Opportunities for a transition to soot-free and zero emission heavy-duty vehicles and fuels

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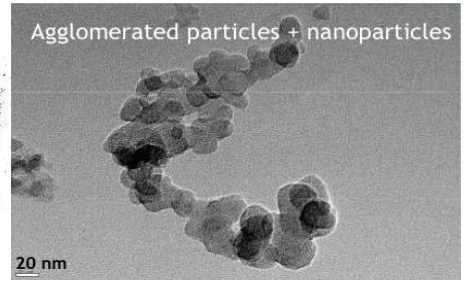
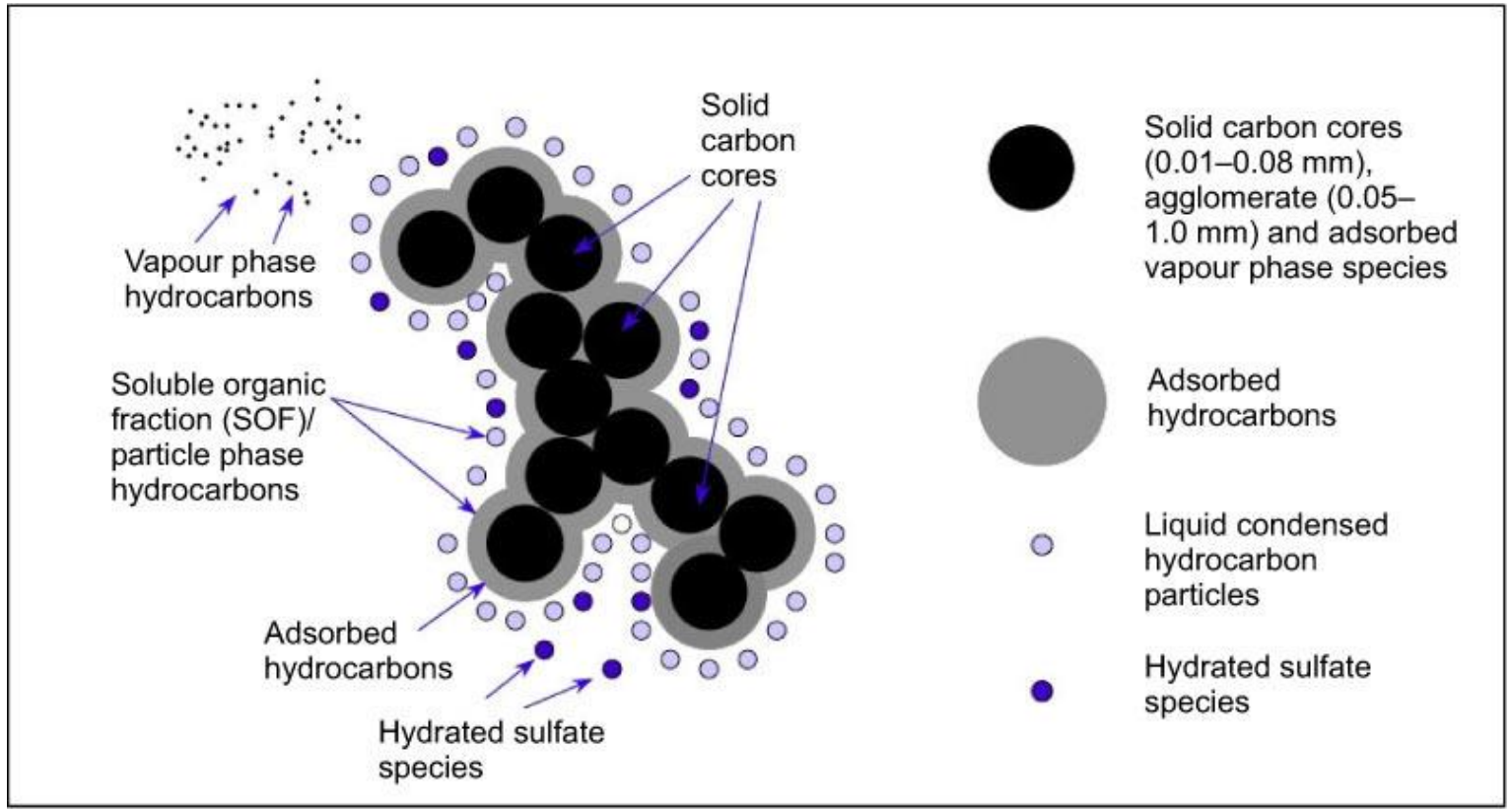
UN environment programme

CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

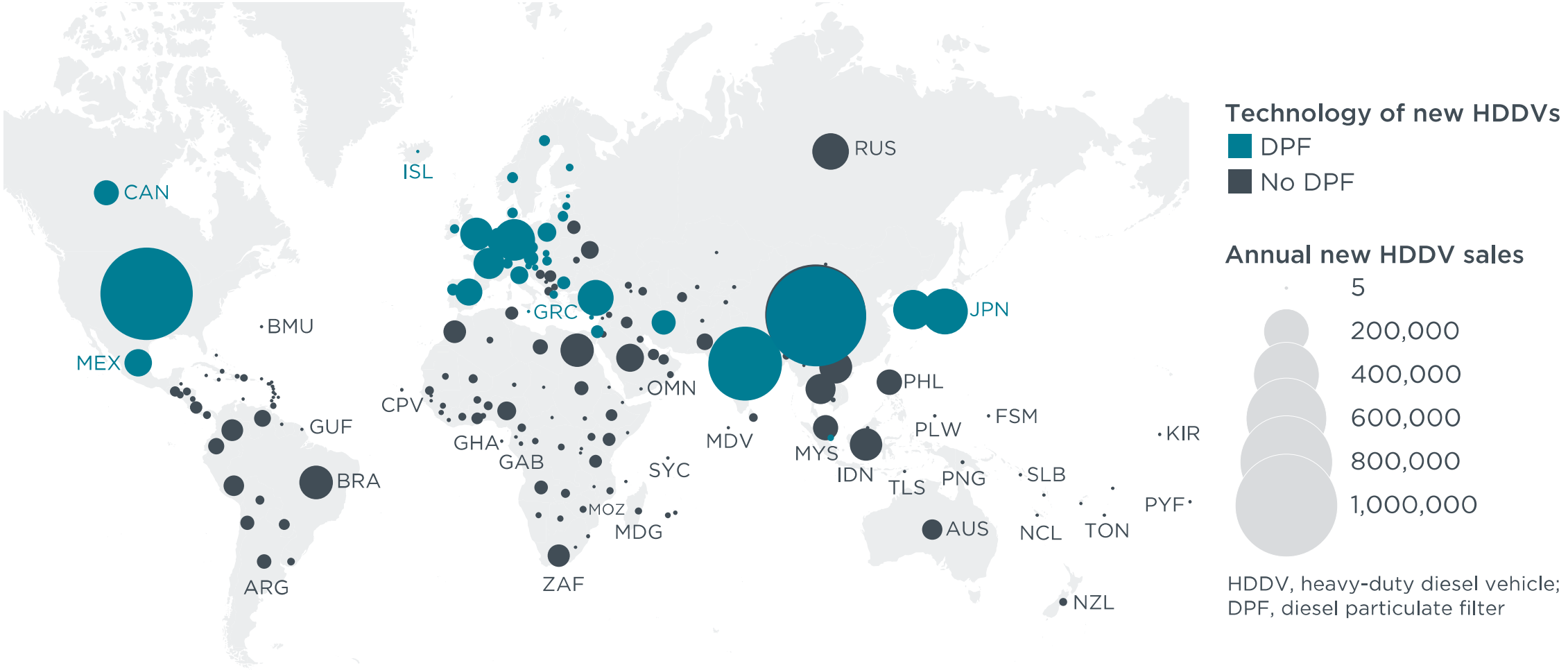
What is black carbon?





The opportunities for soot-free standards are widespread

Implementation of filter-forcing standards for new HDDVs: Adopted policies, 2021



Source: Miller, J., and Jin, L. (2018). Global Progress Toward Soot-Free Diesel Vehicles. https://www.theicct.org/publications/global-progress-toward-soot-free-diesel-vehicles-2018

Figure is modified to illustrate effects of China VI adoption. DPF, diesel particulate filter.

What does it mean in practical terms?

Adopting policies that drive soot-free and zero emission technologies

What are soot-free and zero emission vehicle technologies?

Electric drive engines such as battery-electric, fuel cell, trolley-electric …

Euro VI gas engines

Euro VI Diesel engines and 10ppm S diesel

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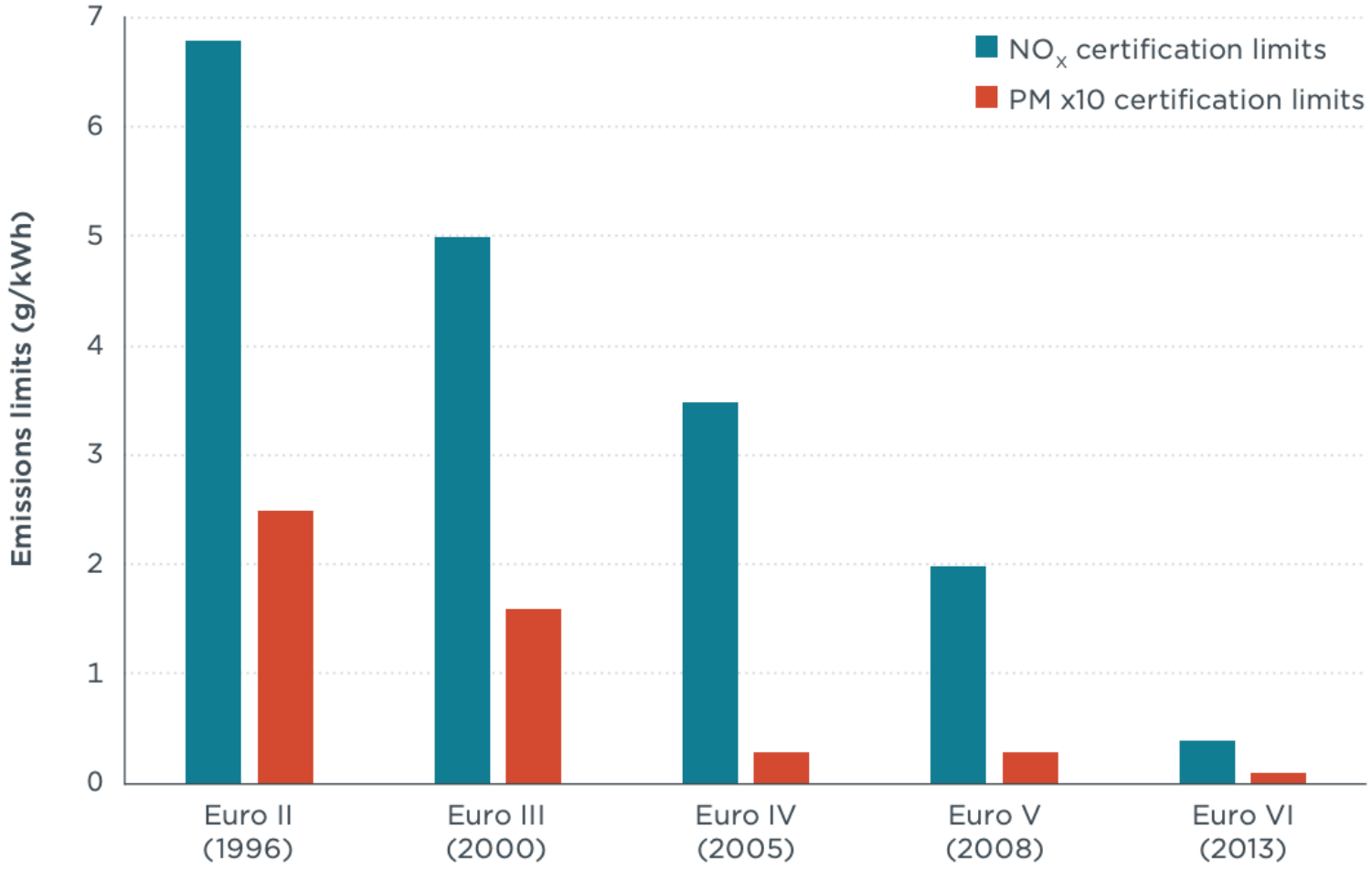
World class policies that drive soot-free and zero emission technologies

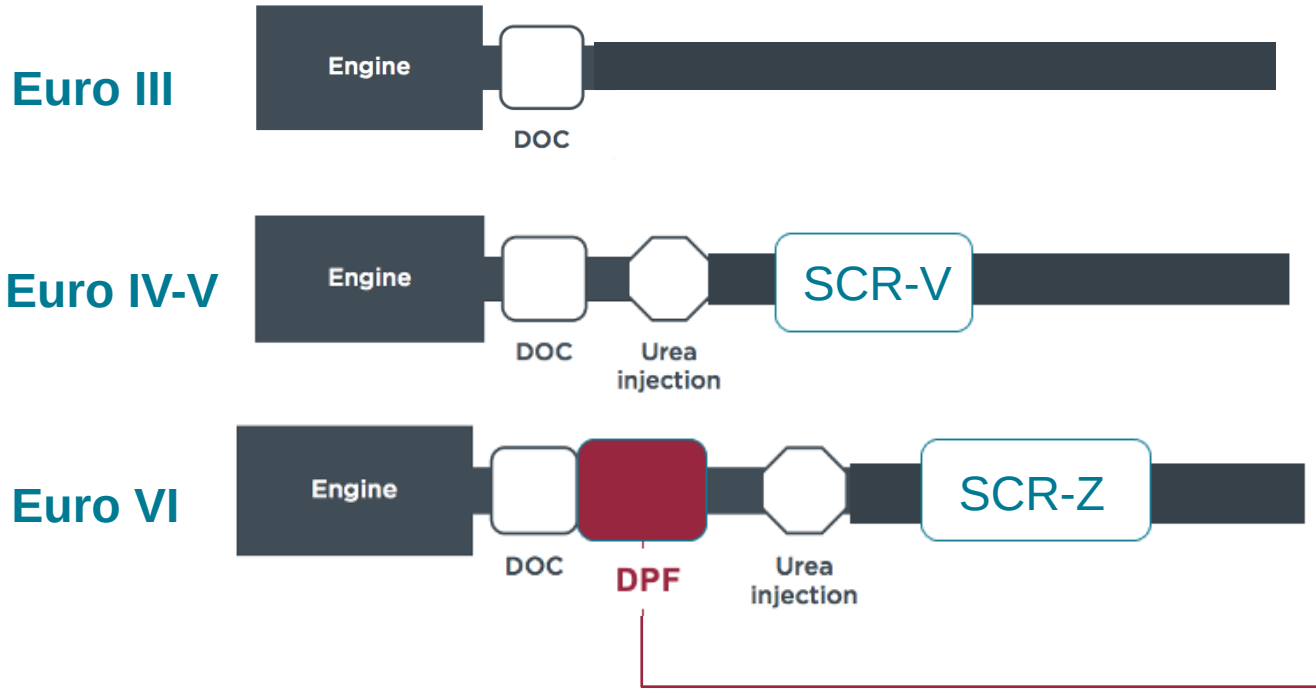
Tailpipe emission standards	Clean, low sulfur fuels	Vehicle electrification policies	Complementary programs
• **Soot-free emission standards** (Euro VI, Bharat VI, China VI, EPA 2010)	• **10 parts per million** (ppm) max sulfur for diesel and gasoline to enable soot-free emission standards	• Policies to accelerate **electric HDV adoption** (Bus electrification mandates, fiscal programs, etc.)	• Programs that address high-emitters, old vehicles, I&M. • Low Emission Zones

Heavy-duty vehicle emission standards



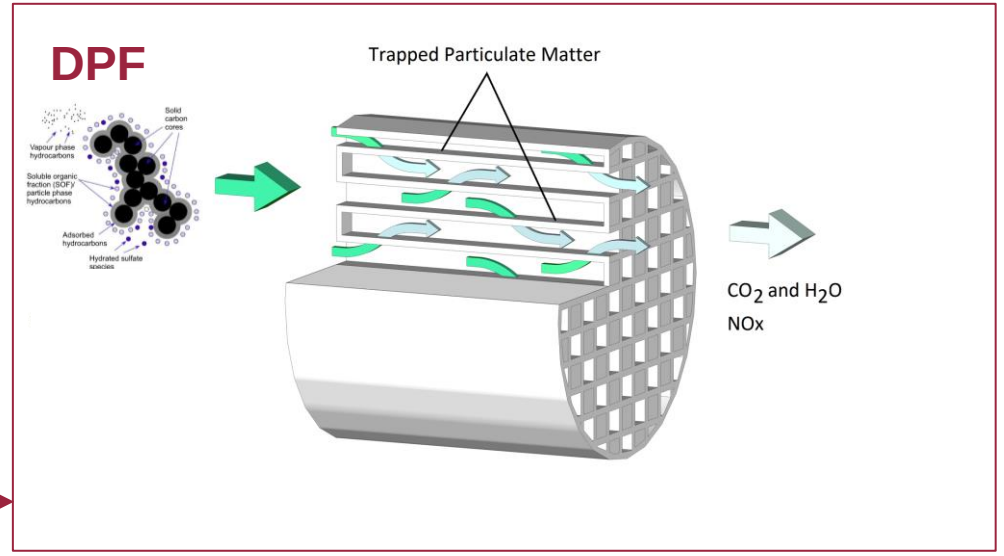
NOx and PM emission standards for diesel engines used in heavy-duty vehicles

Diesel technology evolution according to emission standards



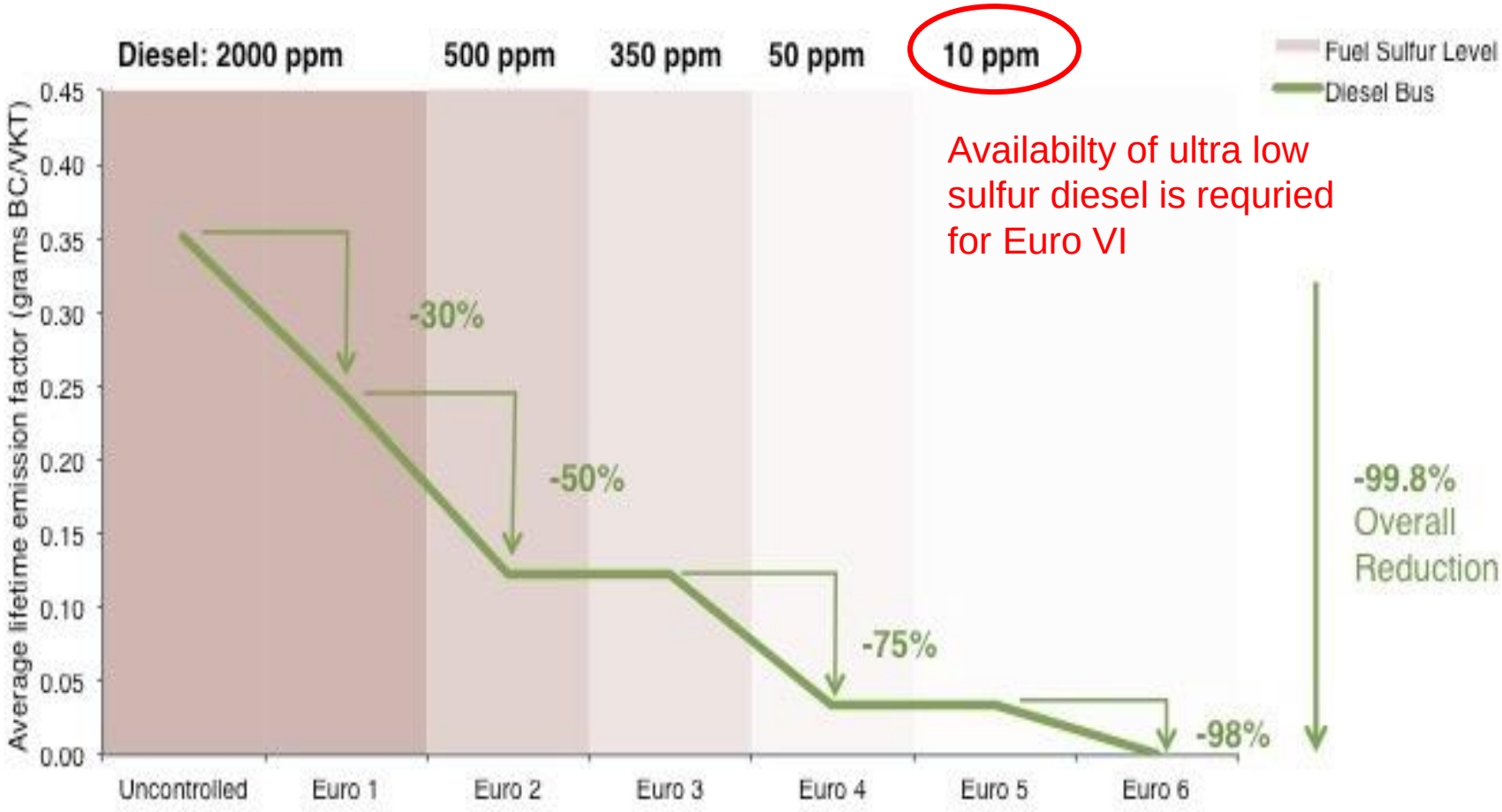
Aftertreatment emissions control

- Diesel oxidation catalyst (DOC)
  - CO (90%), HC (70%)
  - SOF, a component of PM (10-30%)
- Selective catalytic reduction (SCR)
  - NOx (85-95%)
- **Diesel particulate filter (DPF)**
  - PM (+98 %)
  - PN (+99 %)
  - CN (+99 %)



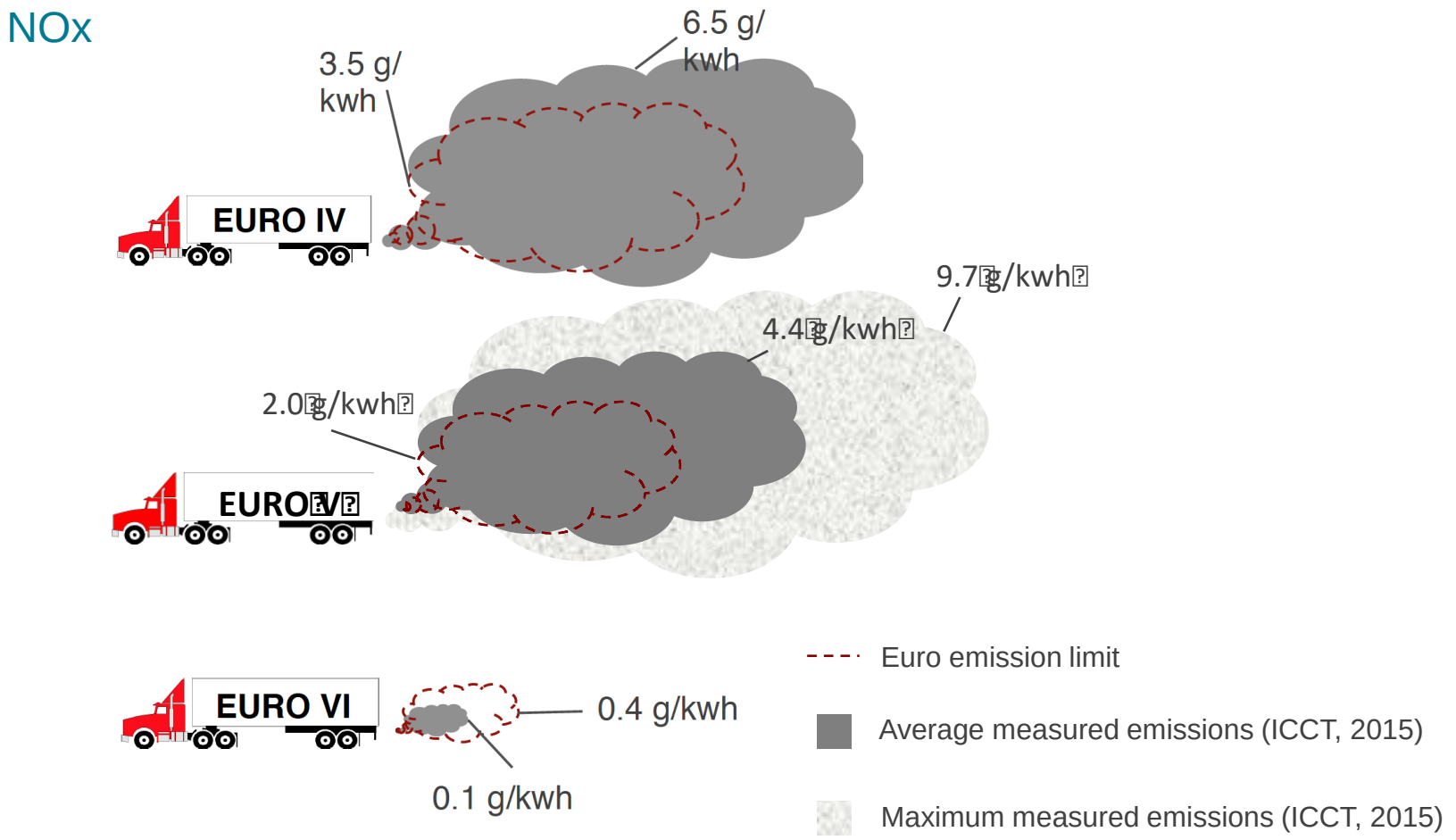
Soot free standards like Euro VI require ultra low sulfur diesel (S < 10 ppm)

Stages of Black Carbon Emissions Control Based on European Regulatory Approach for diesel HDVs



Source: COPERT Emissions Model

Euro VI emission standards are significantly better than Euro V: Virtual PM and BC elimination and best NO_x control



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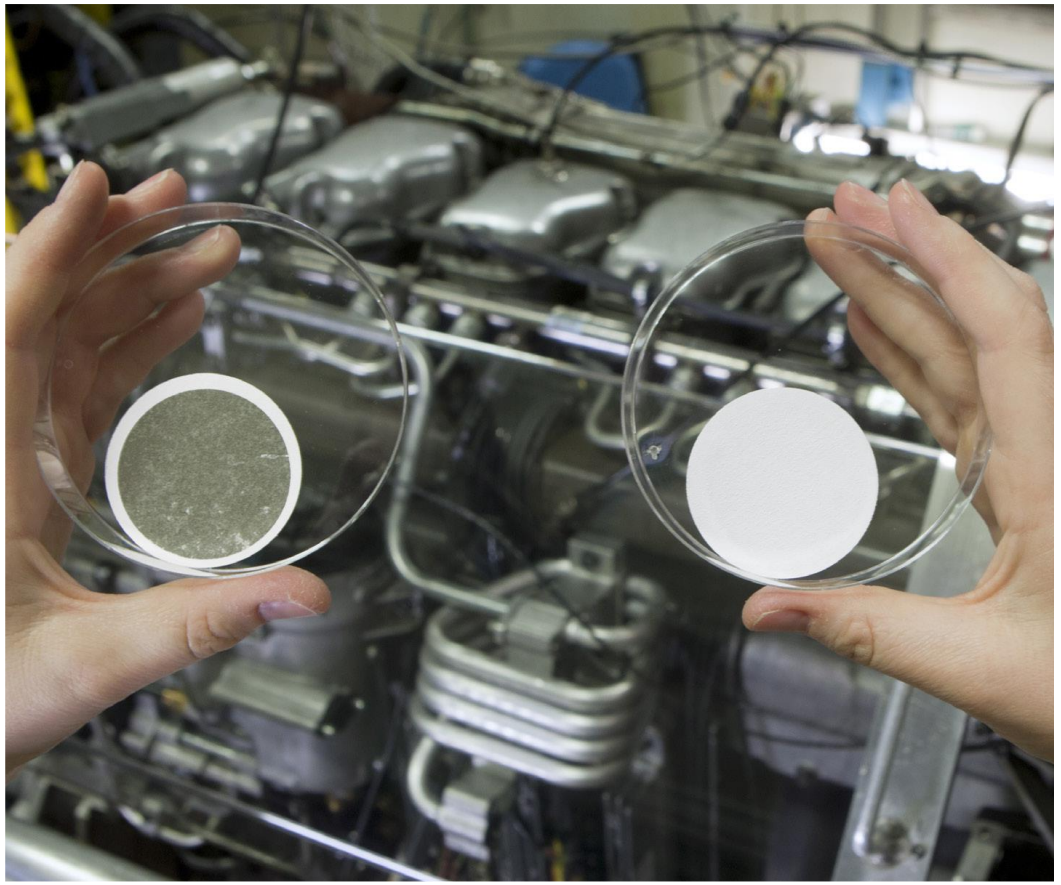
Euro V



Euro VI

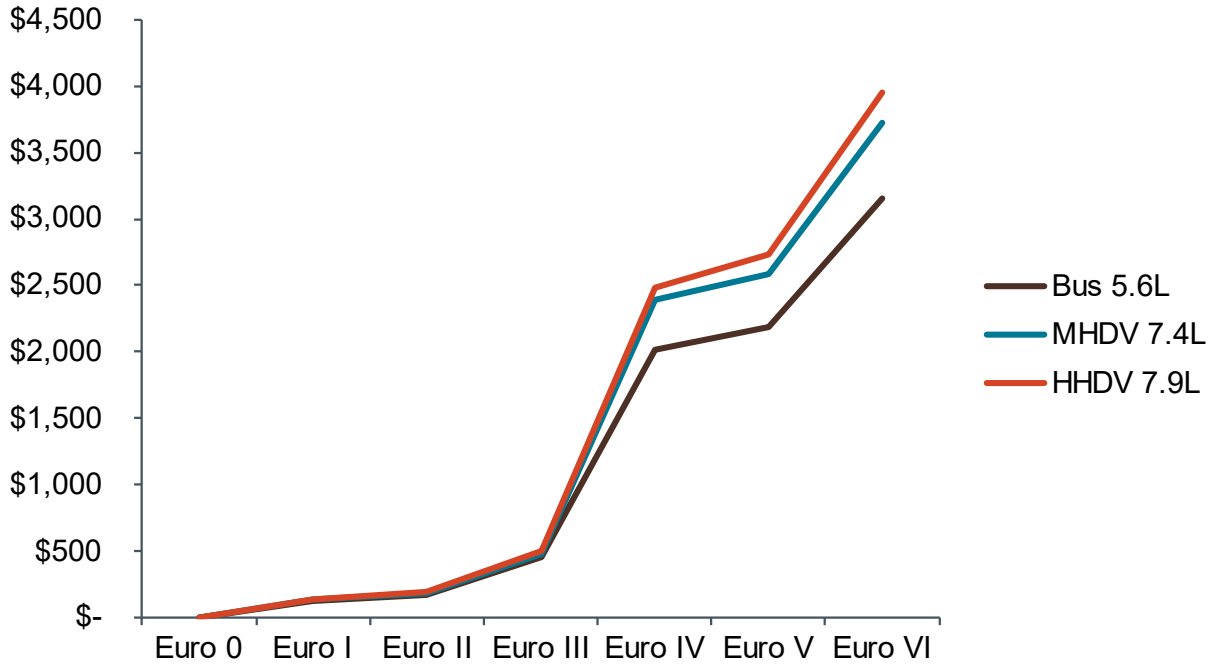
Source: SCANIA

“The difference between Euro V and VI is so remarkable that it can be seen without microscopes or advanced analysis—purely by looking at what comes out of the exhaust.”

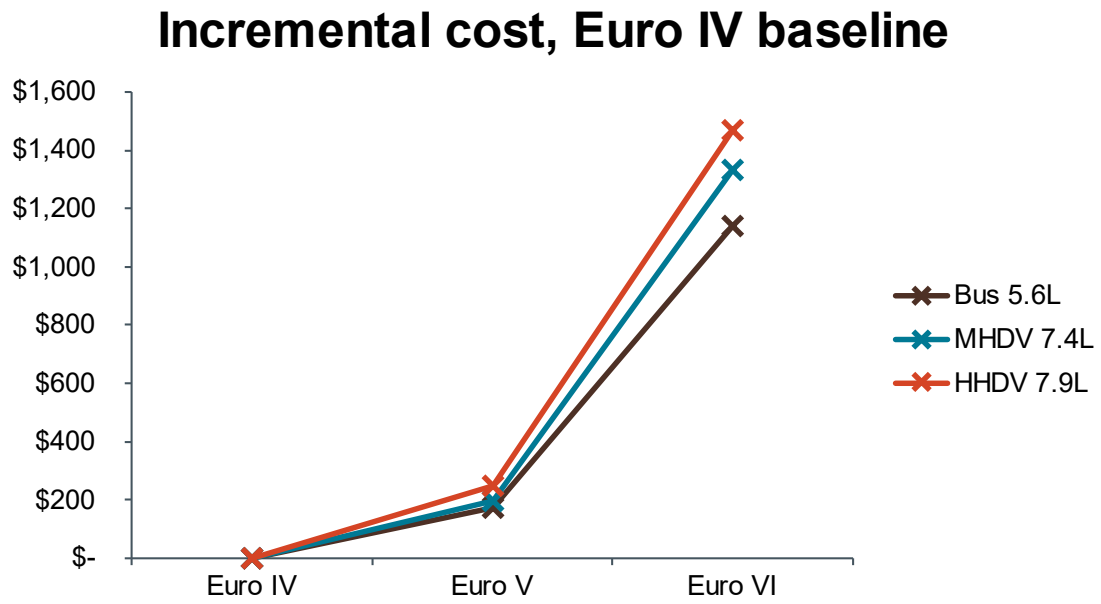
www.scania.com/group/en/wp-content/uploads/sites/2/2017/09/scania-icct-buses.pdf

HDV emission control costs: around 2-4% of new vehicle

Absolute costs of emission control technology for diesel HDVs



If the country is already is at **Euro IV** the costs are much smaller



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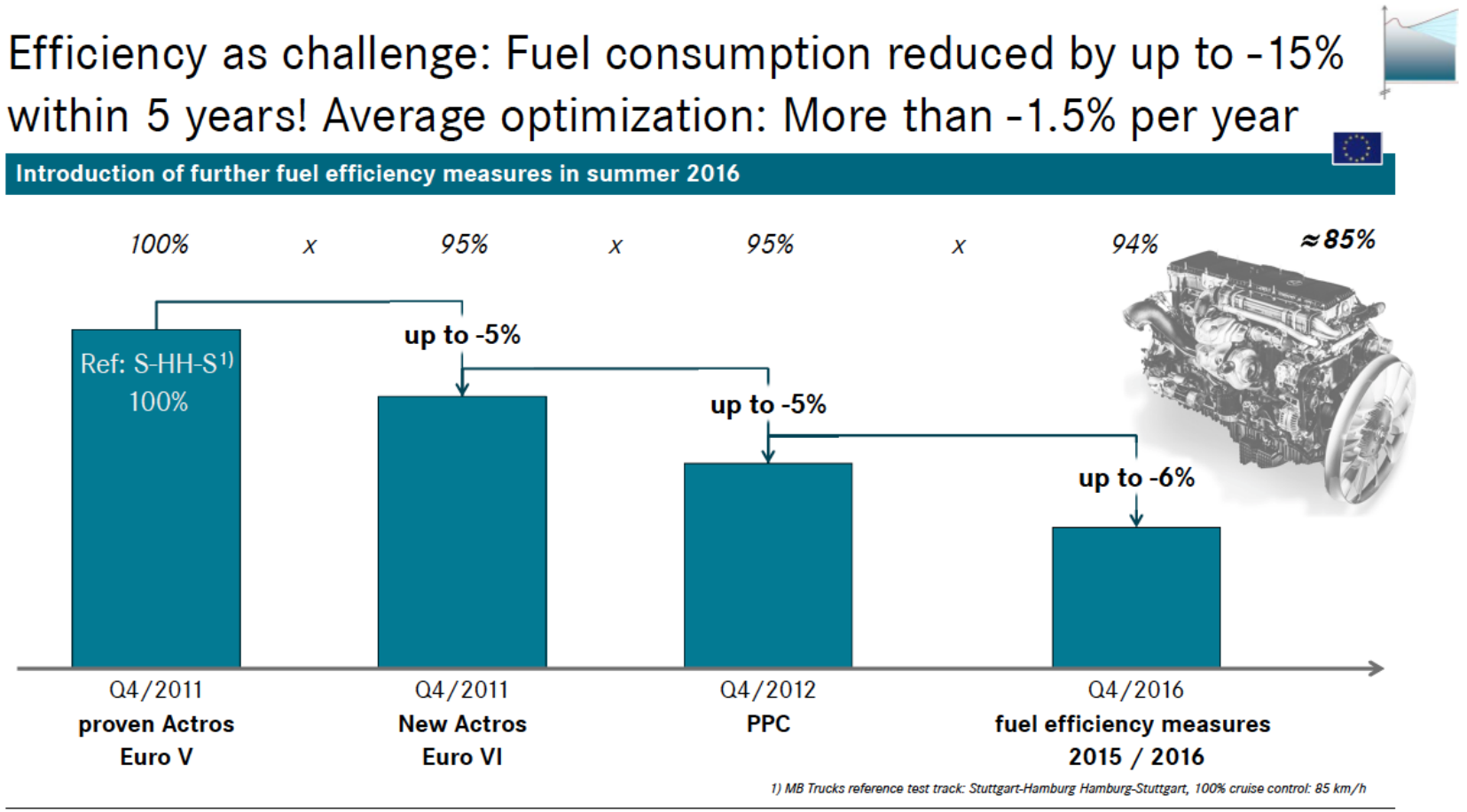
Latest Euro VI would also provide fuel savings
Daimler: 15% fuel consumption reduction



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For new vehicle emission standards and cleaner fuels, benefits always surpass the costs

Rule	Benefits	Costs	Benefit-Cost Ratio
US LDV Tier 3[1]	$6.7b–$19b annually (2030)	$1.5b annually (2030)	5:1 to 13:1
US LDV Tier 2[2]	$25.2b	$5.3b	5:1
US 2010 HDV emissions[3]	$70b annually (2030)	$4.2b annually (2030)	16:1
California Advanced Clean Cars Program (LEV-III)[4]	$10.6b cumulative vehicle operating cost savings	$3.4b cumulative annualized incremental cost	3:1
Mexico HDV NOM-044[5]	$135b (cumulative, 2018–2037)	$12b (cumulative, 2018–2037)	11:1
Euro 5/V and 6/VI[6]	$2,13b (2009 price)	$1,55b (2009 price)	1.4:1
China 6/VI[7]	4.4t RMB	1.8t RMB	2.5:1
India Bharat VI[8]	$43.8b in 2025; $107b in 2035	$14.5b in 2025; $14.2b in 2035	8:1 in 2035

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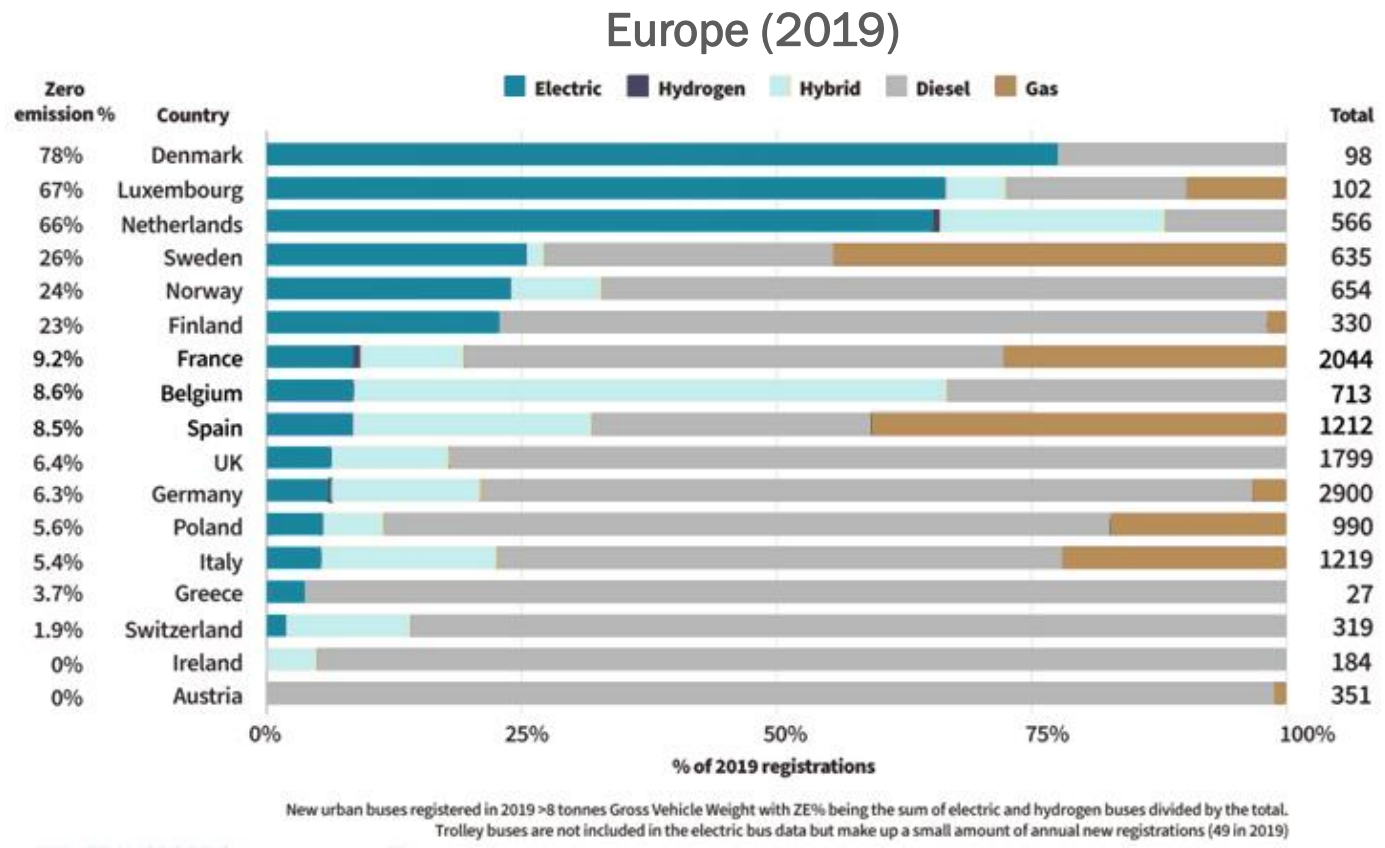
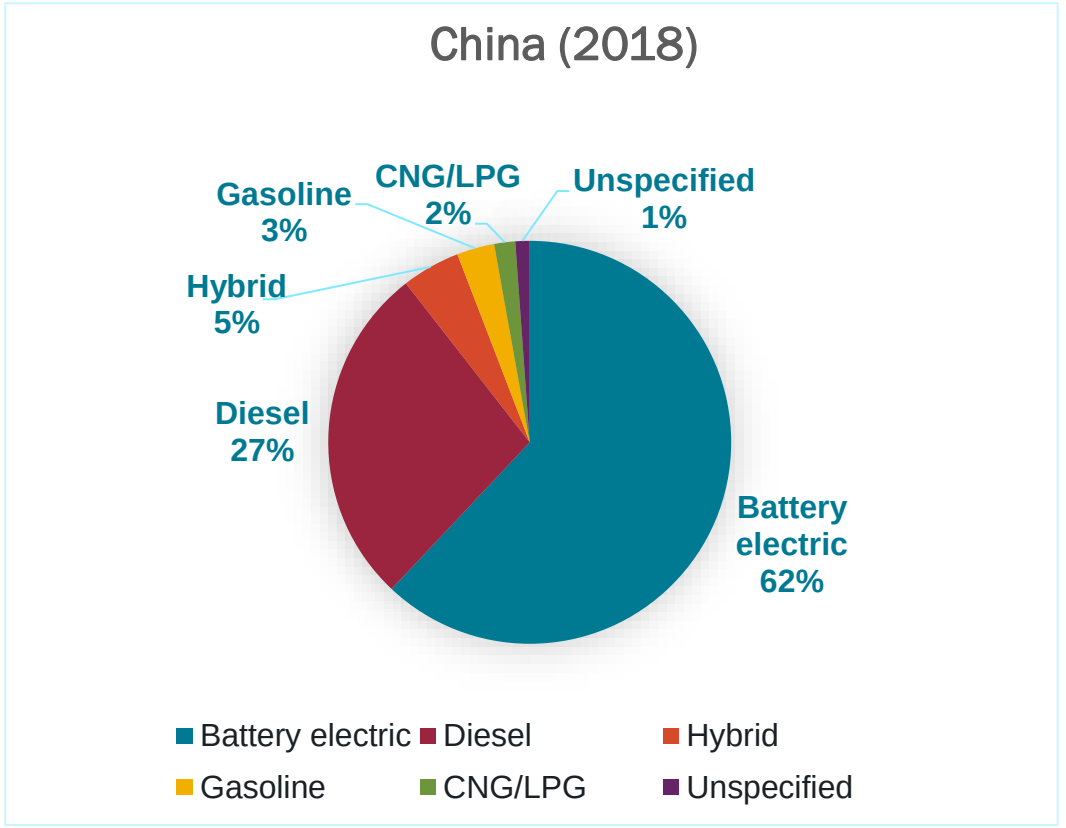
Vehicle electrification policies for HDVs

Zero emission transport is the final goal. This transition has started with e-buses



Source: https://www.transportenvironment.org/press/denmark-luxembourg-netherlands-lead-way-emissions-free-buses



Source: ICCT Databases

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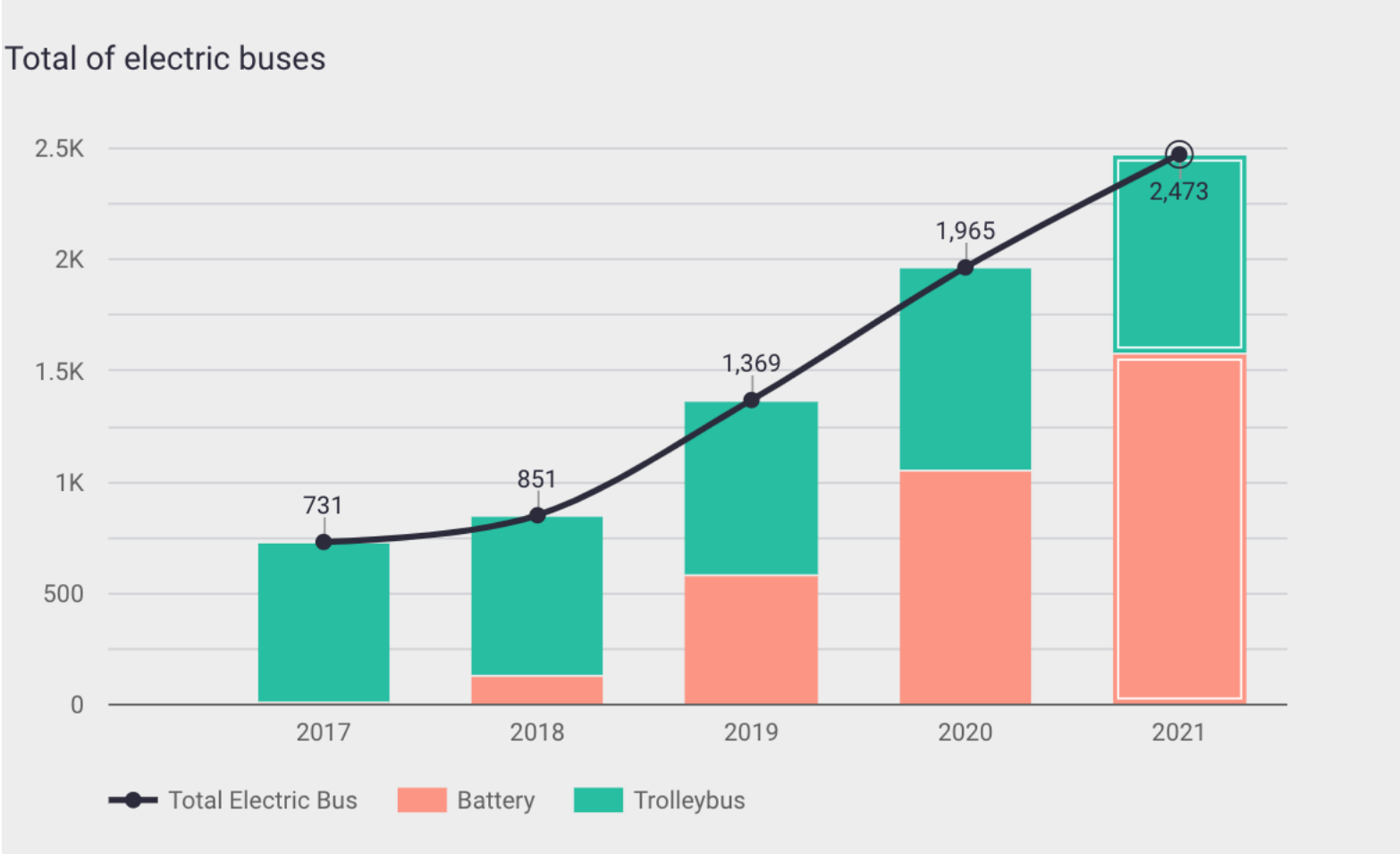
Zero emission bus market in Latin-America is growing

~2500 Zero emission buses in total in 2021



Source: https://www.ebusradar.org/en/home-en/

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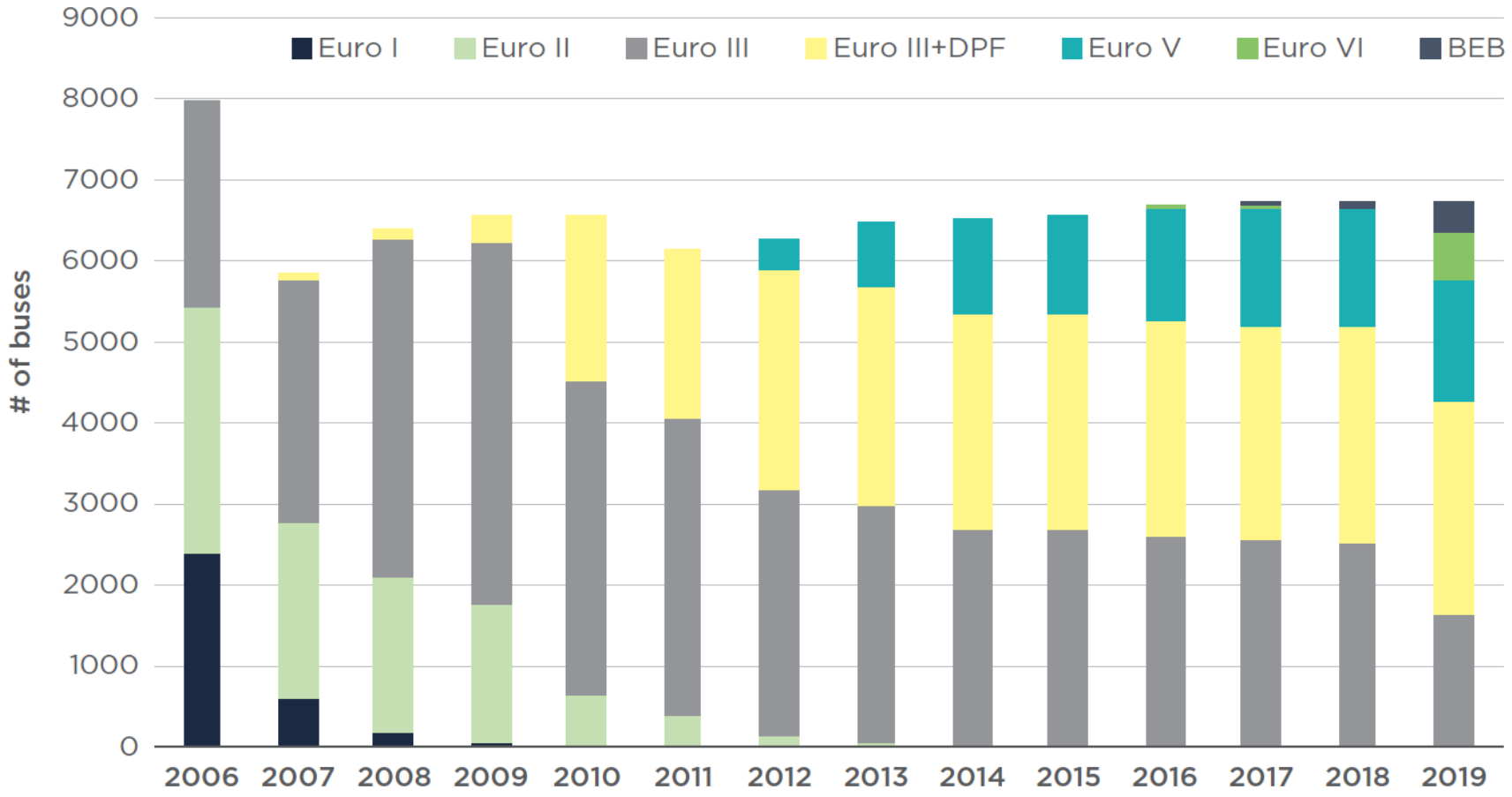
Santiago de Chile: Euro VI and E-bus procurement through regional air quality management strategy



Evolution of urban bus emission control emission control technologies in Santiago
Source: S. Galarza, 2020

Ecological Santiago bus fleet in use by 2020:

1443
Euro VI Buses

776
Electric Buses

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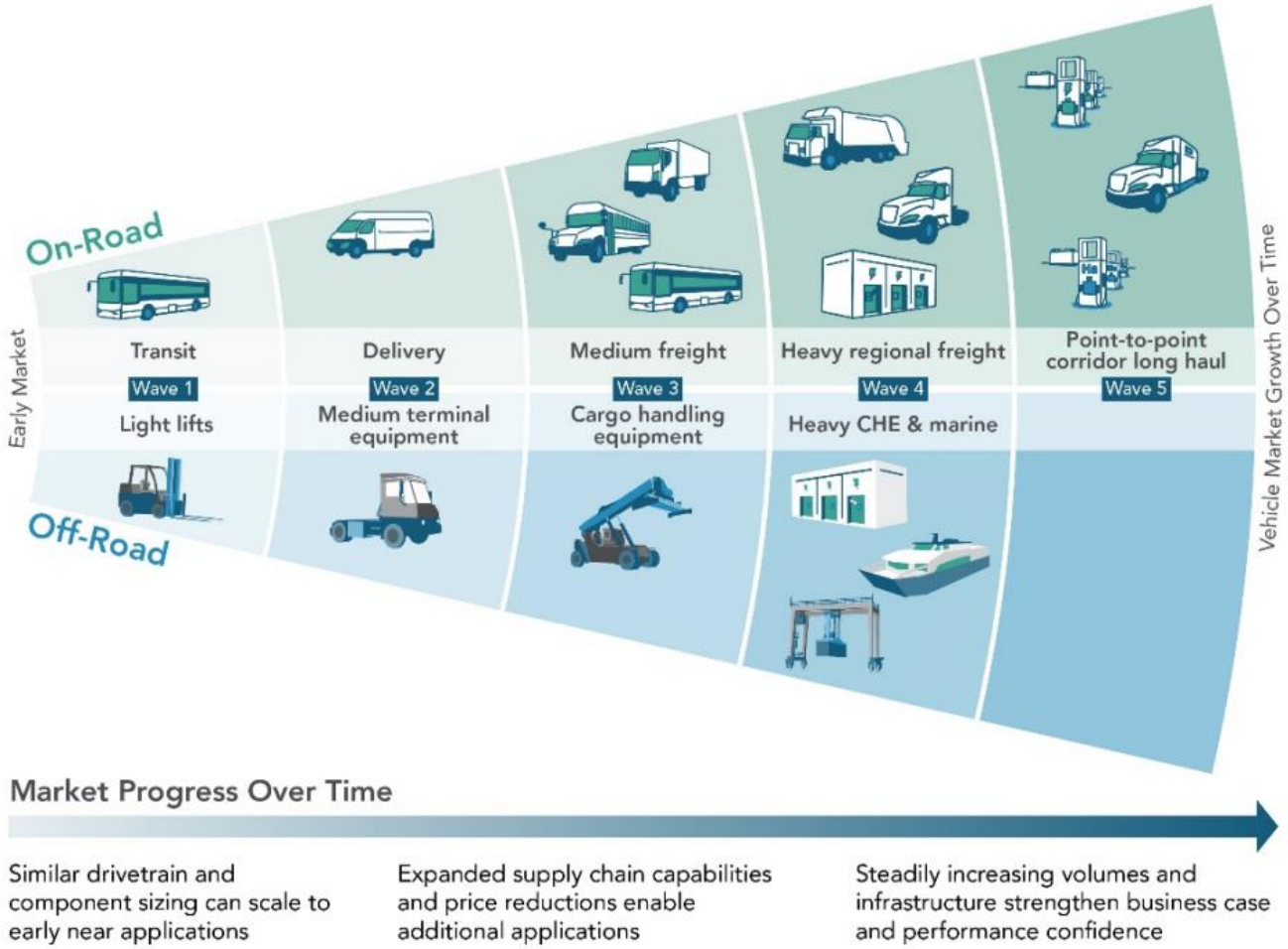
Buses is the starting point for HDV electrification but there is potential in other segments



California's government vision for HDV growth:

- Battery electric transit buses
- Battery electric shuttle and school buses;
- Battery electric delivery vehicles;
- Battery electric garbage trucks;
- Battery electric regional trucks
- Battery electric or fuel-cell long-haul cargo trucks

Source: https://ww2.arb.ca.gov/sites/default/files/2020-11/appd_hd_invest_strat.pdf

Policy actions to accelerate ZEV transition

- **Phase-out targets:** Setting a vision and market signal
- **Binding regulations:** Ensuring model availability and supply
- **Financial incentives:** Making ZEVs cost-effective today
- **Charging infrastructure:** Maximizing ZEVs' convenience
- **Consumer awareness:** Building understanding of ZEVs' benefits

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California Zero Emission Vehicle State Targets

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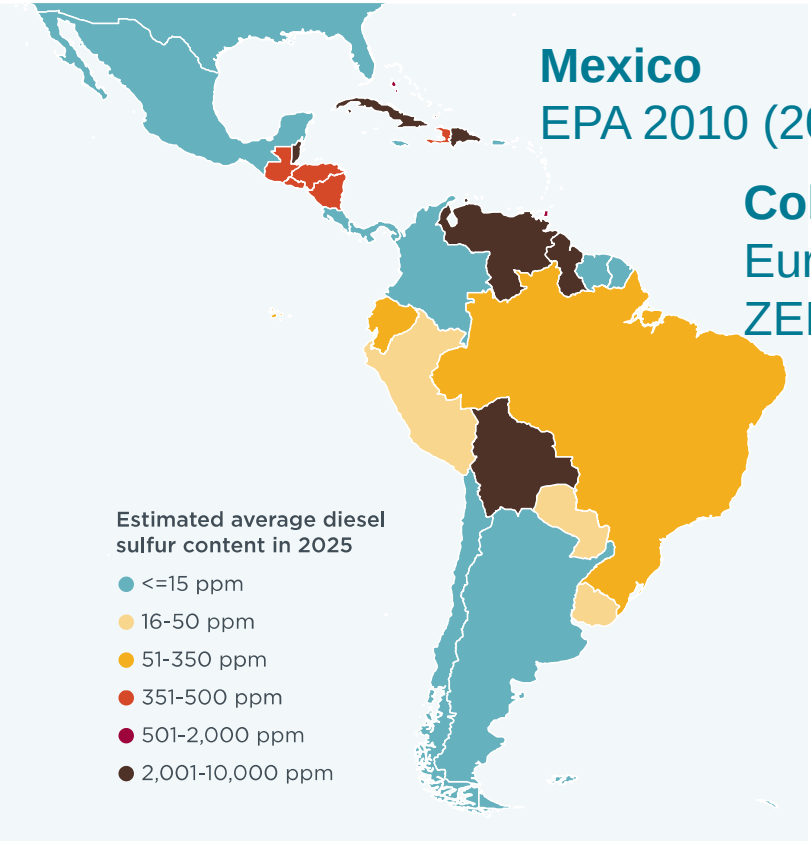
California Zero Emission Bus Mandate

Calendar year	Zero Emission Bus percentage of new bus purchases	
	Large transit agency	Small transit agency
2023*	25%	
2024*	25%	
2025	25%	
2026	50%	25%
2027	50%	25%
2028	50%	25%
2029 and after	100%	100%

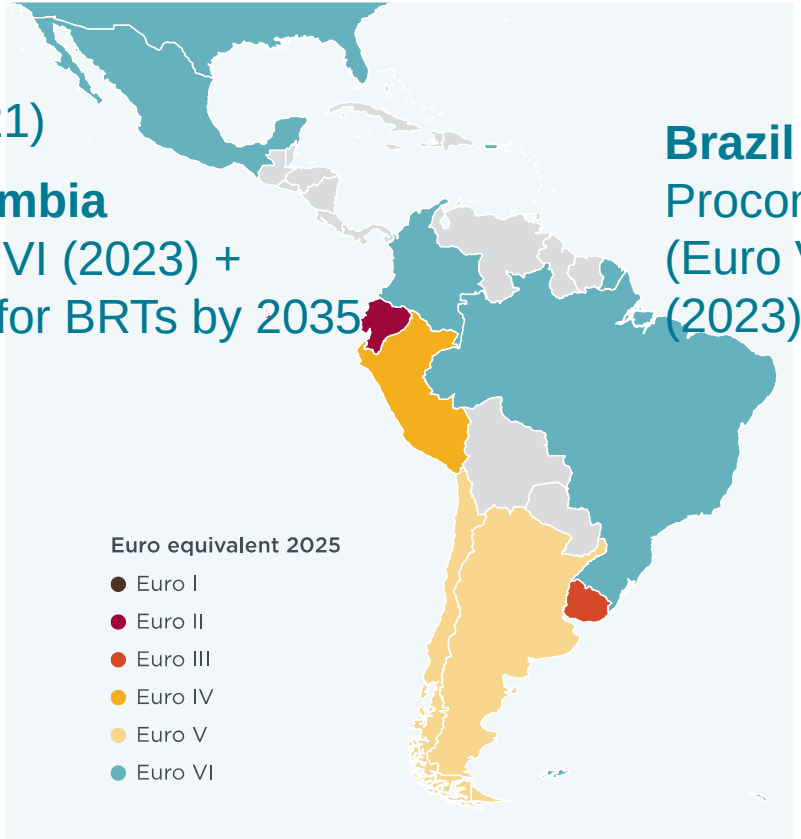
* Potential waiver for early action (more than 1000 ZEBs by December 2020; 1150 by December 2021)

Diesel sulfur content, heavy-duty engine emissions standards, and ZEV policy in Latin America

Diesel fuel sulfur content



Heavy-duty engine emissions standards



Mexico
EPA 2010 (2021)

Colombia
Euro VI (2023) +
ZEB for BRTs by 2035

Brazil
Proconve 8
(Euro VI)
(2023)

Data from:
https://theicct.org/sites/default/files/publications/Global_progress_sootfree_diesel_2019_20190920.pdf

Thank you!

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