Case of China in implementing China 4/IV-5/IV and designing China 6/VI standards

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- An independent non-profit research organization
- Our Mission: To improve environmental performance and efficiency of mobile sources (cars, trucks, marine, aviation) and fuels by supporting government regulatory agencies in world's top vehicle markets.
- Offices in Washington D.C., San Francisco, Berlin, Beijing

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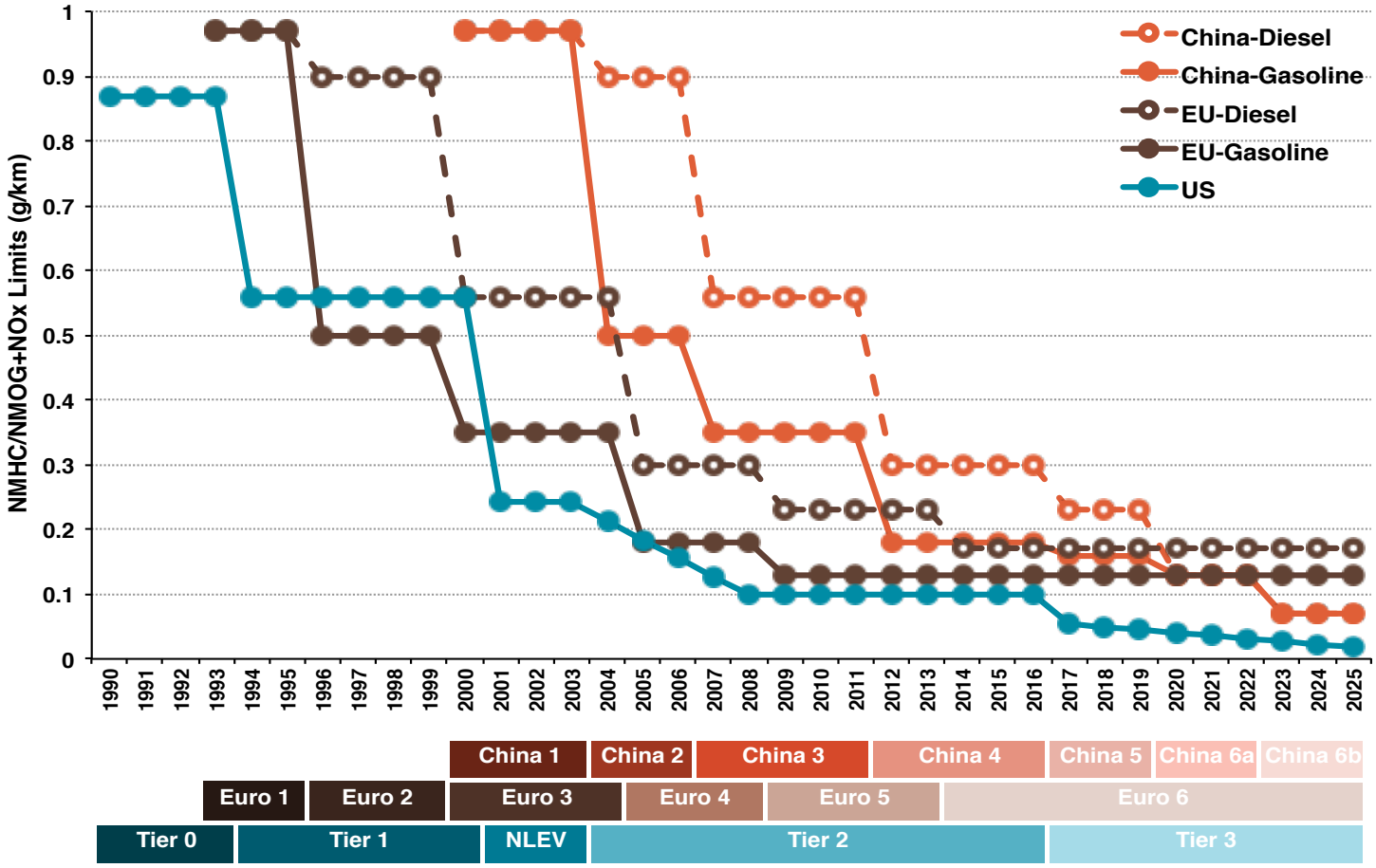
Overview

- Overview China vehicle emission standards
- Implementation of China 4/IV and China 5/V
  - The real-world emissions problem
  - Revised Clear Air Law
- Design of China 6/VI
  - China 6 LDV standard
  - China VI HDV standard (proposal)
  - Supplemental China V HDV standard
- Summary

Overview of China vehicle emission standards

LDV NOx emission requirements



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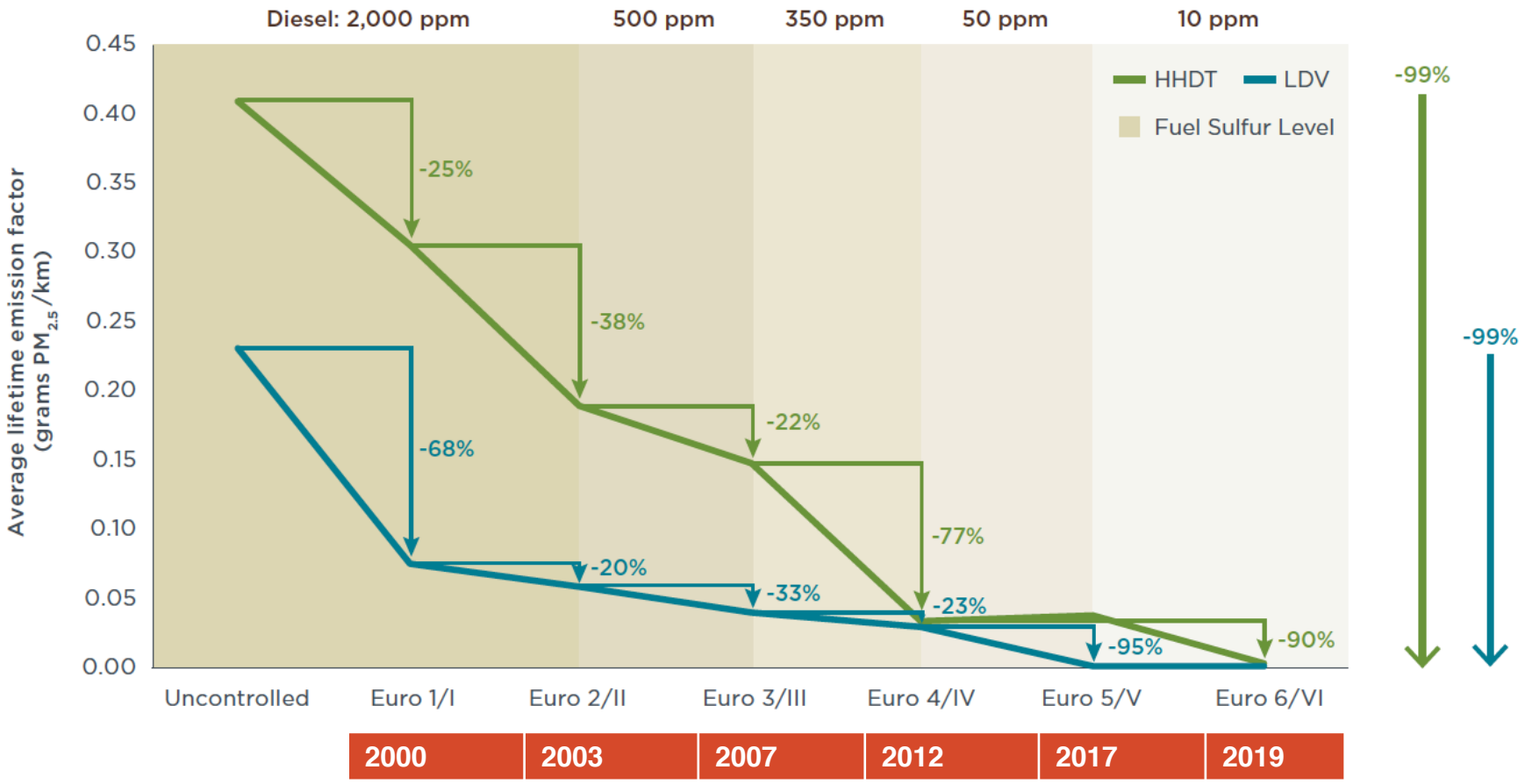
HDV PM emission requirements



PN requirements in proposed China VI

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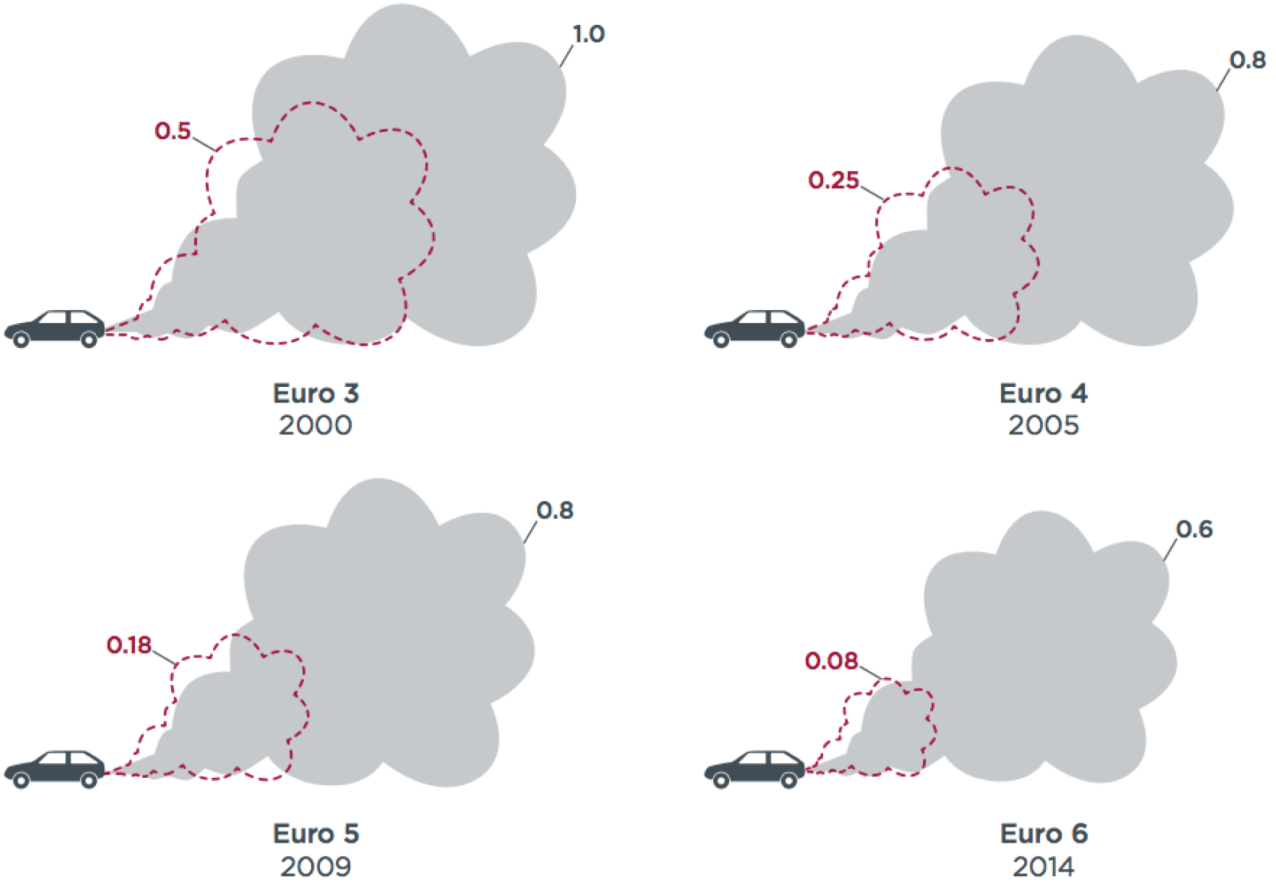
Implementation of China 4/IV

Real world NO_X emissions from diesels are not following the reduction trends set by standards



Source for Euro 3 to Euro 5: Carslaw et al. (2011). Recent evidence concerning higher NOX emissions from passenger cars and light duty vehicles. Journal of Atmosphereic Environment 45 (2011) 7053-7063.

Gasoline LDV emissions have declined significantly as standards improved in China

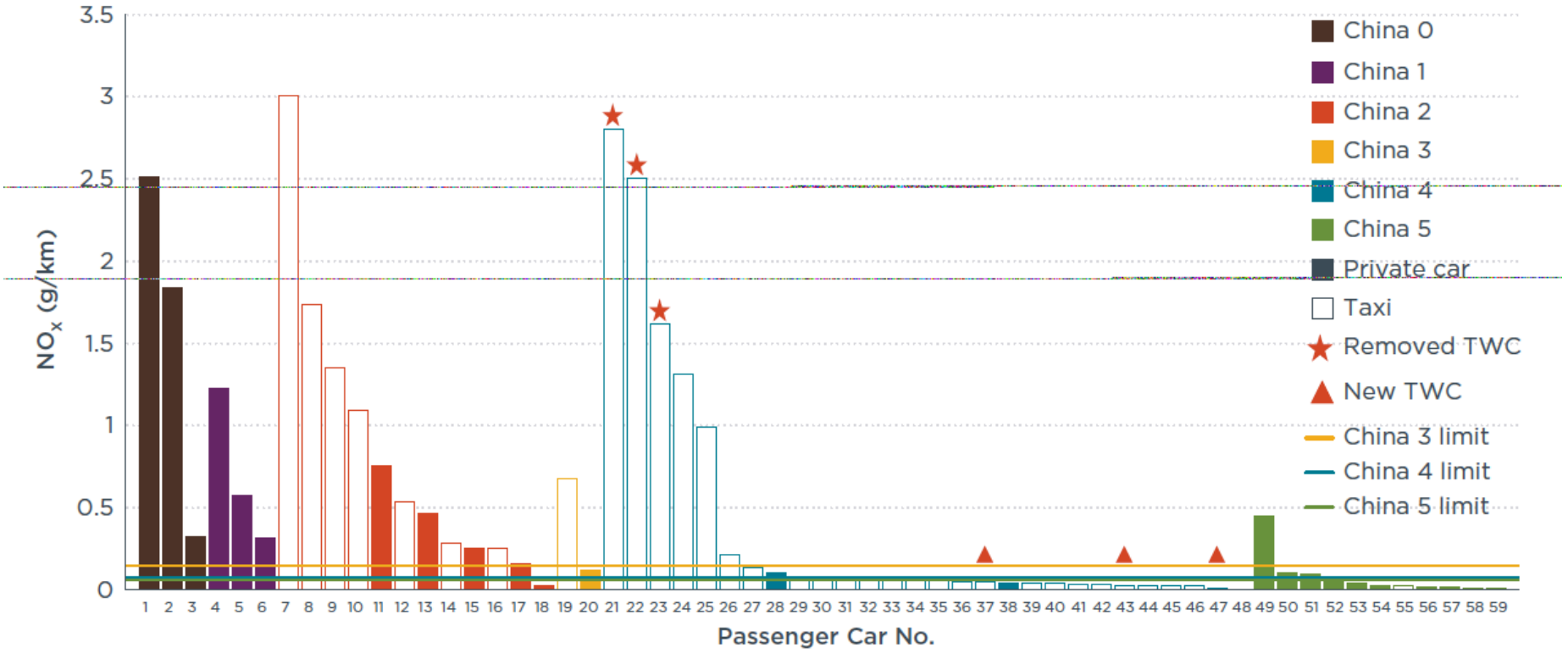


Figure ES1. Real-world NO_x emissions from gasoline cars, by vehicle.

Different colors indicate emissions standards from China 0 to China 5. Solid bars are private cars and open bars are taxis. Stars indicate vehicles with removed TWC. Triangles indicate cars with newly replaced TWC.

https://www.theicct.org/publications/real-world-emissions-china-meta-study-pems-data

While no significant NO_X improvements for diesel HDVs

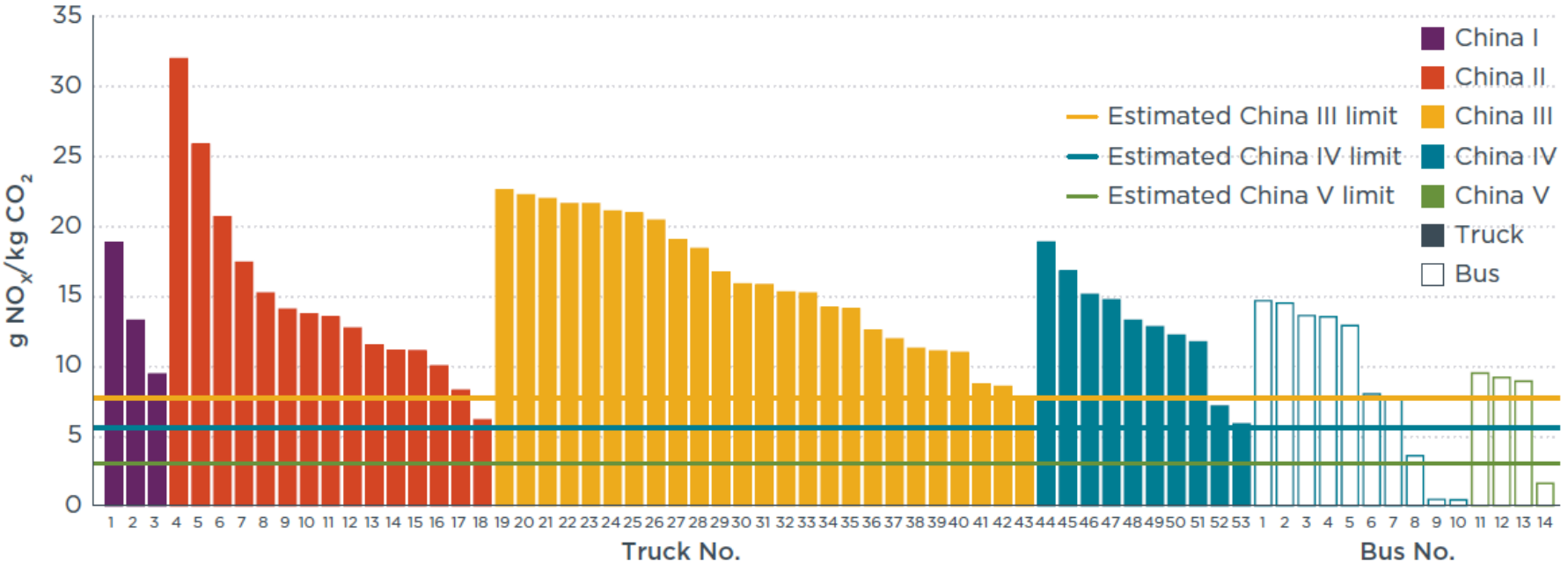


Figure ES2. Real-world NO_x/CO_2 emissions of diesel HDVs, by vehicle.

Different colors indicate emissions standards from China I to China V. Solid bars are diesel trucks and open bars are diesel buses.

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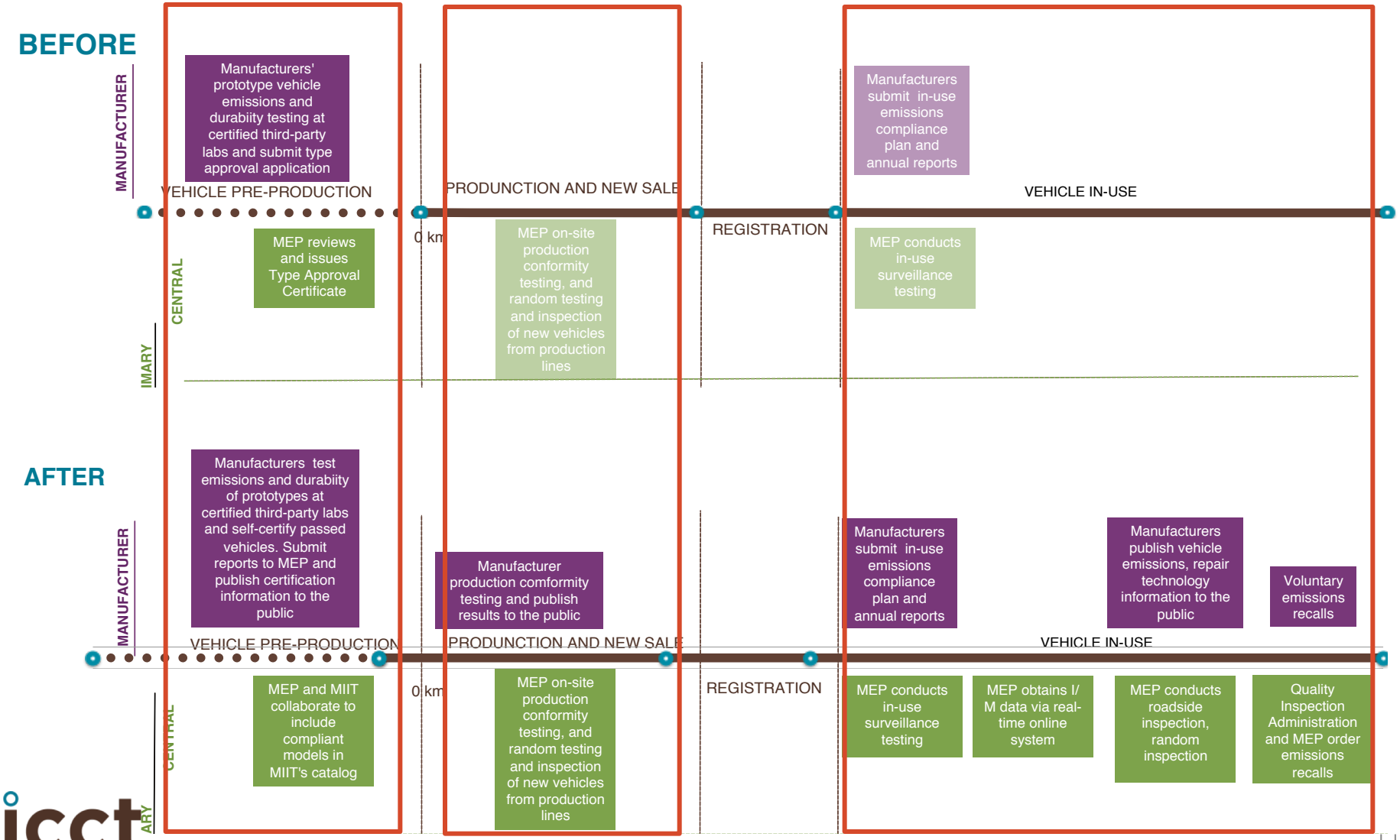
Revised Clean Air Law provides opportunity to enhance compliance and enforcement



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Design of China 6 LDV standard

Highlights of China 6 LDV standard

- Two phases:
  - China 6a (July 1, 2020) – similar to Euro 6 but fuel-neutral
  - China 6b (July 1, 2023) – more stringent than 6a
- Shift from the NEDC to WLTP;
- Adopt real-world driving emissions (RDE) testing – type approval and in-use conformity;
- Enhanced on-board diagnostics (OBD) provisions;
- Enhanced compliance: emission warranty and defect reporting

China 6 RDE regulation

The issue China is facing

No substantial diesel fleet, but there are issues with gasoline LDVs

- Poor calibration that generates high NO_X
- Defect TWC
- Poor in-use compliance
- High ratio of GDI in the future therefore risk of high PN

China 6 RDE regulation

- Based on European RDE package #2, with modifications that address the unique driving conditions in China.
- Not only for pre-production but also for in-use conformity.
- Include PN

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PEMS (RDE) testing

Comparison between Euro 6 and China 6 RDE

Requirement		China 6	Euro 6
Application	Type Test[1]/Approval	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**	Fuel-neutral NO_X: 0.035 g/km PN: 6 x 10^{11} #/km	NO_X: Diesel: 0.08 g/km Gasoline: 0.06 g/km PN***: 6 x 10^{11} #/km
	Conformity factors****(effective date)	NO_X and PN: All new vehicles: 2.1 (7/1/2023) There is chance to refine the technical requirements for RDE	NO_X: 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)***** PN: New types: 1.5 (9/1/2017) All new vehicles: 1.5 (9/1/2018)*****
	Cold starts	Excluded	Included

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.*
****Applicable only to vehicles using direct injection engines.*
*****For the whole trip and for the urban segment separately.*
******N1 Classes 2 and 3, and N2 vehicles are always 1 year later than the dates listed above.*

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Comparison between Euro 6 and China 6 RDE

Requirement		China 6	Euro 6
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	120 km/h (135 km/h for 3% of motorway driving time)	145 km/h (160 km/h for 3% of motorway driving time)
	High-speed duration during motorway segment	At least 5 min driving at >100km/h speed	

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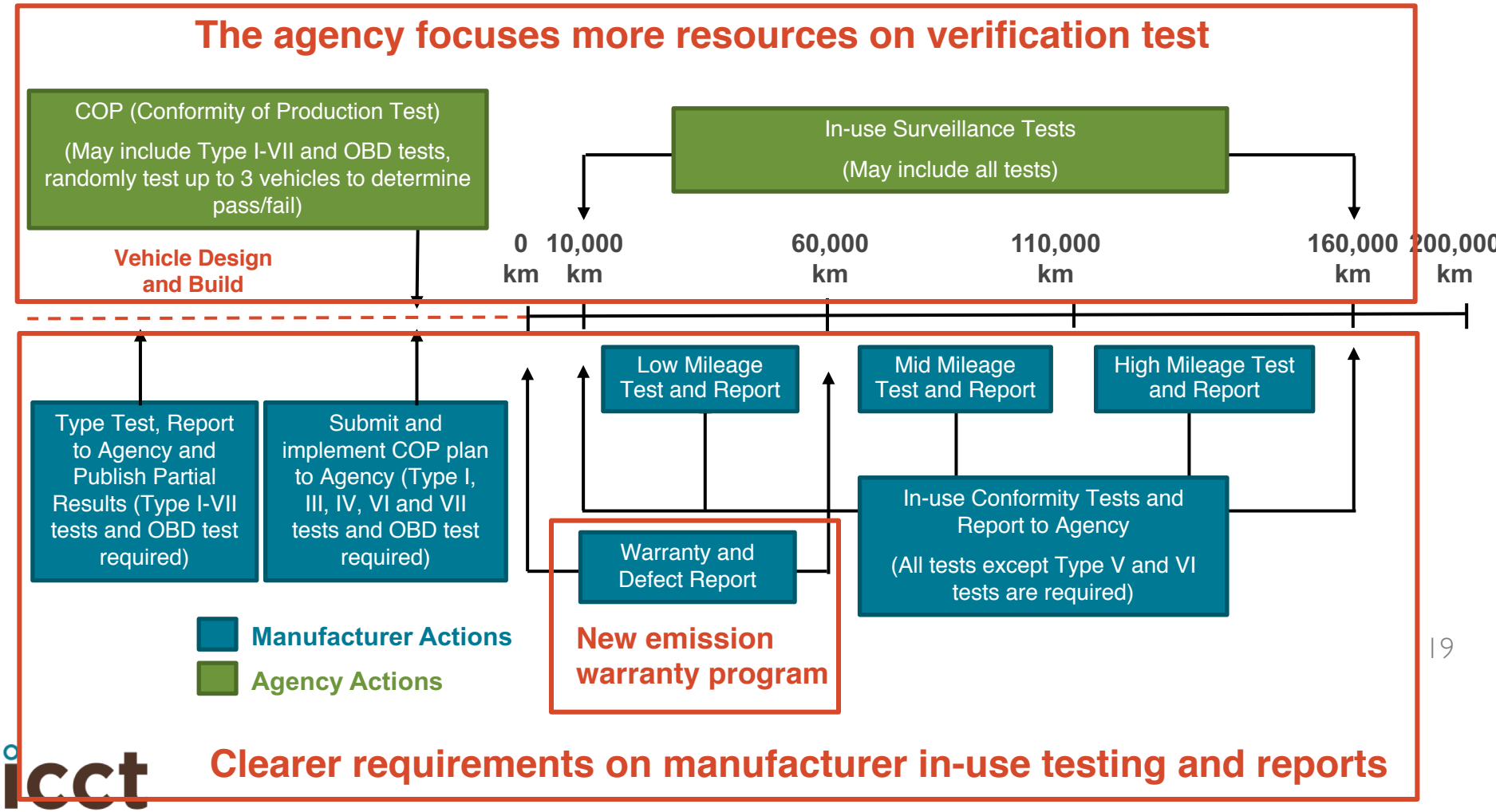
Comparison between Euro 6 and China 6 RDE

Requirement		China 6	Euro 6
Boundary condition	Payload	≤90% of maximum weight	
	Ambient temperature	Moderate: 0°C–30°C Extended: -7°C-0°C, 30°C-35°C	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
	Altitude	Moderate: <700 m Extended: 700 m–1,300 m Further extended: 1,300 m–2,400 m	Moderate: <700 m Extended: 700 m–1,300 m
	Correction factor	Extended: 1.6 Further extended: 1.8	Extended: 1.6
	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	

Comprehensive compliance program in China 6

- No more type approval. OEM self-type tests instead.



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Design of China VI HDV standard (proposal)

China VI HDV standard (proposal)

- Second proposal in April 2017
- Two phases:
  - China VI (Jan 1, 2020) – equivalent to Euro VI
  - China VI b (Jan 1, 2023) –same limits but introduces PN limits for PEMS test, remote OBD etc.
- Three engine tests (WHSC, WHTC, WNTE), one full-vehicle PEMS test.
- PEMS test for both type test and in-use compliance.

Comparison between Euro VI and China VI PEMS standard

		Proposed China VI	Euro VI
Implementation year		2020 for China VI a 2023 for China VI b*	2014
Vehicle tested		Type test, newly produced and in-use	Type approval and in-use
Mandated test frequency		18 months with minimum of 10,000 km and then every two years	18 months with minimum of 25,000 km and then every two years
Emission limits for diesel	**NO_x**	0.69 g/kWh (CF=1.5)	0.69 g/kWh (CF=1.5)
	PN	No limit for China VI a $1.2x10^{12}$ #/kWh for China VI b (CF=2.0)	No
Cold start included		No	No

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Comparison between Euro VI and China VI PEMS standard

		Proposed China VI	Euro VI
Driving shares (% of time duration)	Urban	20%-70%	20%-70%
	Rural	25%-33%	25%-33%
	Motorway	0%-55%	0%-55%
Test length		4x-7x work of WHTC	5x work of WHTC (4x-7x work of WHTC beginning 2018)
Payload		China VI a: 50%-100% China VI b: 10%-100%	50%-60% (10%-100% beginning 2018)
Ambient temperature		-7 °C ~ 38 °C	-7 °C ~ 38 °C
Altitude		<1,700 m in China VI a <2,400 m in China VI b	<1,700 m
Minimum power threshold		10%	15% (10% beginning 2018)

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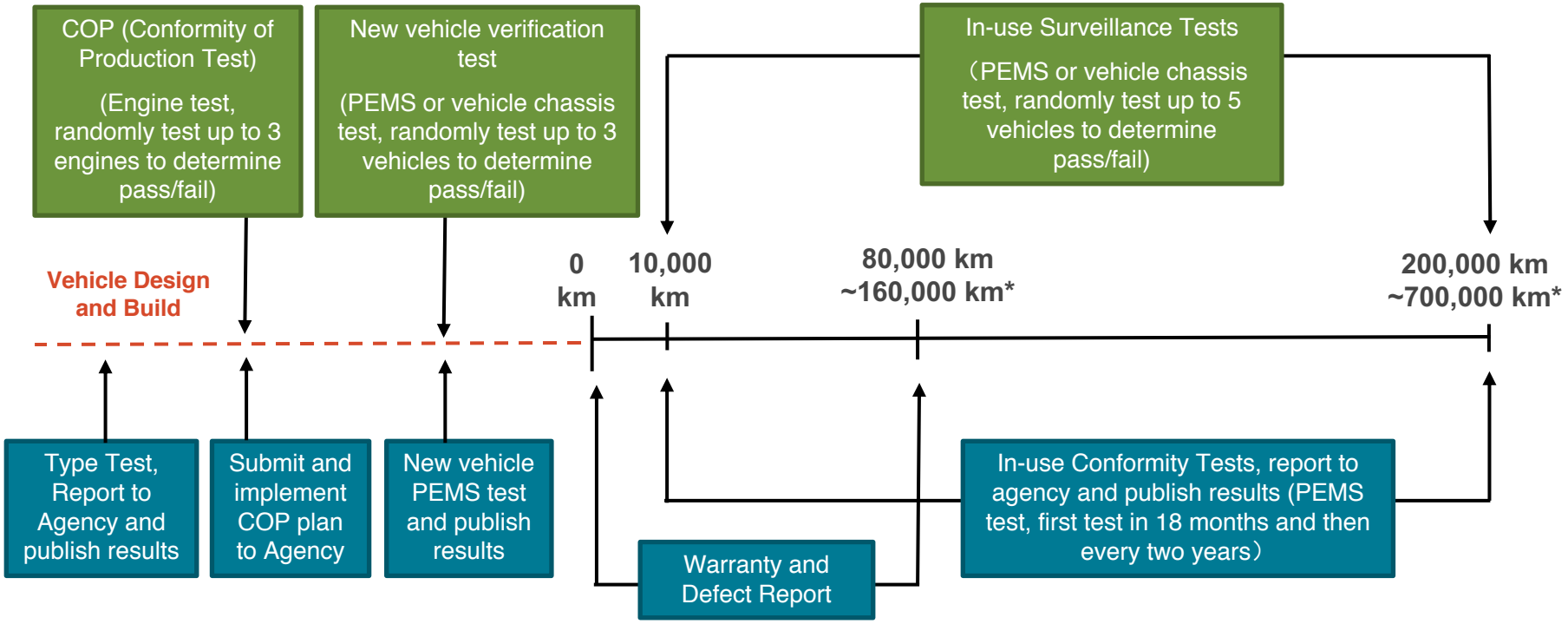
Comprehensive compliance program in China VI



Supplemental China V HDV standard

PEMS standard for China V HDVs

Designed to prevent excess NO_X from China V HDVs.

- Took effect on October 1, 2017
- Additional PEMS testing for new and in-use China V HDVs.
- China is the first country to attempt to solve a known deficiency in the Euro V type-approval process.

Table 1. Emission limits of the supplemental PEMS standard

Stage	Polllutant	CO	NO_x	THC	PM
China V	brake-specific emission limits[a]	≤6 g/kWh (CF=1.5)	≤4 g/kWh (CF=2.0)	Optional	Optional
	Instantaneous emission limits[b]	N.A.	900 ppm	N.A.	N.A.
	[a] 90% of all valid windows shall meet the limit. [b] 95% of the instantaneous NO_x emission rates shall meet the limit.				

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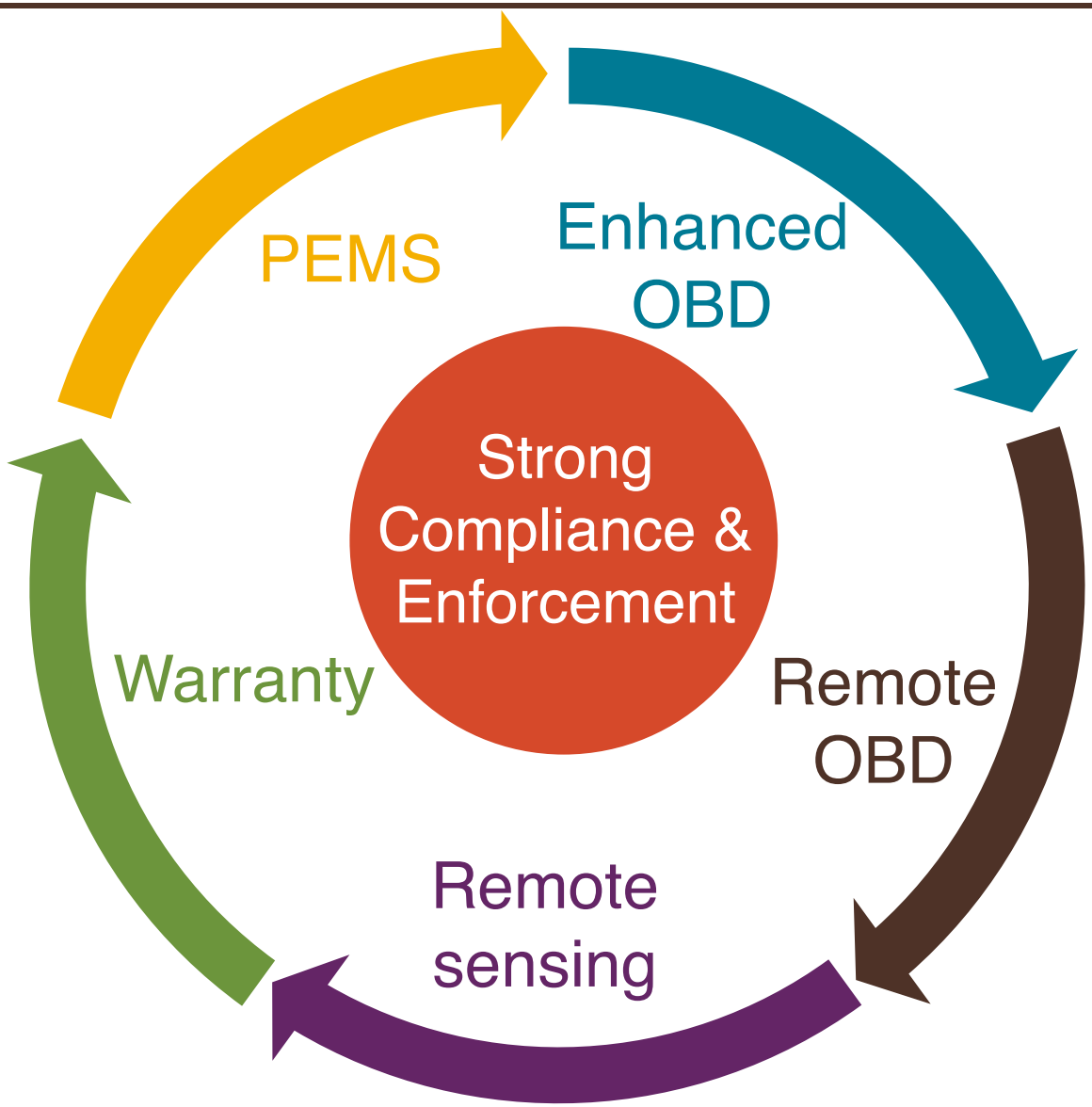
Comparison of supplemental China V, proposed China VI, and Euro VI PEMS standards

		Supplemental China V	Proposed China VI	Euro VI
Implementation year		2017	2020 for China VI a 2023 for China VI b*	2014
Vehicle tested		Newly produced and in-use	Type test, newly produced and in-use	Type approval and in-use
Mandated test frequency		Every two years with minimum of 10,000 km	18 months with minimum of 10,000 km and then every two years	18 months with minimum of 25,000 km and then every two years
Emission limits for diesel	**NO_x**	4 g/kWh (CF=2.0)	0.69 g/kWh (CF=1.5)	0.69 g/kWh (CF=1.5)
	PN	No	No limit for China VI a $1.2x10^{12}$ #/kWh for China VI b (CF=2.0)	No
Cold start included		No	No	No

Summary

China 6/VI make great efforts to address the real-world emissions issue



Summary

1. Real-world emissions still remain high as emission standards continue to tighten.

2. China considers a number of approaches to address this issue
   - Stronger compliance through testing
   - Enhanced enforcement authority to impose penalty
   - Include PEMS testing on new and in-use vehicles
   - Extend PEMS testing to existing fleet
   - Use remote sensing data to identify potential in-use noncompliance
   - Remote OBD with real-time reporting (for HDV only)
   - Integrating OBD check into I/M, periodical in-use checks

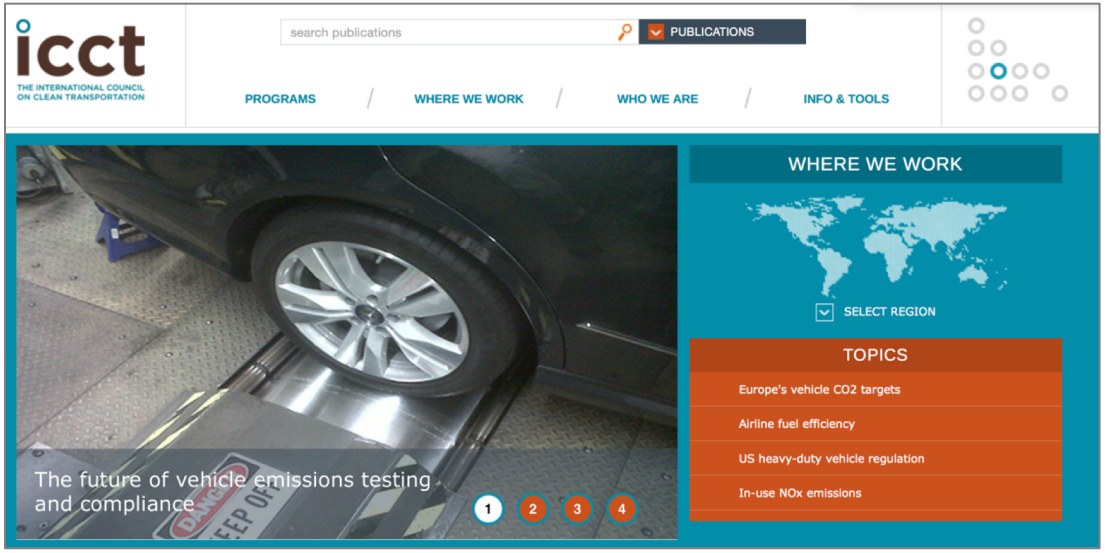
Summary

3. China's PEMS requirements are modified from those adopted in Europe to address its distinct challenges.
   - High altitude
   - Cold temperature
   - Urban congestion

4. Dynamic standard making process supported by testing and collected data

5. Local authority may play a role of introducing more stringent pilot testing and other programs

Thank you!



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