

The European Commission's science and knowledge service

Joint Research Centre



Plug-in hybrid vehicles

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Current dilemmas with passenger cars

- Vehicles allowed LEZ (ULEZ)?
- Incentives & de-taxation?
- Plug-in hybrid cars priority plates?
(e.g., Shanghai)
 - **Under which bases?**
- Which emissions?



Source: tfl.gov.UK

Current dilemmas with vehicles

- **What car should I buy?**
 - What kind of driver?
 - What distance I drive and where?
- Range anxiety



Source: Getty Images/Moment RF

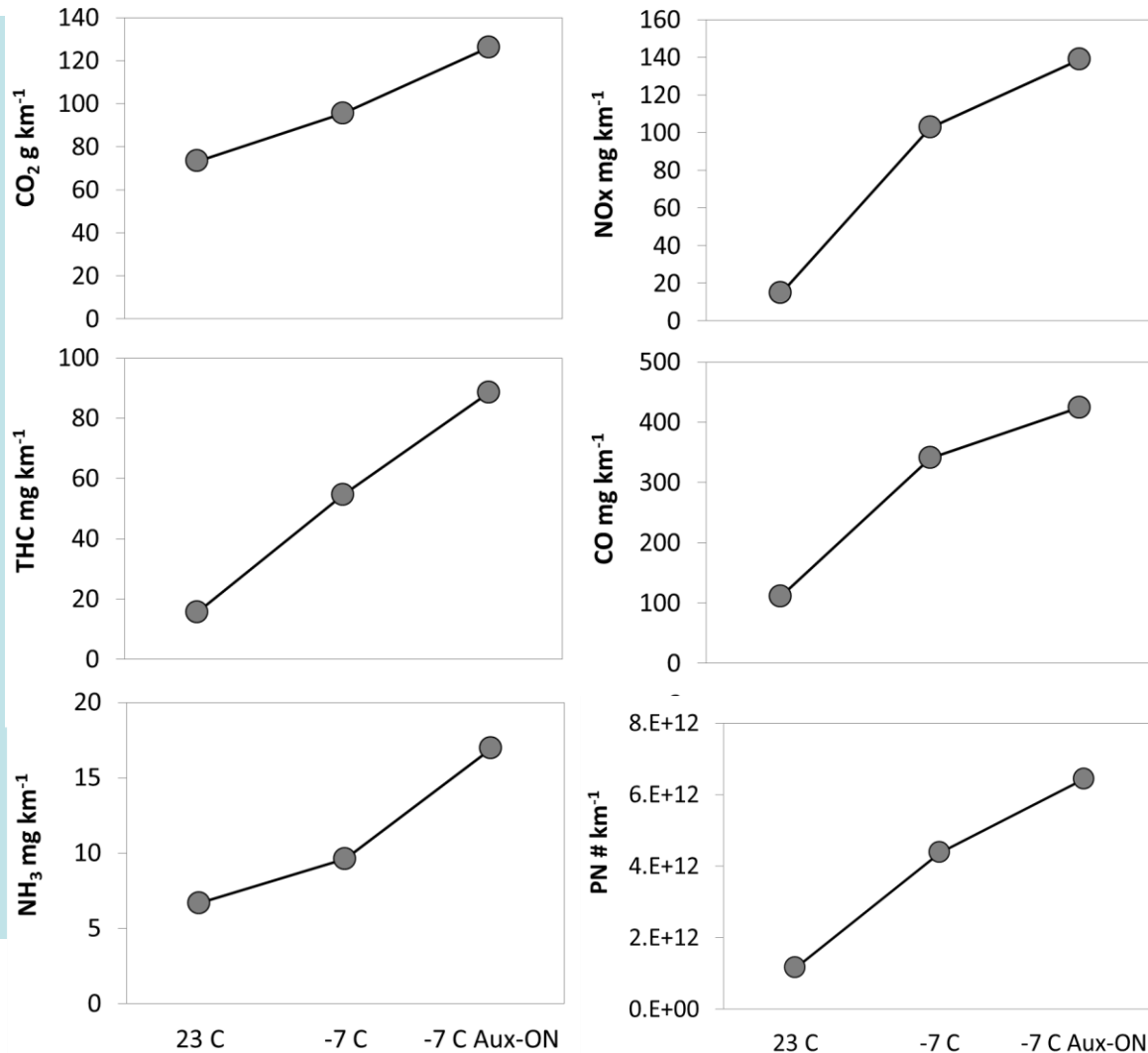
- **Can the ambient conditions impact the emissions of my car?**

Tested vehicles

	Plug-in hybrid-1*	Plug-in hybrid-2*
Internal Combustion Engine (ICE)	GDI	PFI
ICE Displacement (l.)	1.4	2.0
Drivetrain layout	Parallel	Parallel/Series
Battery Type	Li-Ion	Li-Ion
Nominal voltage (V)	345	300
Nominal capacity (kWh)	8.7	12
Emission category	Euro 6b	Euro 6b

*OVC-HEV1 & OVC-HEV2

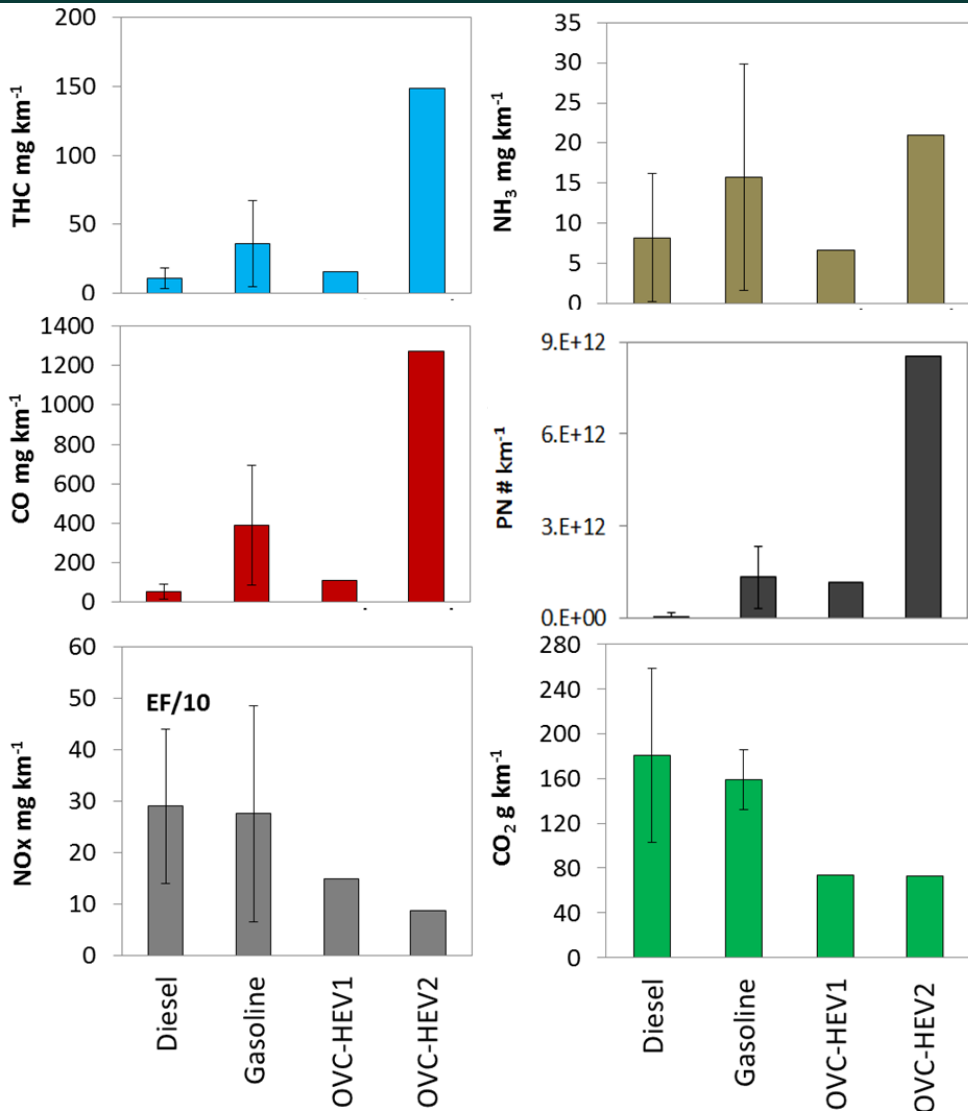
Plug-in hybrid-1 gaseous emissions (23 & -7°C)



Higher emissions at lower T (-7°C)

- CO₂: 30% higher
- NOx: 7 times higher
- THC: 4 times higher
- CO: 3 times higher
- NH₃: 2 times higher
- PN: 4 times higher

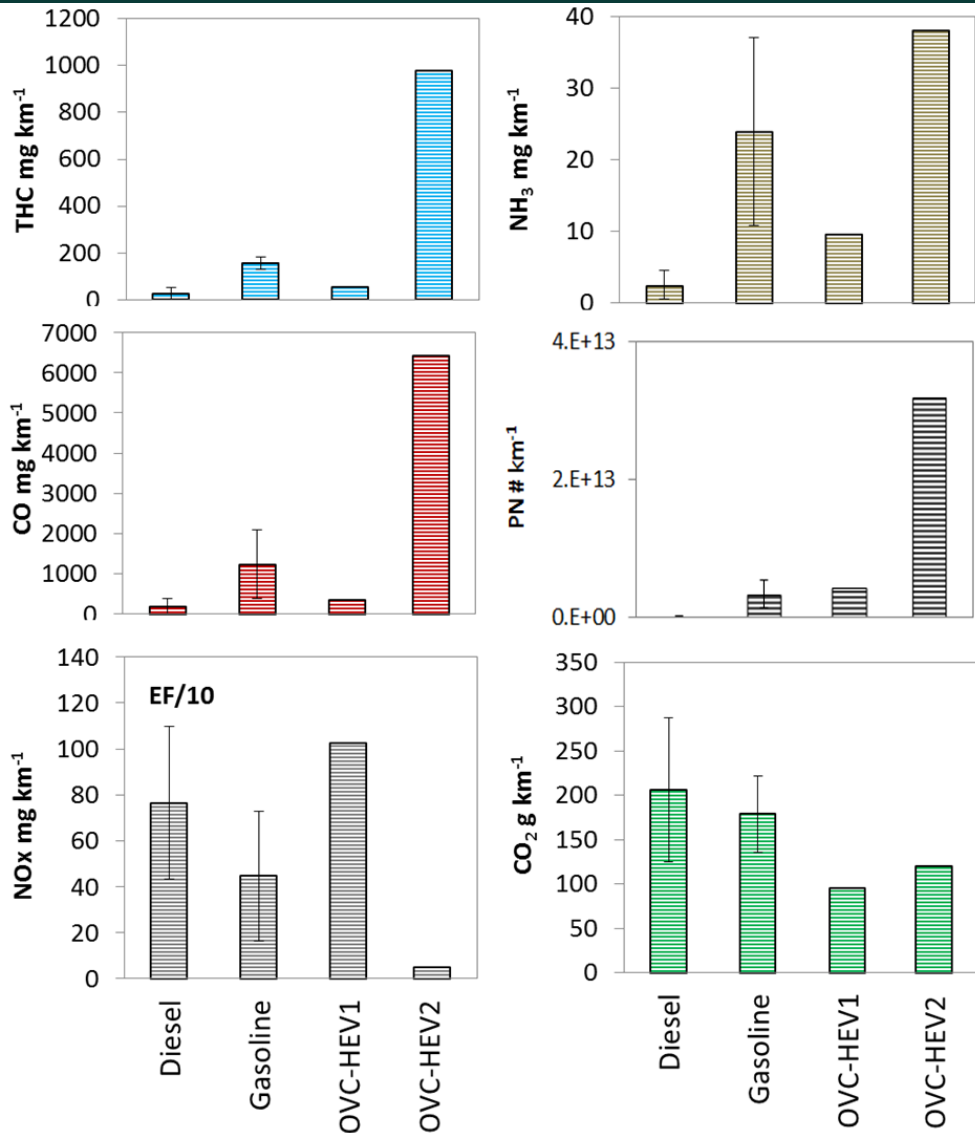
Compared to conventional vehicles (at 23°C)



- CO₂ emissions from the plug-in hybrids were lower than those of conventional gasoline and diesel
- Plug-in hybrid-1: emissions are comparable to conventional Euro 6b gasoline
- Plug-in hybrid-2: emissions of PN, CO, THC and NH₃ are **higher** than conventional Euro 6b gasoline and diesel

Data from diesel and gasoline vehicles can be found at Suarez-Bertoa and Astorga, Impact of cold temperature on Euro 6 passenger car emissions, Environmental Pollution. 234, 318-329. 2018

Compared to conventional vehicles (at -7°C)

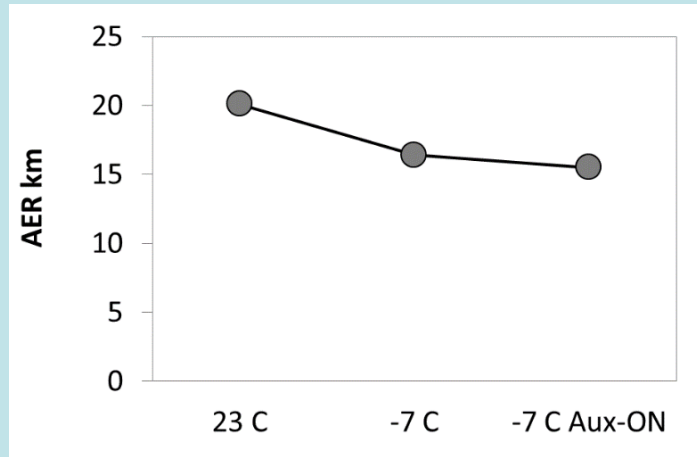


- Plug-in hybrid-1 emissions are comparable to conventional Euro 6b gasoline (except for NO_x)
- Plug-in hybrid-2 emissions of PN, THC and CO are higher than conventional Euro 6b gasoline LDVs
- CO₂ emissions from the plug-in hybrids were lower than those of conventional vehicles but the difference is smaller than tests at 23°C

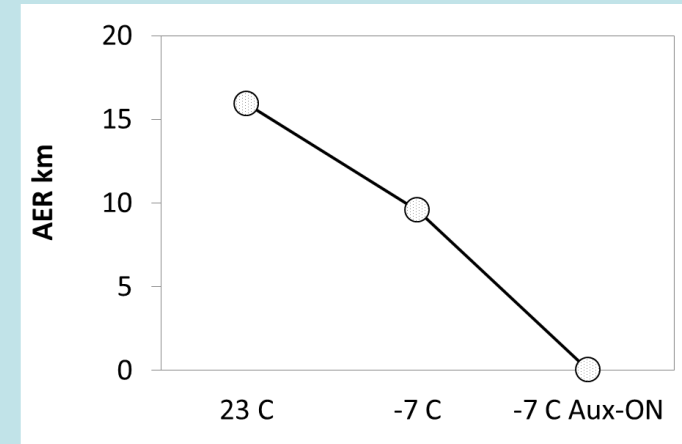
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All electric range (AER)

Plug-in hybrid-1



Plug-in hybrid-2



- Plug-in hybrid-1 AER decreased 18% and Plug-in hybrid-2 40% at -7°C compared to 23°C
- Plug-in hybrid-2 AER **was 0 km at -7°C with heating-ON**
 - Plug-in hybrid-1 decreased 23% at -7°C with heating-ON



T °C	Cycle	Road-Load	Vehicles	Pollutants
-7.0 ±3	UDC	Determined at -7 °C or 10% reduction of coast-down time	S.I. including hybrids + information regarding NOx after-treatment for C.I.	HC, CO
-7.0 ±3	UDC	"	"	THC, CO, CO ₂
-7.0 ±1.7	FTP	Performing coast-down tests and calculating road-load coefficients at -7 °C	Otto-cycle and diesel including multi-fueled, alternative fueled, hybrid electric, and zero emission vehicles	NMHC, CO, CO ₂ *
-6.7	CVS-75	"	Gasoline + information regarding NOx after-treatment for C.I.	CO
-7.0 ±3	Low+ Medium of WLTC	"	S.I. C.I. hybrids	THC, CO, NOx

* CO₂ is analysed and results used for the determination of the vehicle fuel economy. Cold temperature standards apply for CO and NMHC emissions.

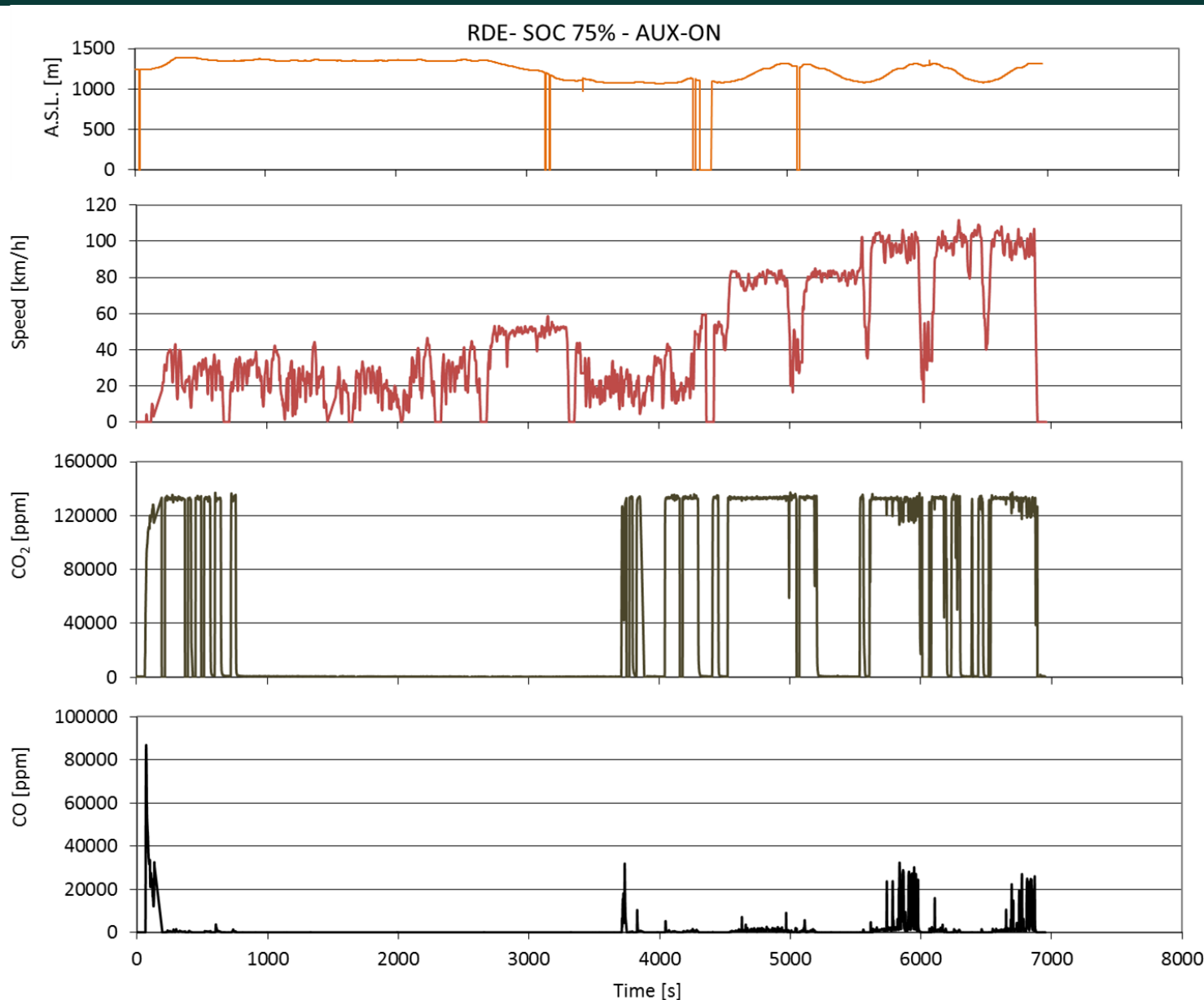
On-road tests and Real Driving Emission Tests (RDE)

Sestriere (Italian Alps) – January 2018



 **PEMS**

Tests on-road – RDE extended conditions



- Ambient temperature -5°C
- ICE starts as soon as heating is activated even at 75% SOC
- Extremely high CO (2.5 g/km) and high PN (3×10^{11} #/km) emissions

Recommendations

- Coordinate research seeking evidence for policy making among EC-DG services facing post-6 vehicle emission standards.
- Work towards a global harmonization of vehicle emission standards.







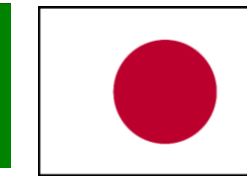





Thank you

Any questions?

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NH₃	×	✓	×	✓	×	×	×	×
N₂O	×	×	✓	×	✓	×	×	×
HCHO	×	×	✓	×	×	✓	×	×
NMOG*	×	×	✓	✓	×	×	×	×
HNCO	×	×	×	×	×	×	×	×

*Includes measurement of methanol, ethanol, formaldehyde and acetaldehyde