

CHINA'S STAGE 6 EMISSION STANDARD FOR NEW LIGHT-DUTY VEHICLES (FINAL RULE)

ICCT **POLICY UPDATES**
 SUMMARIZE
 REGULATORY
 AND OTHER
 DEVELOPMENTS
 RELATED TO CLEAN
 TRANSPORTATION
 WORLDWIDE.

On December 23, 2016, the Ministry of Environmental Protection (MEP) of the People's Republic of China released the final rule of the Stage 6 Limits and Measurement Methods for Emissions from Light-Duty Vehicles¹ (GB18352.6—2016; hereafter referred to as the *China 6 standard* or *China 6*). This standard applies to light-duty vehicles (M1, M2, and N1 categories up to 3,500 kg of maximum mass per the European regulatory classification²) powered primarily by gasoline or diesel. The China 6 standard will take effect beginning on July 1, 2020.

Unlike the previous standard phases, which closely follow the European emission standards, the China 6 standard combines best practices from both European and U.S. regulatory requirements in addition to creating its own. Specifically, the standard features

- » Two sets of fuel-neutral emission limits—China 6a and 6b—for air and climate pollutants, including carbon monoxide (CO), total hydrocarbons (THC), nitrogen oxides (NO_x), particulate matter (PM), particle number (PN), and nitrous oxide (N₂O);
- » A shift from the New European Driving Cycle (NEDC) to the more representative and dynamic World Harmonized Light Vehicle Test Cycle (WLTC) and more rigorous World Harmonized Light Vehicle Test Procedures (WLTP);
- » Adoption of real-world driving emission (RDE) testing and requirements based on the European RDE provision passed in March 2016, with modifications that address the unique driving conditions in China for both type test and in-use conformity;
- » Enhanced on-board diagnostics (OBD) provisions based on the U.S. OBD II program;
- » Stringent evaporative and refueling emission-control requirements equivalent to the U.S. Tier 2 requirement with a streamlined test procedure;
- » Introduction of a low-temperature testing requirement and emission limits for CO, THC, and NO_x for both gasoline and diesel vehicles; and

1 Limits and measurement methods for emissions from light-duty vehicles (CHINA 6). Retrieved from http://kjs.mep.gov.cn/hjbhbz/bzwb/dqjhbh/daydywrwpfbz/201612/t20161223_369476.shtml (in Chinese)

2 At manufacturers' request, M1, M2, N1, and N2 categories over 3,500 kg can also be type-tested according to this standard.

- » A multi-component compliance program involving agency- and manufacturer-run emission tests during pre-production, production, and in-use stages, and China's first emission warranty and defect reporting program.

This policy update provides further details about some of these features, a comparison with emission regulations in other major markets, and a summary of the impact of this rule.

POLICY BACKGROUND

The modern nationwide vehicle emission control program in China began in the late 1990s. The China LDV emission regulations follow European Union regulatory pathways, with the implementation dates of the China LDV standards generally lagging behind the equivalent EU standard by 5–10 years. The China 6 standard was first proposed in May 2016 and finalized in December 2016, with the aim of significantly reducing air pollutant emissions from light-duty vehicles and contributing to addressing severe air pollution in China.

CHINA 6 STANDARD EMISSION LIMITS AND REQUIREMENTS

This section focuses on emission limits and provisions for the new China 6 standard: for normal ambient temperature, real-world emissions, evaporative emissions, low ambient temperature tests, and OBD system provisions.

EXHAUST EMISSIONS TEST UNDER NORMAL AMBIENT TEMPERATURE (TYPE I TEST)

The China 6 standard shifts away from the NEDC and adopts the more dynamic and realistic WLTC and more rigorous WLTP. Compared with NEDC, WLTC has a higher maximum velocity, more frequent and harder accelerations, a smaller share of idling time, and covers a wider spectrum of operating conditions.

There are two sets of emission limits to be implemented in two phases nationwide—China 6a in July 2020 and China 6b in July 2023 (Table 1). Provinces that struggle with severe air pollution may opt to implement both phases earlier than the national schedule.

Limit values for China 6a are generally comparable with those under Euro 6 standard, with two exceptions. First, China 6 emission limits are largely fuel neutral, meaning limits for key pollutants are equally stringent for gasoline and diesel vehicles. This makes the CO limit for gasoline cars and NO_x limit for diesel cars under China 6a more stringent than the corresponding limits under the Euro 6 standard. Second, China 6a regulates two greenhouse gas pollutants N₂O and methane (CH₄). The CH₄ is indirectly regulated with limits of THC and non-methane hydrocarbons (NMHC).

China 6b further lowers the limits by about one third to half of the magnitude for NO_x, THC, NMHC, PM, and CH₄, on top of the China 6a standard.

Table 1. Emission Limits for Type I Test Under China 6a and 6b

Vehicle Category ^[1] /Test Mass (kg)		CO (g/km)	THC (g/km)	NMHC (g/km)	NO _x (g/km)	N ₂ O (g ² /km)	PM (g/km)	PN ^[2] (#/km)
China 6a								
I	All	0.7	0.1	0.068	0.06	0.02	0.0045	6.0 x 10 ¹¹
	TM≤1305	0.7	0.1	0.068	0.06	0.02	0.0045	6.0 x 10 ¹¹
II	1305<TM≤1760	0.88	0.13	0.09	0.075	0.025	0.0045	6.0 x 10 ¹¹
	TM>1760	1	0.16	0.108	0.082	0.03	0.0045	6.0 x 10 ¹¹
China 6b								
I	All	0.5	0.05	0.035	0.035	0.02	0.003	6.0 x 10 ¹¹
	TM≤1305	0.5	0.05	0.035	0.035	0.02	0.003	6.0 x 10 ¹¹
II	1305<TM≤1760	0.63	0.065	0.045	0.045	0.025	0.003	6.0 x 10 ¹¹
	TM>1760	0.74	0.08	0.055	0.05	0.03	0.003	6.0 x 10 ¹¹

[1] Category I refers to passenger vehicles not exceeding 2,500 kg of maximum mass and not exceeding six seats, and Category II refers to all other light-duty vehicles

[2] Before July 1, 2020, a transitioning PN limit of 6.0×10¹² #/km applies on gasoline cars.

REAL-DRIVING EMISSIONS TESTING (RDE)

The China 6 standard includes RDE tests during both vehicle prototype and in-service stages. The emission limits for RDE tests are set as not-to-exceed (NTE) limits expressed as the product of a conformity factor (CF) and emission limits in the Type I Test. The China 6 RDE provision is primarily based on the Euro 6 RDE Package 2 passed in March 2016, with a few enhancements and modifications for the Chinese context. For NO_x and PN, there are only monitoring and recording requirements before July 2023, and CFs will be enforced starting from July 2023. The CFs of NO_x and PN are temporarily set at 2.1 and will be reevaluated by July 2022. CO will be monitored in RDE tests, whereas no CFs have been set thus far. For passenger cars, for example, this leads to NTE limits of 0.0735 g/km for NO_x and 1.26 x 10¹² #/km for PN, which will apply once China 6b takes effect in July 2023. China 6 also extends the altitude boundary condition to 2,400 m compared with 1,300 m for Euro 6 RDE. Accordingly, the second-by-second emission results of RDE tests at extended high altitude (1,300–2,400 m) will be divided by a factor of 1.8 when integrated into the RDE test results.

Table 2 provides a detailed comparison of the requirements and design of the RDE tests between China 6 RDE and the third legislative package of RDE requirements for Euro 6 passed in December 2016 (with certain elements still under discussion). The differences are highlighted in red.

Table 2. Comparison Between Euro 6 and China 6 RDE Requirements

	Requirement	Euro 6	China 6
Application	Type Approval/Test	Yes	Yes
	In-service test	Yes*	Yes
Emission standard	Regulated pollutants	NO _x and PN after monitoring period Monitoring for CO	
	Binding limits in Type I Test**	NO _x : Diesel: 0.08 g/km Gasoline: 0.06 g/km PN: 6 x 10 ¹¹ #/km	Fuel-neutral NO _x : 0.035 g/km PN: 6 x 10 ¹¹ #/km
	Conformity factors***(effective date)	New types: 2.1 (9/1/2017) All new vehicles: 2.1 (9/1/2019) New types: 1.5 (1/1/2020) All new vehicles: 1.5 (1/1/2021)****	All new vehicles: 2.1 (7/1/2023)
	Cold starts	Included	Excluded
Trip requirement	Total trip duration	90-120 min	
	Minimum distance for each segment	Urban: 16 km Rural: 16 km Motorway: 16 km	
	Trip composition	Urban: 29%-44% of total distance Rural: 23%-43% of total distance Motorway: 23%-43% of total distance	
	Average speed	Urban: 15-40 km/h Rural: 60-90 km/h Motorway: >90 km/h	
	Stop percentage during urban segment	6%-30%	
	Maximum speed during motorway segment	145 km/h (160 km/h for 3% of motorway driving time)	120 km/h (135 km/h for 3% of motorway driving time)
	High-speed duration during motorway segment	At least 5 min driving at >100km/h speed;	
Boundary condition	Payload	≤90% of maximum weight	
	Ambient temperature	Before 1/1/2020 (for new types), and 1/1/2021 (for all new vehicles): Moderate: 3°C-30°C Extended: -2°C-3°C and 30°C -35°C Afterward: Moderate: 0°C-30°C Extended: -7°C-0°C, 30°C-35°C	Moderate: 0°C-30°C Extended: -7°C-0°C, 30°C-35°C
	Altitude	Moderate: <700 m Extended: 700 m-1,300 m	Moderate: <700 m Extended: 700 m-1,300 m Further extended: 1,300 m-2,400 m
	Correction factor	Extended: 1.6	Extended: 1.6 Further extended: 1.8
	Altitude requirements	Start and end point shall not differ more than 100 m in altitude Maximum cumulative altitude increase: 1,200 m over a distance of 100 km	
	Dynamic requirements	For each segment, Max. limit is defined as the 95th percentile of v*a (speed * positive acceleration) Min. limit is defined by the RPA (relative positive acceleration)	
	Use of auxiliary systems	Free to use as in real life	
Evaluation methods	Data evaluation methods	Moving average window method or power binning method	Moving average window method
	Verification of test normality in moving average window method	Maximum primary tolerance for the CO ₂ characteristic curve: 30%	Maximum primary tolerance for the CO ₂ characteristic curve: 50%

*Part of RDE fourth legislative package, currently under technical discussion

**The emission limits in this table are for M1 and M2 vehicles in the EU and M1 Category I vehicles in China.

***For the whole trip and for the urban segment separately

****Implementation dates for Classes 2 and 3 of N1 and N2 vehicles are always 1 year later than the dates listed above.

NOTE: Table revised as of 3/20/17.

EVAPORATIVE AND REFUELING EMISSION REQUIREMENTS

The China 6 standard significantly tightens the evaporative emission control over the China 5 standard by lowering emission limits (Table 3) and adopting a creative 48-hour diurnal test procedure under high heat soak conditions ($38 \pm 2^\circ\text{C}$). In addition, China 6 also adopts a refueling emission test and emission limit of 0.05 g/L, similar to the U.S. Tier 2 standard requirement. The combined efforts have the potential to achieve the U.S. Tier 2 evaporative emission control results with a reduced test burden to manufacturers.

Table 3. Emission Limits of Evaporative Emission Test

Vehicle category	Test mass (TM)/(kg)	Emission limits/(g/test)
I	All	0.70
II	$\text{TM} \leq 1,305$	0.70
	$1,305 < \text{TM} \leq 1,760$	0.90
	$1,760 < \text{TM}$	1.20

Table 4 compares the key features of evaporative emission control requirements among the China 5, China 6, and U.S. Tier 2 regulations.

Table 4. Comparison of Key Parameters in Evaporative Emission Test Procedures in China and the United States

Program components	China 5	China 6	US Tier 2
24-hour diurnal + hot soak	2.0 g/test	/	/
48-hour diurnal + hot soak	/	0.7-1.2 g/test	0.65 g/test
72-hour diurnal + hot soak	/	/	0.50 g/test
Hot soak temperature	20-30°C	$38 \pm 2^\circ\text{C}$	35°C
Test cycle	ECE+EUDC	WLTC	UDDS+FTP

LOW-TEMPERATURE EMISSION LIMITS

The China 6 standard includes emission tests and limits for CO, THC, and NO_x on both gasoline and diesel cars under ambient temperatures of $-7(\pm 3)^\circ\text{C}$ over the low- and middle-speed part of the WLTC (Table 5).

Table 5. Emission limits of Type VI Test

Vehicle Category	Test mass (TM)/(kg)	CO (g/km)	THC (g/km)	NO_x (g/km)
I	All	10.0	1.20	0.25
II	$\text{TM} \leq 1,305$	10.0	1.20	0.25
	$1,305 < \text{TM} \leq 1,760$	16.0	1.80	0.50
	$1,760 < \text{TM}$	20.0	2.10	0.80

OBD SYSTEM PROVISIONS

The China 6 OBD provisions are largely based on the California OBD II rule (2013)³ but have removed or exempted a few monitoring requirements to reduce compliance burdens to car manufacturers. A list of exemptions can be found in Appendix A. Compared with the China 5 standard, the China 6 OBD provision includes much more comprehensive monitoring requirements, including monitoring the vapor leak (at least 0.1 mm) from the evaporative emission control system, as well as a number of anti-tampering and anti-fraud requirements, such as a permanent fault code, calibration identification number, and calibration verification number.

OBD emission thresholds, above which the malfunction indicator light is triggered, are shown in Table 6.

Table 6. OBD Emission Threshold

Vehicle category	Test mass (TM)/(kg)	CO (g/km)	NMHC+NO _x (g/km)	PM (g/km)
I	All	1.900	0.260	0.012
II	TM≤1,305	1.900	0.260	0.012
	1,305<TM≤1,760	3.400	0.335	0.012
	1,760<TM	4.300	0.390	0.012

The In-Use Performance Ratio (IUPR) is defined as the frequency of monitoring events per driving cycle or trips, and a higher IUPR requirement increases the opportunity of detecting malfunctions. For different monitoring items, the minimum IUPR requirements in China 6 ranges from 0.1 to 0.336.

Considering the tremendous challenges in fulfilling all OBD requirements, the China 6 standard also includes some requirements regarding OBD deficiency. The regulatory agency allows deficiency of one or more monitoring functions and classifies all deficiencies into two categories—major and minor deficiencies. *Major deficiencies* refer to failures to monitor and detect malfunctions of major emission-control systems (or systems that affect emissions), such as catalyst, misfire, exhaust gas recirculation (EGR), and diesel/gasoline particulate filter (DPF/GPF), which lead to emission levels higher than the OBD emission threshold but less than twice the OBD emission thresholds. Manufacturers are allowed to apply for up to three major deficiency items. *Minor deficiencies* refer to other failures to meet the OBD requirements. The regulatory agency, however, does not allow deficiencies that lead to emission levels above twice the threshold amounts. Depending on complexity of the deficiencies, manufacturers are allowed to have up to a 3-year grace period to address the issues. The standard has not specified any penalty for the deficiencies.

³ Title 13, Section 1968.2, California Code of Regulations

COMPLIANCE PROGRAM

The compliance program in the China 6 standard is the most comprehensive ever in China, and it includes a number of manufacturer-run and agency-run emission tests from vehicle prototype throughout vehicle useful life. Manufacturers are required to test their vehicles at low (10,000–60,000 km), medium (60,000–110,000 km), and high (110,000–160,000 km) mileages and report their test results to the regulatory agency. Then, the agency has the authority to randomly test in-use vehicles up to 160,000 km of driving. For the manufacturer-run tests, manufacturers must perform at least six of the eight required type tests⁴. Nevertheless, the regulatory agency may conduct all type tests for its verification test program. A full list of the type tests can be found in Appendix B.

China 6 also introduces the very first emission warranty and defect-reporting requirement in China. Manufacturers are required to warrant a list of emission-control parts in their new vehicles for a minimum of 3 years/60,000 km (whichever arrives sooner). Manufacturers are also required to record the maintenance of emission warranty parts and related OBD malfunctions and reasons. If the maintenance rate of an emission warranty part exceeds 4%, manufacturers shall report it to authorities within 30 days. These program elements are plotted in Figure 1, against a mileage scale indicating vehicle useful life.

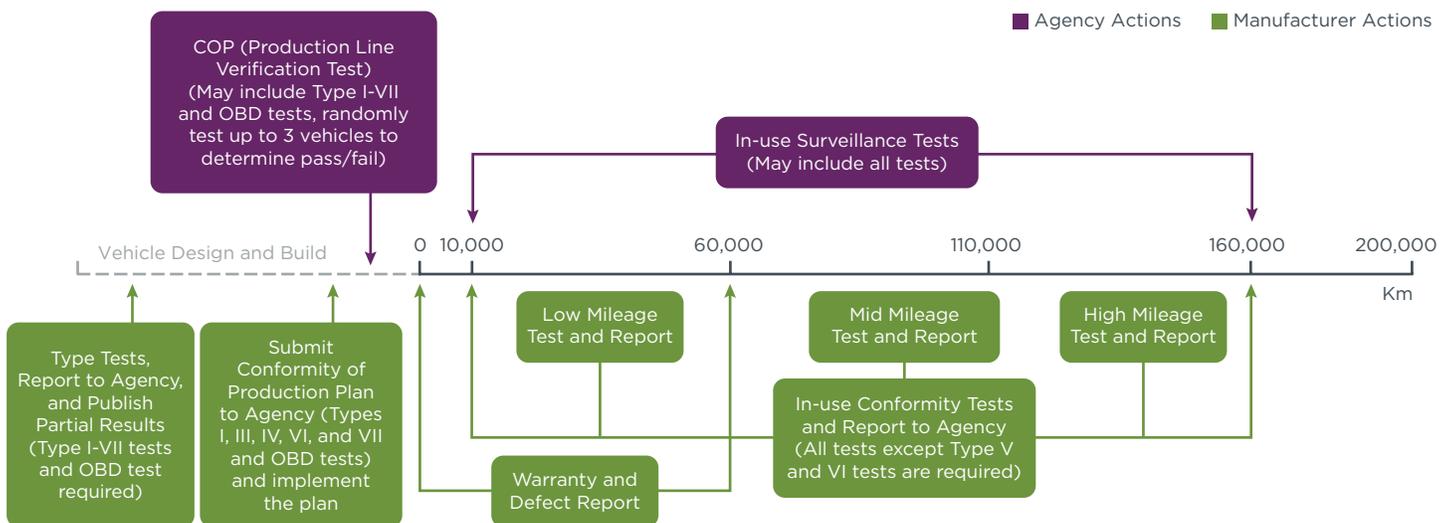


Figure 1. Illustration of China 6 Compliance Program

4 Per requirements in China's newly amended Air Pollution and Control Law, starting from the China 6 regulation, the regulatory agency no longer type approves new vehicle models. The Chinese MEP used to have a procedure of issuing certification to new vehicle models that are tested to comply with emission standards. This procedure was referred to as *vehicle type approval*. Under the new law, vehicle manufacturers self-test and self-certify their new vehicle models and need to report to the regulatory agency and publish required information to the public. MEP still establishes the test protocols and emission limits for all required tests. The set of tests are referred to as *type tests*. The China 6 standard includes eight type tests: Type I-VII tests plus the OBD test. A full list of the type tests can be found in Appendix B.

In addition, the China 6 standard prohibits the use of a defeat device, with language similar to that used in the European regulation. Specifically, a *defeat device* is defined as “a device or design strategy which through measuring, sensing or reacting to vehicle operational parameters (including vehicle speed, engine speed, transmission gear, temperature, altitude, intake manifold vacuum or any other parameter) activates, adjusts, delays or suspends the operation of any part of the emission control system, that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use. And the following measures shall not be considered as defeat devices:

- » The need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle;
- » The device does not function beyond the requirements of engine starting;
- » The devices or strategies are truly effective in Type I, II, III, IV, VI and VII Tests.”

However, the standard does not specify any procedure or details of reporting or evaluation of defeat devices.

INTERNATIONAL CONTEXT

The China 6 standard is one of the most stringent emission standards around the world for the post-2020 time frame, as shown in Figures 2 and 3, which compare emission limits for two major air pollutants—non-methane organic gas (NMOG)+NO_x and PM—among China, Europe, and the United States. Regardless of test procedure differences, the NMOG+NO_x limits under China 6a are comparable or slightly more stringent than those under Euro 6. The limits under China 6b are significantly tightened over the Euro 6 limits and are approaching the stringency level of the U.S. Tier 3 standard. A similar pattern exists in the PM emission limit comparison among the three regions.

Adoption of the China 6 standard also helps narrow the gap between China and the world’s leading markets in tightening their emission requirements for new light-duty vehicles. As Figures 2 and 3 show, it has taken China about a decade and half from its very first emission regulation to a world-class emission standard. In the United States and European Union, this took almost a full decade longer.

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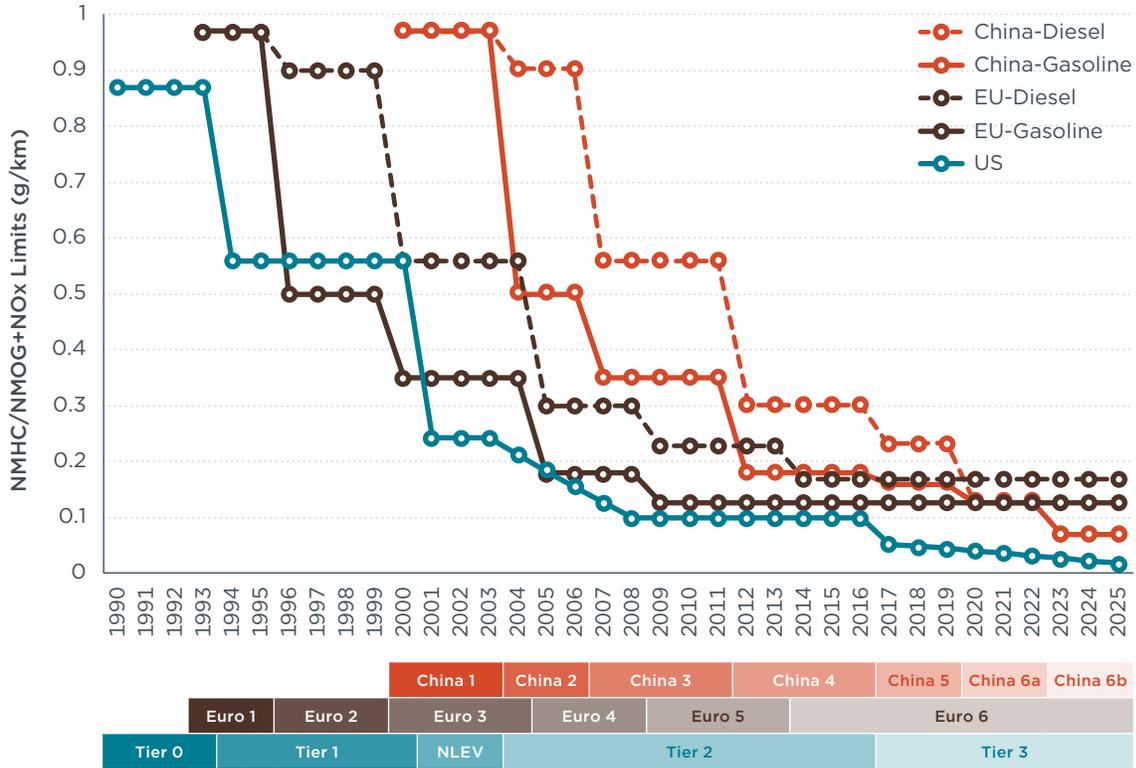


Figure 2. Comparison of NMOG/NMHC+NO_x emission requirements in China, the European Union, and the United States during 1990–2025.

Notes: [1] For gasoline vehicles, the European Union regulated HC and NO_x prior to the Euro 5 standard, but only began to regulate NMHC emissions beginning with Euro 5. Therefore, the NMHC+NO_x limit values for the Euro 1–4 standards were approximated by using HC+NO_x limits or summing up the separate HC and NO_x limits. For diesel vehicles, the EU regulates HC+NO_x emission.

[2] Similar to Europe, China regulated HC and NO_x for gasoline vehicles separately for gasoline vehicles before the China 6 standard. The sum of the two pollutant emission limits was used as a proxy for NMHC+NO_x limits. Beginning with the China 6 standard, there are direct NMHC and NO_x limits. For diesel vehicles, China regulated HC+NO_x emission before the China 6 standard.

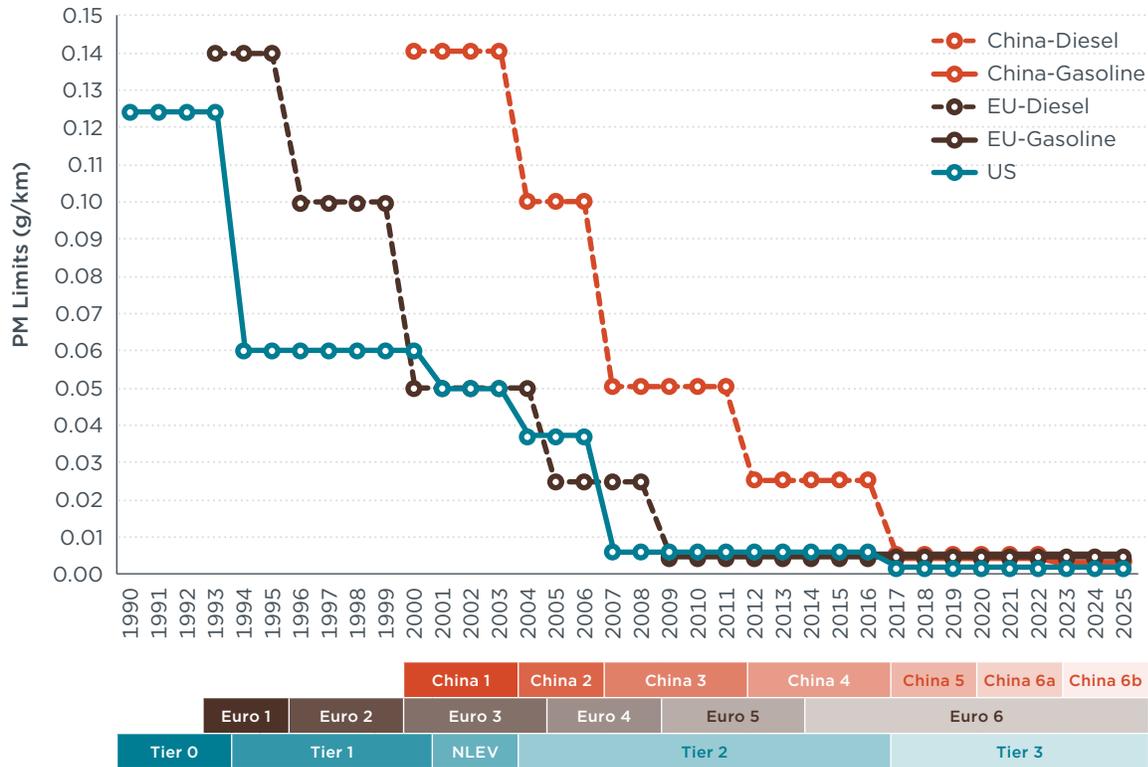


Figure 3. Comparison of PM emission requirements in China, the European Union, and the United States during 1990–2025.

ESTIMATED BENEFITS

We conducted an independent analysis to estimate emissions and health benefits of the China 6 standard.⁵ The total PM_{2.5} and ozone-related health benefits from implementing the China 6 standard are valued at USD 42.4 billion (CNY 284.3 billion) at a cost of USD 4.8 billion (CNY 31.8 billion) in the year 2030, with a benefit-to-cost ratio of 8.9:1 and annual net benefit of USD 37.7 billion (CNY 252.4 billion). Table 7 provides the projected reductions of six conventional air pollutants from LDVs in the entire nation and also in three key regions in 2030 with implementation of China 6 over the China 5 standard.⁶ The modeled annual emission differences for PM_{2.5} and NO_x at the national scale are illustrated in Figure 4.

5 The analysis was based on the proposal of China 6 standard released in May 2016 and does not reflect the changes from the proposal to the final rule. The analysis will be published later.
 6 For this analysis, we assumed the three key regions will adopt China 6b with advanced schedule.

Table 7. Projected Emission Reduction from Light-Duty Vehicles in 2030 (thousand tons)

	CO	NO _x	PM _{2.5}	HC			BC	OC
				Tailpipe	Evap.	Total		
China (incl. three key regions)	3,396	1,001	25.92	550	3,633	4,184	5.62	2.00
Jing Jin Ji Region	431	107	3.15	70.16	N/A	N/A	0.56	0.21
Yangtze River Delta Region	705	202	5.42	117	N/A	N/A	1.11	0.40
Guangdong	401	172	3.59	70.86	N/A	N/A	1.04	0.33

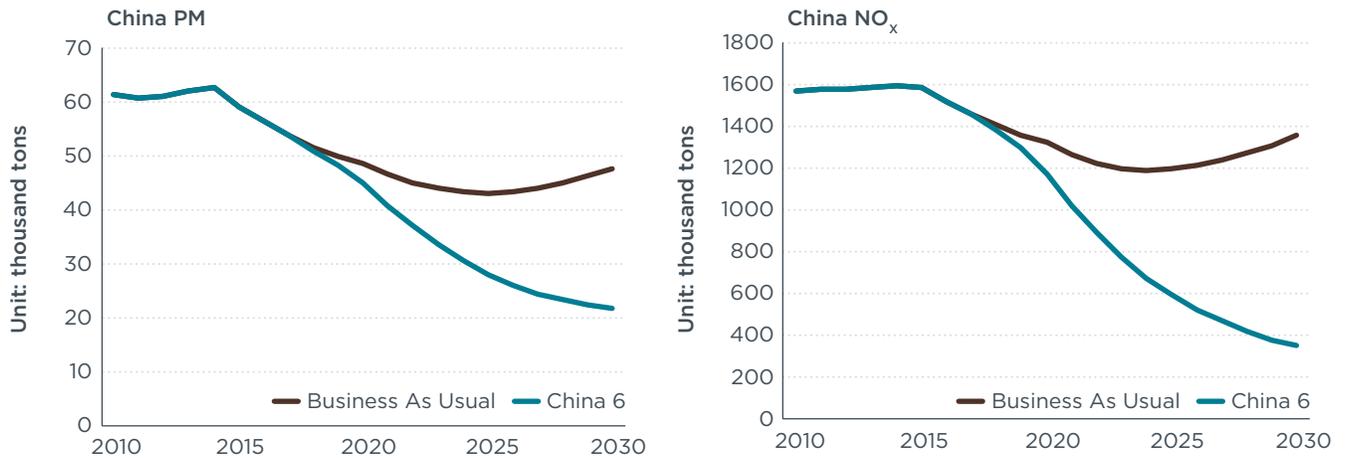


Figure 4. Estimated Annual LDV Emissions Modeling Results for PM_{2.5} and NO_x at the National Level

APPENDIX A. REDUCED OBD REQUIREMENTS AND EXEMPTIONS COMPARED WITH OBD II

For light-duty gasoline vehicles, the following items are removed or considered as exemptions:

- » The option of using a 2.3-mm vapor leak for evaporative system monitoring (only a 1-mm leak is included in China 6),
- » Monitoring a direct ozone reduction (DOR) system,
- » Monitoring the emission correlated air/fuel ratio cylinder imbalance,
- » Added exemption conditions of monitoring a crankcase ventilation system, and
- » Added exemption conditions of evaporative system monitoring.

For light-duty diesel vehicles, the following items are removed or considered as exemptions:

- » Monitoring of heat to assist in DPF regeneration;
- » Monitoring of auxiliary gas to facilitate a selective catalytic reduction (SCR) reaction;
- » Monitoring of fuel injection quantity and timing;
- » Monitoring of the EGR catalyst performance;
- » Monitoring of the complete failure of post-SCR catalyst;
- » Monitoring of fuel control error compensation during the production and maintenance stages;
- » Monitoring of the slow response in close-loop control for SCR, EGR, boost pressure control system (PCR), and fuel-supply systems;
- » Added exemption conditions of monitoring frequent DPF regeneration, and incomplete regeneration; and
- » Added exemption conditions of monitoring the crankcase ventilation system.

APPENDIX B. TYPE TESTS AND APPLICATION

Type test items	Light-duty vehicle equipped with positive-ignition engine (including HEV)			Light-duty vehicle equipped with compression-ignition engine (including HEV)
	Gasoline vehicles	Bi-fuel vehicles	Mono-fuel gas vehicles	
Type I – Gaseous pollutants	YES	YES	YES	YES
Type I – PM	YES	YES (Test gasoline only)	NO	YES
Type I – PN	YES	YES (Test gasoline only)	NO	YES
Type II	YES	YES (Test gasoline only)	YES	YES
Type III	YES	YES (Test gasoline only)	YES	YES
Type IV	YES	YES (Test gasoline only)	NO	NO
Type V	YES	YES (Test gas fuel only)	YES	YES
Type VI	YES	YES (Test gasoline only)	YES	YES
Type VII	YES	YES (Test gasoline only)	NO	NO
OBD system	YES	YES	YES	YES

*Note:**Type I Test: exhaust emissions test after a cold start at normal ambient temperature**Type II Test: real-driving emissions (RDE) test**Type III Test: crankcase pollutants emissions test**Type IV Test: evaporative emissions test**Type V Test: pollution-control devices durability test**Type VI Test: CO, THC, and NO_x emissions test after a cold start at low ambient temperature**Type VII Test: refueling evaporative emissions test*