



EUROPEAN EMISSION STANDARDS EVOLUTION AND IMPACT ON AUTOMOTIVE MARKET

POLLUTANT AND GREENHOUSE GAS EMISSIONS [LDV]



Carbon monoxide (CO), highly toxic, measured in mg/km



Unburned hydrocarbons (HC), toxicity depends on the detailed chemical composition, measured in mg/km



Nitrogen oxides NO and NO2 (commonly treated as **NOx**) harmful to human health and photochemical effects in the atmosphere measured in mg/km



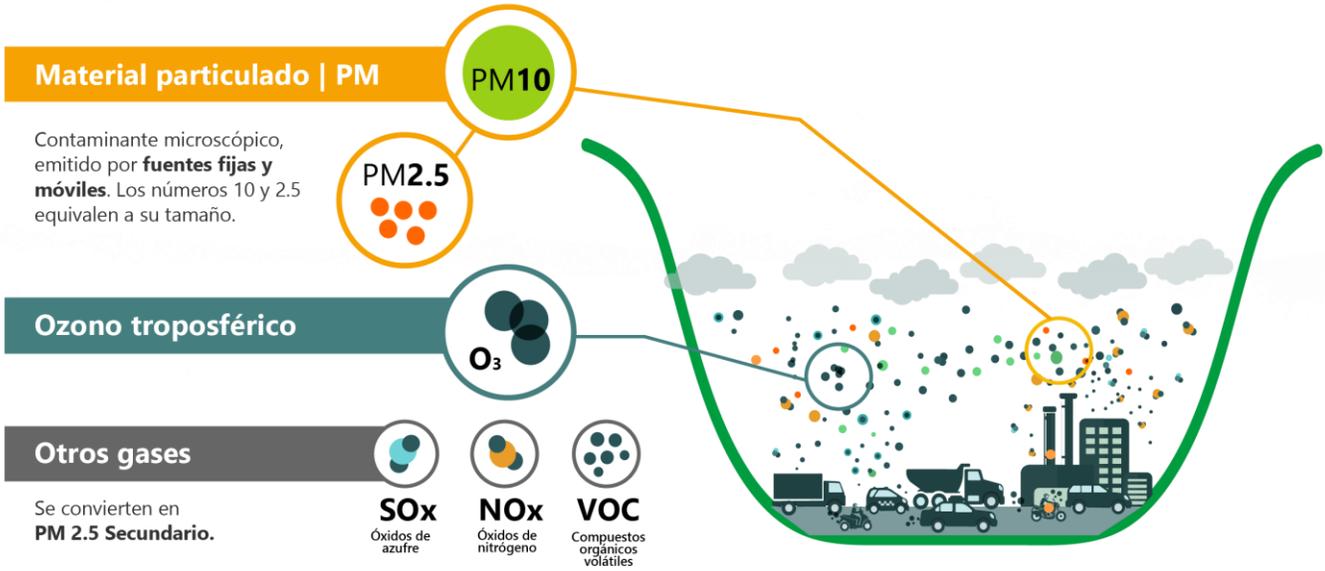
Particulates (soot and ash) measured as **PM** in mg/km and PN measured in number/km



CO2 is the natural result of the combustion process of carbon containing fuels (Gasoline, Diesel, but also alcohols and natural gas). CO2 is by far the most important greenhouse gas.



Methane (CH4) can be a bi-product of the combustion as other unburned hydrocarbons.



POLLUTANT AND GREENHOUSE GAS EMISSIONS [LDV]



Carbon monoxide (CO), highly toxic, measured in mg/km



Unburned hydrocarbons (HC), toxicity depends on the detailed chemical composition, measured in mg/km



Nitrogen oxides NO and NO₂ (commonly treated as **NO_x**) harmful to human health and photochemical effects in the atmosphere measured in mg/km



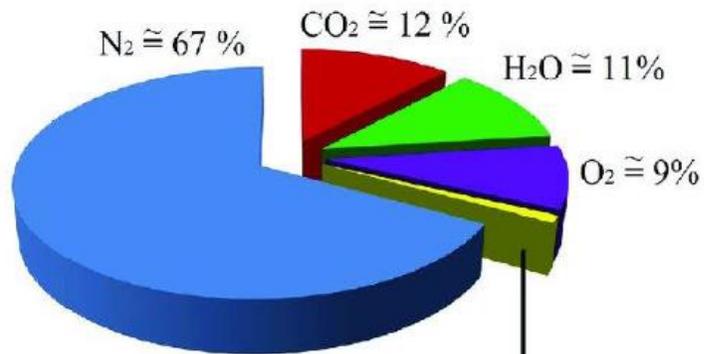
Particulates (soot and ash) measured as **PM** in mg/km and **PN** measured in number/km



CO₂ is the natural result of the combustion process of carbon containing fuels (Gasoline, Diesel, but also alcohols and natural gas). CO₂ is by far the most important greenhouse gas.



Methane (CH₄) can be a bi-product of the combustion as other unburned hydrocarbons.



Pollutant Emissions ≈ 1%				
CO	HC	NO _x	SO ₂	PM



POLLUTANTS MEAN LESS THAN 1% TOTAL EMISSIONS



EVEN SO THEY ARE A MAIN FOCUS



OF THE INDUSTRY

EURO EMISSION STANDARDS EVOLUTION

1970

Europe's first Emission Legislation (Council Directive 70/220/EEC)

1992

Creation and Enforcement of EURO 1



**Introduction of
Catalytic Converter**



**Enforcement of
Unleaded Gasoline**

EURO EMISSION STANDARDS EVOLUTION

Stage	Date	CO	HC	HC+NOx	NOx	PM	PN
		g/km					#/km
Compression Ignition (Diesel)							
Euro 1†	1992.07	2.72 (3.16)	–	0.97 (1.13)	–	0.14 (0.18)	–
Euro 2, IDI	1996.01	1.0	–	0.7	–	0.08	–
Euro 2, DI	1996.01 ^a	1.0	–	0.9	–	0.10	–
Euro 3	2000.01	0.64	–	0.56	0.50	0.05	–
Euro 4	2005.01	0.50	–	0.30	0.25	0.025	–
Euro 5a	2009.09 ^b	0.50	–	0.23	0.18	0.005 ^f	–
Euro 5b	2011.09 ^c	0.50	–	0.23	0.18	0.005 ^f	6.0×10 ¹¹
Euro 6	2014.09	0.50	–	0.17	0.08	0.005 ^f	6.0×10 ¹¹
Positive Ignition (Gasoline)							
Euro 1†	1992.07	2.72 (3.16)	–	0.97 (1.13)	–	–	–
Euro 2	1996.01	2.2	–	0.5	–	–	–
Euro 3	2000.01	2.30	0.20	–	0.15	–	–
Euro 4	2005.01	1.0	0.10	–	0.08	–	–
Euro 5	2009.09 ^b	1.0	0.10 ^d	–	0.06	0.005 ^{e,f}	–
Euro 6	2014.09	1.0	0.10 ^d	–	0.06	0.005 ^{e,f}	6.0×10 ¹¹ e.g

Notes:

* At the Euro 1-4 stages, passenger vehicles > 2,500 kg were type approved as Category N₁ vehicles

† Values in brackets are conformity of production (COP) limits

a. until 1999.09.30 (after that date DI engines must meet the IDI limits)

b. 2011.01 for all models

c. 2013.01 for all models

d. and NMHC = 0.068 g/km

e. applicable only to vehicles using DI engines

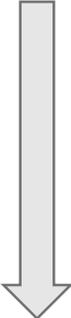
f. 0.0045 g/km using the PMP measurement procedure

g. 6.0×10¹² 1/km within first three years from Euro 6 effective dates

EURO EMISSION STANDARDS EVOLUTION

Stage	Date	CO	HC	HC+NOx	NOx	PM	PN
		g/km					
Compression Ignition (Diesel)							
Euro 1†	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	0.14 (0.18)	-
Euro 2, IDI	1996.01	1.0	-	0.7	-	0.08	-
Euro 2, DI	1996.01 ^a	1.0	-	0.9	-	0.10	-
Euro 3	2000.01	0.64 -81%	-	0.56 -82%	0.50	0.05 -96%	-
Euro 4	2005.01	0.50	-	0.30	0.25	0.025	-
Euro 5a	2009.09 ^b	0.50	-	0.23	0.18	0.005 ^f	-
Euro 5b	2011.09 ^c	0.50	-	0.23	0.18	0.005 ^f	6.0×10 ¹¹
Euro 6	2014.09	0.50	-	0.17	0.08	0.005 ^f	6.0×10 ¹¹
Positive Ignition (Gasoline)							
Euro 1†	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	-	-
Euro 2	1996.01	2.2	-	0.5	-	-	-
Euro 3	2000.01	2.30	0.20	-	0.15	-	-
Euro 4	2005.01	1.0	0.10	-	0.08	-	-
Euro 5	2009.09 ^b	1.0	0.10 ^d	-	0.06	0.005 ^{e,f}	-
Euro 6	2014.09	1.0	0.10 ^d	-	0.06	0.005 ^{e,f}	6.0×10 ¹¹ e,g

1992



2015

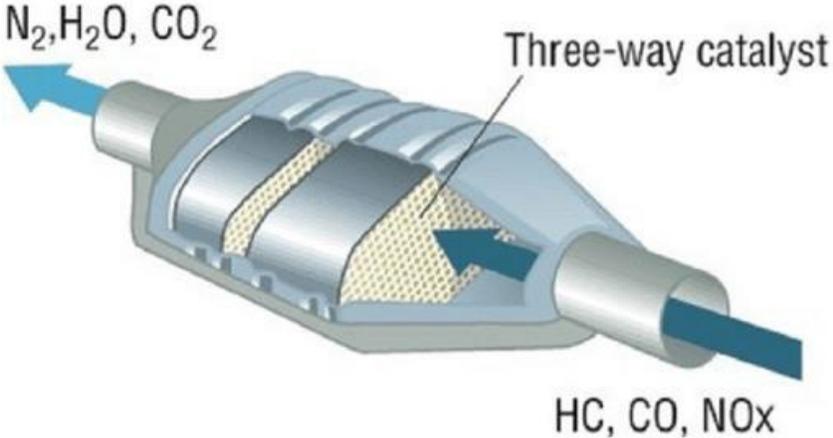
- 86%

Notes:

- * At the Euro 1-4 stages, passenger vehicles > 2,500 kg were type approved as Category N₁ vehicles
- † Values in brackets are conformity of production (COP) limits
- a. until 1999.09.30 (after that date DI engines must meet the IDI limits)
- b. 2011.01 for all models
- c. 2013.01 for all models
- d. and NMHC = 0.068 g/km
- e. applicable only to vehicles using DI engines
- f. 0.0045 g/km using the PMP measurement procedure
- g. 6.0×10¹² 1/km within first three years from Euro 6 effective dates

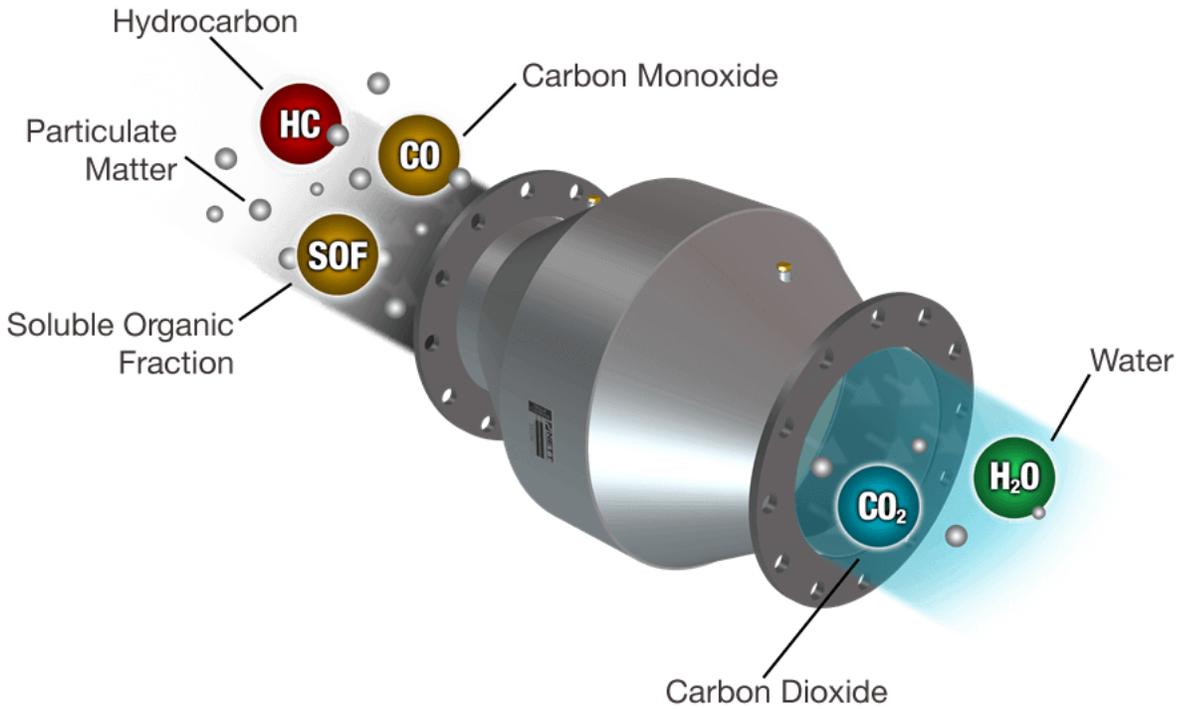
EURO EMISSION STANDARDS AND TECHNOLOGY EVOLUTION

Standard	Year	Petrol		Diesel	
		Engine Measures	Exhaust	Engine Measures	Exhaust
Euro 1	1992	Fuel Injection	3 way Catalyst + lambda	Combustion System and intake systems improvement	----



EURO EMISSION STANDARDS AND TECHNOLOGY EVOLUTION

Standard	Year	Petrol		Diesel	
		Engine Measures	Exhaust	Engine Measures	Exhaust
Euro 1	1992	Fuel Injection	3 way Catalyst + lambda	Combustion System and intake systems improvement	----
Euro 2	1996	Improved ECU	Larger Catalyst	Direct Injection; Fuel pressure improvement	Oxidation catalyst



https://ec.europa.eu/jrc/sites/jrcsh/files/policies-reduce-air-emissions_19oct-morning_2.pdf

EURO EMISSION STANDARDS AND TECHNOLOGY EVOLUTION

Standard	Year	Petrol		Diesel	
		Engine Measures	Exhaust	Engine Measures	Exhaust
Euro 1	1992	Fuel Injection	3 way Catalyst + lambda	Combustion System and intake systems improvement	----
Euro 2	1996	Improved ECU	Larger Catalyst	Direct Injection; Fuel pressure improvement	Oxidation catalyst
Euro 3	2000	OBD	Pre-Catalyst + Dual lambda	EGR, Common Rail	Pre-Catalyst and Main Catalyst



https://ec.europa.eu/jrc/sites/jrcsh/files/policies-reduce-air-emissions_19oct-morning_2.pdf

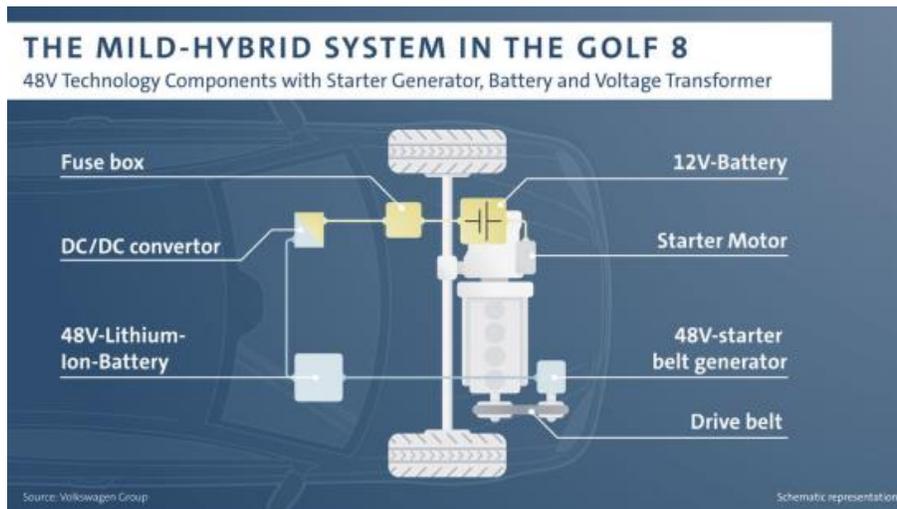
EURO EMISSION STANDARDS AND TECHNOLOGY EVOLUTION

Standard	Year	Petrol		Diesel	
		Engine Measures	Exhaust	Engine Measures	Exhaust
Euro 1	1992	Fuel Injection	3 way Catalyst + lambda	Combustion System and intake systems improvement	----
Euro 2	1996	Improved ECU	Larger Catalyst	Direct Injection; Fuel pressure improvement	Oxidation catalyst
Euro 3	2000	OBD	Pre-Catalyst + Dual lambda	EGR, Common Rail	Pre-Catalyst and Main Catalyst
Euro 4	2005	System Optimization	Closer placement of 1st Catalyst	Multiple Injection; Pressure Increase	Pre-Catalyst and Main Catalyst Start of DPF usage



EURO EMISSION STANDARDS AND TECHNOLOGY EVOLUTION

Standard	Year	Petrol		Diesel	
		Engine Measures	Exhaust	Engine Measures	Exhaust
Euro 1	1992	Fuel Injection	3 way Catalyst + lambda	Combustion System and intake systems improvement	----
Euro 2	1996	Improved ECU	Larger Catalyst	Direct Injection; Fuel pressure improvement	Oxidation catalyst
Euro 3	2000	OBD	Pre-Catalyst + Dual lambda	EGR, Common Rail	Pre-Catalyst and Main Catalyst
Euro 4	2005	System Optimization	Closer placement of 1st Catalyst	Multiple Injection; Pressure Increase	Pre-Catalyst and Main Catalyst Start of DPF usage
Euro 5	2010	Mainstream Direct Injection; VVT; S&S; MHEV	More thermally durable - placed just after manifold	Cooled EGR and Combustion Optimization	DPF Mandatory



EURO EMISSION STANDARDS AND TECHNOLOGY EVOLUTION

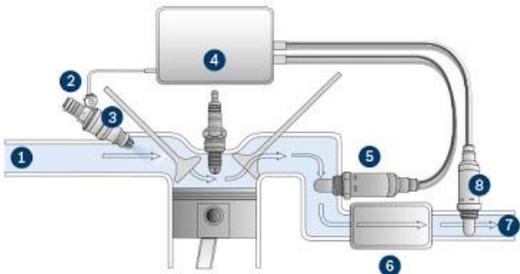
Standard	Year	Petrol		Diesel	
		Engine Measures	Exhaust	Engine Measures	Exhaust
Euro 1	1992	Fuel Injection	3 way Catalyst + lambda	Combustion System and intake systems improvement	----
Euro 2	1996	Improved ECU	Larger Catalyst	Direct Injection; Fuel pressure improvement	Oxidation catalyst
Euro 3	2000	OBD	Pre-Catalyst + Dual lambda	EGR, Common Rail	Pre-Catalyst and Main Catalyst
Euro 4	2005	System Optimization	Closer placement of 1st Catalyst	Multiple Injection; Pressure Increase	Pre-Catalyst and Main Catalyst Start of DPF usage
Euro 5	2010	Mainstream Direct Injection; VVT; S&S; MHEV	More thermally durable - placed just after manifold	Cooled EGR and Combustion Optimization	DPF Mandatory
Euro 6	2014	GDI – Controlled Combustion	Start usage of GPF	High Pressure Injection	SCR

EURO EMISSION STANDARDS AND TECHNOLOGY EVOLUTION

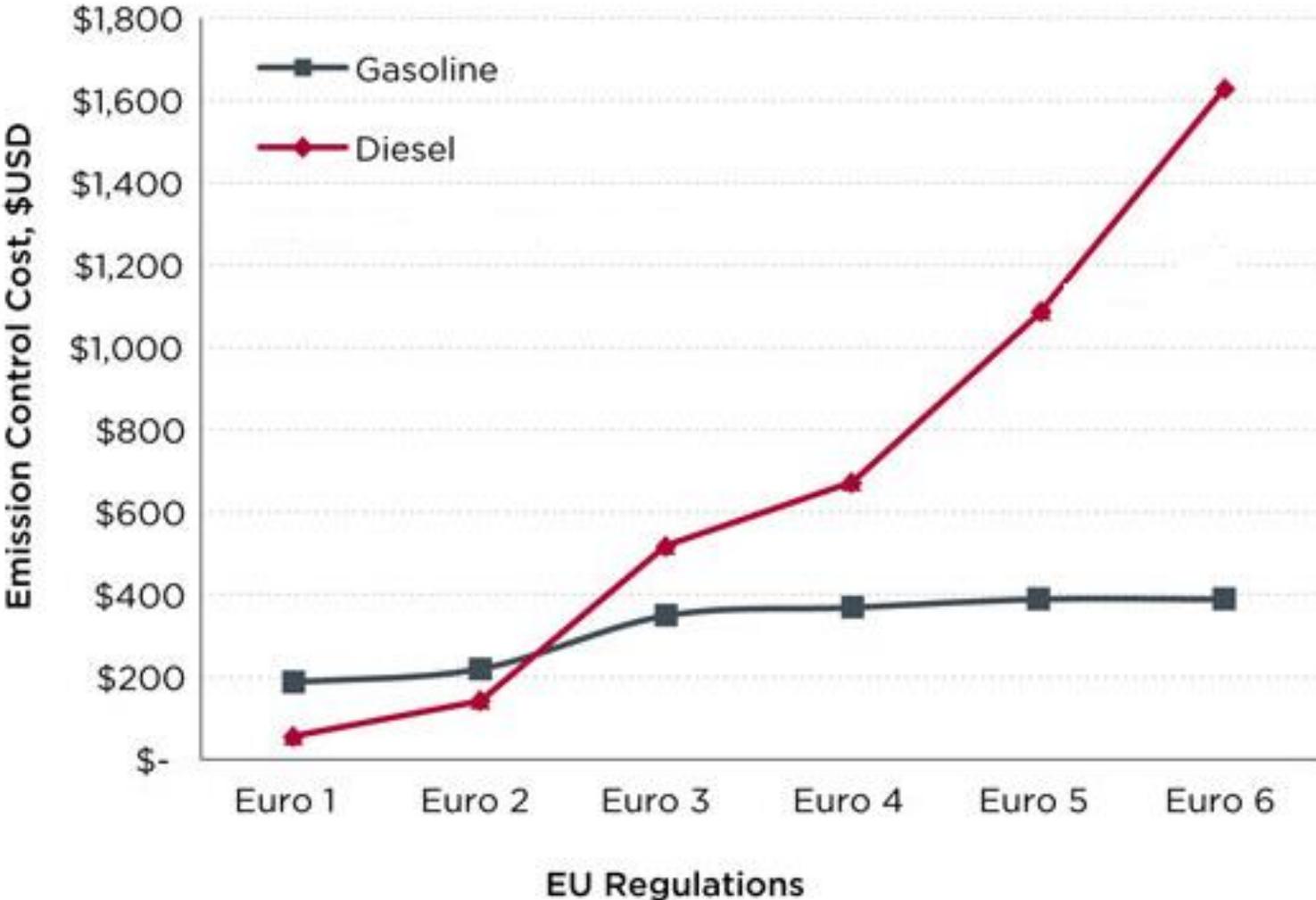
Standard	Year	Petrol		Diesel	
		Engine Measures	Exhaust	Engine Measures	Exhaust
Euro 1	1992	Fuel Injection	3 way Catalyst + lambda	Combustion System and intake systems improvement	----
Euro 2	1996	Improved ECU	Larger Catalyst	Direct Injection; Fuel pressure improvement	Oxidation catalyst
Euro 3	2000	OBD	Pre-Catalyst + Dual lambda	EGR / Common Rail	Pre-Catalyst and Main Catalyst
Euro 4	2005	System Optimization	Closer placement of 1st Catalyst	Multiple Injection; Pressure Increase	Pre-Catalyst and Main Catalyst Start of DPF usage
Euro 5	2010	Mainstream Direct Injection; VVT; S&S MHEV	More thermally durable - placed just after manifold	Cooled EGR and Combustion Optimization	DPF Mandatory
Euro 6	2014	GDI – Controlled Combustion	Start usage of GPF	High Pressure Injection	SCR



- Lambda control loop**
- 1 Intake air
 - 2 Fuel supply
 - 3 Injector
 - 4 Electronic control unit
 - 5 Control sensor (upstream of catalytic converter)
 - 6 Catalytic converter
 - 7 Exhaust gas
 - 8 Diagnostic sensor (downstream of catalytic converter)

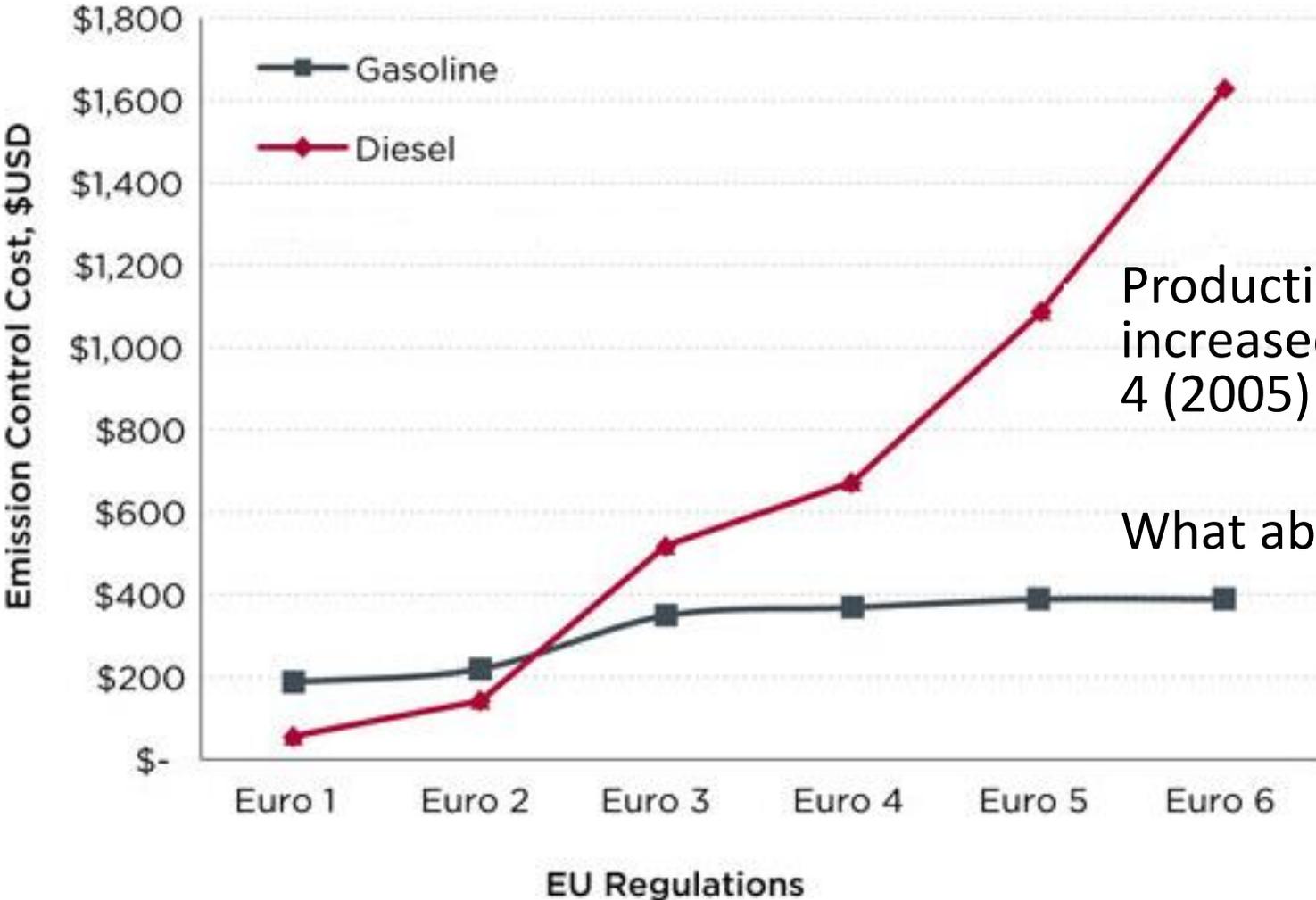


HOW MUCH DID IT COST TO GET TO EURO 6?



Estimated Average Cumulative Emission Control Technology Cost for Gasoline and Diesel Engine assuming 2.0L Engine

HOW MUCH DID IT COST TO GET TO EURO 6?

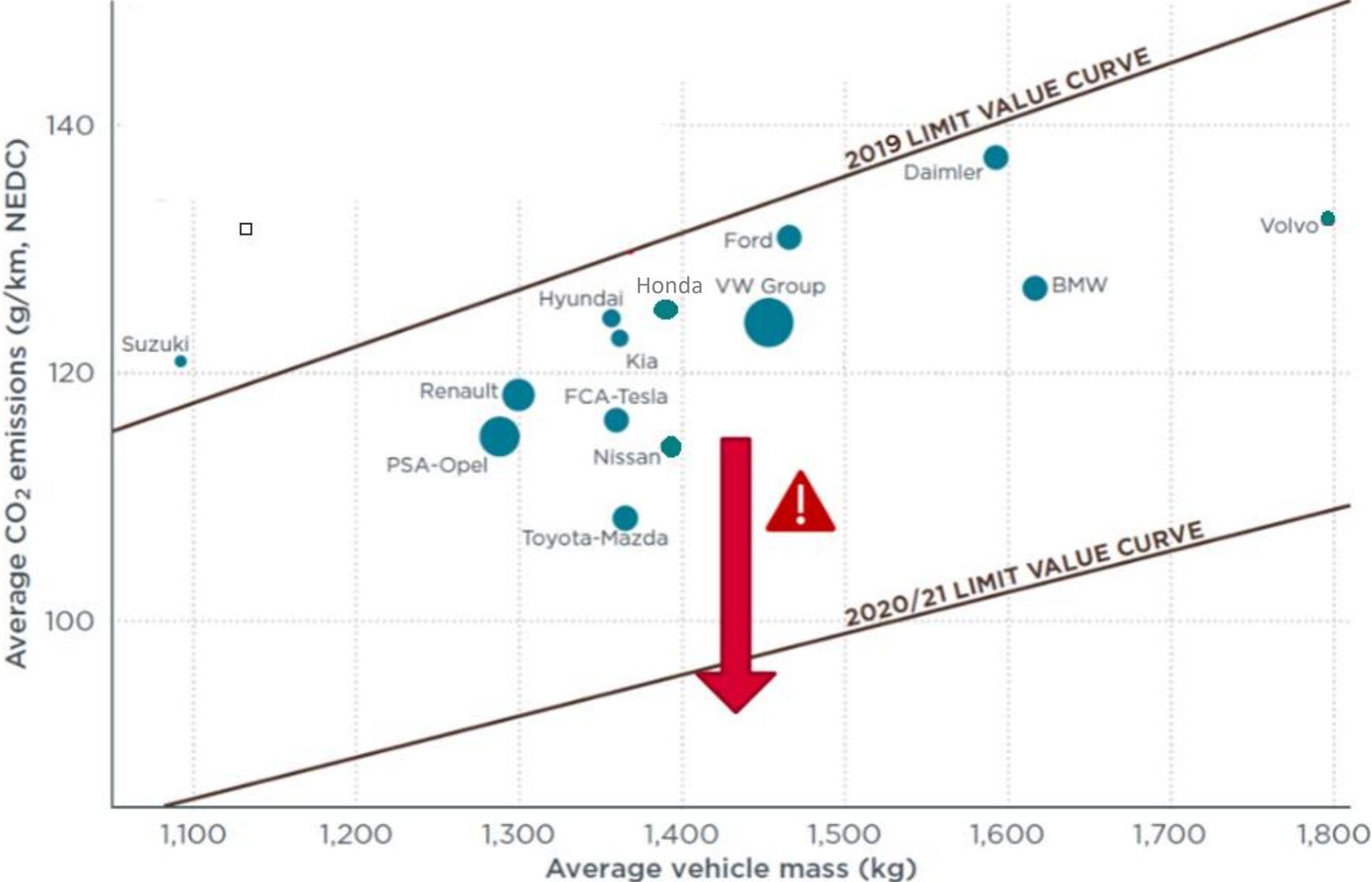


Production cost for a diesel car increased 1.000 USD since euro 4 (2005)!

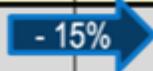
What about Retail Price?

Estimated Average Cumulative Emission Control Technology Cost for Gasoline and Diesel Engine assuming 2.0L Engine

CHALLENGE FROM 2019 TO 2020/ 21



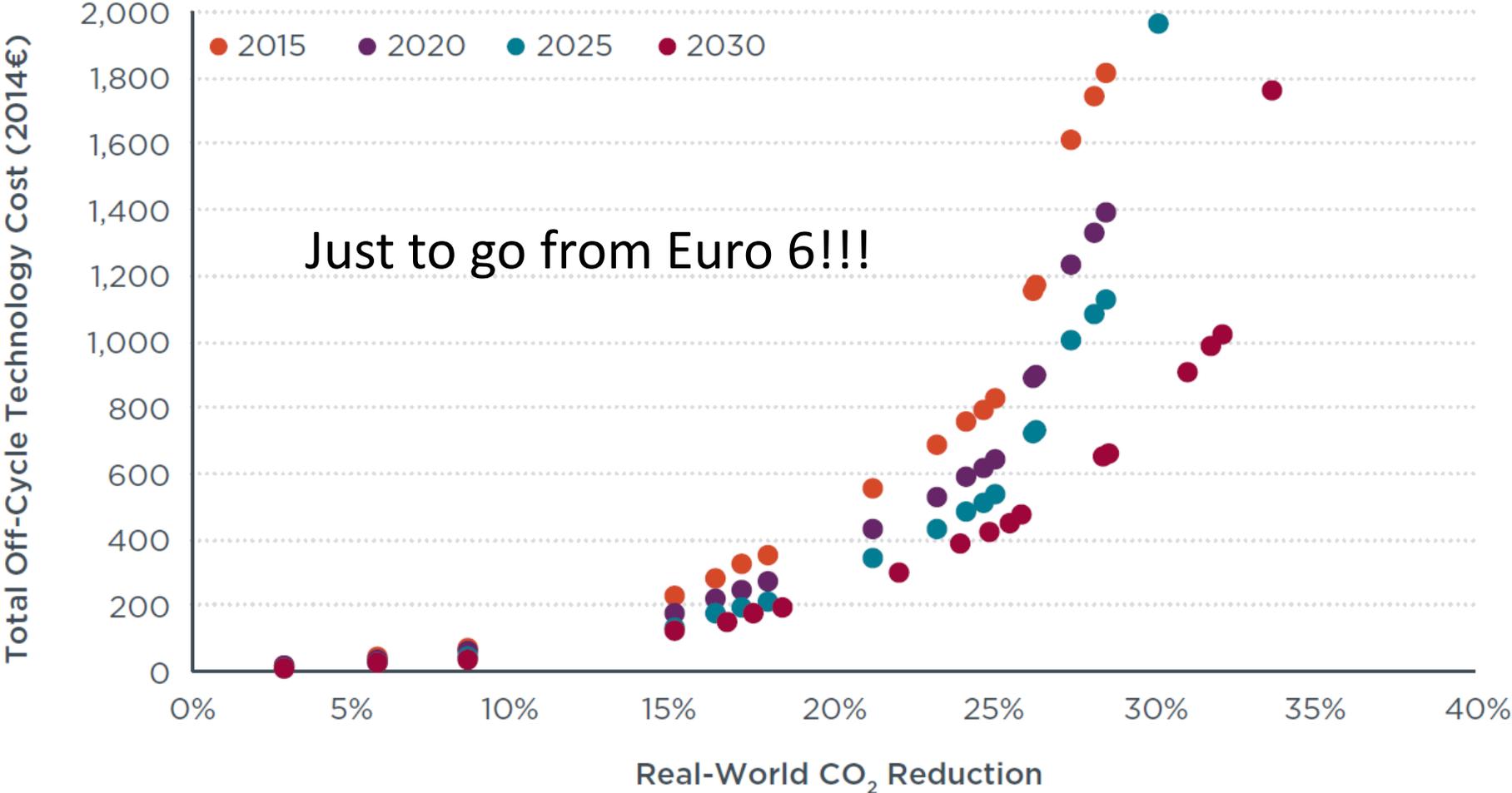
CO2 STANDARDS 2020- 2030

<i>Reg. (EU) 2019/631</i>	2020	2021	2022	2023	2024	2025+	2030+
NEDC CO2 target [gCO2/km]	 95	95				81	59
Indicative WLTP CO2 target [gCO2/km]	Oem A	[110]				[95]	 [70]
Flexibilities	Phase-in 95% of fleet						
	ZLEV* Super credit multipliers Max 7,5gCO2/km within 3 years			Exceed below ZLEV* Benchmarks Max 5% target relieve each year			
	2	1,67	1,33	15%		35%	
	Eco-innovations Max 7 gCO2/km each year						

* ZLEV = Zero- and Low Emission Vehicle (< 50 gCO2/km ≈ BEV/PHEV)

Penalty: 95€/ g CO2 / car

HOW MUCH WILL IT COST?



Off-Cycle Technology Package Benefits and Costs (base 2014 Euro6, Lower-Medium Car)

https://theicct.org/sites/default/files/publications/EU-Cost-Curves_ICCT_nov2016.pdf

EURO 7 – WHAT CONSEQUENCES FOR INDUSTRY?



Diesel ban



- **NO₂ => separate limit**
- **NH₃ => Mandatory SCR system**

- **PM/PN from Tyres/Brakes**
- **Durability => Extension / Removal, Guarantee**
- **RDE**
- **Focused Testing => Cold Start / High Load**

EURO 7 – WHAT CONSEQUENCES FOR INDUSTRY?



Diesel ban



- NO₂ => separate limit
- NH₃ => Mandatory SCR system

- PM/PN from Tyres/Brakes
- Durability => Extension / Removal, Guarantee
- RDE
- Focused Testing => Cold Start / High Load

EURO 7 - ELECTRIC VEHICLES IMPACT



Range at -7 °C
(consumer information)



Vehicle Battery Durability
requirements
[70%] of range (8 years / 160K km)



Brake emissions &
consideration of regenerative
braking



The image features the European Union flag, which consists of a blue field with twelve five-pointed gold stars arranged in a circle. The flag is shown waving on a white flagpole against a clear blue sky. A semi-transparent blue rectangular box is overlaid on the flag, and the text "EU 'Fit For 55' Package" is centered within this box in a white, bold, sans-serif font. At the bottom of the image, there are several horizontal, wavy bands in shades of blue and white, creating a decorative border.

EU 'Fit For 55' Package

EU "FIT FOR 55"

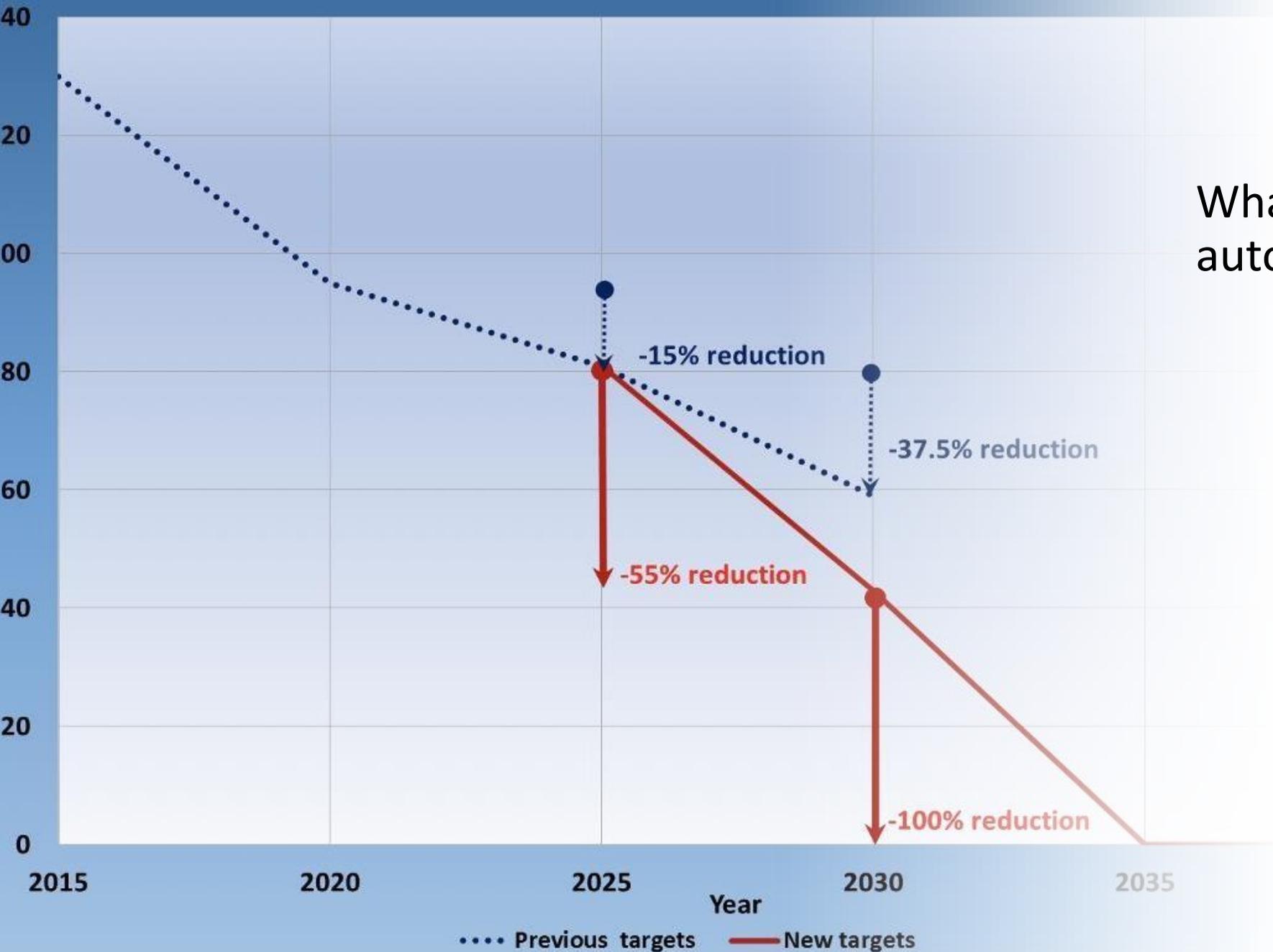
CAR INDUSTRY AFFECTED BY 3 WORK PACKAGES



Measures to reach 2030 CO2 reduction



What does this mean for the automotive industry?



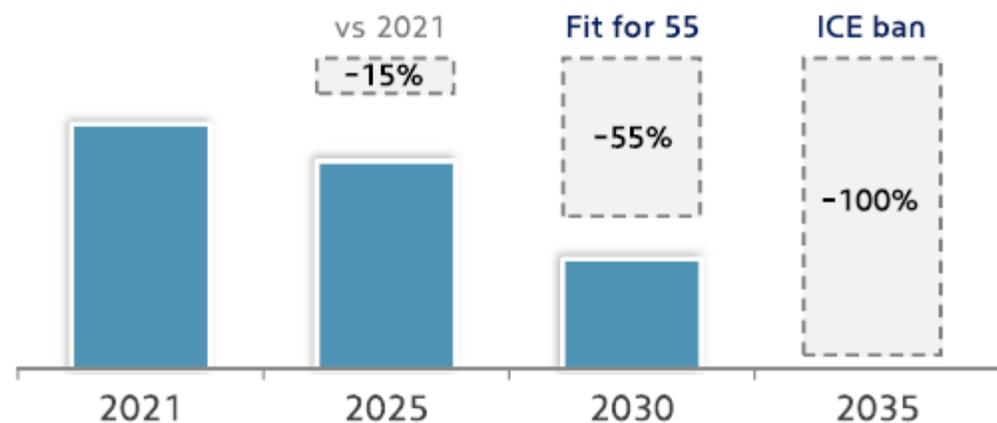
EU “FIT FOR 55”

THE ROADMAP HAS BEEN REDRAWN

Year	2020	2025	2030	2035
Target for cars	95g CO2/km)	-15% (81g CO2/km)	-55% (43g CO2/km)	-100% (0g CO2/km)
Target for vans	147g CO2/km)	-15% (125g CO2/km)	-50% (74g CO2/km)	-100% (0g CO2/km)
Comments	Cars and vans have separate fleet average targets	Unchanged from previous targets	A tightening of the previous -37.5% reduction for new cars (-31% for new vans)	The -100% reduction for 2035 effectively bans ICE petrol & diesel cars by 2035.

EU "FIT FOR 55"

1. CO2 emission standards for cars and vans



➔ CO2 reduction of 55% requires high EV sales share

2. Alternative fuels infrastructure Regulation

- Charging infrastructure is crucial for the required uptake of E-mobility
- ACEA is asking for 6 million public charging points until 2030

➔ Member States are reluctant to invest in infrastructure

3. Renewable energy directive

- The electricity for E-mobility has to be renewable
- Requirements are set to increase this share

➔ Electricity for E-mobility should not from coal power plant

EU "FIT FOR 55"

WHAT ABOUT COSTS?

-37.5% by 2030 versus 2021 baseline	
2017 European Commission estimate (EC, 2017)	€1,610
2018 ICCT estimate (ICCT, 2018)	€870
2021 ICCT estimate (ICCT, 2021)	€940

-50% by 2030 versus 2021 baseline	
2017 European Commission estimate	€2,750
2018 ICCT estimate	€1,160
2021 ICCT estimate	€1,220
2021 European Commission estimate	€1,910

EU "FIT FOR 55"

HOW WILL 2030 AND 2035 LOOK?

2020

- 10% EV/ PHEV

2030 => - 55% => 43g CO2/Km

- 50% EV/ PHEV
- 30% HEV
- 20% ICE/ MHEV

EU "FIT FOR 55"

HOW WILL 2030 AND 2035 LOOK?

2020

- 10% EV/ PHEV

2030 => - 55% => 43g CO2/Km

- 50% EV/ PHEV
- 30% HEV
- 20% ICE/ MHEV

Average Automotive
Product Cycle

5Yr

EU "FIT FOR 55"

HOW WILL 2030 AND 2035 LOOK?

2020

- 10% EV/ PHEV

2030 => - 55% => 43g CO2/Km

- 50% EV/ PHEV
- 30% HEV
- 20% ICE/ MHEV

Average Automotive
Product Cycle

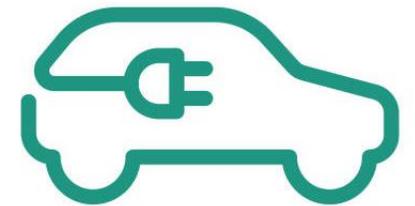
5Yr



10%



Less than 2 product cycles

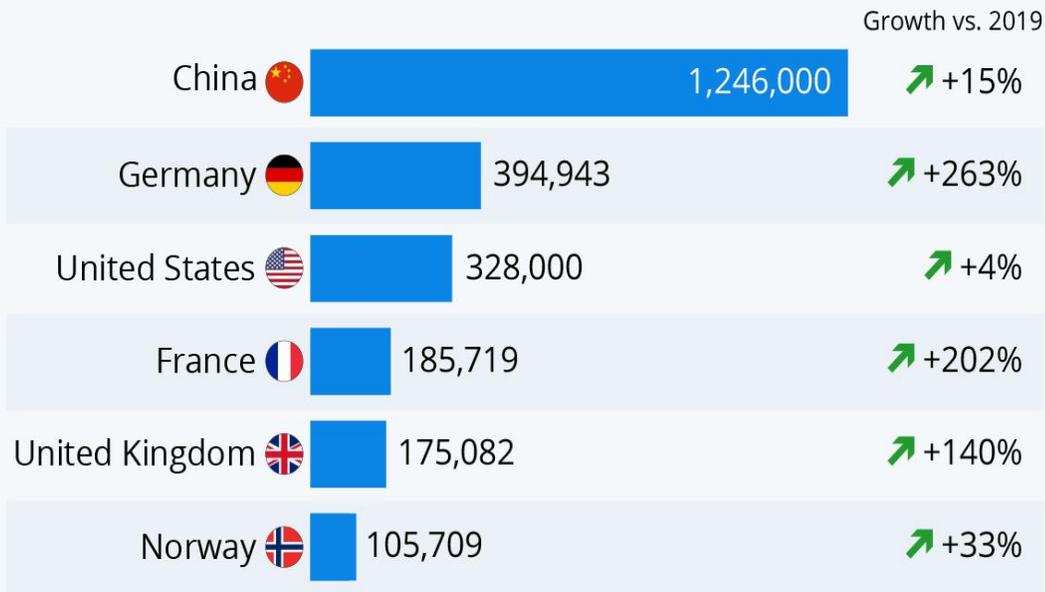


50%

TOWARDS 0 EMISSIONS!

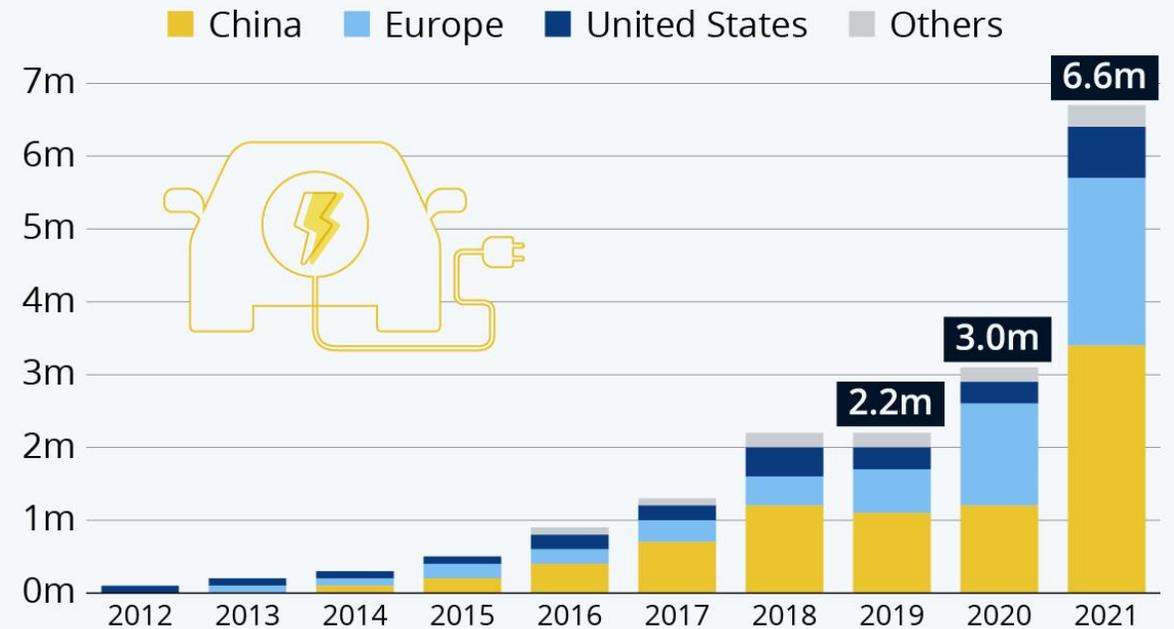
Who Leads the Charge Towards Electric Mobility?

Largest markets in terms of plug-in electric passenger car sales in 2020*



Global Electric Car Sales Doubled in 2021

Global registrations of electric vehicles (incl. plug-in hybrids), by region*



TOWARDS 0 EMISSIONS! - PORTUGAL



EV 2020 => 5,4% M/S

EV 2021 => 9,1% M/S (+63%)

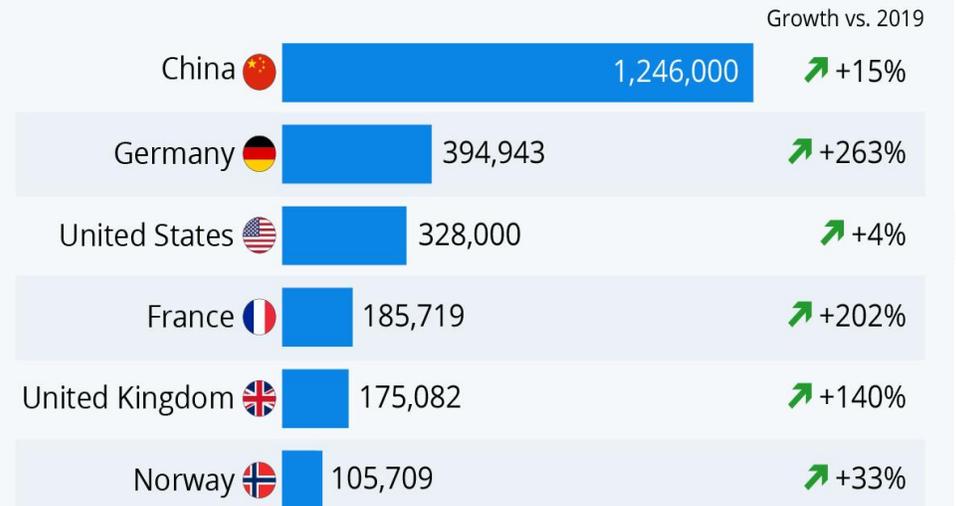
EV 2022 YTM => 10,0% M/S (+88%)

NOV 2021 => 18,1%

Best EV month ever

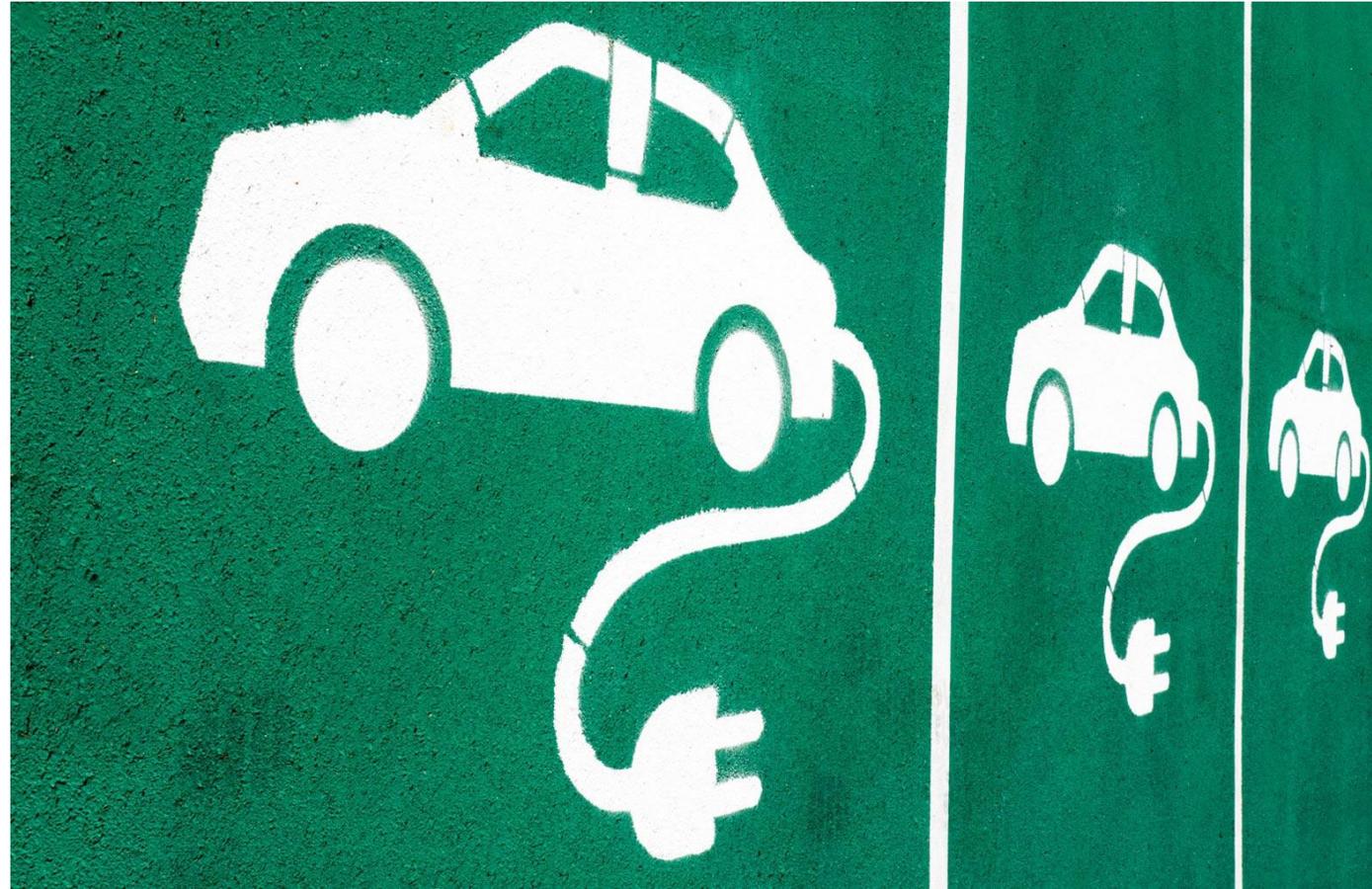
Who Leads the Charge Towards Electric Mobility?

Largest markets in terms of plug-in electric passenger car sales in 2020*



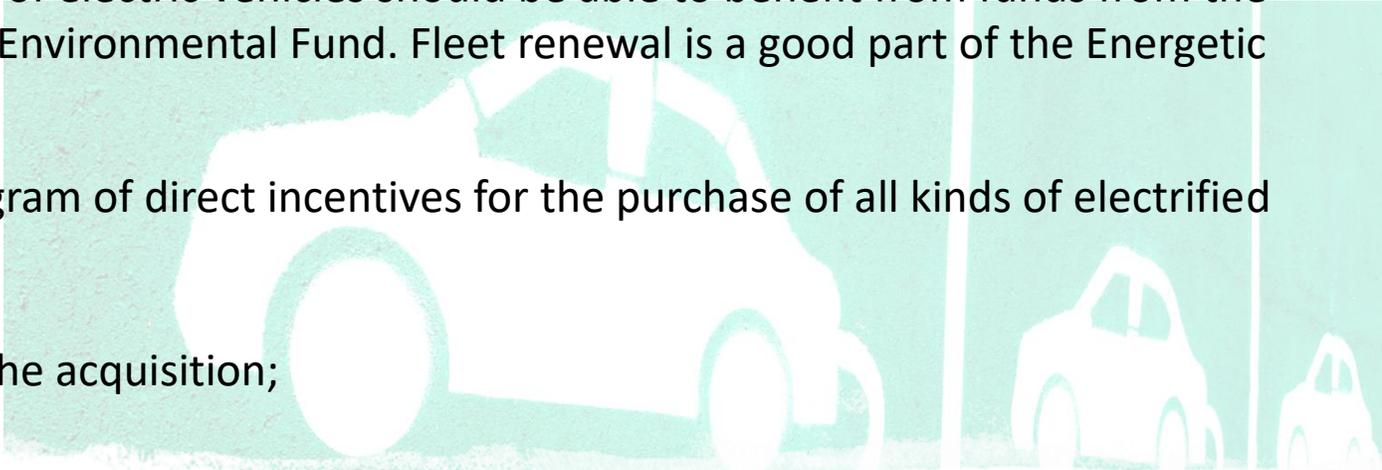
TOWARDS 0 EMISSIONS! - PORTUGAL

THE NEED FOR PUBLIC POLICIES



TOWARDS 0 EMISSIONS! - PORTUGAL

THE NEED FOR PUBLIC POLICIES

1. Recover end of life scrappage incentives, encouraging the purchase of low emission vehicles. This is the only way that truly allows and fastens the fleet renewal;
 2. The financial framework of incentives for the purchase of electric vehicles should be able to benefit from funds from the PRR, and not just to be based on the State Budget or the Environmental Fund. Fleet renewal is a good part of the Energetic Transition;
 3. Implement a consistent, predictable and universal program of direct incentives for the purchase of all kinds of electrified vehicles;
 4. Transfer Tax burden from acquisition to usage, easing the acquisition;
 5. For the new model of automotive taxation in the post-decarbonization period, a broad debate should be proposed between Authorities and all stakeholders, in order to avoid unilateral solutions by the State and to find consensus solutions.
- 



THANK YOU!