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Thermal Exploitation of Wastes in Lignite Combustion Facilities

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PTOLEMAIS, GREECE

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INTRODUCTION

The term 'waste wood' is referred to every wooden product that has been used at least for once as commercial product and remains now as waste for disposal or recycling / reuse

- **old or destroyed furniture**
- **demolition and construction wood**
- **boxes and pallets**
- **old power poles**
- **railway sleepers**

WASTE WOOD THERMAL RECYCLING

Advantages:

- The waste wood quantities are equally distributed in all continents, compared to the oil and natural gas reserves
- The wood combustion has neutral CO_2 emissions balance
- The extensive use of waste wood in industrial boilers contributes to the substitution of fossil fuels by a renewable energy source and, consequently, to the preservation of domestic fuel resources
- The European Union is preparing Directives, which will enforce the radical reduction of biodegradable municipal solid waste quantities that are disposed of by landfilling. Therefore, the need for material and energy recovery from waste will become in the near future more and more necessary.

WASTE WOOD POTENTIAL IN GREECE

FUEL CHARACTERISTICS

	Ptolemais Lignite	Uncontaminated Waste Wood	Railway sleepers	Demolition wood	Power Poles	MDF residues
Proximate Analysis (% wt)						
Moisture	60.0	28.2	13.35	15.73	13.35	6.78
Volatiles	23.36	67.49	73.13	74.83	73.13	83.99
Fixed Carbon	12.32	3.70	12.74	7.92	12.74	8.73
Combustibles	35.68	71.19	85.87	82.75	85.87	92.72
Ash	4.32	0.61	0.78	1.52	0.78	0.50
Calorific values (kJ/kg, as received basis)						
Gross	8 160	15 475	16 815	18 620	20 160	18 519
Net	6 314	14 081	15 463	17 188	18 716	17 142

FUEL CHARACTERISTICS

	Ptolemais Lignite	Uncontaminated Waste Wood	Railway sleepers	Demolition wood	Power Poles	MDF residues
Ultimate Analysis (% wt, dry basis)						
C	49.96	39.58	39.29	34.68	45.34	46.49
H	4.65	5.17	4.66	4.41	5.38	5.98
N	1.26	0.08	0.16	0.05	0.18	2.37
S	1.06	0.19	0.0	0.10	0.00	0.30
O *	32.27	54.13	41.77	43.52	48.20	44.32

** by subtraction*

ASH CHARACTERISTICS

Ash analysis % wt	Ptolemais Lignite	Uncontaminated wood	Railway sleepers	Demolition wood	Power Poles	MDF residues
SiO_2	32.08	14.45	13.43	14.45	13.43	3.01
Al_2O_3	9.30	2.71	0.00	1.21	2.50	1.59
Fe_2O_3	7.18	1.61	15.04	4.46	4.50	0.00
MgO	6.67	8.00	2.91	5.05	5.60	10.00
K_2O	0.36	10.04	4.83	17.23	1.75	1.69
Na_2O	0.00	0.17	7.1	1.39	0.74	4.50
CaO	40.00	51.30	54.41	53.79	57.45	63.50
P_2O_5	0.64	2.82	0.72	1.08	0.88	4.50
SO_3	2.06	-	-	-	-	-
Rest	1.71	8.90	1.55	1.34	13.15	11.21

FUEL & ASH CHARACTERISTICS

- Lignite has much higher moisture content which seriously influences the combustibles content and calorific value. Low ash percentages are found in the waste wood samples.
- Values of carbon and hydrogen content are comparable between lignite and waste wood. Negligible sulphur and increased oxygen contents are detected in waste wood.
- CaO has the highest concentration in all samples, while SiO_2 is intensively present in lignite. The increased percentages of alkali metals and the lower content of silica and alumina compounds are anticipated to worsen the fusibility behaviour of waste wood species.

SCOPE OF THE CO-COMBUSTION TESTS

AIM

To prove that firing systems based on moving stoker or fluidised bed technology can thermally recycle a fraction of waste wood at a substantial percentage together with locally available solid fuels.

OBJECTIVES

- to investigate the operation of a pilot CFBC installation and an industrial scale boiler during co-combustion of waste wood and lignite,
- to determine the CO, SO_2, and NO emissions,
- to measure the PCDD/F and heavy metal emissions in the industrial boiler and,
- to correlate gas emissions with the fuel blend properties.

CO-COMBUSTION TESTS AT THE CFBC FACILITY

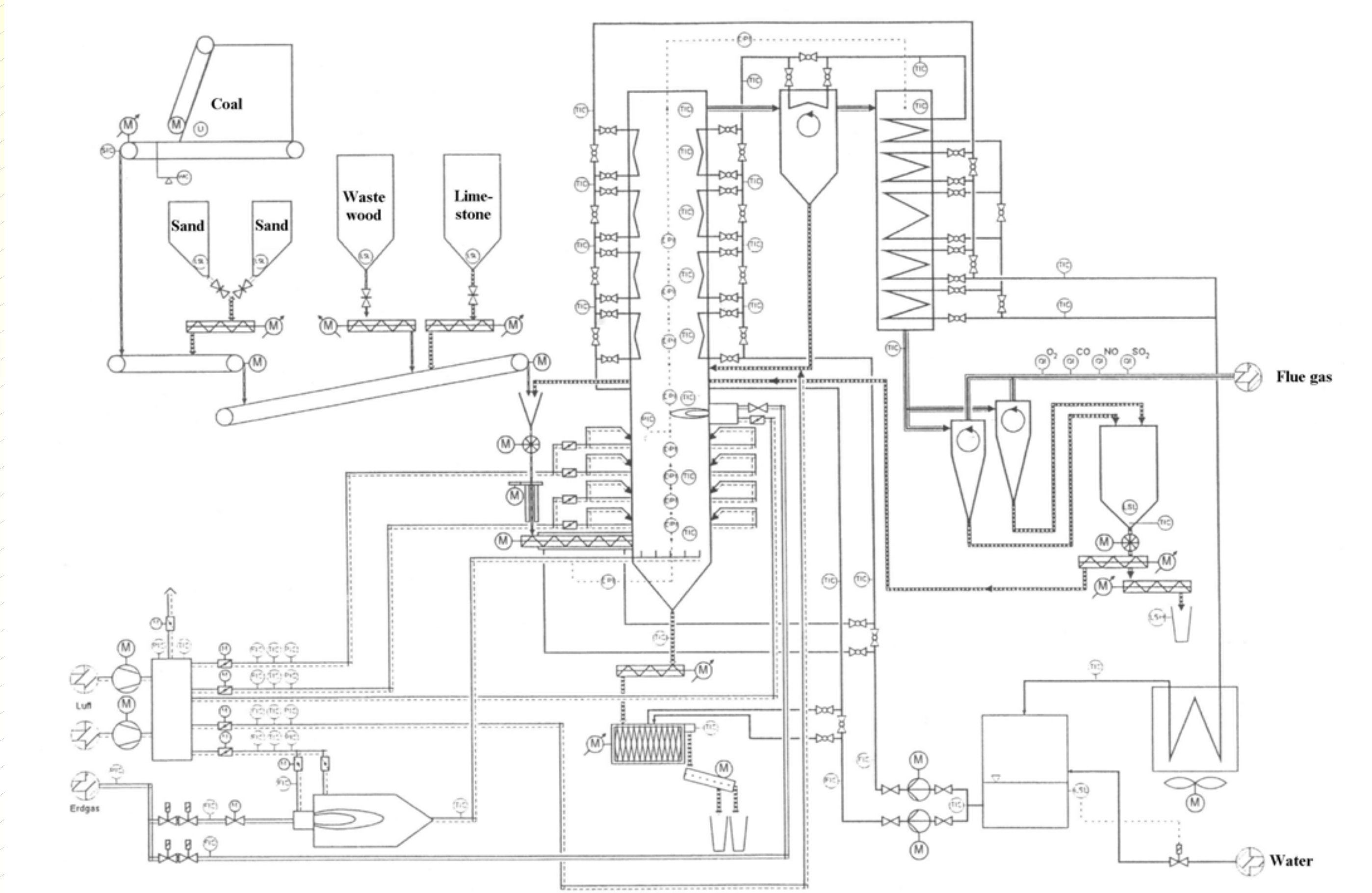


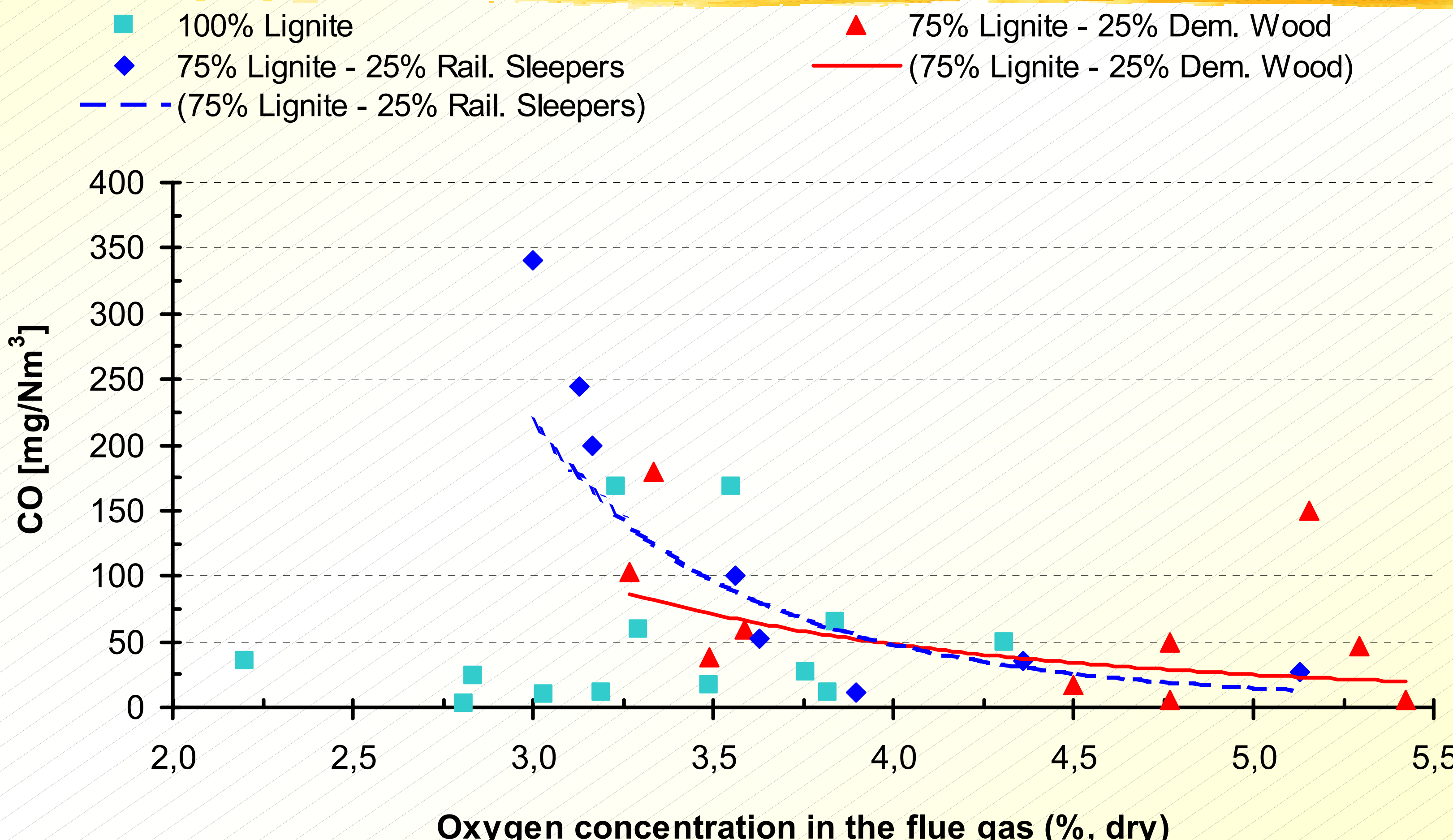
Diagram of the Circulating Fluidised Bed test facility

CO-COMBUSTION TESTS AT THE CFBC FACILITY

Fuel blend	(% weight)	Duration [hh:mm]	Remarks
Lignite	100	05:00	Without limestone
Lignite	100	08:10	Without limestone
Lignite / Railway sleepers	75 / 25	Interrupted	Fuel feeding problems
Lignite / Demolition wood	75 / 25	09:25	Without limestone
Lignite	100	08:13	Without limestone
Lignite / Railway sleepers	75 / 25	08:04	Limestone addition
Lignite / Demolition wood	75 / 25	08:04	Limestone addition
Lignite / Railway sleepers	75 / 25	08:21	Limestone addition
Lignite	100	24:00	Limestone addition in specific time periods
Lignite / Demolition wood	75 / 25	48:14	Limestone addition in specific time periods

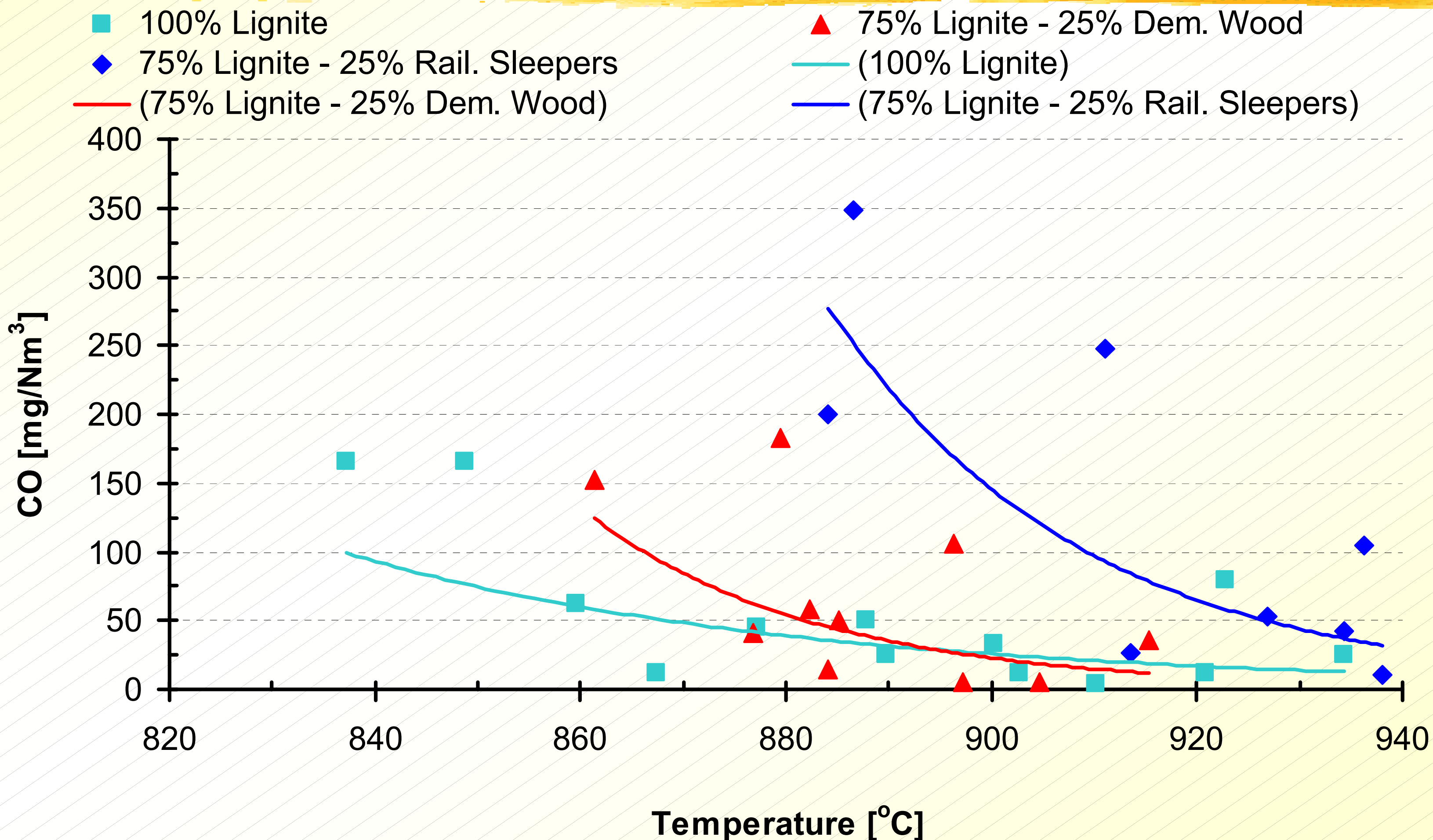
Fuel Test Matrix

CO-COMBUSTION TESTS AT THE CFBC FACILITY



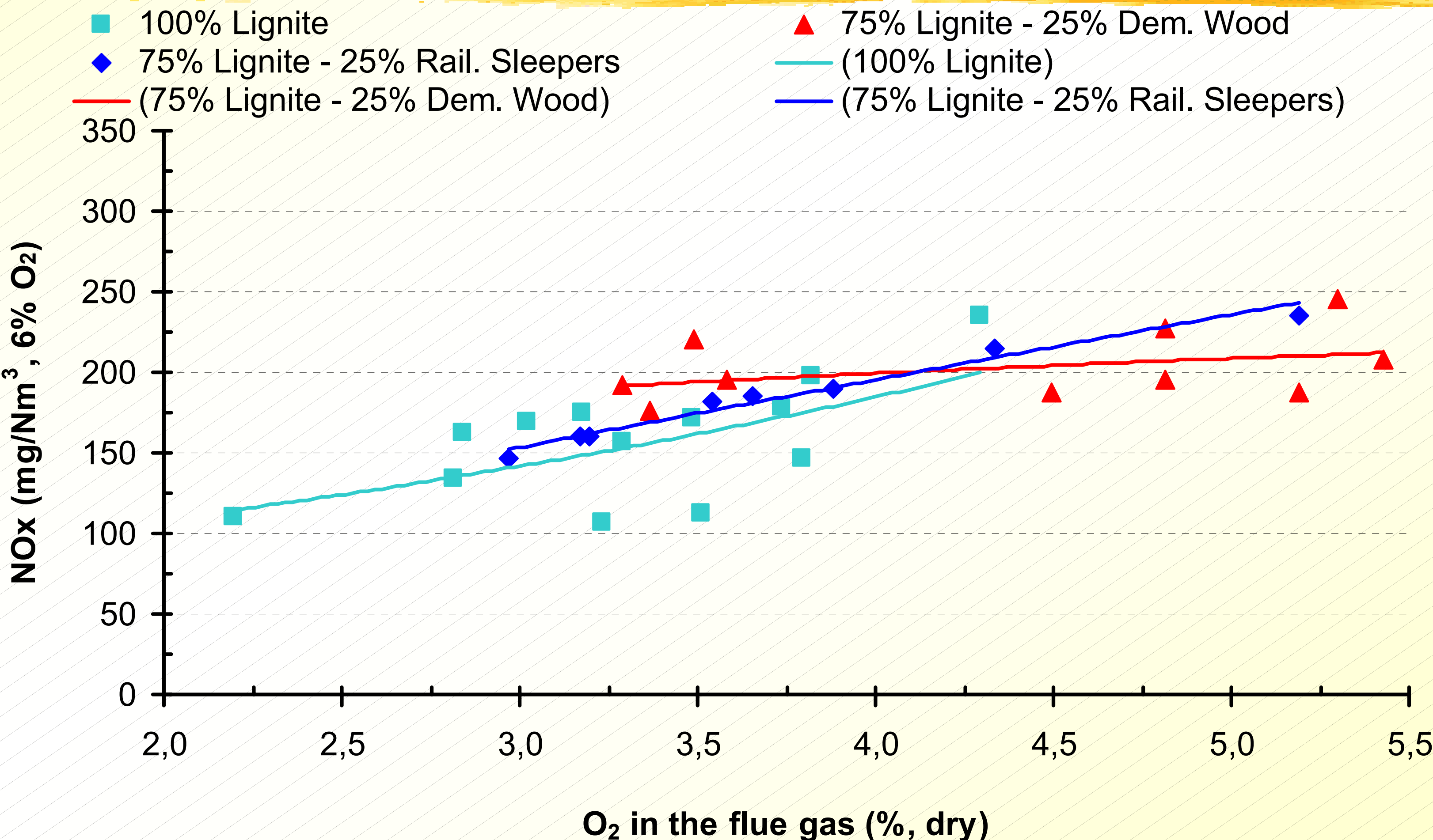
CO emission as a function of O_2 concentration

CO-COMBUSTION TESTS AT THE CFBC FACILITY



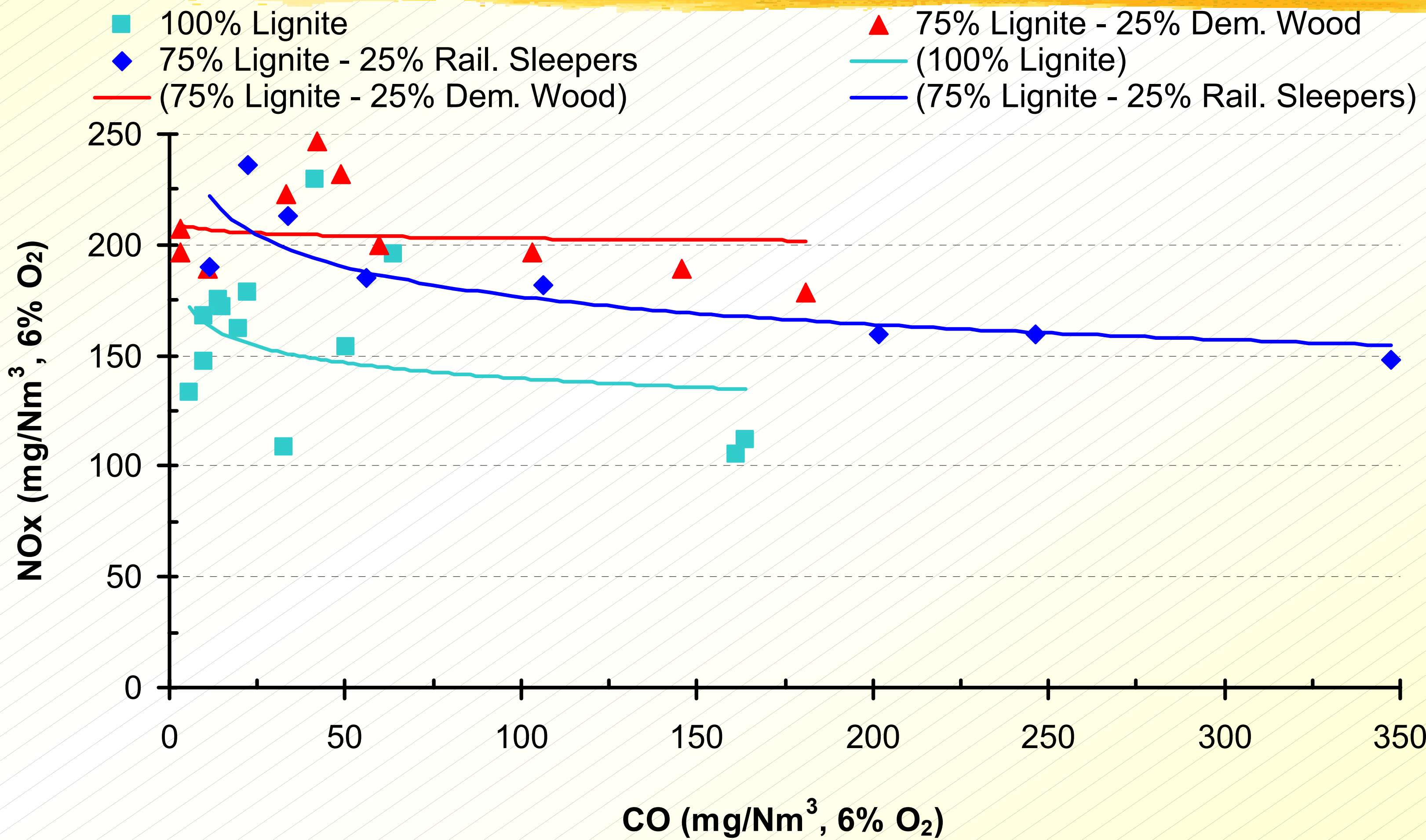
CO emission as a function of bed temperature

CO-COMBUSTION TESTS AT THE CFBC FACILITY



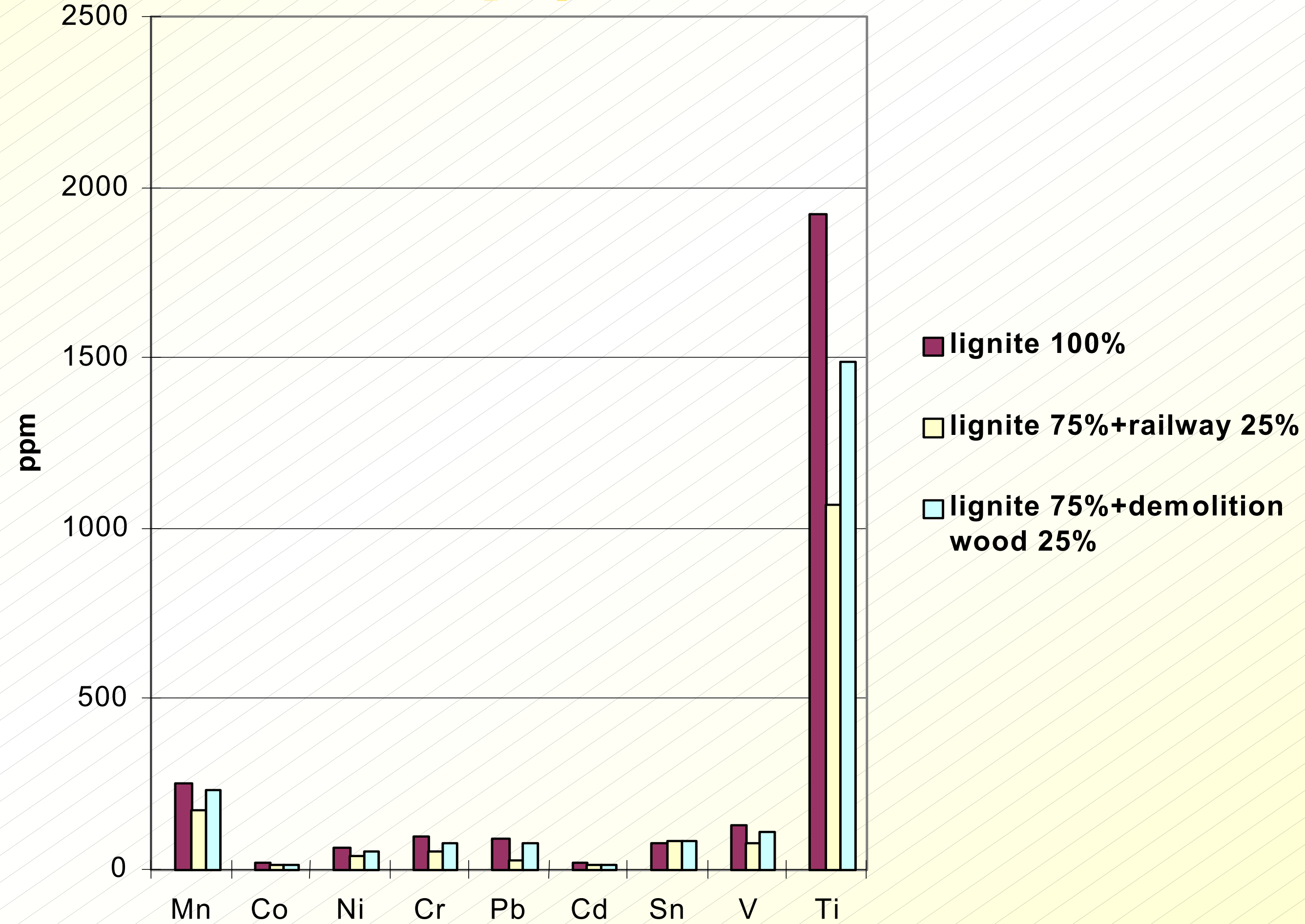
NOx emissions as a function of O_2 concentration in the flue gas

CO-COMBUSTION TESTS AT THE CFBC FACILITY



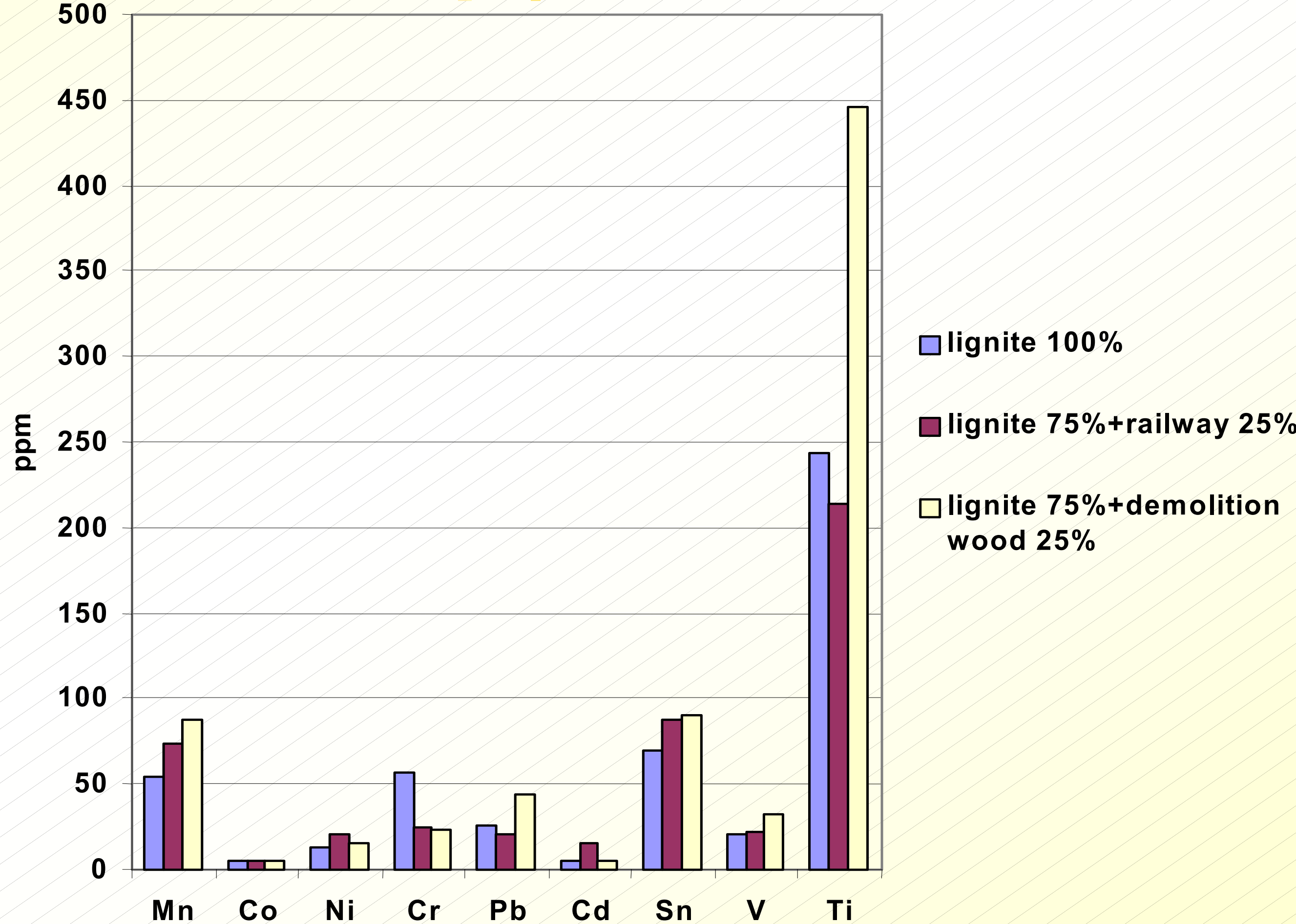
NOx emissions as a function of CO emission

CO-COMBUSTION TESTS AT THE CFBC FACILITY



Heavy metal emissions in the fly ash particles

CO-COMBUSTION TESTS AT THE CFBC FACILITY

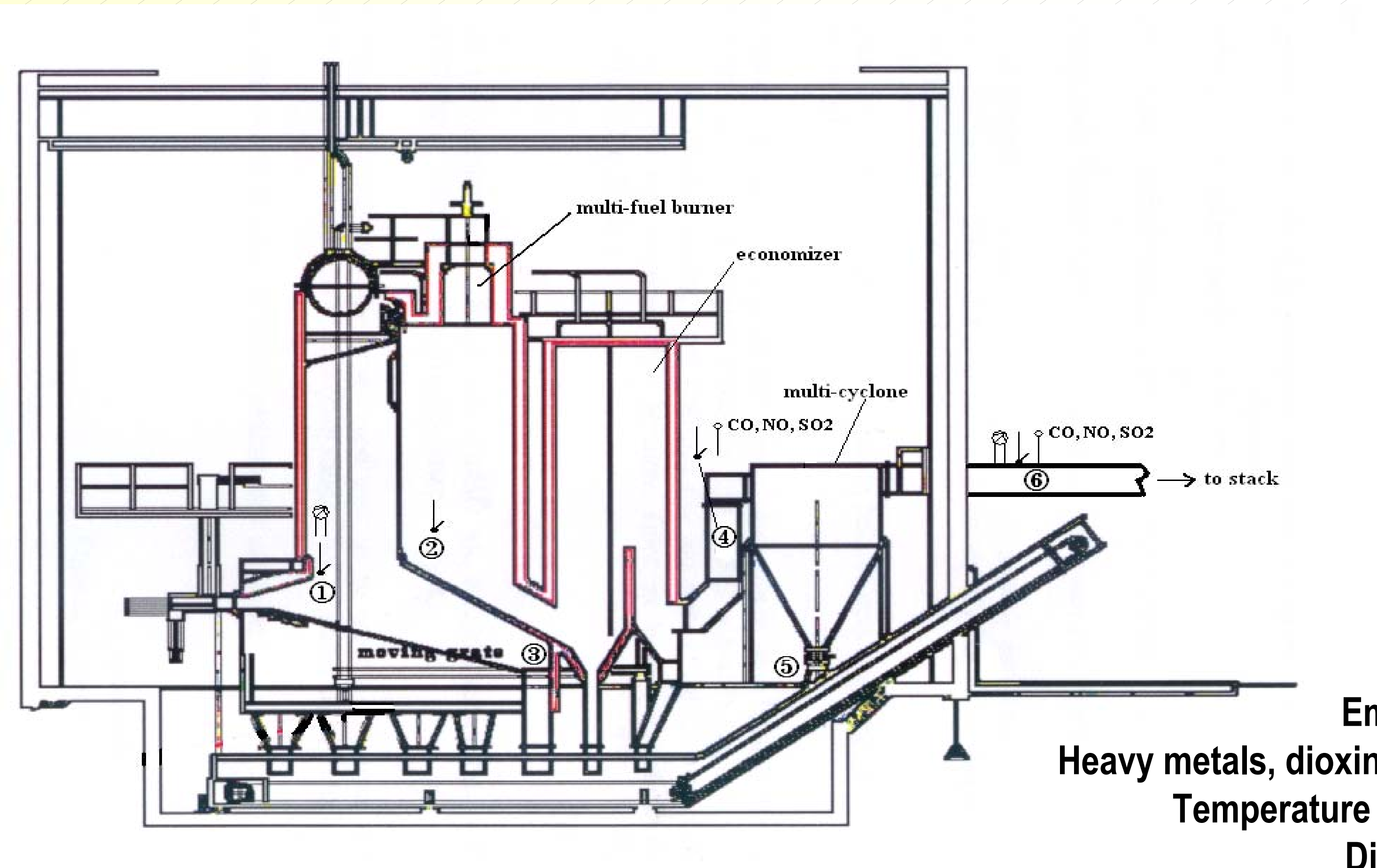


Heavy metal emissions in the ash samples collected from the bed

CO-COMBUSTION TESTS AT THE CFBC FACILITY

- Despite the variations in the moisture content of the xylitic lignite during its burning, CO emission was controlled when the bed temperature raised up to 850 ^{o}C. CO peaks were observed when waste wood and especially railway sleepers were used with lignite, due to fuel handling problems. Higher excess air ratio and bed temperature were applied in this case.
- SO_2 emission was lower than the limit value of 400 mg/ Nm^3, when limestone was used. It is estimated that Ca/S values between 2 - 3 are sufficient for the desulphurisation process.
- NOx emissions were dependent on O_2 concentration and CO emission in all test cases.
- Increased heavy metal concentrations were observed in fly ash particles removed from the filter surface, while titanium was mostly present in ash samples collected from the bed and the combustion chamber.

CO-COMBUSTION TESTS AT THE MOVING STOKER BOILER



Emissions recording: 4,6
Heavy metals, dioxin and furan sampling: 6
Temperature measurements: 1,2,4,6
Differential pressure: 1-6
Ash sampling: 3,5

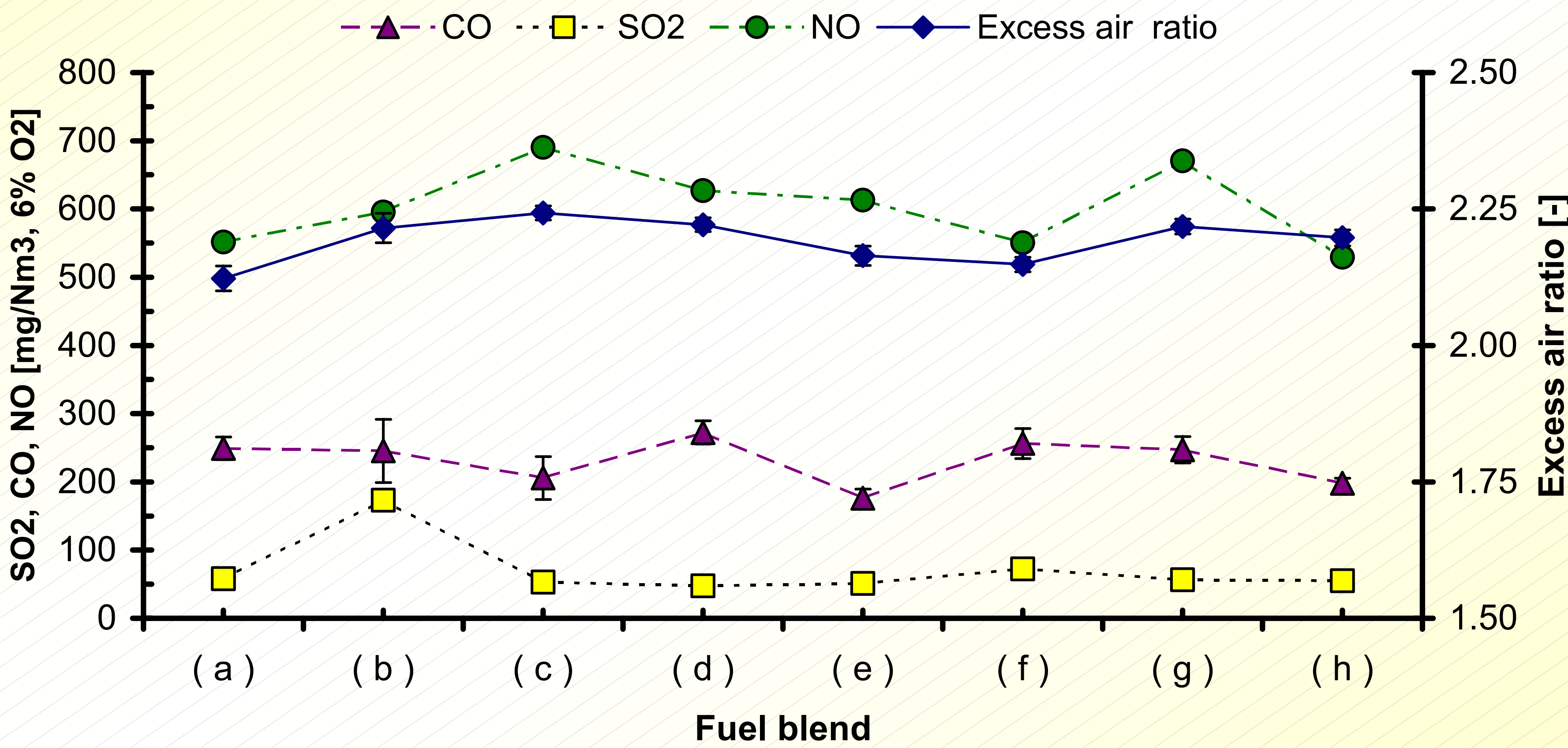
Boiler Configuration

CO-COMBUSTION TESTS AT THE MOVING STOKER BOILER

Fuel blend	Symbol	(% weight)	(% thermal input)
Uncontaminated wood – Lignite	(a)	80 / 20	88.4 / 11.6
Uncontaminated wood – Lignite	(b)	60 / 40	74.1 / 25.9
Uncontaminated wood	(c)	100	100
MDF	(d)	100	100
MDF – Lignite	(e)	80 / 20	90.7 / 9.3
Uncontaminated wood – Lignite – Power poles	(f)	60 / 20 / 20	64.1 / 11.2 / 24.7
Uncontaminated wood – Lignite – MDF	(g)	60 / 20 / 20	62.6 / 10.9 / 26.5
MDF – Lignite – Power poles	(h)	60 / 20 / 20	69.4 / 9.5 / 21.1

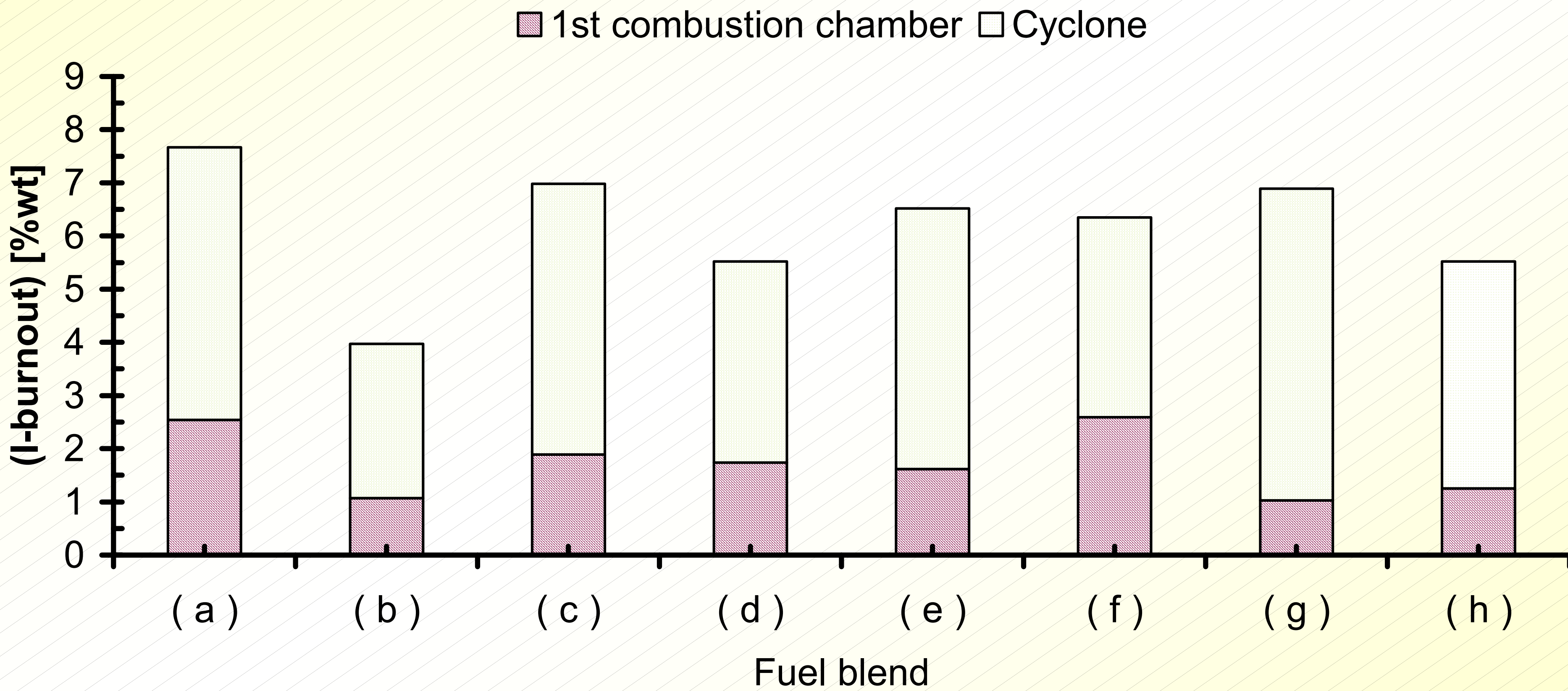
Fuel Test Matrix

CO-COMBUSTION TESTS AT THE MOVING STOKER BOILER



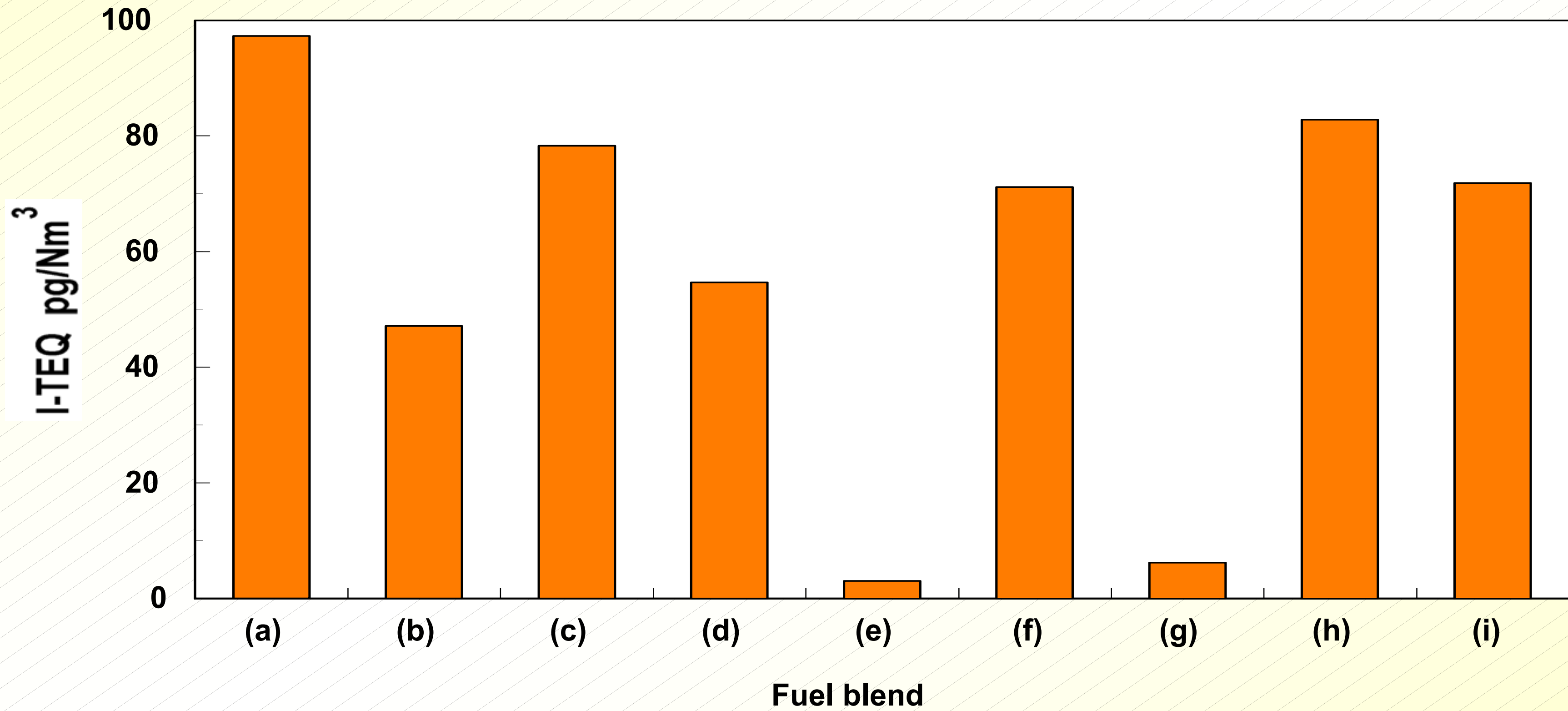
CO, SO_2 and NO emissions

CO-COMBUSTION TESTS AT THE MOVING STOKER BOILER



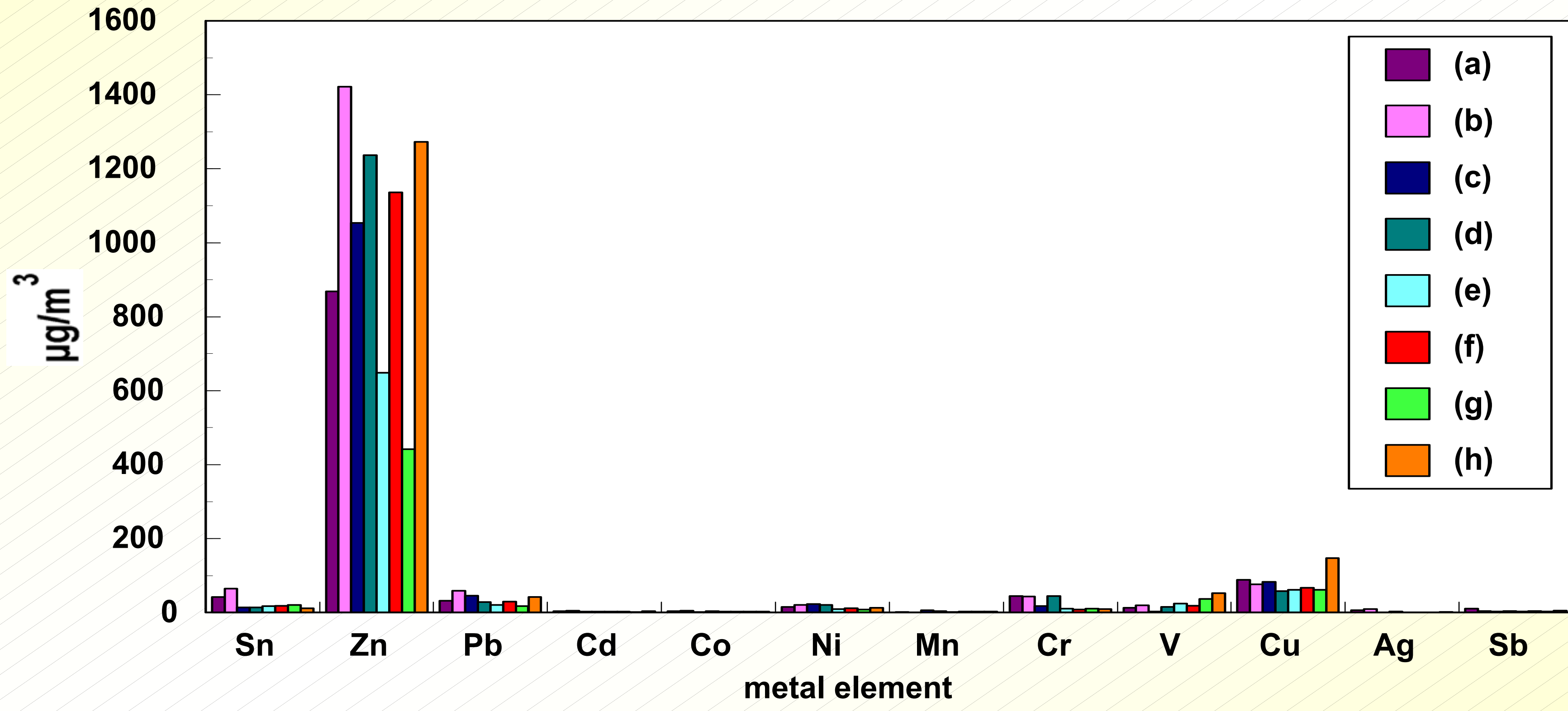
Unburnt fuel content in ash

CO-COMBUSTION TESTS AT THE MOVING STOKER BOILER



I-TEQ values during the co-combustion tests

CO-COMBUSTION TESTS AT THE MOVING STOKER BOILER



Heavy metal emissions in the flue gases

CO-COMBUSTION TESTS AT THE MOVING STOKER BOILER

Emissions and Combustion Efficiency

- The values of CO emissions confirm the results for the unburnt fuel content of the ash samples collected during the tests and do not deviate much from the reference values of the uncontaminated wood/lignite blends
- The use of MDF instead of uncontaminated wood in the fuel blend with lignite brought about a slight improvement of the combustion efficiency
- The unburnt fuel content was decreased when the lignite percentage in the fuel blend was increased
- NO emissions were directly dependent on the operating conditions and especially the excess air ratio

CO-COMBUSTION TESTS AT THE MOVING STOKER BOILER

Emissions and Combustion Efficiency (continued)

- SO_2 emissions were negligible in all the test cases and they were only slightly increased when the lignite percentage was increased, as a result of the fuel's higher sulphur content.
- PCDD/F emissions were below the legislative limit value of 0.1 TEQ ng/Nm^3, with the lowest values obtained for the lignite-MDF dust mixture. Lower chlorinated compounds predominated over the higher ones, similar to typical combustion profiles.
- Metal elements emissions in the flue gases and the solid residues were lower than anticipated from the guidelines. Zinc and iron were found in the highest concentrations.

DEMONSTRATION OF THE CO-COMBUSTION MODE

Six-month operation mode with the co-combustion of MDF / Lignite / Uncontaminated wood in the proportion of 60 / 20 / 20 (%weight).

No significant problems in the boiler operation, concerning the emitted pollutants, the fuel transportation system, the ash removal system and the gas cleaning equipment were observed.

Consequently, in case of the systematical co-combustion performance, there will be no need for:

- ✓ waste gas scrubbing, and
- ✓ additional maintenance costs of the boiler

CONCLUSIONS

- ✓ The co-combustion of waste wood and lignite is technically feasible in industrial facilities with moving grate or fluidised bed furnace, meeting in parallel the legislative limits for the pollutant emissions.
- ✓ Waste wood is a promising option for industrial and district heating boilers. This is particularly true for wood processing industries.
- ✓ The development of solid waste management companies, which will collect and transform the waste wood into an easy to handle bio-fuel, will contribute significantly to the increase of the share of waste wood combustion in the energy balance of Greece.