FUEL EFFICIENCY OF NEW EUROPEAN HD VEHICLES

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Business from technology

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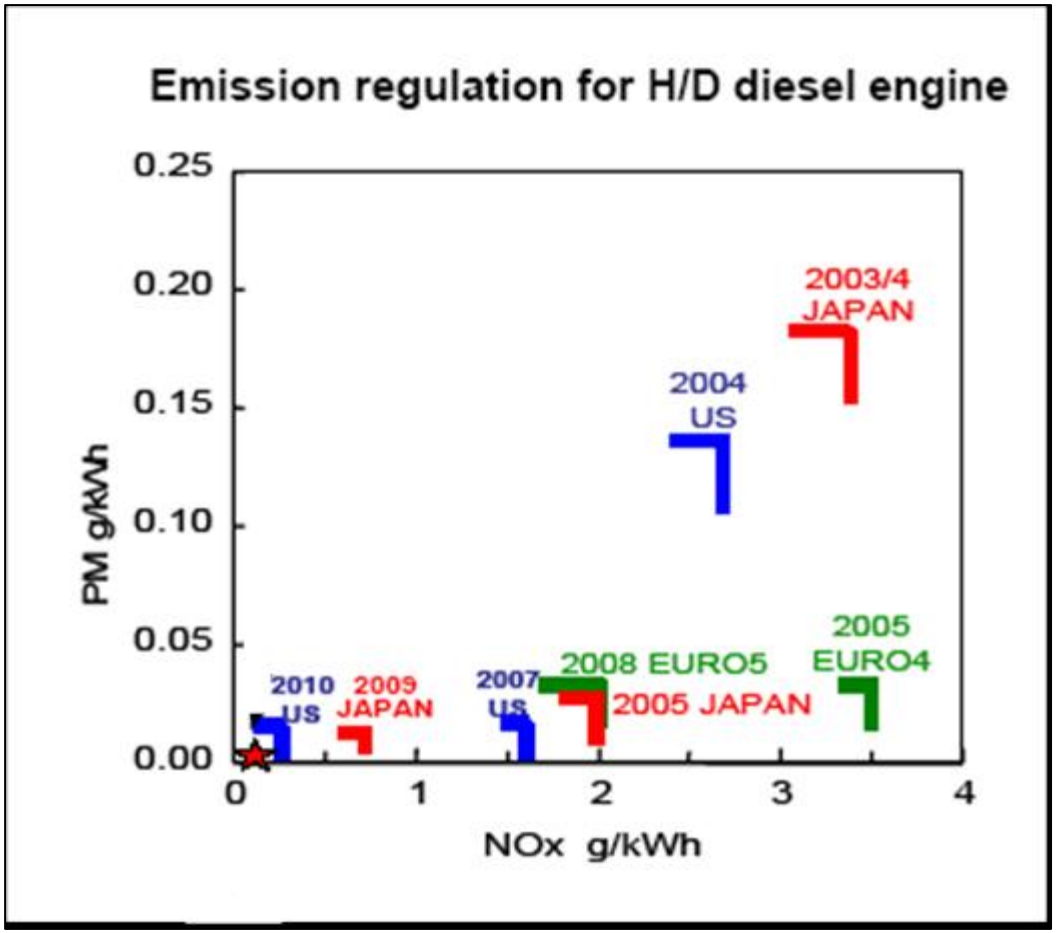
OUTLINE

- Background – Euro 4
- Test methods
- Test vehicles
- Truck & bus results
- Conclusions

BACKGROUND – EURO 4/5

- The Euro 4 requirements definitely entered into force in October 2006, Euro 5 will be introduced in 2009
  - the Euro 5 requirements roughly correspond to US 2007 requirements
- The new emission limits are forcing manufacturers to use high volume EGR or/and exhaust after-treatment systems
  - SCR (Selective urea catalyst system) is the preferred emission reduction technology in Europe
  - however, some manufacturers have opted for EGR technology

EQUIVALENCE OF EMISSION REGULATONS



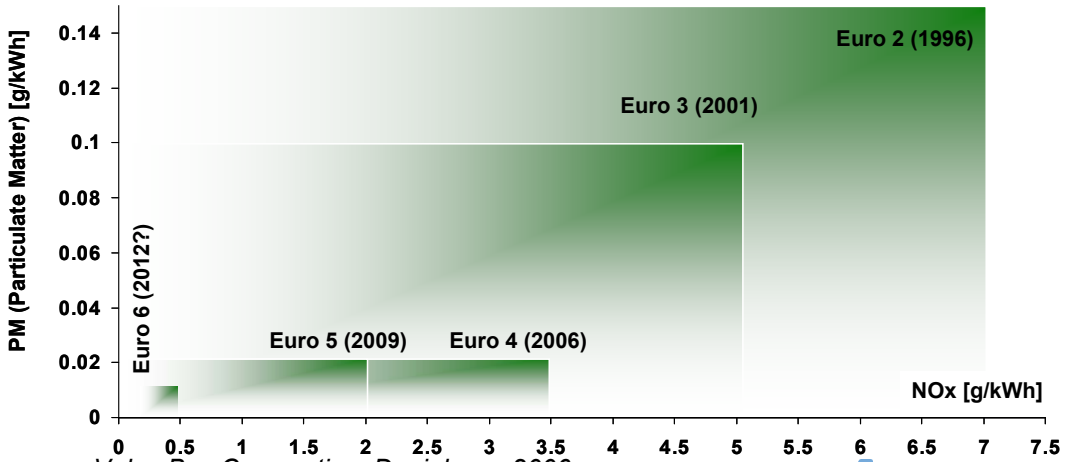
Oikawa et al 2005

BACKGROUND – EURO 4/5

- Engine manufacturers' choices to meet Euro 4 emission regulations
  - SCR (Selective Catalytic Reduction)
    - Volvo
    - Mercedes-Benz
    - Iveco
    - and others..
  - EGR (Exhaust Gas Recirculation)
    - Scania
    - MAN (+ partial particulate filter PM-KAT)

BACKGROUND – EURO 4/5

- How do new Euro 4 trucks and buses perform under real-world driving?
- What happens to fuel economy, is there an automatic fuel penalty for low emissions?
- Will more stringent emission regulations actually provide reduced real-life emissions?



Volvo Bus Corporation, Danielsson 2006

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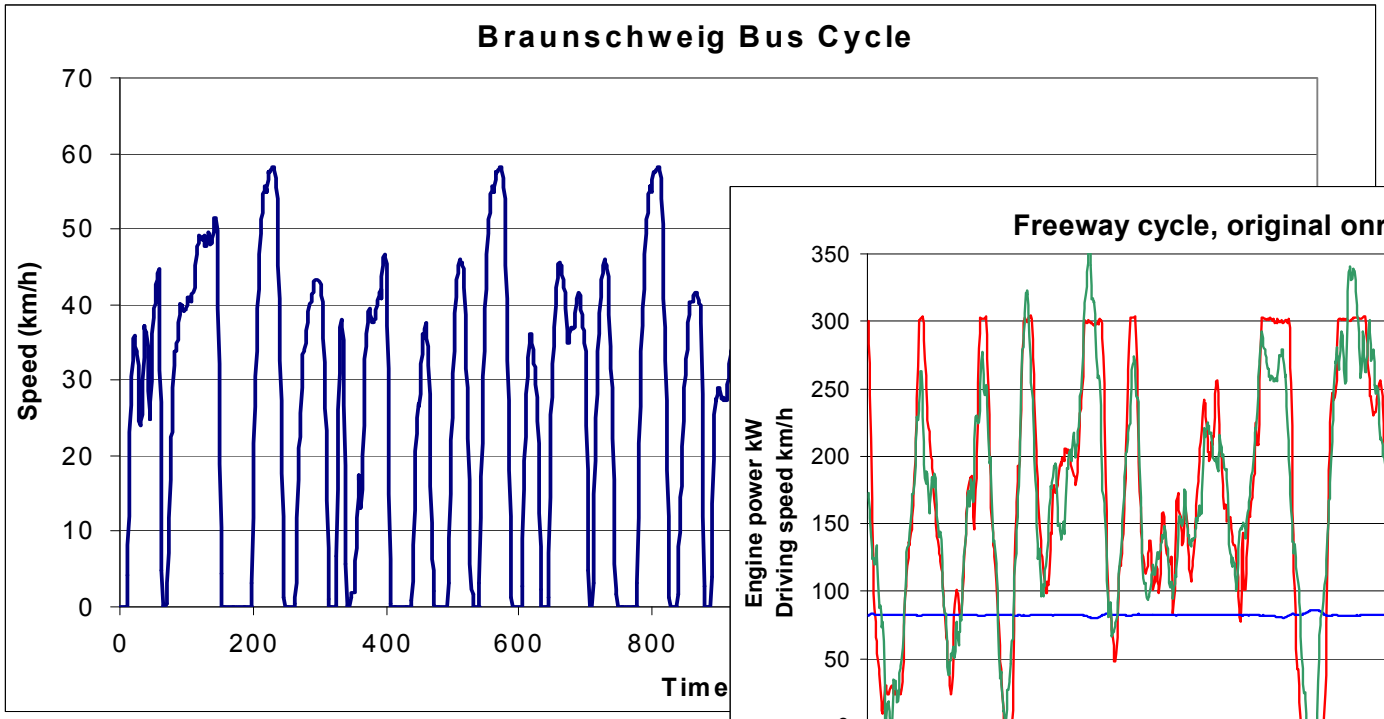
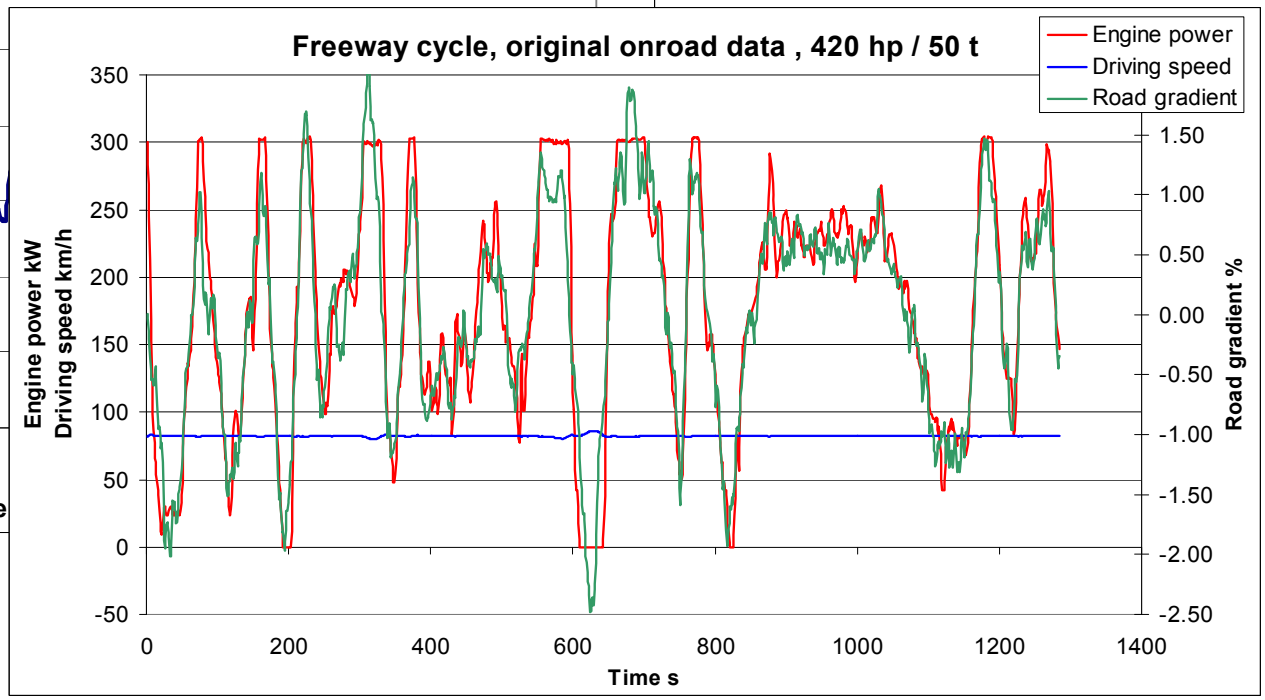
TEST METHODS

- Real world transient driving cycles on a HD chassis dynamometer
  - City bus cycles
    - Braunschweig – city center driving
    - Helsinki 2 – city center driving
    - Helsinki 3 – suburban driving
  - Heavy duty truck cycles
    - Delivery – max 26t (metric tons)
    - Highway – max 60t
    - Freeway – max 60t (using cruise control)

TEST METHODS





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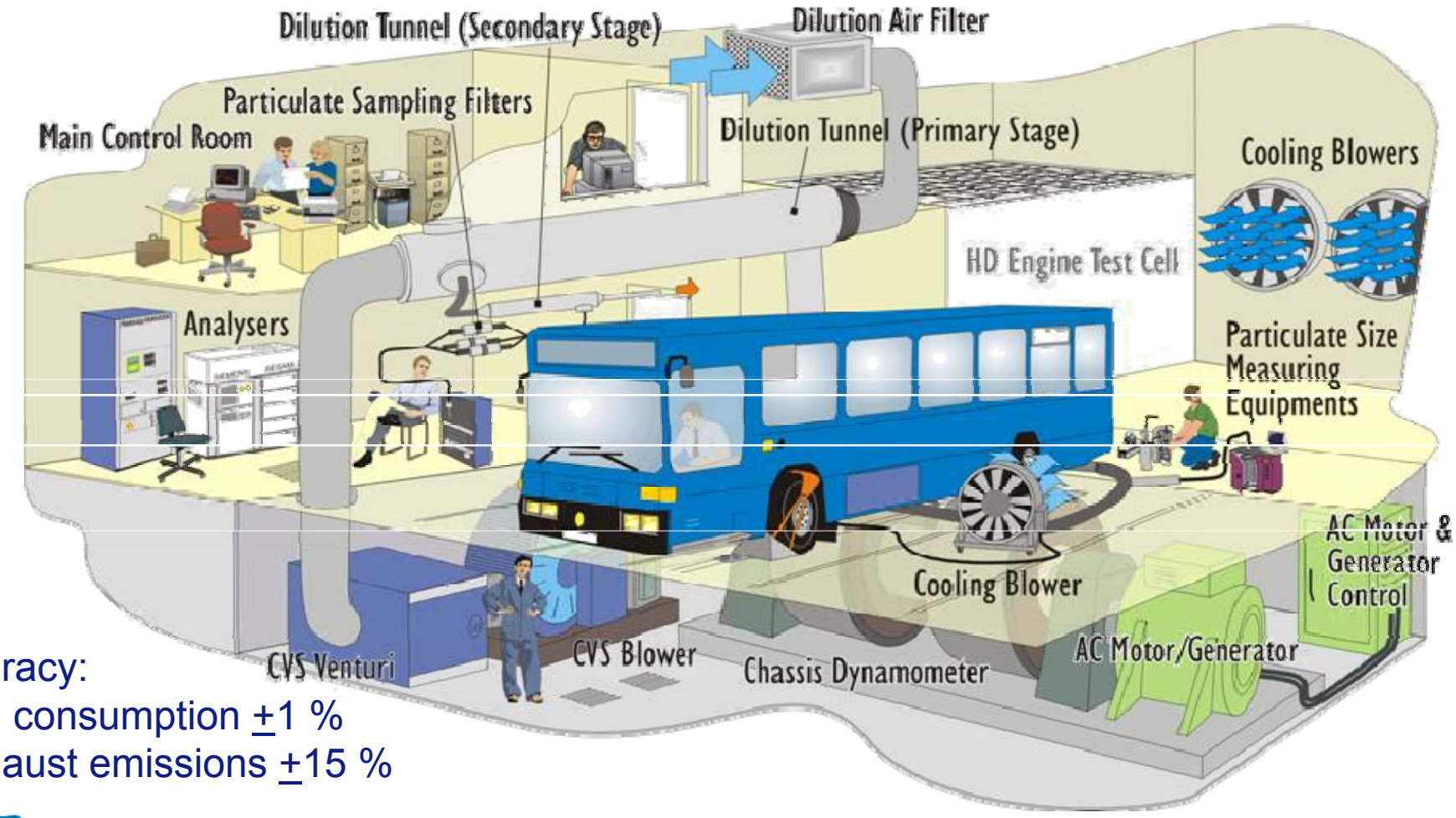
TEST METHODS

- Significant work has been devoted to the development of realistic and accurate fuel consumption measurements
  - Realistic duty cycles, including road gradient simulation for HD trucks
  - Standardization of test conditions and elimination of variations
    - standardized test fuel (ultra low sulfur)
    - special sets of conditioned measurement tires
    - fixed test procedures, including warm-ups and conditioning of the vehicle
    - elimination of influence from, e.g., air compressor and cooling fan
    - etc..

TEST METHODS - FACILITY



Accuracy:
- fuel consumption ±1 %
- exhaust emissions ±15 %

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TEST VEHICLES – CITY BUSES

Volvo – Brand A

- 4x2 Euro 3 MY 2005
- 4x2 Euro 4 SCR MY 2006
- 6x2 Euro 5 SCR MY 2006

Mercedes-Benz – Brand B

- 4x2 Euro 4 SCR MY 2006

Scania – Brand C

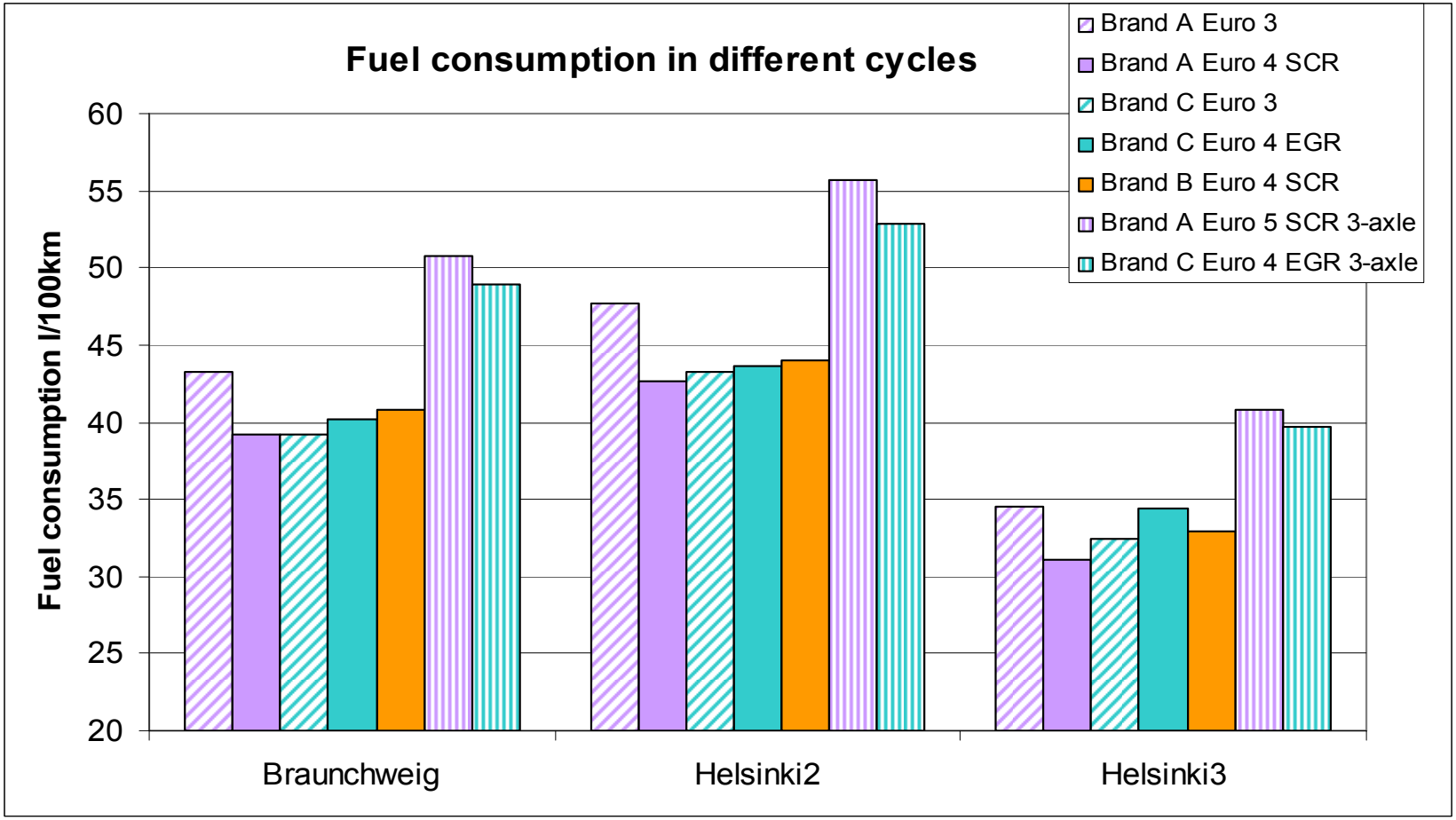
- 4x2 Euro 3 MY 2005
- 4x2 Euro 4 EGR MY 2006
- 6x2 Euro 4 EGR MY 2006

TEST VEHICLES - TRUCKS

Euro 4 trucks, all model year 2006

- Scania R470, EGR
- MAN TGA.430, EGR + PM-KAT
- MB Actros 1844, SCR
- Volvo FH480, SCR
- Iveco Stralis 420, SCR

FUEL CONSUMPTION – CITY BUSES



Study for the Finnish Public Transport Association

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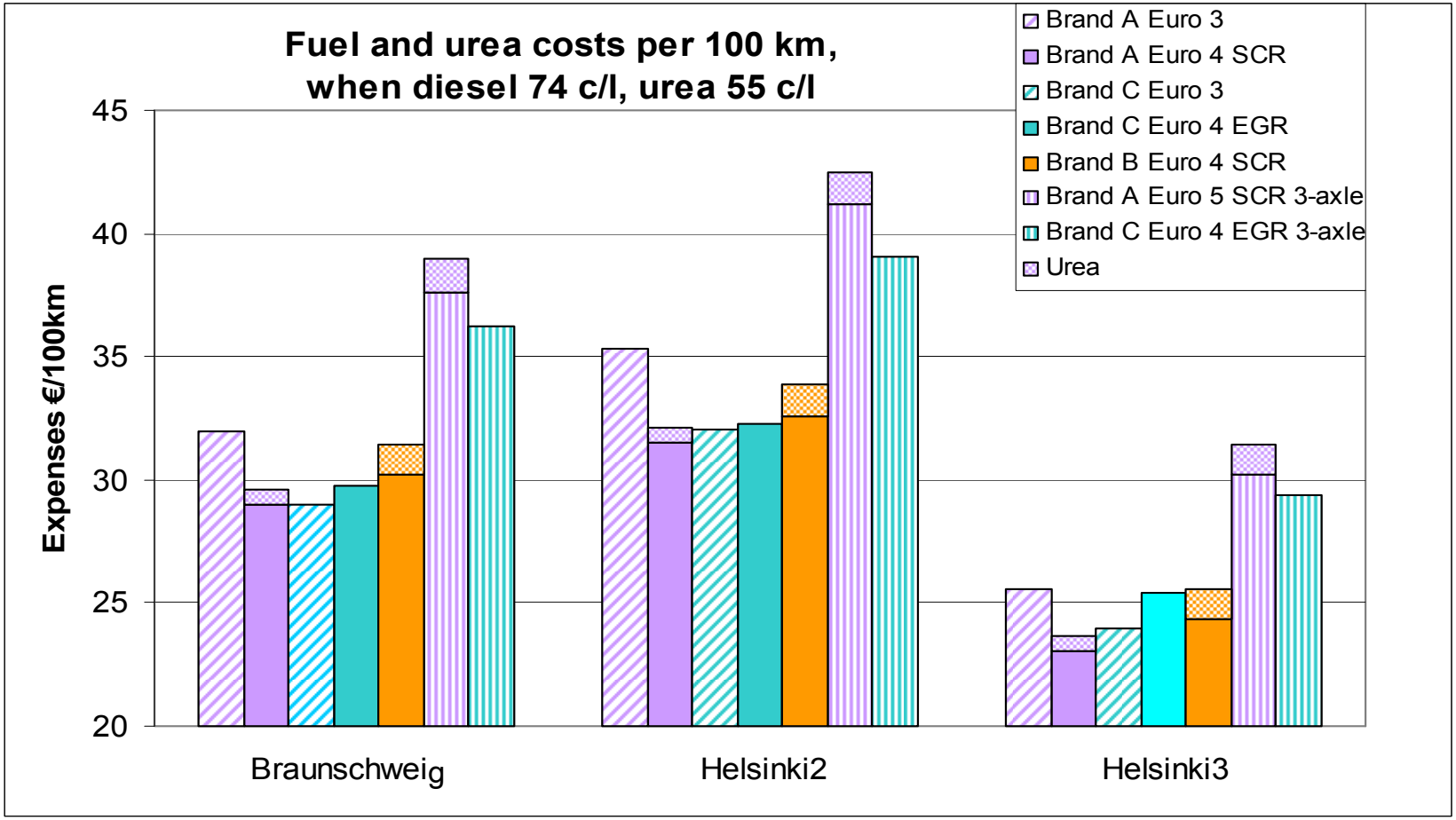
FUEL AND UREA COSTS – CITY BUSES



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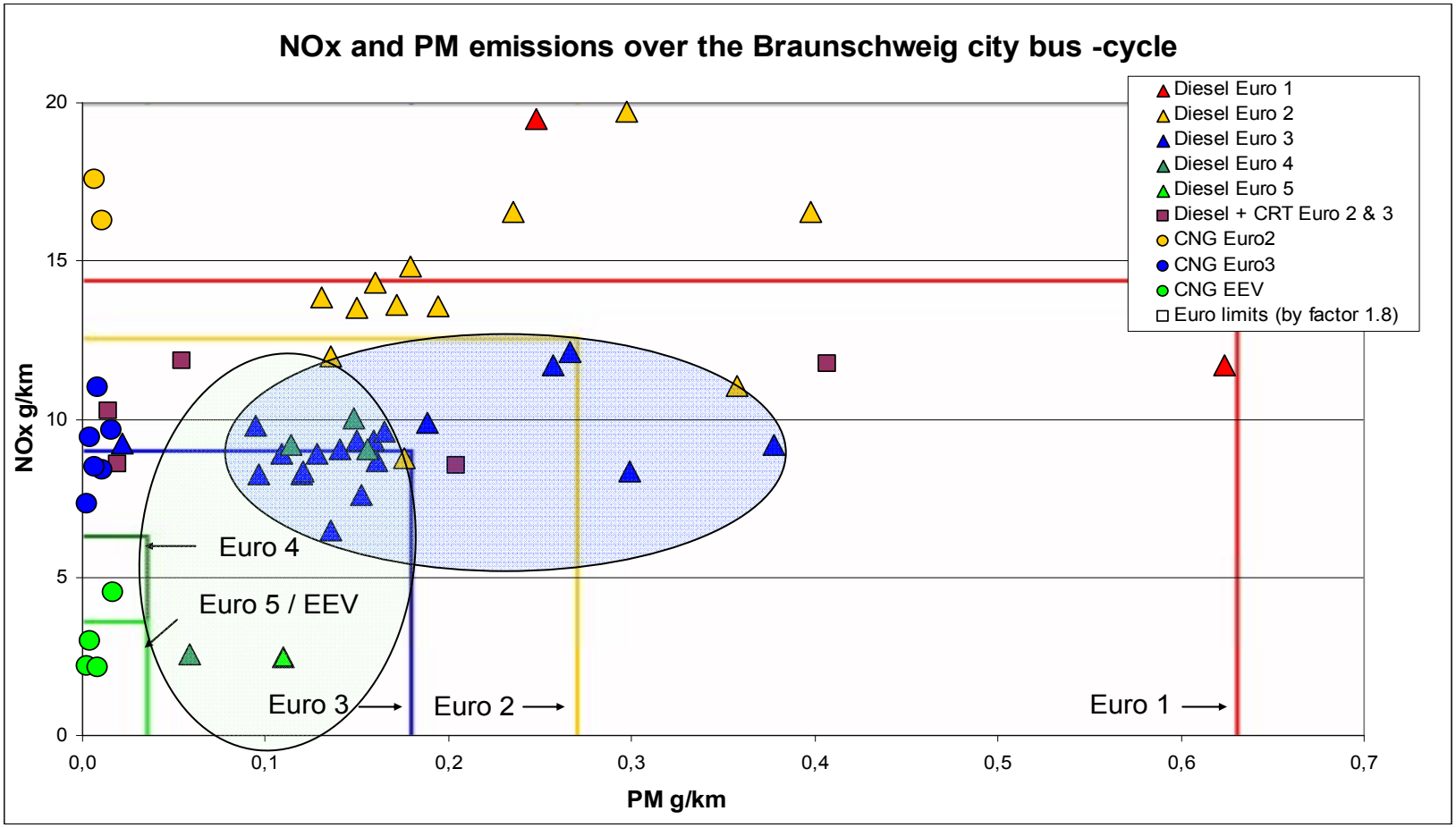
EMISSION RESULTS - CITY BUSES



Summary of all VTT's measurements conducted at VTT between 2002 and 2006

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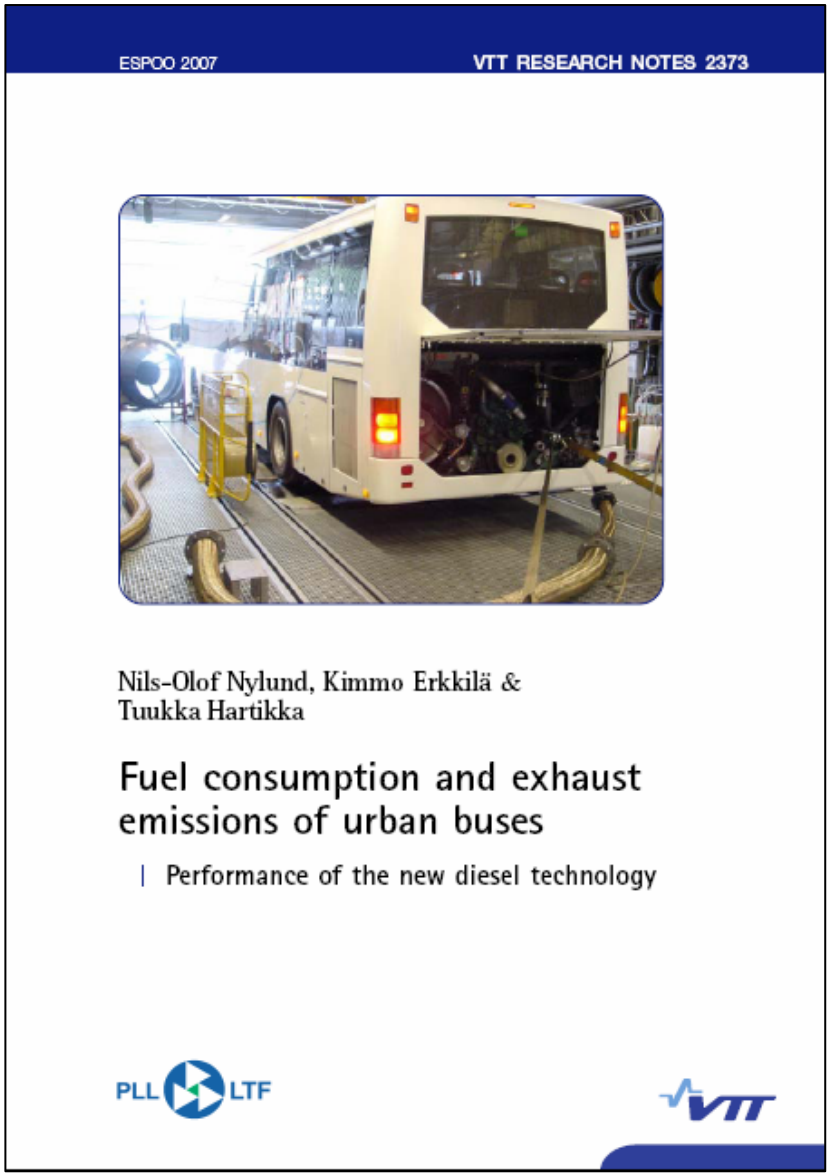

First report disclosing vehicle brands and models

Available on the Internet:
http://www.vtt.fi/inf/pdf/tiedotteet/2007/T2373.pdf

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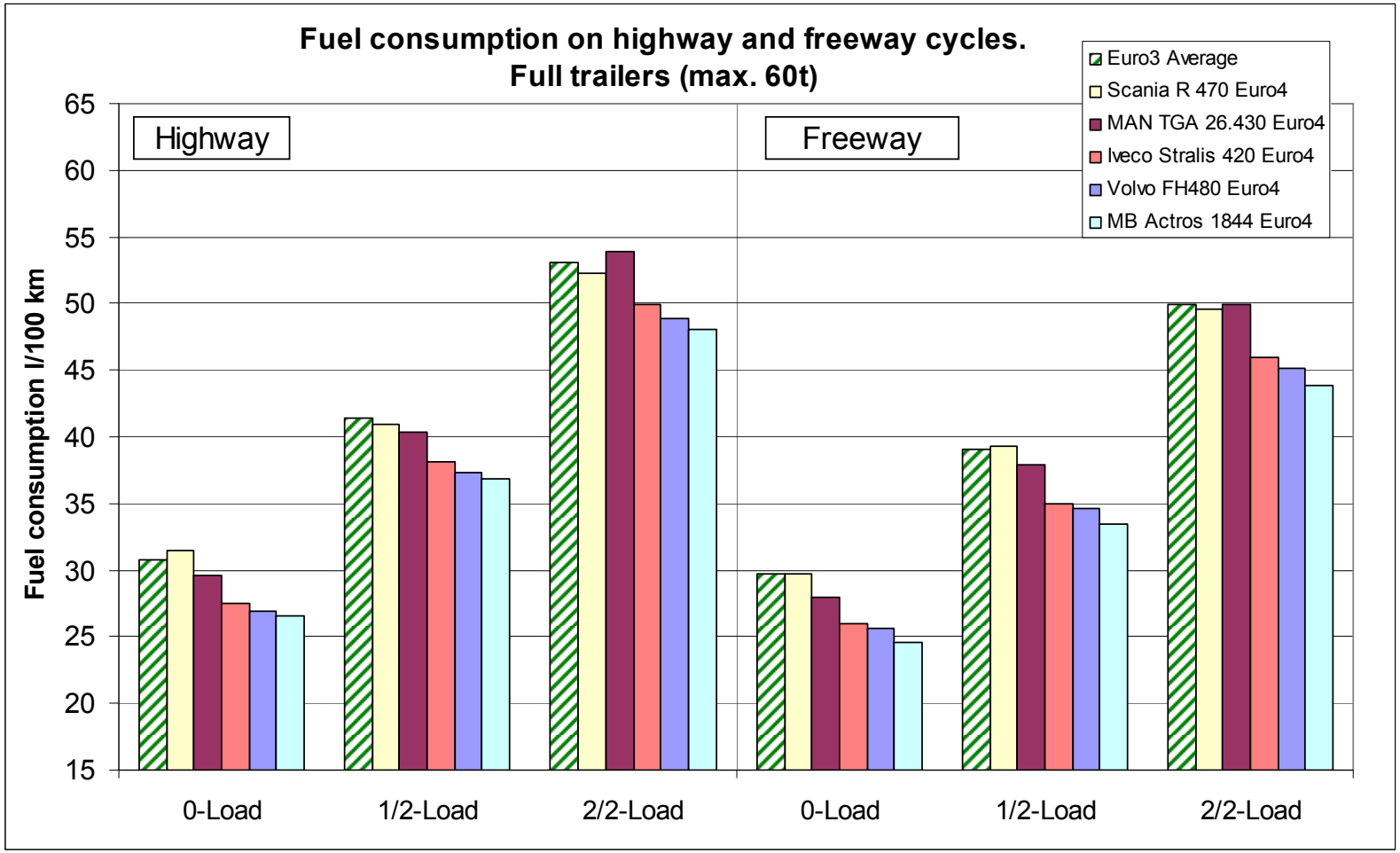
FUEL CONSUMTION – HD TRUCKS



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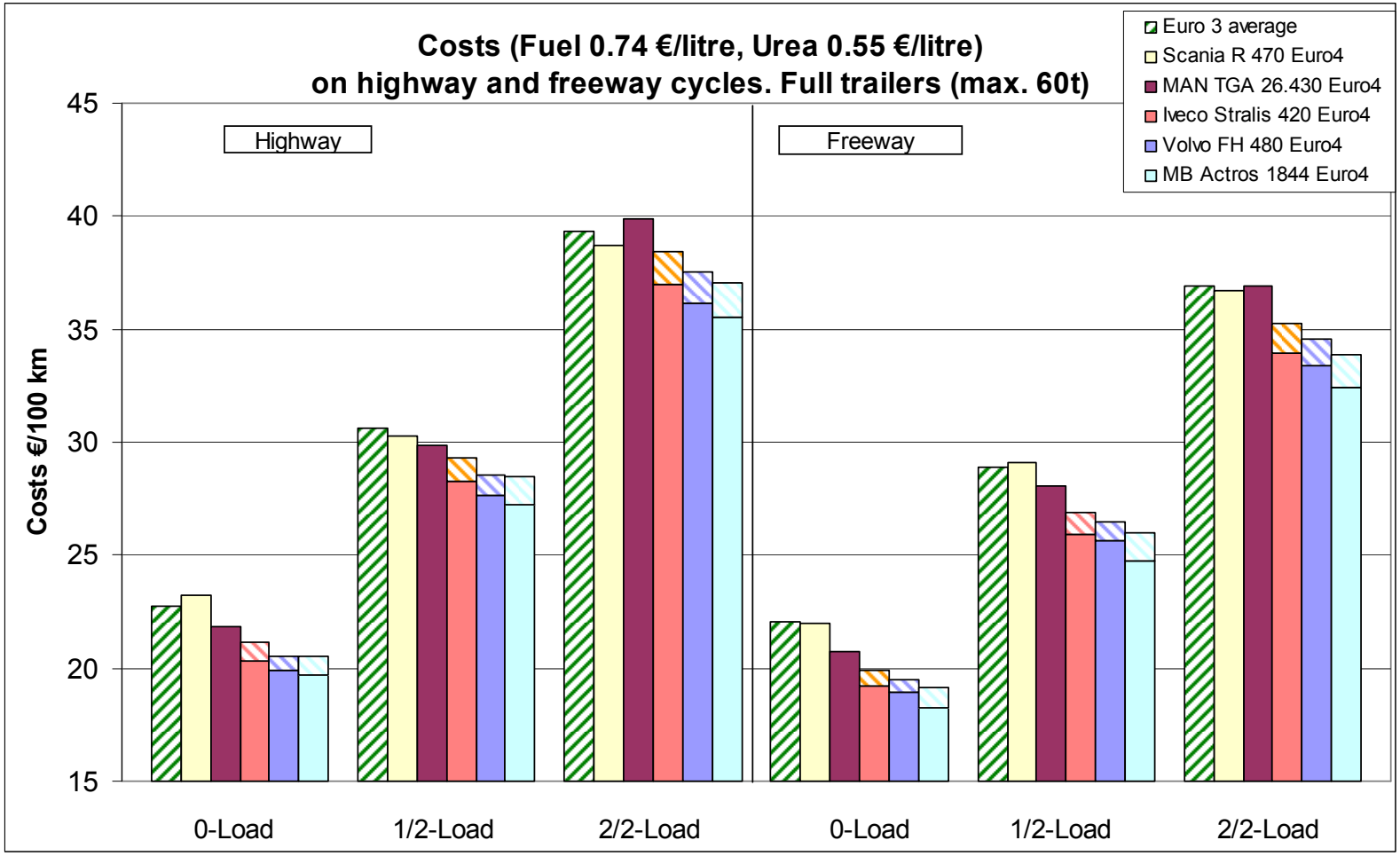
FUEL AND UREA COSTS – HD TRUCKS



Average results for tested truck models:

E3 → E4 SCR
=> costs - 7%

E3 → E4 EGR

=> costs -1%

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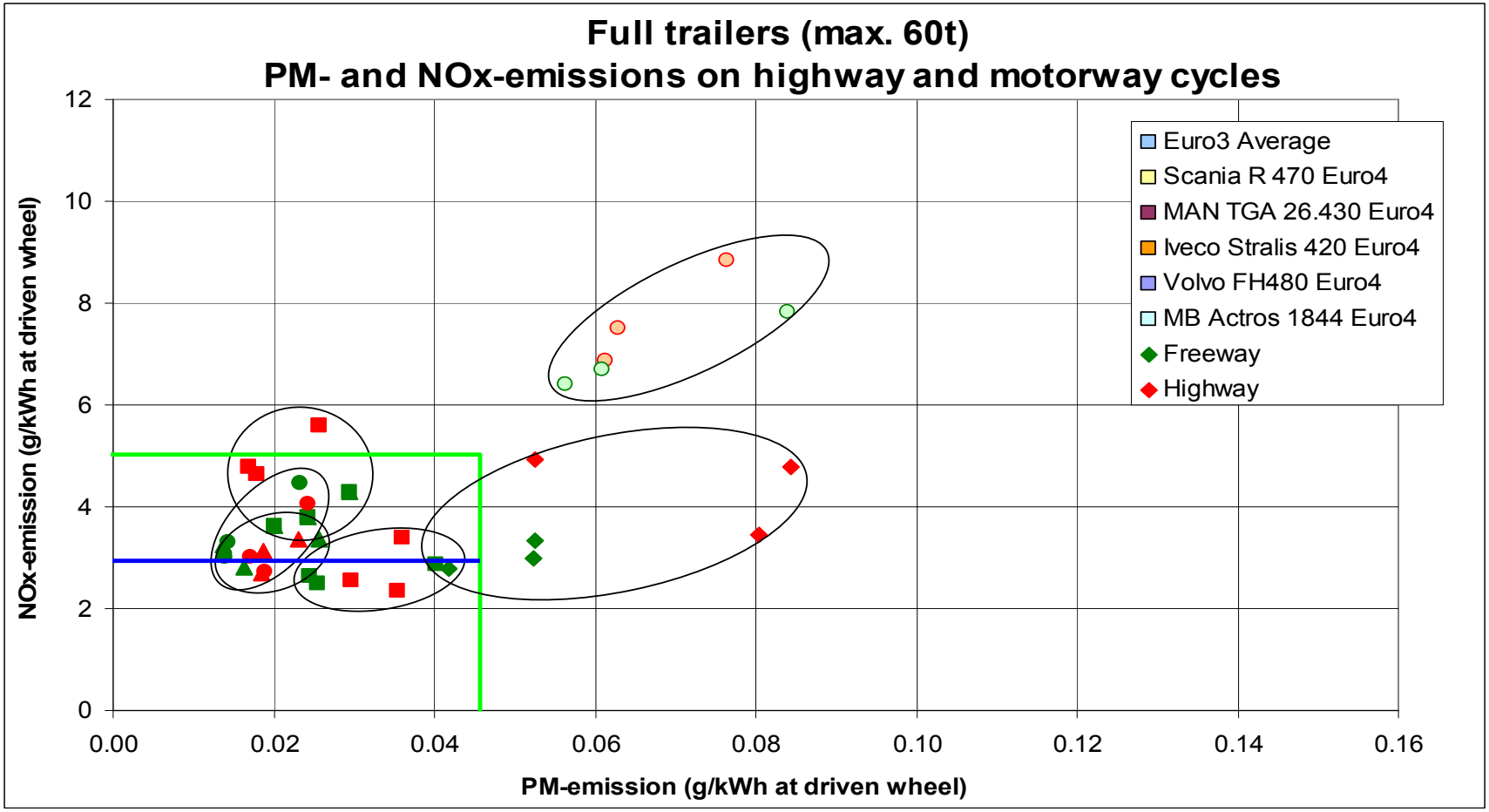
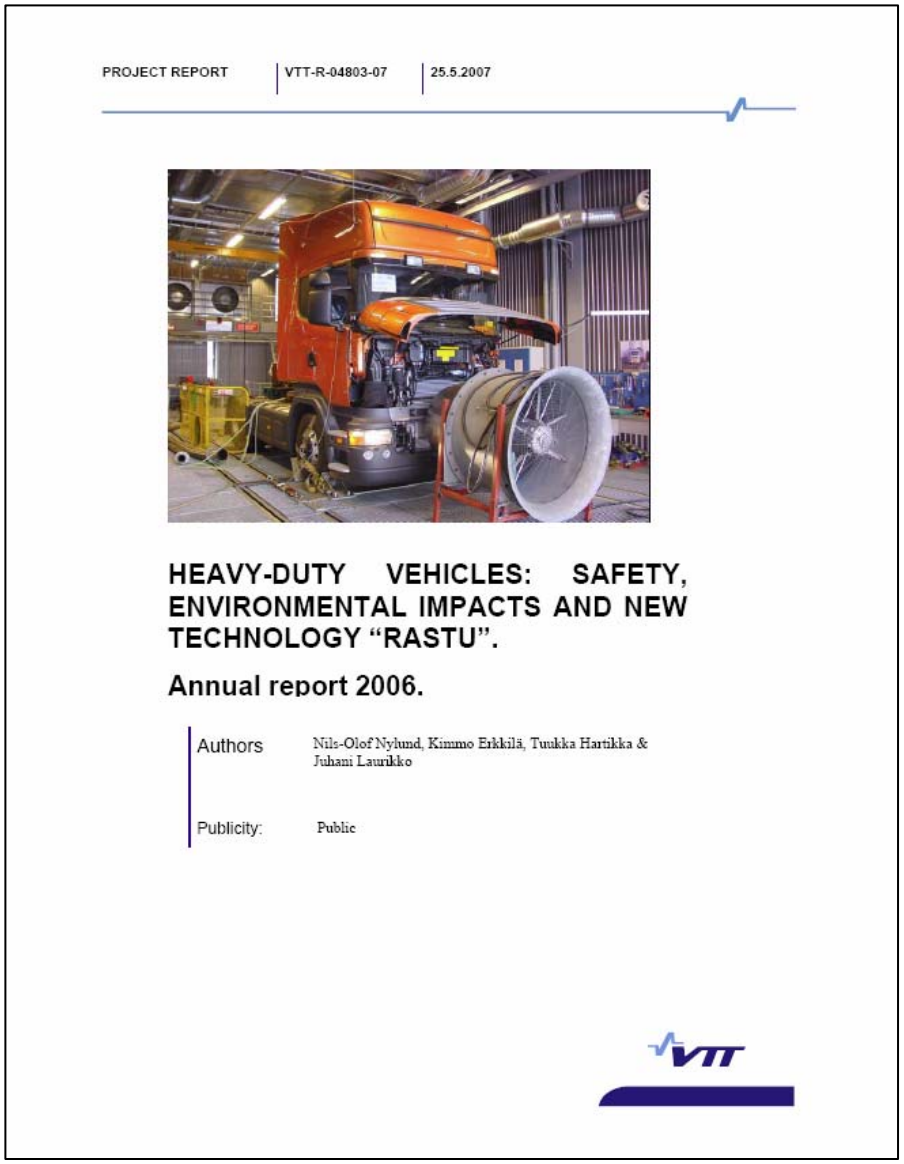
EMISSION RESULTS – HD TRUCKS





PROJECT REPORT | VTT-R-04803-07 | 25.5.2007

HEAVY-DUTY VEHICLES: SAFETY, ENVIRONMENTAL IMPACTS AND NEW TECHNOLOGY "RASTU".

Annual report 2006.

Authors: Nils-Olof Nylund, Kimmo Erkkilä, Tuukka Hartikka & Juhani Laurikko

Publicity: Public

The Euro 4 truck results are included in the Annual Report for 2006 of VTT's "RASTU" project on HD vehicles.

Available on the Internet: http://www.motiva.fi/rastu/

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CONCLUSIONS

- European engine manufacturers have taken two different approaches to meet the Euro 4/5 emission regulations, the EGR and the SCR route (SCR being the more common solution)
- On an average, the introduction of Euro 4 emission regulations has not increased fuel consumption

- City buses:
  - most of the measured Euro 4/5 city buses produced Euro 3 equivalent emissions
  - one SCR bus demonstrated low emission levels in real world driving cycles
  - no clear winner (EGR vs. SCR) for fuel consumption or emissions

CONCLUSIONS

- HD trucks
  - SCR technology provided significantly better fuel economy than EGR technology
  - both EGR and SCR technology performed well regarding exhaust emissions as the real-world emissions corresponded to the anticipated Euro 4 level
  - along with the differences in exhaust control strategies, the differences in engine sophistication also affect the fuel consumption results
  - the results depict the performance of the first new Euro 4 vehicles
  - further improvements in exhaust performance and fuel efficiency is expected for both EGR and SCR vehicles

FUTURE WORK

- Some vehicles will be subjected to follow-up to define the emission stability of new emission control technologies in the long run
- Some measurements will be done to evaluate the emission performance in cold climate conditions
- One truck did not work properly (high PM emissions) -> measurements need to be redone
- VTT's emission database will be updated with data on new bus and truck types

Thanks for your attention!