On-road emissions of light-duty vehicles in Europe

Real Road, Real Driving, and Real Emissions Seminar

National Institute of Environmental Research (NIER)

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DG - Joint Research Centre (JRC)

IET - Institute for Energy and Transport

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The Joint Research Centre

The Joint Research Centre (JRC) is the in-house scientific and technical service of the European Commission

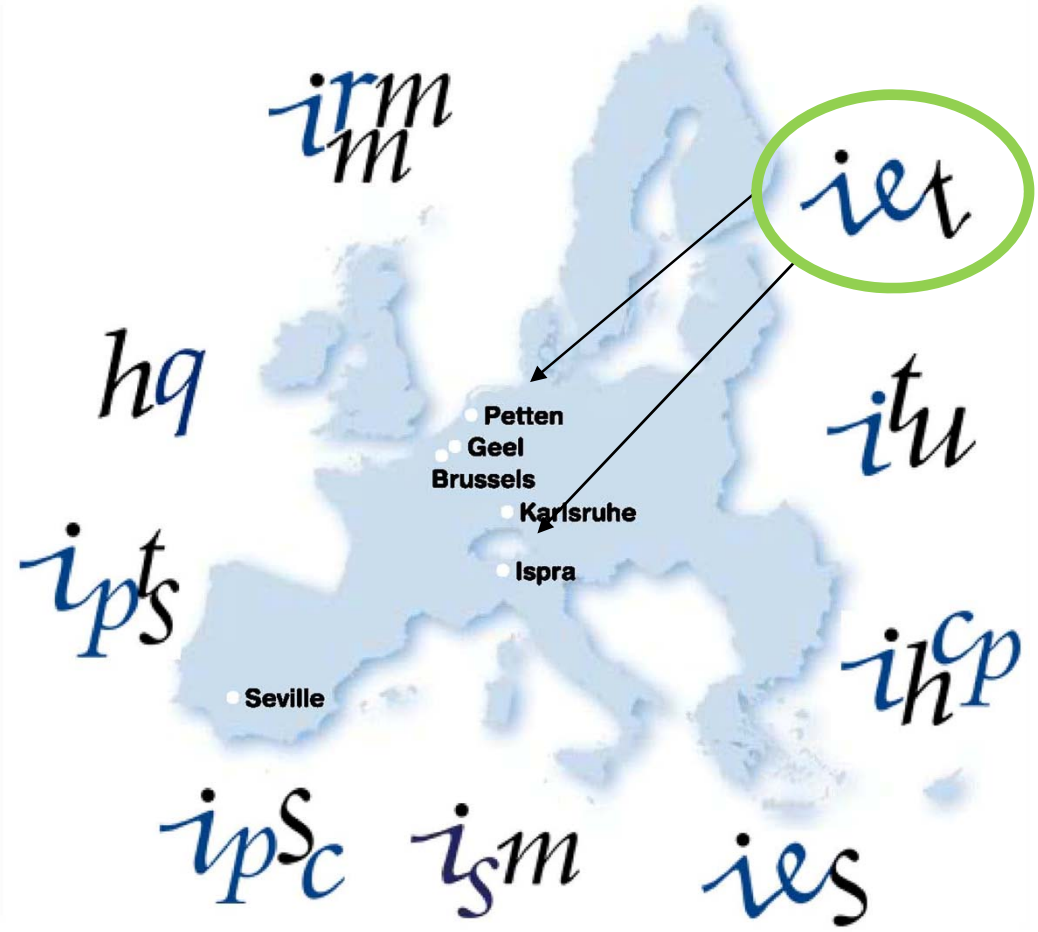
Mission:

- **to provide scientific advice and technical know-how to the European Commission**
- **to support a wide range of EU policies independent of private or national interests**

The Joint Research Centre

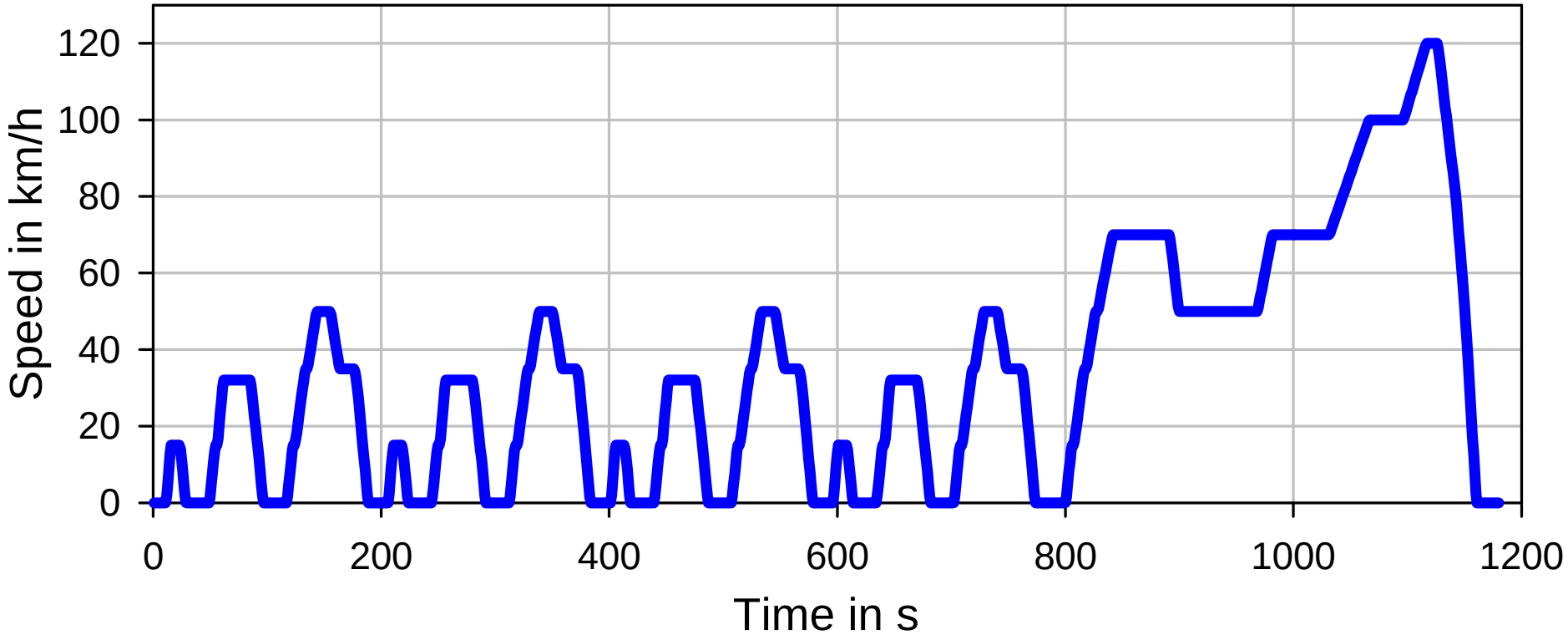
Headquarters located in Brussels

7 institutes; 2750 employees; annual budget of €330 million ($430 million)



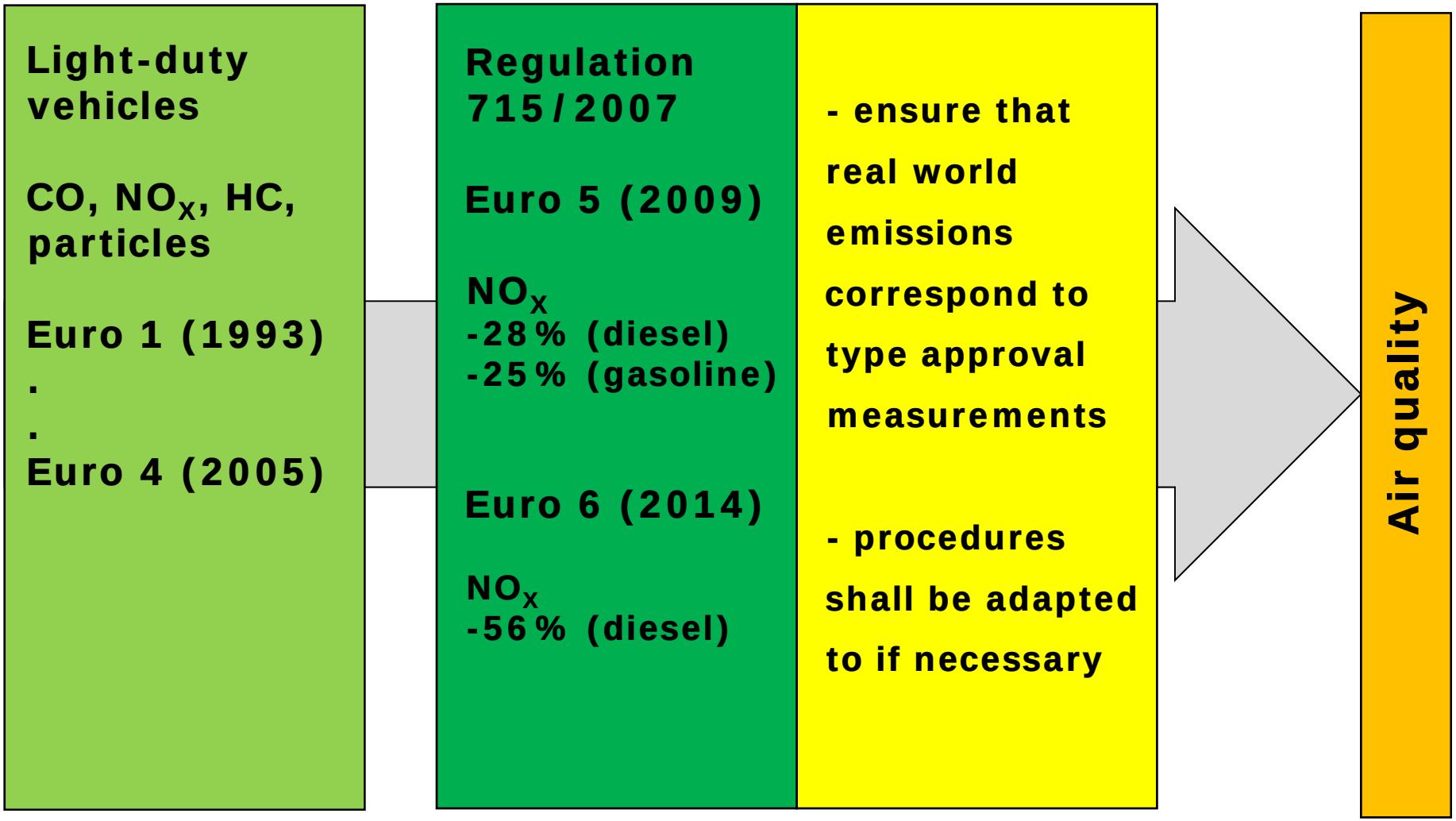
European emissions legislation

Type 1 Test - Tail-pipe emissions: type approval and in-service conformity testing in the laboratory based on the New European Driving Cycle (NEDC)



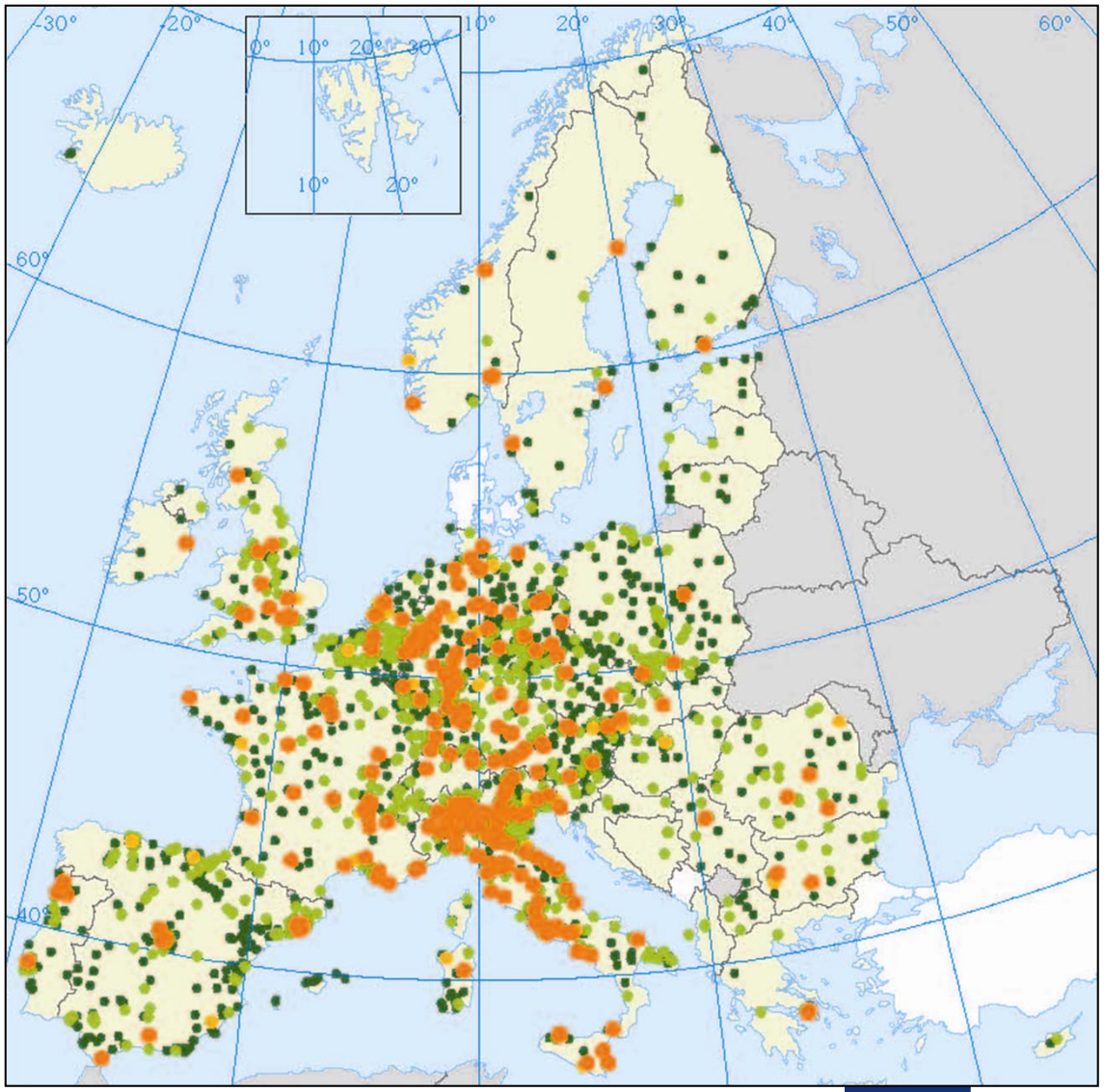
European emissions legislation

Type I: Tailpipe emissions after cold start



European emissions legislation

Background: Urban NO_2 pollution in the EU



Annual mean, nitrogen dioxide, 2009, based on daily averages with percentage of valid measurements 75 % in µg/m³

- ≤ 20
- 20–40
- 40–42
- ≥ 42
- No data
- Outside data coverage

Source: Copyright EEA (2011)

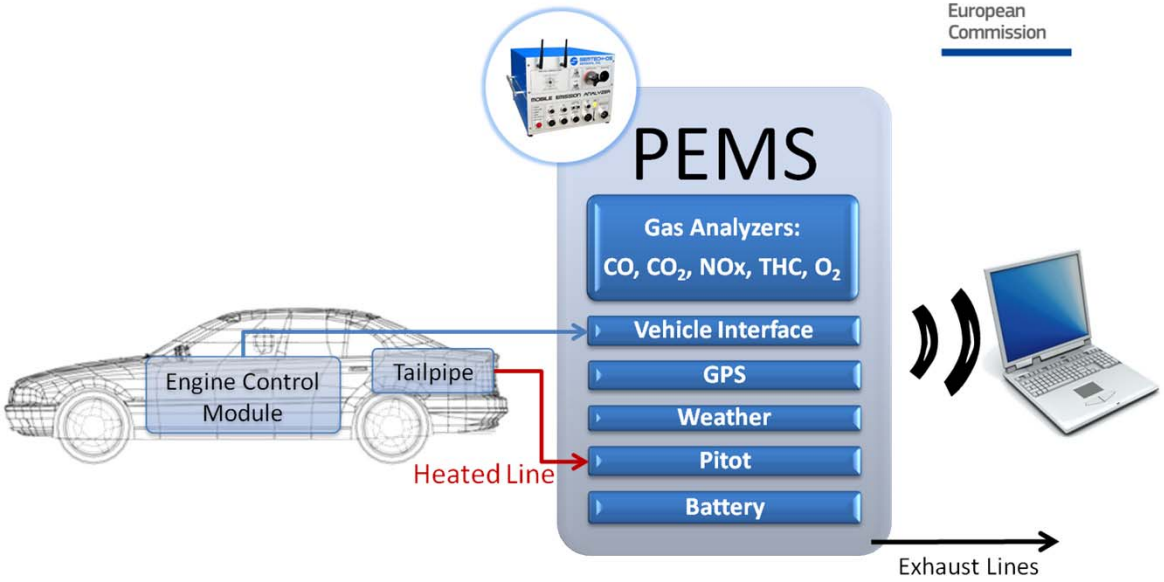
PEMS testing at JRC

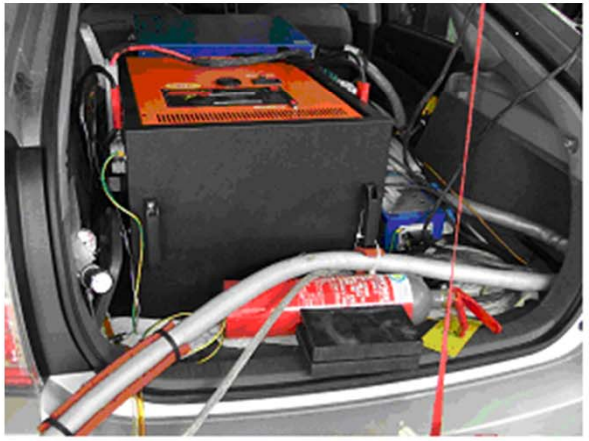
- Regulation 715/2007 provides the basis for PEMS testing at the JRC

- Since 2007: PEMS testing of >15 light-duty diesel and gasoline vehicles (Euro 3-6)

- Experience since 2004: heavy-duty vehicle testing (feasibility of in-service conformity testing; pilot testing)

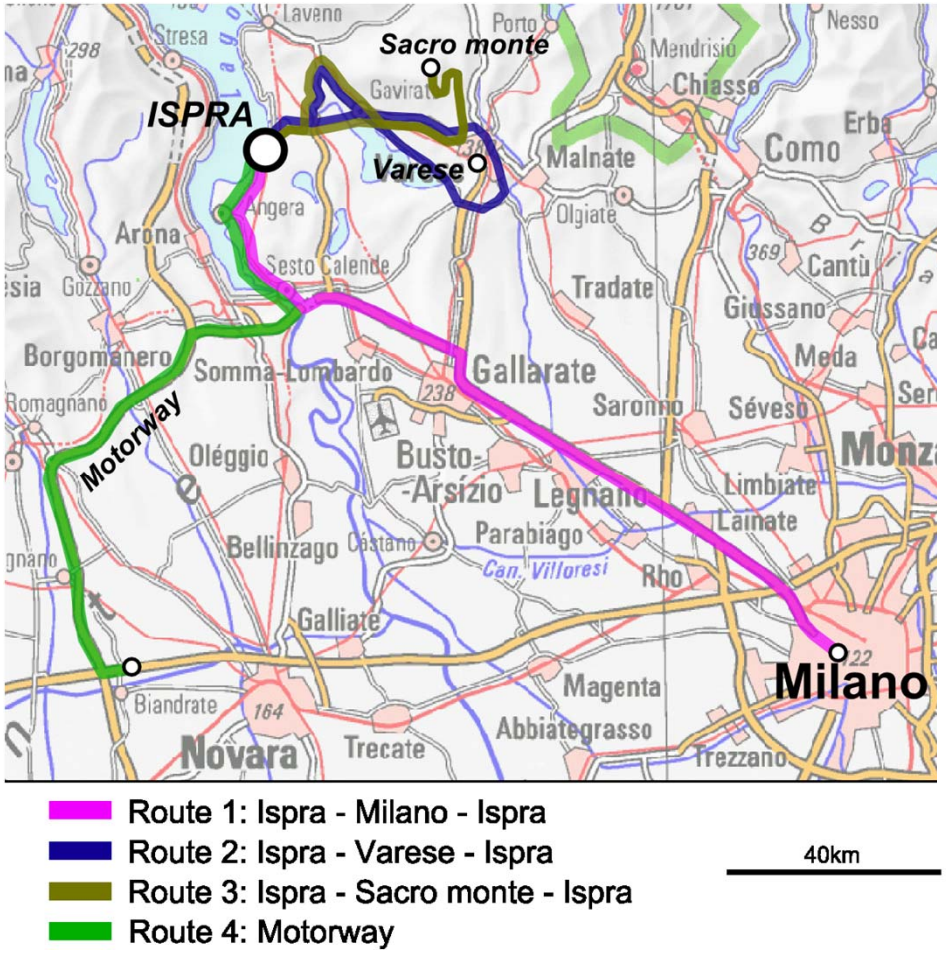
PEMS equipment

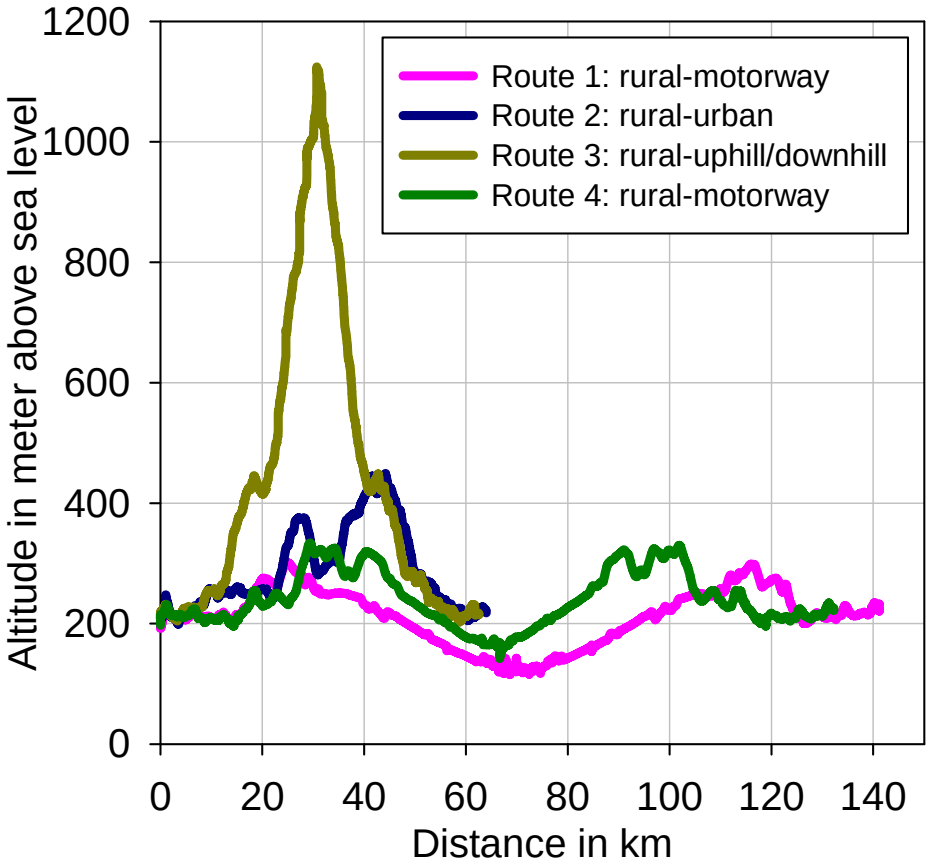




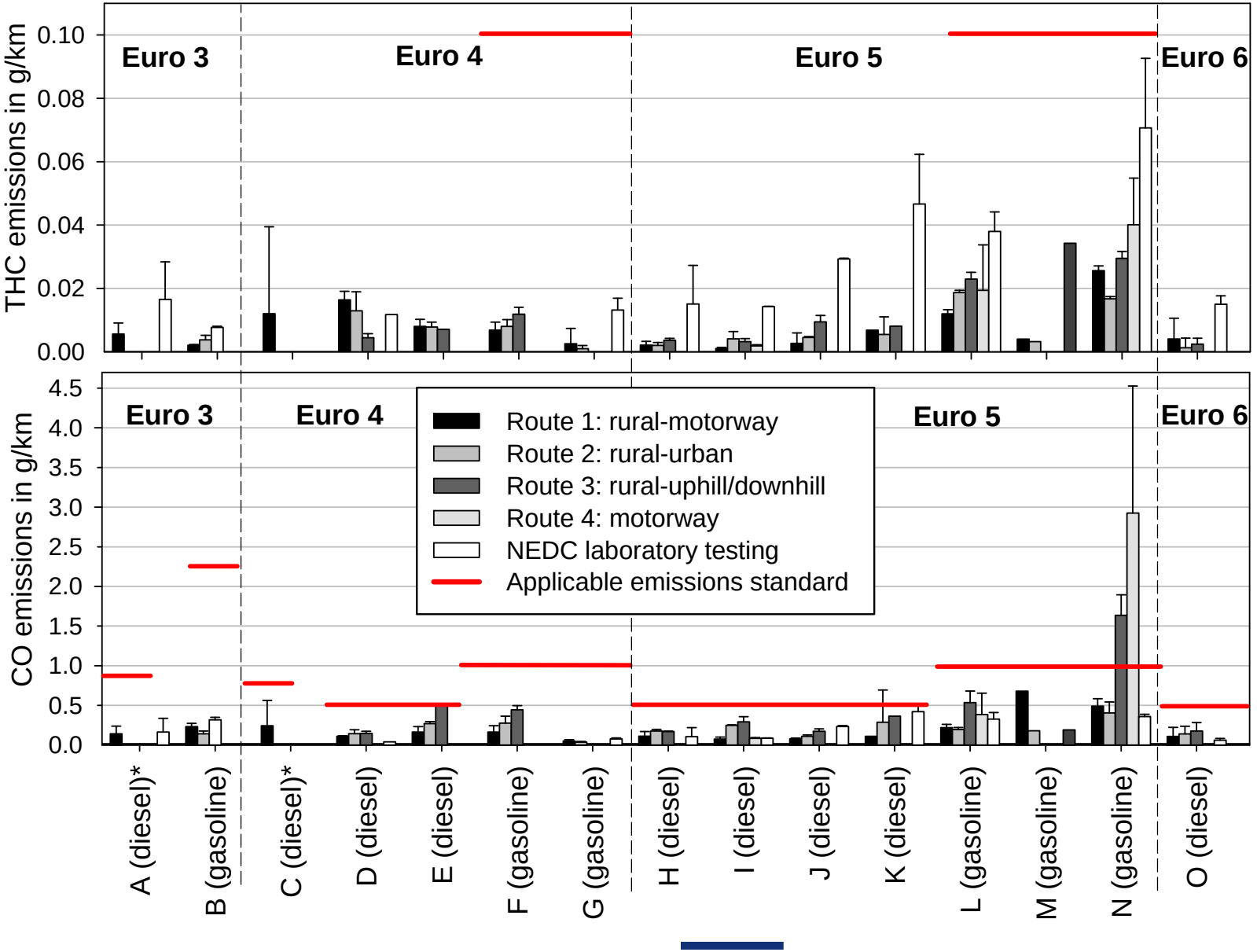
- **Power supply by batteries for test durations of up to 2 h**
- **PEMS (including batteries) 120 kg + 80 kg of the co-driver**

Test routes

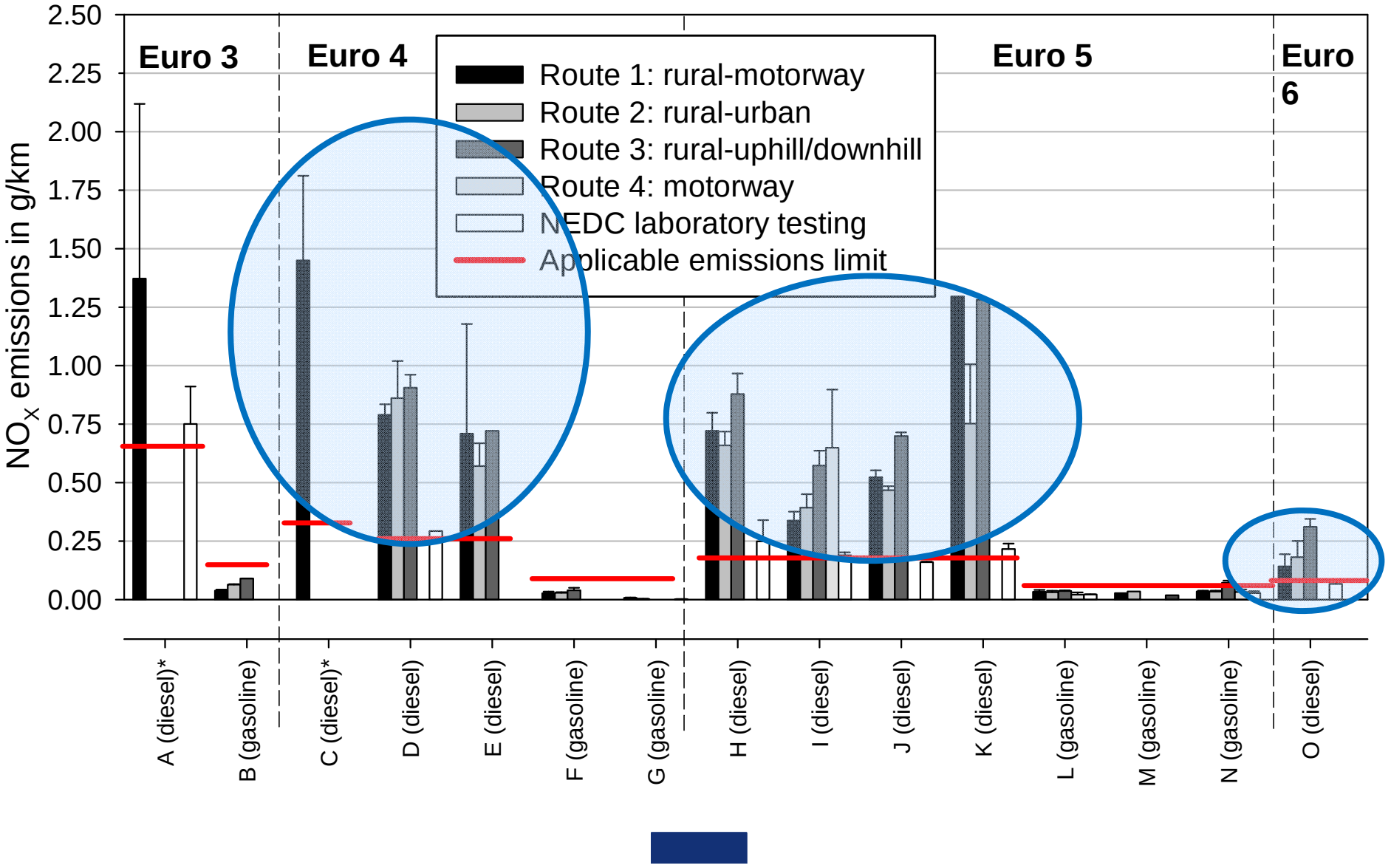

ISPRA
Sacro monte
Varese
Milano
Motorway
Route 1: Ispra - Milano - Ispra
Route 2: Ispra - Varese - Ispra
Route 3: Ispra - Sacro monte - Ispra
Route 4: Motorway
40km


Route 1: rural-motorway
Route 2: rural-urban
Route 3: rural-uphill/downhill
Route 4: rural-motorway
Altitude in meter above sea level
Distance in km
0
200
400
600
800
1000
1200
0
20
40
60
80
100
120
140

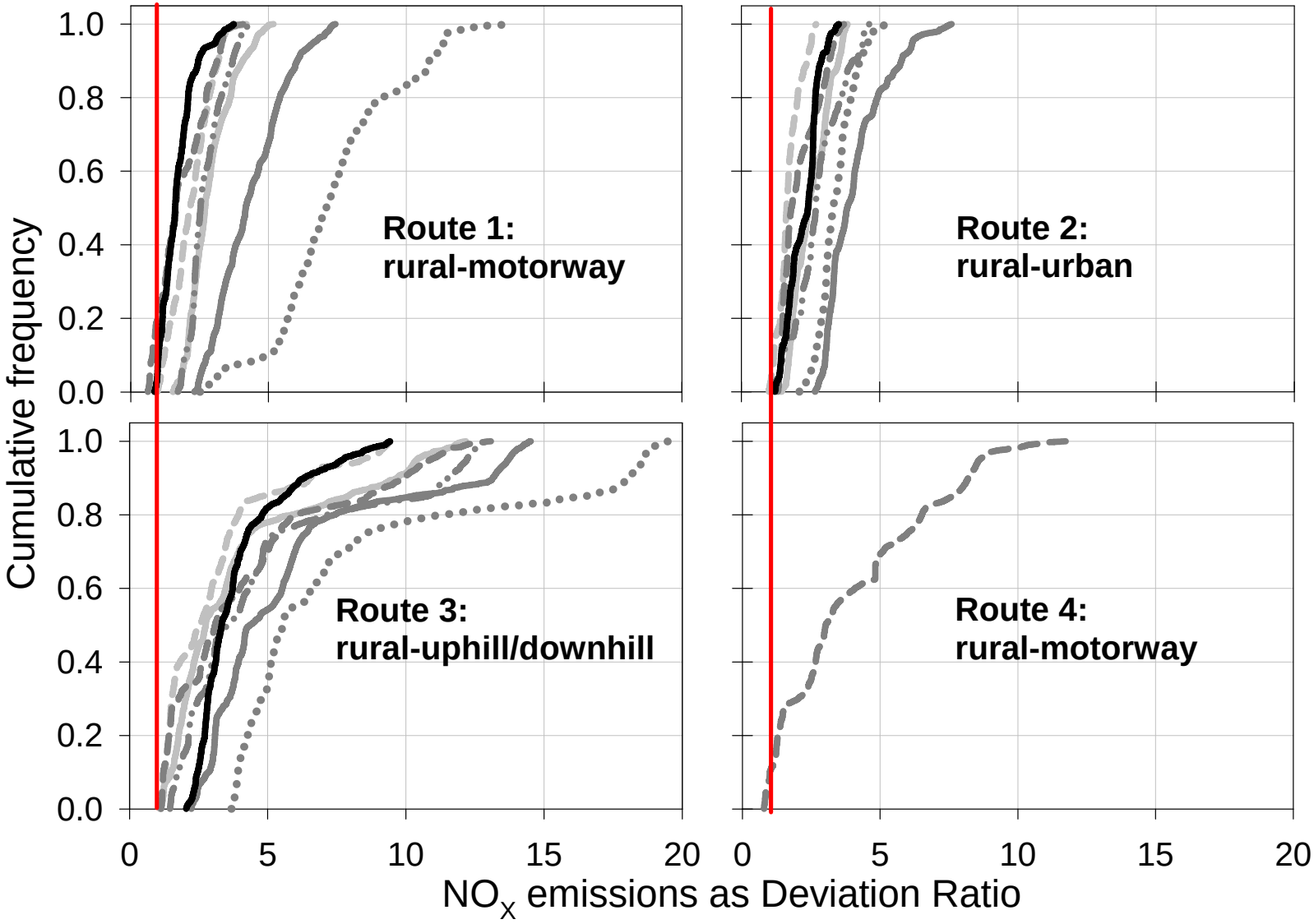
On-road emissions – THC/CO



On-road emissions - NO_x

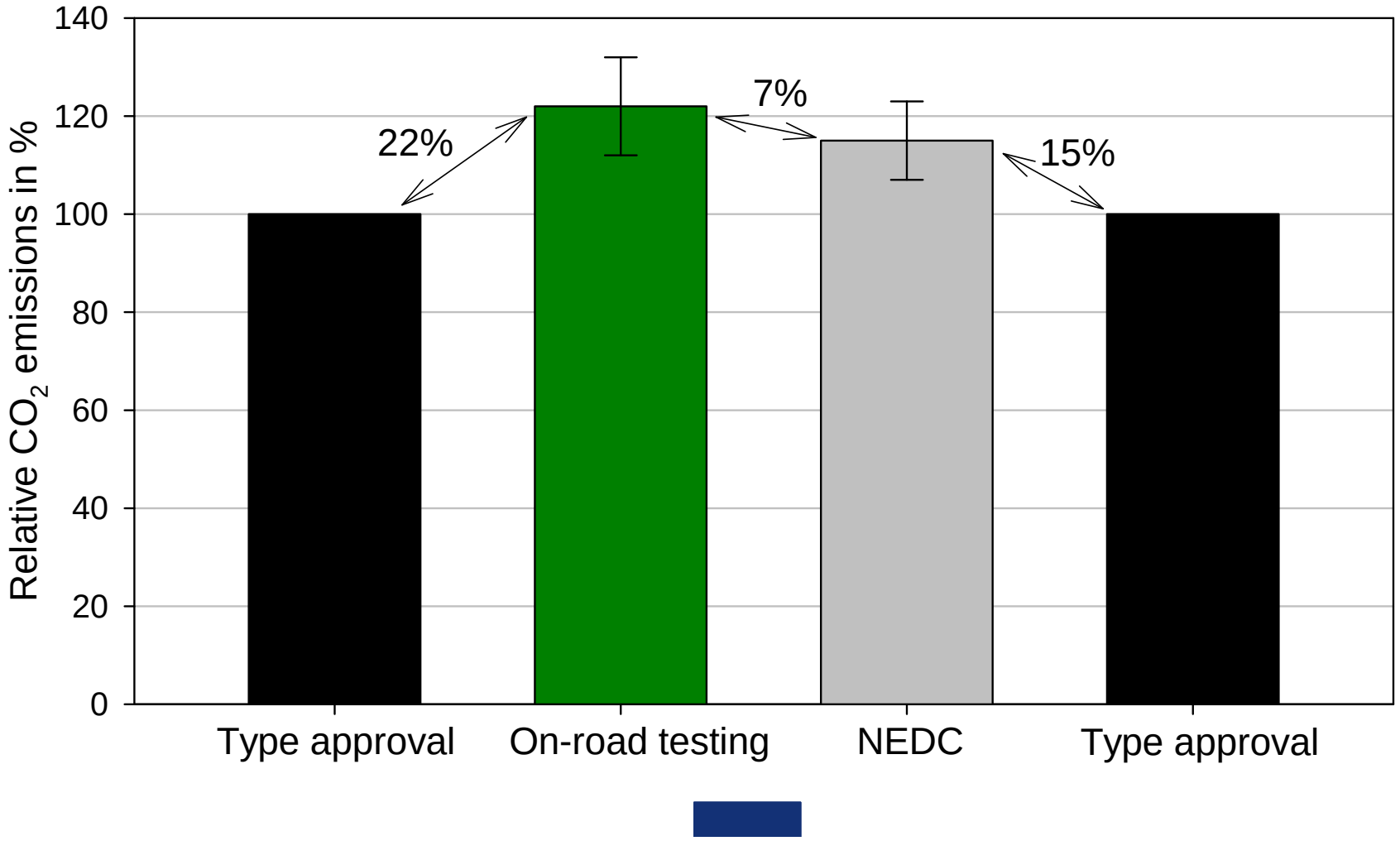


Emissions analysis - NO_x



On-road emissions – CO_2

No emissions standard for individual light-duty vehicles but a fleet-average target of 130 g/km



Implications

- Substantially elevated NO_X emissions of diesel vehicles during real-world on-road driving
- Persisting air quality problems in urban areas

- European Commission establishes a complementary emissions test procedure

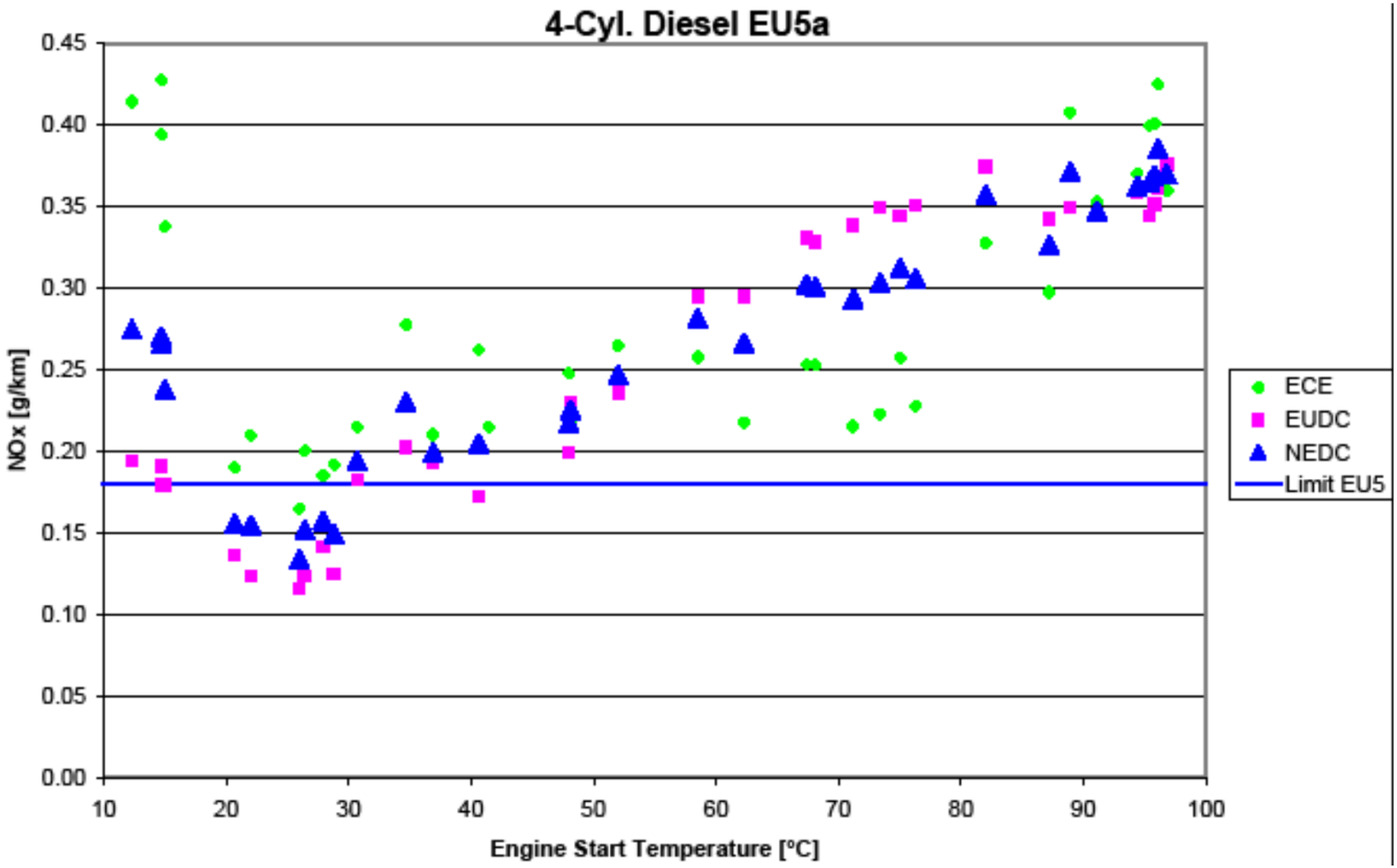
- Two candidates:
  - Laboratory testing with a random driving cycle
  - On-road emissions testing with PEMS

Implications

- Factors potentially explaining elevated on-road emissions
  - Polluting driving conditions covered only for a short time by the laboratory driving cycle
  - Polluting driving conditions not covered in the laboratory
  - Operating conditions not covered in the laboratory
  - Overall test duration

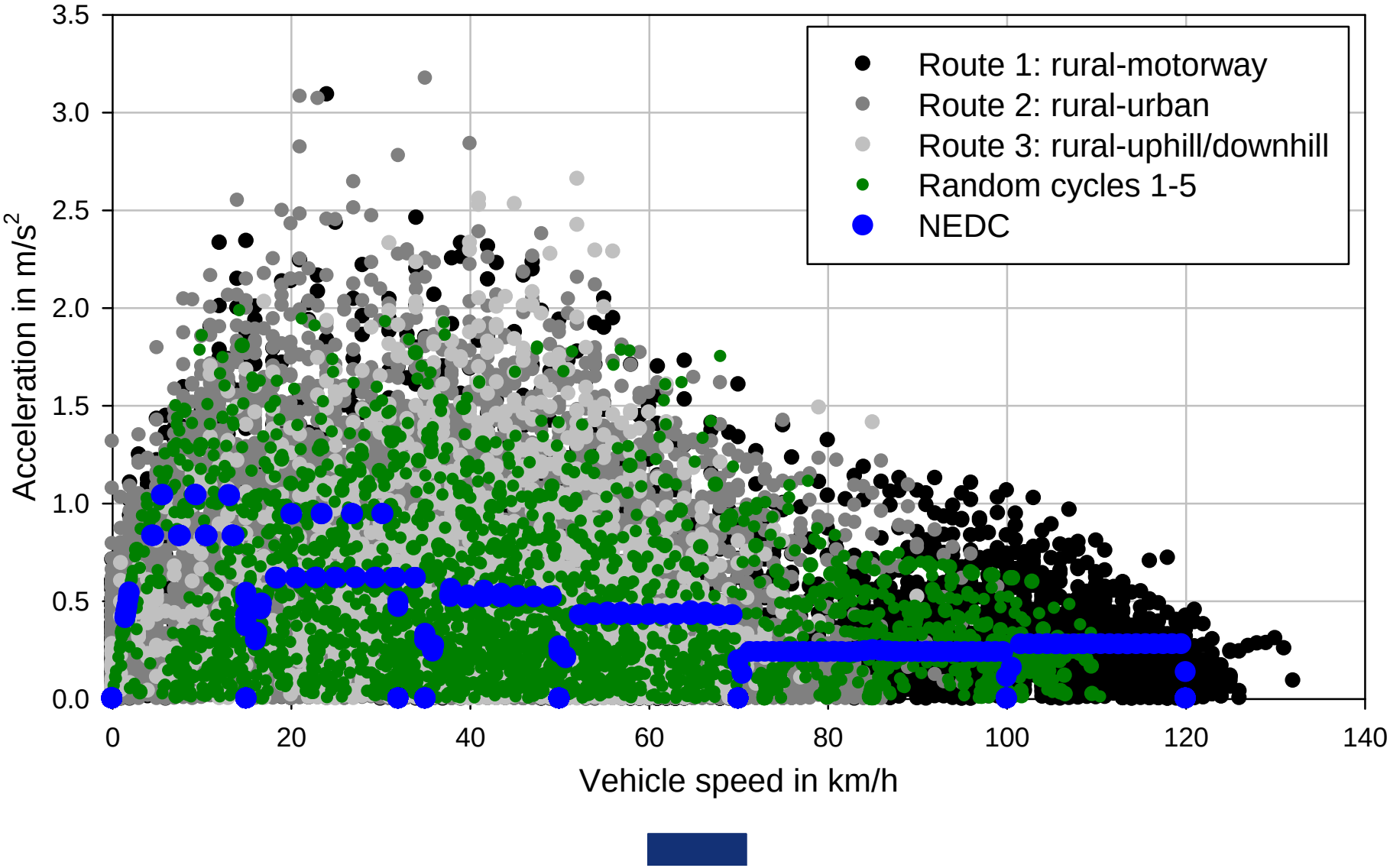
Critical aspects

NEDC: NO_X emissions as function of engine start temperature

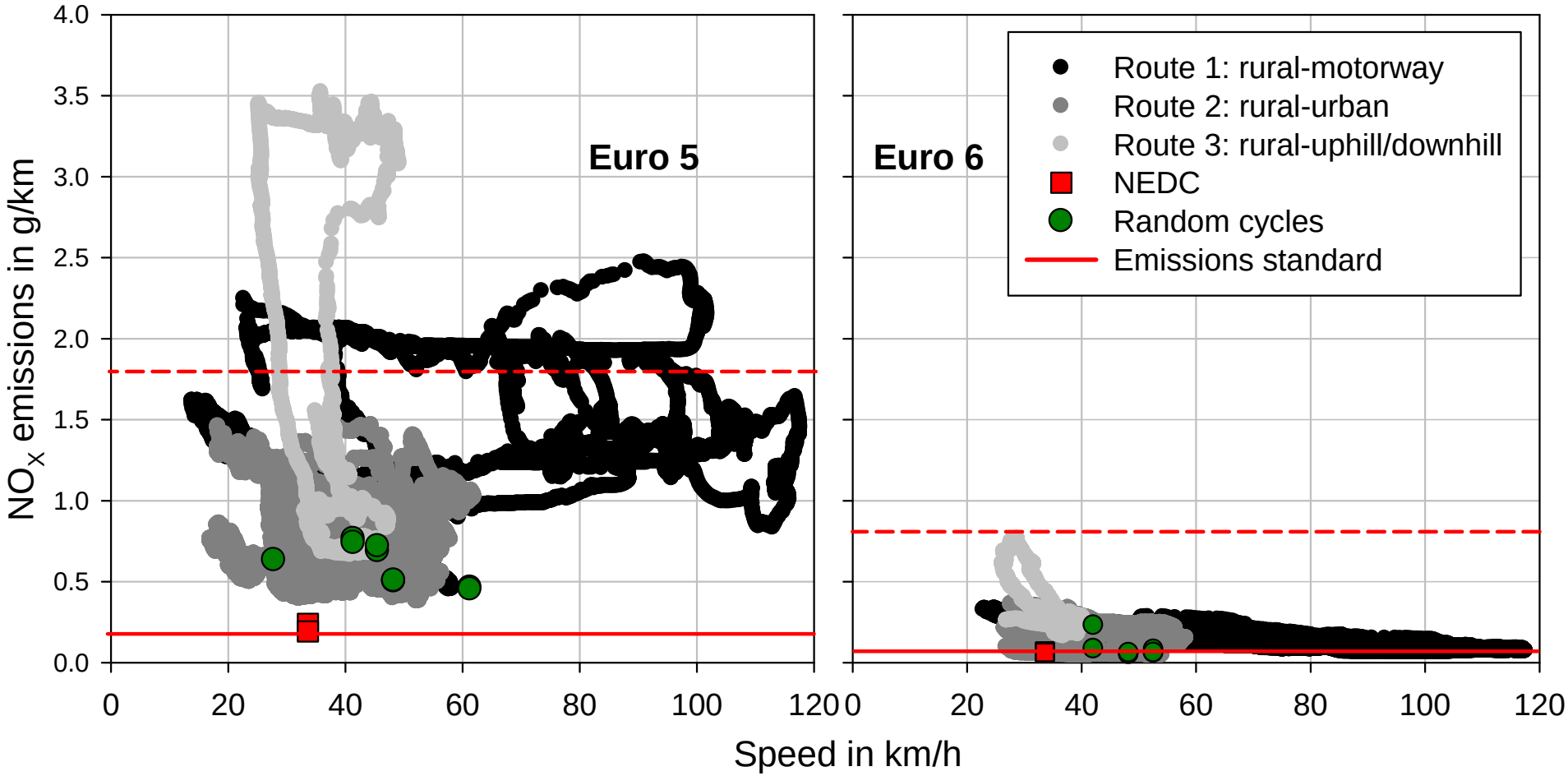


Source: Kühlwein et al. (2012)

Critical aspects



Critical aspects



Outlook

- Decision about a complementary Type1 test procedure by June 2012
- Development and pilot testing until the end of 2013
- Definition of boundary conditions, data characterization, and ‘not-to-exceed’ limits
- Gradual implementation from 2014 onwards?

- NO_2 air pollution vs. distance-specific NO_X emissions of light-duty vehicles…

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JRC Scientific and Technical Reports

Analyzing on-road emissions of light-duty vehicles with Portable Emission Measurement Systems (PEMS)

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On-Road Emissions of Light-Duty Vehicles in Europe

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Supporting Information

Supplemental slides

Regulation 715/2007 specifies emission standards; for passenger cars:

in g/km		THC/NMHC	CO	NO_X	NO_X+THC	PM	PN
Euro 5 spark ignition	2009-2012	0.100/ 0.068	1.000	0.060	-	0.005/ 0.0045	-
Euro 6 spark ignition	From 2014	0.100/ 0.068	1.000	0.060	-	0.0045	$6*10^{12}$/ $6*10^{11}$
Euro 5 diesel	2009-2012	-	0.500	0.180	0.230	0.005/ 0.0045	$6*10^{11}$
Euro 6 diesel	From 2014	-	0.500	0.080	0.170	0.0045	$6*10^{11}$

CO_2: fleet-average emissions target of 130 g/km

Supplemental slides

- 2004-2005: feasibility of PEMS for in-service conformity testing of heavy-duty vehicles
- 2007-2008: PEMS heavy-duty pilot program
- Since 2007: PEMS testing of >15 light-duty vehicles
- Since 2010: PEMS pilot program for non-road machinery

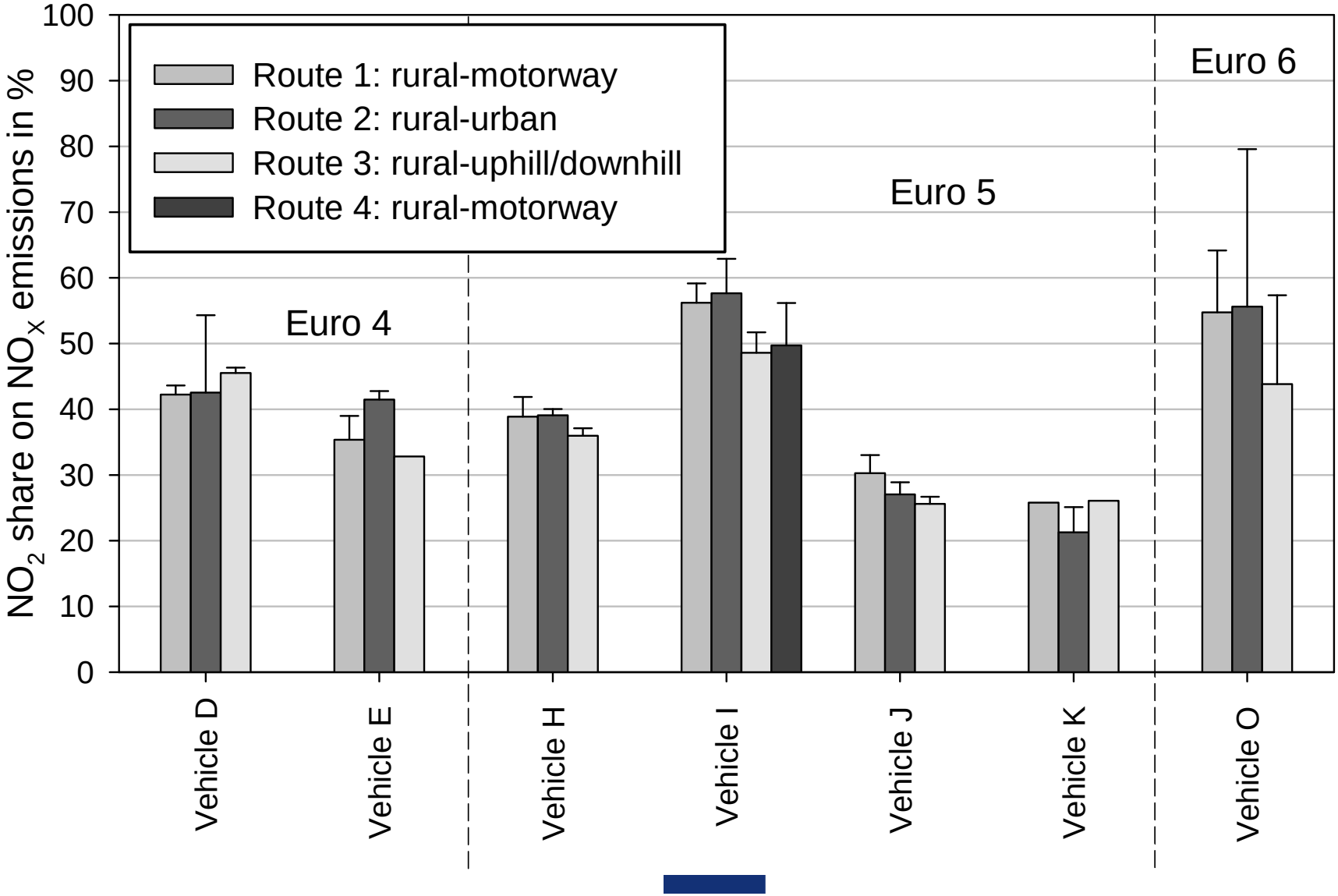
- Light-duty vehicles: diesel and gasoline cars; Euro 3-6

Supplemental slides

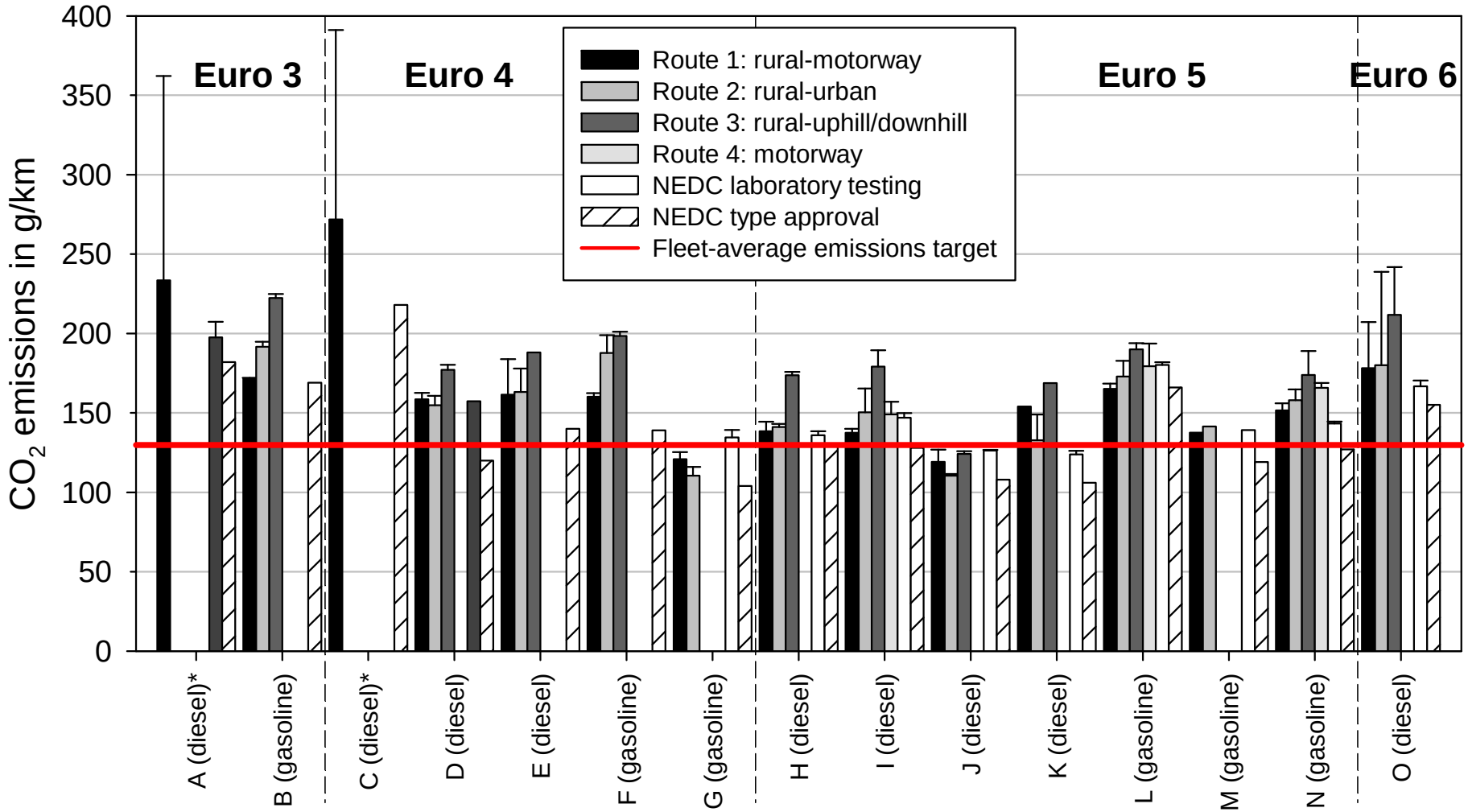
Parameter	Device
THC	Heated-flame ionization detector
$CO+CO_2$	Non-dispersive infrared analyzer
$NO+NO_2$	Non-dispersive ultraviolet analyzer
Exhaust flow rate	Exhaust flow meter (EFM)
Exhaust temperature	EFM temperature sensor
Vehicle speed	GPS/ECU
Vehicle position and altitude	GPS
Acceleration	GPS/ECU
Distance	GPS/ECU
Ambient humidity	Humidity sensor
Ambient temperature	Temperature sensor
Ambient air pressure	Barometer

- **Emissions testing from cold start, including cranking**
- **Use of commercial fuels**

Supplemental slides



Supplemental slides



Supplemental slides

The averaging window approach: