFC calculation is based.

In 2014, the target range of the various domestic passenger car auto companies was between 4.3 and 6.9L/100km. The target value of Phase IV of companies with output of over 100,000 concentrated in the range of 4.5-5.9L/100km. The target value of most of the auto companies is consistent with national goals, about 5 L/100km.

Figure 26 shows the ratio of CAFC values of domestic auto companies with an annual output of more than 100,000 to the target values for the Phase IV *excluding NEVs*. This year there were only two car companies with the ratio higher than 160% - FAW and Guangzhou Automobile Group (GAC). Companies with ratio lower than 130% were Geely Automobile, Changan Mazda, BMW Brilliance and BYD Auto, Changan Suzuki.

Comparing CAFC value in 2014 and the 2020 target value, it seems that small auto companies' production would be able to achieve the target more easily since not only are their gaps to the 2020 goal smaller, but also the 2020 goal imposes strict limits to large vehicles. CAFC decline is directly related to product structure adjustment and technology integration. These processes typically take 3-5 years; therefore, in order to achieve the 2020 goal, auto companies must increase their CAFC improvement rate quickly.

Figure 27 shows the ratio of CAFC values of domestic auto companies with annual output more than 100,000 to the target values for the Phase IV *including NEVs*. Some new energy automotive enterprises have significantly reduced their CAFC/$T_{CAFC\text{-}IV}$. Among these are Geely Automobile, Jiang Nan Automobile, and BYD Automobile. Beijing Automobile and Chery also substantially reduced their actual CAFC distance from their Phase IV target value.

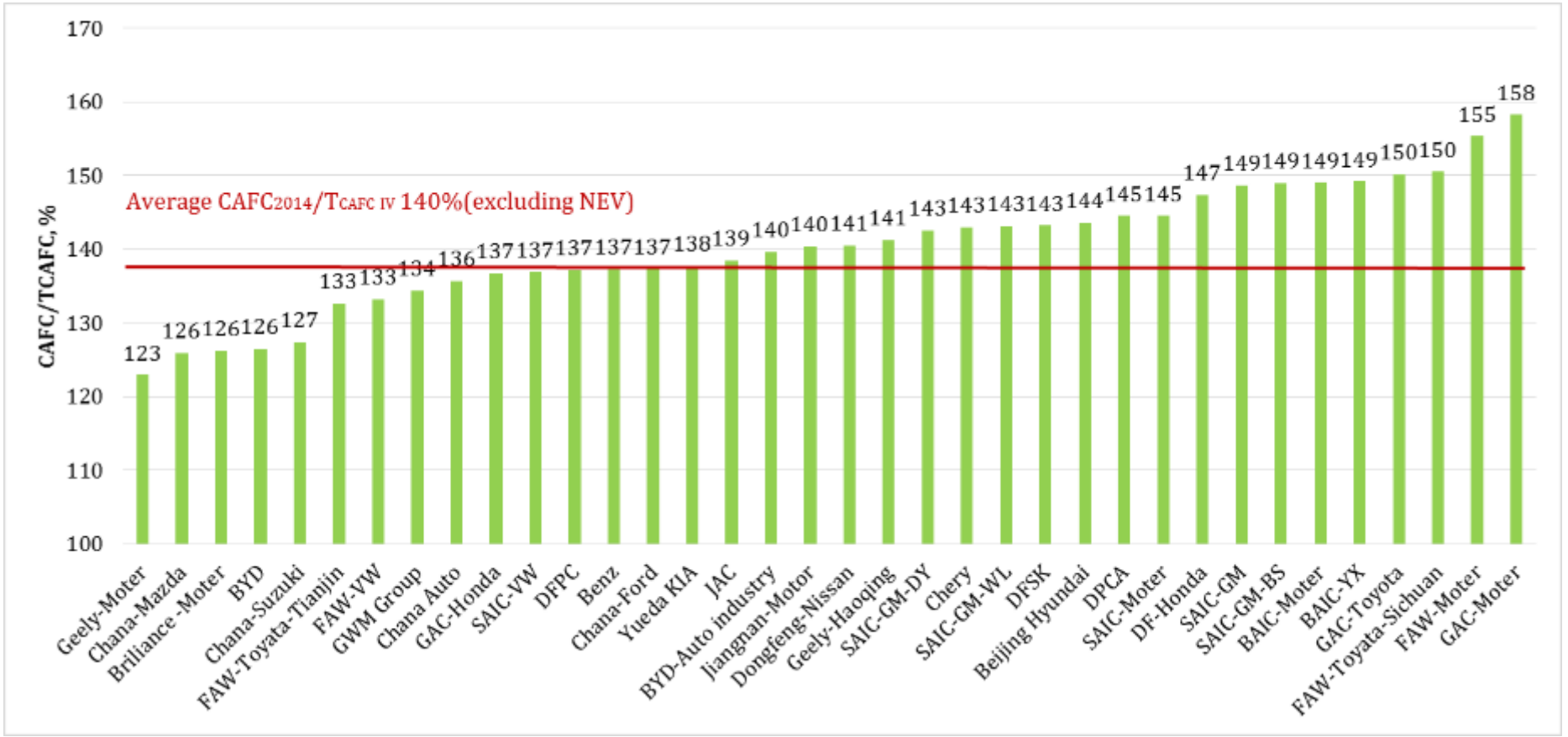


Figure 27: Domestic auto companies' CAFC/$T_{CAFC-IV}$ excluding NEVs

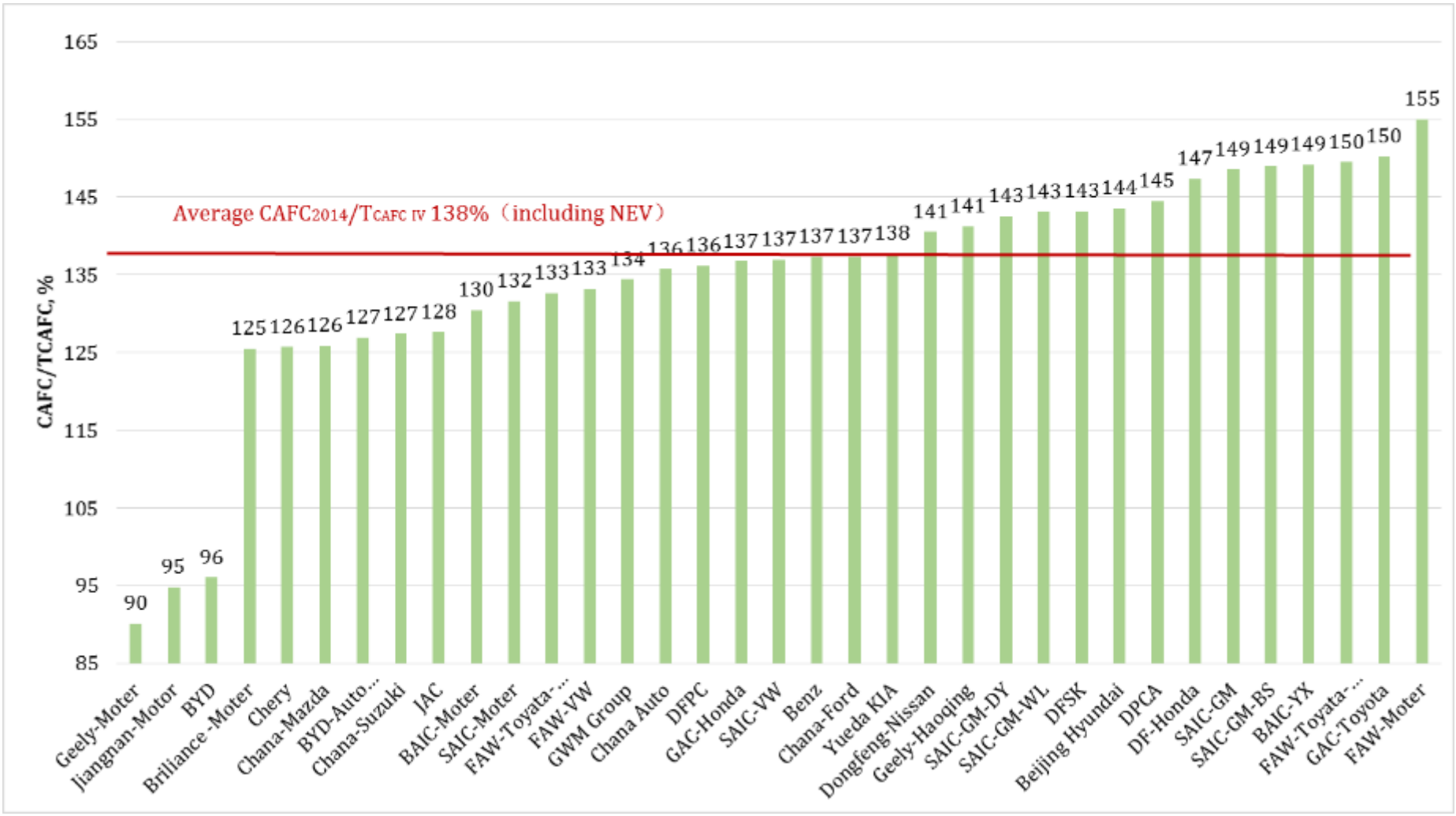


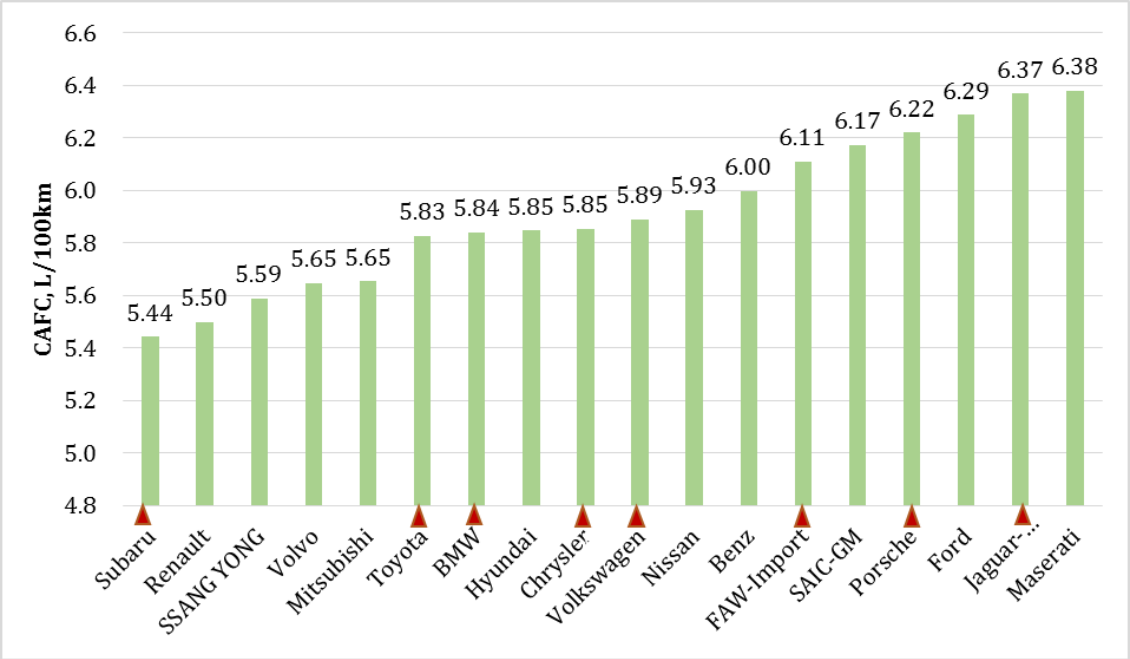
Figure 28: Domestic auto companies' CAFC/$T_{CAFC\text{-}IV}$ including NEVs

5.3 Phase IV T_{CAFC} of importing auto companies

Importing auto companies $T_{CAFC\ Phase\ IV}$ was 5.93 L/100km, similar to that of 2013 and 0.85 L/100km higher than the target fuel consumption of domestic passenger car. The $T_{CAFC\ Phase\ IV}$ of various import auto companies ranges between 4.6 and 6.6L/100km, among which that of SUZUKI is the lowest with 4.6 L/100km, and Jaguar Land Rover, Maserati and other luxury brands target value is relatively high, about 100km 6.4L/, as shown in **Figure 30**.

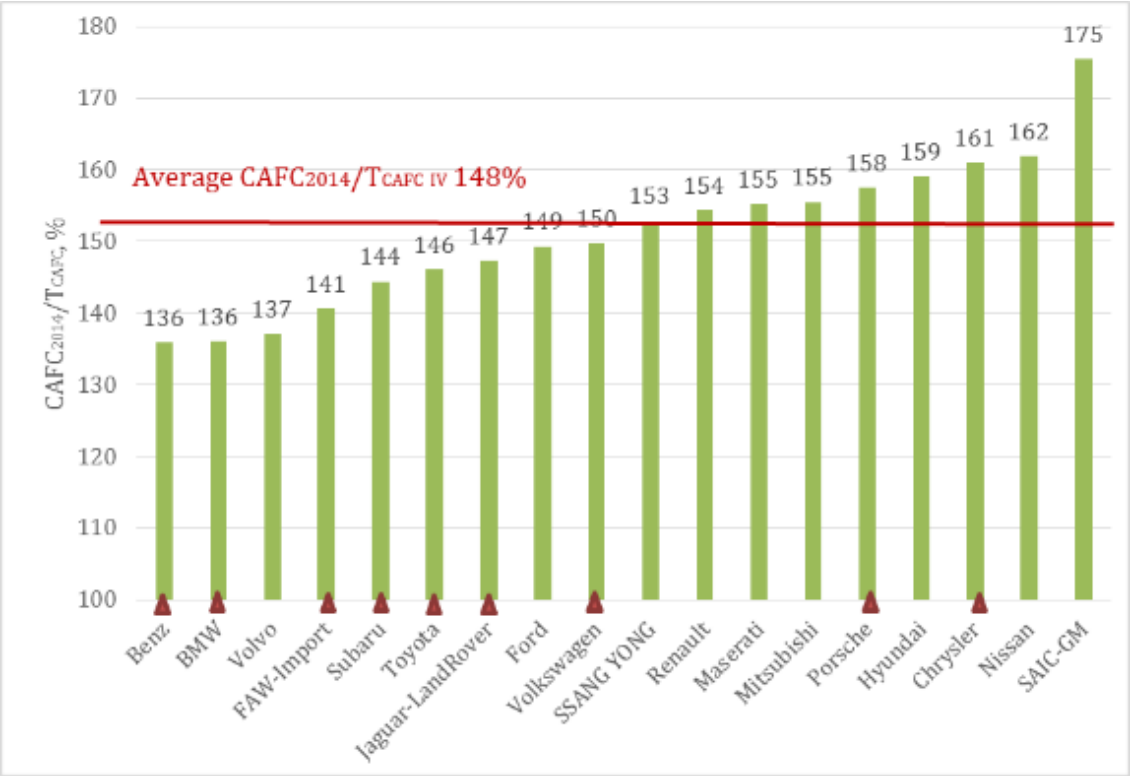
The ratio of CAFC to $T_{CAFC\ Phase\ IV}$ was 148.4%, down 7% from last year and 10% higher than that of domestic auto companies. Since Phase III, importing auto companies are obligated to meet China's passenger fuel consumption standards, aimed at a $CAFC_{2016}/T_{CAFC\ Phase\ IV}$ of 134%. Therefore, $CAFC_{2016}/T_{CAFCIV}$ of importing auto companies still need to fall by 15% in the coming two years (by 2016), posing an great implementation challenge.

Figure 29: $T_{CAFC\ Phase\ IV}$ of importing auto companies



Note: The figure shows those auto companies with import volume more than 10,000, ▲ is marked for auto companies with import volume over 50,000.

Figure 30: CAFC/ $T_{CAFC\ Phase\ IV}$ of importing auto companies



Note: The figure shows those auto companies with import volume more than 10000, ▲ is marked for auto companies with import volume over 50,000.

Figure 30 lists CAFC to $T_{CAFC\ Phase\ IV}$ ratio of importing auto companies, and ▲ marks auto companies with import volume exceeding 50,000 – obligated to the standard. The ratio of most of companies was below 150%, while Porsche and Chrysler achieved a ration as high as 158% and 161% respectively. The ratio of Mercedes Benz, BMW and Volvo was below 140%, and it is not difficult to achieve the target value of 134%.

In order to decrease from the current CAFC of 9.15 L/100km to the target value of 5.93 L/100km in 2020, import cars must maintain the average annual decline of 6%. In recent years, importing auto companies' CAFC have decreased at the average rate of 5%, therefore the target is achievable should more efforts be made.

5.4 2020 national goal achievement

According to "the energy-saving and new energy automotive industry development plan (2012-2020)," the average fuel consumption of passenger cars should be reduced to 5L/100km by 2020. While the average fuel consumption level of domestic auto companies in 2014 was 7.01 L/100km, accounting for 138% of the target, by combining importing auto companies' CAFC the national market have reached 7.12 L/100km, accounting for 140% of the target value.

The implementation plan of CAFC/ $T_{CAFC\text{-}IV}$ standard is detailed in **Table 15**. The CAFC/ $T_{CAFC\text{-}IV}$ ratio should fall by 10% between 2018 and 2020, and the CAFC should fall by about 0.5

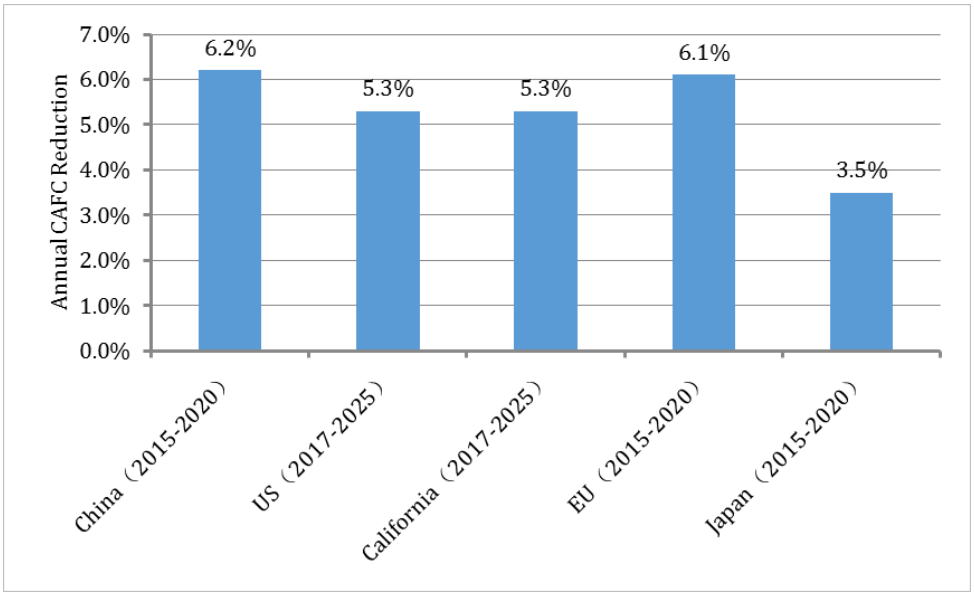
L/100km every year or at a rate of 9%. During the entire Phase IV (2016-2020), the average CAFC decline rate should be 6.2% while in the last seven years (2006-2014) the average annual reduction rate was less than 2%. Therefore, in order to achieve the 2020 goal massive adoption of advanced energy-saving technologies, development of NEVs and credit mechanism integration are due.

Table 15: The implementation plan of CAFC/ $T_{CAFC\ Phase\ IV}$

Year	CAFC/ $T_{CAFC2020}$	Annual reduction rate *percentage points*	CAFC L/100km	CAFC annual reduction L/100km	Annual reduction rate
2014	140%	3	7.12	0.21	**-2.8%**
2015	138%	3	6.90	0.22	**-3.1%**
2016	134%	4	6.70	0.20	**-2.9%**
2017	128%	6	6.40	0.30	**-4.5%**
2018	120%	8	6.00	0.40	**-6.3%**
2019	110%	10	5.50	0.50	**-8.3%**
2020	100%	10	5.00	0.50	**-9.1%**
CAFC average annual decline rate during 2016-2020					**-6.2%**

According to regional fuel consumption targets detailed in **Table 6**, the average annual fuel consumption reduction rate in China needs to reach 6.2%. This reduction rate is more intense than that of the United States, the European Union, and Japan.

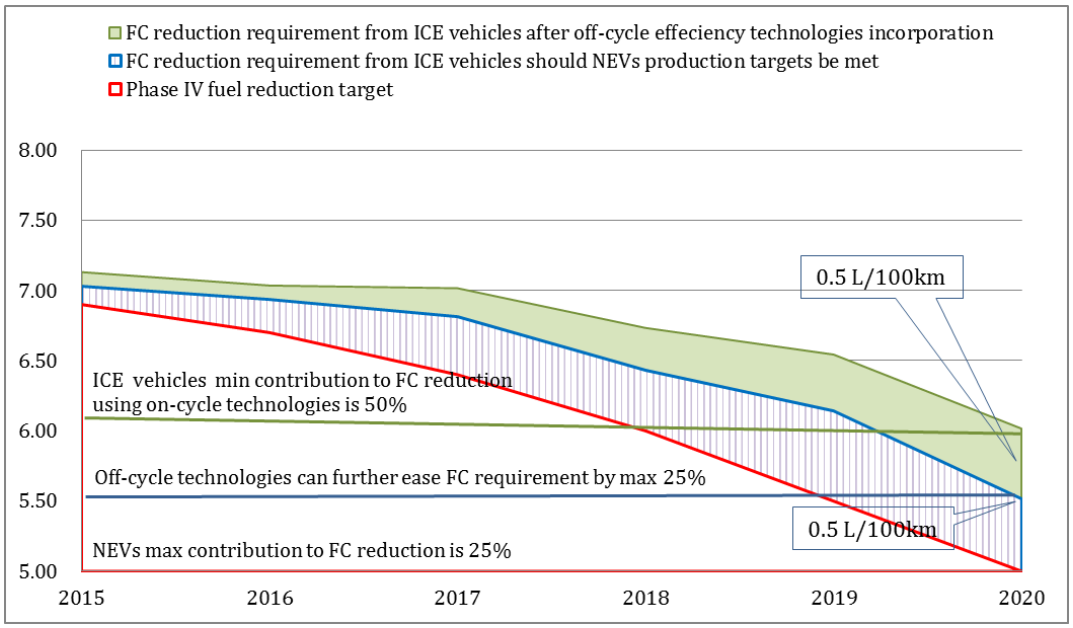
Figure 31: Annual average FC reduction rate needed for meeting the coming target in various regimes



5.5 Advanced energy saving technologies

During the implementation period of the Phase IV (2016-2020), ICE vehicles are projected to account for over 95% of the market share, therefore energy saving technology integration and constant improvement is crucial for the realization of the national fuel consumption target of 2020. In order to encourage the application of new energy saving technologies, "passenger car fuel consumption evaluation methods and indicators (2014)" determined that the installation of Kinetic Energy Recovery Systems (KERS), high-efficiency air conditioning, idle start stop devices, and shift reminder devices could reduce fuel consumption by less than 0.5 L/100km. This can be translated to the easing for CAFC average annual reduction from 6.2% to 4.8%. NEVs preferential calculation includes 5 times production of 0 fuel consumption vehicle, which will be translated to 0.5 L/100km at a maximum. Both supply-side incentives and demand side incentives for energy saving technology integration could lead to a reduction of 1L/100km in the fuel consumption, accounting for 50% of the total required reduction (from a target of 5L/100km to 6L/100km). In the case, the average fuel consumption of traditional vehicles only need to fall from the 2016 target level of 6.9L/100km to 6.0L/100km by 2020, maintaining an average annual reduction of about 3%. ICCT and other international agencies have analyzed the potential of energy saving technologies in bringing FC improvements and claim technology can have an impact of 50% on FC performance in China.

Figure 32: Energy saving technologies' incentives impact of the fuel consumption target



5.6 CAFC credits trading mechanism

"The passenger car enterprise average fuel consumption calculation method" simply articulates the concept of credits and outlines credits calculations methods, however still lack credits value calculation method and trading management guidelines. It is however noted that credits could be forwarded 3 years to compensate for a company's need in its CAFC calculation for meeting the target that annually increases in stringency.

The credits trading mechanism needs further research, so as to establish a trading platform and encourage enterprises' to reduce their fleet's fuel consumption. The mechanism can be built upon the experiences of other similar credits systems (such as California zero emission vehicle experience) for ensuring the system is effectively pushing companies forward into an ear of clean and efficient vehicles.

6 Conclusions

1) The Phase IV standard of China passenger car fuel consumption will be formally implemented as of 2016. The average single model FC limit will be 20% stricter to that of the Phase III, while the average single model target value will be 30-40% stricter. New energy vehicles and alternative fuel vehicles will be incorporated into the CAFC accounting system, and advanced technologies will be accredited with FC calculation reduction incentives. The CAFC management system is projected to become clearer and include mainly administrative penalties. The management of imported cars is still relatively loose and a CAFC credits management approach is still under formulation.

2) The fuel assumption of 3/4 of 2014 models reached the target value of the Phase III (the limit value of the Phase IV), yet the remaining 25% have only 2 years left for meeting the requirement. There is still much room for technological improvement.

3) The average fuel consumption of domestic passenger car companies was 7.22L/100km in 2014 (excluding new energy vehicles), down 1.5% from last year, while independent companies' CAFC increased by 3%. Domestic companies still have to reduce 0.3L/100km for achieving the 2016 target, and since the average annual reduction of previous year was 2% there is still work to be done. The incorporation of New Energy Vehicles (NEVs) led to a national average decline of 0.1L/100km, spearheaded by independent companies (which saw a 0.38L/km decline attributed to NEVs). The impact of NEV incorporation on ranged 20-30%, with domestic companies such as BYD automobile, Geely Automobile, Jiangnan Automobile leading the trend. NEVs are therefore projected to assist companies in achieving the national 2015 goal of 6.9L/100km in Phase IV limits.

4) When comparing $CAFC_{2014}/T_{CAFC\text{-}IV}$ of 138% and $CAFC_{2016}/T_{CAFC\text{-}IV}$ target of 134%, and considering that last year a 6 percentage points reduction was achieved, the transition to Phase IV in terms of corporate average fuel consumption – would probably occur smoothly. 14 companies producing small vehicles and NEVs that have an annual production capacity of over 1million cars scored a $CAFC_{2014}/T_{CAFC\text{-}IV}$ of less than 134% already, such as Geely, Jiangnan, and BYD. Companies producing large passenger cars, such as TOYOTA, Sichuan FAW TOYOTA, and FAW, reached a $CAFC_{2014}/T_{CAFC\text{-}IV}$ of over 150% singling these companies will be facing great implementation challenges throughout Phase IV.

5) Imported companies are faced with increasingly stringent targets, since included in the binding fuel consumption standards of Phase III, an FC decline target of as much as 15%. The average $CAFC_{2014}/T_{CAFC\text{-}IV}$ of importing companies was 148%, 10 percentage points higher than that of domestic passenger car companies, and striving at a Phase IV target of 5.93L/100km, nearly 1L/100km less stringent than that of China's average CAFC target. However, there are several large importing companies with relatively good $CAFC_{2014}/T_{CAFC\text{-}IV}$ performance (136% for Mercedes Benz and BMW, and 137% for Volvo).

6) Based on an experimental calculation of potential fuel consumption credits accumulation over the past three years (2012-2014), a total of 12,140,000L/100km CAFC credit and 780,000 L/100km CAFC debts have been produced (section 1.1.3 elaborates on CAFC credit and debts calculation), demonstrating an imbalance of as much as 15 times. A large

concentration of credits was accumulated by limited number of auto companies, indicating that technology and credits transfer should be created for enabling improvements without compromising China's auto sector competitiveness. Yet a credits system should be carefully designed, and should be based on robust assumptions of supply and demand as well as realistic penalties that would avoid the abuse of the credits mechanism for the sake of costs reduction rather than technology improvements.

7) The accounting of NEVs during Phase IV will enable a decline of 0.5L/100km at most from the corporate average fuel consumption (CAFC) value. By achieving the maximum amount of two credits, a corporate average fuel consumption would be reduced by 1L/100km, accounting for half of Phase IV's (2016-2020) total target (6.9 L/100km down to 5 L/100km). In this case, the average fuel consumption reduction of traditional vehicles only needs to be 0.9L/km, thus maintaining average annual decline of about 3.3%, instead of 6.2%. Advanced energy-saving technologies such as kinetic energy recovery systems (KERS), high efficiency air conditioning, idle start and stop device, and shift reminder device, would each enable a reduction of 0.5L/100km in the FC of models in which they are integrated.

Appendix I: CAFC and T_{CAFC} calculation method and example

This section details the specific case of an imaginary Company A for the goal of providing an example as for how CAFC and T_{CAFC} are calculated. The section is divided to 5 steps for clarity purposes.

I. Calculation basic rules

1. Calculate the data of produced and imported cars in A company separately
2. If there are 2 types of cars under a single model serial number (e.g. AT/MT, or vehicle mass; in company A case that is M2 model), the solution is: (i) selecting the minimum vehicle curb-weight (in Company A case that should be 1340kg) and (ii) the maximum FC available (in Company A case that would be 7.5L/100km), and (iii) the minimum target available (in Company A case that would be 7.3L/100km).

Exmple Company A: list of models to be included in the calculation exmaple

Subject	Vehicle Model	Vehicle mass Kg	Fuel Type	Transmission type	Seats	Comprehensive driving condition Fuel consumption L/100km	Fuel consumption Target value L/100km			2014 production	2014 Import	Remarks
							Type	Phase III target	Phase IV target			
A Domestic	M1	1165	Dual-fuel	MT	7-8	6.5	2	6.8	4.9	2734		
A Domestic	M2	1340	gasoline	MT	5.7	7.3	1	7.3	5.1	4275		
A Domestic	M2	1380	gasoline	AT	5	7.5	2	7.6	5.3	3663		
A Domestic	M3	1420	HEV	CVT	5	4.3	2	7.6	5.3	20		
A Domestic	M4	1560	PHEV	AT	5	2.6	2	8.4	5.7	122		Driving mileage 60km

A Domestic	M5	1560	PHEV	AT	5	2.7	2	8.4	5.7	100		Driving mileage 40km
A Domestic	M6	1440	EV	MT	5	0	1	7.7	5.3	15		
A Import	M7	1570	gasoline	AT	5	8.2	2	8.4	5.7		514	Import
A Import	M8	1615	diesel	AT	5	8.4	2	8.4	5.7		708	Import
A Import	M9	1922	gasoline	AT	5	11.0	2	9.6	6.4		3806	Import
A Import	M10	1840	EV	MT	5	0	1	8.9	5.9		50	Import

Note: in the type of FC target value, "1" stands for ordinary vehicles, and "2" stands for special structure vehicles.

II. Calculation of A company's domestic passenger cars CAFC (excluding NEVs)

1. Corporation average fuel consumption [see I2ii for the special case of M2]

$$CAFC = \frac{\sum_{i=1}^{N} FCi \times Vi}{\sum_{i=1}^{N} Vi} = \frac{6.5 \times 2734 + 7.5 \times (4275 + 3663) + 4.3 \times 20}{2734 + (4275 + 3663) + 20}$$

$$= 7.24L / 100km$$

2. Target value of CAFC [see I2iii for the special case of M2]

$$T_{CAFC} = \frac{\sum_{i=1}^{N} Ti \times Vi}{\sum_{i=1}^{N} Vi} = \frac{6.8 \times 2734 + 7.3 \times (4275 + 3663) + 7.6 \times 20}{2734 + (4275 + 3663) + 20}$$

$$= 7.17 L / 100 km$$

3. Ratio of CAFC actual value to target value

CAFC/ T_{CAFC}=7.24/7.17=100.9%

4. Credits calculation

The CAFC actual value of A company's should be 100%, however for 2014 it can reach up to 103% (as specified in **GB27999**).

Since in Company A case the CAFC/T_{CAFC} is between 100% and 103% it is not entitled to any credits neither it is in any debt of credits (as explained in section 1.1.3).

III. CAFC calculation of A company's imported passenger cars (excluding NEVs)

1. Actual value of average fuel consumption

$$CAFC = \frac{\sum_{i=1}^{N} FCi \times Vi}{\sum_{i=1}^{N} Vi} = \frac{8.2 \times 514 + 8.4 \times 708 + 11.0 \times 3806}{514 + 708 + 3806}$$

$$= 10.35 L / 100 km$$

2. Target value of average fuel consumption

$$T_{CAFC} = \frac{\sum_{i=1}^{N} Ti \times Vi}{\sum_{i=1}^{N} Vi} = \frac{8.4 \times 514 + 8.4 \times 708 + 9.6 \times 3806}{514 + 708 + 3806}$$

$$= 9.31L / 100km$$

3. Ratio of CAFC actual value to target value (CAFC/ T_{CAFC})

CAFC/ T_{CAFC}=10.35/9.31=111.1%

4. Credits for above/below the target value

A company's imported passenger cars CAFC/T_{CAFC} in 2014 exceeded 103% it is in credits debt. The debt as calculated as follows:

$$(T_{CAFC} - CAFC) \times \sum_{i=1}^{N} Vi = (9.31 \times 103\% - 10.35) \times (514 + 708 + 3806)$$

$$= -3825L / 100km$$

IV. **Calculation for assessing whether A company's domestic passenger cars CAFC achieved the national average fuel consumption target including NEVs (this process is conducted by the government and not by the companies themselves)**

1. Data processing

- The electric driving range of Company A's PHEV M4 is 60 kilometers (the minimum requirement of 50km for PHEVs, as articulated in **Table 4**), so its fuel consumption is calculated as 0L/100km calculation, and each such vehicle is calculated as 5 vehicles;

- The electric driving range of PHEV M5 is 40 kilometers (less than the minimum requirement of 50km for PHEVs, as articulated in **Table 4**) therefore its fuel consumption is calculated as 2.7L/100km calculation, and each such vehicle is calculated as an Energy Saving Vehicle (ESV), counted as 3 vehicles;

- The PEV M6 fuel consumption is calculated as 0L/100km calculation (in accordance with **Table 4**), and each such vehicle is calculated as 5 vehicles;

2. CAFC actual value

$$CAFC' = \frac{\sum_{i=1}^{N} FCi' \times Vi'}{\sum_{i=1}^{N} Vi'}$$

$$= \frac{6.5 \times 2734 + 7.5 \times (4275 + 3663) + 4.3 \times 20 + 0 \times 122 + 2.7 \times 100 + 0 \times 15}{2734 + (4275 + 3663) + 20 + 122 \times 5 + 100 \times 3 + 15 \times 5}$$

$$= 6.65L / 100km$$

Calculation on whether A company's domestic passenger cars CAFC achieved the national average fuel consumption target of importing auto companies – similar to that of domestic cars

Appendix II: Limit values and target values of vehicle fuel consumption in the Phases I, II, III and IV

Curb-weight (kg)	Phase I: FC Limit (L/100km)		Phase II,III: FC Limit (L/100km)		Phase IV: Limit (L/100km)		Phase III: Target (L/100km)		Phase IV: Target (L/100km)
	MT	AT or/and above 3 seat rows	MT	AT or/and above 3 seat rows	MT	AT or/and above 3 seat rows	MT	AT or/and above 3 seat rows	普通乘用车*
Implementation	7/2005-1/2008 (New Cars) 7/2006-1/2009 (Entire Production)		1/2008-current (New Cars) 1/2009-current (Entire Production)		1/2016-N / A (New Cars) 1/2017 (Entire Production)		1/2012-2015		2016-2020
CM≤750	7.2	7.6	6.2	6.6	5.2	5.6	5.2	5.6	3.9
750＜CM≤865	7.2	7.6	6.5	6.9	5.5	5.9	5.5	5.9	4.1
865＜CM≤980	7.7	8.2	7	7.4	5.8	6.2	5.8	6.2	4.3
980＜CM≤1090	8.3	8.8	7.5	8	6.1	6.5	6.1	6.5	4.5
1090＜CM≤1205	8.9	9.4	8.1	8.6	6.5	6.8	6.5	6.8	4.7
1205＜CM≤1320	9.5	10.1	8.6	9.1	6.9	7.2	6.9	7.2	4.9
1320＜CM≤1430	10.1	10.7	9.2	9.8	7.3	7.6	7.3	7.6	5.1
1430＜CM≤1540	10.7	11.5	9.7	10.3	7.7	8.0	7.7	8.0	5.3
1540＜CM≤1660	11.3	12	10.2	10.8	8.1	8.4	8.1	8.4	5.5
1660＜CM≤1770	11.9	12.6	10.7	11.3	8.5	8.8	8.5	8.8	5.7
1770＜CM≤1880	12.4	13.1	11.1	11.8	8.9	9.2	8.9	9.2	5.9
1880＜CM≤2000	12.8	13.6	11.5	12.2	9.3	9.6	9.3	9.6	6.2
2000＜CM≤2110	13.2	14	11.9	12.6	9.7	10.1	9.7	10.1	6.4
2110＜CM≤2280	13.7	14.5	12.3	13	10.1	10.6	10.1	10.6	6.6
2280＜CM≤2510	14.6	15.5	13.1	13.9	10.8	11.2	10.8	11.2	7.0
2510＜CM	15.5	16.4	13.9	14.7	11.5	11.9	11.5	11.9	7.3
* For vehicles with 3 rows not exceeding 1090 kg, vehicle target is 105% the per-weight target; over 3 rows vehicles target is 103% of the per-weight target.									

Appendix III: 61 domestic auto companies producing > 10,000

Company	Full Name in Chinese	JV or ID*	Models in 2014
Beijing-Benz	北京奔驰汽车有限公司	JV	**BENZ-GLK, BENZ-E200,BENZ-C200**
Beijing Hyundai	北京现代汽车有限公司	JV	**ELANTRA,VERNA,ix35**
BAIC-Foton	北汽福田汽车股份有限公司	ID	**MP-X,MIDI**
BAIC-Moter	北京汽车股份有限公司	ID	**Weiwang, E150, E130**
BAIC-YX	北汽银翔汽车有限公司	ID	**M20**
BYD-Auto	比亚迪汽车有限公司	ID	**F3,L3,G3**
BYD-Auto industry	比亚迪汽车工业有限公司	ID	**Sirui,G6,M6,F0,F6**
Chery	江西昌河铃木汽车有限责任公司	JV	**Big Dipper, Freda, Liana**
Changhe- Jiangxi	江西昌河汽车有限责任公司	ID	**Freda**
Xin Da Di-Chengdu	成都新大地汽车有限责任公司	ID	**Emgrand, GX, GC**
Chana-Ford	长安福特汽车有限公司	JV	**KUGA,MONDEO,VOLVO S80, FOCUS**
Chana-Suzuki	重庆长安铃木汽车有限公司	JV	**Alto, Lingyang ,Swift**
Chana-Mazda	长安马自达汽车有限公司	JV	**Mazda series,CX5,Fiesta**
Chana-Chongqing	重庆长安汽车股份有限公司	ID	**Star, EADO, Benni, Honor**
Chana-Hebei	河北长安汽车有限公司	ID	**Xingguang, Ruixing**
GWM	长城汽车股份有限公司	ID	**Voleex C30,C50,HAVAL M, HAVAL H**
DF-Honda	东风本田汽车有限公司	JV	**CR-V, CIVIC,SPIRIOR**
DF-Moter	东风汽车公司	JV	**S30,H30,A60**
DF-LZM	东风柳州汽车有限公司	JV	**Lingzhi,Jingyi**
Dongfeng-Nissan	东风汽车有限公司	JV	**Tiida,Sunny,QASHQAI ,SYLPHY**
DPCA (Dongfeng-Peugeot-Citroen)	神龙汽车有限公司	JV	**C-Elysee,C-Quatre**
DFSK	东风小康汽车有限公司	ID	**Xiaokang**
DF-YL	东风裕隆汽车有限公司	JV	**Luxgen**
DF-KIA	东风悦达起亚汽车有限公司	JV	**K2,K5,Sportage**
Soueast Moter	东南（福建）汽车工业有限公司	JV	**LIONVEL,LANCEREX, V5**
Benz-Fujian	福建奔驰汽车工业有限公司	JV	**Vito, Viano**
GAC-Honda	广汽本田汽车有限公司	JV	**CITY, ACCORD, Crosstour**
GAC-Moter	广州汽车集团乘用车有限公司	ID	**Trumpchi**

GAC-Fiat	广汽菲亚特汽车有限公司	JV	**Viaggio**
GAC-Toyota	广汽丰田汽车有限公司	JV	**Camery, Yaris,Highlander**
GAC-Gonow	广汽吉奥汽车有限公司	ID	**Xia'ao,Aoxuan,GX5**
GAC-Mitsubishi	广汽三菱汽车有限公司	JV	**PAJERO,AXR**
Hafei-Moter	哈飞汽车股份有公司	ID	**Alsvin, Luzun,Xinminyi**
Haima-Moter	海马轿车有限公司	ID	**M3**
Hawtai-Moter	荣成华泰汽车有限公司	ID	**Aishang,Wangzi,**
Haima-Commecial Motor	海马商务汽车有限公司	ID	**FSTAR**
Chana-Hefei	合肥长安汽车有限公司	ID	**Benben mini，CX20**
Briliance-BMW	华晨宝马汽车有限公司	JV	**BMW5,BMW3,BMWX1**
Briliance -Jinbei	沈阳华晨金杯汽车有限公司	ID	**Junjie**
Briliance -Moter	华晨汽车集团控股有限公司	ID	**V5,H530**
Haipu Motor	上海华普汽车有限公司	ID	**Haijing**
Geely-Haoqing	浙江豪情汽车制造有限公司	ID	**Yuanjing,GLEAGLE**
Geely-Moter	浙江吉利汽车有限公司	ID	**Dihao,Ziyoujian**
JAC	安徽江淮汽车股份有限公司	ID	**Heyue, Ruifeng,Tongyue**
JMC-Landwind	江铃控股有限公司	JV	**Landwind X8，X5**
JMC	江铃汽车股份有限公司	JV	**Yusheng**
Jiangnan-Motor	湖南江南汽车制造有限公司	ID	**Z300,TT**
Chery	奇瑞汽车股份有限公司	ID	**Ruihu,QQ,E5**
SAIC-VW	上海大众汽车有限公司	JV	**Passat, LAVIDA,Tiguan**
SAIC-GM	上海通用汽车有限公司	JV	**LaCrosse, Malibu**
SAIC-GM-DY	上海通用东岳汽车有限公司	JV	**ENCORE,AVEO,Excelle**
SAIC-Moter	上海汽车集团股份有限公司	ID	**MG3,Rongwei 550,MG6**
FAW-Toyata-Sichuan	四川一汽丰田汽车有限公司	JV	**RAV,LAND CRUISER, PRADO**
FAW-Toyata-Tianjin	天津一汽丰田汽车有限公司	JV	**Vios,REIZ,COROLLA**
SAIC-GM-BS	上海通用（沈阳）北盛汽车有限公司	JV	**Cruze,Captiva**
SAIC-GM-WL	上汽通用五菱汽车股份有限公司	JV	**Wulingzhiguagn, Baojun 630**
FAW-VW	一汽-大众汽车有限公司	JV	**Jetta, Audi A4, Audi Q5**
FAW-Haima	一汽海马汽车有限公司	ID	**Family,Freema,S7**
FAW-Jinlin	一汽吉林汽车有限公司	ID	**Jiabao, Yasen**
FAW-Moter	中国第一汽车集团公司	JV	**BESTURN,Mazda6,Hongqi**
FAW-Xiali	天津一汽夏利汽车股份有限公司	ID	**Xiali, Weizhi**
PSA-Chana	长安标致雪铁龙汽车有限公司	JV	**DS5**

DF-Nissan-Zhengzhou	郑州日产汽车有限公司	JV	**Shuaike,NV200,Paladin**
Lifan-Car	重庆力帆乘用车有限公司	ID	**Lifan320,620,520**
Linfan-Moter	重庆力帆汽车有限公司	ID	**Xinshun, Fushun**

Appendix IV: 25 importing auto companies

Company	Chinese Full name of Registered Vehicle Importers	Agent brands
Aston Martin	阿斯顿马丁拉共达（中国）汽车销售有限公司	**Aston Martin**
BMW	宝马（中国）汽车贸易有限公司	**BMW, Mini-cooper, Rolls-Royce**
Porsche	保时捷（中国）汽车销售有限公司	**Porsche**
Lotus	北京路特斯汽车销售有限公司	**Lotus**
Honda	本田技研工业（中国）投资有限公司	**Acura**
Peugeot Citroen	标致雪铁龙（中国）汽车贸易有限公司	**Peugeot, Citroen**
Volkswagen	大众汽车（中国）销售有限公司	**VW, Lamborghini ,Seat, Skoda, Bentley**
Dongfeng	东风汽车有限公司	**Nissan**
Ferrari	法拉利玛莎拉蒂汽车国际贸易（上海）有限公司	**Ferrari, Maserati**
Toyota	丰田汽车（中国）投资有限公司	**Toyota, Lexus**
Ford	福特汽车（中国）有限公司	**Ford**
GAC-Honda	广汽本田汽车有限公司	**Honda**
Jaguar-LandRover	捷豹路虎汽车贸易（上海）有限公司	**Jaguar, Land Rover**
Chrysler	克莱斯勒（中国）汽车销售有限公司	**Chrysler, Dodge, Jeep**
Renault	雷诺（北京）汽车有限公司	**Renault**
Suzuki	铃木（中国）投资有限公司	**Suzuki**
Mazda	马自达（中国）企业管理有限公司	**Mazda**
Maserati	玛莎拉蒂（中国）汽车贸易有限公司	**Maserati**
McLaren	迈凯伦汽车销售（上海）有限公司	**McLaren**
Benz	梅赛德斯-奔驰（中国）汽车销售有限公司	**Smart, Benz**
Nissan	日产（中国）投资有限公司	**Infiniti**
Mitsubishi	三菱汽车销售（中国）有限公司	**Mitsubishi**
SAIC-GM	上汽通用汽车销售有限公司	**Buick, Cadillac, Chevrolet**
Ssangyong	双龙汽车（上海）有限公司	**Ssangyong**
Subaru	斯巴鲁汽车（中国）有限公司	**Subaru**
GM	通用汽车（中国）投资有限公司	**Opel**
Volvo	沃尔沃汽车销售（上海）有限公司	**Volvo**
Hyundai	现代汽车（中国）投资有限公司	**Hyundai, KIA**
FAW-Import	一汽进出口有限公司	**Audi**

Appendix V: 61 domestic auto companies fuel consumption details

Company	CAFC2014 /$T_{CAFC\ IV}$ %	$T_{CAFC\ IV}$ L/100km	CAFC2014 /$T_{CAFC\ III}$ %	2014 CAFC L/100km	$T_{CAFC2014}$ L/100km	2014 Credits L/100km	2014 vehicle weight Kg	2014 Production
SAIC-VW	133.2%	5.22	89.7%	6.96	7.76	1453378	1428	1,816,723
FAW-VW	136.9%	5.01	93.8%	6.86	7.31	773297	1317	1,718,438
SAIC-GM-WL	143.1%	4.95	102.2%	7.08	6.93	0	1181	1,545,177
Beijing Hyundai	143.6%	4.95	98.8%	7.11	7.20	100773	1296	1,119,698
DFPC	137.1%	4.95	94.2%	6.78	7.20	393176	1269	936,133
Chana-Chongqing	135.7%	4.91	96.2%	6.66	6.92	241268	1200	927,955
Chana-Ford	137.4%	5.22	92.1%	7.16	7.77	457093	1439	749,333
(Dongfeng-Peugeot-Citroen)	144.5%	5.07	99.1%	7.32	7.39	50122	1332	716,032
SAIC-GM	148.7%	5.29	99.6%	7.86	7.89	19765	1451	658,844
DF-KIA	142.6%	4.90	99.0%	7.00	7.07	45092	1268	644,166
SAIC-GM-DY	137.7%	4.95	95.7%	6.82	7.13	197434	1297	636,884
GWM	134.4%	5.29	92.3%	7.11	7.70	341981	1453	579,628
GAC-Honda	136.8%	5.06	92.5%	6.89	7.45	286267	1340	511,191
FAW-Toyata-Tianjin	132.7%	4.83	91.6%	6.40	6.99	260707	1233	441,876
SAIC-GM-BS	149.0%	5.38	101.5%	8.01	7.89	0	1504	385,448

GAC-Toyota	150.2%	5.25	100.4%	7.89	7.86	0	1451	379,923
Chery	142.9%	5.01	99.0%	7.15	7.22	22644	1318	323,486
DF-Moter	147.4%	5.27	97.9%	7.75	7.92	54450	1473	320,293
FAW-Moter	155.3%	5.25	104.6%	8.18	7.82	-38528	1449	296,366
Briliance-BMW	126.2%	5.60	82.2%	7.06	8.59	439630	1667	287,340
Dongfeng-Nissan	140.5%	5.39	97.2%	7.64	7.86	50900	1467	231,365
BAIC-Moter	149.1%	4.70	102.9%	7.03	6.83	0	1200	212,832
BYD-Auto industry	126.5%	5.01	88.1%	6.24	7.08	176626	1261	210,269
Geely-Haoqing	141.2%	4.98	100.3%	7.06	7.04	0	1281	201,355
DF-XK	143.2%	4.95	102.5%	7.10	6.93	0	1146	185,383
SAIC-Moter	144.5%	5.03	99.2%	7.22	7.28	10210	1331	170,165
Chana-Mazda	125.9%	4.98	85.9%	6.27	7.30	173552	1288	168,497
Chana-Suzuki	127.4%	4.53	91.3%	5.77	6.32	91314	1045	166,026
BAIC-YX	149.2%	4.94	105.8%	7.34	6.94	-30961	1246	162,954
JAC	138.5%	5.53	94.9%	7.66	8.07	66614	1541	162,474
Geely-Moter	122.9%	4.88	89.0%	6.16	6.92	117973	1245	155,228
Beijing-Benz	137.3%	5.86	89.0%	8.04	9.03	144665	1785	146,126
FAW-Toyata-Sichuan	150.5%	5.55	98.8%	8.43	8.53	14245	1647	142,455
GAC-Moter	158.2%	5.40	105.7%	8.55	8.09	-30040	1542	136,546
BYD-Auto industry	139.7%	5.44	98.4%	7.60	7.72	14942	1463	124,518
Jiangnan-Motor	140.4%	5.00	97.4%	7.01	7.20	20090	1301	105,736
Briliance -Jinbei	142.5%	5.24	105.7%	8.16	7.72	-20784	1411	98,971
Changhe-Suzuki	133.7%	4.54	100.5%	6.07	6.04	0	992	96,766
DF-LZM	135.8%	4.95	95.2%	6.74	7.08	30549	1259	89,851
FAW-Haima	134.6%	5.16	92.7%	6.94	7.49	46721	1377	84,947

Haima-Moter	135.2%	4.91	95.5%	6.65	6.96	26149	1249	84,350
Chana-Hebei	132.2%	5.07	94.9%	6.75	7.11	28412	1222	78,921
GAC-Fiat	138.9%	5.25	93.1%	7.29	7.83	37301	1457	69,075
FAW-Xiali	133.5%	4.38	98.5%	5.85	5.94	6065	943	67,394
Soueast Moter	126.4%	4.80	91.2%	6.14	6.73	39443	1170	66,853
GAC-Mitsubishi	147.5%	5.20	99.9%	7.65	7.66	652	1444	65,207
DF-Nissan-Zhengzhou	143.1%	5.34	101.0%	7.85	7.77	0	1431	56,559
DF-YL	168.3%	5.46	111.9%	9.19	8.21	-39559	1567	54,191
Briliance -Moter	135.6%	5.00	94.6%	6.81	7.20	17585	1305	45,089
FAW-Jinlin	151.6%	4.78	108.3%	7.21	6.66	-12601	1140	36,004
成都新大地	158.2%	5.32	106.5%	8.69	8.16	-9811	1547	33,832
JMC-Landwind	146.6%	5.63	106.1%	8.93	8.42	-8729	1630	33,572
JMC	138.0%	6.17	93.1%	8.91	9.57	21488	1954	32,557
BAIC-Foton	141.5%	6.03	102.0%	9.08	8.90	0	1737	29,434
DF-Honda	151.0%	4.83	108.3%	7.29	6.73	-10502	1080	29,172
PSA-Chana	138.6%	5.37	92.7%	7.44	8.03	15903	1512	26,955
Chana-Hefei	119.7%	4.34	88.6%	5.21	5.88	14213	936	21,213
GAC-Gonow	151.4%	5.28	108.1%	7.99	7.39	-5877	1359	15,466
Linfan-Moter	155.1%	5.06	109.5%	7.85	7.17	-6674	1275	14,509
Lifan-Car	138.5%	4.75	98.2%	6.50	6.62	1572	1187	13,099
Benz-Fujian	180.2%	6.82	115.6%	12.29	10.63	-13620	2192	10,164

Appendix VI: 28 importing auto companies fuel consumption details

Company	CAFC2014 /$T_{CAFC\ IV}$	$T_{CAFC\ IV}$	CAFC2014 /$T_{CAFC\ III}$	2014 CAFC	$T_{CAFC2014}$	2014 Credits	2014 average vehicle mass	2014 displacement	2014 production
	%	L/100km	%	L/100km	L/100km	L/100km	Kg	L	
BMW	136%	5.8	87.9%	8.0	9.0	210513	2.3	1792	194959
Benz	136%	6.0	87.1%	8.2	9.4	176907	2.6	1844	144113
Chrysler	161%	5.9	103.6%	9.4	9.1	-7683	2.5	1786	135698
Jaguar-LandRover	147%	6.4	93.3%	9.4	10.1	85231	2.4	2091	127264
Toyota	146%	5.8	94.3%	8.5	9.0	51126	2.6	1776	101157
Volkswagen	150%	5.9	97.0%	8.8	9.1	24000	2.1	1804	88266
FAW-Import	141%	6.1	90.7%	8.6	9.5	74093	2.6	1922	83061
Subaru	144%	5.4	97.2%	7.9	8.1	13885	2.3	1530	64636
Porsche	158%	6.2	100.0%	9.8	9.8	0	2.8	1995	52517
Volvo	137%	5.6	89.3%	7.7	8.7	46054	2.1	1687	49684
Hyundai	159%	5.8	102.6%	9.3	9.1	0	2.3	1777	46190
SAIC-GM	175%	6.2	112.2%	10.8	9.7	-37293	2.9	1981	42532
Ford	149%	6.3	95.0%	9.4	9.9	20323	2.6	1989	41766
Renault	154%	5.5	101.3%	8.5	8.4	0	2.2	1586	36024
Nissan	162%	5.9	104.1%	9.6	9.2	-3383	2.7	1810	34345

Mitsubishi	160%	5.5	102.3%	8.8	8.6	0	2.5	1669	23286
Ssangyong	155%	5.5	99.6%	8.5	8.6	374	2.0	1649	14136
Maserati	155%	6.4	98.2%	9.9	10.1	1920	3.1	2005	10202
Honda	165%	5.8	106.7%	9.6	9.0	-1937	3.1	1770	5879
Suzuki	162%	4.6	112.3%	7.5	6.6	-2671	1.5	1138	4762
Peugeot Citroen	149%	5.2	103.0%	7.8	7.6	111	1.9	1370	3154
Mazda	152%	5.5	99.4%	8.4	8.4	0	2.0	1572	2500
Dongfeng	177%	6.6	112.0%	11.6	10.4	-639	4.0	2203	782
Ferrari	220%	5.6	144.0%	12.4	8.6	-1848	4.8	1664	568
GM	169%	5.6	108.7%	9.5	8.7	-214	2.0	1690	522
McLaren	210%	5.6	142.0%	11.7	8.2	-804	3.8	1535	209
Aston Martin	238%	6.0	152.4%	14.3	9.4	-517	5.8	1915	209
Lotus	184%	4.9	112.5%	9.0	8.0	-29	3.3	1442	49

Note: 1. The passenger car production of the above enterprises in 2014 exceeded 10000;

2. CAFC actual value and target value of domestic passenger car auto companies in 2014 and are published by MIIT;

3. CAFC target values in 2020 is calculated based on passenger car production in 2014 and Phase IV model target, available through China's Automobile Industry Association;

4. In order to ensure the consistency of data sources, while calculating CAFC / $T_{CAFC\,IV}$, iCET conducted CAFC actual value and target value accounting according to the model output data obtained from the China Automobile Industry Association, rather than directly using public data of MIIT.

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