Overview of the AECC Heavy-duty Euro VI Programme and Emissions Results on European Cycles

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AECC Technical Seminar
on Heavy-duty Engine Emissions

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Association for Emissions Control by Catalyst AISBL

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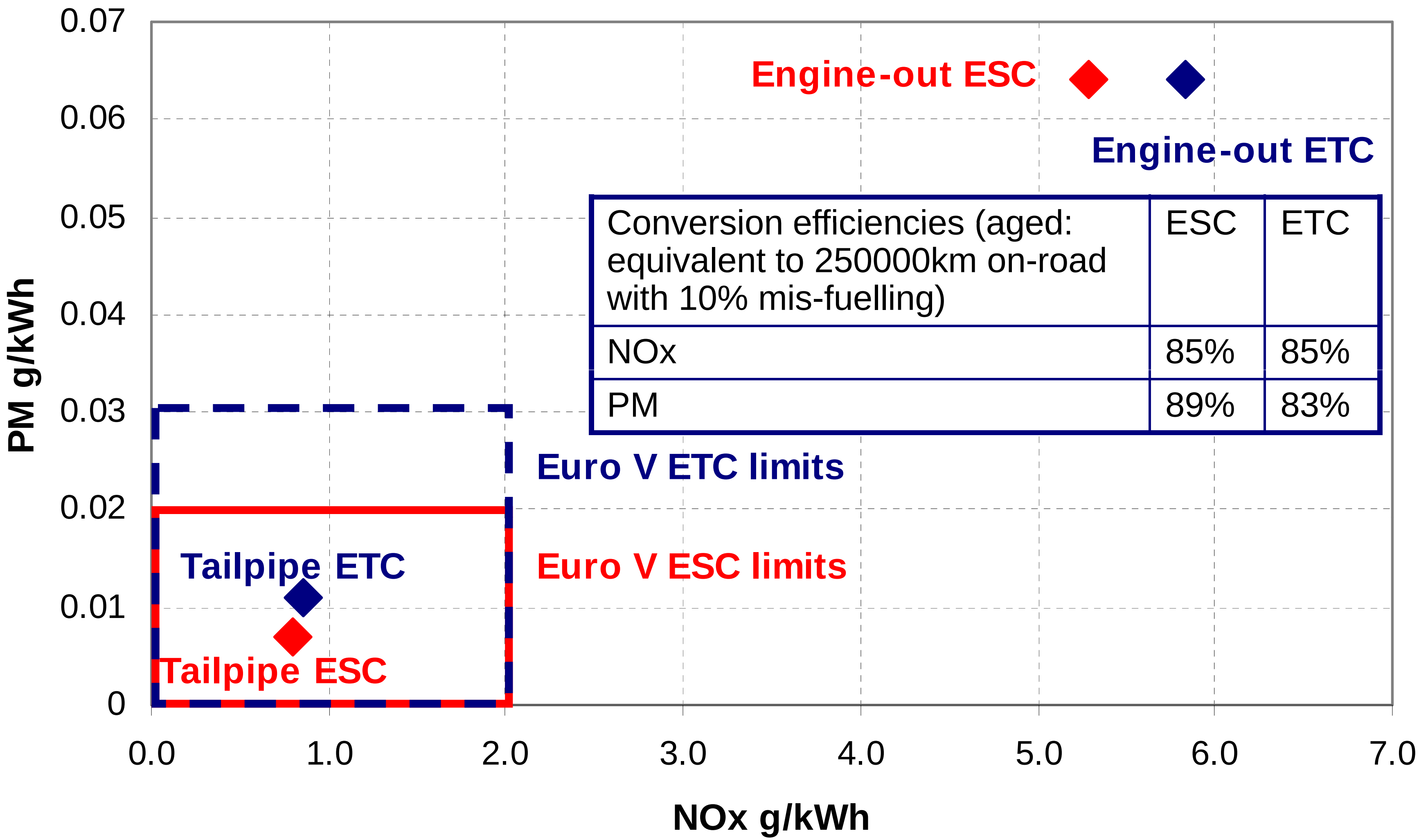
Results of AECC heavy-duty Euro V demonstration programme (2002)



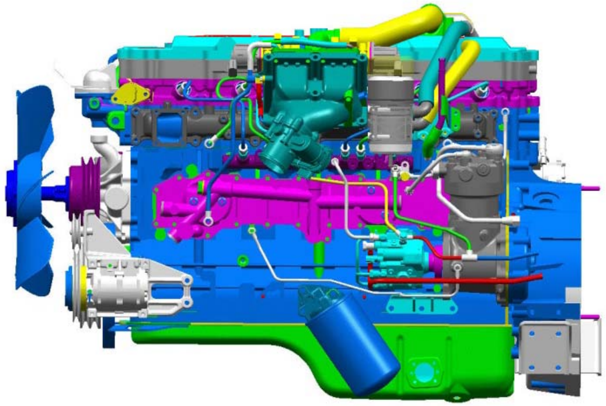
Conversion efficiencies (aged: equivalent to 250000km on-road with 10% mis-fuelling)	ESC	ETC
NOx	85%	85%
PM	89%	83%

Objectives of AECC heavy-duty Euro VI test programme

- Demonstrate the performance of an integrated emissions control system on a modern, low NOx engine.
- Compare current gravimetric and heavy-duty PMP method for particulate mass (PM).
- Assess heavy-duty PMP particle number methodology.
- Provide data on European and World-harmonised transient and steady-state test procedures.
- Provide NTE (not-to-exceed) data for appropriate test points.
- Provide comparison data on US-FTP, Japanese and World-harmonised non-road cycles.
- Provide data on regulated and non-regulated emissions.

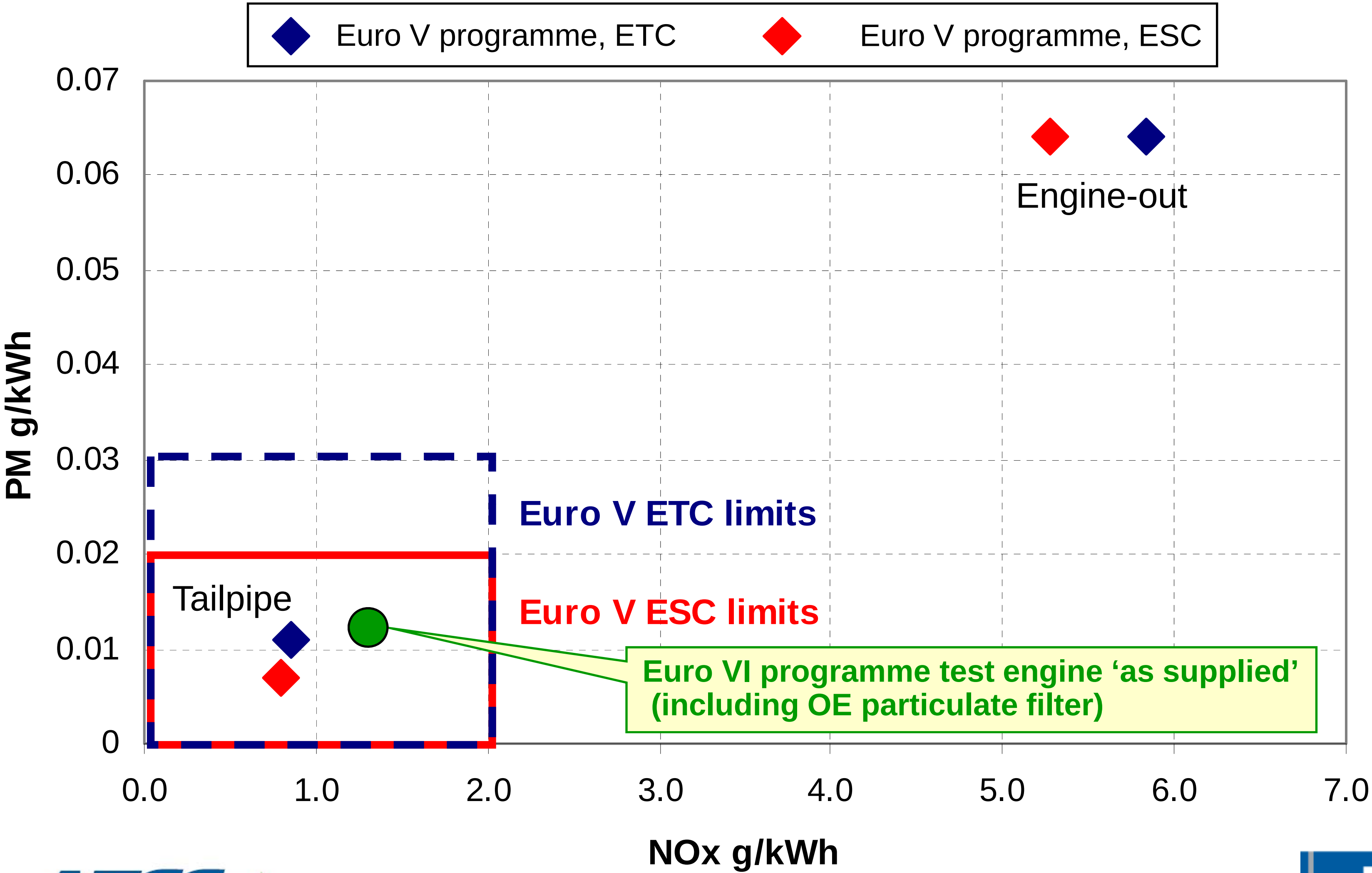
AECC heavy-duty Euro VI test engine

- Engine designed for US2007, provided by an engine manufacturer
  - 6 cylinder 7.5 litre engine
  - Common rail
  - Turbocharged (fixed vane)
  - Max. injection pressure 180Mpa
  - Cooled lambda-feedback EGR
  - Original particulate filter replaced by AECC system.



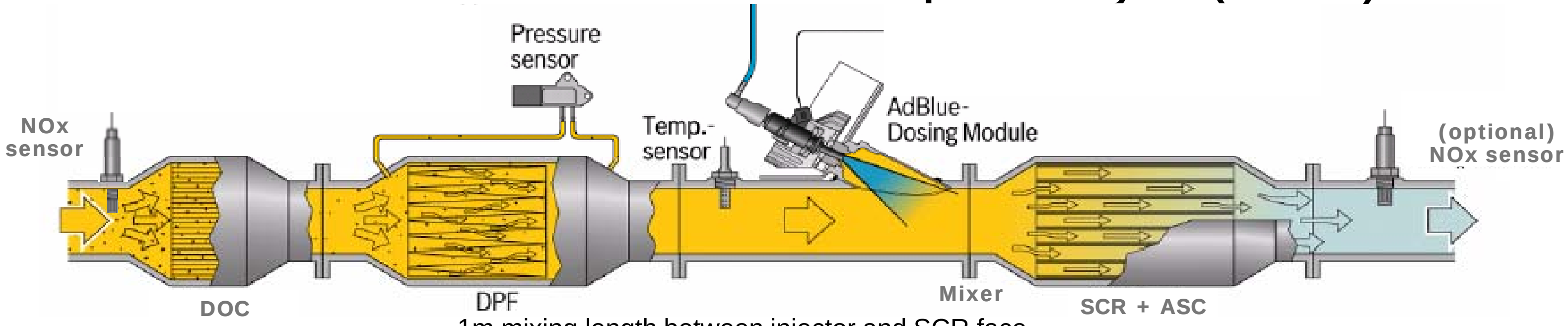
- No modification to base engine calibration
  - no changes made to optimise engine-out emissions on the European cycles
  - No change to calibration or regeneration strategy
  - engine-out emissions are 'as received'.

AECC heavy-duty Euro VI test engine compared to Euro V test engine



Emissions control system for AECC heavy-duty Euro VI test programme

- Oxidation catalyst (DOC), catalyst-based particulate filter and urea-SCR with ammonia slip catalyst (ASC).



1m mixing length between injector and SCR face.

- System oven aged for 200hours at 600ºC.
- Bosch advanced airless urea dosing system.
- NOx sensors at engine-out and downstream of the SCR system (upstream as input for dosing control, second as monitor; not for closed loop control).
- No optimisation was undertaken.
- Basic urea dosing system calibration for the ESC, ETC and WHTC, but no specific calibration for other cycles

Further optimisation potential

- Thermal Management
  - a heating strategy is expected to be used in future to further improve cold NOx emissions and particulate filter regeneration.
- System design
  - Component volumes and integration would be optimised for a production application.
- System optimisation
  - including full urea dosing calibration and distribution.
- Engine calibration.

Regulated emissions measurement

- Triplicate tests were carried out for tailpipe emissions on each of the test cycles.
  - Results have been averaged for these tests.
- Additional tests to measure engine-out emissions through the CVS system.
- Simultaneous sampling of emissions.
  - Gaseous — engine-out – raw sample
after catalysts – CVS system.
  - PM — engine out – Mini Dilution Tunnel (MDLT)
after catalysts – secondary tunnel.
- Standard Diesel reference fuel CEC RF-06 (max. 10ppm S)
- Low ash 10w-40 engine lubricant.
- AdBlue® aqueous urea to DIN 70070 specification.

Preconditioning procedures

- For repeatability, the daily test regime started with a cold start test (WHTC, FTP or NRTC) and finished with a standard preconditioning regime.

- The end-of day preconditioning consisted of

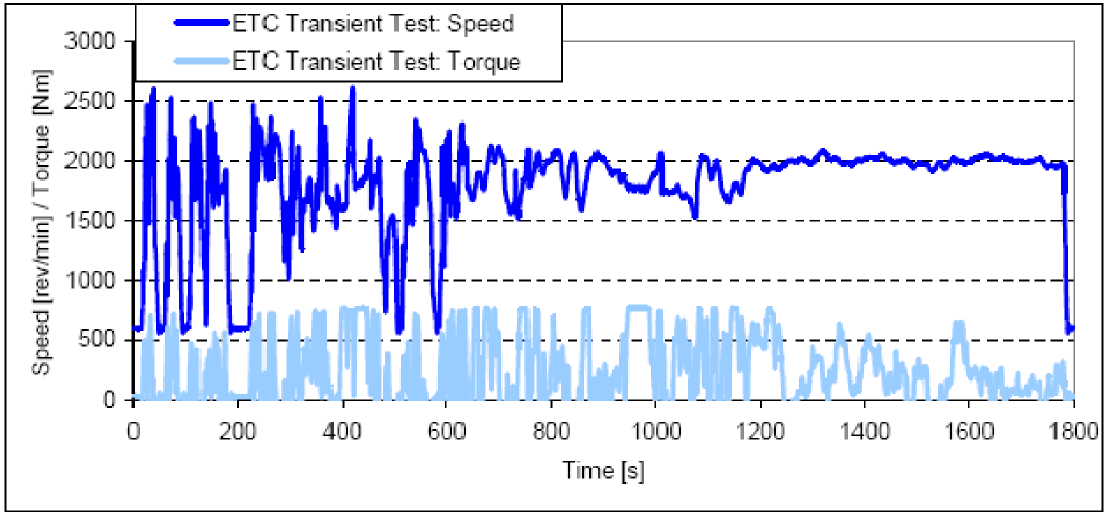
- mode 4 warm-up:	15 min.	2130 rev/min.	560 Nm
- followed by:	60 min.	2575 rev/min.	700 Nm
- then:	60 min.	1300 rev/min.	150 Nm

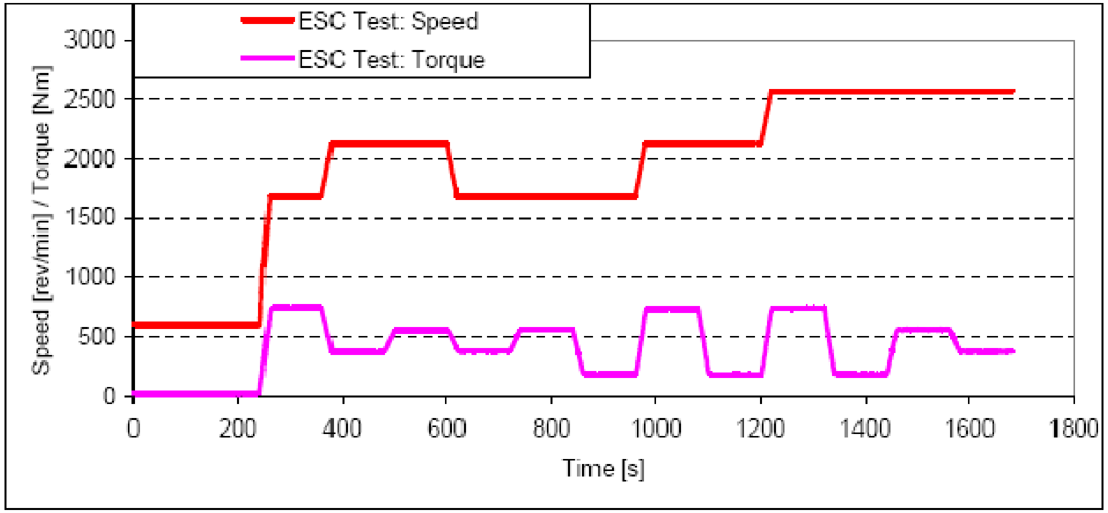
- Following each test cycle the engine was run at a Mode 4 standardisation condition for 15 minutes.

- Pre-test conditioning

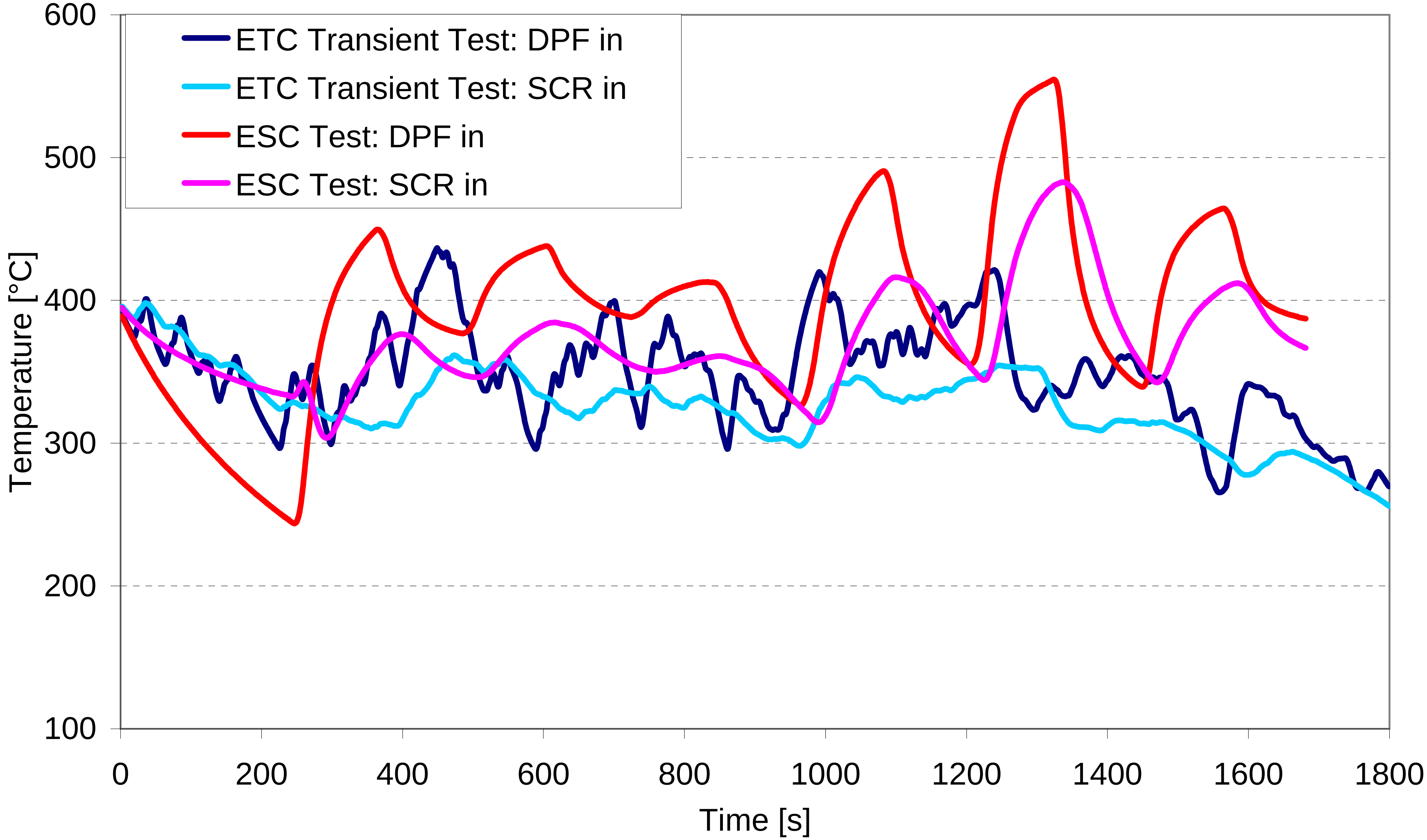
- ETC, JE05, ESC:	7.5 min. mode 4 (2130 rev/min, 560 Nm)
- WHSC:	10 min. mode 9 (1816 rev/min, 373 Nm) followed by 5 min. soak.

Speed and torque for the European transient and steady state cycles

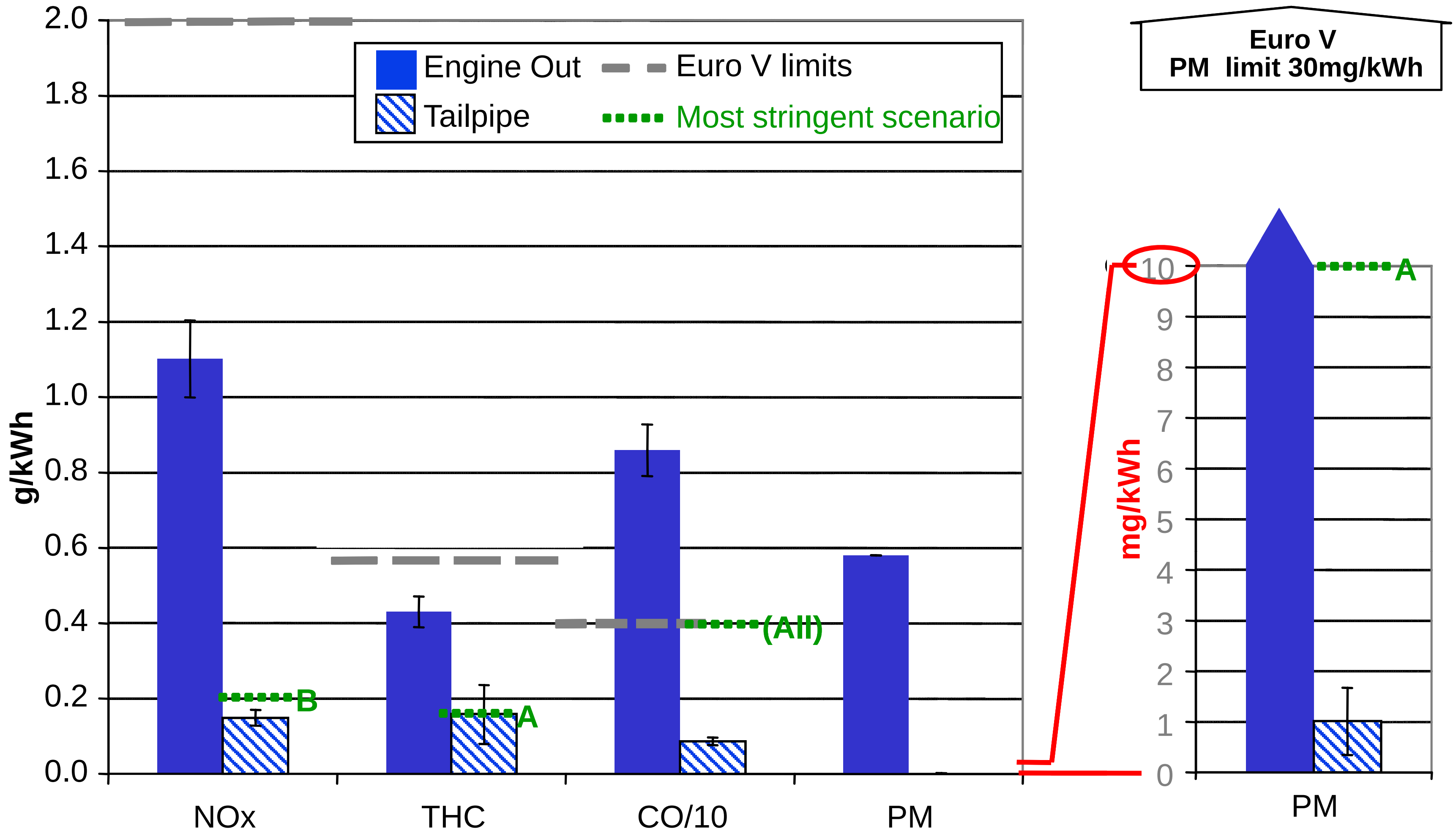




System temperatures for the European transient and steady state cycles



ETC results for engine-out and tailpipe



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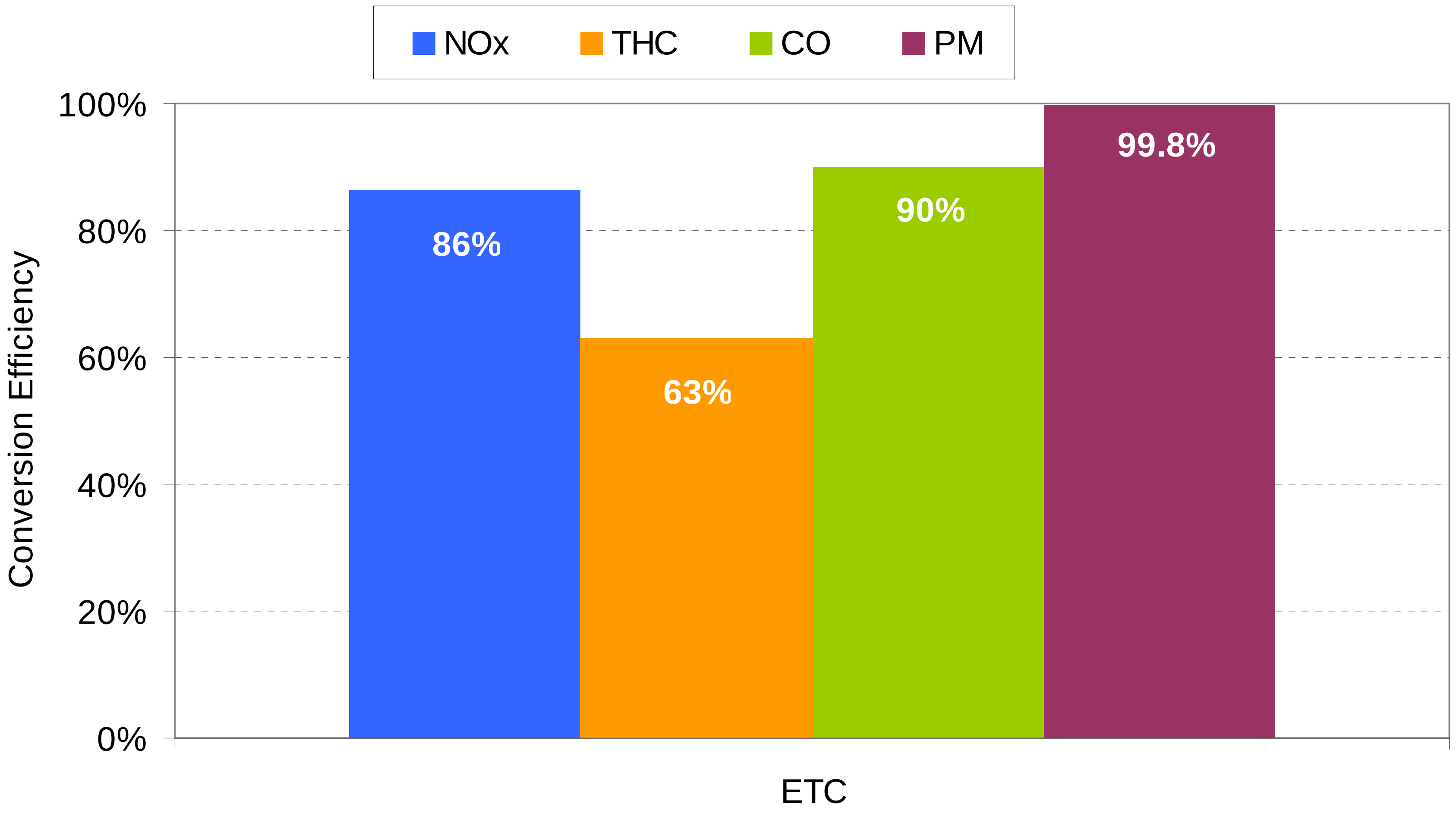
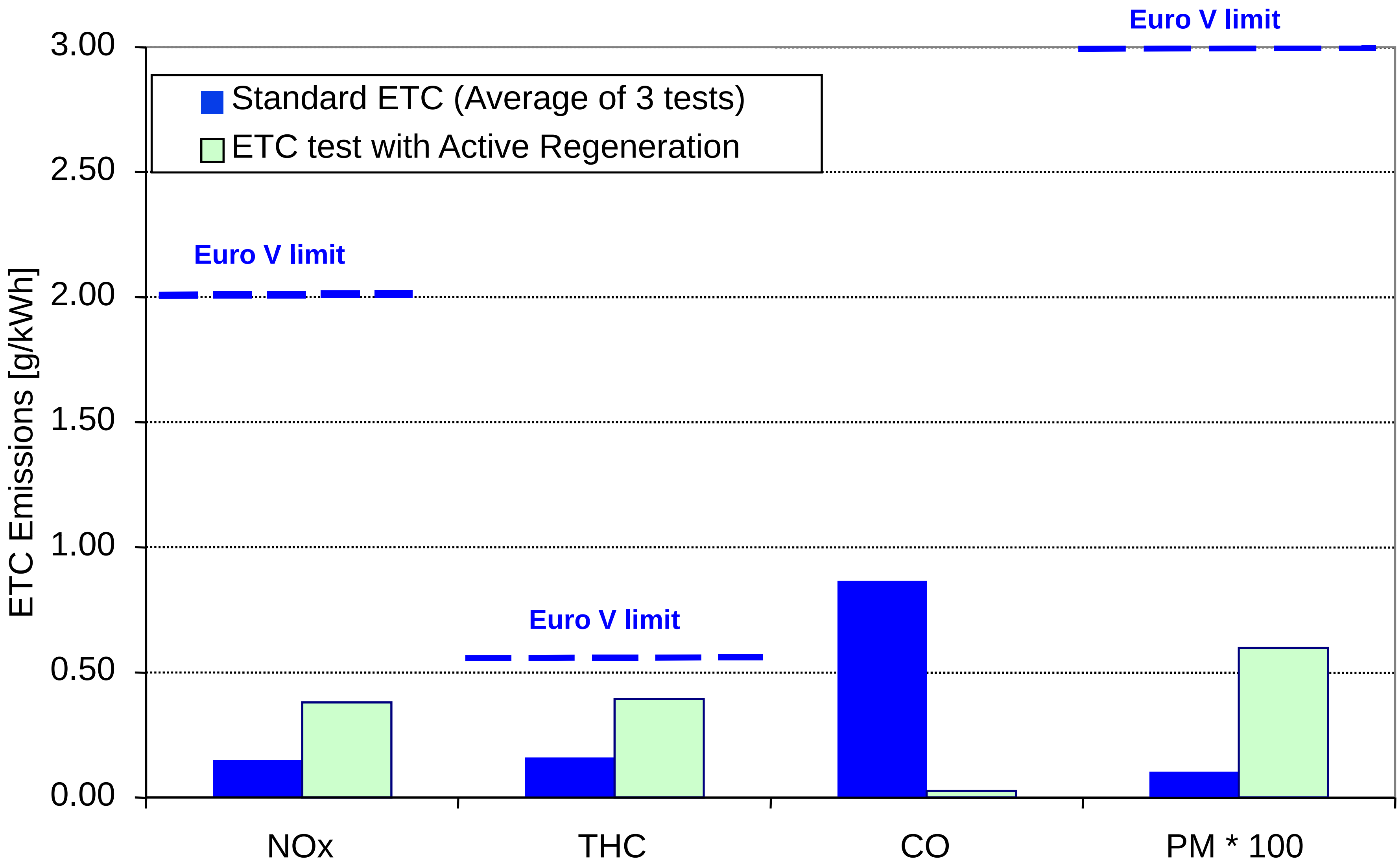
Conversion efficiencies for ETC

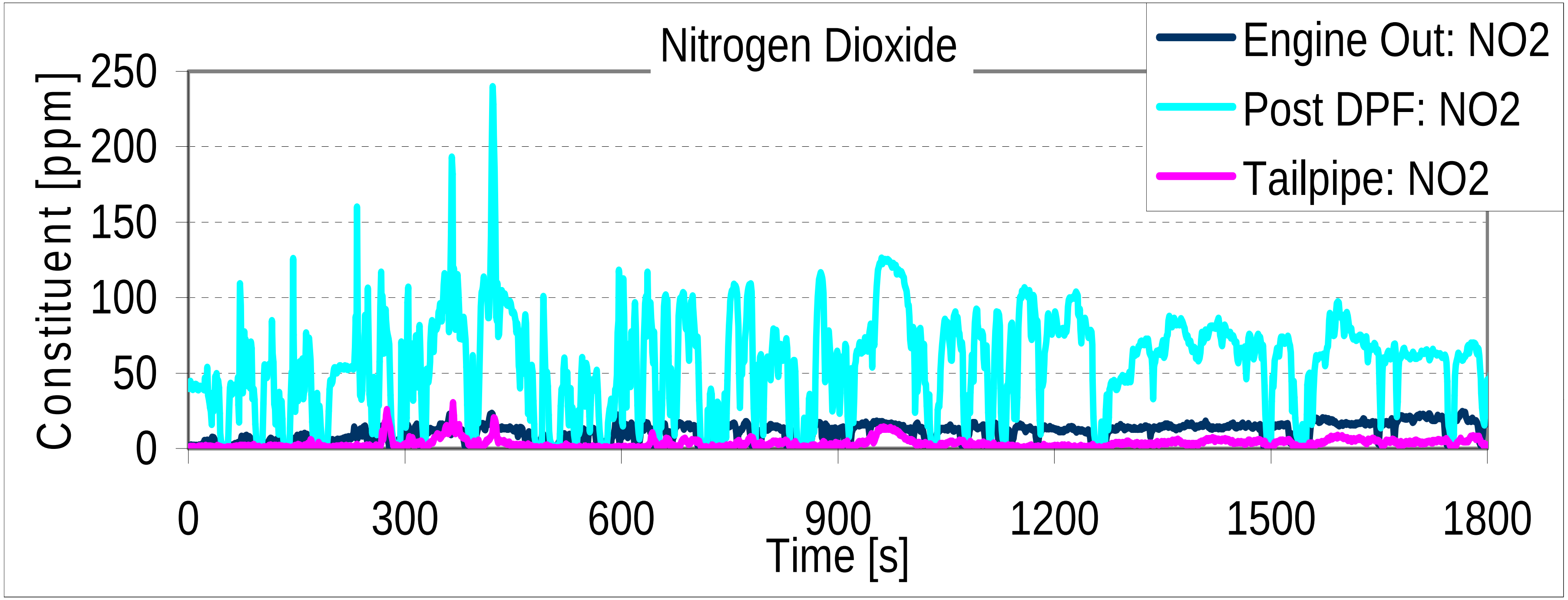


Tailpipe regulated emissions on ETC with active particulate filter regeneration

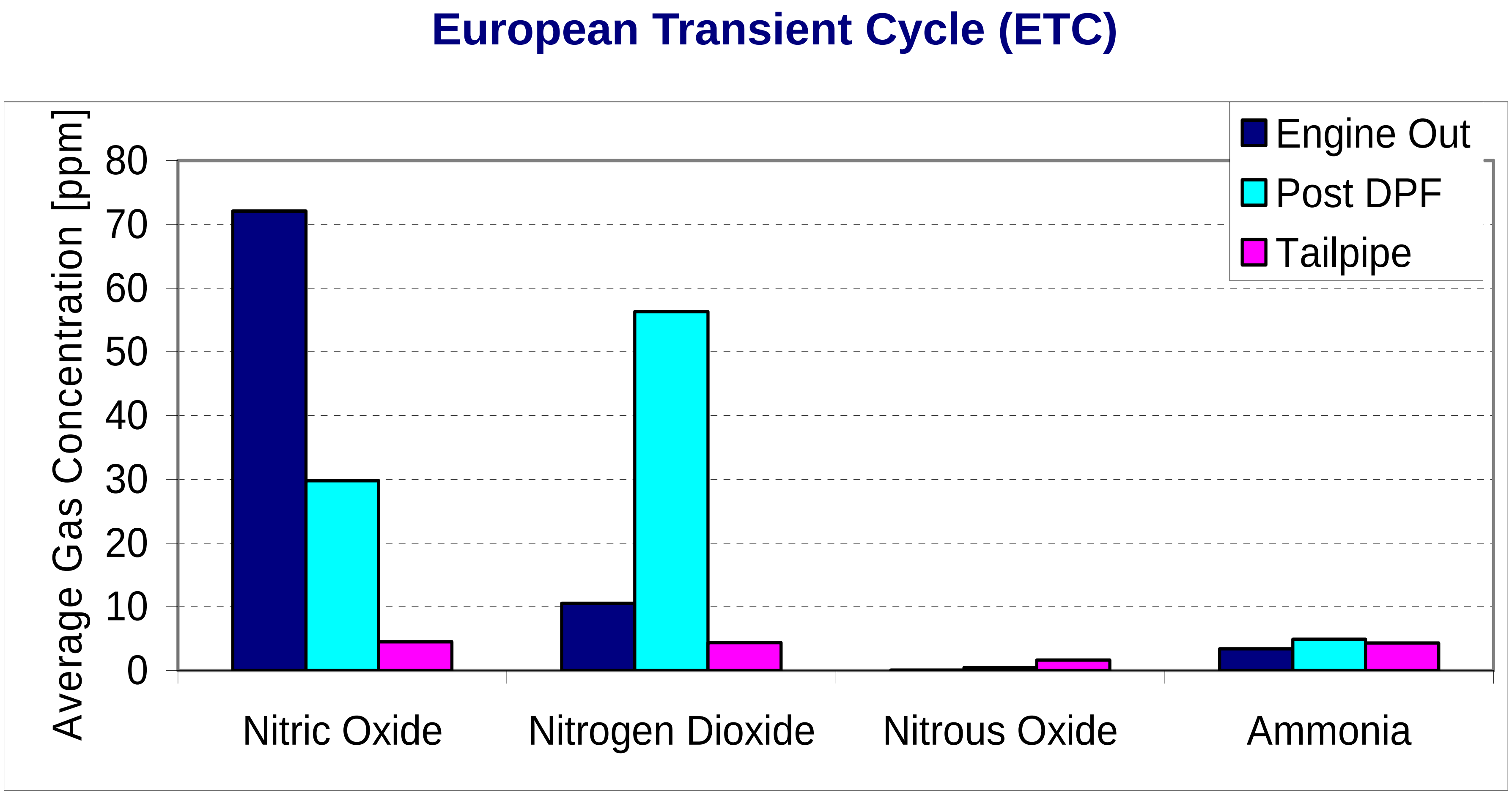


Continuous trace for NO_2 on the ETC

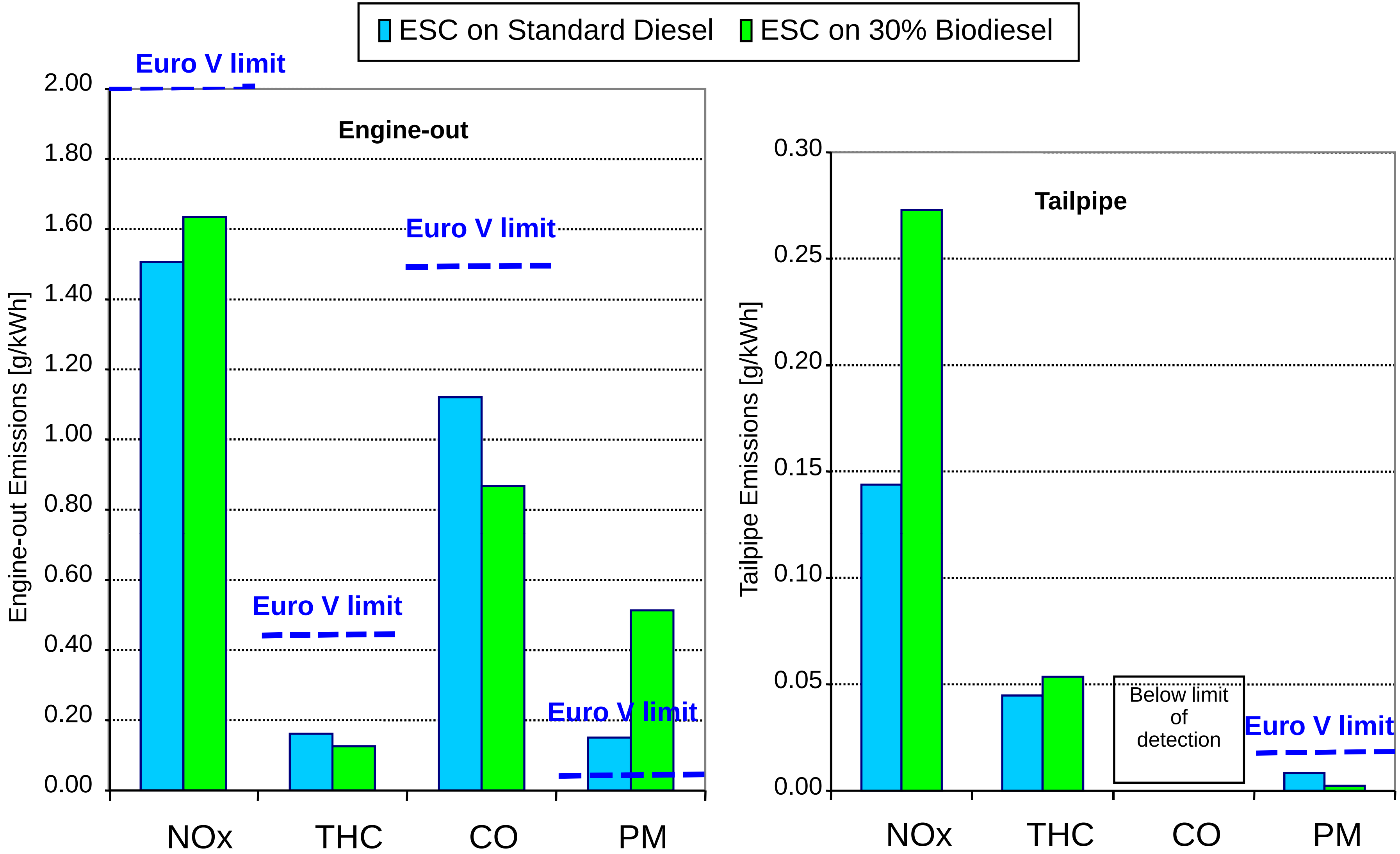
European Transient Cycle (ETC)



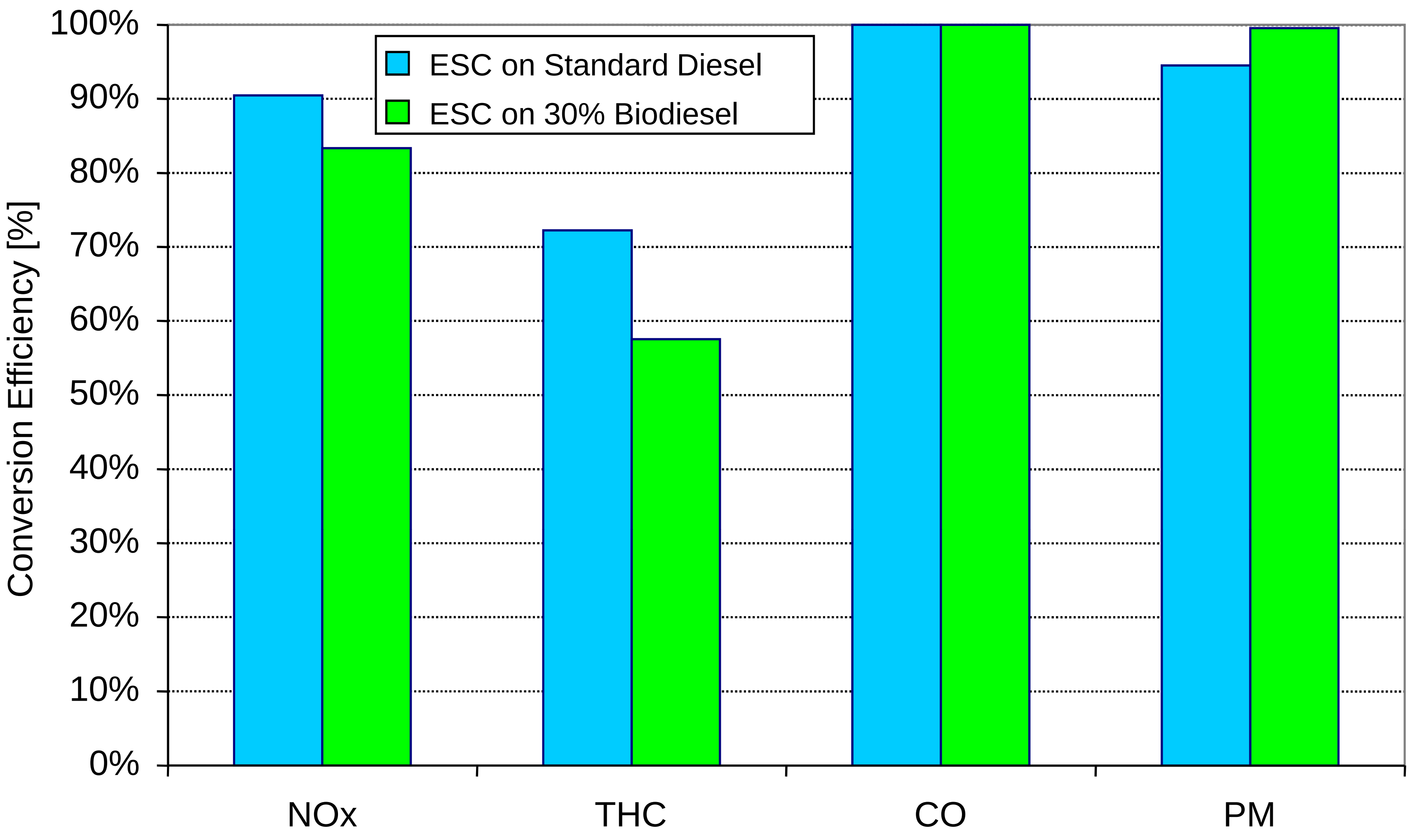
Profile of nitrogen species through the emissions control system



Emissions over ESC using standard fuel and B30 biodiesel

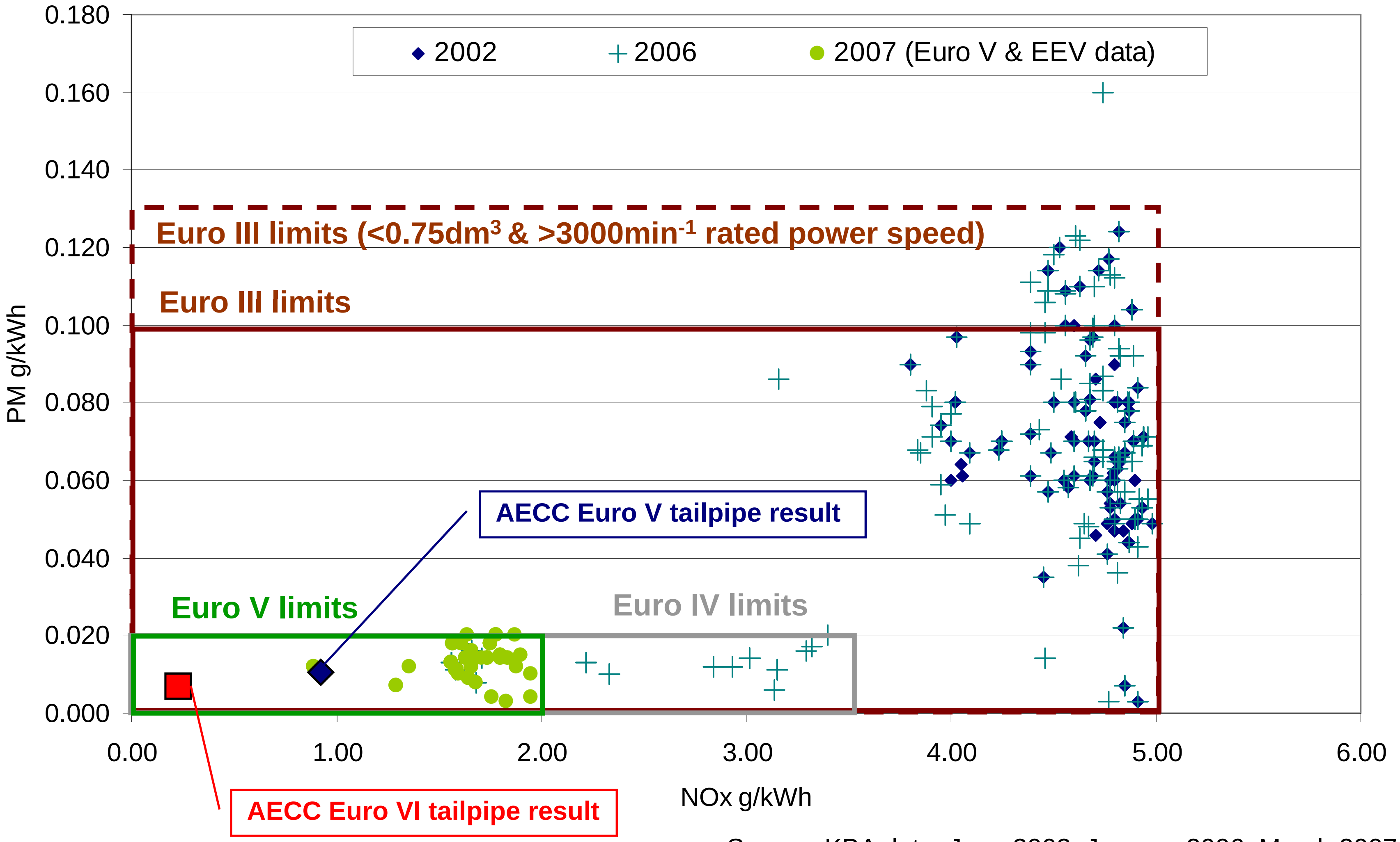


Conversion efficiencies over ESC



Regulated emissions summary

- A state-of-the-art engine system comprising a low emissions engine and an emissions control system produced substantial reductions in all regulated pollutants.
- The system was not fully optimised; there was no thermal management and the engine calibration was not modified.
- NOx conversion efficiency was 86% over the ETC and 90% over the ESC, resulting in tailpipe levels of 150mg/kWh.
- PM conversion efficiencies was 99.8% over the ETC, resulting in PM tailpipe levels of 1mg/kWh when measured with the partial flow method. For the ESC, release of low volatility materials in mode 10 reduced efficiency to 94.3%.
- The combined engine and emissions control system met the most stringent scenarios from the Commission's Euro VI internet consultation.



Source: KBA data, June 2002, January 2006, March 2007

Thank you for your attention