

48th IEA-FBC workshop

***Future challenges for waste combustion
and co-combustion in FBC***

Combustion of MBM in Fluidized Bed

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Outline

- Introduction
- Aim
- Experimental Work
- Results
- Conclusions
- Acknowledgment

Introduction

- Feeding Meat and Bone Meal (MBM) to cattle, sheep or goats has been banned within the EU since 1 of July 1994. The quantities to be eliminated are measured in millions of tons.
- Disposal to landfill is not an option, as simply burying the material cannot destroy any potential Bovine Spongiform Encephalopathy (BSE) pathogens.

Introduction

- One disposal option is the co-combustion of coal and MBM, to ensure that any living organism is totally destroyed and at the same time valorising its energetic potential.
- Fluidised Bed Co-combustion is considered as it has the ability of being able to combust coal and other materials in an efficient way, at lower temperatures (750-850°C) with lower pollutant emissions.

Aim

- This experimental work aims at determining the optimum parameters for the co-combustion of MBM and coal, as well as its environmental impact through the monitorisation of ashes and gases.

Experimental Work

Fuel Analysis

Combustion Tests

Flue Gas Characterization

Biological Effects

MBM

Coal - Cerejon

1st run – 100%MBM

2nd run– 50%Coal-50%MBM

3rd run– 80%Coal-20%MBM

4th run– 100%Coal

Protein Resistance to Combustion

Eco-Toxicity

Fuel Analysis

MBM

Coal - Cerejon

XRF – Qualitative Analysis

Proximate Analysis

Ultimate Analysis

Heavy Metals

MBM

XRF – Qualitative Analysis

Principal Elements	Ca			
Trace Elements	Fe	P	Cl	
	Zn	Sr		
Possible Presence	S	K		

Proximate Analysis

MBM

Parameter	Method	
Moisture (a.r.) (% w/w)	Gravimetric	6.8
Ash (a.r.) (% w/w)	Gravimetric	34.4
Volatile matter (a.r.) (% w/w)	NP 3423	32.7
Fixed Carbon (a.r.) (% w/w)	(difference)	26.1
HHV (a.r.) (kJ/kg)	ASTM D 5865	14190
LHV (a.r.) (kJ/kg)	ASTM D 5865	13065

Proximate Analysis

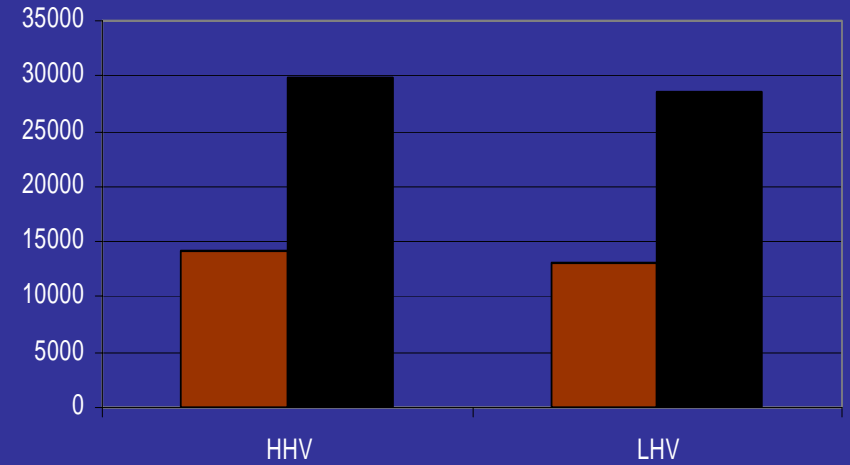
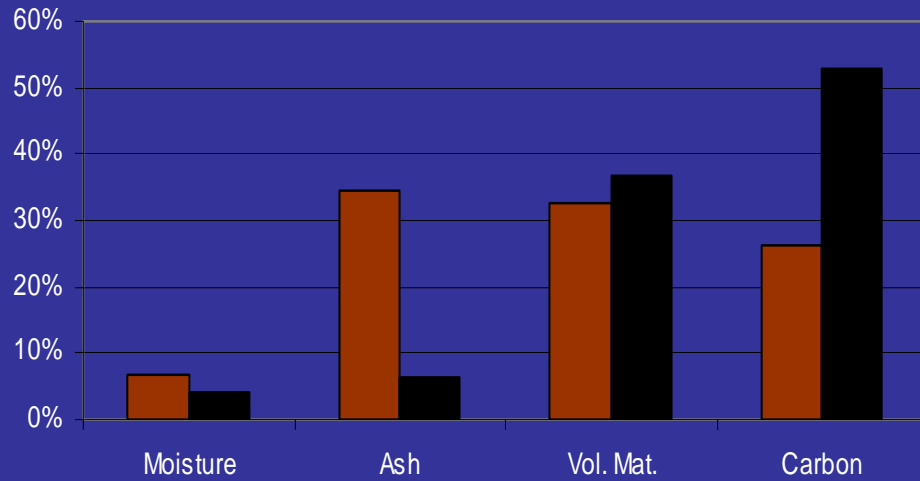
Coal - Cerejon

Parameter	Method	
Moisture (a.r.) (% w/w)	Gravimetric	4.2
Ash (a.r.) (% w/w)	Gravimetric	6.2
Volatile matter (a.r.) (% w/w)	NP 3423	36.6
Fixed Carbon (a.r.) (% w/w)	(difference)	53.0
HHV (a.r.) (kJ/kg)	ASTM D 5865	29780
LHV (a.r.) (kJ/kg)	ASTM D 5865	28590

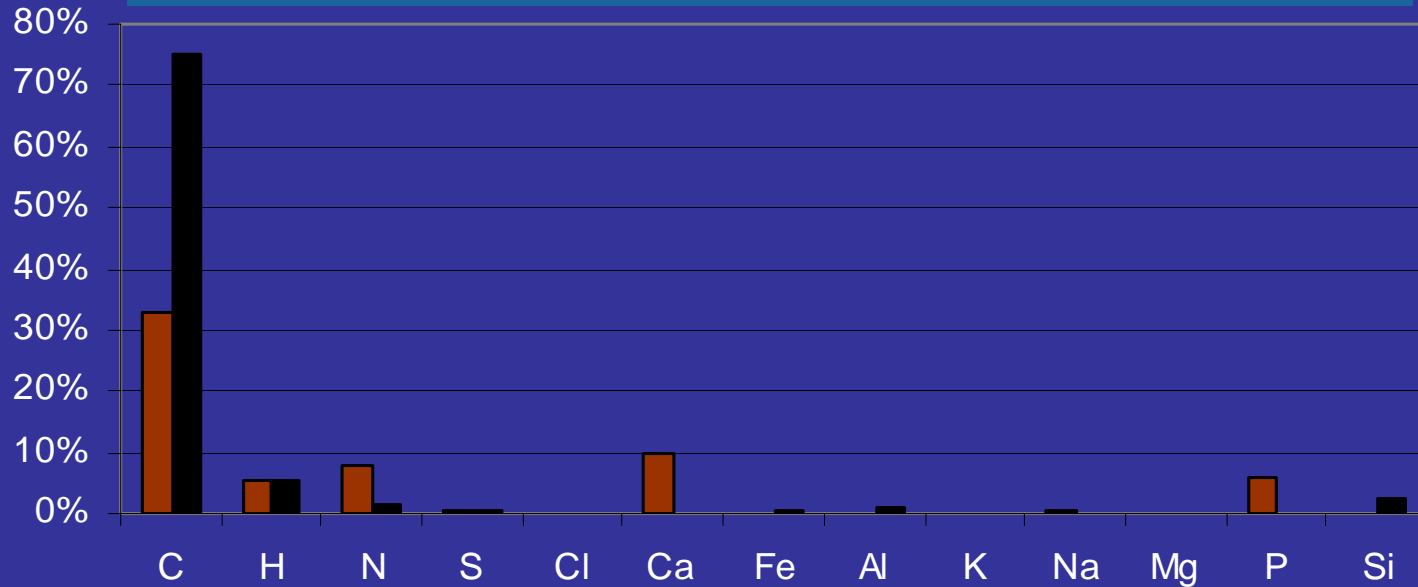
Ultimate Analysis

MBM		Coal - Cerejon
(a.r.) %		
C	32.9	75
H	5.3	5.6
N	7.8	1.4
S	0.28	0.7
Cl	0.24	<(LQ=0.05)
Ca	9.9	0.15
Fe	0.03	0.46
Al	<(LQ = 0.02)	0.77
K	0.24	0.17
Na	0.51	0.09
Mg	0.23	0.12
P	6.0	0.04
Si	<(LQ = 0.15)	2.58

Proximate Analysis



Ultimate Analysis

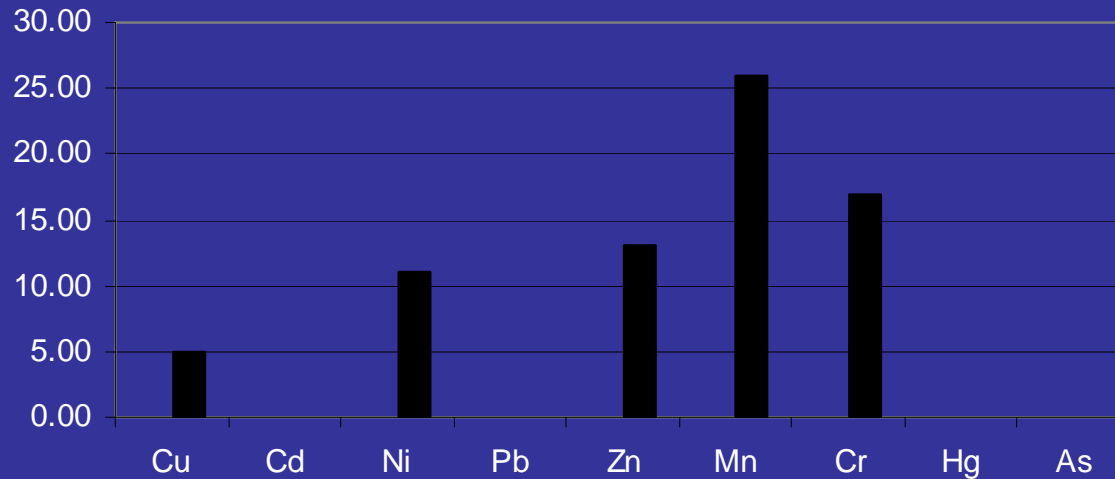


Heavy Metals

MBM

Coal - Cerejon

(a.r.) % mg/kg		
Cu	< (LQ = 5)	5
Cd	< (LQ = 5)	<(LQ=2.5)
Ni	< (LQ = 5)	11
Pb	< (LQ = 5)	<(LQ=2.5)
Zn	< (LQ = 5)	13
Mn	< (LQ = 5)	26
Cr	< (LQ = 5)	17
Hg	< (LQ = 0.003)	0.05
As	< (LQ = 25)	5



Combustion Tests

1st run – 100% MBM



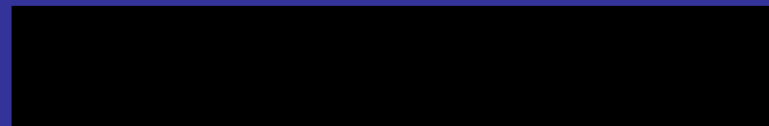
2nd run– 50% MBM- 50% Coal



3rd run– 20% MBM- 80% Coal



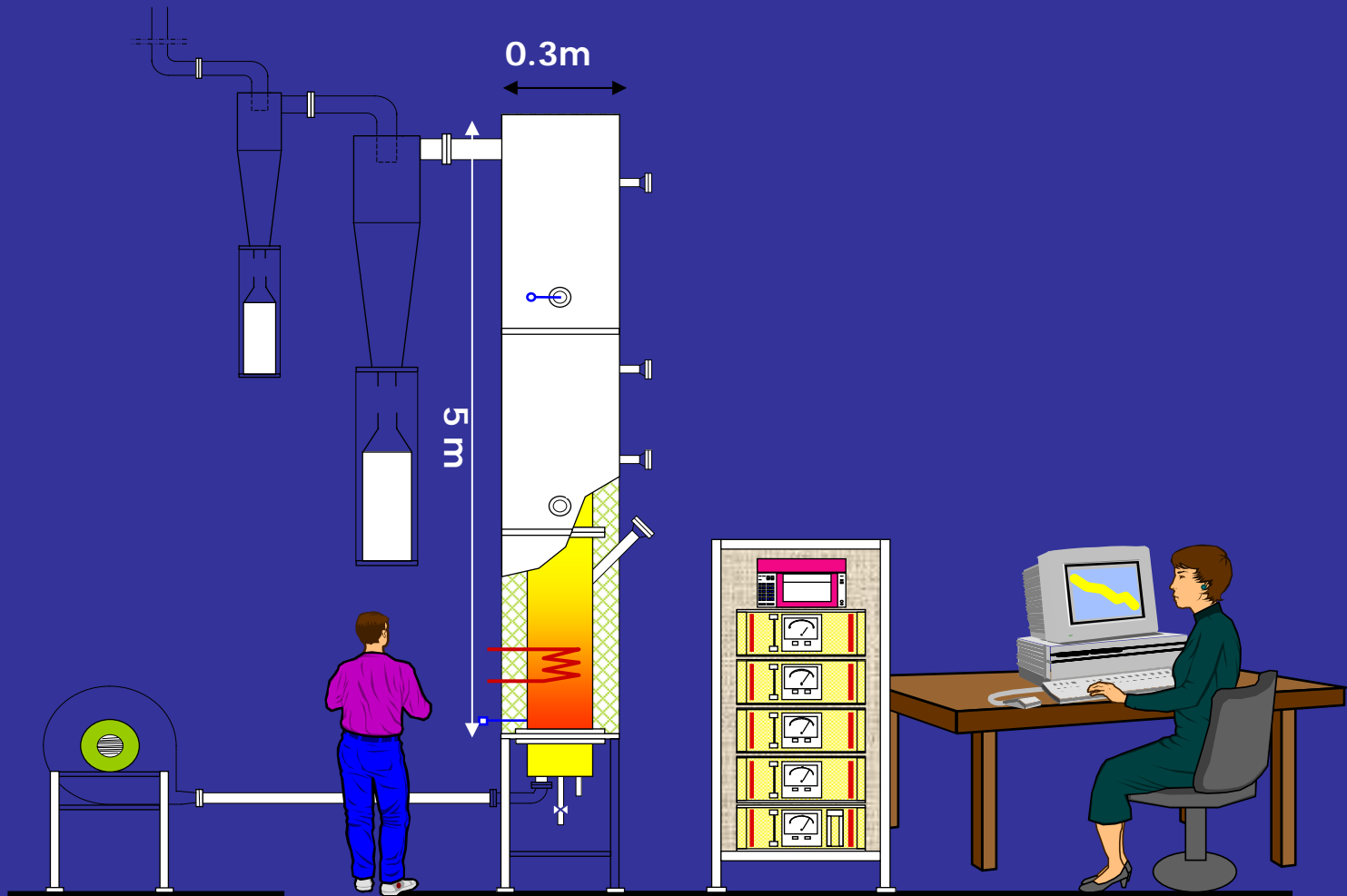
4th run– 100% Coal

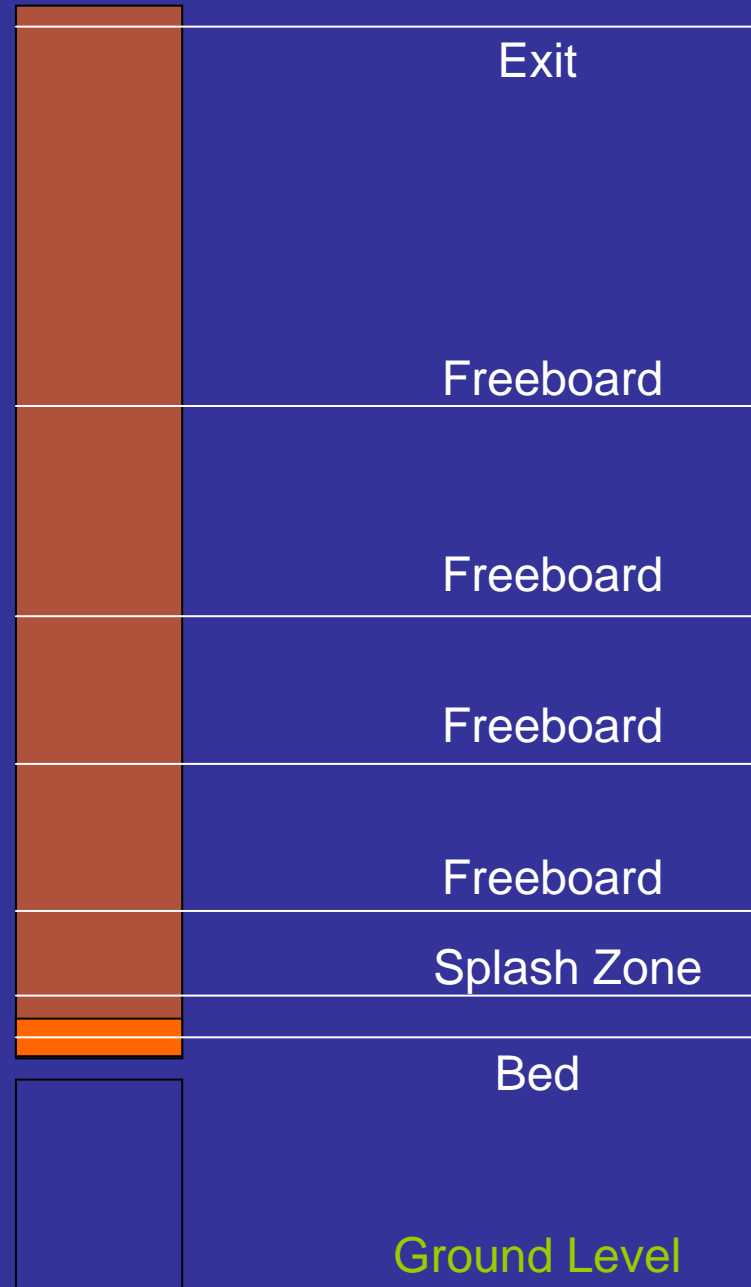
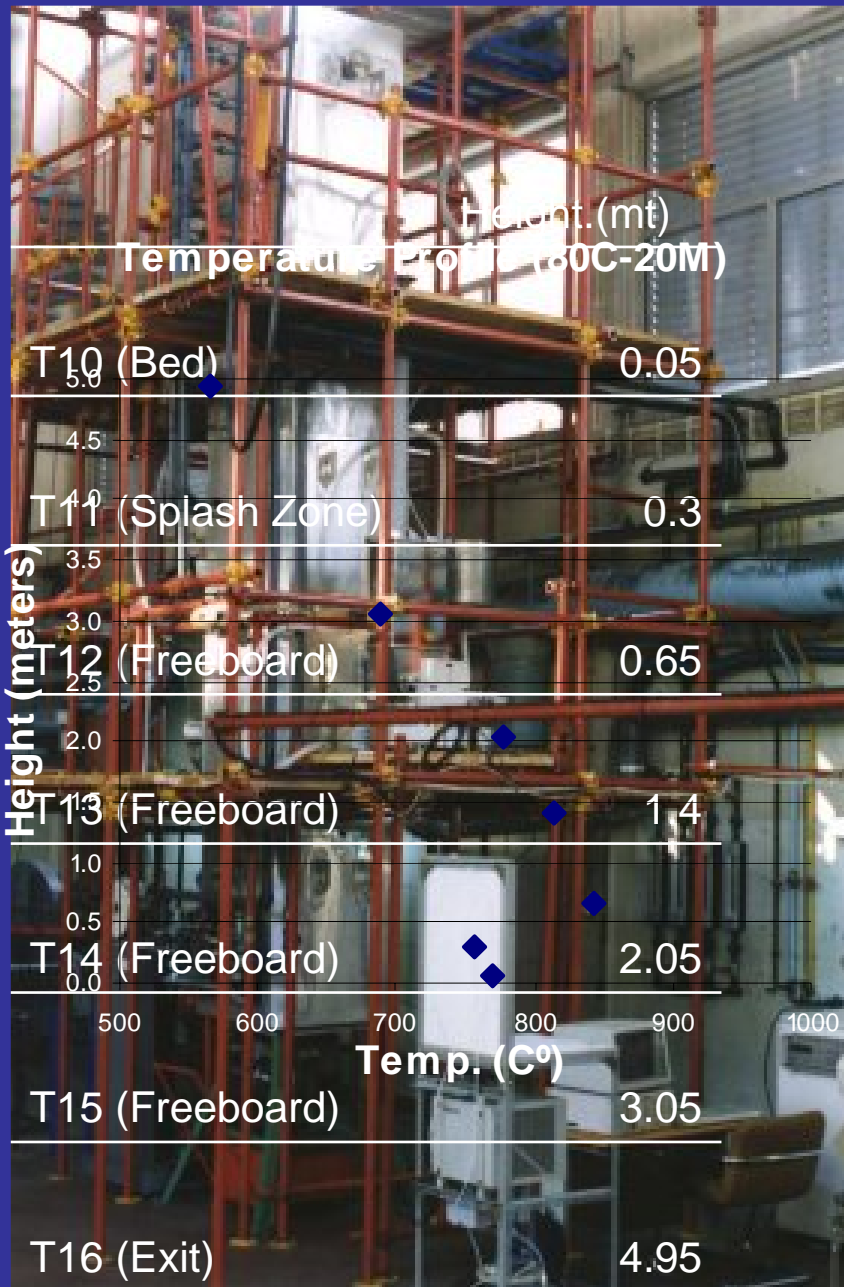


Coal - Cerejon

MBM

The Fluidized Bed Facility



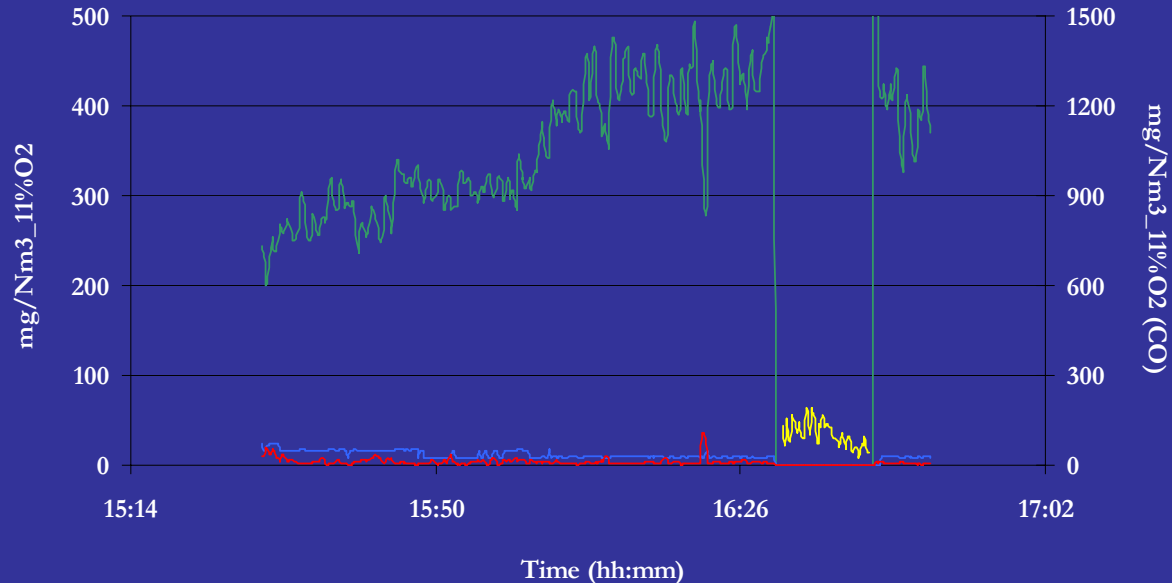
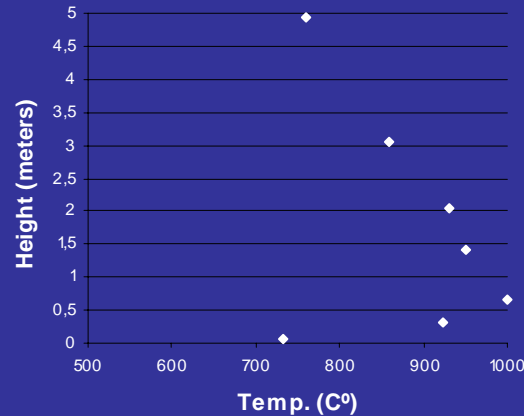


Combustion Tests

1st run – 100% MBM

Mass	
Feeding Rate	16.5 kg/h
Mass of Burned Fuel	72.41 kg
Total Ash Collected	21.3 kg
Ash Rate	29%
Flow	
Fluidization Speed	0.81 m/s
Total Air Flow	110.7 Nm ³ /h
Air 1	58%
Air 2	42%
Concentrations*	mg/Nm ³
CO	8
N ₂ O	37
NO _x	398
SO ₂	14
VOC's	10

Temperature Profile (100M)



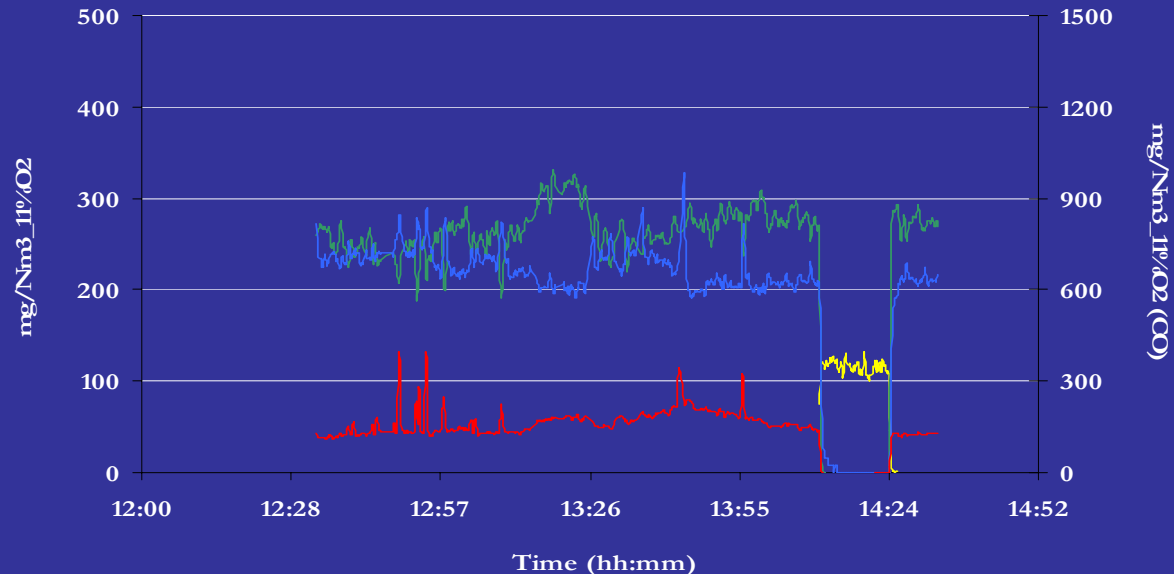
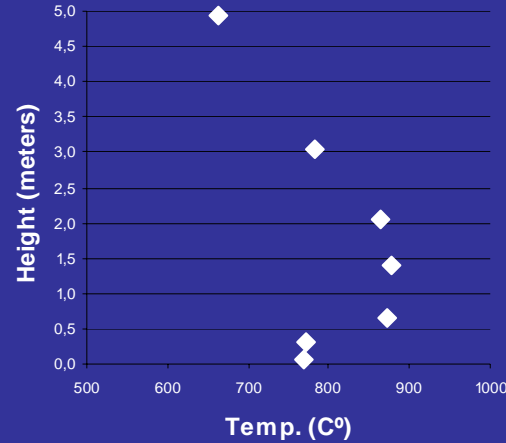
— N₂O — NO_x — SO₂ — CO

Combustion Tests

2nd run— 50% MBM- 50% Coal

Mass	
Feeding Rate	11.72 kg/h
Mass of Burned Fuel	52.62 kg
Total Ash Collected	14.58 kg
Ash Rate	28%
Flow	
Fluidization Speed	1 m/s
Total Air Flow	110Nm ³ /h
Air 1	72%
Air 2	28%
Concentrations*	mg/Nm ³
CO	165
N ₂ O	115
NO _x	273
SO ₂	321
VOC's	4

Temperature Profile (50C-50M)



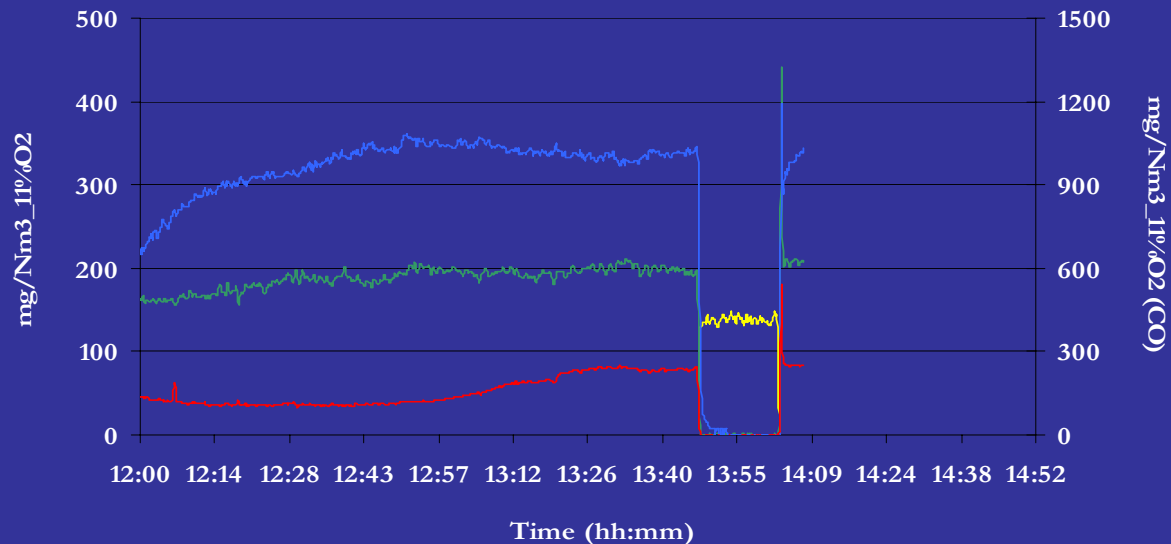
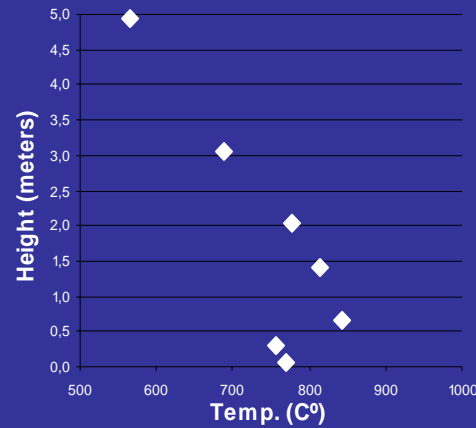
— N₂O — NO_x — SO₂ — CO

Combustion Tests

3rd run— 20% MBM- 80% Coal

Mass	
Feeding Rate	10.51 kg/h
Mass of Burned Fuel	36.23 kg
Total Ash Collected	7.5 kg
Ash Rate	21%
Flow	
Fluidization Speed	1.13 m/s
Total Air Flow	112.5 Nm3/h
Air 1	79%
Air 2	21%
Concentrations*	mg/Nm3
CO	281
N2O	139
NOX	201
SO2	502
VOC's	6

Temperature Profile (80C-20M)



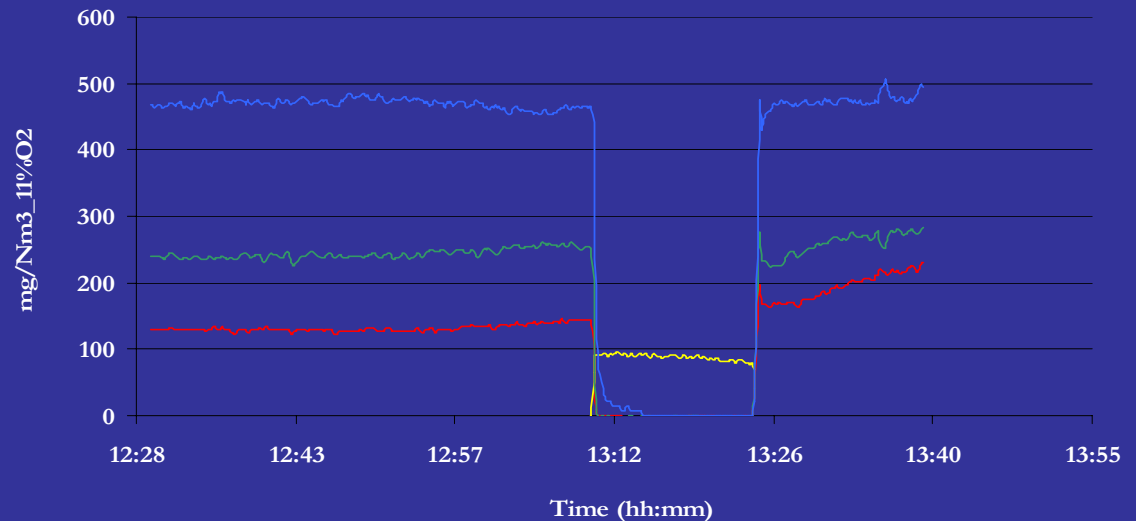
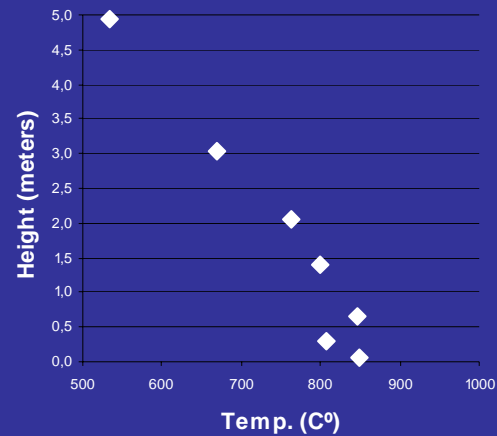
— N2O — NOX — SO2 — CO

Combustion Tests

4th run– 100% Coal

Mass	
Feeding Rate	9.76 kg/h
Mass of Burned Fuel	35.64 kg
Total Ash Collected	5.85 kg
Ash Rate	16.5%
Flow	
Fluidization Speed	1.13 m/s
Total Air Flow	108.6 Nm ³ /h
Air 1	82%
Air 2	18%
Concentrations*	mg/Nm ³
CO	270
N ₂ O	86
NO _x	259
SO ₂	713
VOC's	2

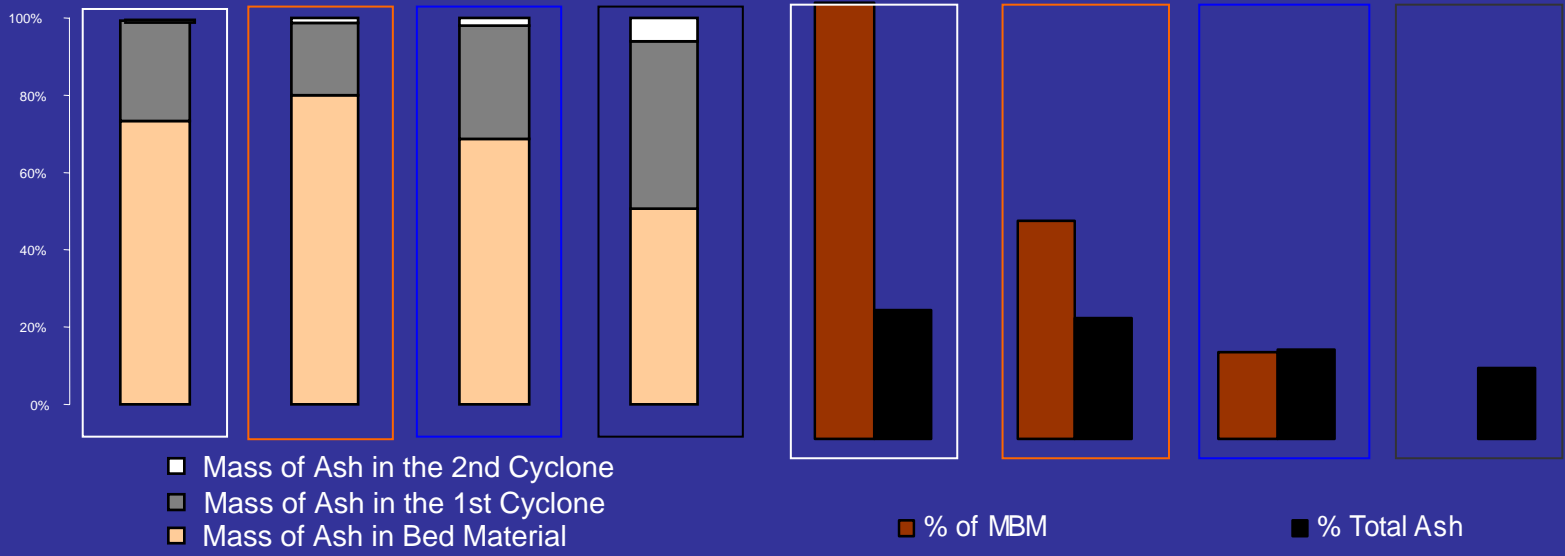
Temperature Profile (100C)



— CO — N₂O — NO_x — SO₂

Ash Distribution for the 4 Runs (%)

Total Ash % on the 4 Runs



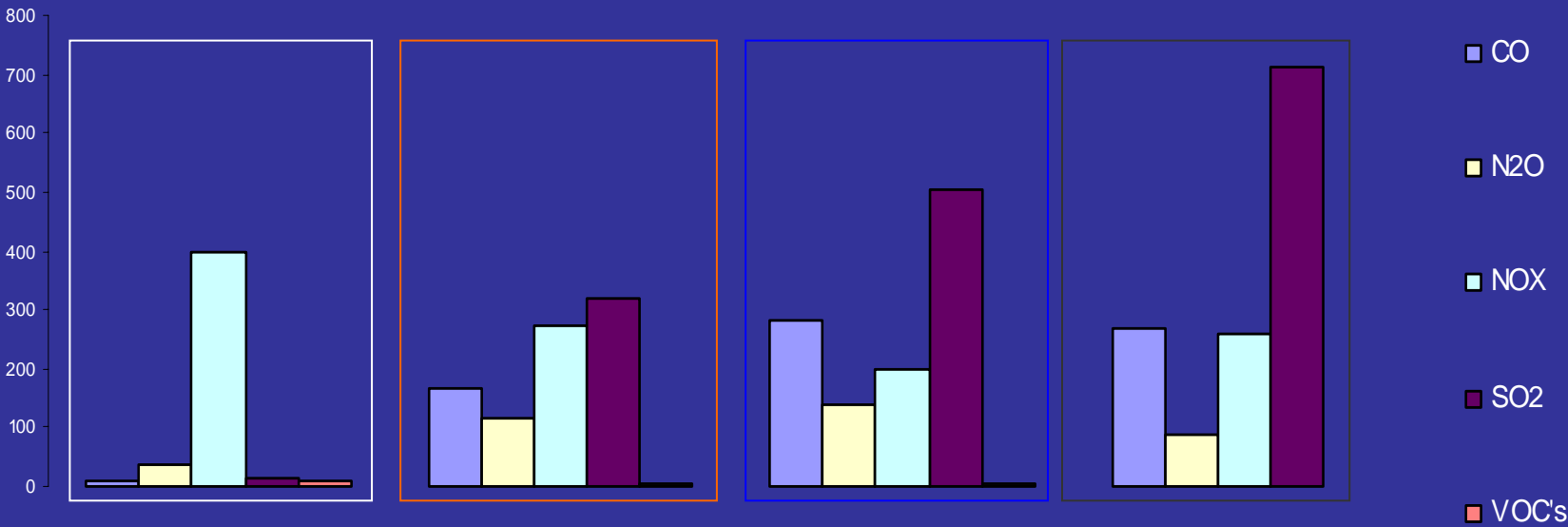
**100
MBM**

**50%
MBM
50%
Coal**

**20%
MBM
80%
Coal**

**100%
Coal**

Average Flue Gas Concentration mg/Nm3 (4 Runs)



Stack Gas Emission Characterization

1st run– 100%MBM

2nd run– 50%Coal-50%MBM

3rd run– 80%Coal-20%MBM

4th run–100%Coal



Operational Parameters

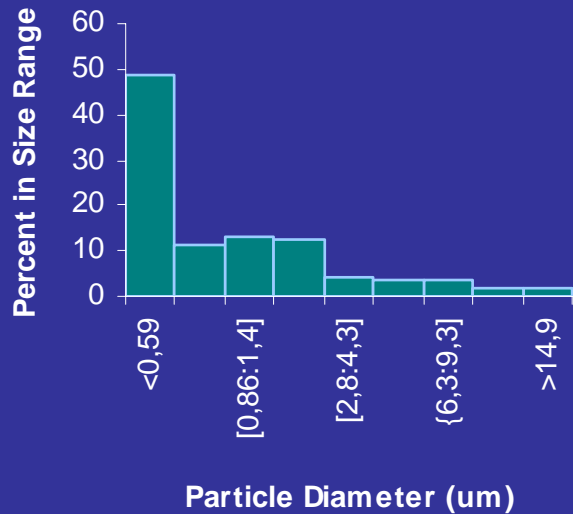
	100MBM	50C50MBM	20MBM80C	100COAL
O₂ (%) (V/V)	12.5	9.5	7.0	9
CO₂ (%) (V/V)	8.2	10.7	11.6	12.2
Moisture in Gases(%) (V/V)	4.71	4.63	4.66	4.68
Molecular Mass (g/mol)	29.26	29.25	30.37	28.68
Gas Temperature (°C)	157.1	151.6	158.6	110.2
Stack Gas Velocity (m/s)	2.44	2.39	2.52	2.16
Dry Gas Flow Rate (Nm³/h)	183.9	182.7	189.6	182.8

Stack Gas Emission Concentrations

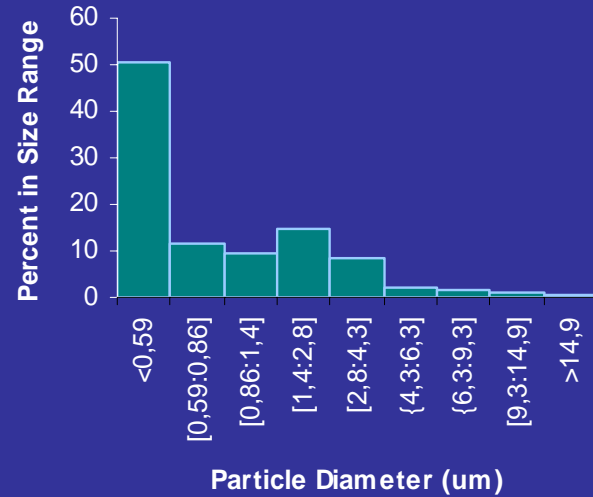
	100MBM	50C50MBM	20MBM80C	100COAL
TSP	391.9	88.2	117.5	122.2
SO ₂	14	321	502	713
NO _x	398	273	201	259
CO	8	165	239	203
VOC	10	4	6	2
Cl ⁻	21.0	93.1	39.8	8.1
F ⁻	<LQ	<LQ	<LQ	<LQ
Cd	0.001	0.001	0.000	0.002
Cr	0.547	0.093	0.115	0.024
Cu	0.068	0.038	0.026	0.025
Ni	0.013	0.110	0.062	0.017
Pb	0.069	0.059	0.022	0.016
Zn	-	0.003	0.006	-
Mn	0.004	0.029	0.026	0.025

Particle Size Analysis of TSP in Stack

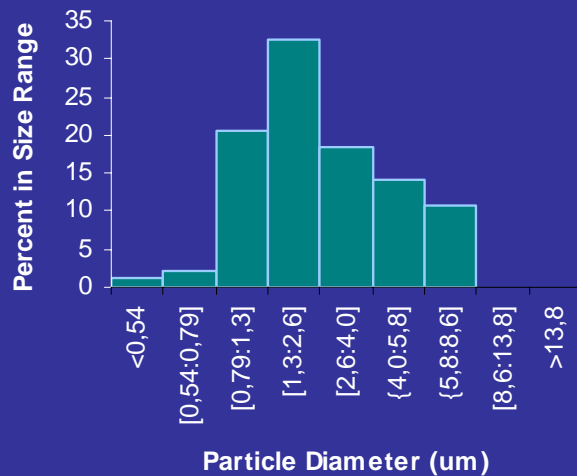
1st run– 100%MBM



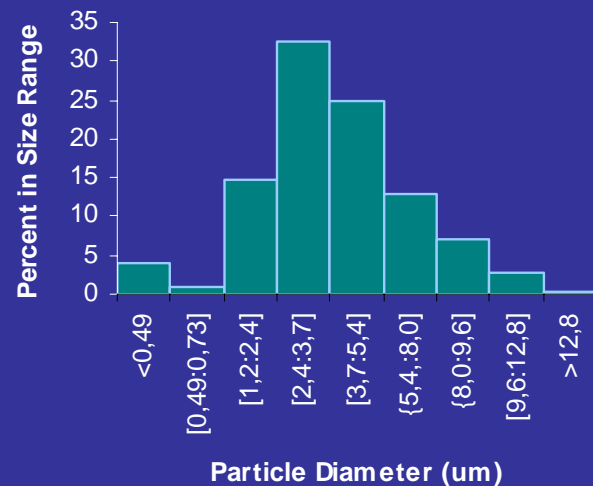
2nd run– 50%Coal-50%MBM



3rd run– 80%Coal-20%MBM



4th run–100%Coal



Biological Effects

Protein Resistance to Combustion

Eco-Toxicity

Protein Resistance to Combustion

1st run– 100%MBM

Sample - MBM

Ash

Bed Material

Eco-Toxicity

Eluates - DIN 38414-S4,1984

Microtox (Microbics,1994)

Determinação da inibição da bioluminescência da bactéria *Vibrio fischeri* (CE50-5min).

Conclusions

- Co-combustion tests of coal and MBM were carried out at INETI, at a FBC at pilot scale, to investigate the combustion efficiency by modifying the following conditions: coal/meet bone ratio in the feeding, bed temperature, freeboard temperature, excess air levels and primary/secondary air ratios.
- It was found that the co-combustion of coal with MBM was feasible, with minor impact on the emissions and particularly the NO_x , N_2O , VOC, CO_2 , and also on the composition of the ashes produced.
- The ashes from the bed, the cyclones and the stack were collected and analysed for biological activity, ecotoxicity and amino acid concentration. According to the results, it was determined if the ashes were suitable to be deposited in municipal landfills.

Acknowledgment

- This work has been carried out with a financial grant from European Coal and Steel Community (Contract 7220-PR-144).