GRPE/WHDC/FE34

WHDC DEVELOPMENT - REFERENCE FUEL PROGRAMME

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Objectives of the programme

- To investigate the effect of different reference fuels on the emissions of Euro V / US2007 engines measured over the WHTC cycle.

- The programme is being carried out in collaboration with the engine manufacturers

TEST Engines (provided by OICA)

- EURO V Engine
  - MAN 2066LF18
  - 6 Cylinders intercooler Turbo Diesel Engine 10.5 l 300 kW
  - Common Rail Injection System
  - Euro V emission control device SCR with Urea injection

- US 2007 Engine
  - Cummins ISX500
  - 6 Cylinders intercooler Turbo Diesel Engine 14.9 L. 373 kW
  - HPI Electronic injection System DPF and Cooled EGR
  - EPA 2007, CARB 2007 Emission Certification

TEST FUELS

		Fuel A	Fuel B	Fuel C
		RF-06-03	RF-06-03+5% FAME	US 86.113-07
Density @ 15 C	kg/m3	833.6	833.6	845.4
Cetane Number		52.9	53.1	46.9
Distillation				
IBP	ºC	204	207	197.5
10% v/v	ºC	233.7		217.7
50% v/v	ºC	275.3	278.1	272.3
90% v/v	ºC	322.3		311.6
95% v/v	ºC	348.4	349	
FBP	ºC	357.7	356.7	333.6
Viscosity @ 40 C	mm2/s	2.93	2.93	2.55
Aromatics				
Total	%wt	23.4	22.8	36.3
Mono	%wt	19	18.8	
Poly	%wt	4.4	4	
Sulphur	mg/kg	1.6	1.7	7
Net heating value	MJ/kg	43.199	42.942	42.886
FAME	%vol		5.1	
Oxygen	%wt		0.7	

Test fuels: main differences

- Fuel A (European Ref.) vs Fuel B (European Ref. + 5% FAME)
  - Very similar properties
  - 0.7 % oxygen content in Fuel B
  - Reduced heating value (- 0.6 %)

- Fuel C (US Ref.) vs Fuel A (European Ref.)
  - Higher density (+1.4%)
  - Lower average boiling point (much lower T95%)
  - Higher total aromatic content (36% vs 23%)
  - Lower heating value but higher density -> higher volumetric heating value (+0.68%)

Results

US 2007 Engine

TEST MATRIX

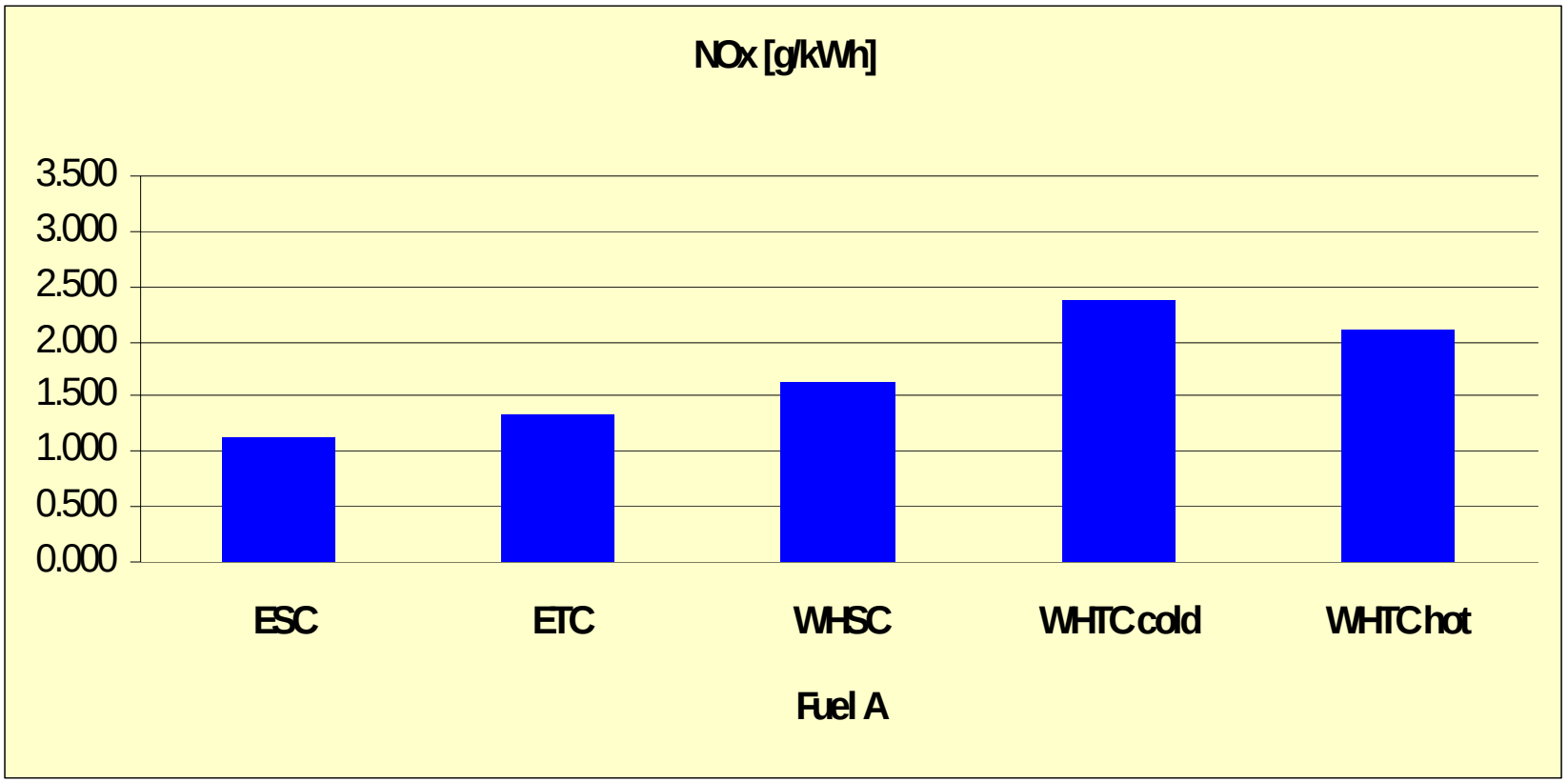
	Fuel	Day 1	Day 2	Day 3
1	A	COLD WHTC#1	COLD WHTC#1	COLD WHTC#1
2	regen	HOT WHTC#2	HOT WHTC#6	HOT WHSC#4
3	FLC	HOT WHTC#3	HOT WHSC#1	HOT WHSC#5
4	Build up	HOT WHTC#4	HOT WHSC#2	
5		HOT WHTC#5	HOT WHSC#3	

Regen regeneration phase (set by ECM)

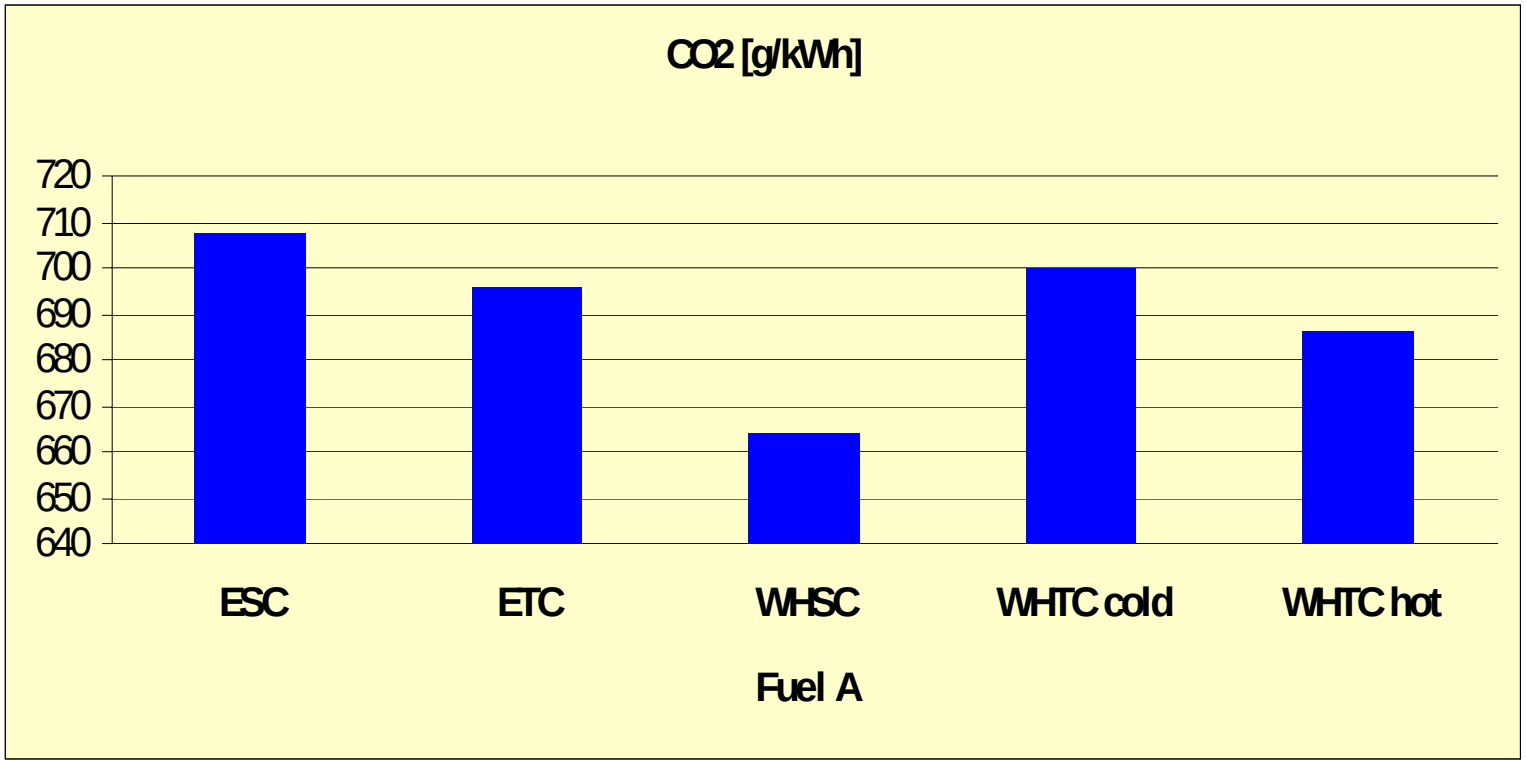
FLC full load Power Curve

Build up soot cake: (45 min) Medium Load Medium speed

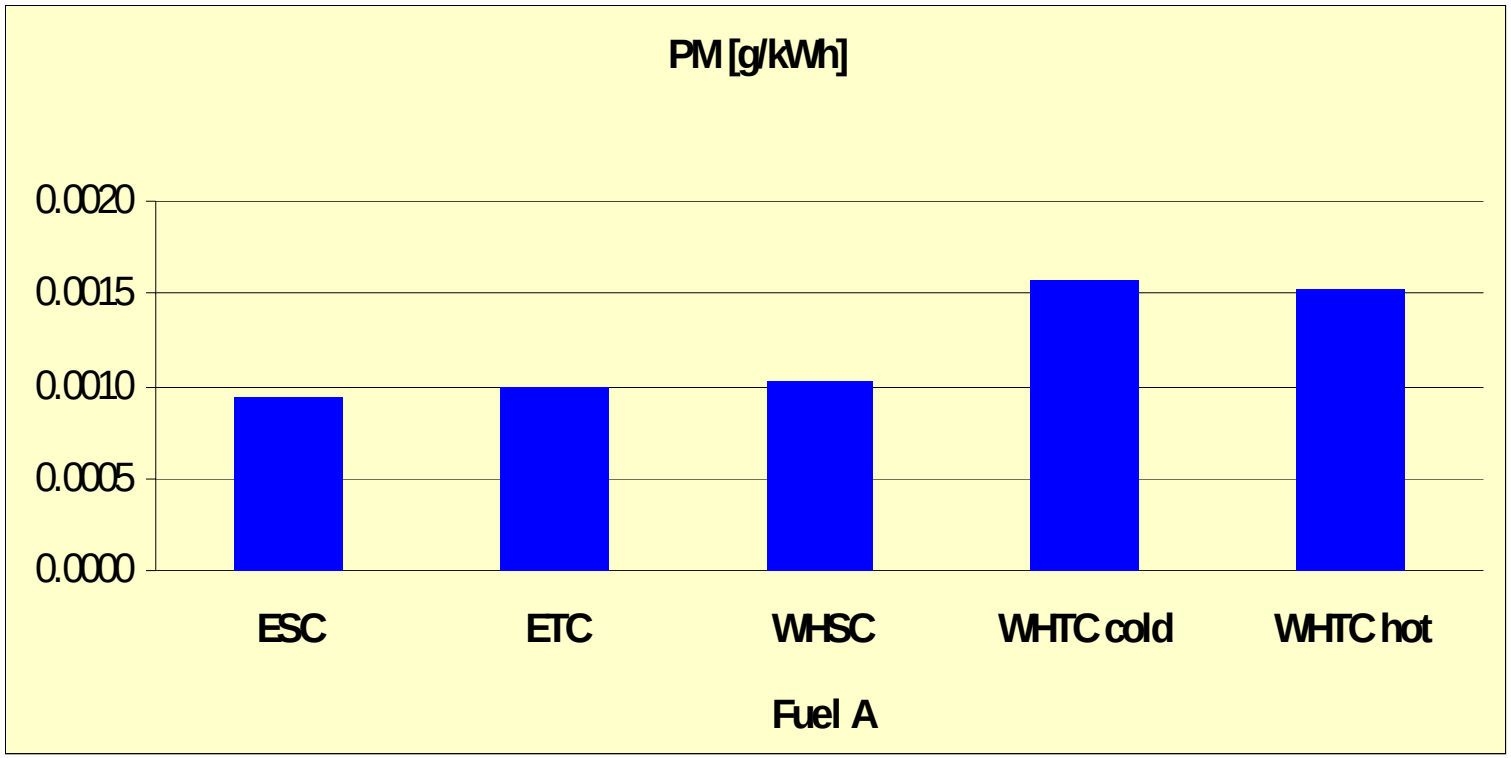
Emission comparison on different cycles



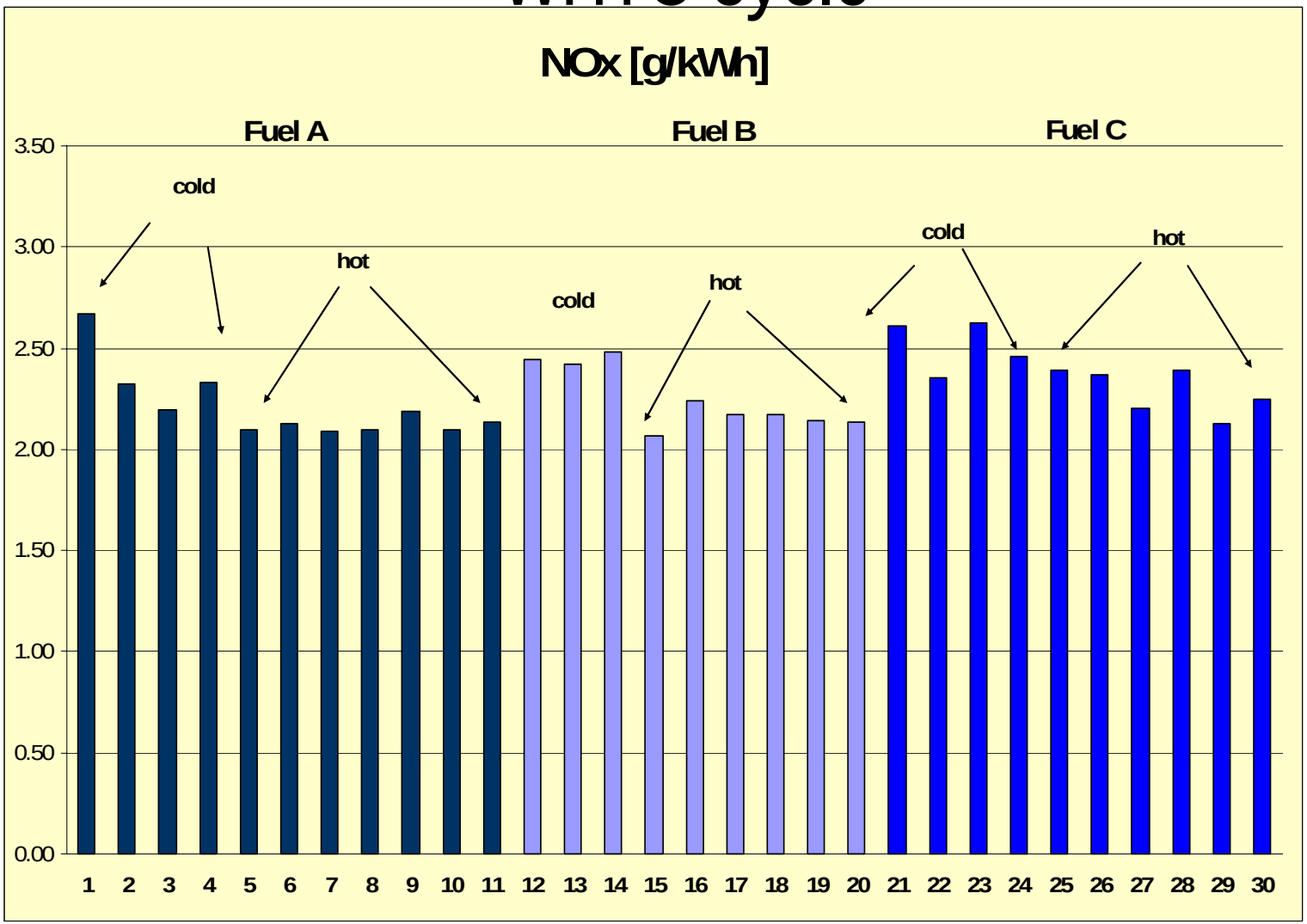
Emission comparison on different cycles



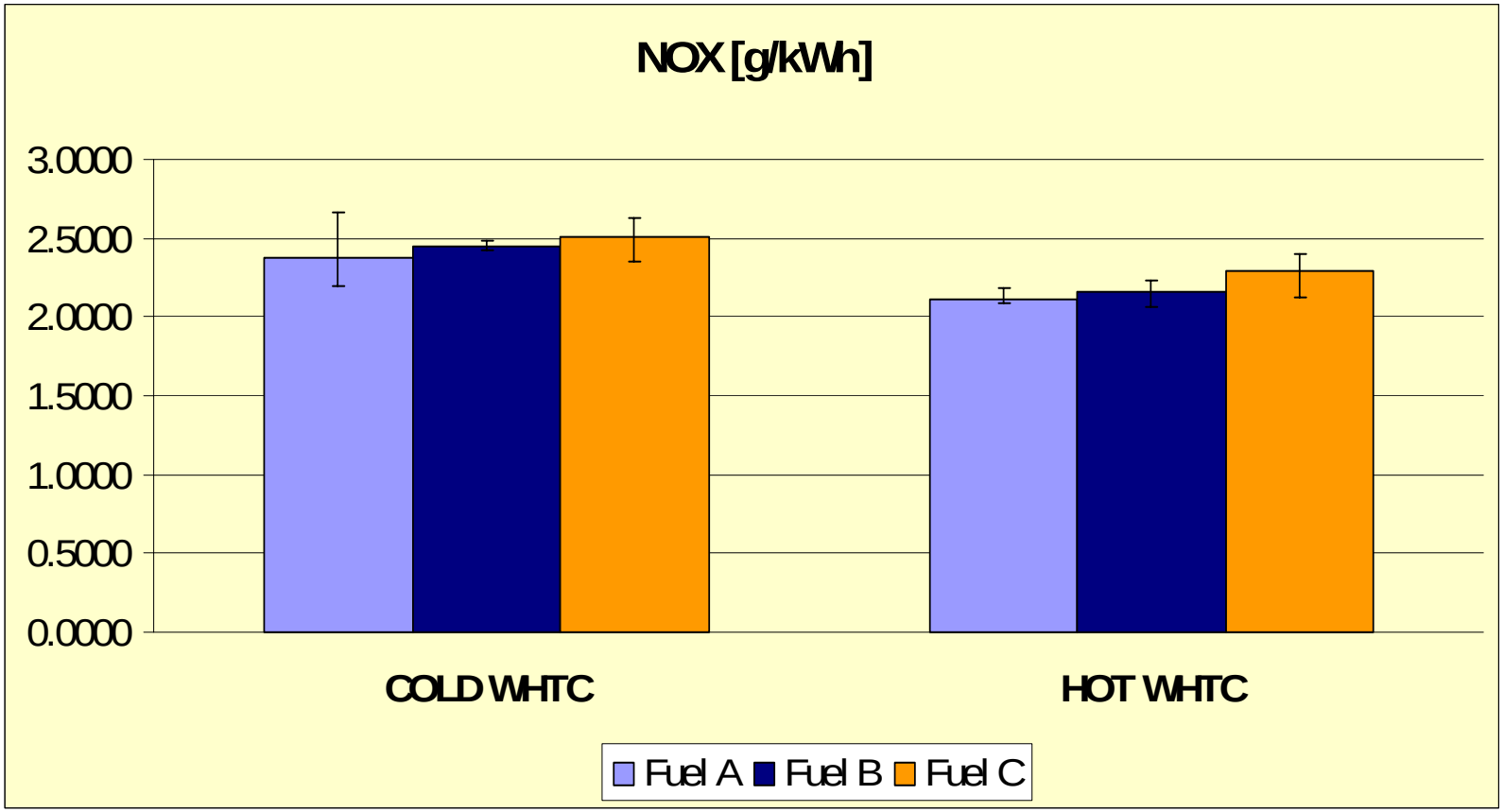
Emission comparison on different cycles



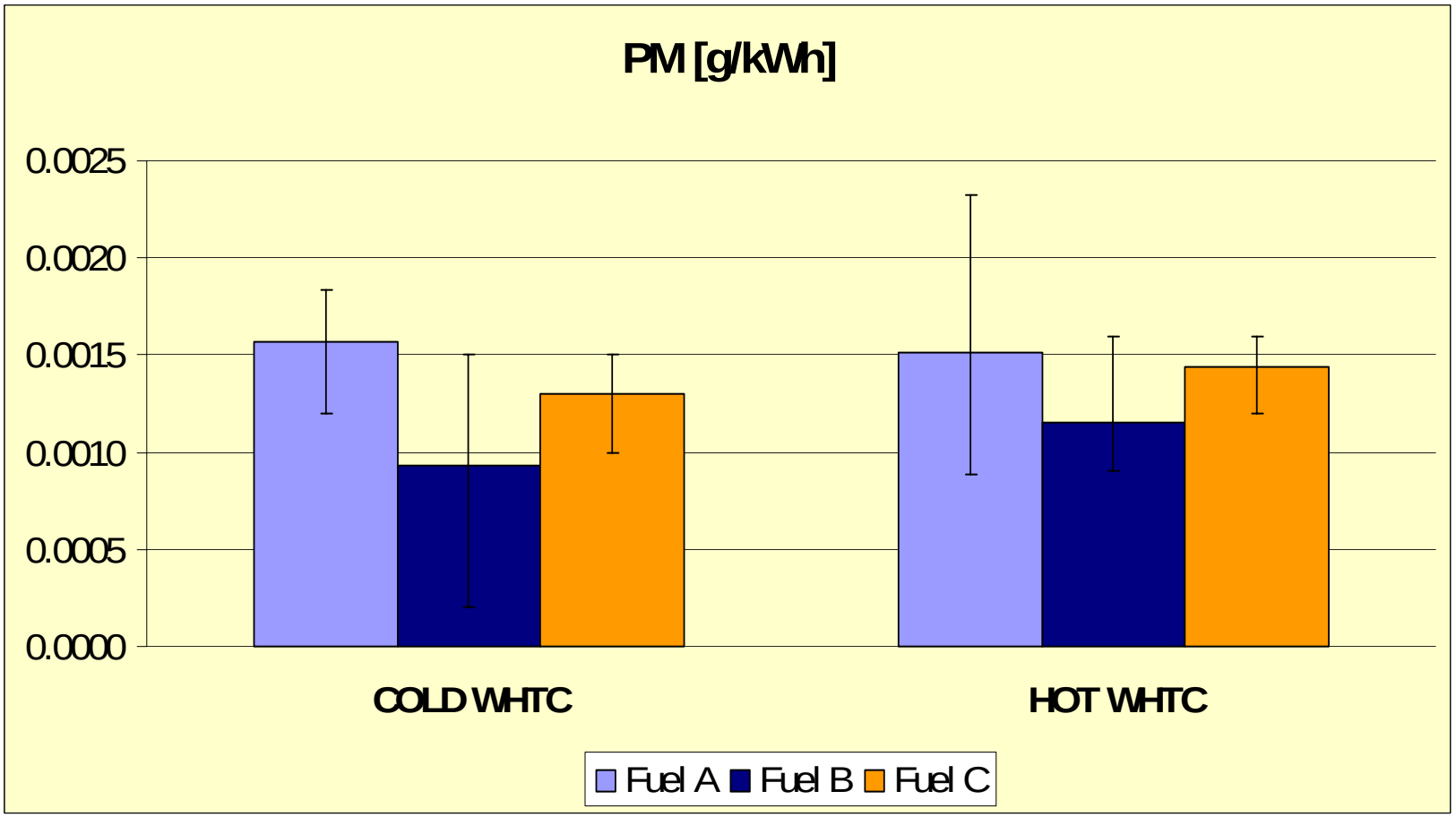
WHTC cycle


NOx [g/kWh]
Fuel A
Fuel B
Fuel C
cold
hot
cold
hot
cold
hot
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

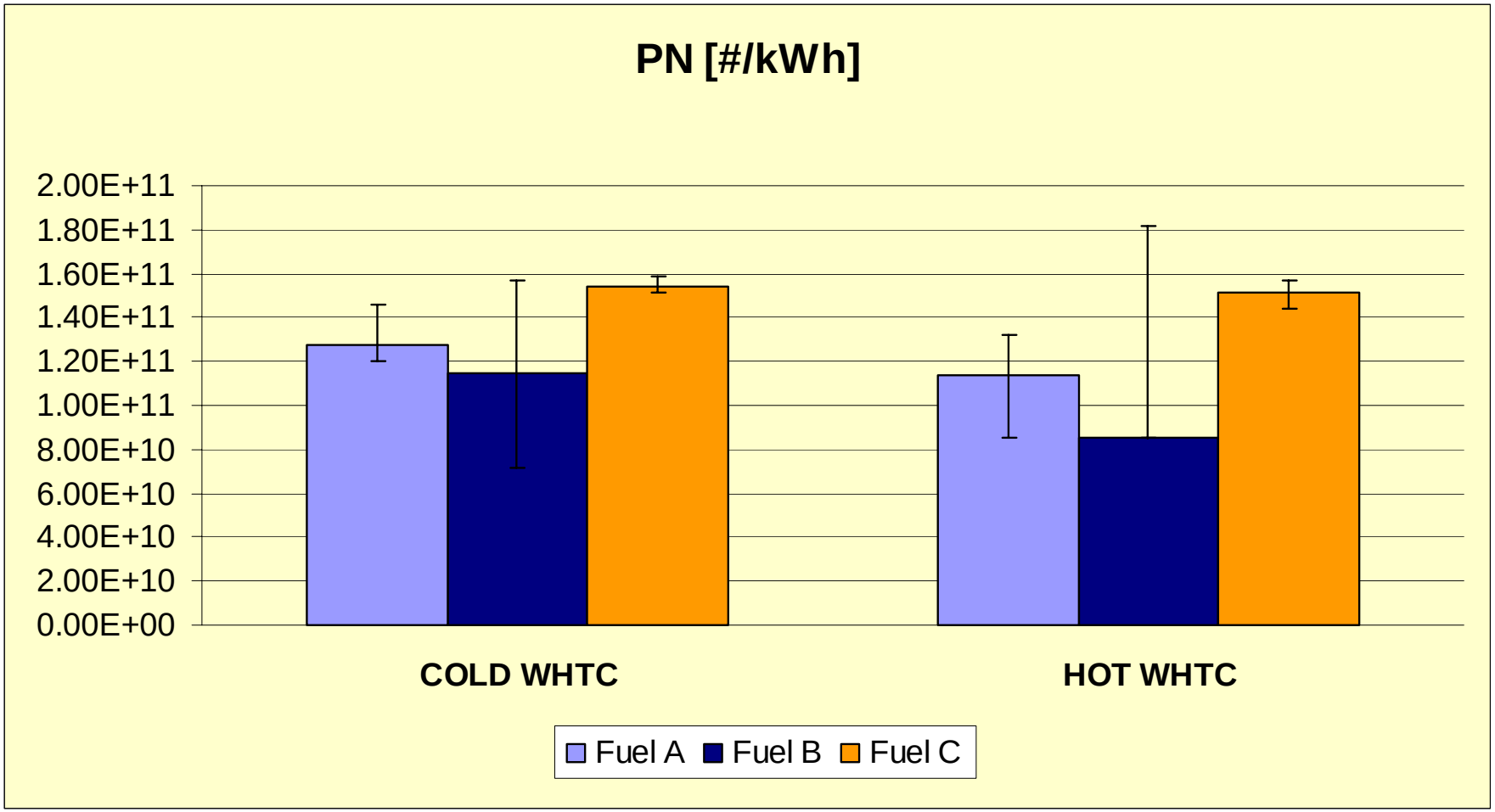
WHTC cycle


NOX [g/kWh]
3.0000
2.5000
2.0000
1.5000
1.0000
0.5000
0.0000
COLD WHTC
HOT WHTC
Fuel A
Fuel B
Fuel C

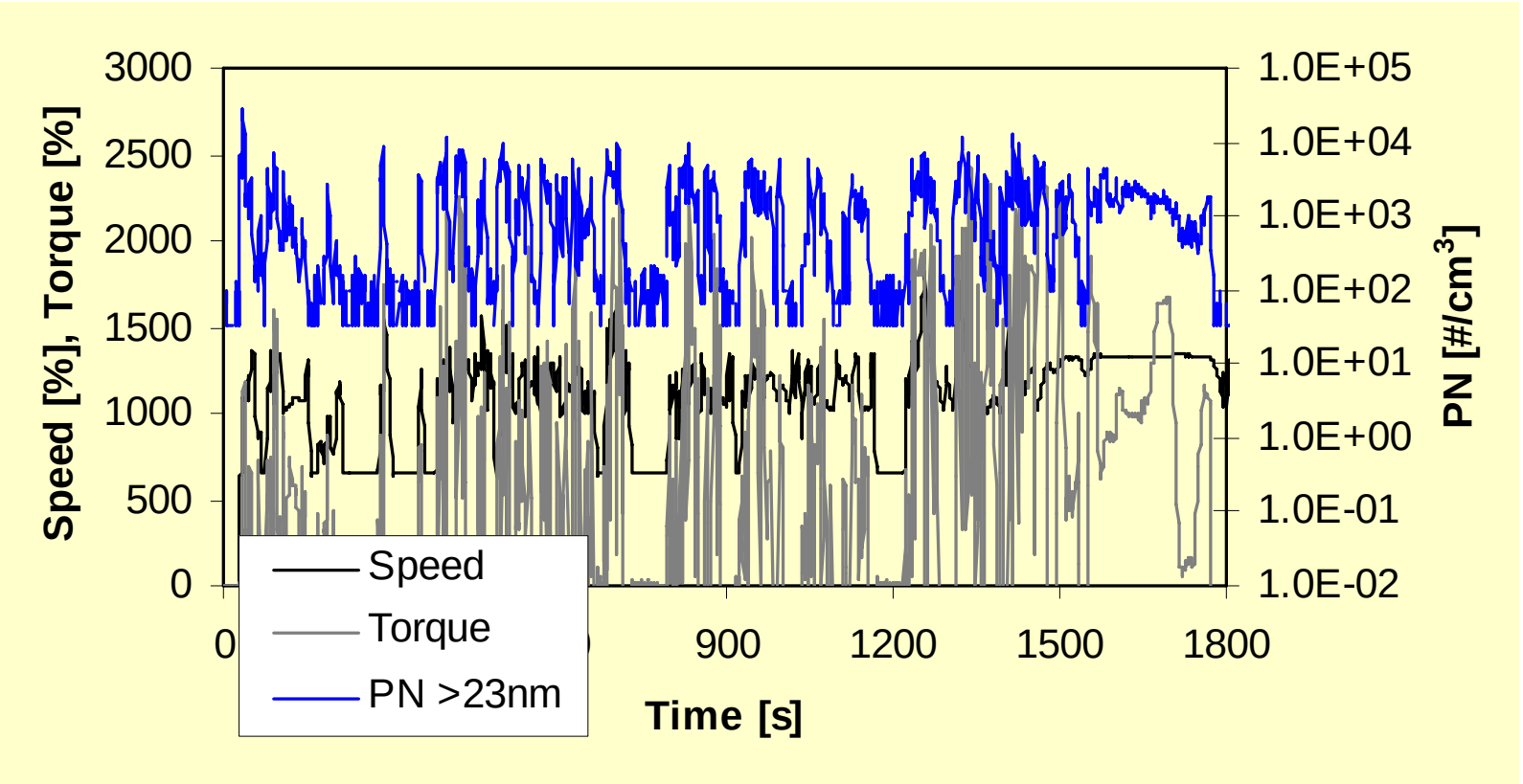
WHTC cycle


PM [g/kWh]
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
COLD WHTC
HOT WHTC
Fuel A
Fuel B
Fuel C

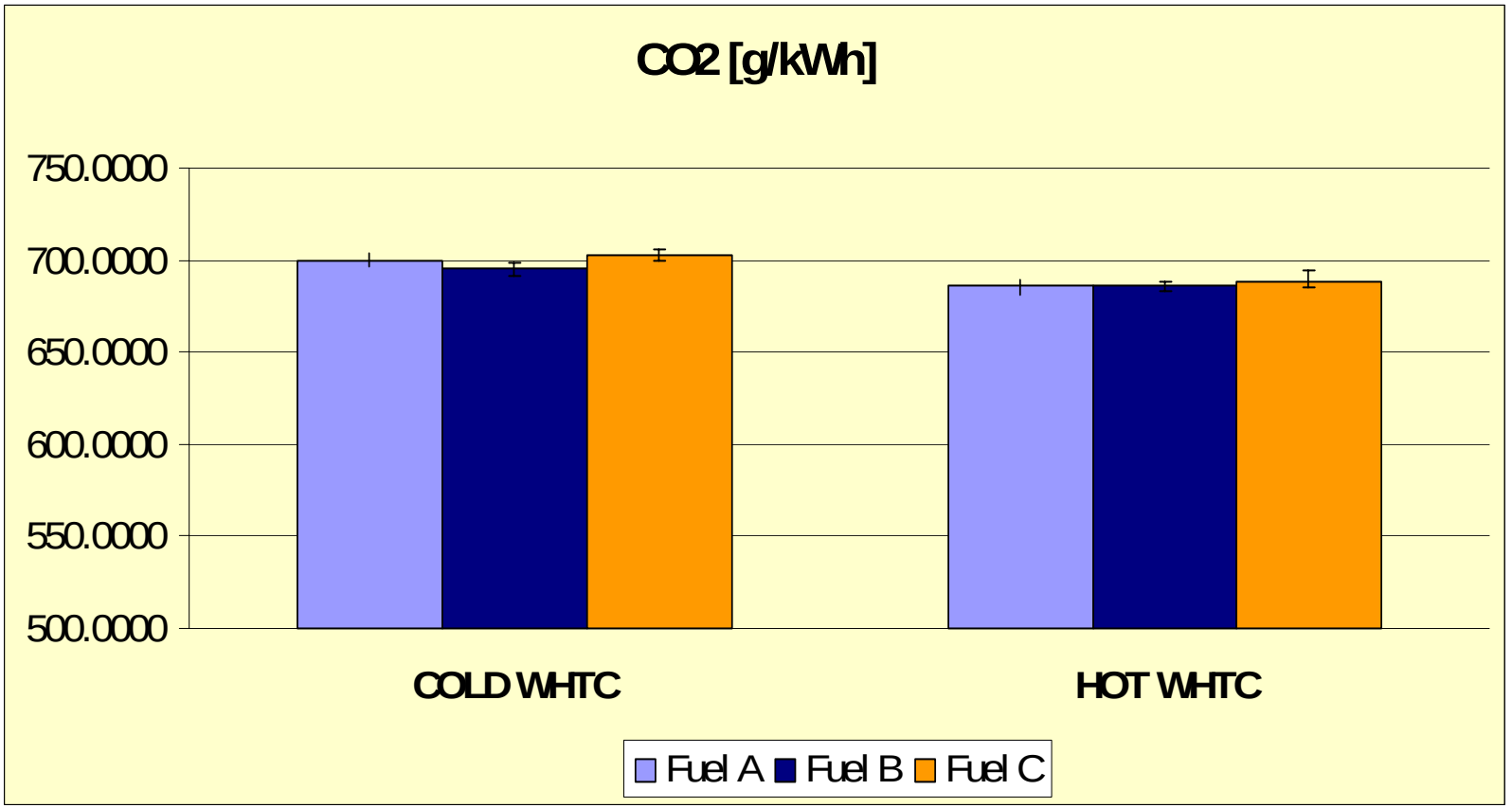
WHTC cycle


PN [#/kWh]
2.00E+11
1.80E+11
1.60E+11
1.40E+11
1.20E+11
1.00E+11
8.00E+10
6.00E+10
4.00E+10
2.00E+10
0.00E+00
COLD WHTC
HOT WHTC
Fuel A
Fuel B
Fuel C

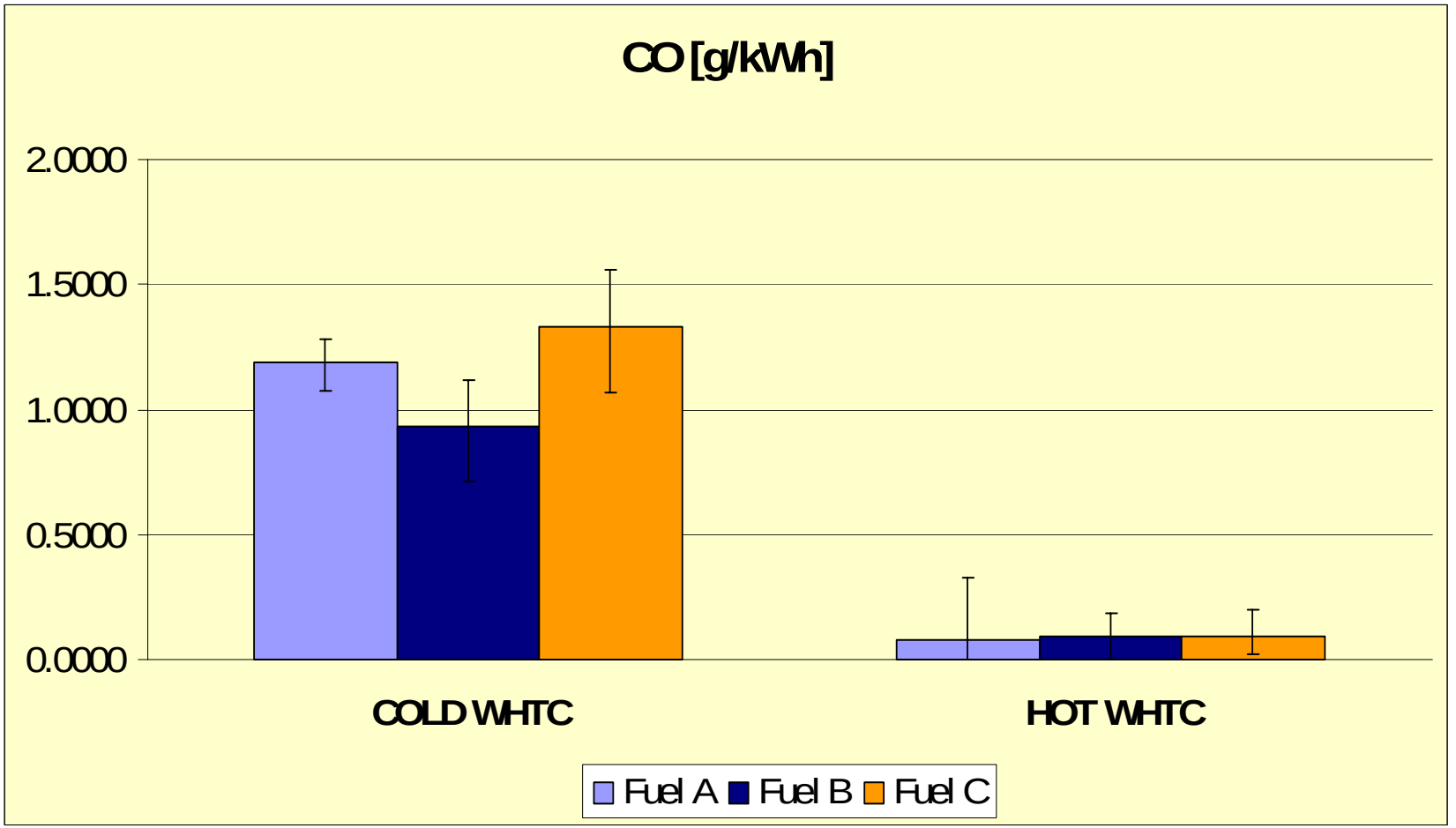
WHTC cycle


Speed [%], Torque [%]
3000
2500
2000
1500
1000
500
0
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
1.0E+00
1.0E-01
1.0E-02
PN [#/cm3]
0
900
1200
1500
1800
Time [s]
Speed
Torque
PN >23nm

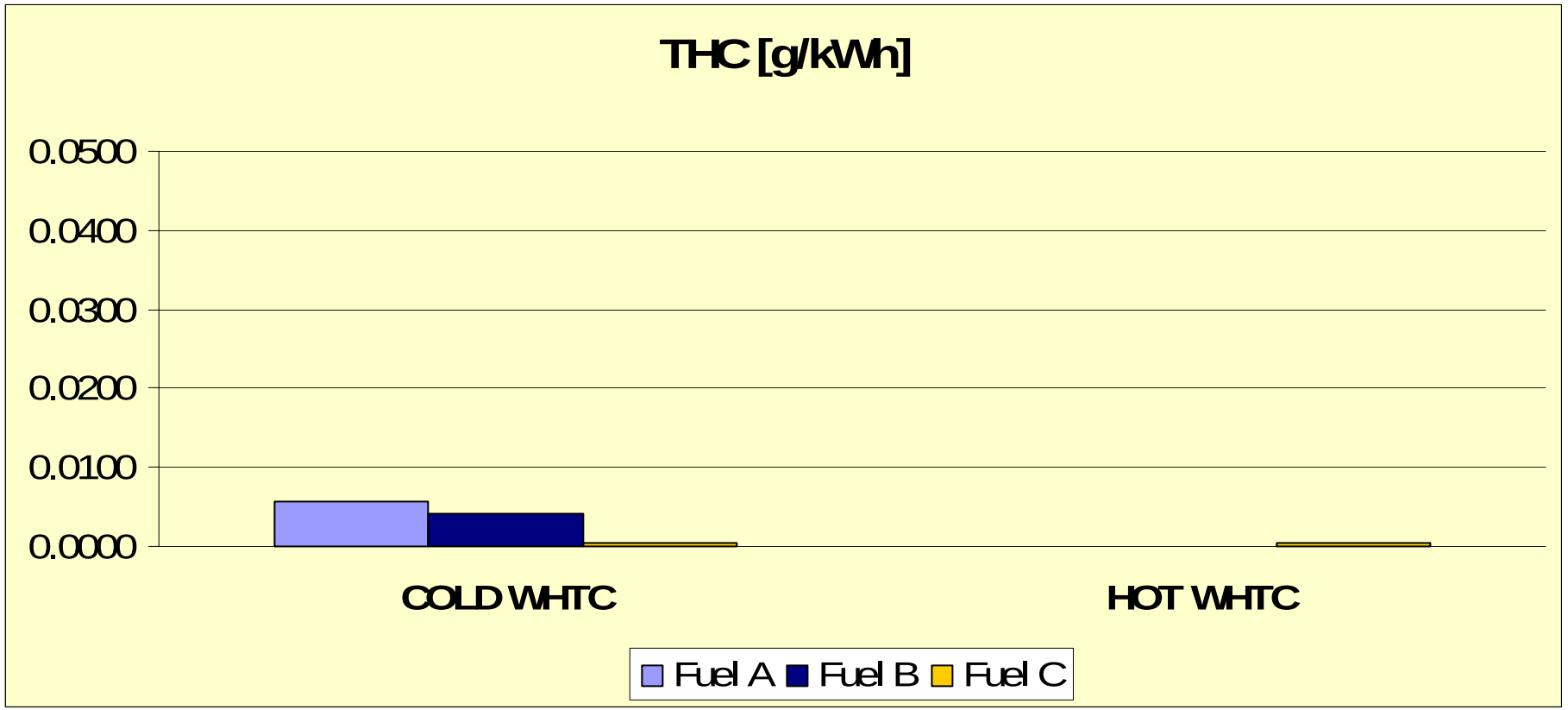
WHTC cycle


CO2 [g/kWh]
750.0000
700.0000
650.0000
600.0000
550.0000
500.0000
COLD WHTC
HOT WHTC
Fuel A
Fuel B
Fuel C

WHTC cycle


CO [g/kWh]
2.0000
1.5000
1.0000
0.5000
0.0000
COLD WHTC
HOT WHTC
Fuel A
Fuel B
Fuel C

WHTC cycle


THC [g/kWh]
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
COLD WHTC
HOT WHTC
Fuel A
Fuel B
Fuel C

Thank you!

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