International approaches to vehicular emissions regulation: Expectations and realities

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HEI webinar series

Understanding Ultrafine Particles & Health: How Can We Make Progress

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Key themes

- Impacts of U.S. and EU regulatory programs on vehicle emission control technology developments and UFP emissions
- Application of in-use testing methods to evaluate real-world emissions performance
- Global developments in vehicle emissions control programs
- Implications for other mobile sources of PM and PN emissions
- Future developments in U.S. and EU regulatory programs

Euro VI and EPA 2010 standards have effectively mandated the use of diesel particulate filters (DPFs) in HD diesel engines

- PN limit introduced in Euro VI standard to ensure DPF application
- 10 mg/bhp-hr PM limit in U.S. standards has been sufficient to force use of DPFs

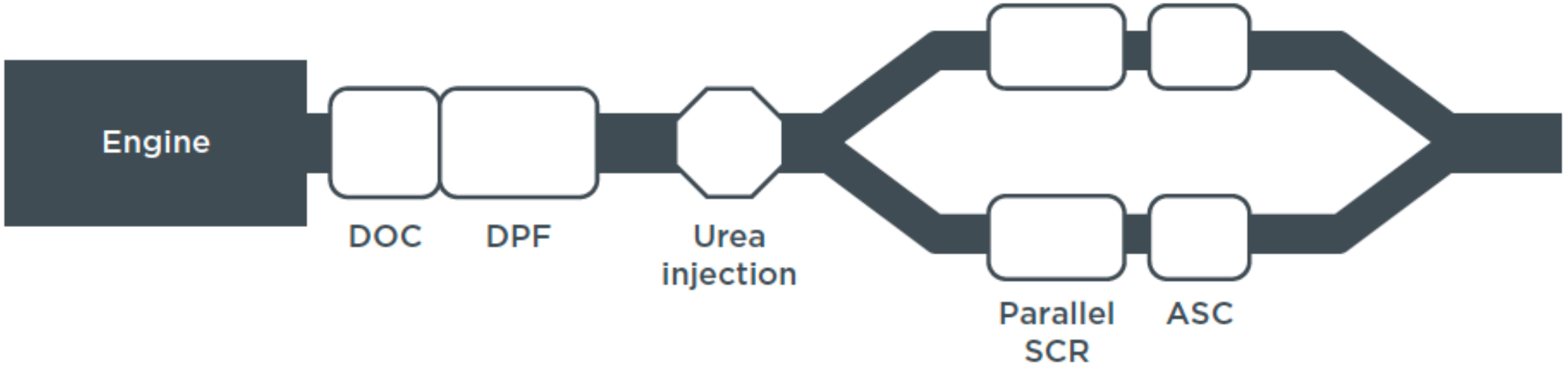
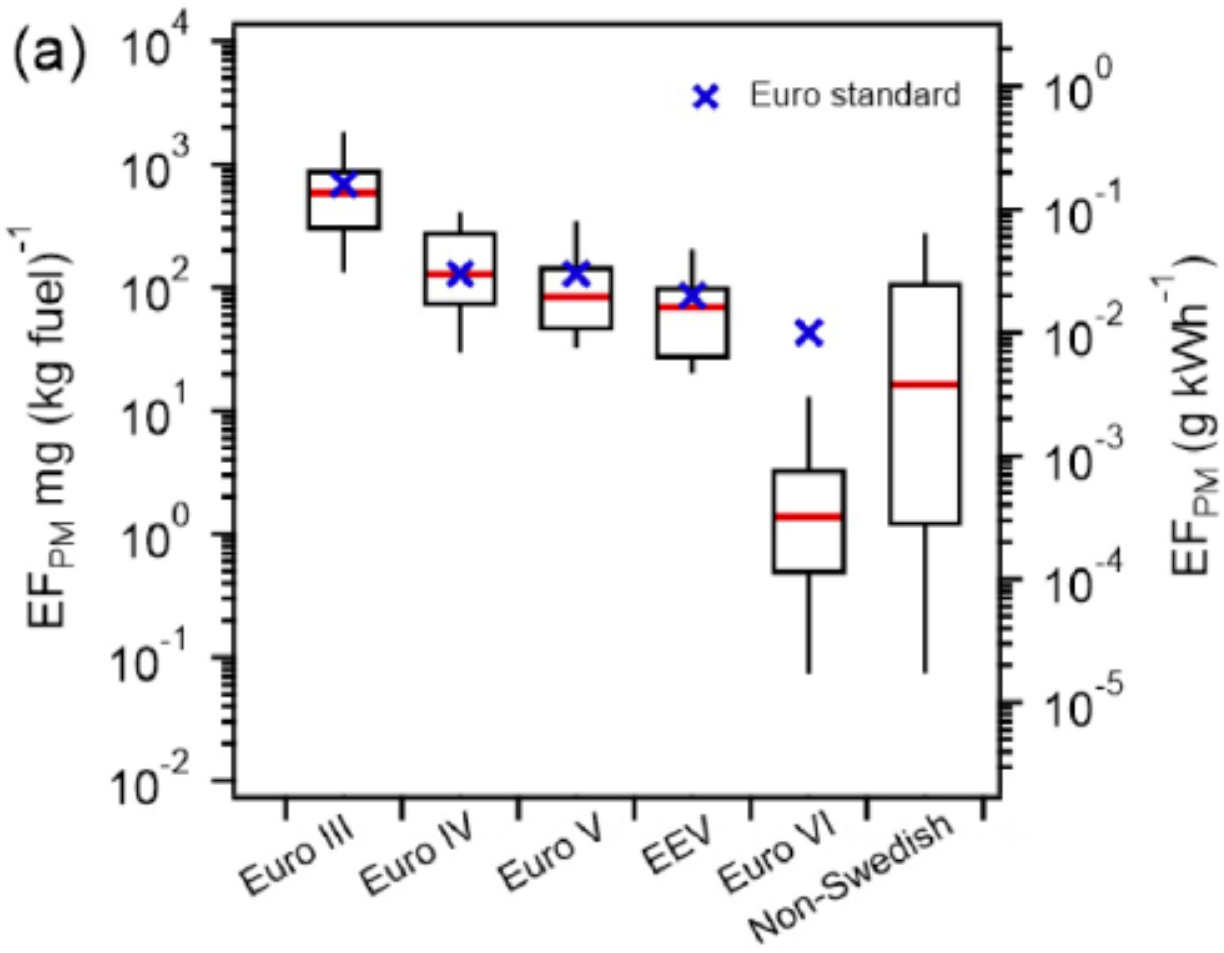
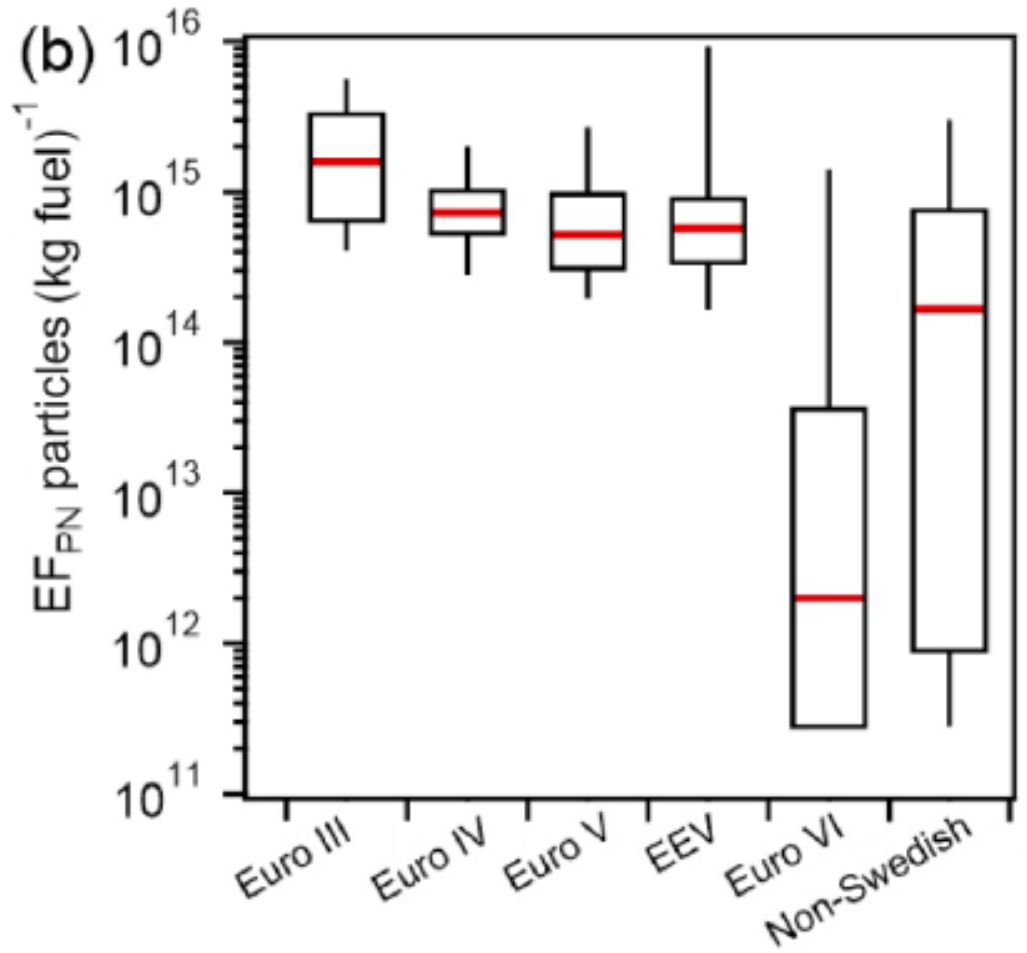


Figure 6. DPF + SCR system for Euro VI or US 2010 compliance.

Source: https://theicct.org/sites/default/files/publications/Future%20_HDV_standards_opportunity_20191125.pdf

Real-world testing demonstrates PM and PN emissions benefits of Euro VI trucks





Source: Zhou et al., Atmos. Chem. Phys., 20, 1701–1722, 2020, https://doi.org/10.5194/acp-20-1701-2020

In-use monitoring important for detecting DPF defects/durability issues & tampering

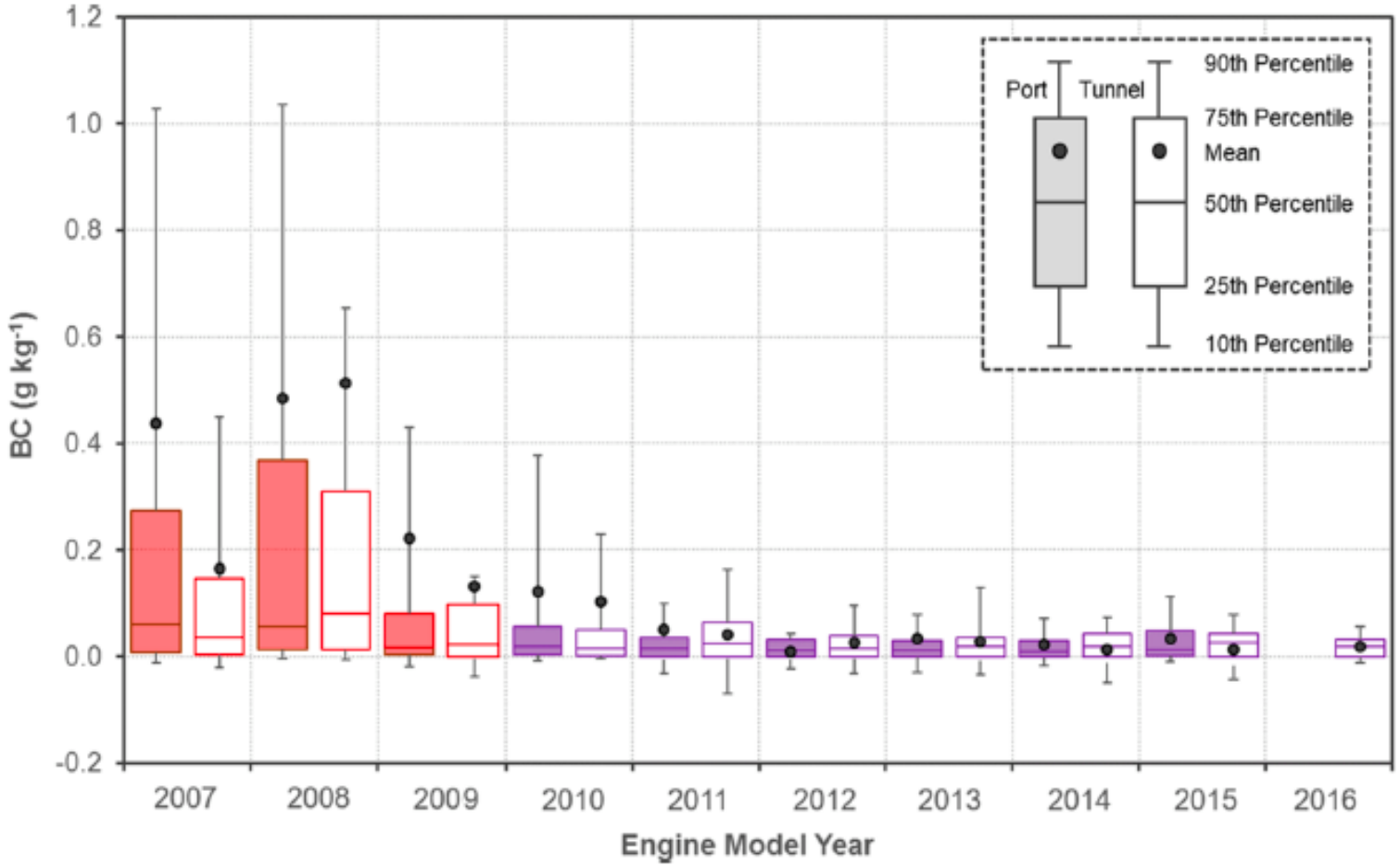
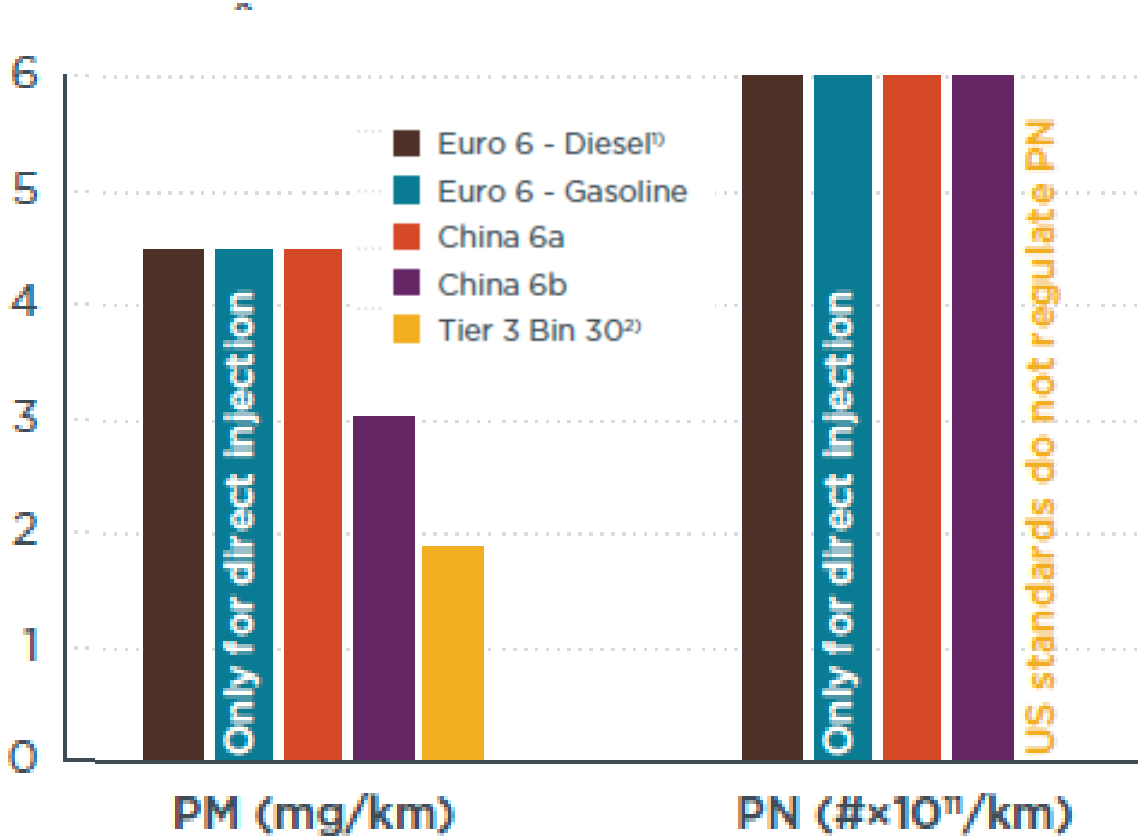


Figure 4. Distribution of measured black carbon (BC) emission factors by engine model year for trucks operating at the Port of Oakland and Caldecott Tunnel in 2015.

Source: Preble et al., Environ. Sci. Technol. 2018, 52, 11913−11921

The U.S. and EU have followed different approaches to regulating particle emissions from LDVs



Source: https://theicct.org/publications/recommendations-post-euro-6-eu

- U.S. Tier 3
  - Fuel and technology neutral
  - PM mass limit (3 mg/mi)
  - CA LEV III 1 mg/mi limit in 2025
- EU Euro 6
  - PN limit in addition to PM limits
  - Diesel and GDI vehicles only
  - Real Driving Emission (RDE) test requirements
- Differences in regulatory approaches influence emission control technology adoption

London vehicle remote sensing study shows improvements in diesel car PM emissions with introduction of PN limit

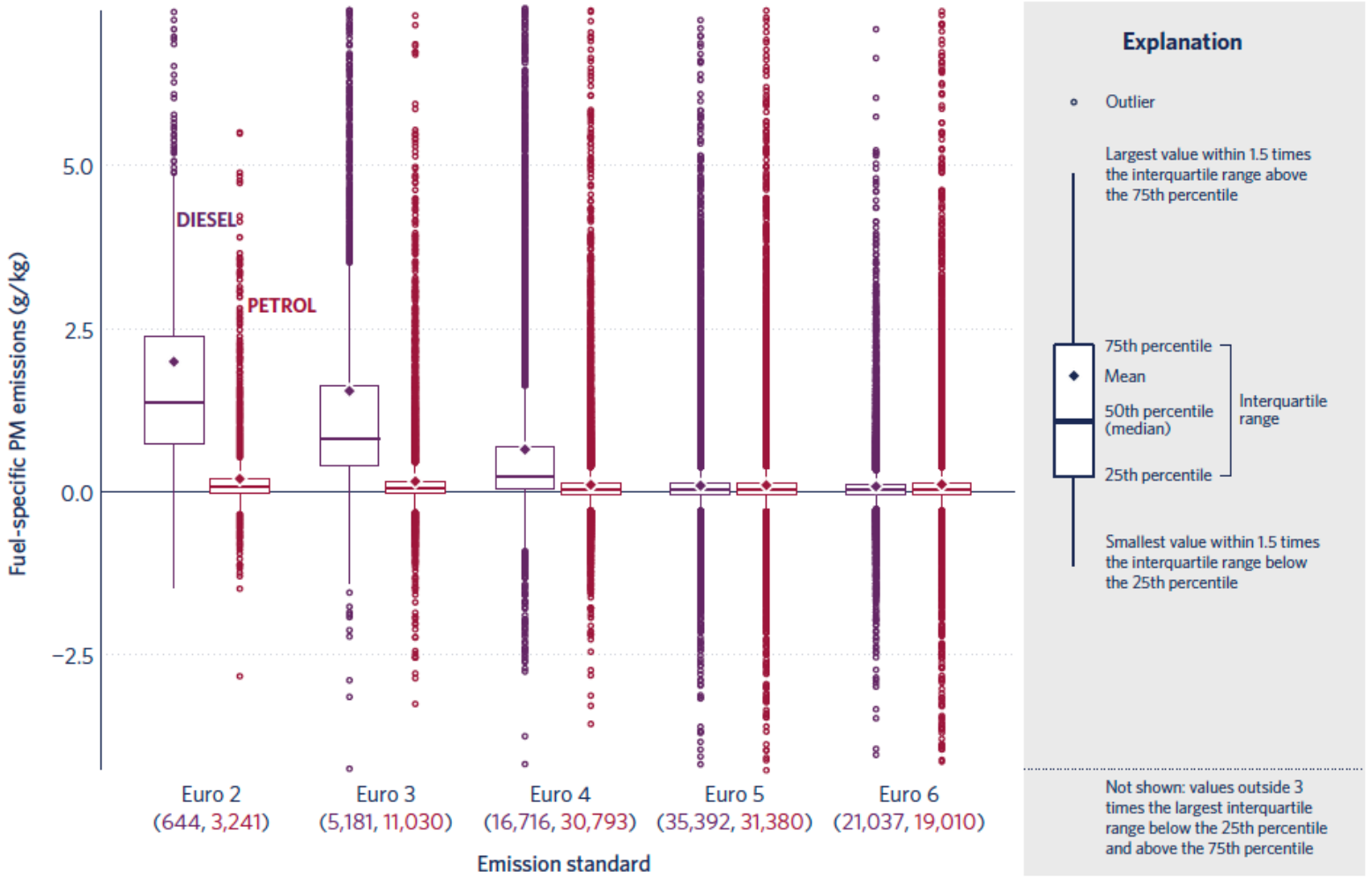
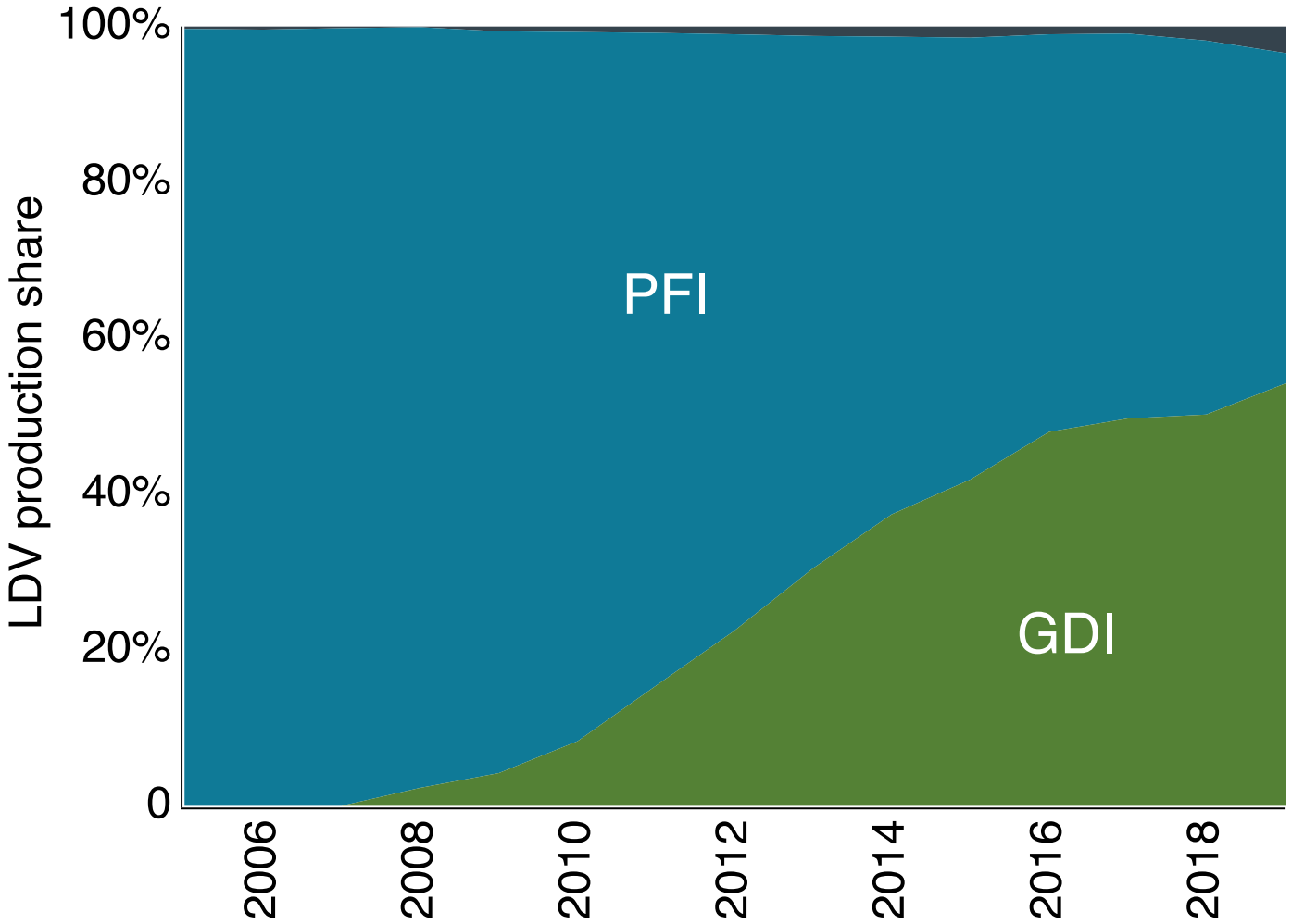


Figure 10. Boxplot of fuel-specific PM emissions of passenger cars by Euro standard and fuel type.
Notes: The number of measurements is presented in parentheses. An explanation of boxplots is presented at the right.[21]

Source: https://theicct.org/publications/true-london-dec2018

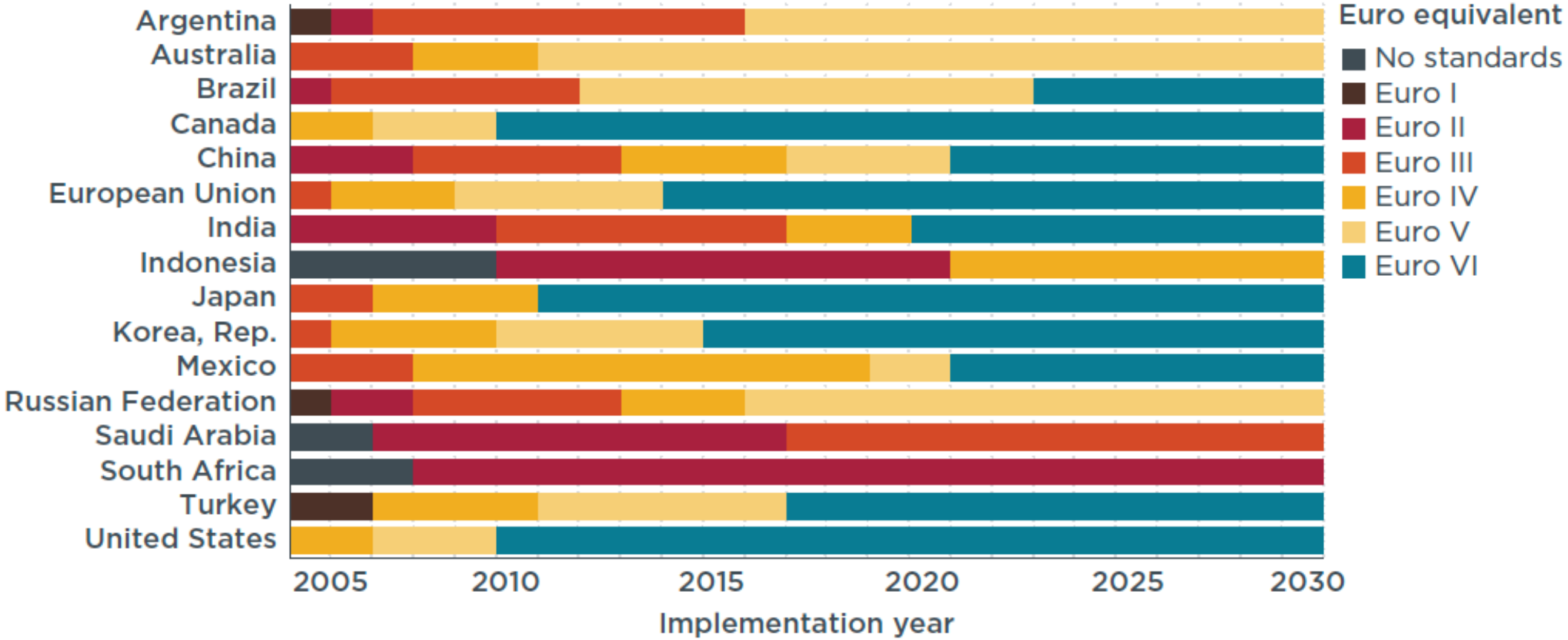
Fuel economy and CO_2 emission standards have accelerated market penetration of GDI engines



- U.S. Tier 3 PM limit can be met without GPF
- RDE PN limit expected to drive wide deployment of GPFs in the EU
- Widespread use of DPFs for diesel vehicles and increased GDI market share will change the nature of urban vehicular PN emissions

Source: USEPA 2019 Automotive Trends Report

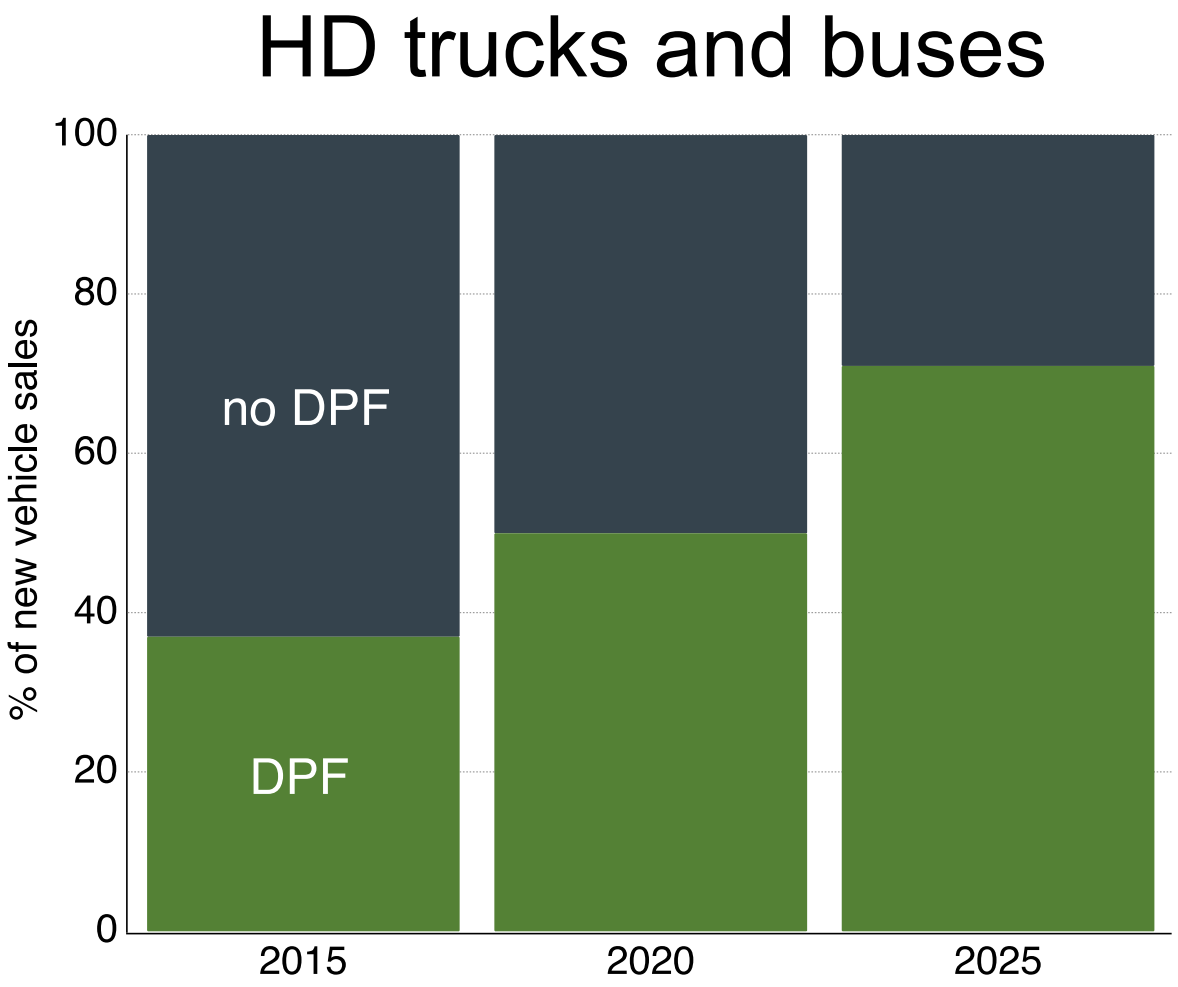
Implementation of Euro VI-equivalent HD engine standards will force DPFs in major vehicle markets

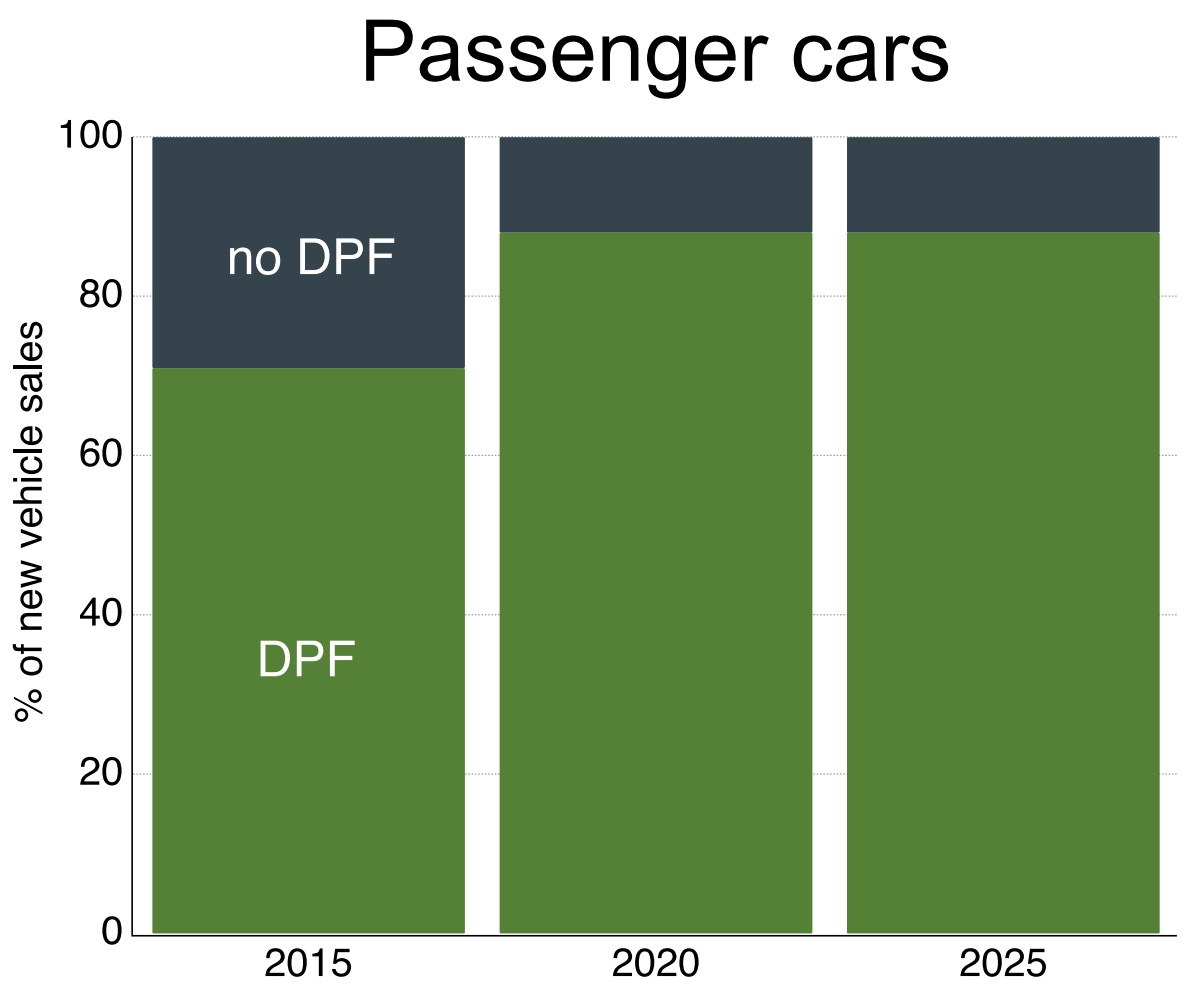


5 countries implementing Euro VI standards between 2020–2023 projected to account for 1/3 of global sales of new HDVs in 2025

Source: https://theicct.org/publications/cost-benefit-analysis-euro-vi-hdv-argentina

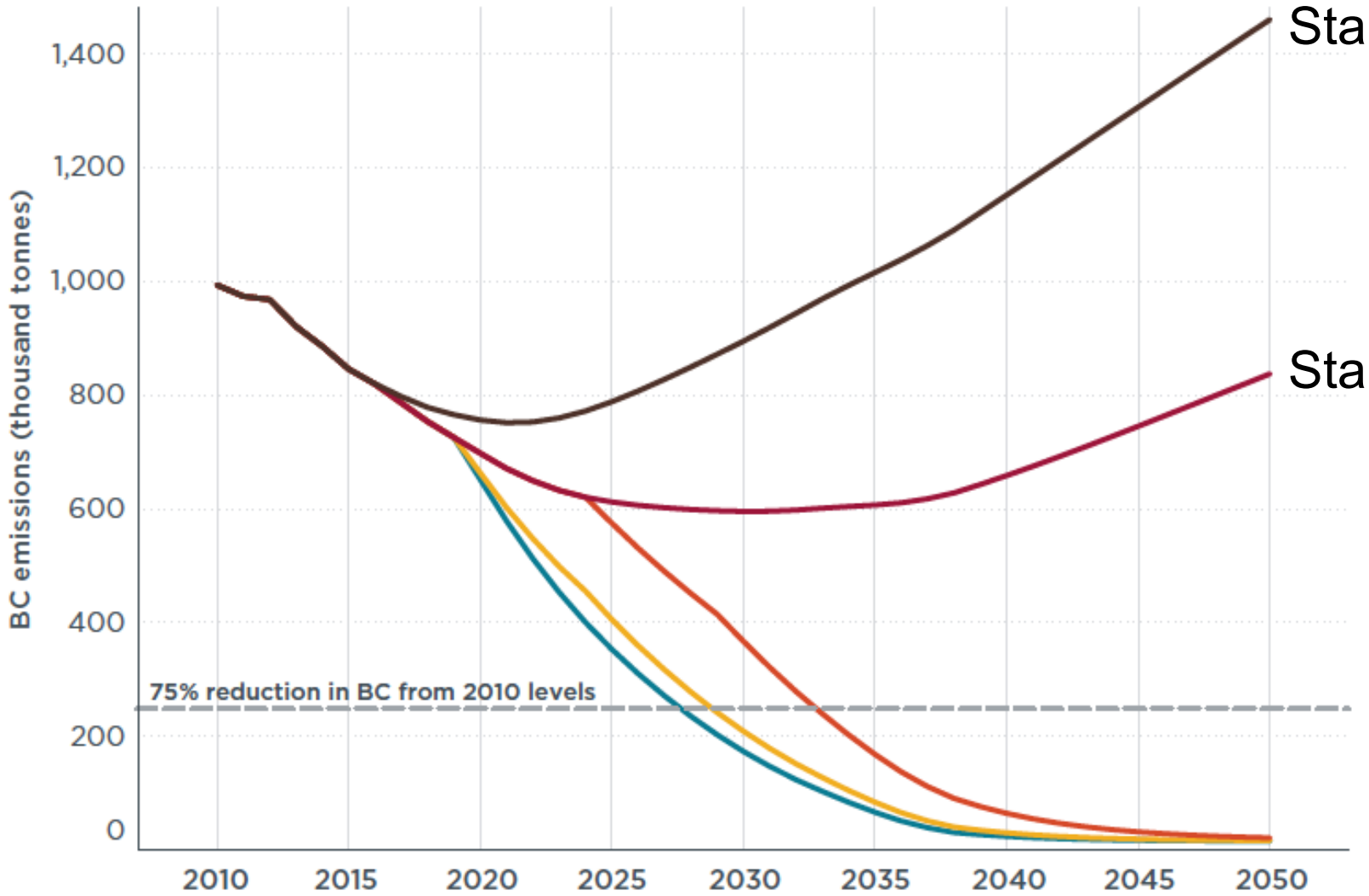
Share of new diesel vehicles with DPFs projected to grow with global expansion of Euro 6/VI-equivalent standards





Source: https://theicct.org/publications/global-progress-toward-soot-free-diesel-vehicles-2019

But more countries will need to follow suit to curb global emissions



Standards in force in 2015

Standards adopted as of July 2019

Euro 6/VI standards adopted by all countries

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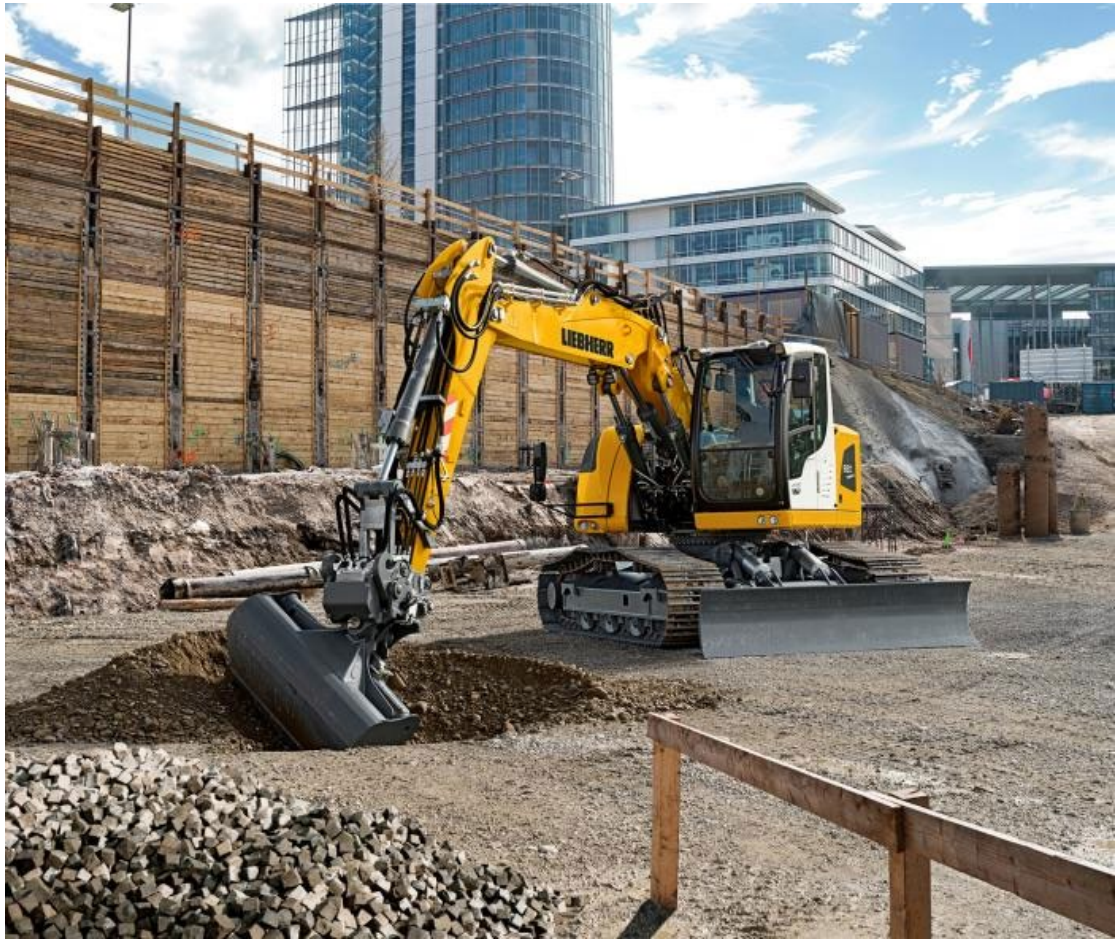
Source: https://theicct.org/publications/global-progress-toward-soot-free-diesel-vehicles-2019

The EU has moved ahead of the U.S. in controlling emissions from non-road engines



- EU Stage V standards tightened PM limits and introduced PN limit
- U.S. Tier 4f PM limits can be met without a DPF

Table 3. Assessment of the use of diesel particulate filters in Tier 4f certified engine families

Power class	Tier 4f certified engine families	Engine families equipped with DPF	DPF-equipped engines meeting Stage V PM and NO_x limits
19–37 kW	162	48%	95%
37–56 kW	315	41%	82%
56–75 kW	13	0%	NA
75–130 kW	117	32%	78%
130–560 kW	339	41%	94%

Source: https://theicct.org/publications/emission_reduction_tech_cost_non_road_diesel

Motorcycles and mopeds may grow in importance as source of urban PM & PN emissions

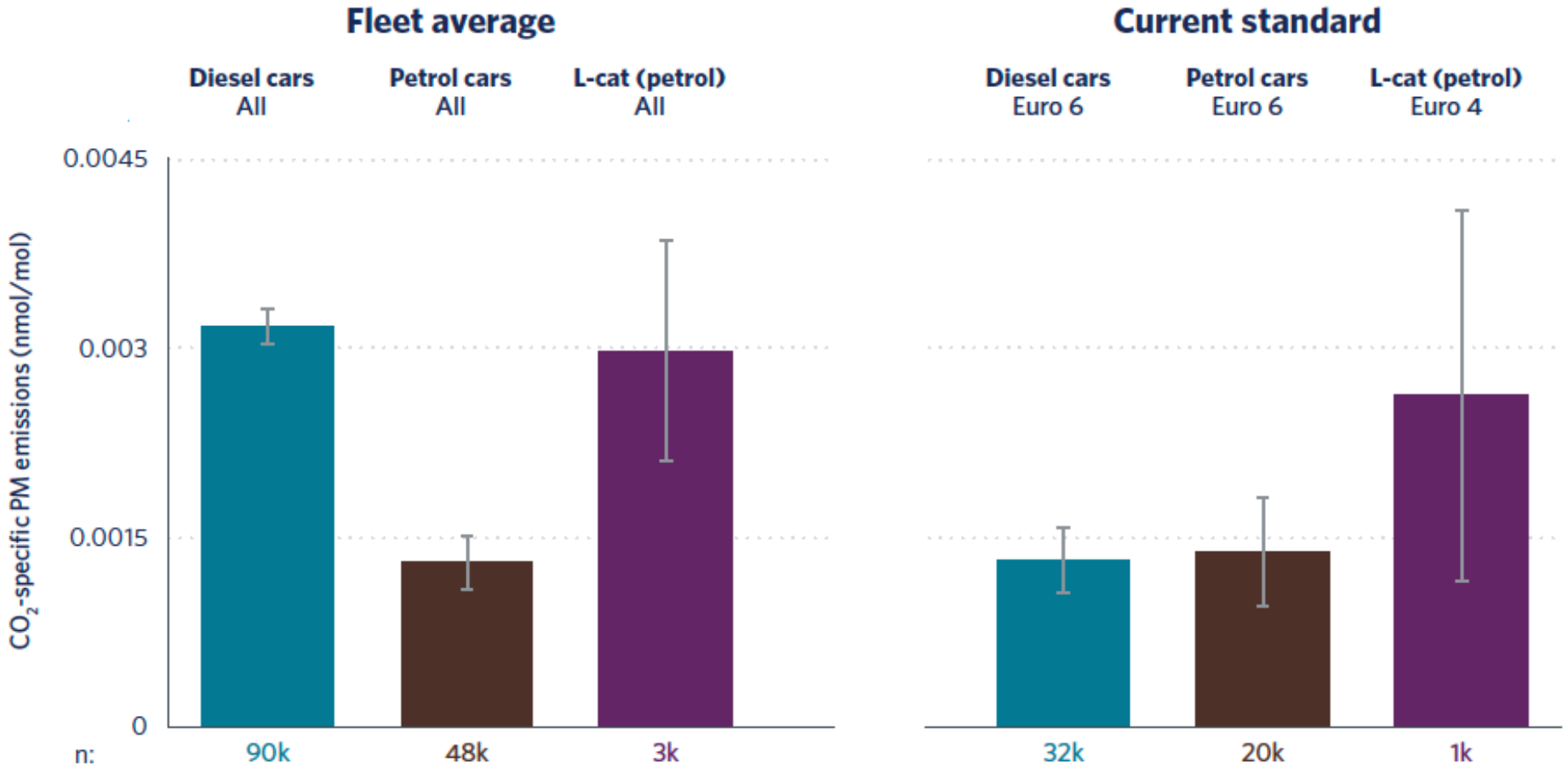


Figure 18. Average CO, NO_x, and PM emissions from L-category vehicles, diesel cars, and petrol cars for the entire measured fleet (left) and for vehicles certified to current Euro standards (right).

Future developments in U.S. and EU regulatory programs

- Post-Euro 6/VI standards are under development and may be the end of the line for ICE regulations
  - Objectives: Ensure vehicles are as clean as possible under all driving conditions and over entire useful life
  - Fuel and technology neutral standards (e.g. extension of PN limit to PFI vehicles)
  - Inclusion of particulates between 10–23 nm in total regulated count
  - Non-tailpipe emissions
- In the U.S., regulatory focus is on HD NO_x emissions
  - California Heavy-Duty Low NO_x program
  - EPA Cleaner Trucks Initiative

Summary

- Euro VI and EPA 2010 standards have made DPFs universal on new trucks and buses sold in the U.S. and EU. Expansion of Euro VI-equivalent standards to major markets (India, China, Brazil) is a major development in HD truck and bus emissions control. Further expansion is needed to curb global emissions from the sector.
- Fuel economy and CO_2 standards for LDVs are driving increased market penetration of GDI engines with implications for PN emissions. Best available control technology (GPF) not required to meet U.S. PM limit.
- In-use testing is important for tracking real-world effectiveness of regulatory programs and for monitoring emissions performance over time.
- As emissions from LDVs and HDVs are controlled, the relative importance of other mobile sources that, to date, have been subject to less stringent standards may grow
- Development of post-Euro VI/6 will have global importance and may be the end of the line for ICE emissions regulation.