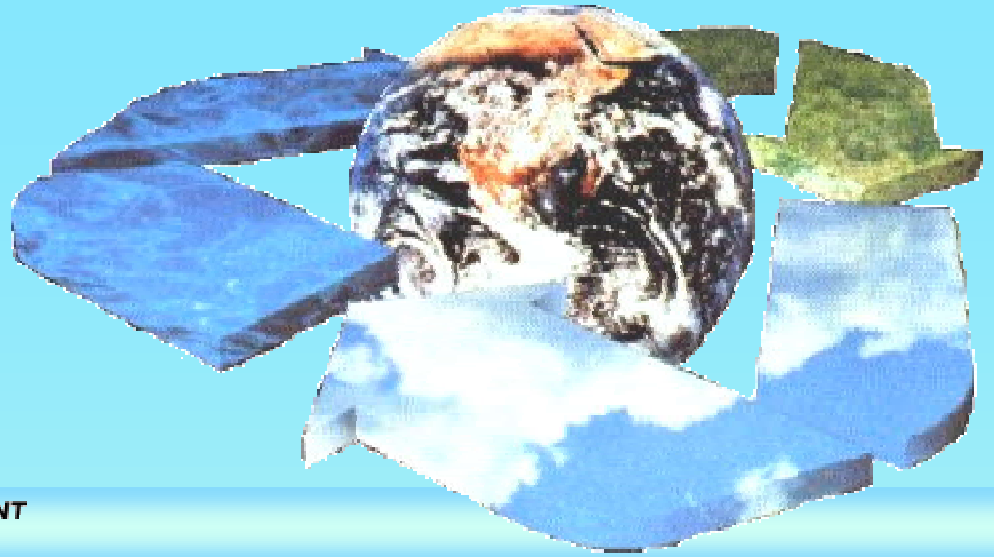

Ecotraffic

ENERGY RESEARCH, DEVELOPMENT, DEMONSTRATION, AND DEPLOYMENT
ENVIRONMENTAL CONSULTANTS

A Comparison of Two Gasoline and Two Diesel Cars with Varying Emission Control Technologies

DEER 2002, August 25-29

Peter Ahlvik, Ecotraffic ERD[3] AB

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- Olle Hådell and Pär Gustafsson, the Swedish National Road Administration
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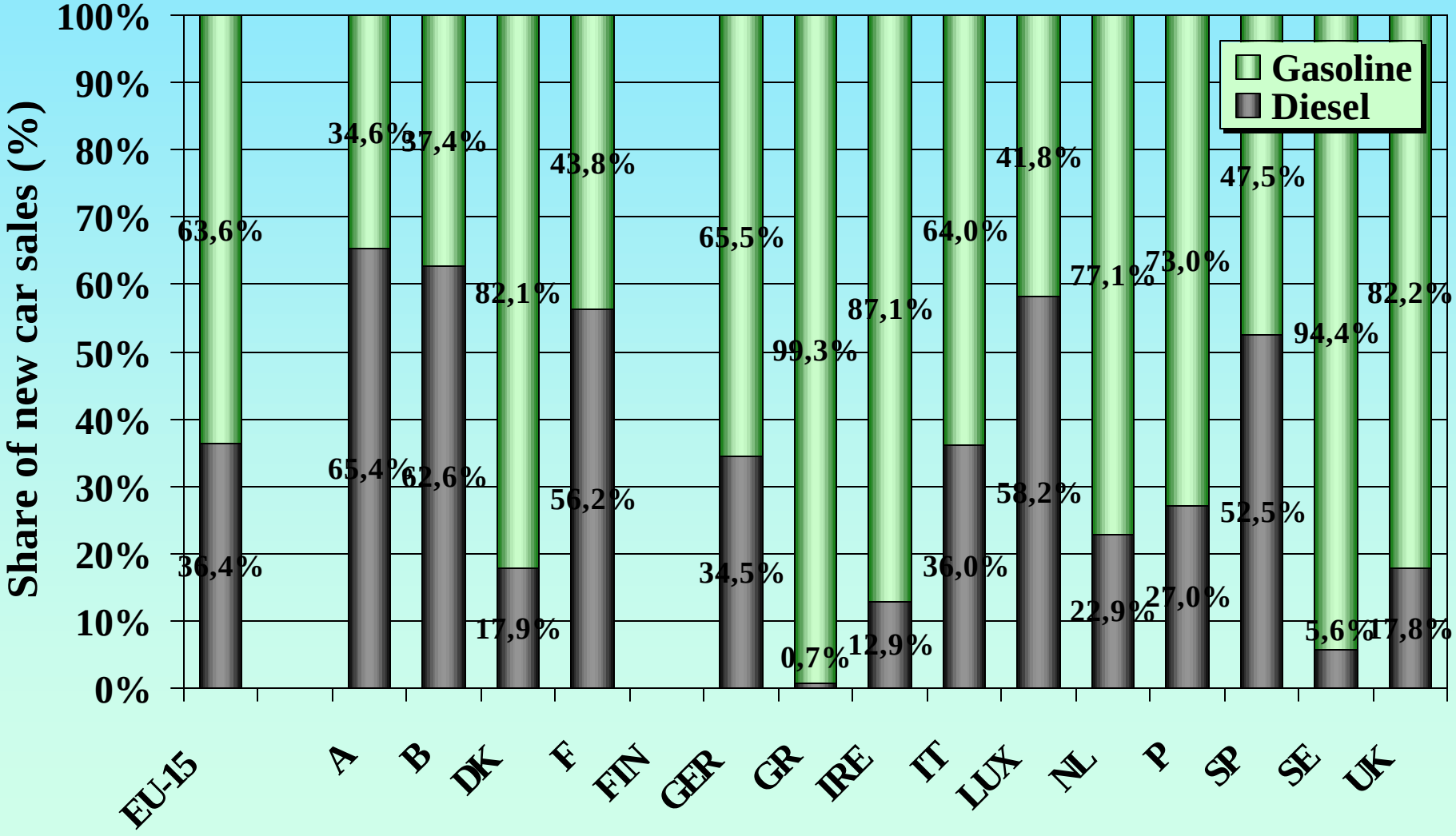
Outline of the presentation

- Introduction and background
- Selection of test cars
- Measurement program
- Results, exhaust emissions
- Results, impact on health and environment
- Outlook
- Discussion and summary

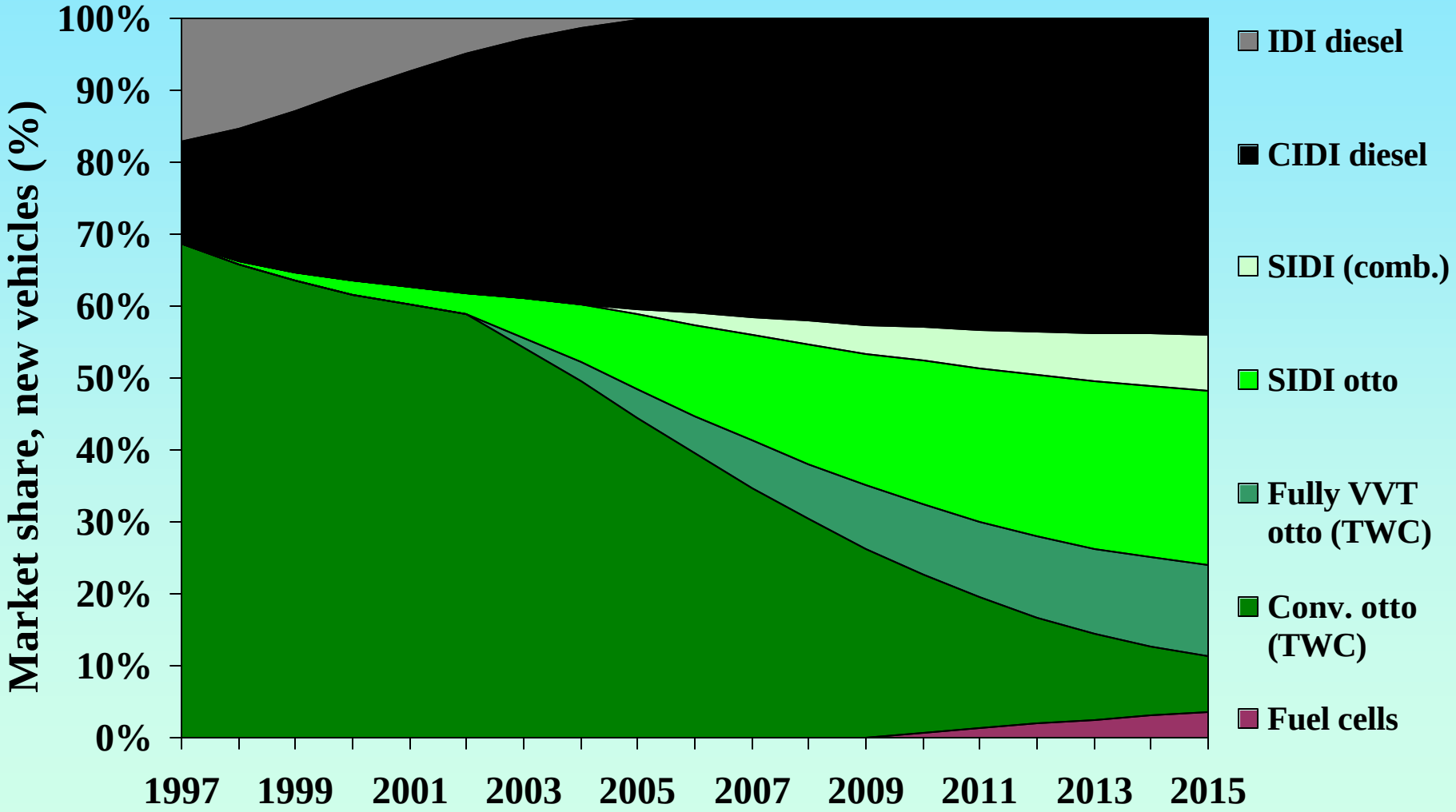
What's new in this study?

- First tests (in Sweden) of unregulated (harmful) emissions components on:
  - Newer diesel cars than MY'93 (e.g. direct injection)
  - Diesel cars with high-pressure injection
  - Ultra-low sulfur diesel fuel (introduced in 1990)
- Complementary driving cycles/temp.: cold start at -7°C, US06, overtaking (70-110 km/h)
- Calculation of impact of exhaust emissions
- Low-cost project (about $ 135 000)
- Inspiration for an open-minded debate (in Swe.)

Diesel and gasoline share of new car sales in Europe, 2001



Ecotraffic's forecast for future energy converters i the EU



Why are diesel cars so popular in Europe (except in Sweden..)?

Mercedes E 240 (gasoline)

Power: 130 kW
Torque: 240 Nm
Acc.: 9.1 s (0-100)
Speed: 236 km/h
FC: 10.9 l/100 km
CO_2: 262 g/km

Mercedes E 270 CDI (diesel)

Power: 130 kW
Torque: 400 Nm
Acc.: 9.0 s (0-100)
Speed: 233 km/h
FC: 6.5 l/100 km
CO_2: 172 g/km

Selection of test cars

- Peugeot 307, 80 kW 1,6 liter gasoline (**SI-P**)
- VW Golf 77, kW 1,6 liter gasoline (**SI-G**)

- Peugeot 307, 80 kW 2,0 HDi FAP diesel with CR injection and particulate filter (**CI-CR/DPF**)
- VW Golf, 96 kW 1,9 TDI diesel, high-pressure unit injectors (**CI-UI/HP**)

Fuels used: Swedish Environmental Class 1 diesel fuel (<10 ppm S) and Swedish Gasoline according to EU 2005 specification (<50 ppm S)

Emission development for VW Golf diesel cars

Source: mot No. 12, May 26, 2001

Euro 2

Euro 3

Euro 4

90 hp, Euro 2, MY'93

90 hp, Euro 2, MY'96

Test car

130 hp, Euro 3, MY'01

150 hp, Euro 3, MY'01

100 hp, Euro 3, MY'01

100 hp, Euro 4, MY'01/02

Potential for 4-V tech

?

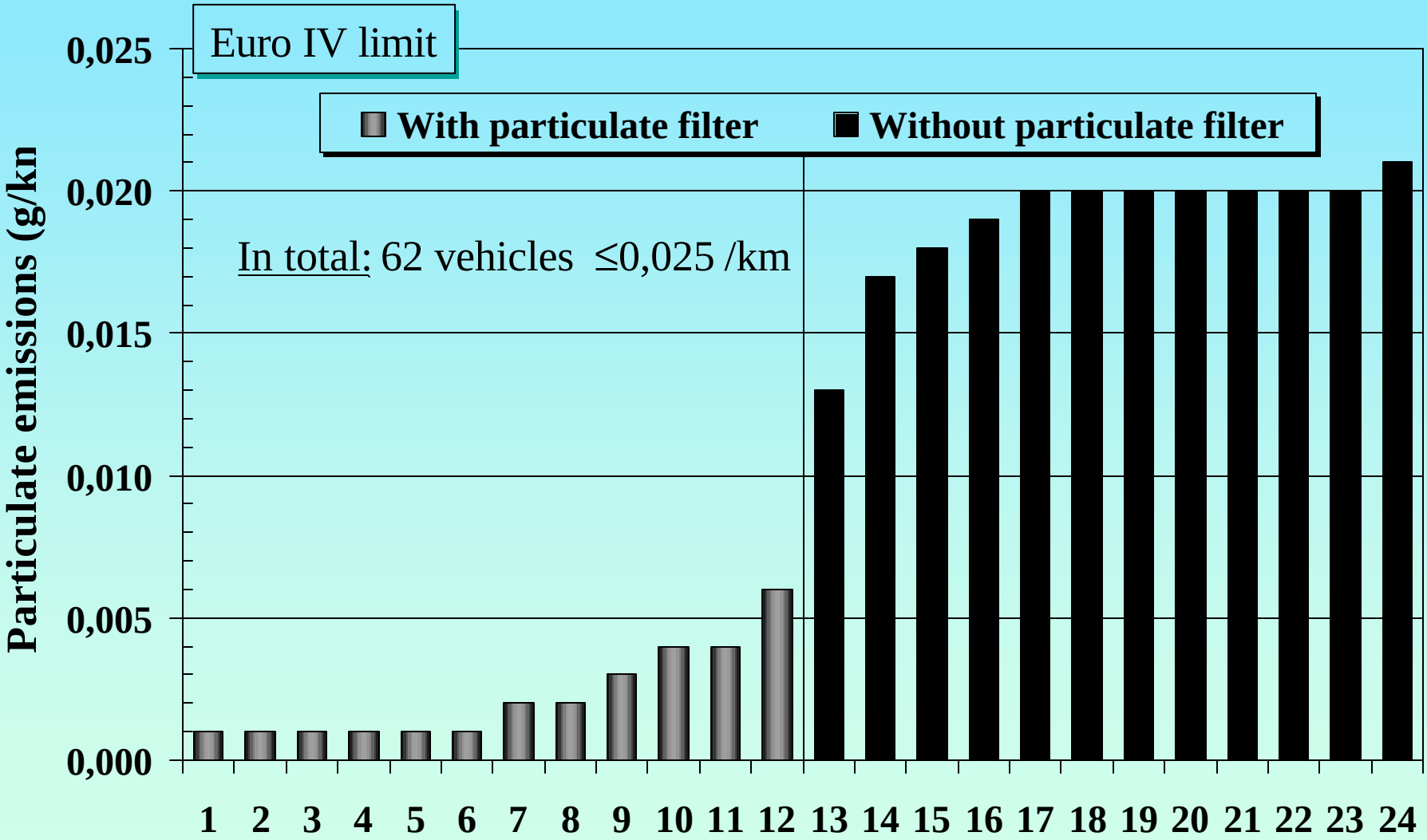
Particulate emissions (g/km)

0,00 0,01 0,02 0,03 0,04 0,05 0,06 0,07 0,08 0,09 0,10

$HC+NO_X$ emissions (g/km)

0,0 0,1 0,2 0,3 0,4 0,5 0,6 0,7 0,8

Certification data for particulate emissions (source: VCA)



Measurement program - Driving cycles

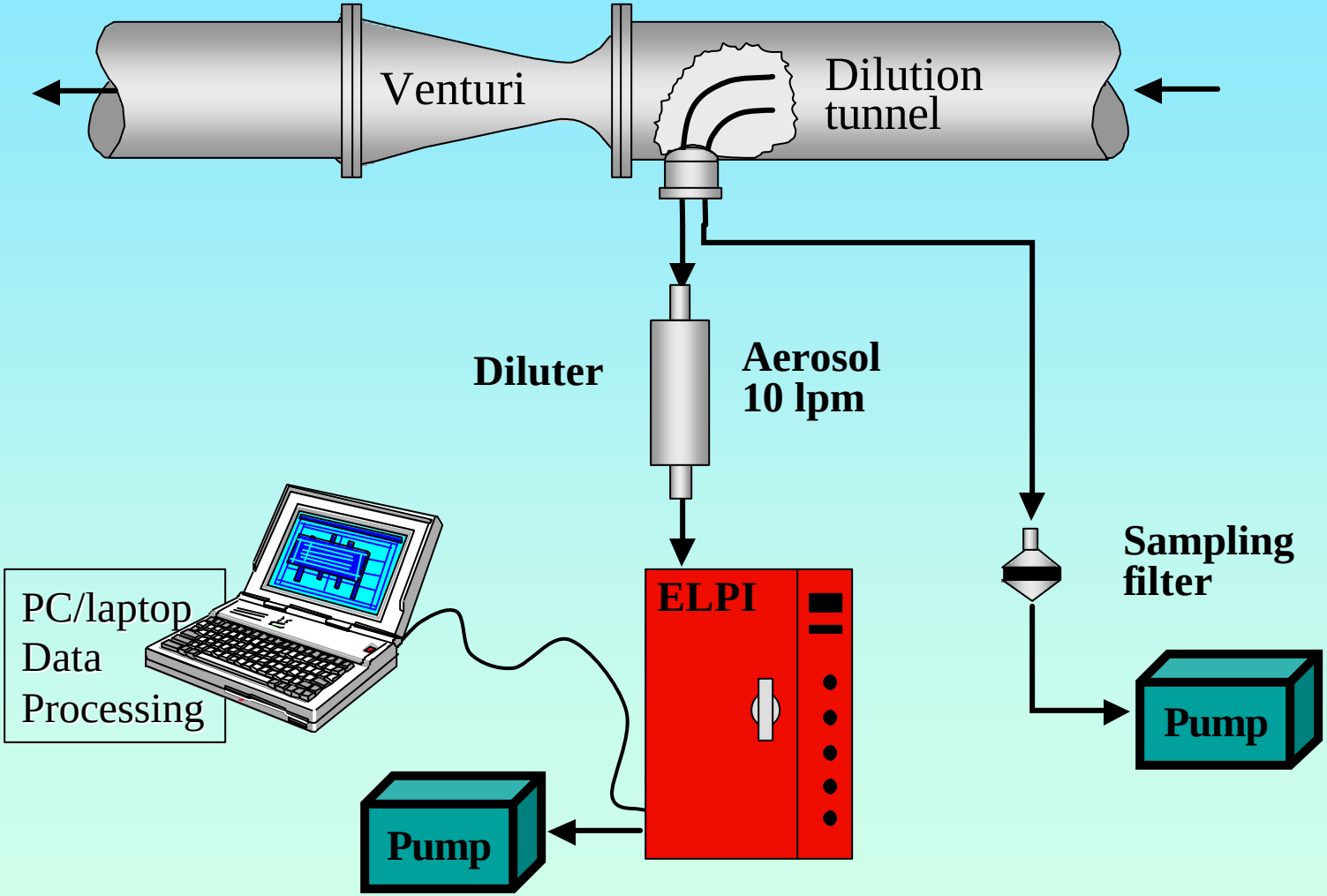
- NEDC test at +22°C
- NEDC test at –7°C
- US06 test (“tougher” driving cycle)
- Overtaking, 70 – 110 km/h. “Simulating” overtaking of a truck with maximum acceleration

Measurement program - Emissions components

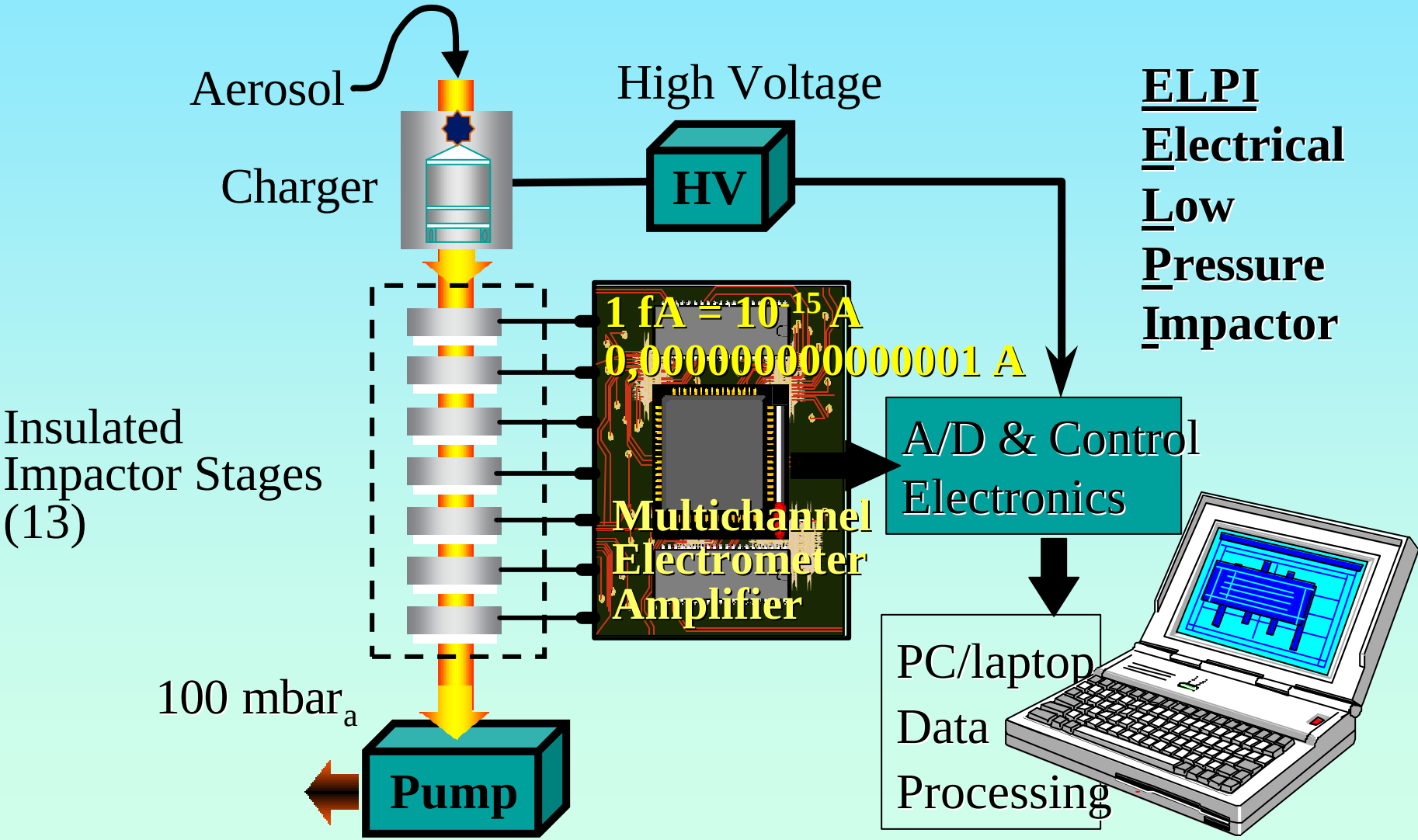
- Measurements at the chassis dyno of MTC
- Regulated emissions: CO, HC, NO_X, part.
- Unregulated gaseous emissions
  - Nitrous oxide (N_2O), ammonia (NH_3)
  - Aldehydes: formaldehyde and acetaldehyde
  - Light aromatics: benzene
  - Alkenes: ethene, propene, 1,3-butadiene
  - Acrylamide
  - Polycyclic aromatic hydrocarbons (PAH)
- Particle number and size distribution

Emission testing at MTC

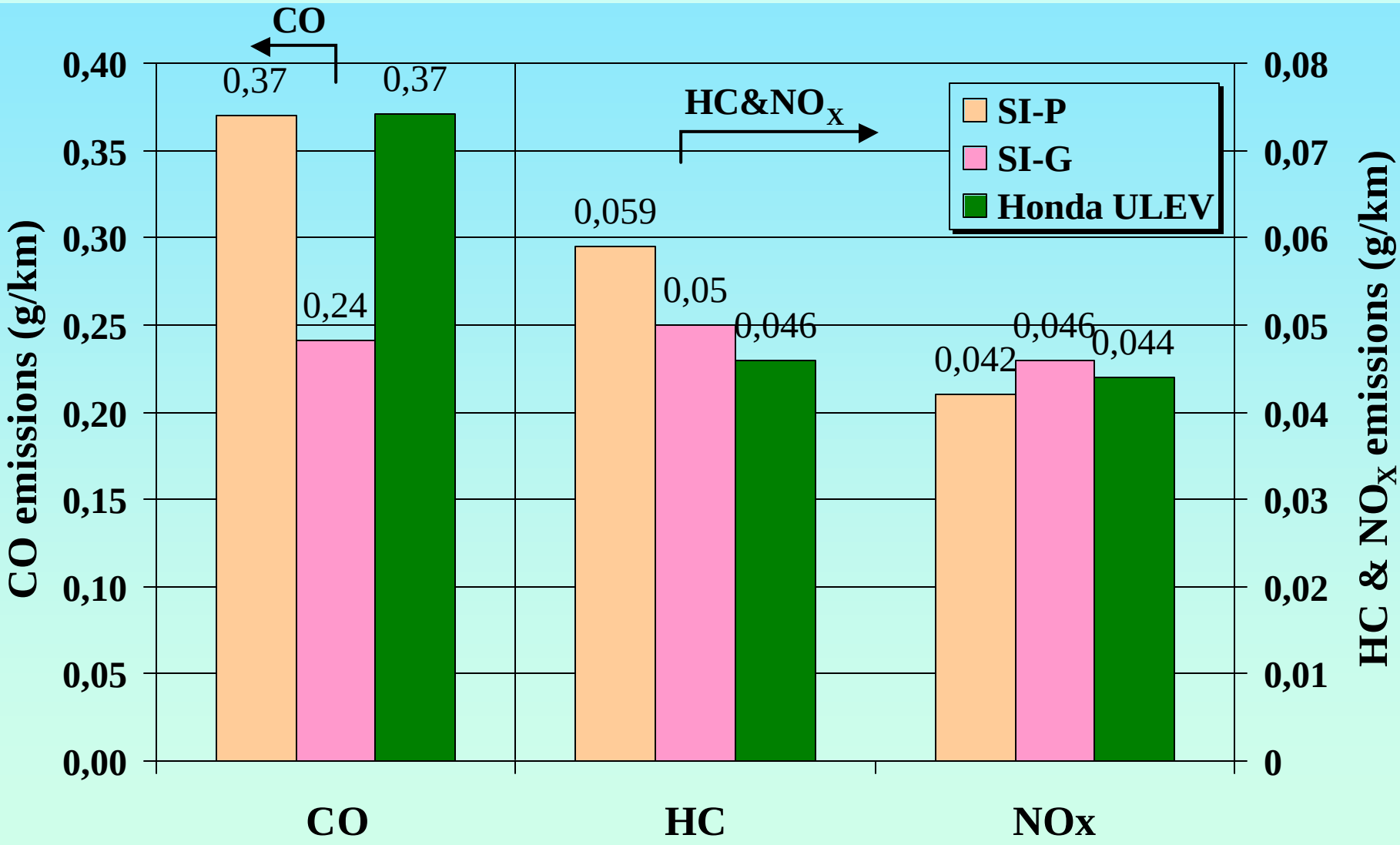
Instrument set-up for particle size measurements with ELPI



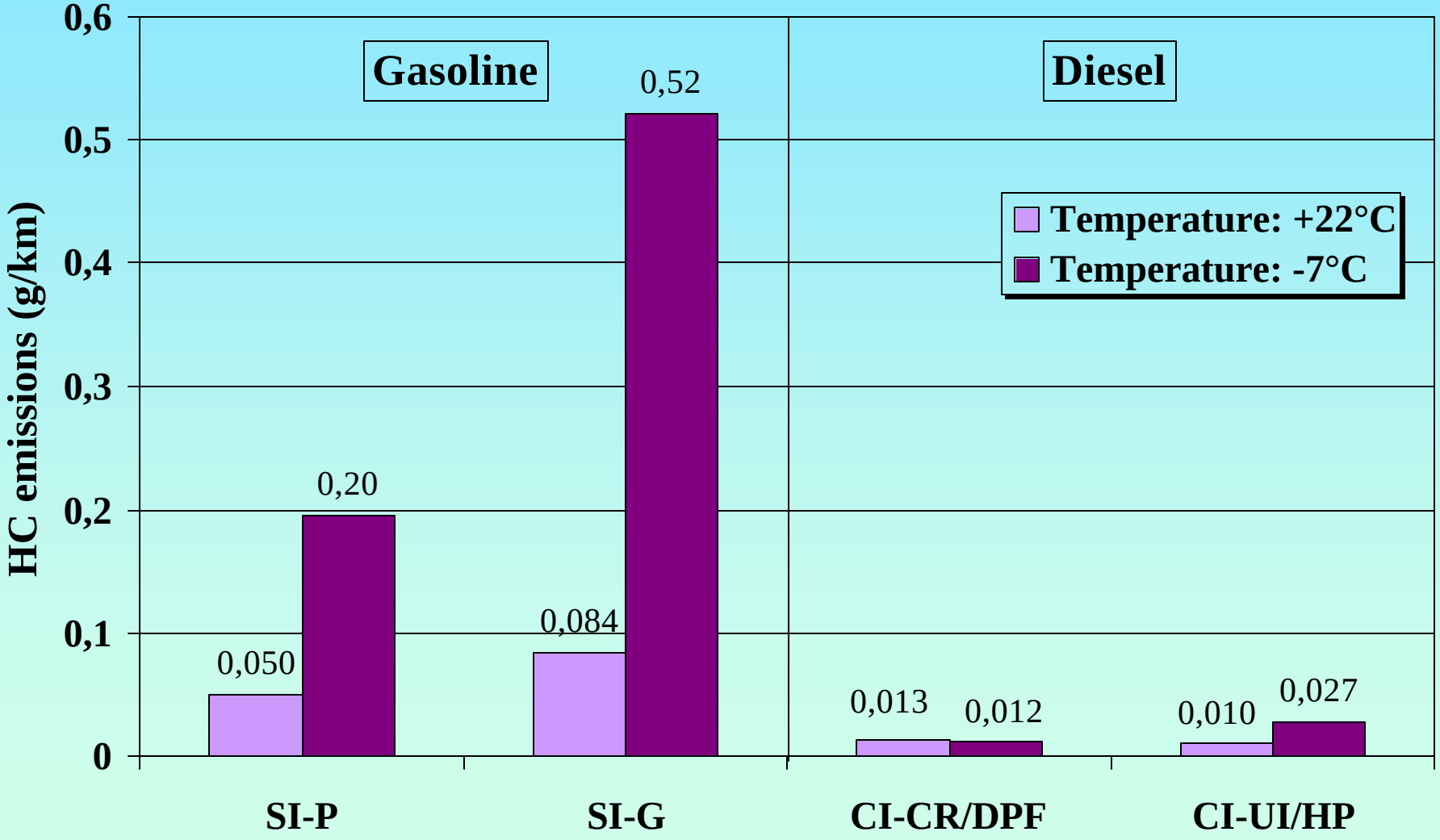
Schematic lay-out of the ELPI instrument



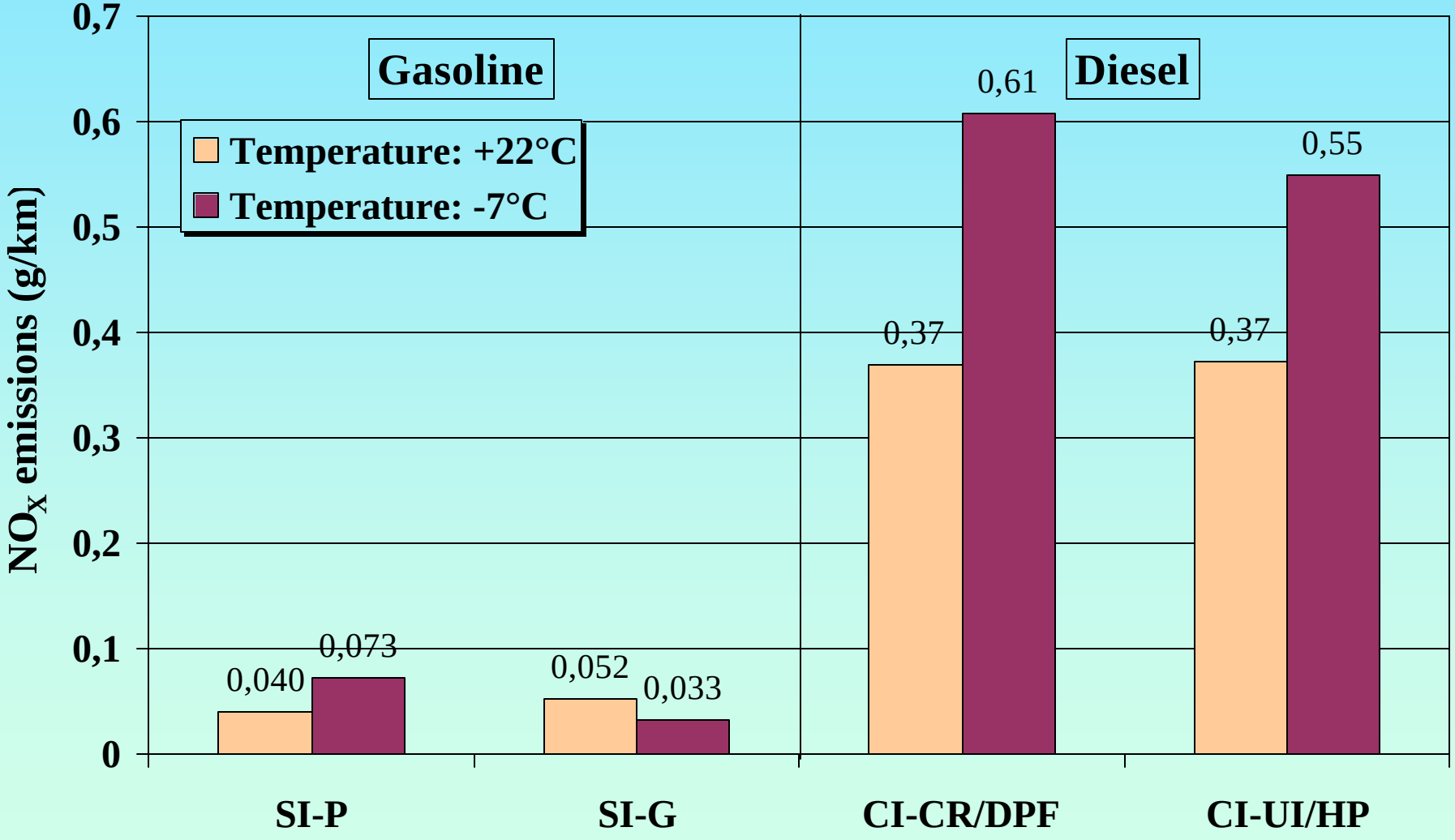
Emissions for the gasoline cars in comparison to a Honda ULEV



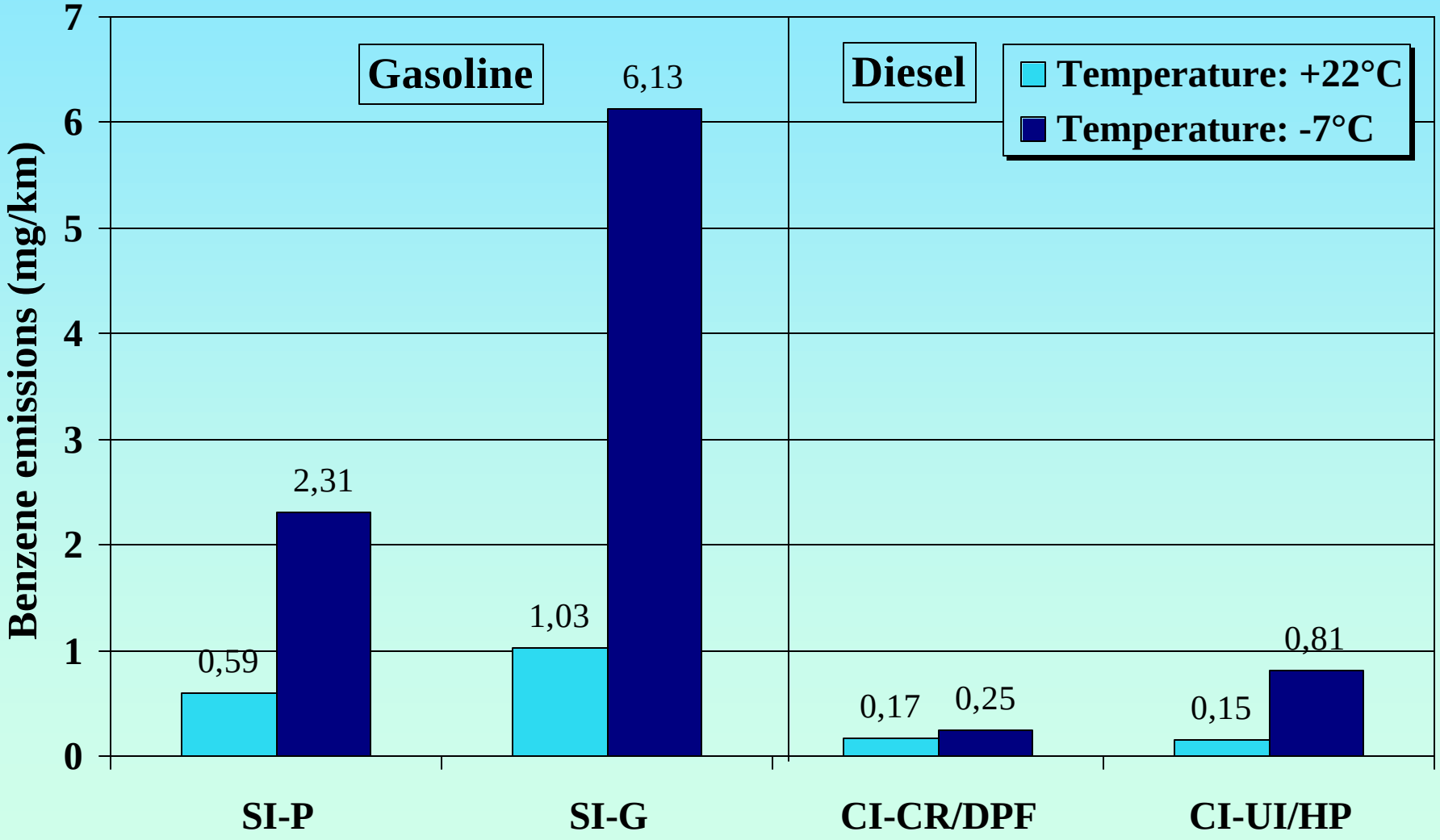
HC emissions in NEDC



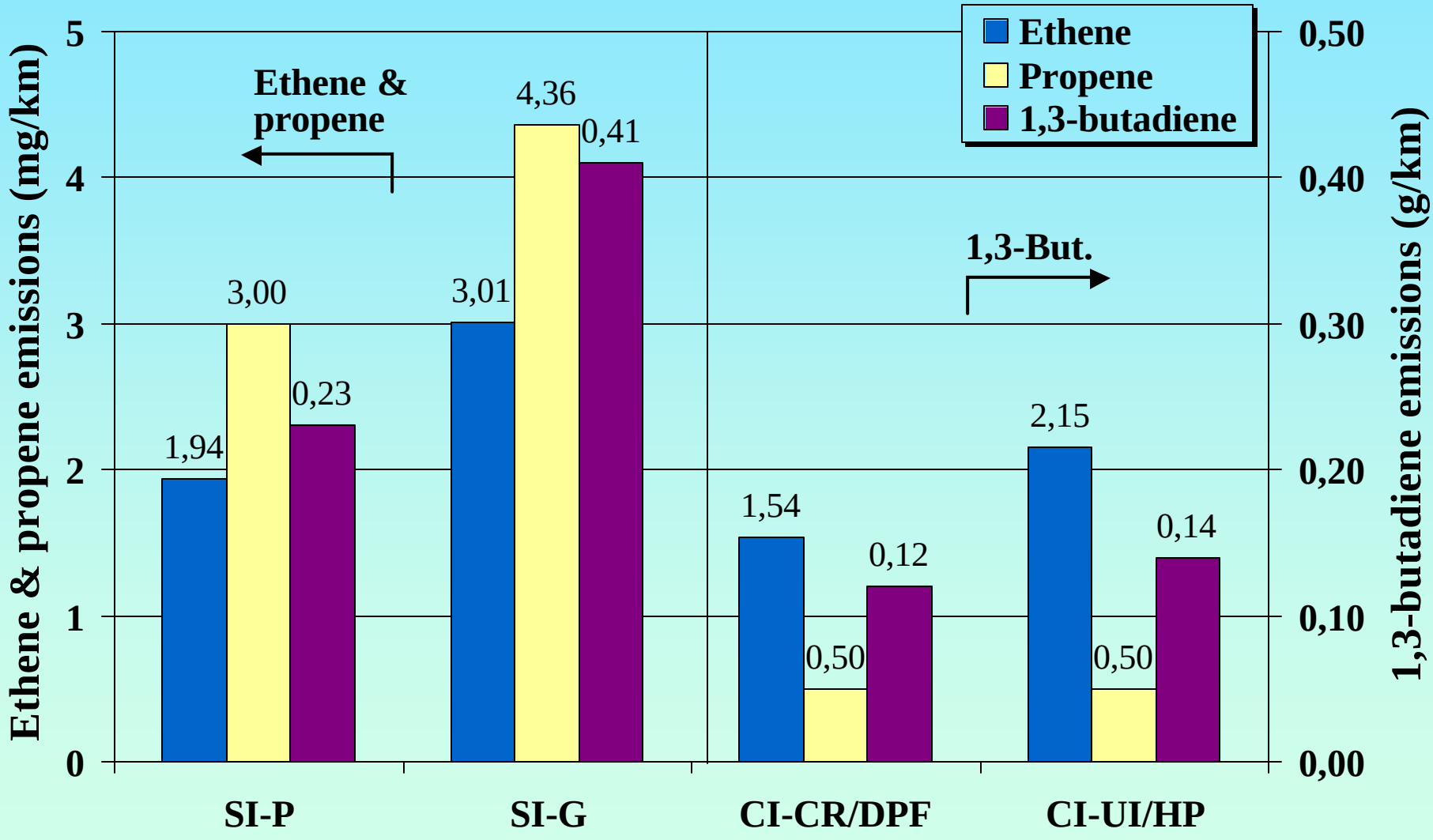
NO_X emissions in NEDC



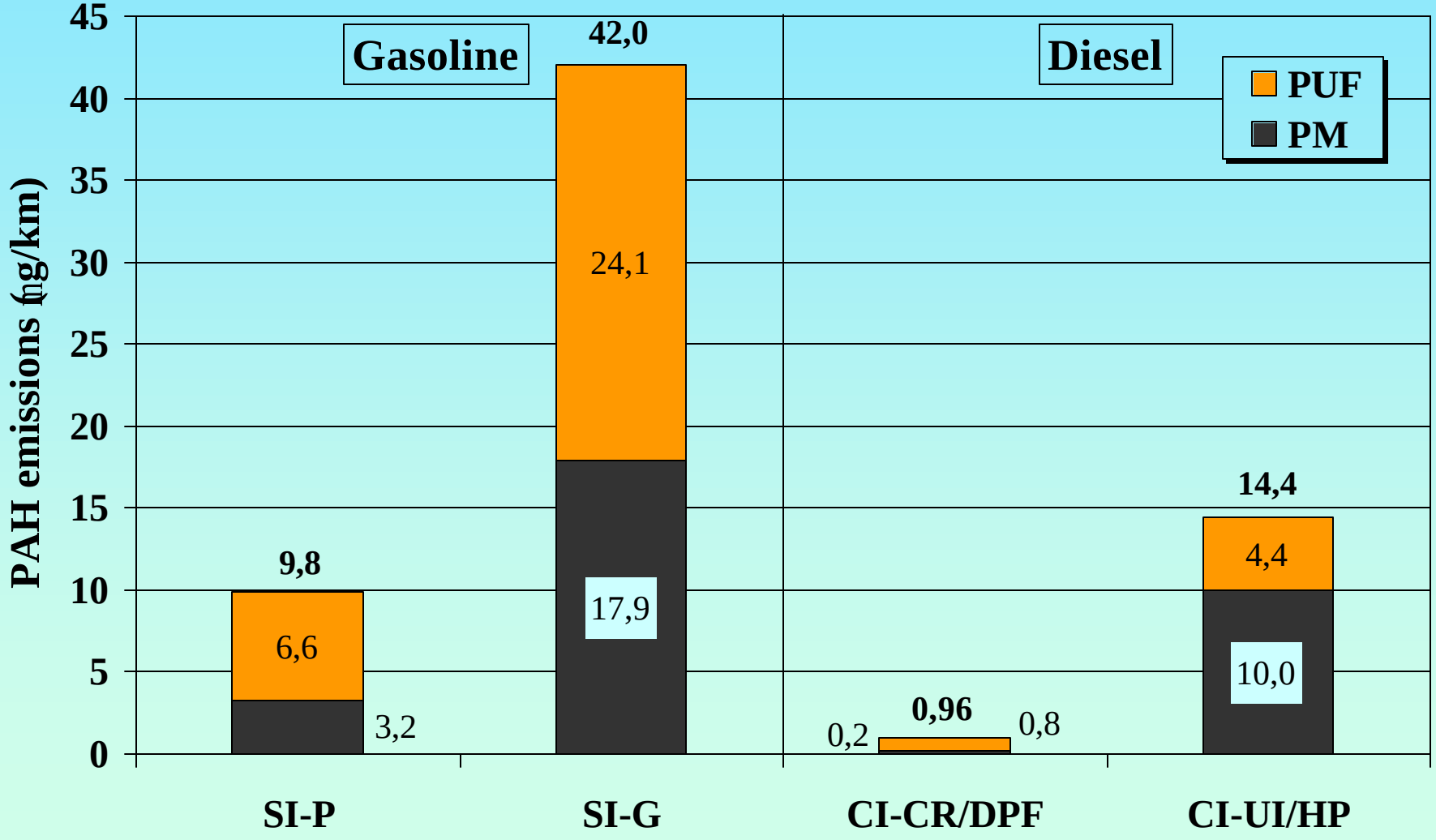
Benzene emissions in NEDC



Emissions of alkenes in NEDC Interpolated to +7°C



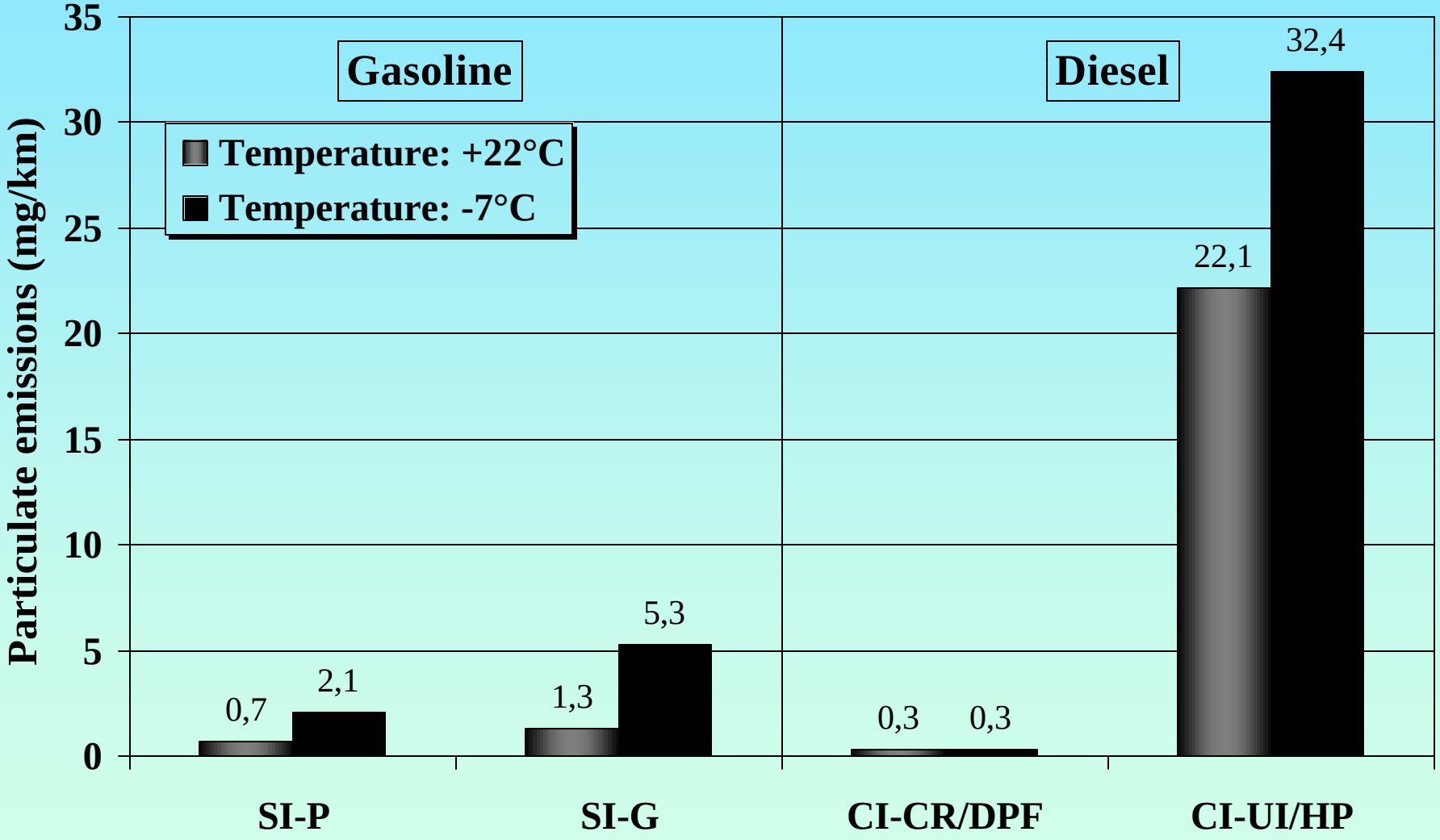
PAH emissions i NEDC Interpolated to +7°C



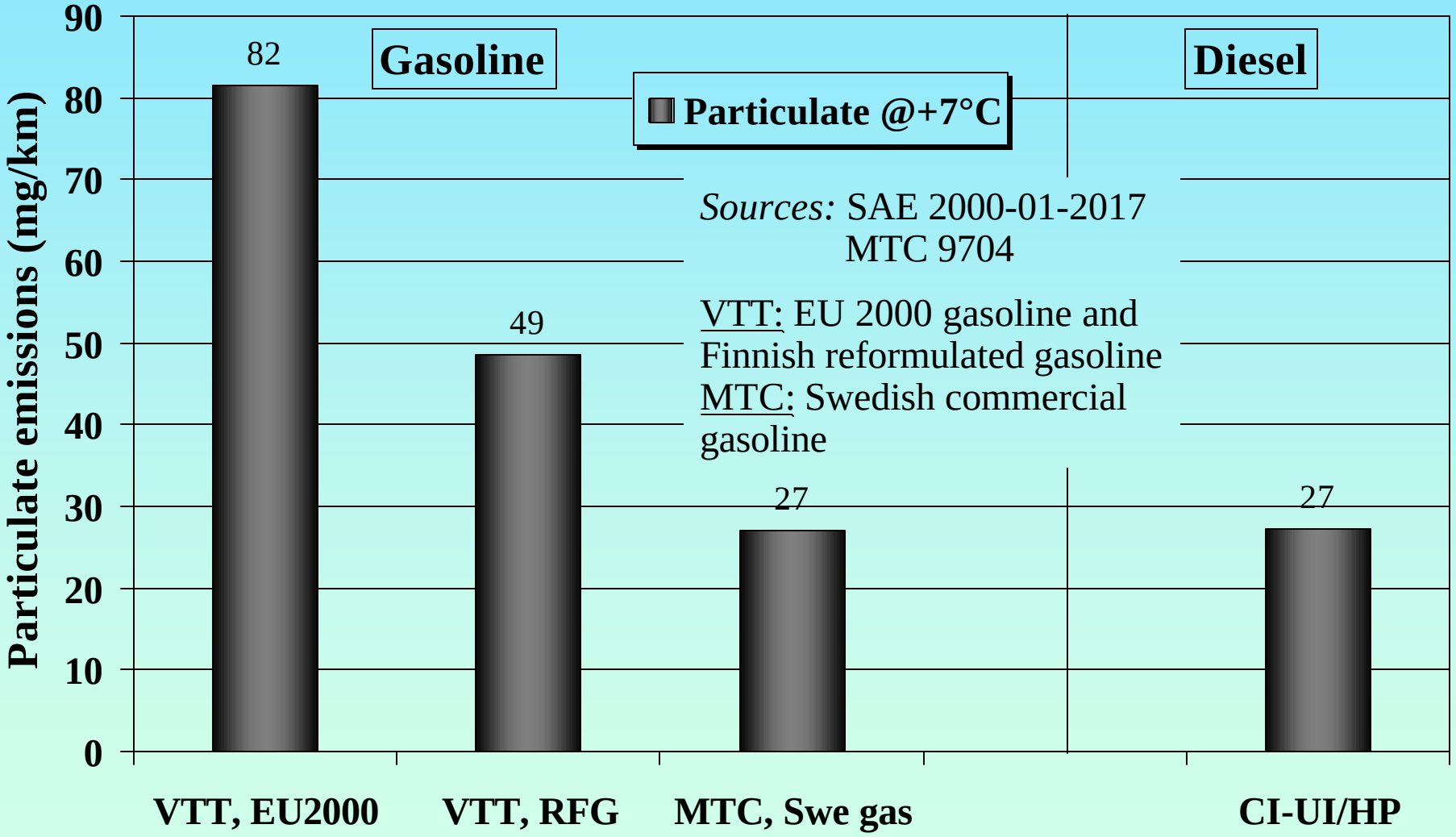
Other unregulated emissions

- Nitrous oxide (N_2O): in general low levels, however higher for diesel (mix-up?)
- Ammonia (NH_3) in NEDC: gasoline=low, diesel=0. Higher level for gasoline in US06
- Aldehydes: gasoline=0, diesel=0 or at the detection level at +22°C, 3 mg vid -7°C
- Acrylamide: not detectable in the overtaking test, below detection limit in US06 for all cars except in one case (CI-UI/HP), where it was 2 times higher than detection limit

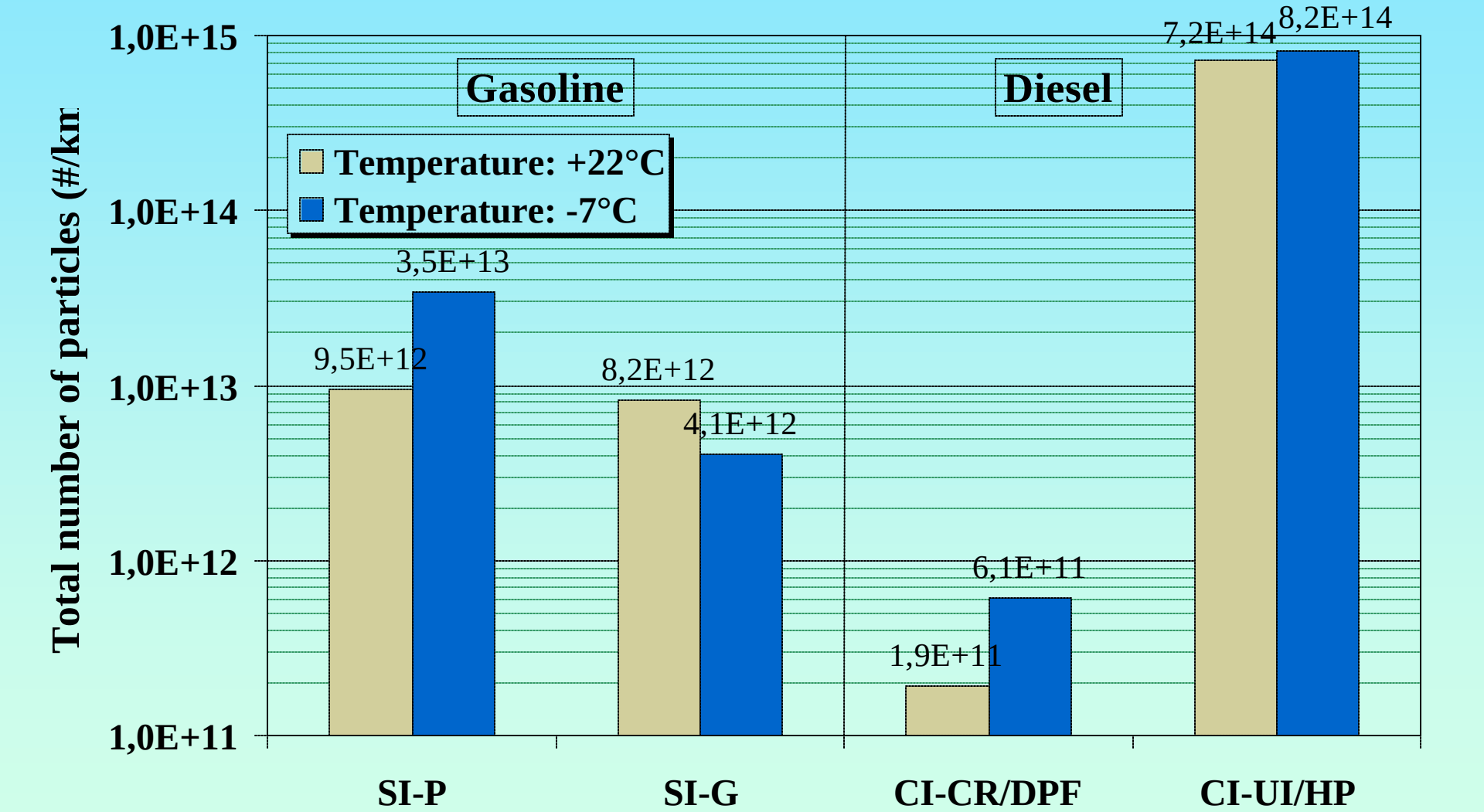
Particulate emissions in NEDC



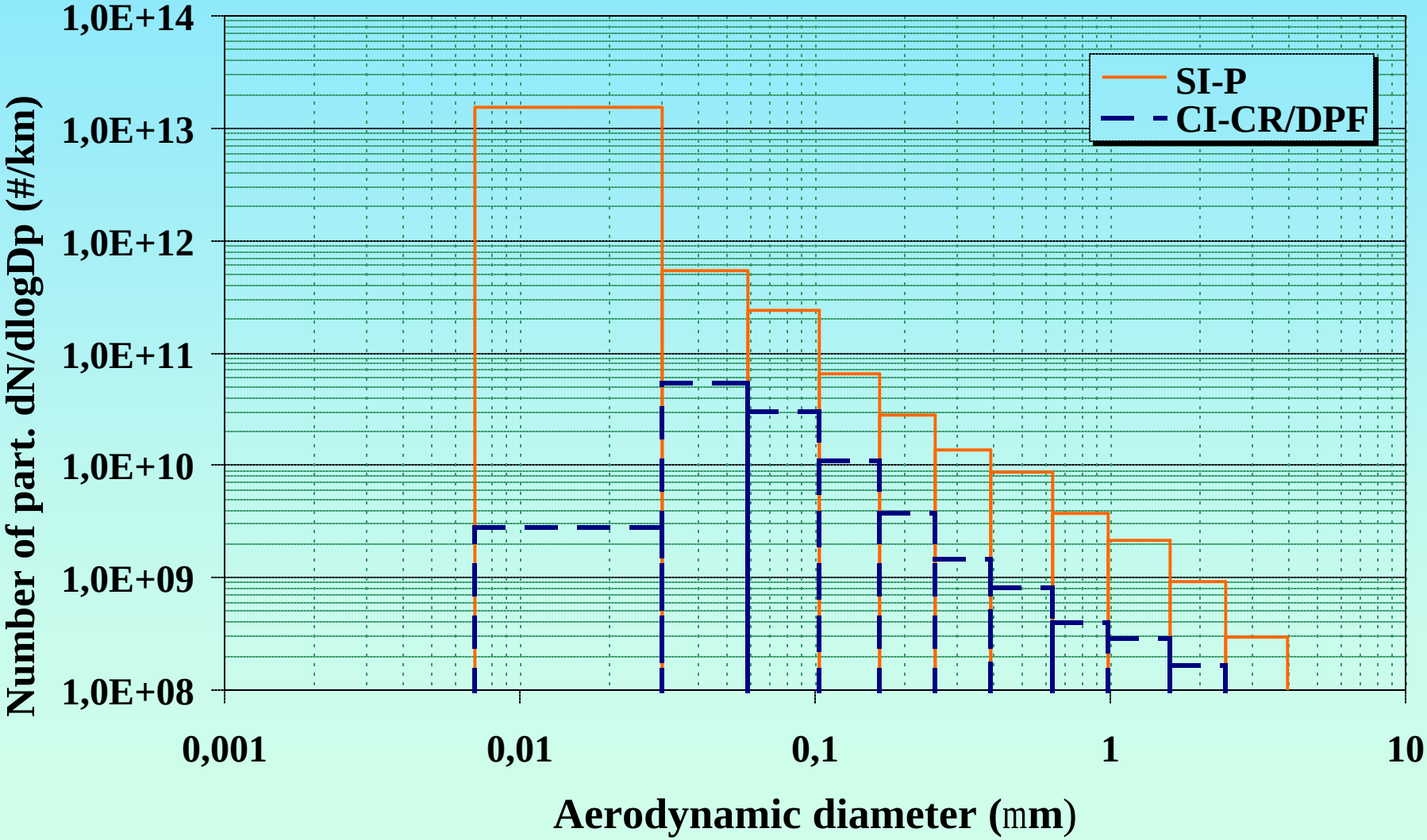
Particulate emissions compared to gasoline direct injection cars



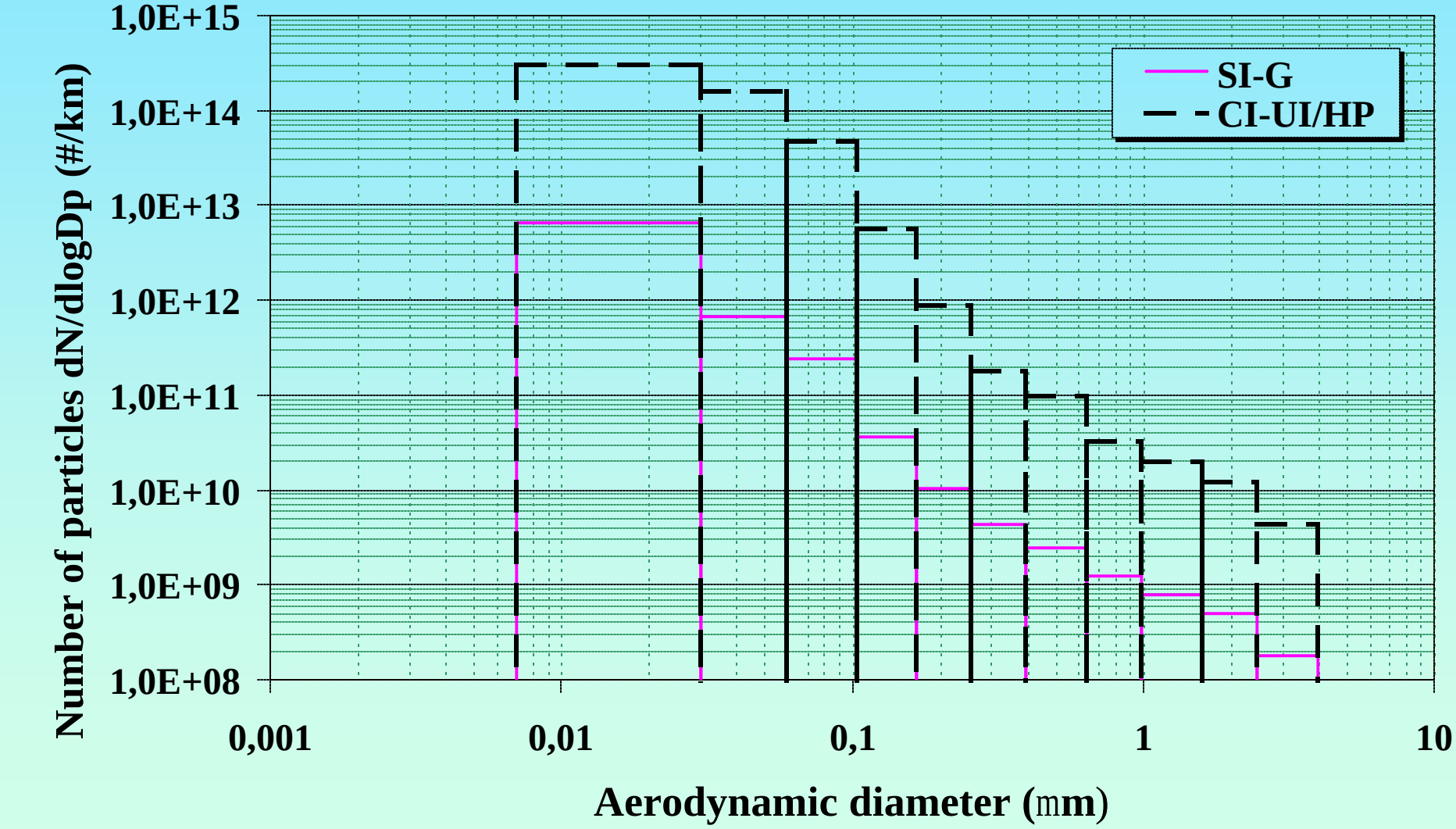
Total number of particles in NEDC



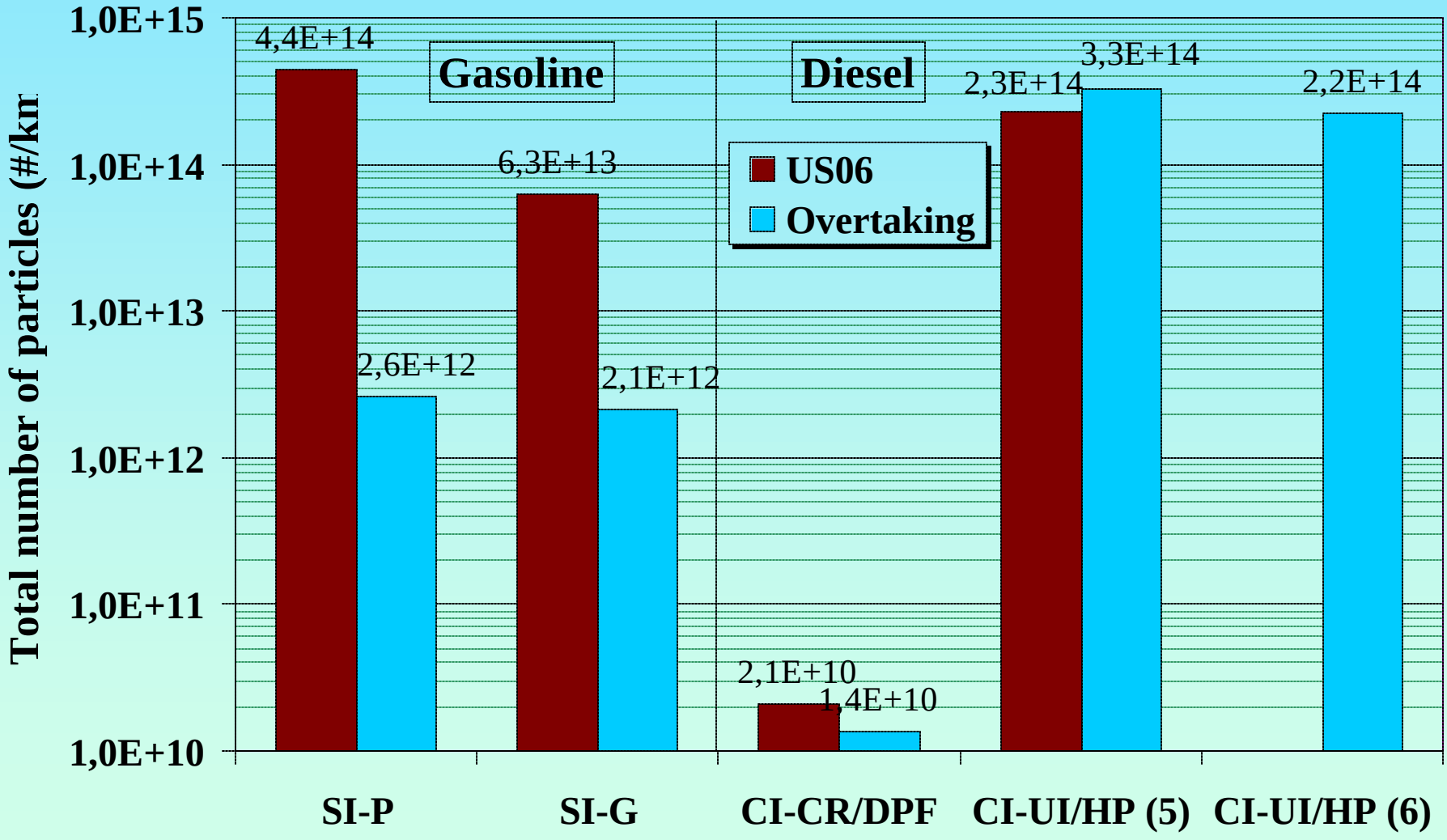
Particle size distribution for the Peugeot cars in NEDC at +22°C



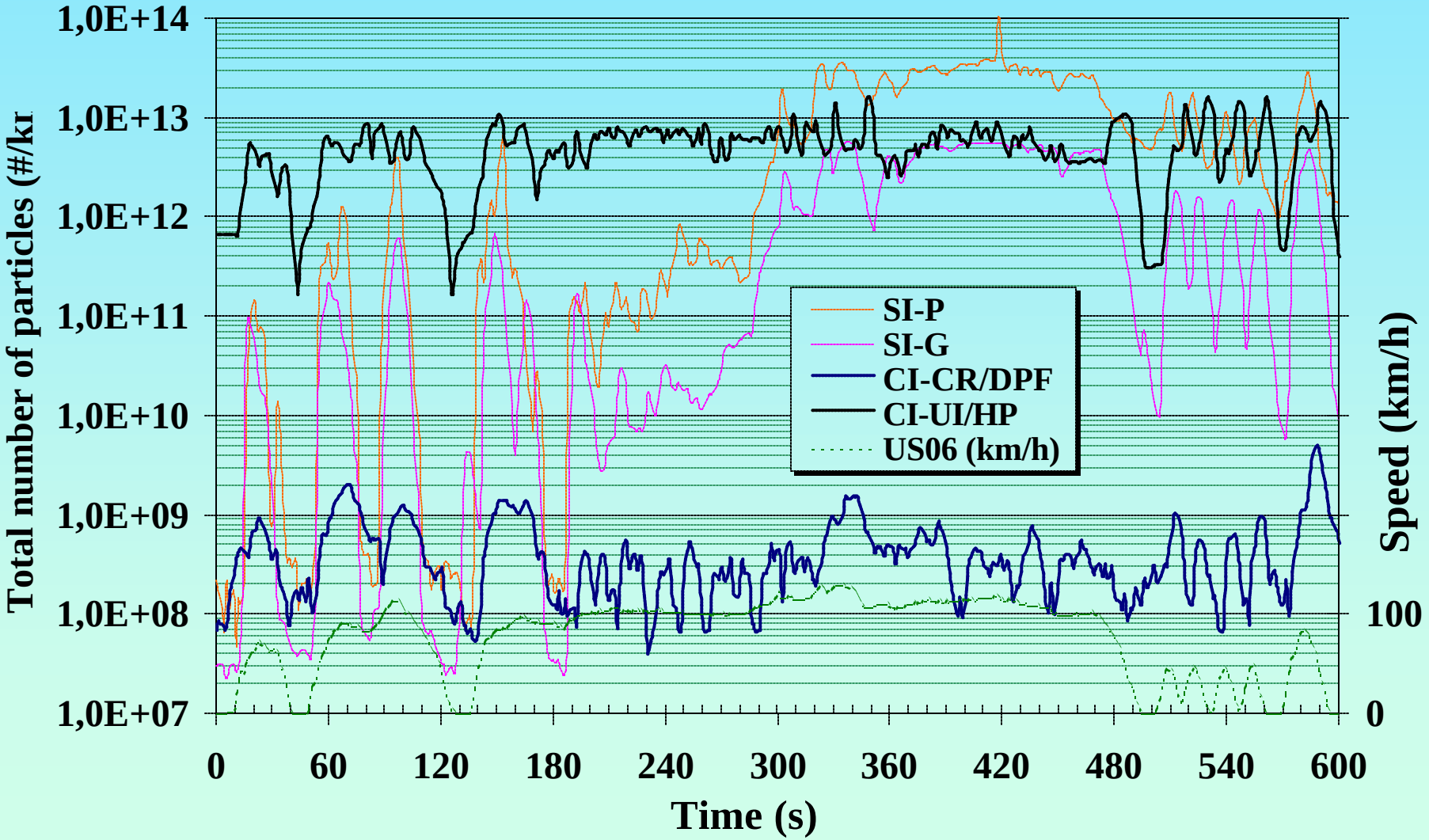
Particle size distribution for the VW Golf cars i NEDC at +22°C



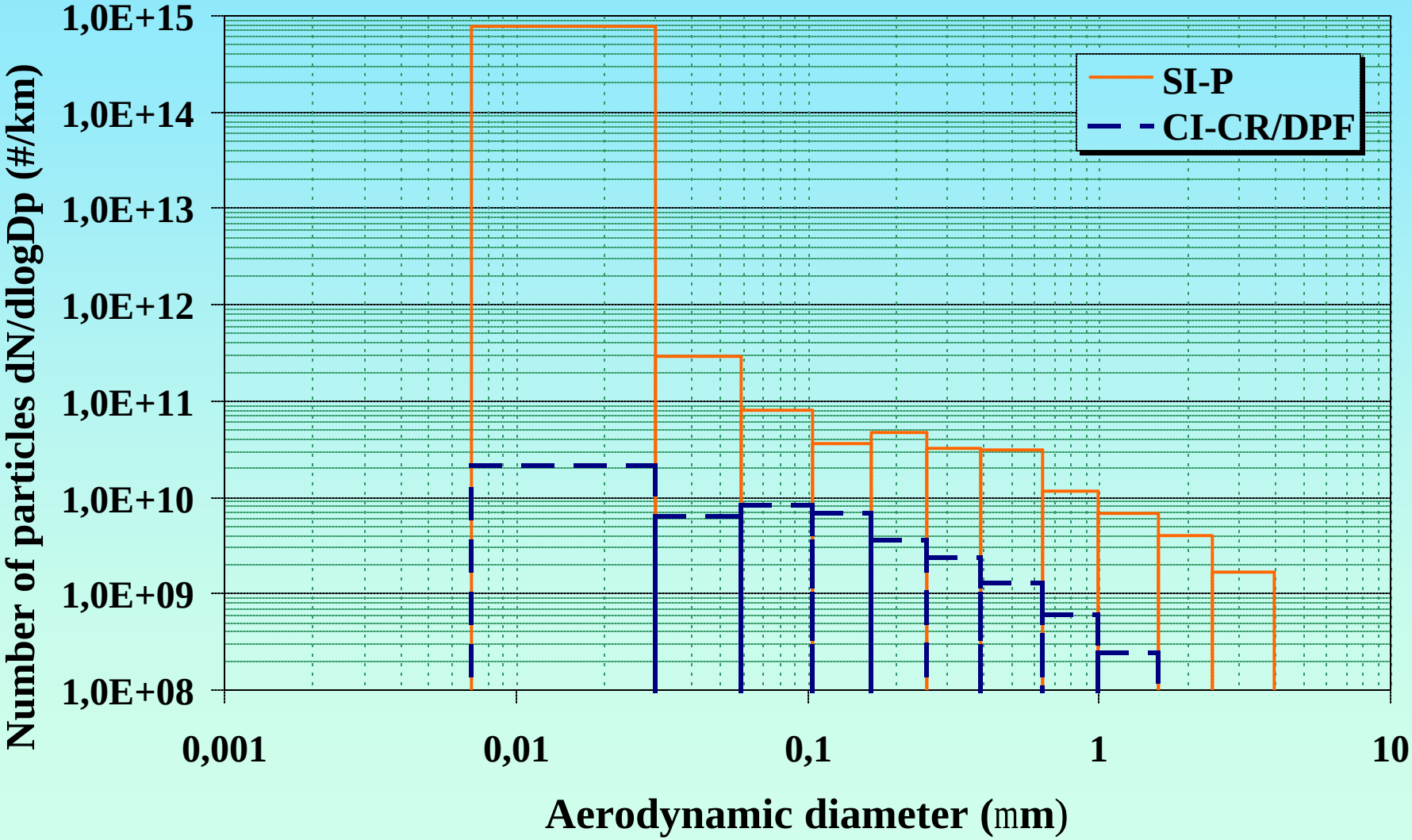
Total number of particles in US06 and during overtaking



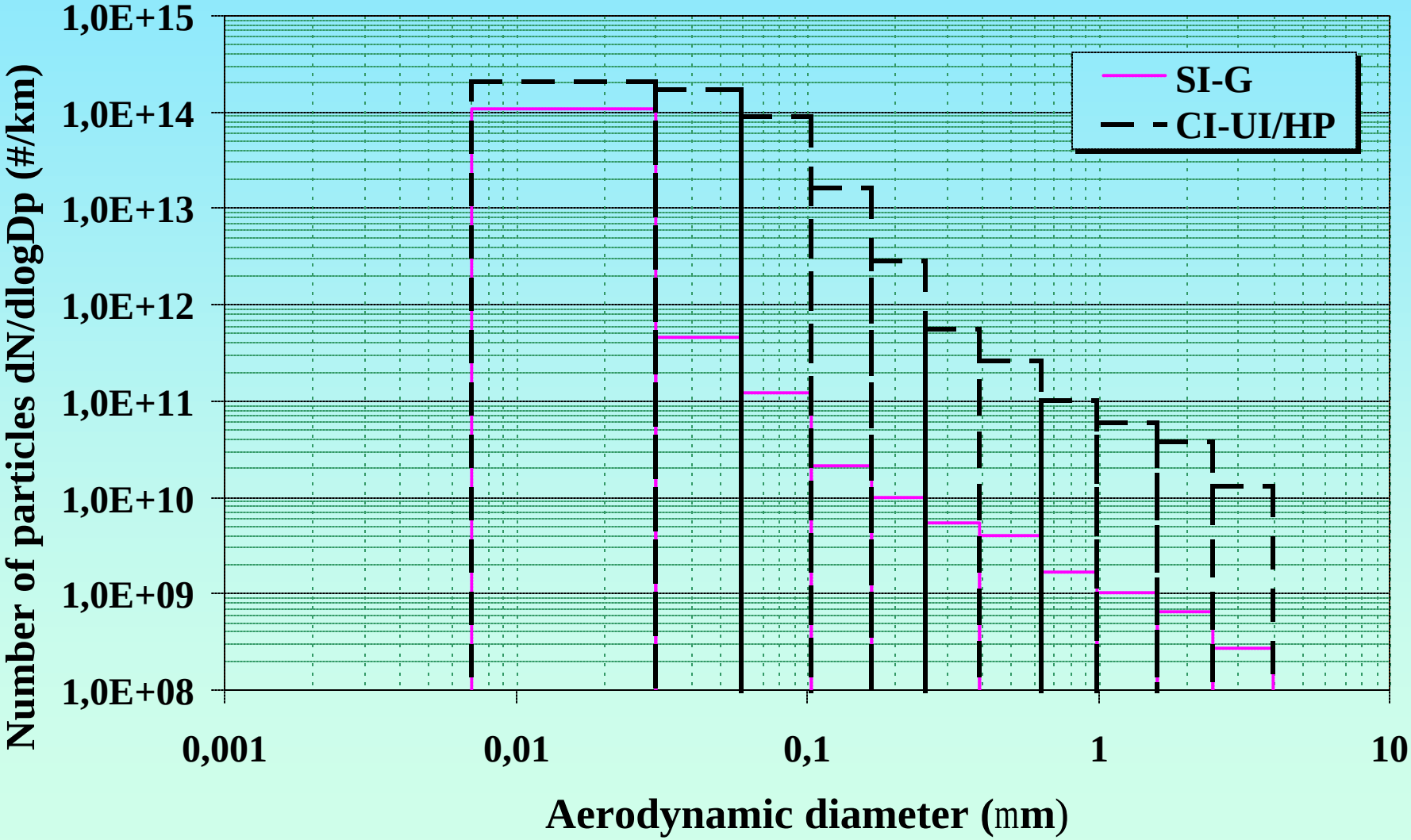
Total number of particles in real time in US06



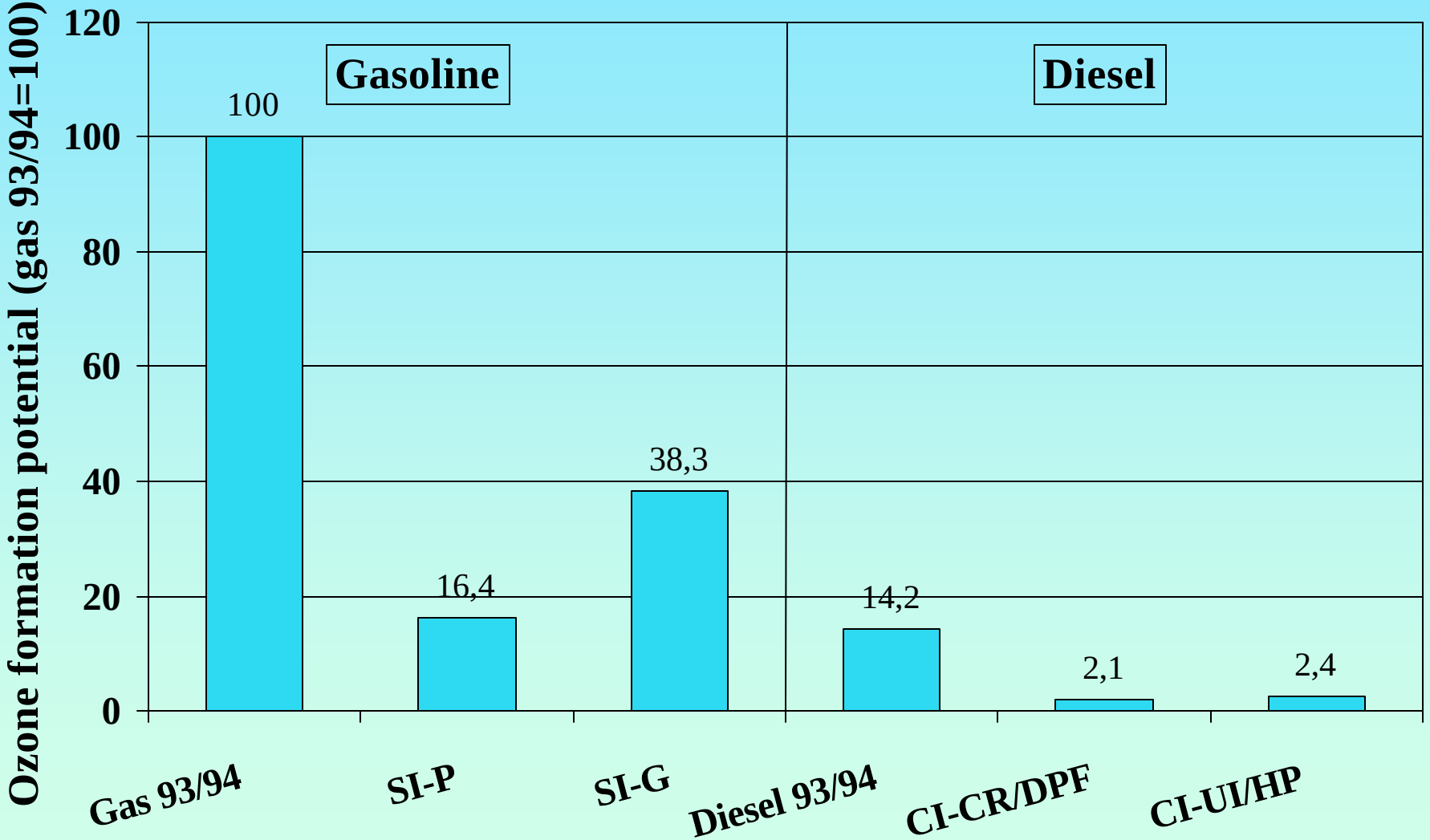
Particle size distribution for the Peugeot cars in US06



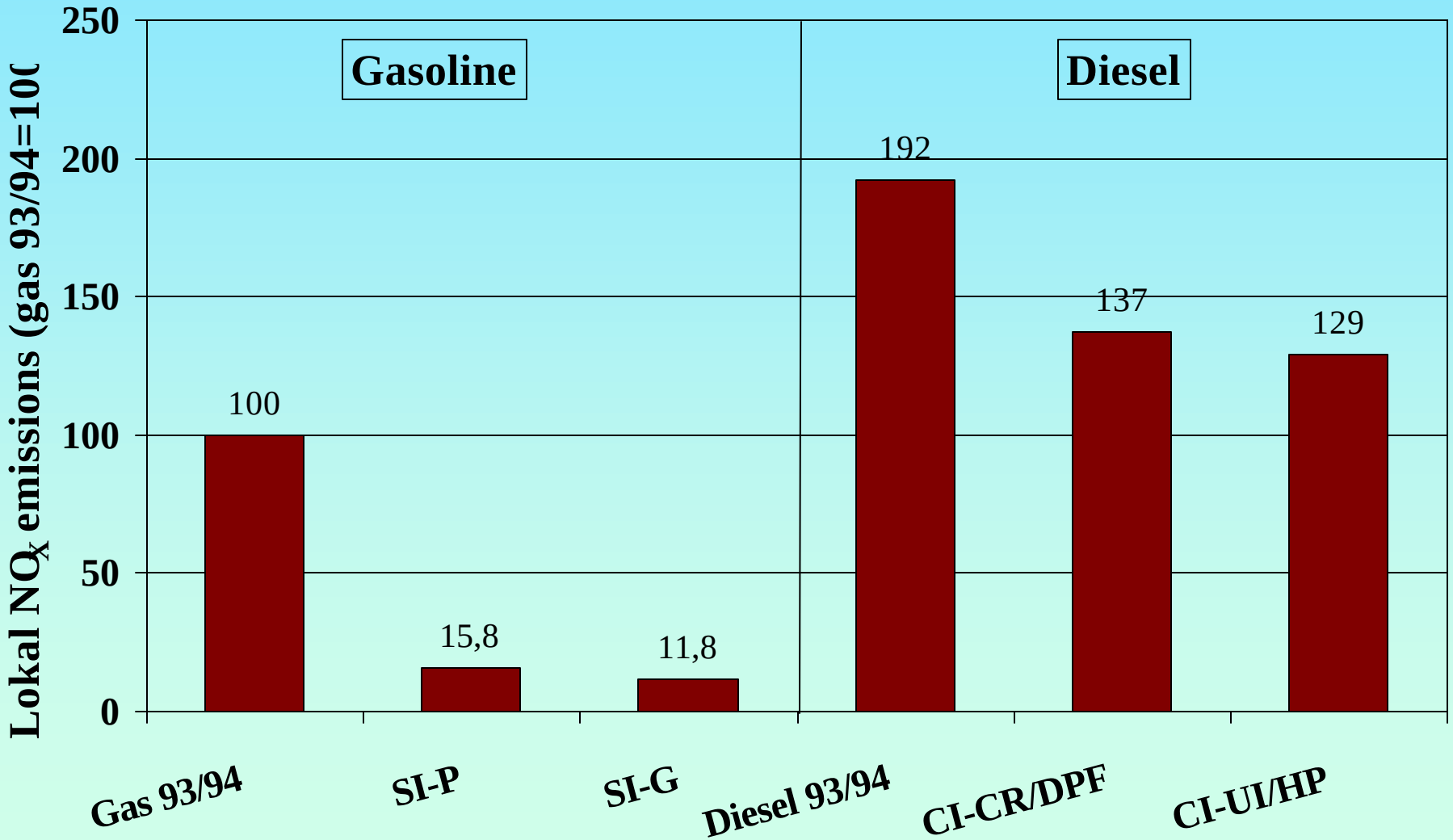
Particle size distribution for the VW Golf cars in US06



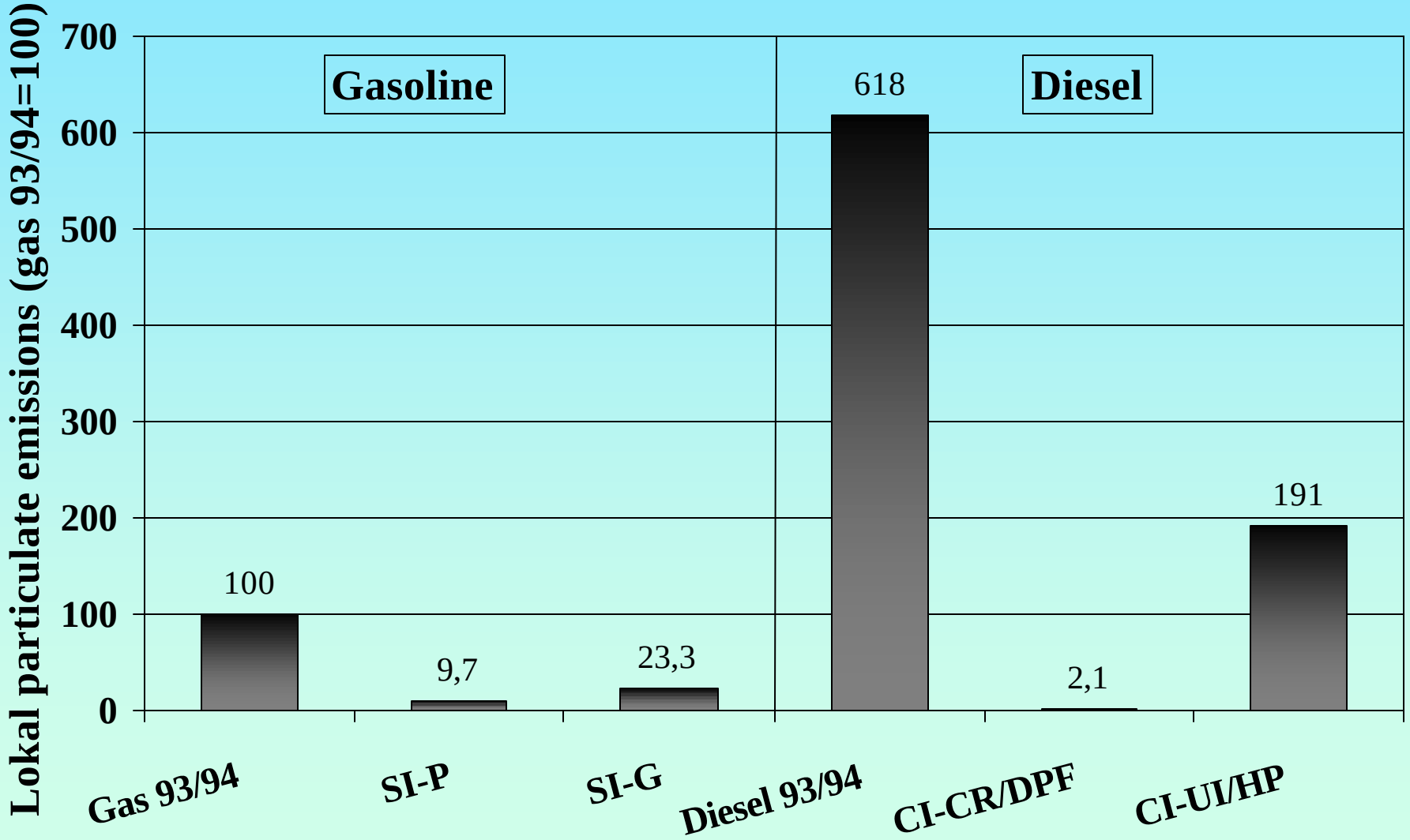
Ozone formation potential, +14°C



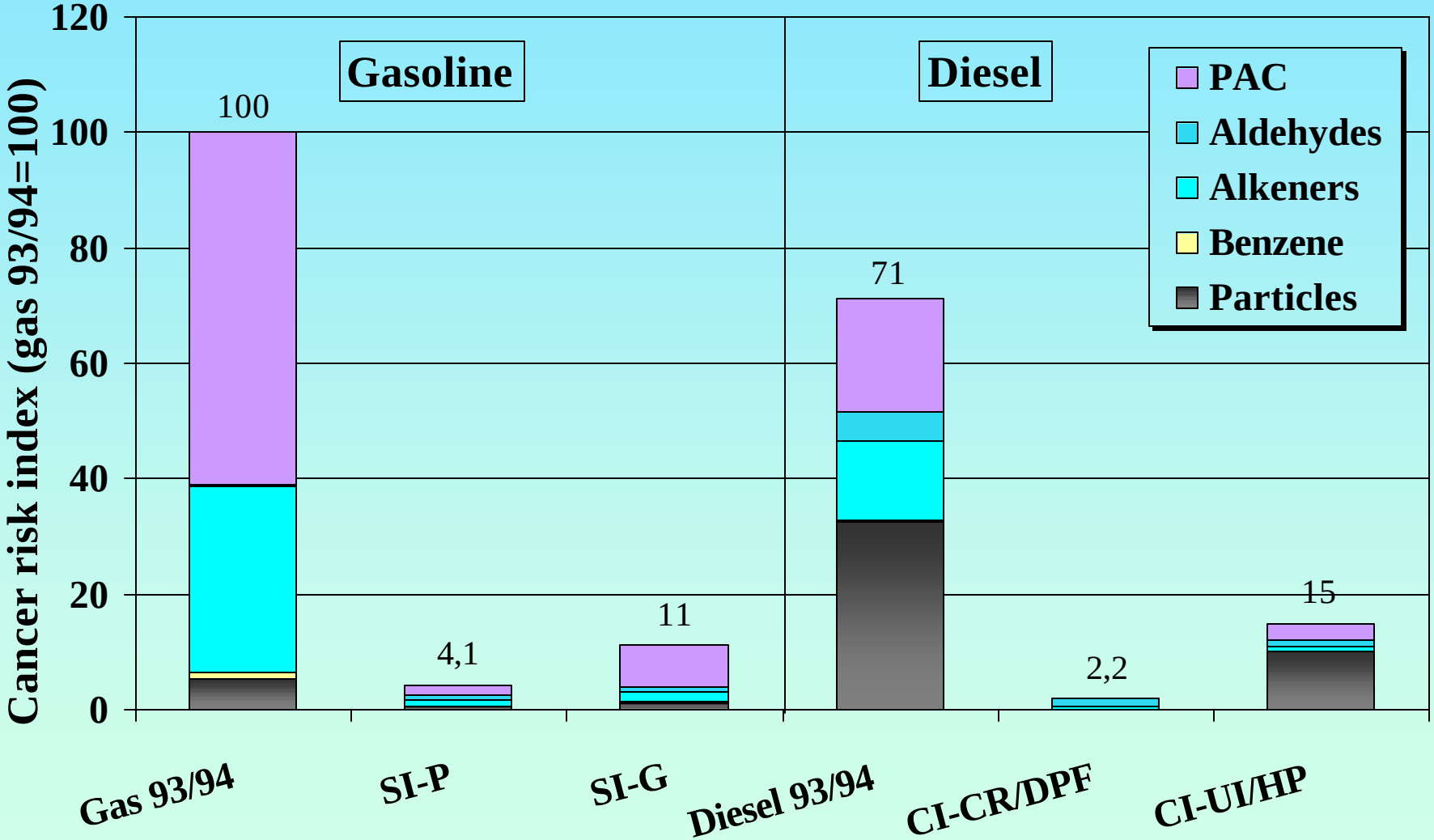
Local NO_X emissions, +7°C



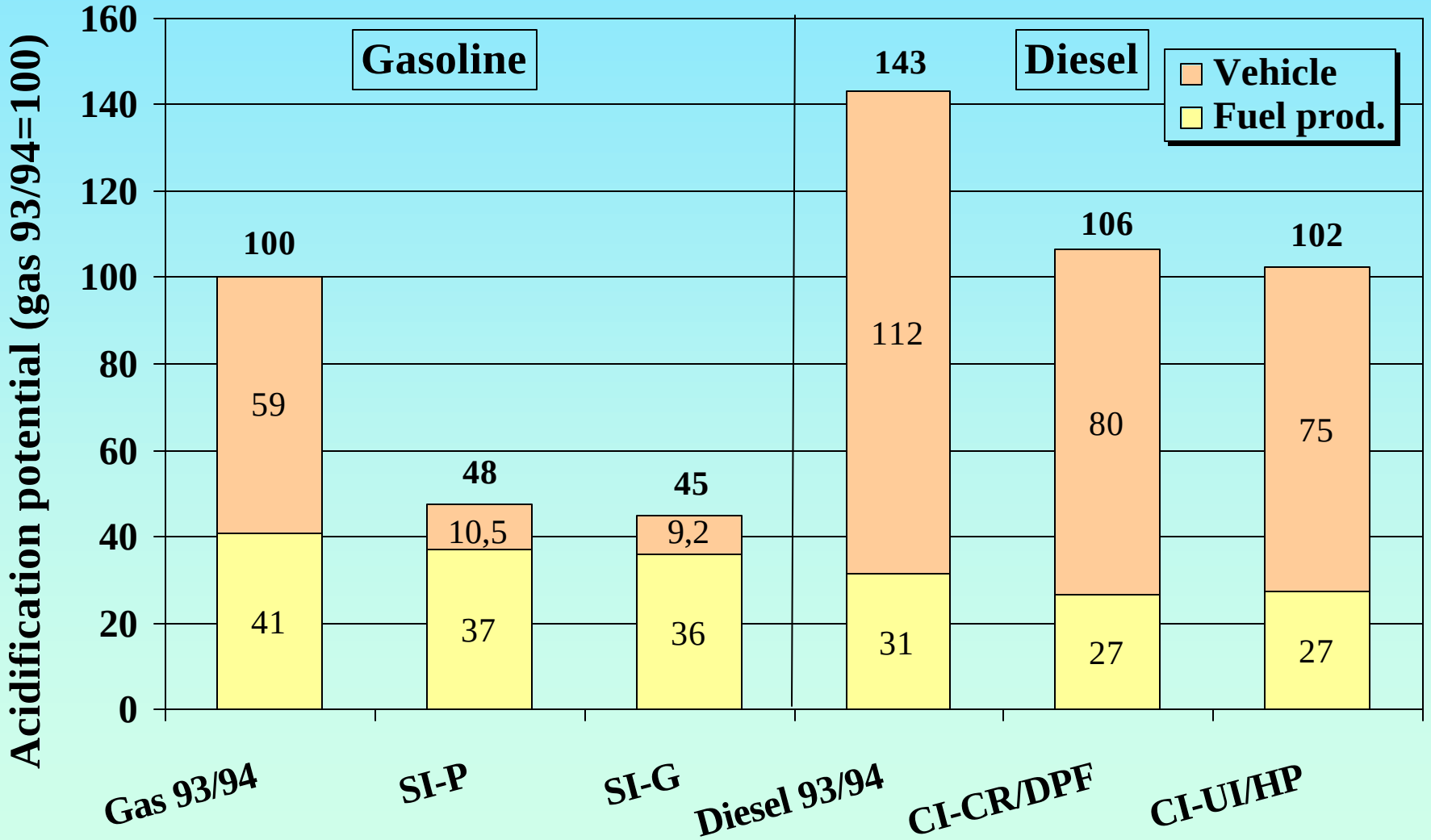
Local particulate emissions, +7°C



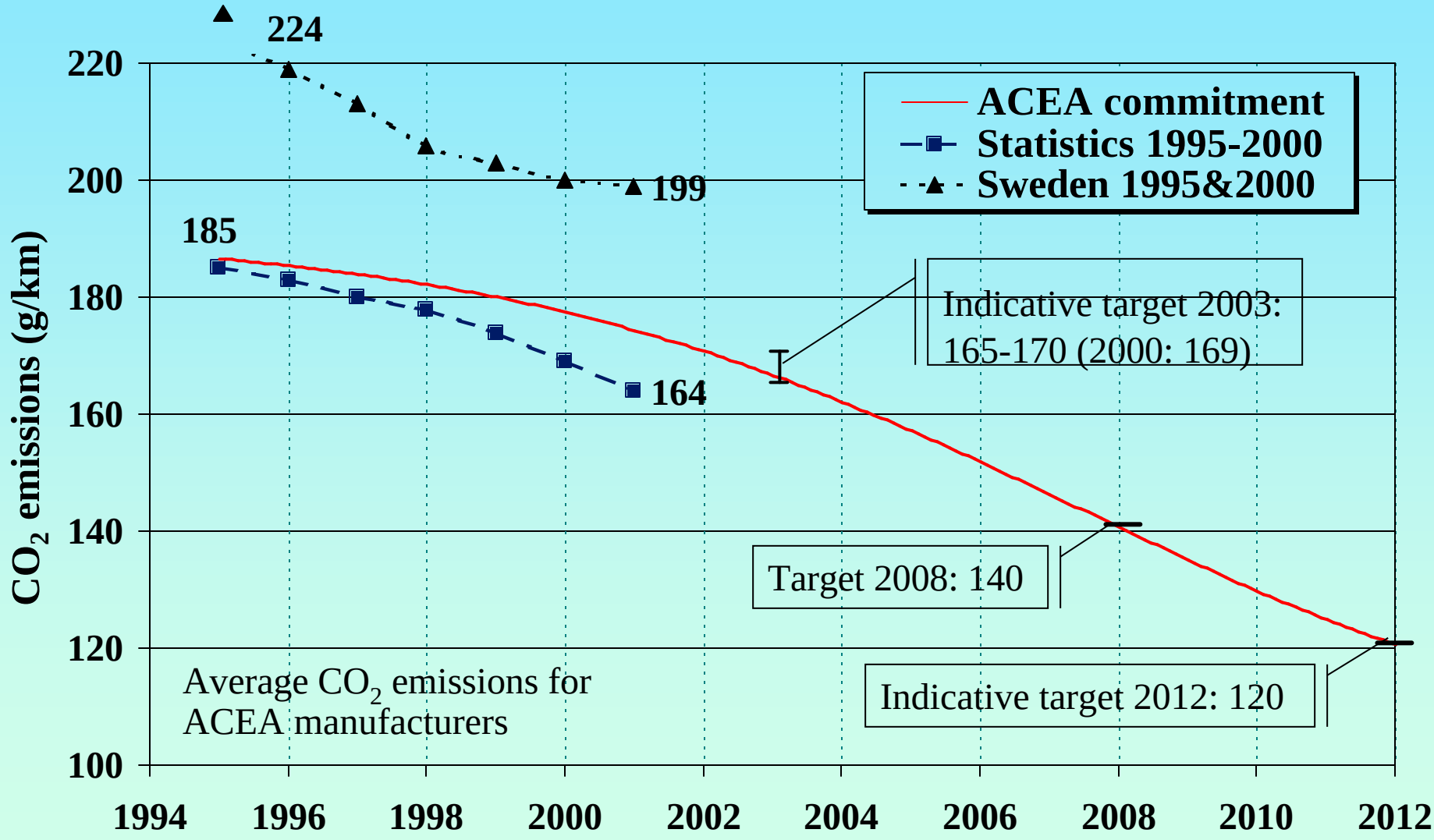
Cancer risk index (gas 93/94=100) URFs by Törnqvist/Ehrenberg



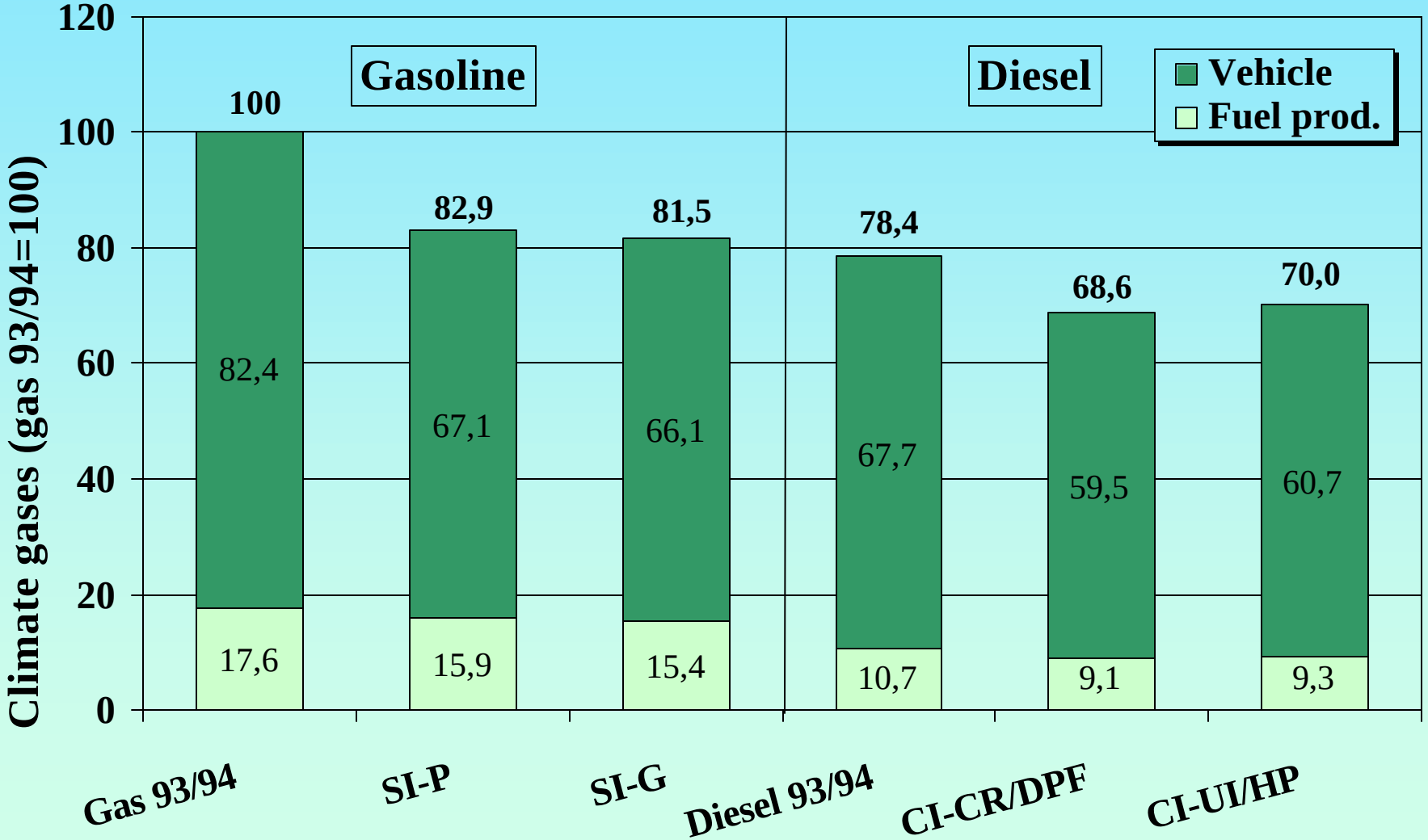
Acidification potential NO_X-equivalents



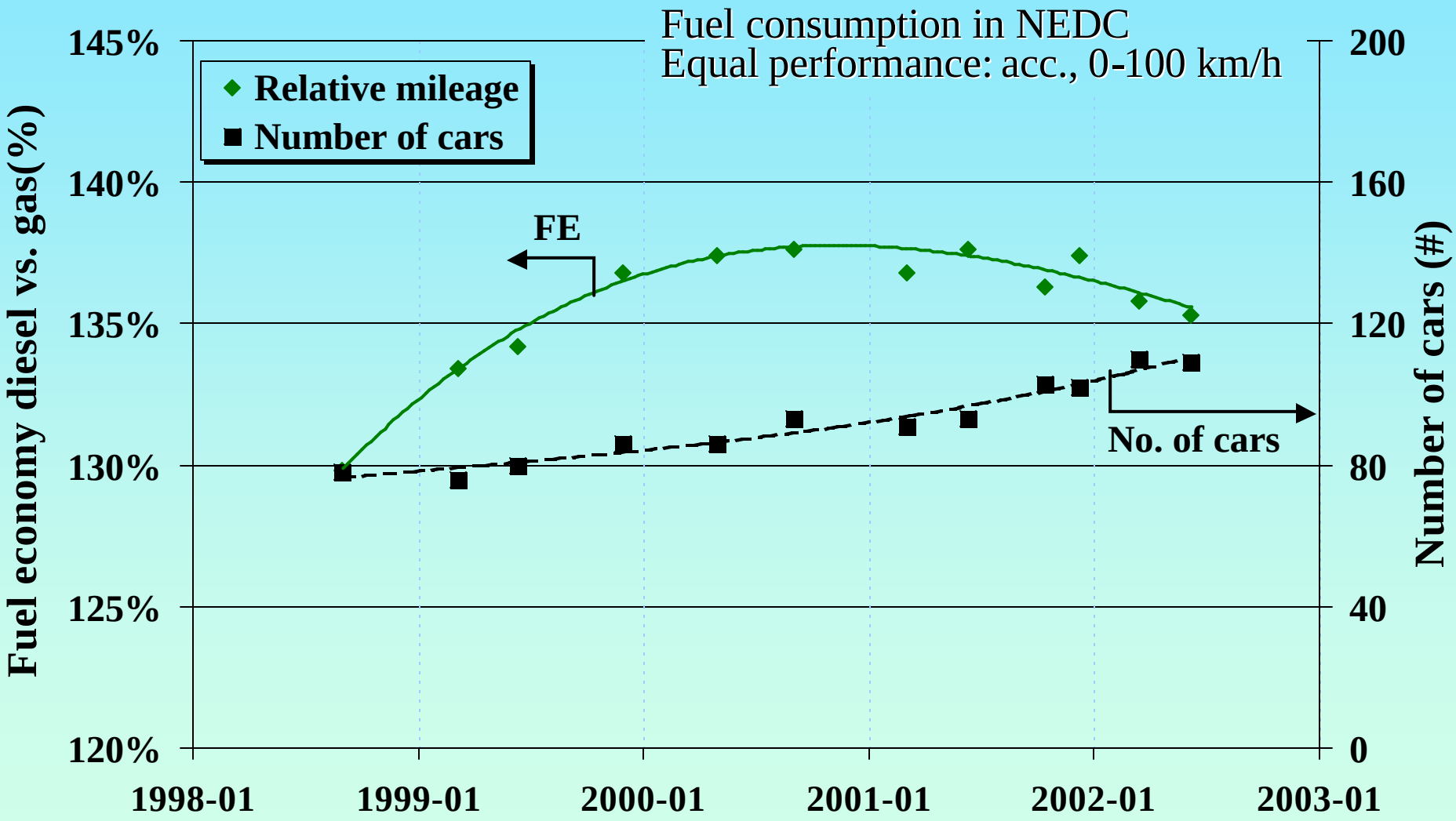
Voluntary CO_2 reduction by EU car manufacturers (ACEA)



Emissions of climate gases CO_2- equivalents



Relative mileage for gasoline and diesel cars with similar performance



Outlook

- Euro V, EEV (low-emission) not yet decided
- Phase-in of ultra-low sulfur fuel…
- Gasoline fuel econ. must (and will) improve
- Tax harmonization on diesel fuel in EU?
- Activities in Sweden
  - Workshop on diesel emissions this fall
  - Future fuel and vehicle taxation is discussed
  - Additional tests on cars (?)
  - CNG/diesel comparison on transit buses
- Fuels for future diesel engines?

Conclusions 1(2) - Emissions

- CO, HC lower for diesel, NO_X higher
- PM higher for diesel w/o DPF, lower with.
- Ammonia, N_2O low for all cars in general
- Aldehydes: “zero” for gasoline, low for diesel
- PAH low for all cars, extremely low with DPF
- Most harmful gaseous emiss. lower for diesel
- Number of particles & size is influenced by the driving pattern (→ new driving cycle?). The particulate filter is very effective (→ advantage for diesel in the future?)

Conclusions 2(2) - Impact on health and environment

- Ozone formation, fuel consumption, climate gases, energy use are lower for diesel
- Impact related to NO_X lower for gasoline: local NO_2, acidification, eutrophication
- Cancer risk: low, in general, but with varying results (PM filter → future advantage for diesel?)
- Gasoline development: low emissions=TWC; low fuel consumption: direct injection (NO_X, PM?)
- Diesel engine development: fuel consumption, particulate filter, NO_X catalyst
- Is there a new view on diesel cars (e.g. US EPA)?

This concludes my presentation

- Thank you for your attention!
- Questions?
- More information is available at the Internet at:

www.vv.se
www.ecotraffic.se