

# Overview of Emissions on World-Harmonised and Non-road Cycles from the AECC Euro VI Programme

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AECC Technical Steering Committee

AECC Technical Seminar  
on Heavy-duty Engine Emissions  
Brussels, 25 October 2007



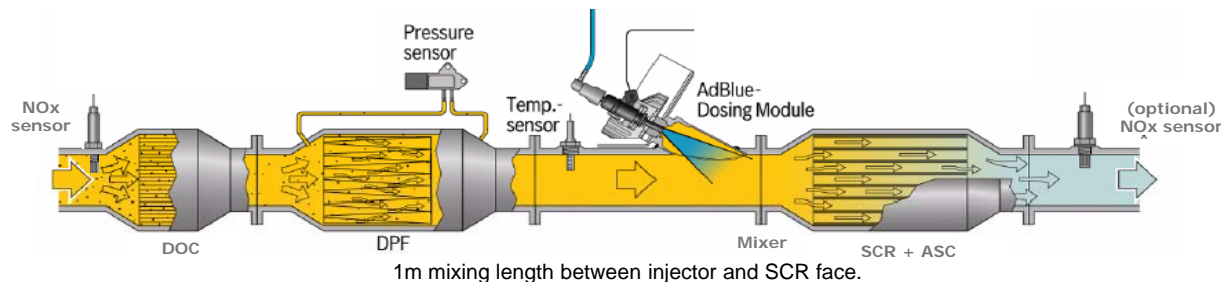
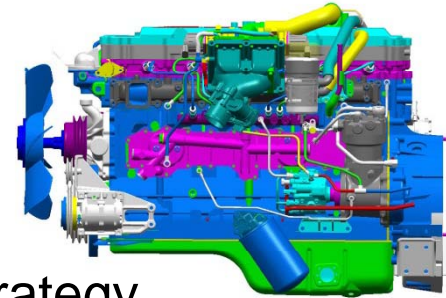
Association for Emissions Control by Catalyst AISBL

# Contents

- Introduction
- WHTC
- NRTC
- Steady-state cycles (WHSC and NRSC)
- Summary

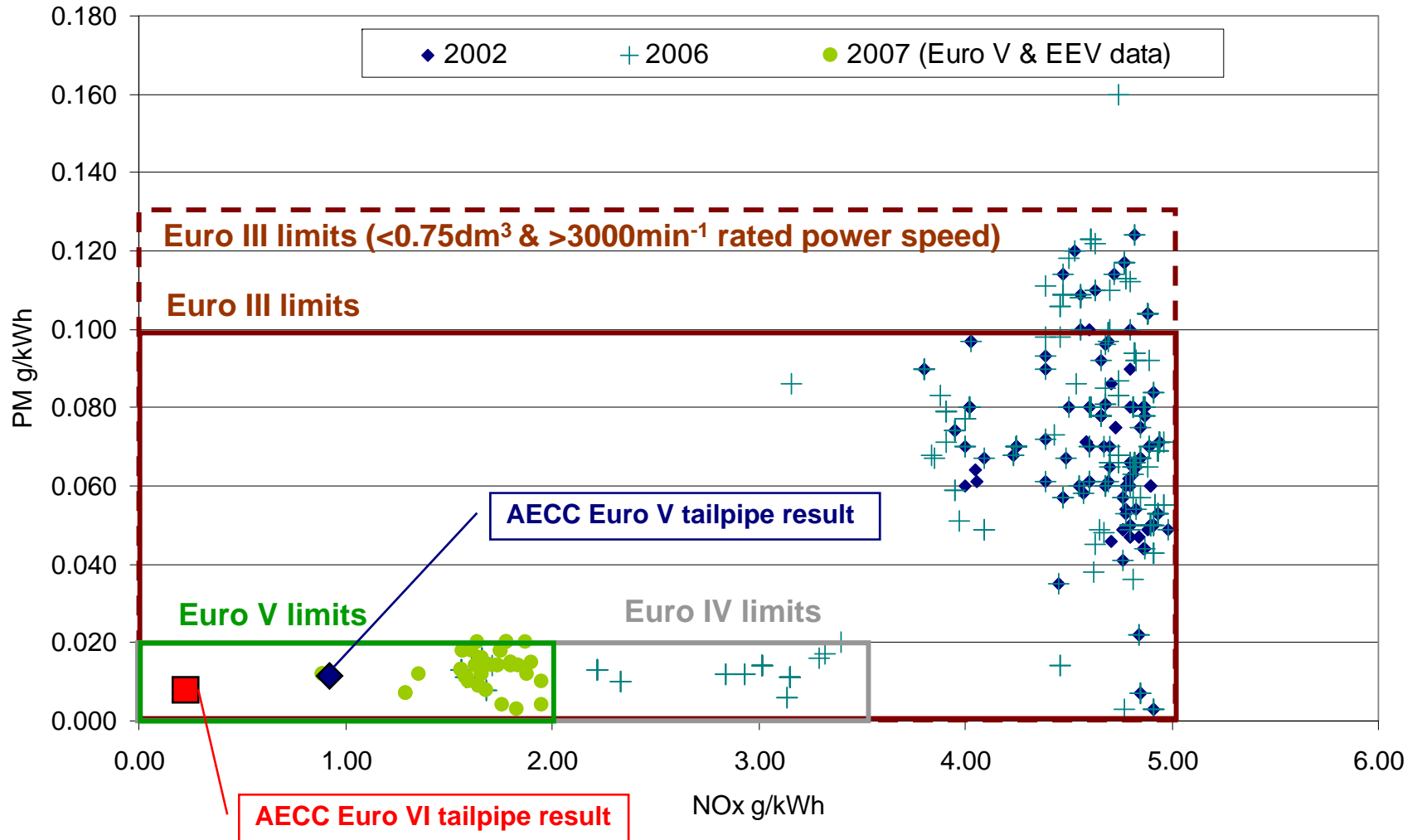
# AECC heavy-duty Euro VI test engine

- 6 cylinder 7.5 litre engine designed for US2007
  - Common rail
  - Turbocharged
  - EGR
  - No modification to base engine calibration
  - No change to calibration or regeneration strategy.
- AECC emissions control system + Bosch advanced airless urea dosing system
  - Basic urea dosing system calibration for the ESC, ETC and WHTC
  - No specific calibration for other cycles.



- No thermal management.

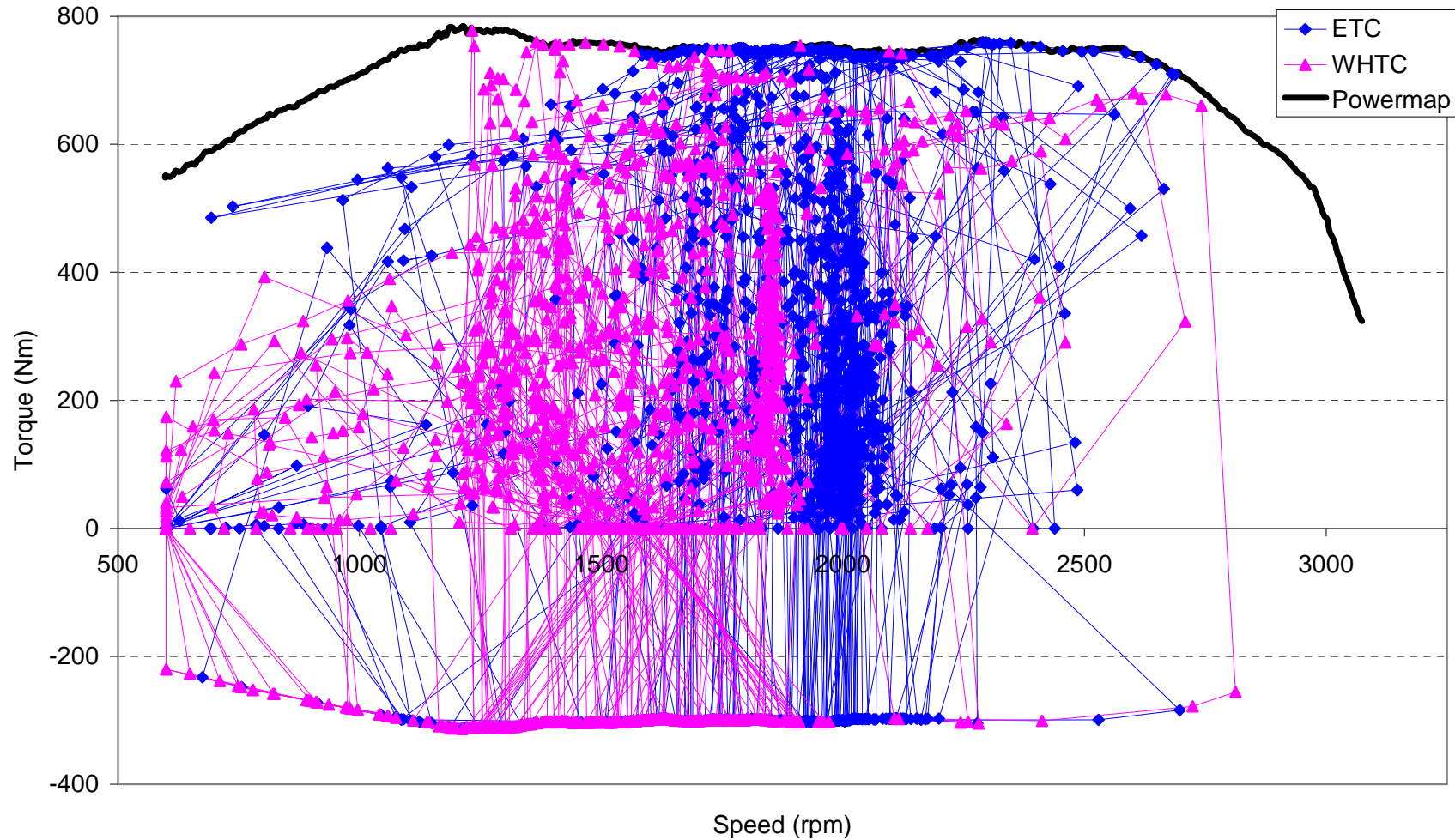
# PM vs NOx (ESC test)



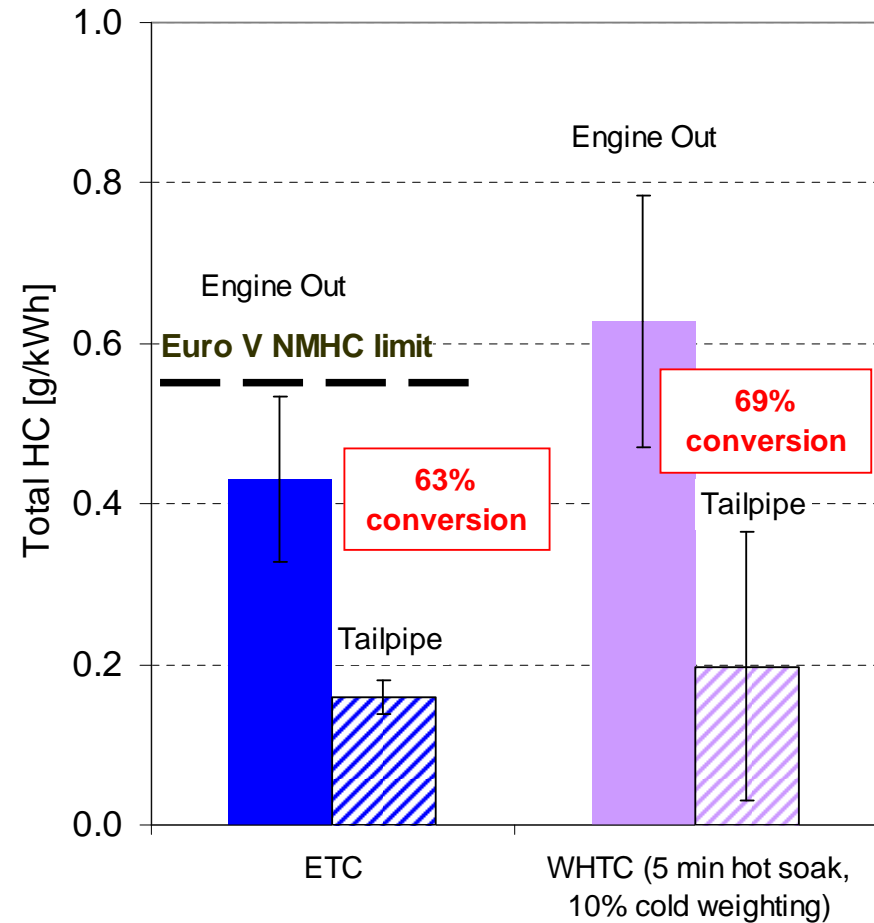
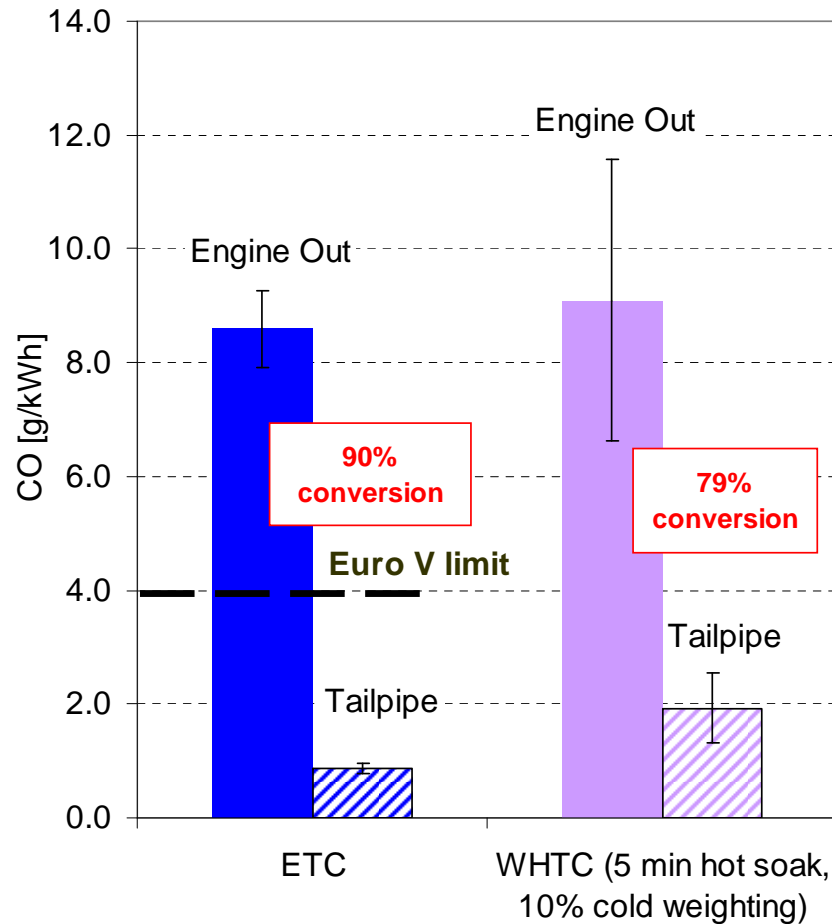
Source: KBA data, June 2002, January 2006, March 2007

# ETC and WHTC cycle comparison

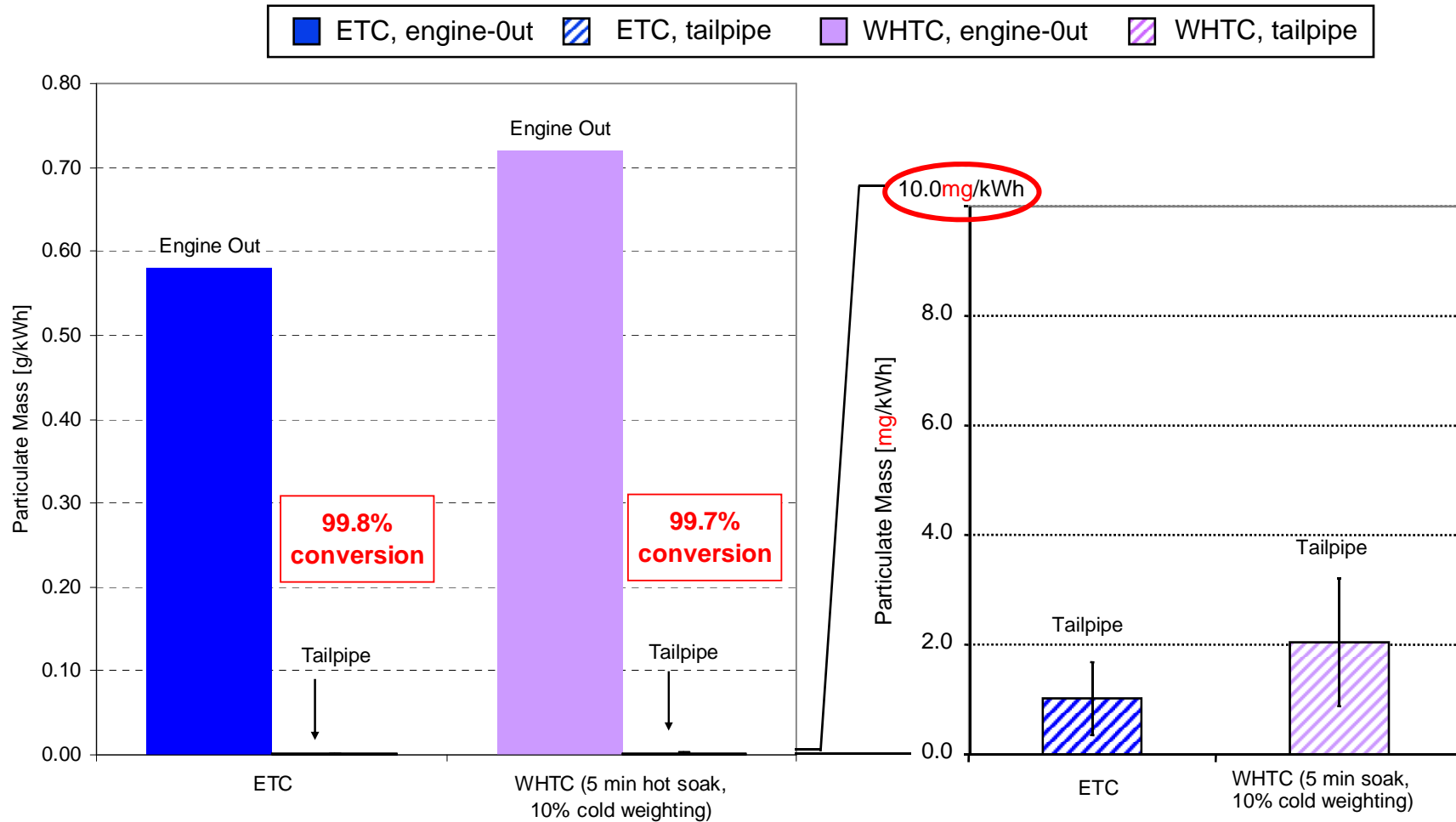
WHTC operates at lower speeds and loads than ETC.



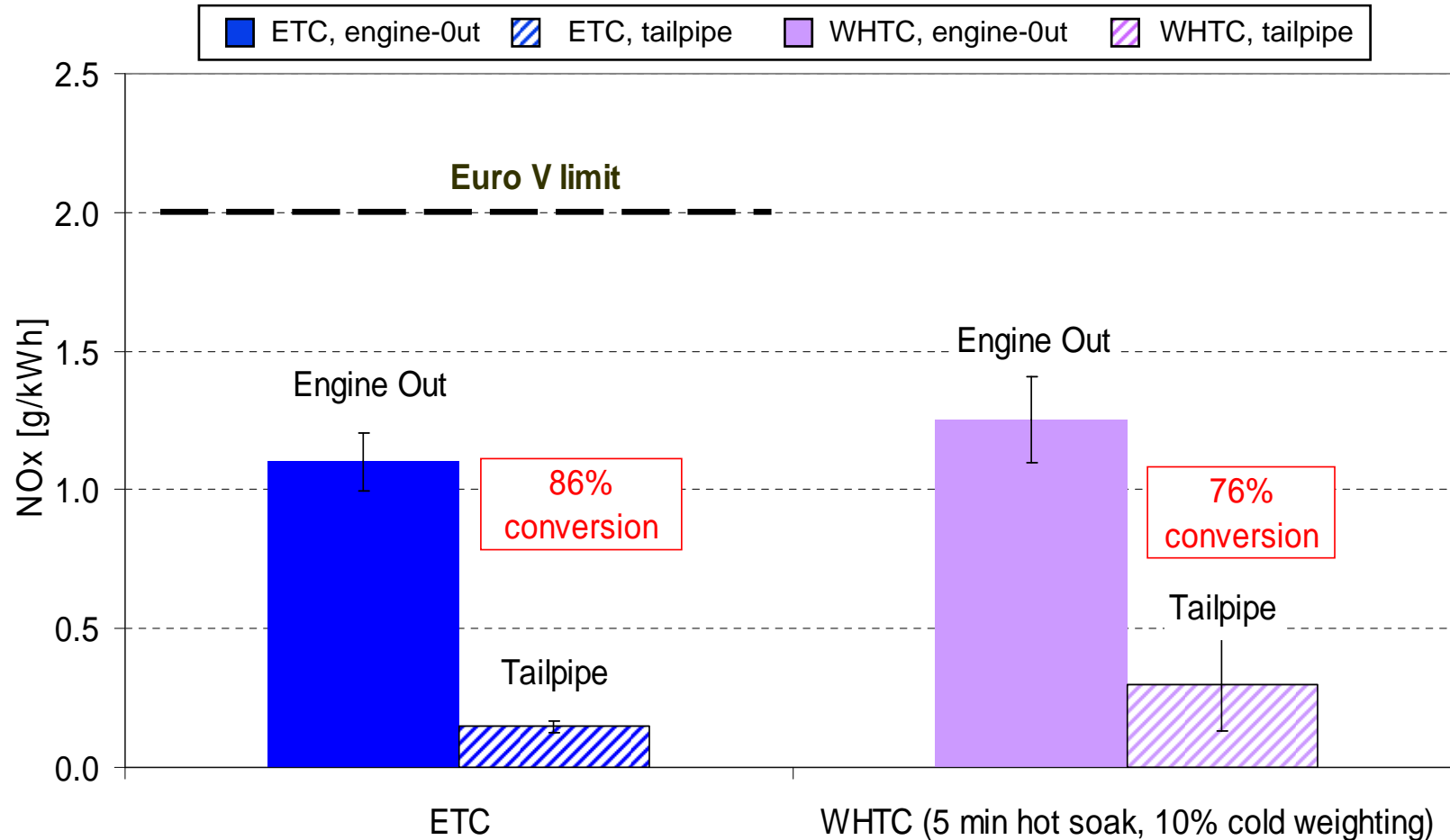
# ETC and WHTC tests: CO & HC emissions for engine-out and tailpipe



# ETC and WHTC tests: PM emissions for engine-out and tailpipe

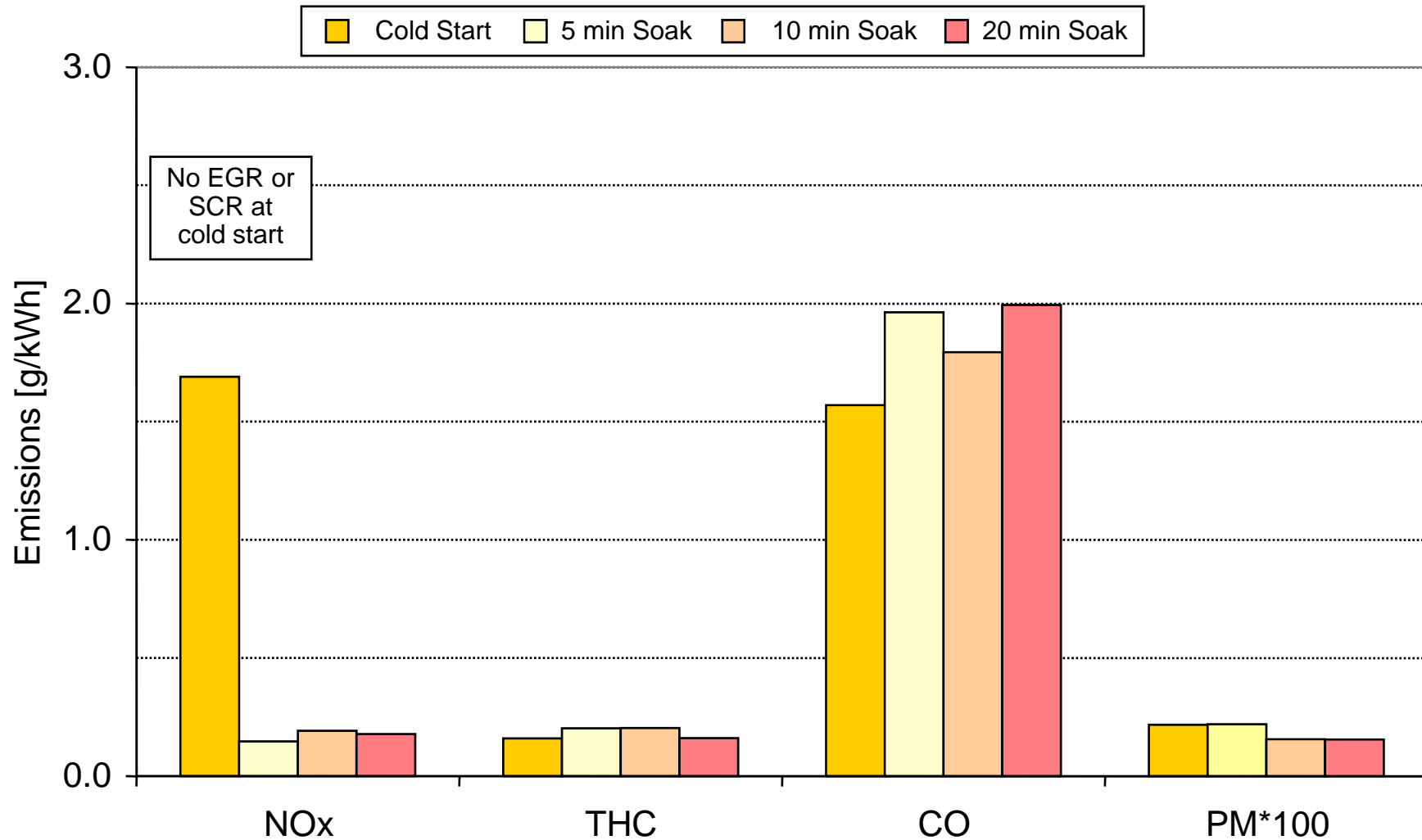


# ETC and WHTC tests: NOx emissions for engine-out and tailpipe

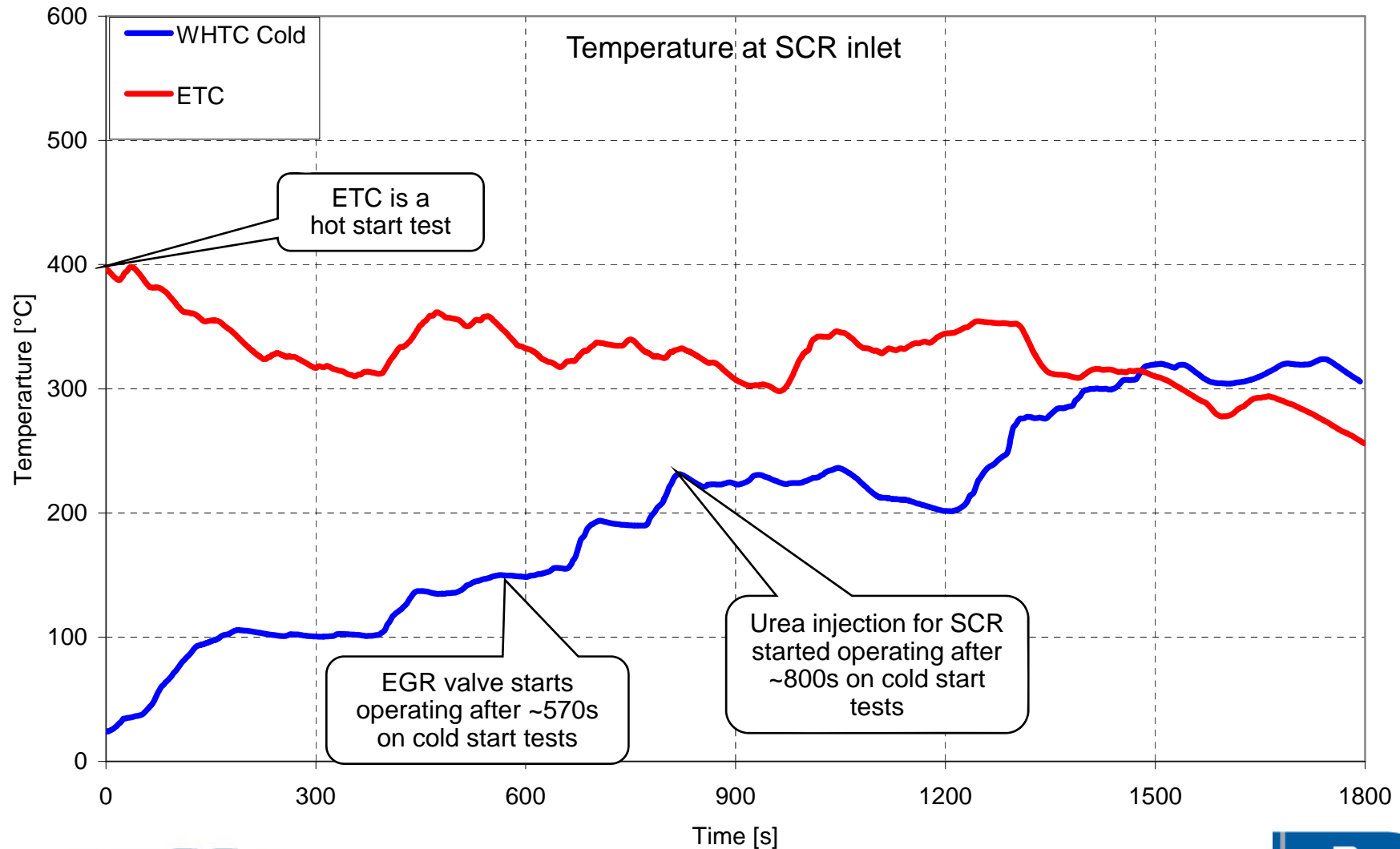




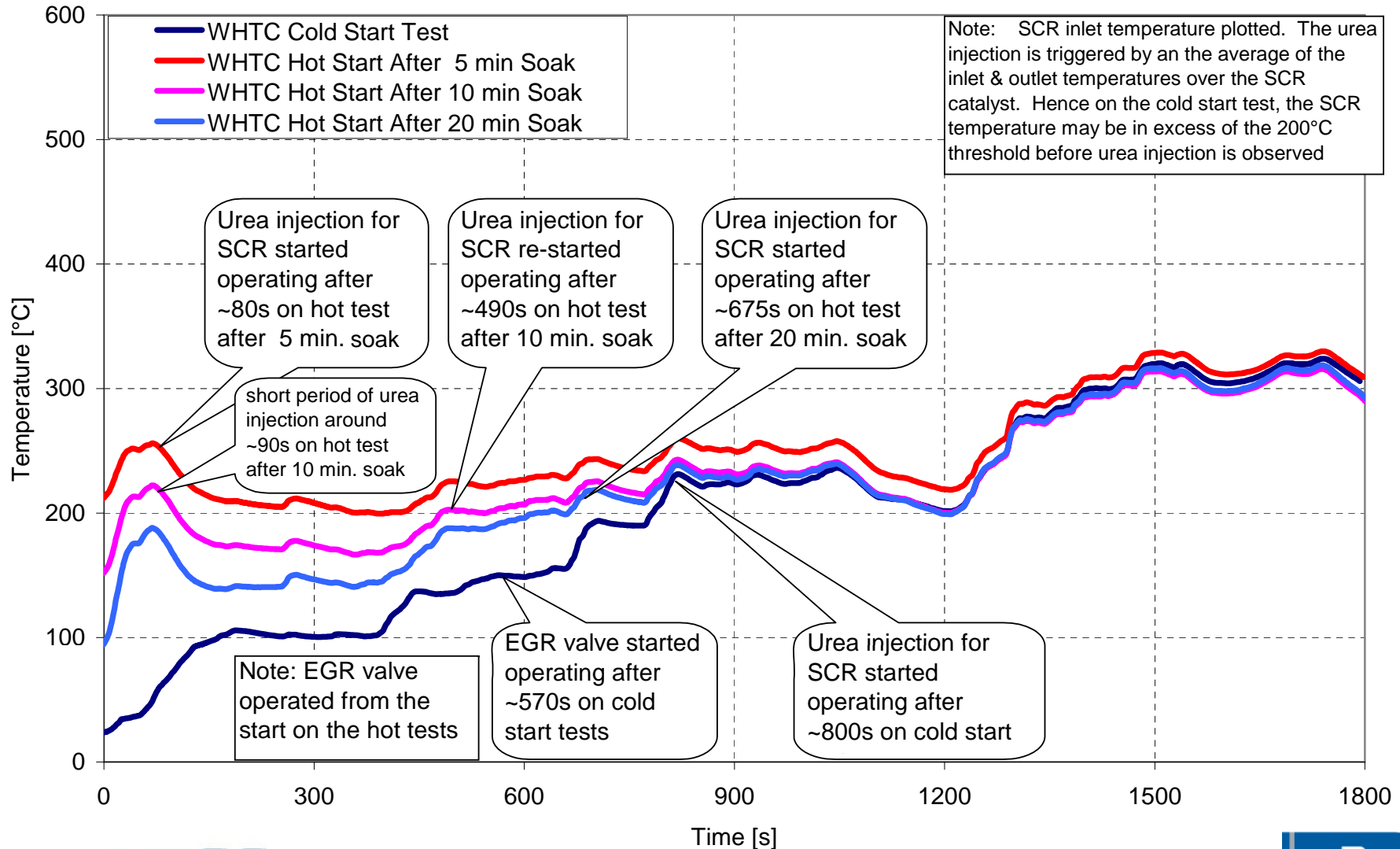
# Tailpipe cold and hot start WHTC results showing effect of hot soak period



# SCR temperatures for ETC and cold start WHTC



# SCR temperatures for WHTC options



# Summary of WHTC composite results

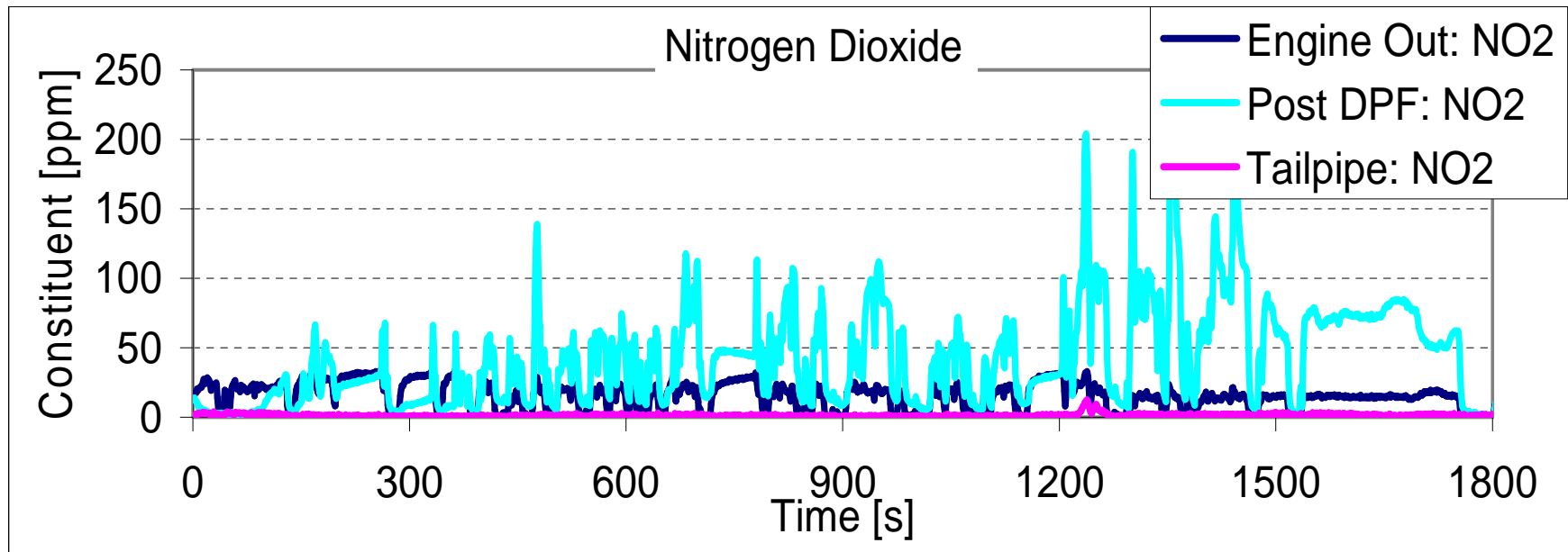
Test Procedure		Emissions [g/kWh]											
		THC			NOx			CO			PM		
		Engine Out	Tail pipe	Conv. Effy.	Engine Out	Tail pipe	Conv. Effy.	Engine Out	Tail pipe	Conv. Effy.	Engine Out	Tail pipe	Conv. Effy.
WHTC	cold	0.662	0.159	76%	2.338	1.689	28%	6.314	1.570	75%	0.594	0.002	99.6%
WHTC	hot ( 5 min)	0.624	0.202	68%	1.131	0.147	87%	9.403	1.962	79%	0.735	0.002	99.7%
10% cold	weighted	0.628	0.198	69%	1.252	0.301	76%	9.094	1.922	79%	0.721	0.002	99.7%
(EU-composite WHTC)													
WHTC	cold	0.662	0.159	76%	2.338	1.689	28%	6.314	1.570	75%	0.594	0.002	99.6%
WHTC	hot (10 min)	0.570	0.204	64%	1.232	0.191	84%	8.039	1.794	78%	0.735	0.002	99.8%
10% cold	weighted	0.579	0.199	66%	1.343	0.341	75%	7.866	1.772	77%	0.721	0.002	99.8%
(US-composite WHTC)													
WHTC	cold	0.662	0.159	76%	2.338	1.689	28%	6.314	1.570	75%	0.594	0.002	99.6%
WHTC	hot (20 min)	0.574	0.161	72%	1.193	0.178	85%	8.321	1.993	76%	0.735	0.002	99.8%
10% cold	weighted	0.583	0.161	72%	1.308	0.329	75%	8.121	1.951	76%	0.721	0.002	99.8%
14% cold	weighted	0.586	0.160	73%	1.357	0.394	71%	8.034	1.933	76%	0.715	0.002	99.8%

Hot NOx conversion efficiencies ~85%.

PM reduction efficiencies >99.5%.

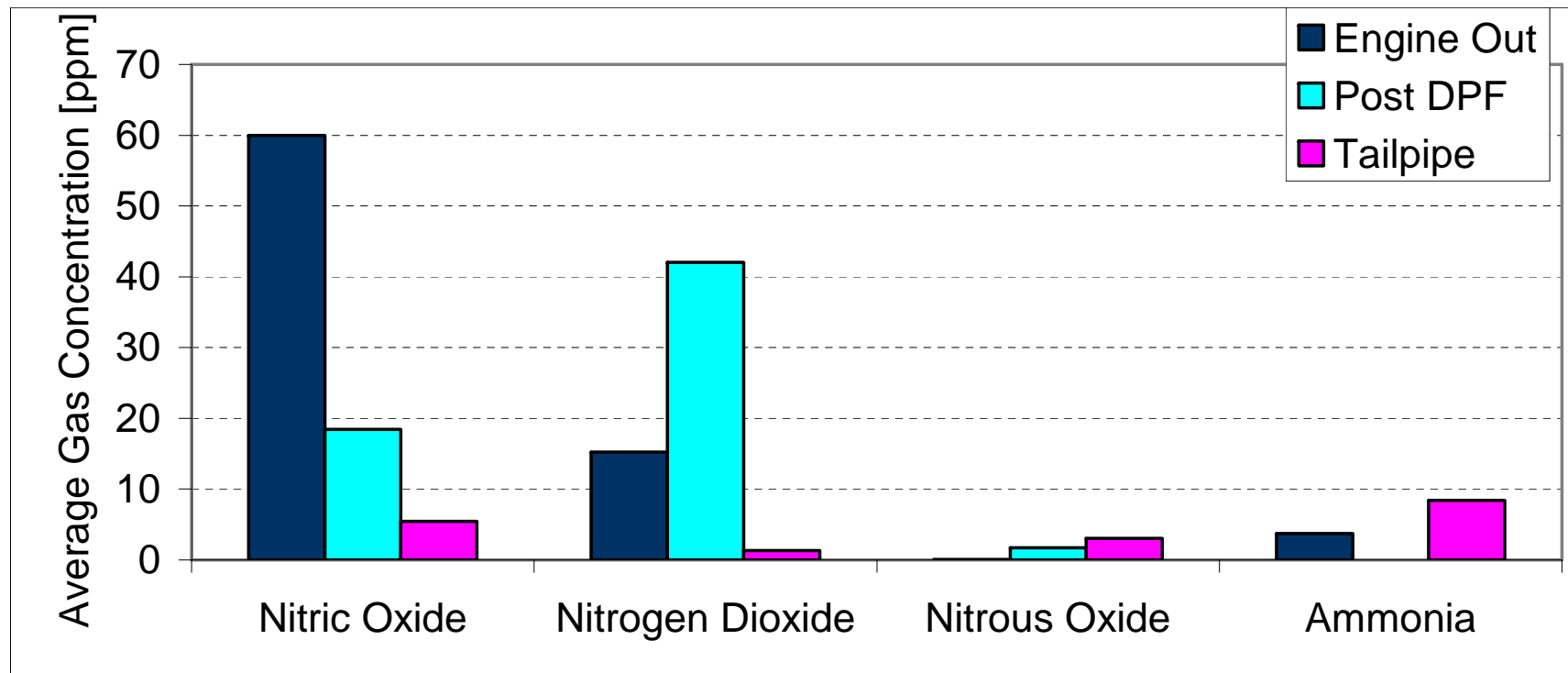
# Continuous trace for NO<sub>2</sub> on the WHTC

## World Harmonised Transient Cycle (WHTC)

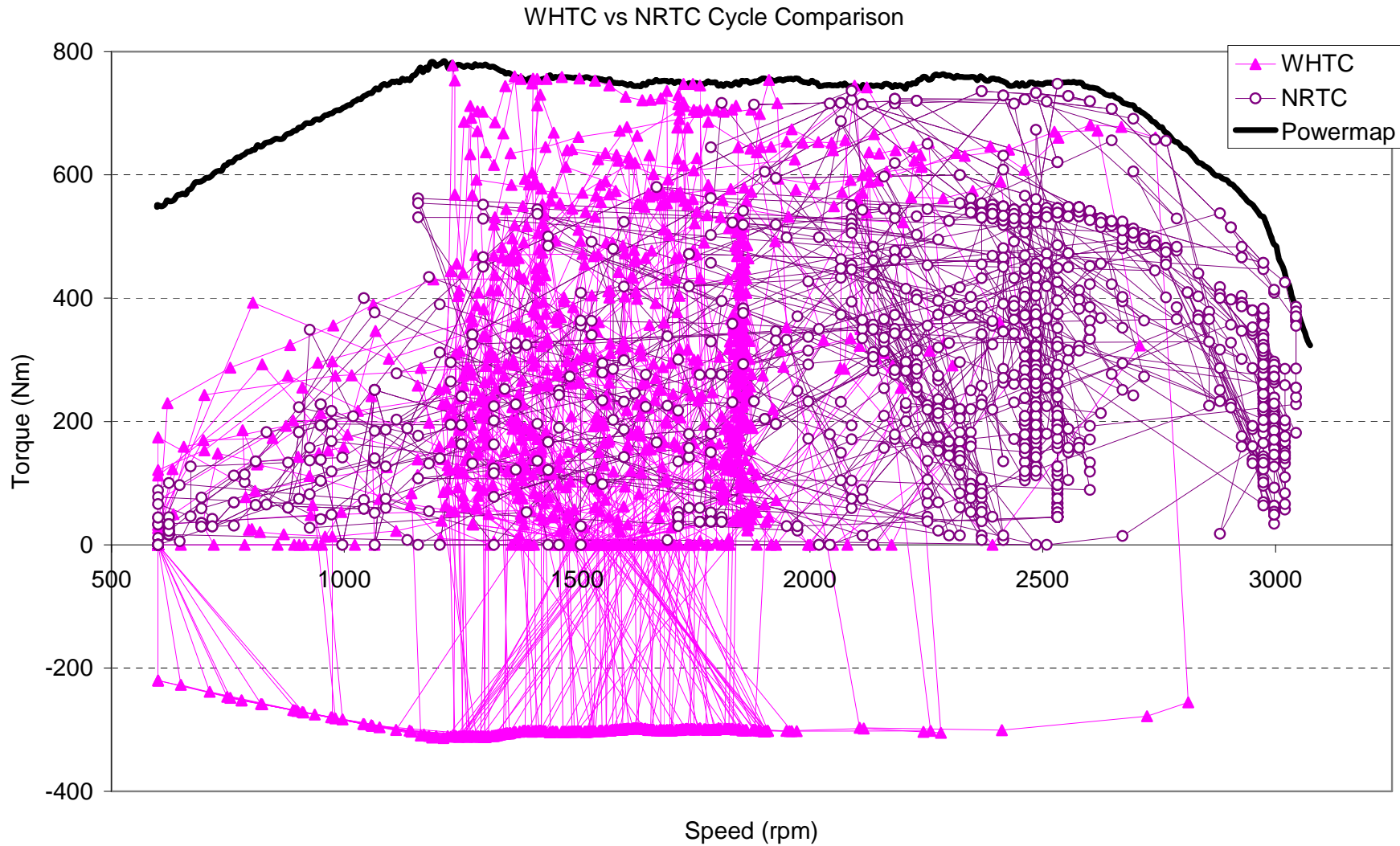


# Profile of nitrogen species through the emissions control system

World Harmonised Transient Cycle (WHTC)

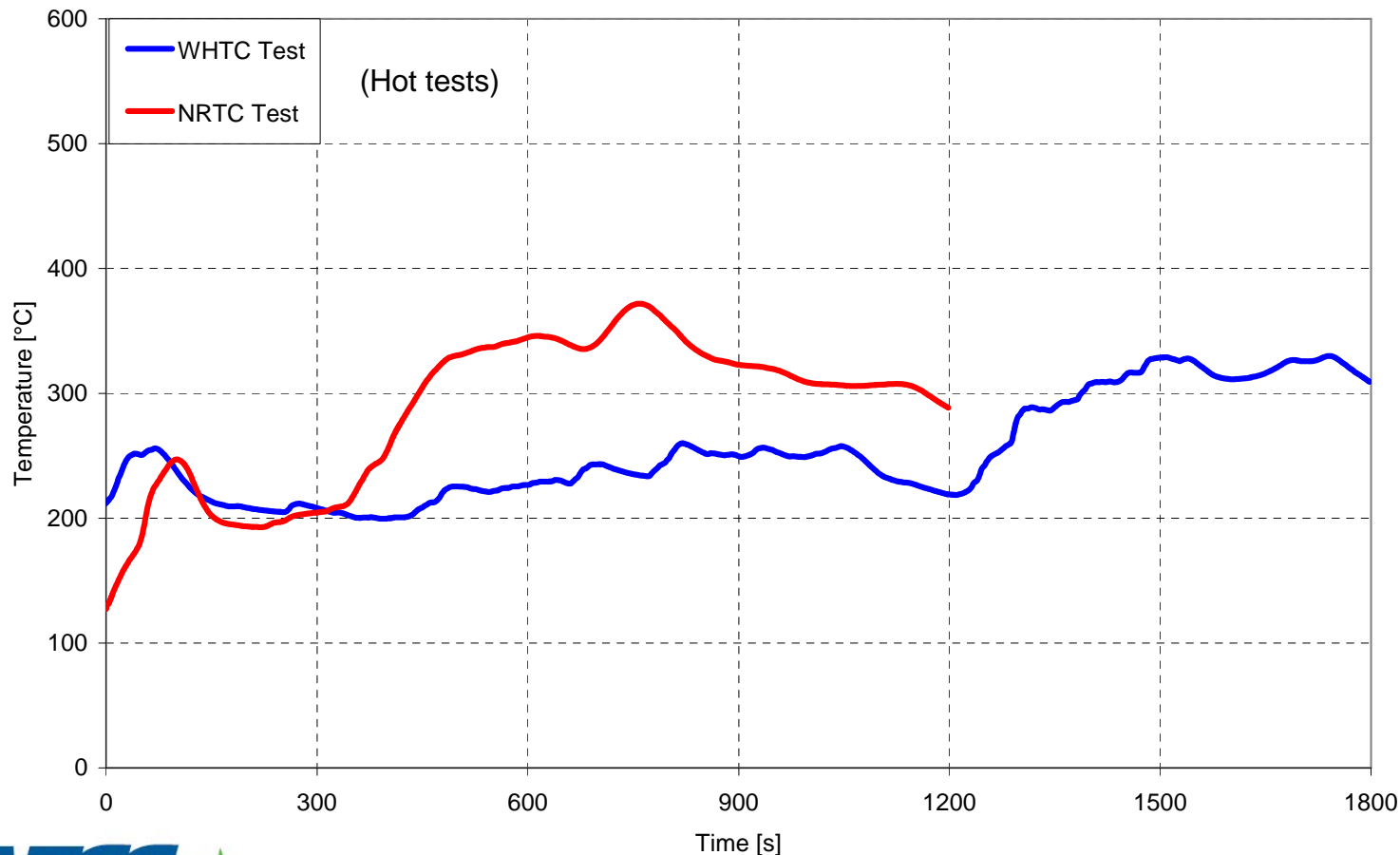


# WHTC and NRTC cycle comparison



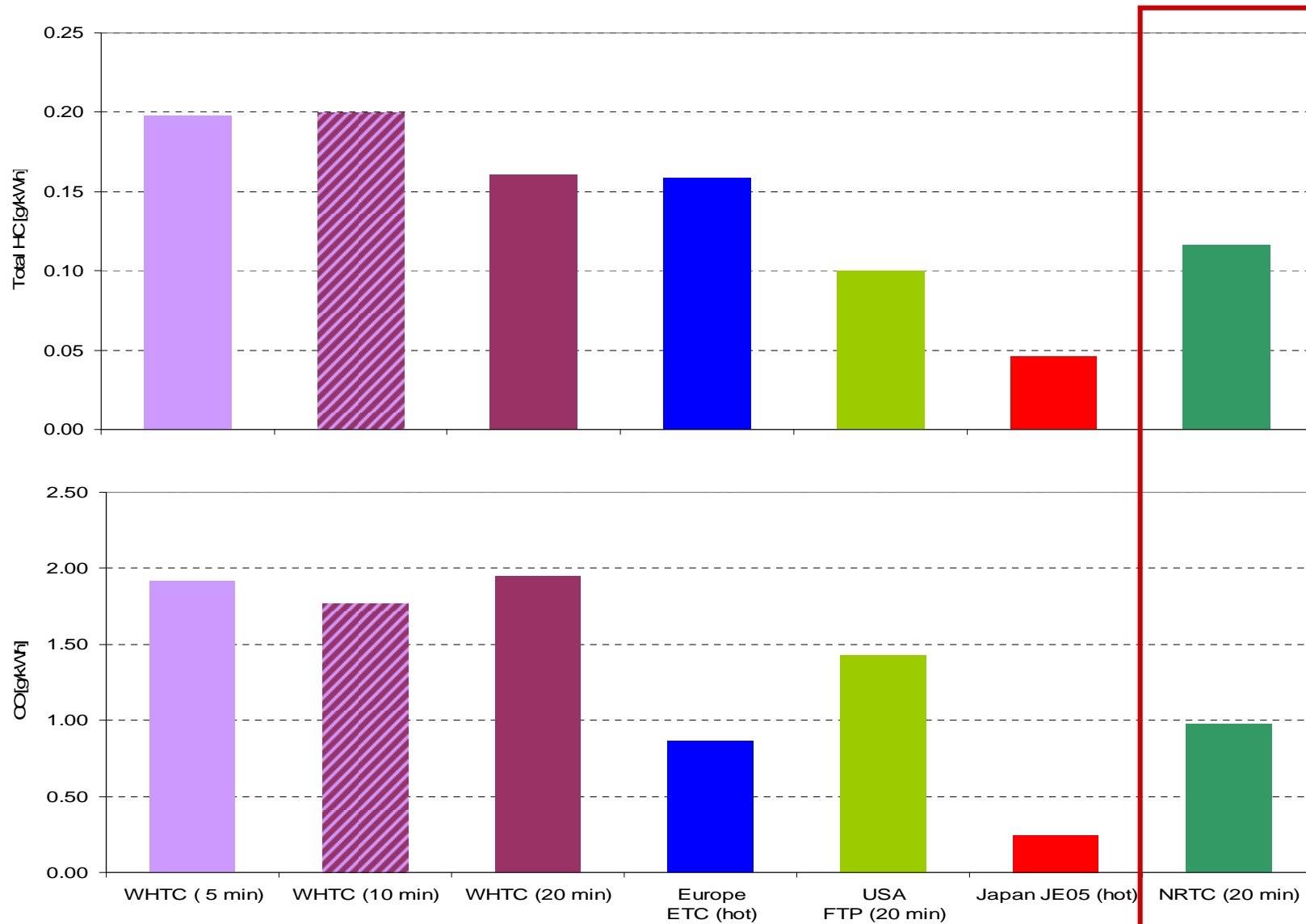
# Non-Road Transient Cycle

- Cold start weighting factors: EU is 10%; US is 5%.
- Soak time between the cold and hot tests is 20 minutes.
- Cold start: EGR and low SCR inlet temperature for first 300s.
- Hot tests: SCR inlet temperature reaches 200°C after 60s.

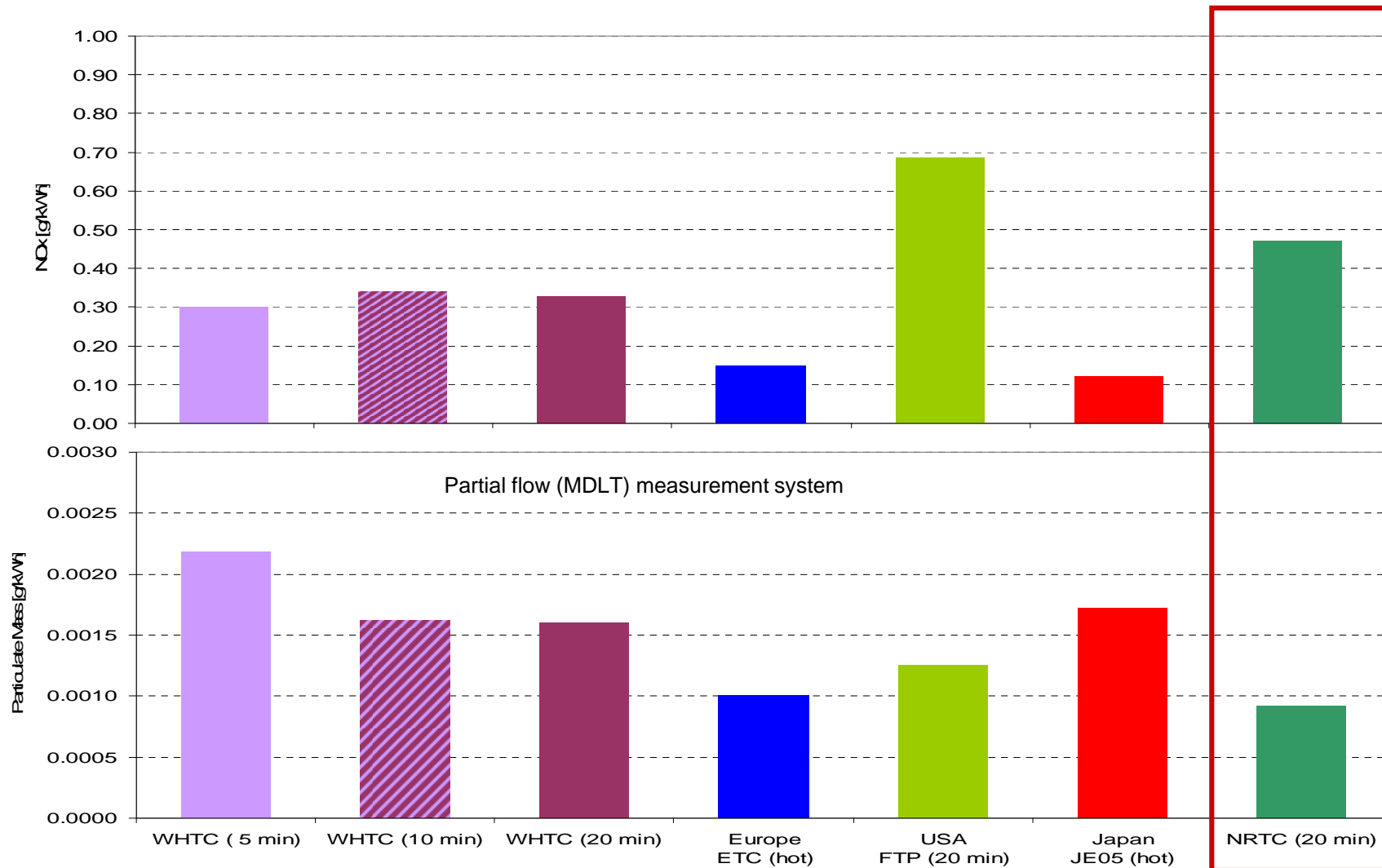




# HC and CO for non-road transient cycle

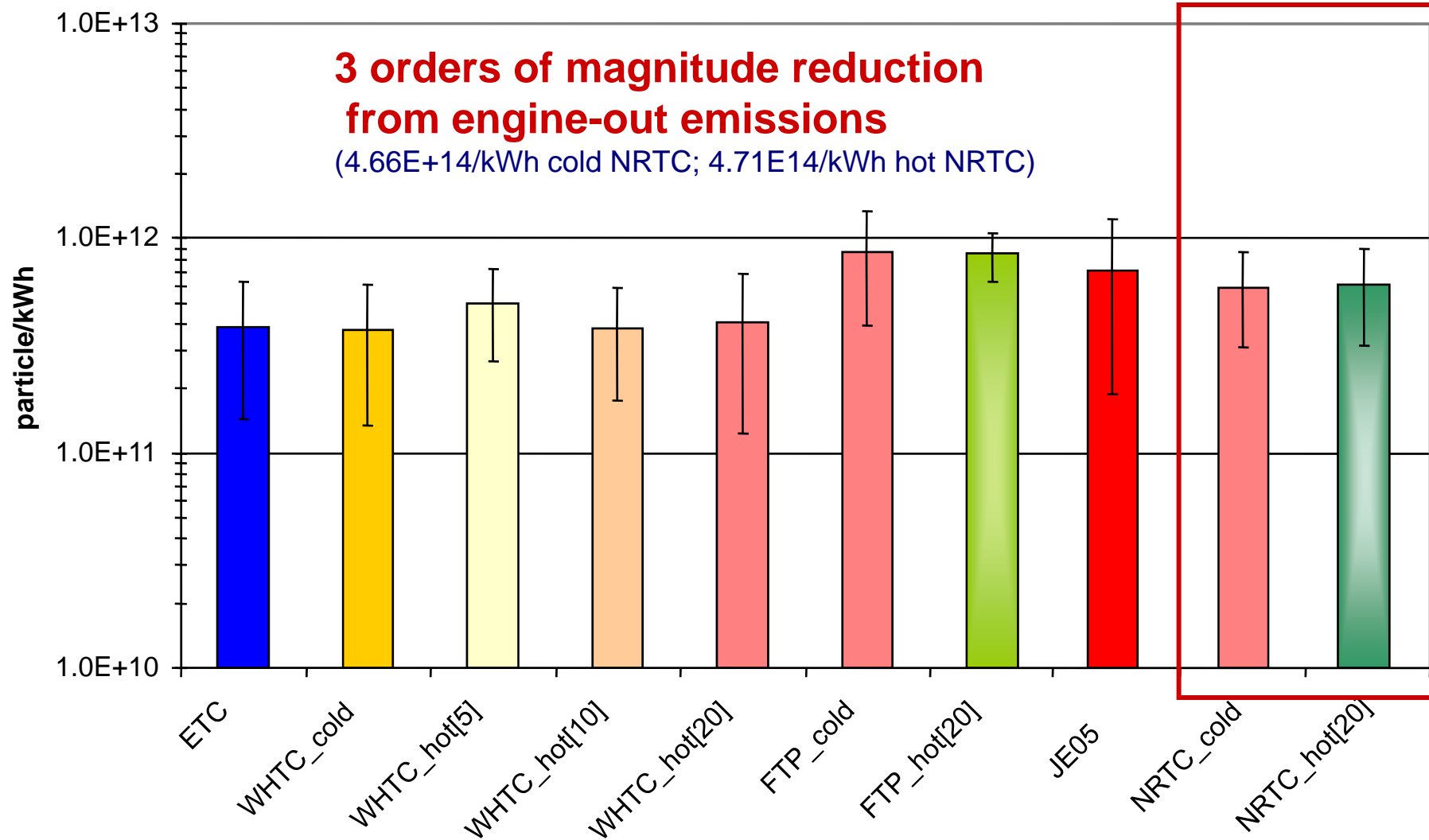


# NOx and PM for non-road transient cycle



Note: PM limit for Stages IIIB & IV is 25mg/kWh. Average test result is <1mg/kWh

# Particle numbers measurements over non-road transient cycle

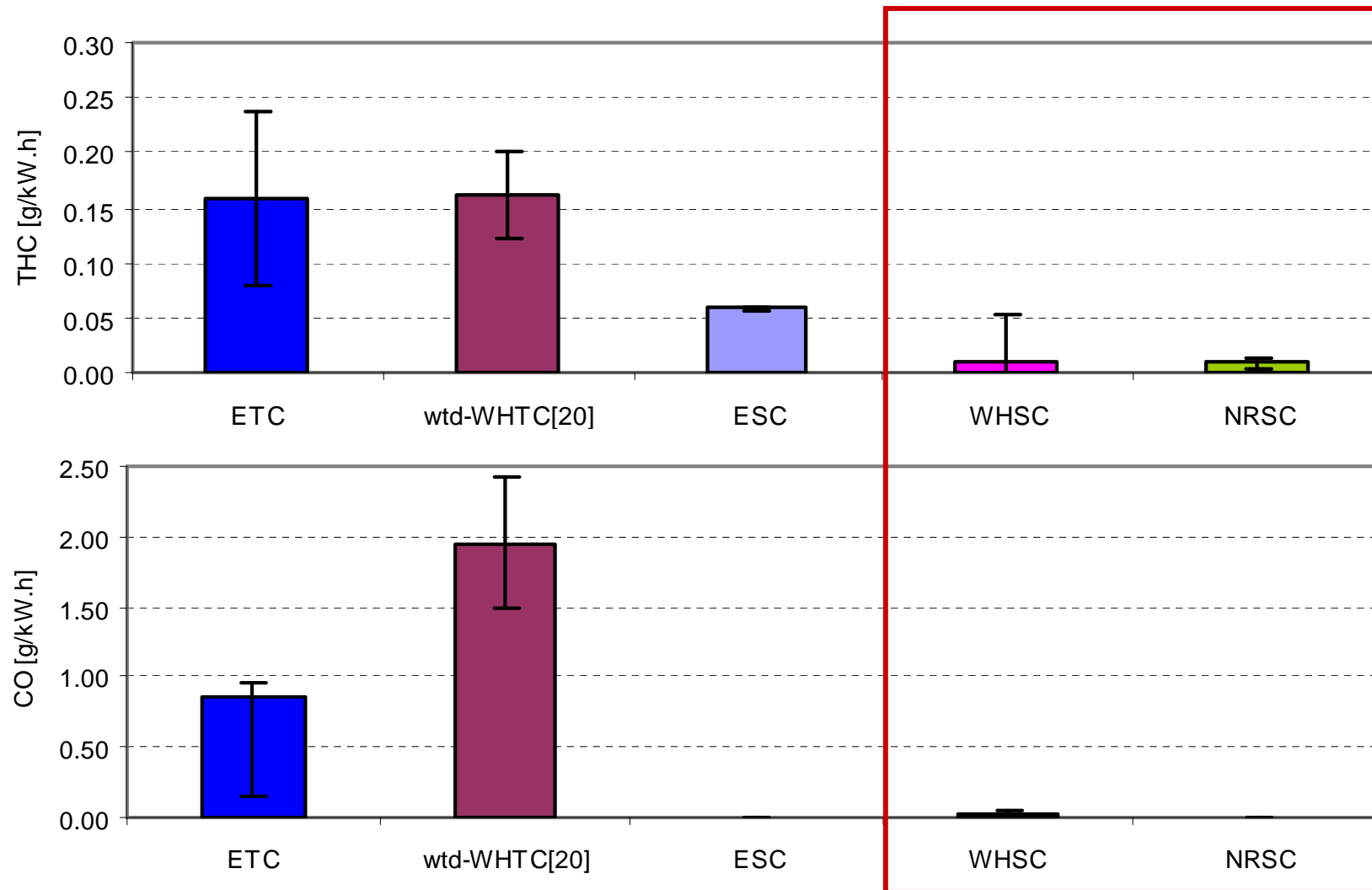


# NRTC composite results

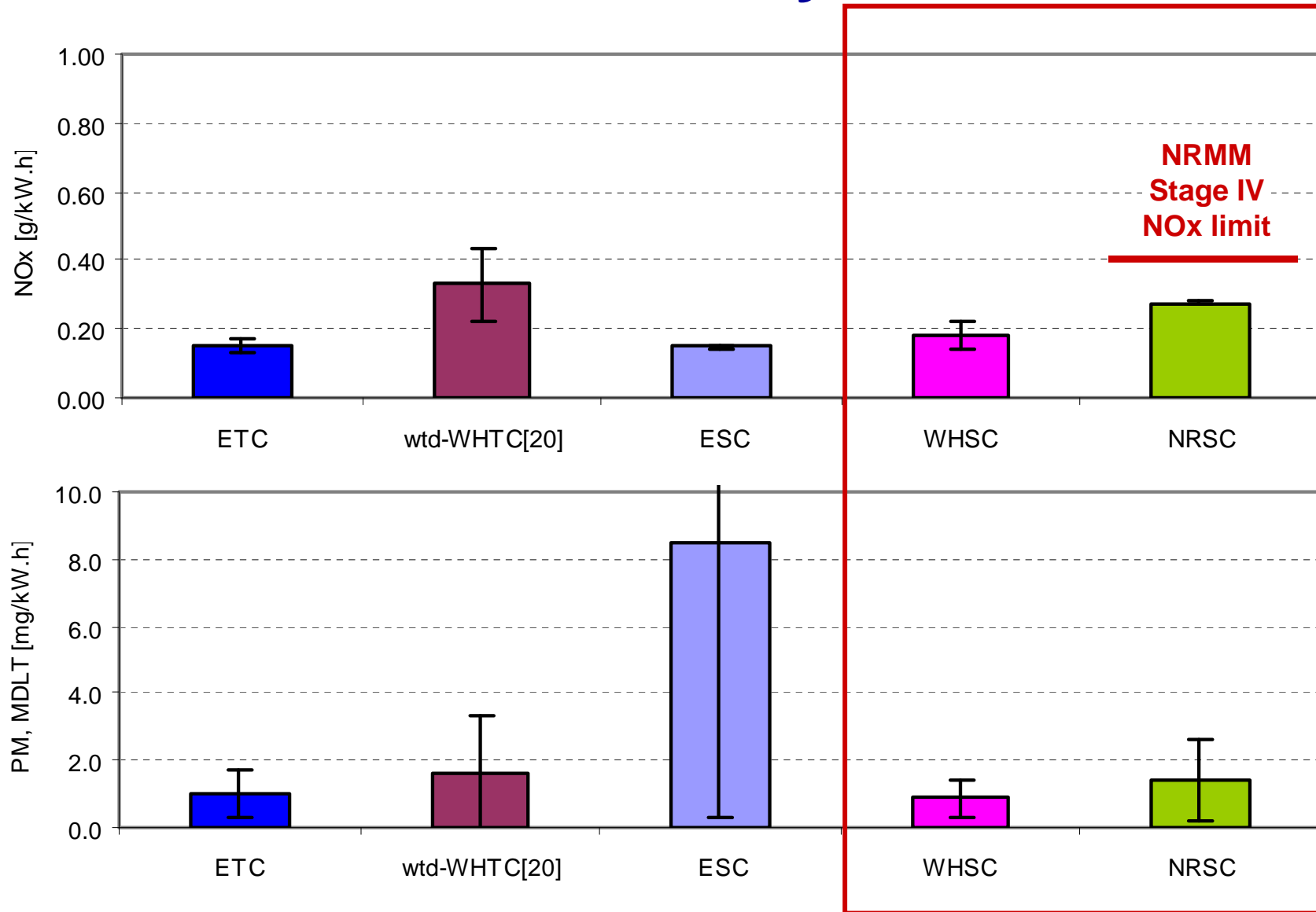
Test Procedure		Emissions [g/kW.h]											
		THC			NOx			CO			PM		
		Engine Out	Tail pipe	Conv. Effy.	Engine Out	Tail pipe	Conv. Effy.	Engine Out	Tail pipe	Conv. Effy.	Engine Out	Tail pipe	Conv. Effy.
NRTC cold	cold	0.584	0.070	88%	2.217	1.220	45%	4.380	0.719	84%	0.541	0.001	99.8%
NRTC hot	hot (20 min)	0.775	0.122	84%	1.486	0.388	74%	6.820	1.007	85%	0.505	0.001	99.8%
<b>NRTC (EU)</b>	10% cold wtd.	0.756	0.116	85%	1.559	0.471	70%	6.576	0.978	85%	0.509	0.001	99.8%
NRTC cold	cold	0.584	0.070	88%	2.217	1.220	45%	4.380	0.719	84%	0.541	0.001	99.8%
NRTC hot	hot (20 min)	0.775	0.122	84%	1.486	0.388	74%	6.820	1.007	85%	0.505	0.001	99.8%
<b>NRTC (US)</b>	5% cold wtd.	0.766	0.119	84%	1.523	0.429	72%	6.698	0.992	85%	0.507	0.001	99.8%

- No optimisation was undertaken.
  - No change to engine calibration from US2007 HD basis.
  - 'One-shot' system sizing: would be optimised for production.
  - Urea dosing was not optimised for non-road cycles.
  - No thermal management strategy to improve cold NOx emissions.

# HC and CO for steady-state tests



# NOx and PM for steady-state tests



# Summary

- Over the EU-composite World Harmonised Transient Cycle, NOx emissions were 0.3g/kWh and PM emissions were 2mg/kWh.
- NOx conversion efficiency over the hot-start WHTC was similar to that for the ETC (85%). Cold start efficiency was lower as the EGR did not operate until 570s and the system did not reach minimum urea injection until 800s on cold tests.
- The system was not fully optimised; there was no thermal management to assist cold start NOx emissions.
- The Non-Road Transient Cycle has higher speeds and loads than the WHTC, resulting in faster achievement of operating temperatures.
- Over the EU-composite Non-Road Transient Cycle, NOx emissions were 0.471g/kWh and PM emissions were 1mg/kWh.



- Home
- AECC
- Air Quality & Health Effects
- Emissions Legislation
- Engine & Vehicle Emissions
- Technology
- Applications
- Publications
- Newsletter
- Future focus

## Acknowledgements

the OE engine manufacturer  
Bosch, urea dosing system supplier  
Yara International, urea supplier  
Ricardo UK and the AECC Members

### Who are AECC and what we do ?

AECC is an international non-profit scientific association of European companies making technologies for automobile exhaust emissions control.

The members of AECC are companies operating worldwide in the research, development, testing and production of emission control technologies for emissions control.

main catalysts are metal based (metallic substrates for catalysts and monoliths), autocatalysis (substrates with catalytic materials incorporated or coated), adsorbents, filter based technology for control of the diesel emissions (diesel particulate, lean burn engines), and speciality materials incorporated into the catalytic converter or filter.

Catalyst-equipped cars were first introduced in the USA in 1974 but only appeared on European roads in 1985 and in 1993 legislation forced their use on cars. Now more than 275 million of the world's 500 million cars and over 85% of all new cars produced worldwide are equipped with autocatalysts. Catalytic converters and filters are also fitted to heavy-duty vehicles, motorcycles and non-road engines and

### What are the emission control technologies?

Exhaust gas contains carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx) and particulate matter. The technologies used to remove these pollutants from exhaust to remove harmful gases and particles are:

- autocatalysis
- adsorbents (traps)
- filters

There are more details on the technology pages.



## Thank you for your attention