Utilisation of Low Grade Fuels in Fluidised Bed Combustors

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Structure of Presentation

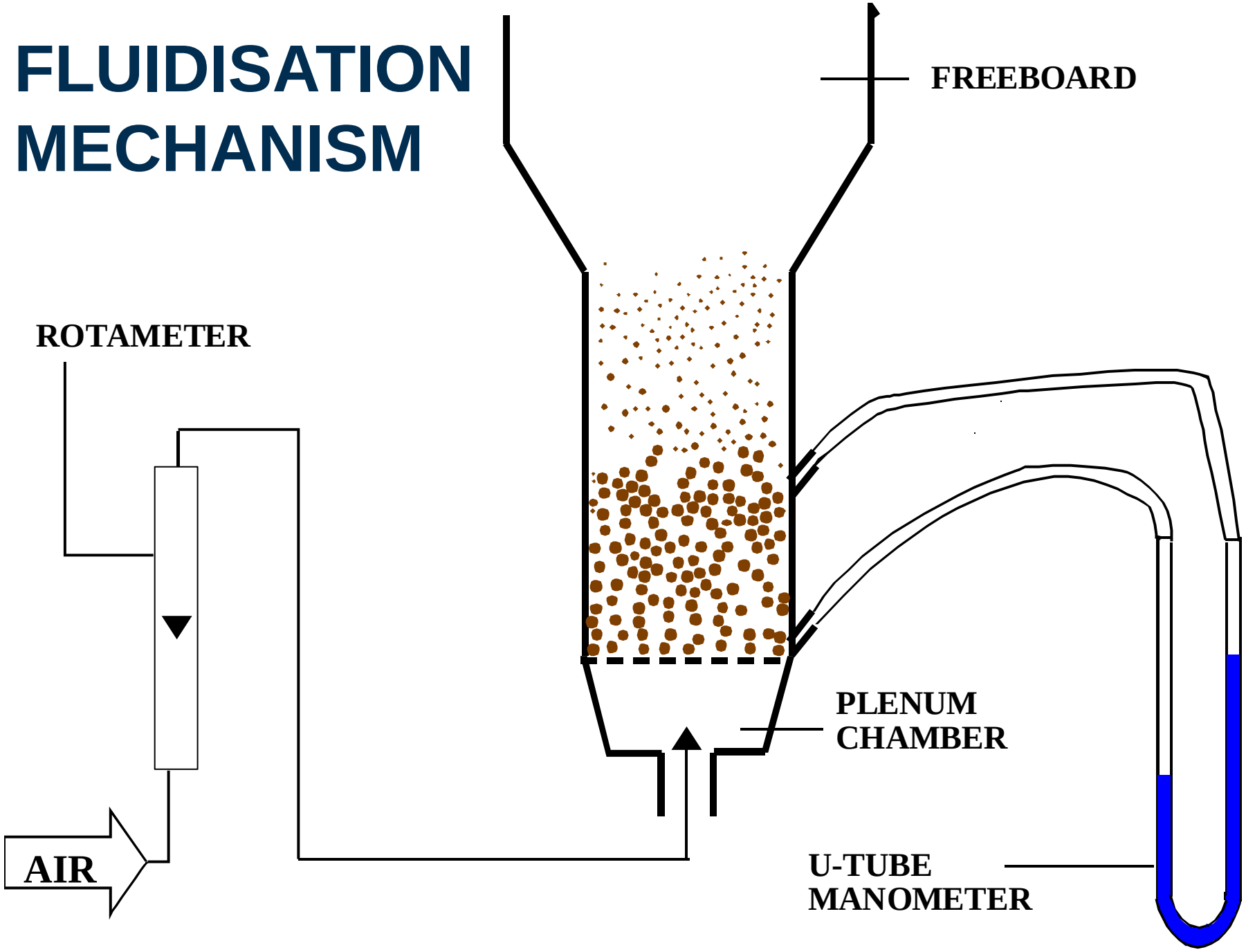
- South African Coal situation
- FBC 101
- Types of coals and fuels tested
- Test facilities
- Results
- Some examples of (CSIR) FBC in SA
- Conclusions and Recommendations

SA Coal Situation

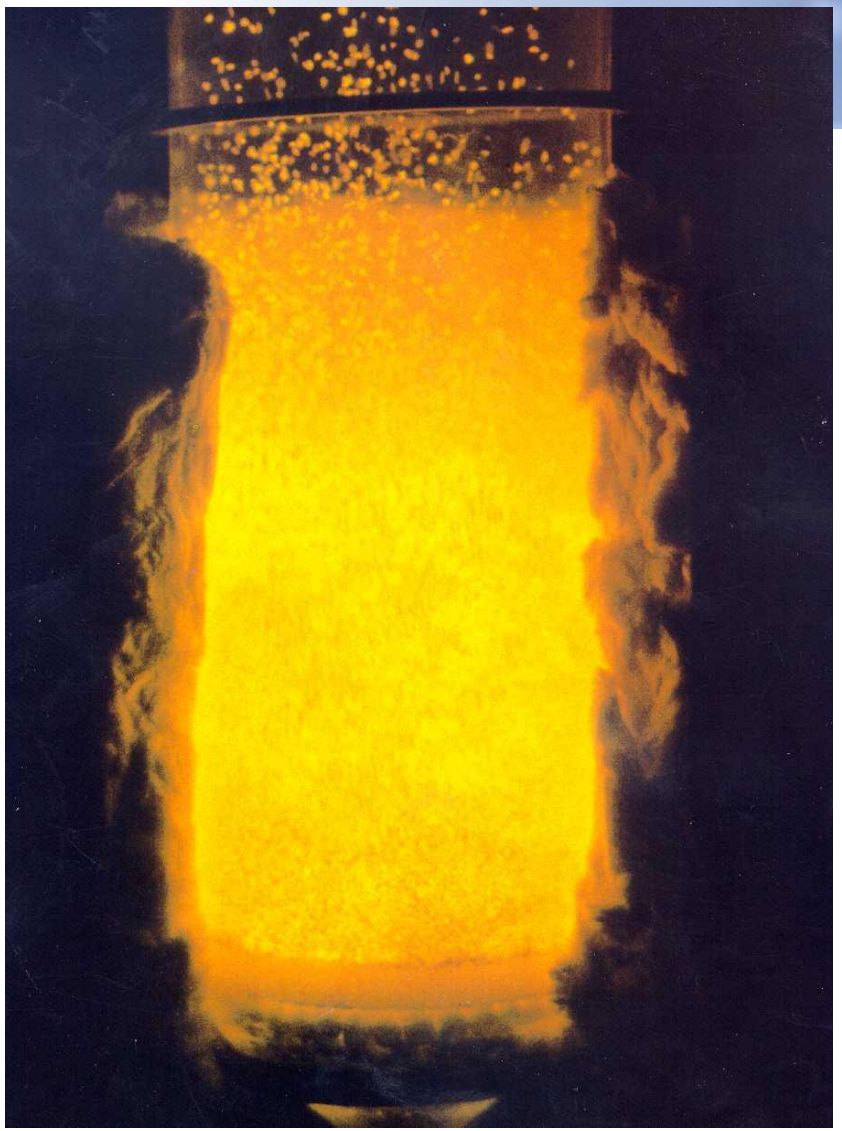
- 250 Mt of coal mined per year
- Value R65 Bn
  - R34 Bn local sales
  - R31 Bn export sales
- Coal discarded in 2009: 67.5 Mt

Source: Prevost, X. 2010

FLUIDISATION MECHANISM



Fluidised Bed Combustion



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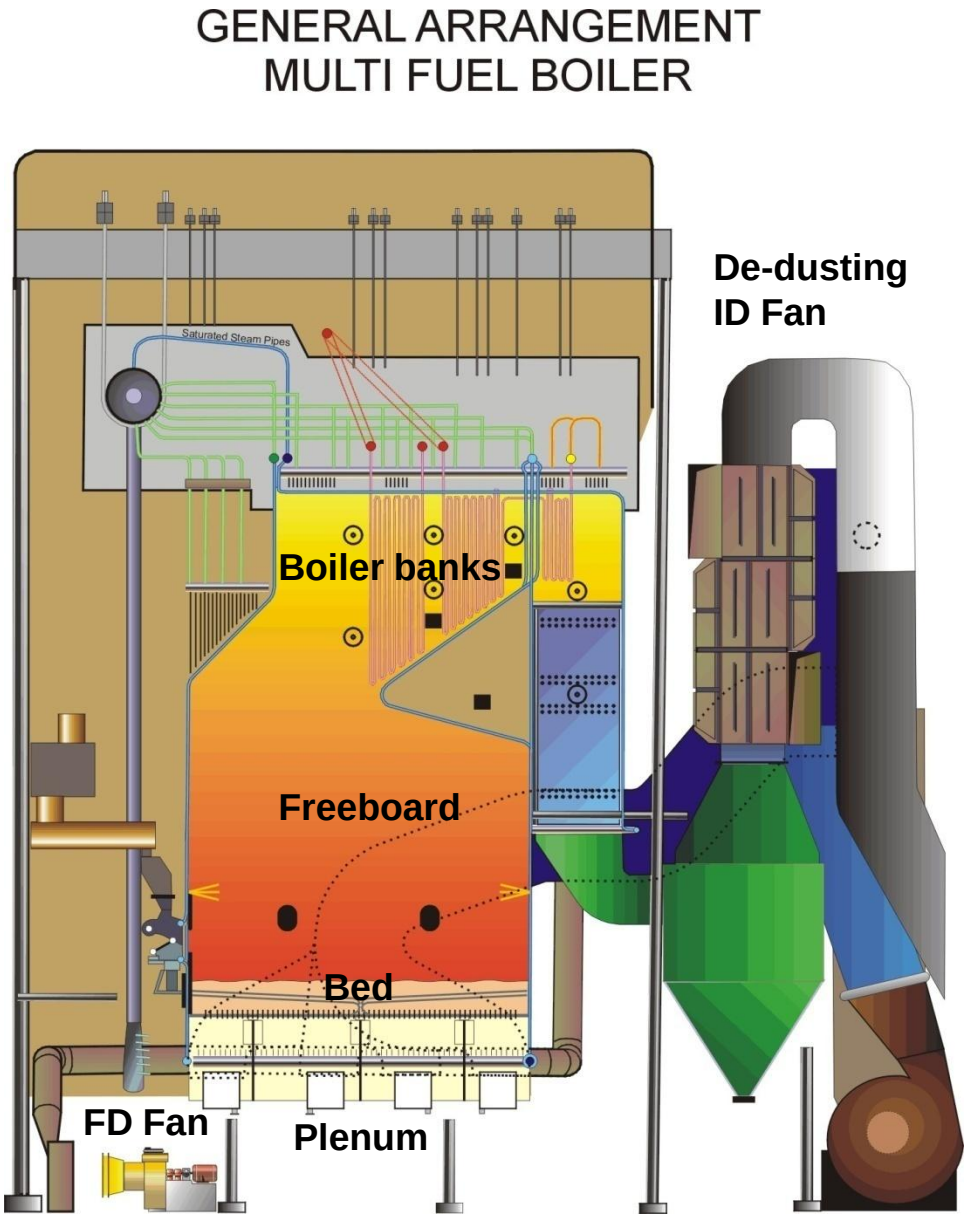
Fluidised Bed Combustion



Source: Babcock

Types of Coal Tested

- Discards (High ash)
- Duff (High fines content)
- Slurry/Slimes (Fine, high water content)
- Biomass sludge (Co-fired)

Coal Analyses (H_2O, Prox, Ult, CV and AFT)

ANALYSIS	Applicable Standard	Boschmans Duff	Tavistock Duff	Greenside discards	Utrecht Anthracite Discards	Goedehoop Slurry (ad)	Biomass Sludge (Coffee grounds)
MOISTURE	SANS 589						N/A
Sup (%)		2.4	1.8	5.6	9.1	6.3	
Inh (%)		2.2	4.6	4.0	1.5	4.4	
Total (%)		4.5	6.3	9.4	10.5	10.4	
PROXIMATE							
H_20 (%)	SABS 925	2.7	3.9	2.8	1.6	2.6	5.7
Ash (%)	ISO 1171	18.7	18.9	44.1	42.4	20.7	14.60
Volatiles (%)	ISO 562	24.7	25.8	19.8	10.3	26.2	N/A
FC (%)	By diff.	53.9	51.4	33.3	45.7	50.5	N/A
ULTIMATE							
C (%)	ISO 12902	64.31	58.41	40.78	46.61	60.24	67.70
H (%)	ISO 12902	3.46	3.15	2.63	2.03	3.64	3.40
N (%)	ISO 12902	1.44	1.35	0.89	1.44	1.52	1.60
S (%)	ISO 19759	0.75	0.66	2.77	1.53	1.00	0.00
O (%)	By diff.	8.64	10.53	6.03	4.39	10.30	7.00
GCV (MJ/kg)	ISO 1928	25	24.1	16.5	18.1	24.6	26.60
AFT	ISO 540						N/A
DT (°C)		1340	1290	1160	1280	1380	
HT (°C)		1350	1390	1230	1330	+1400	
FT (°C)		1390	1400	1300	1370	+1400	

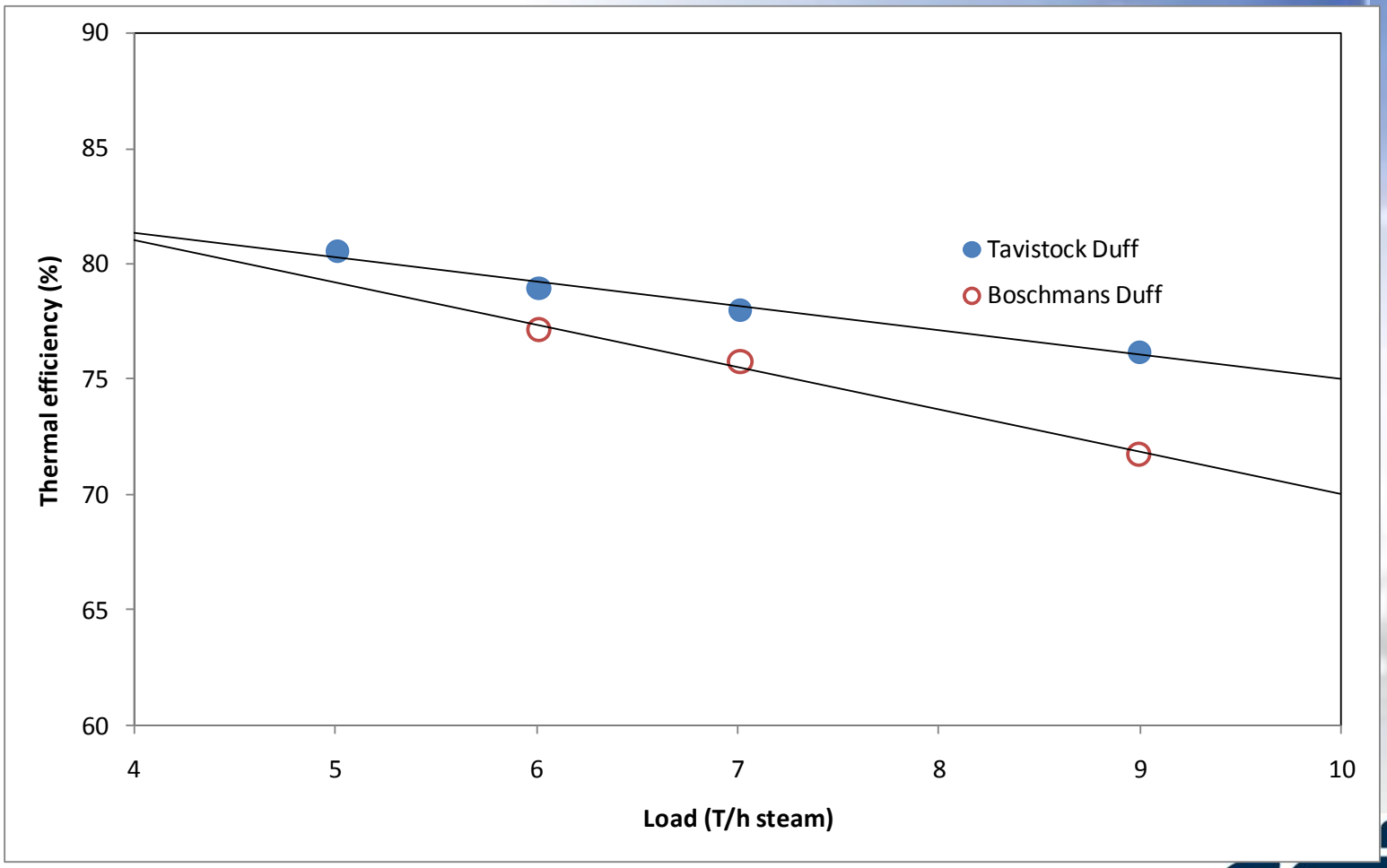
Test Facilities - NFBC

Test Facilities - MPFB

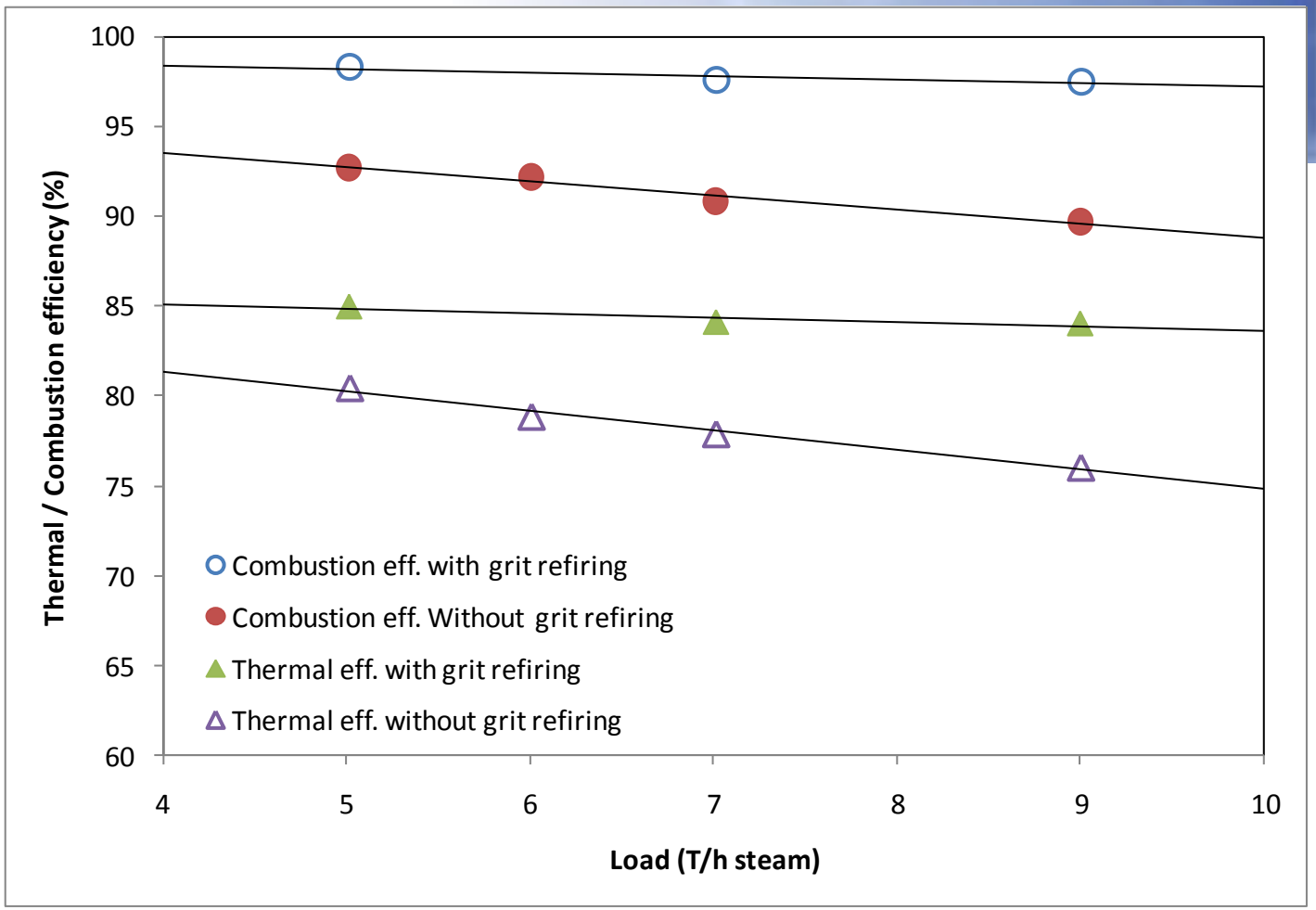
Results

- Performance Indicators
  - Thermal efficiency (heat to steam)
  - Combustion efficiency
  - “Operability”

Duff Combustion – Effect of Load



Duff Combustion (Tavistock)– Grit Re-firing



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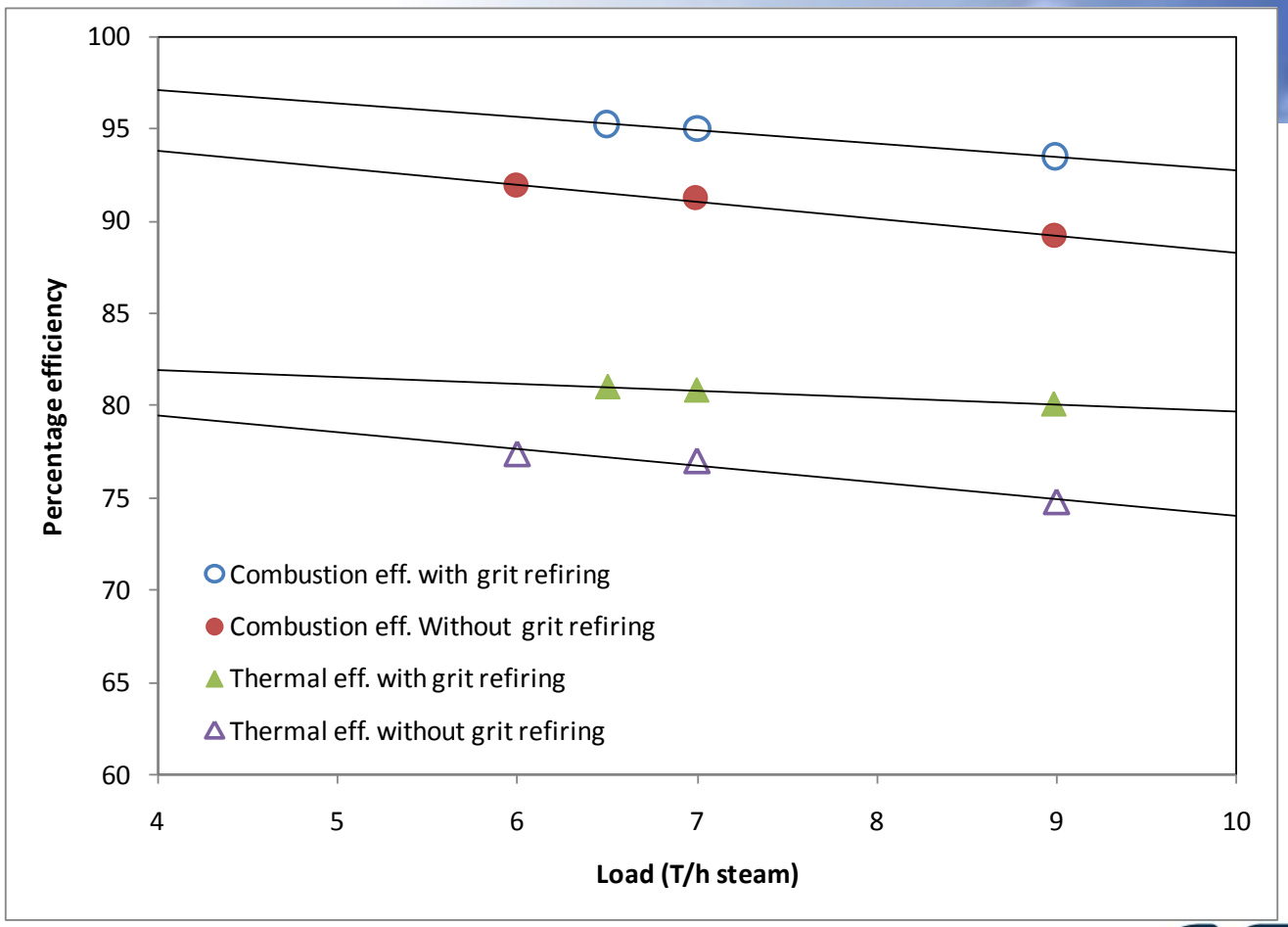
Discard Combustion (Greenside)– Grit Re-firing and Load



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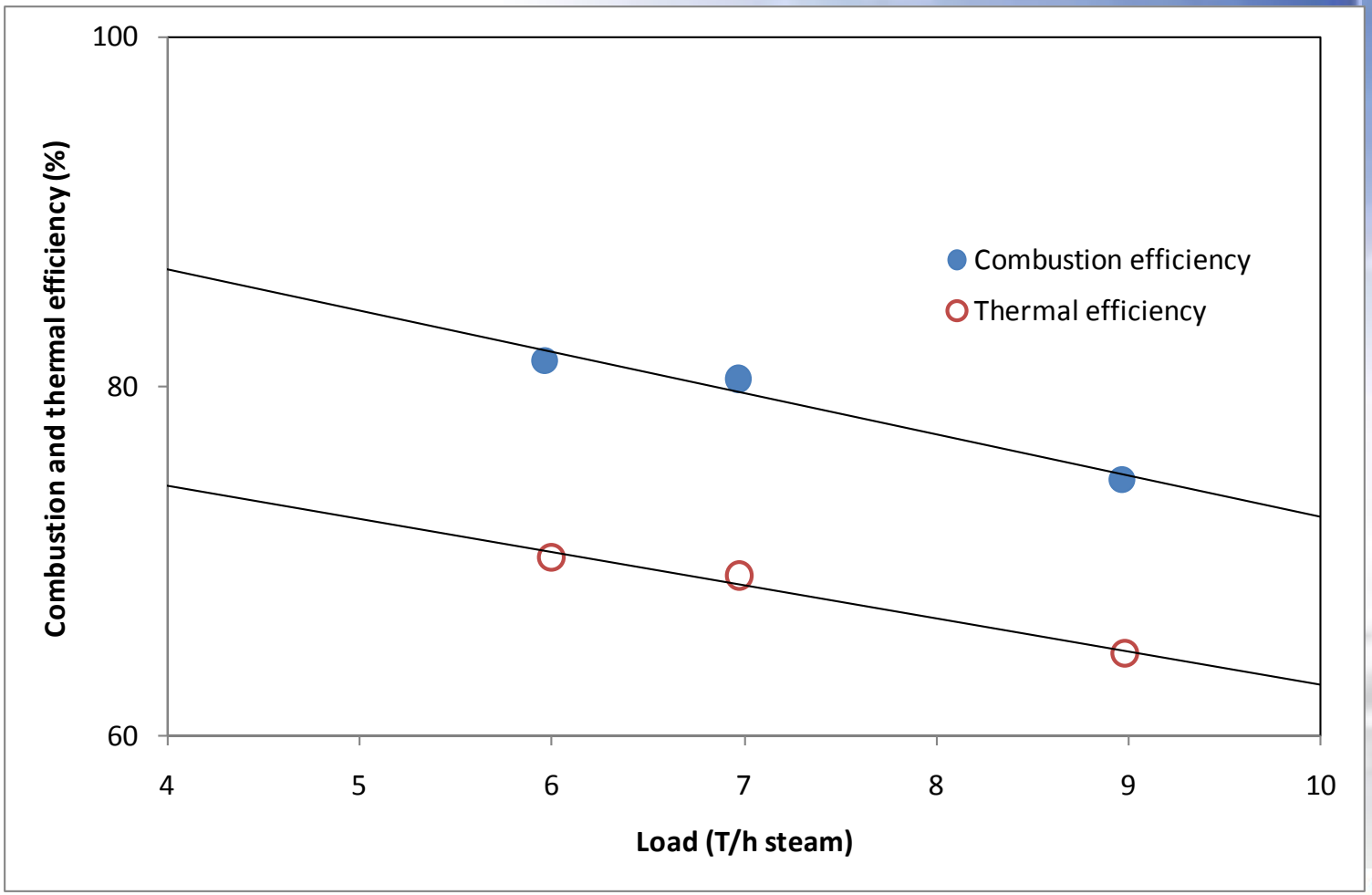
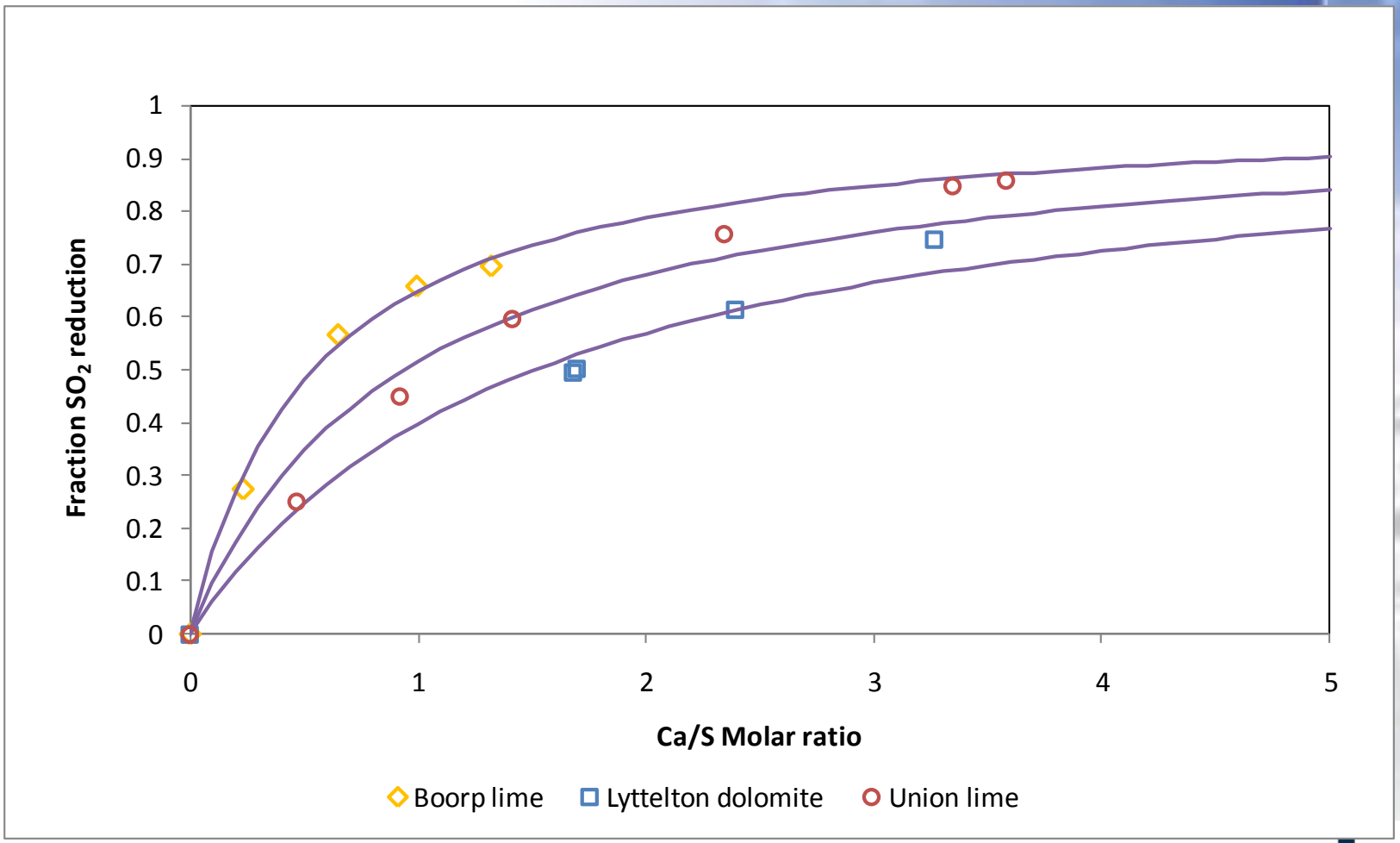
Anthracite Discards – Effect of Load

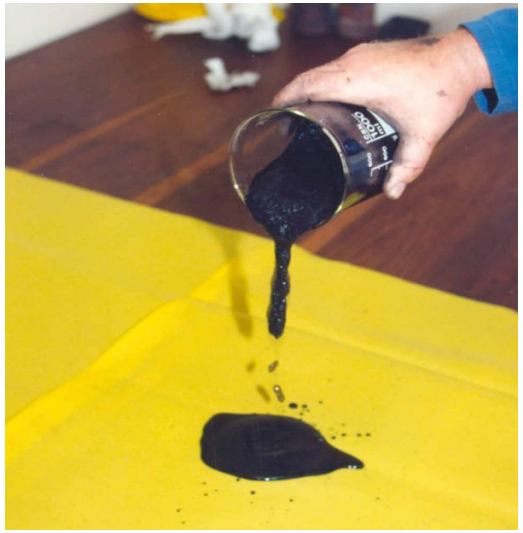


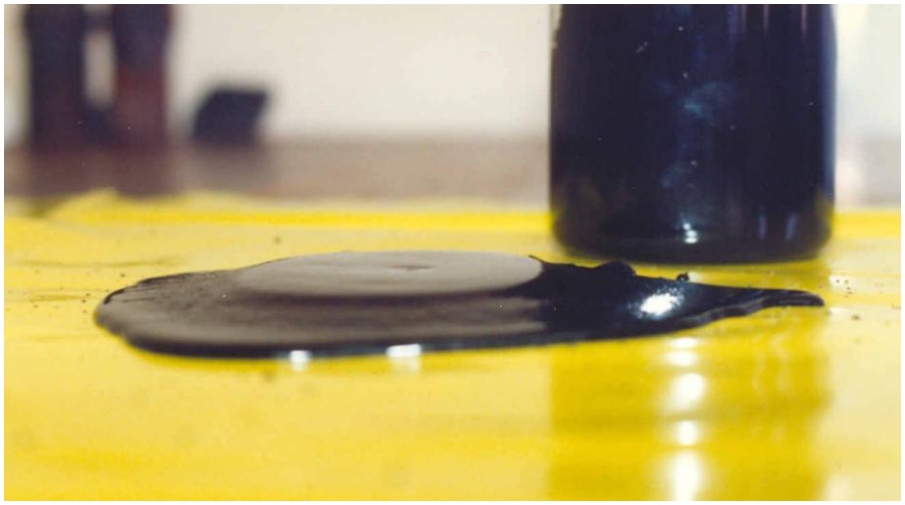
Sulphur Capture – Sorbent Efficacy



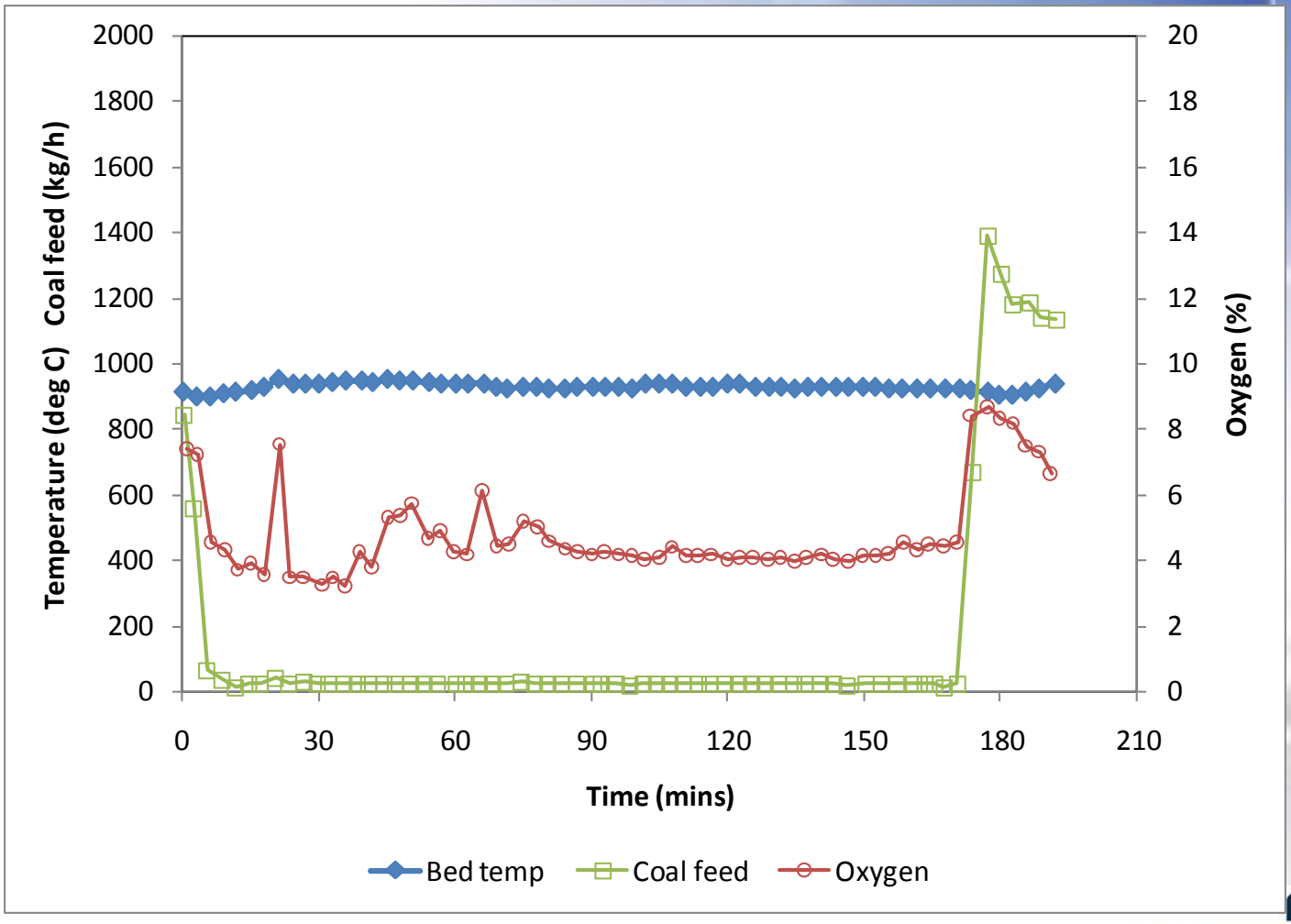
Source: Petrie and North, 1989

Slurry Combustion





Slurry Combustion - Operation



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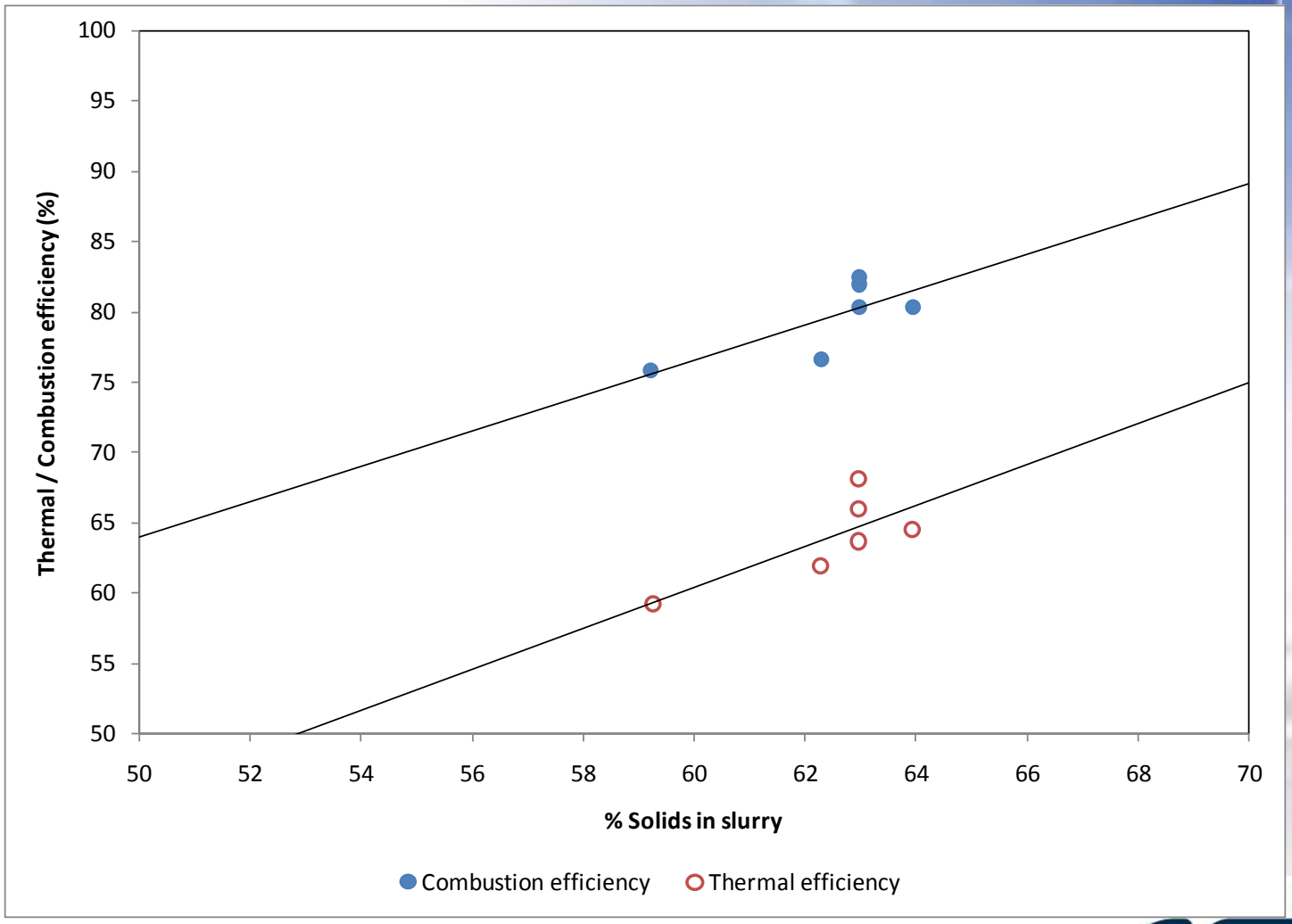
Slurry Combustion - Efficiencies



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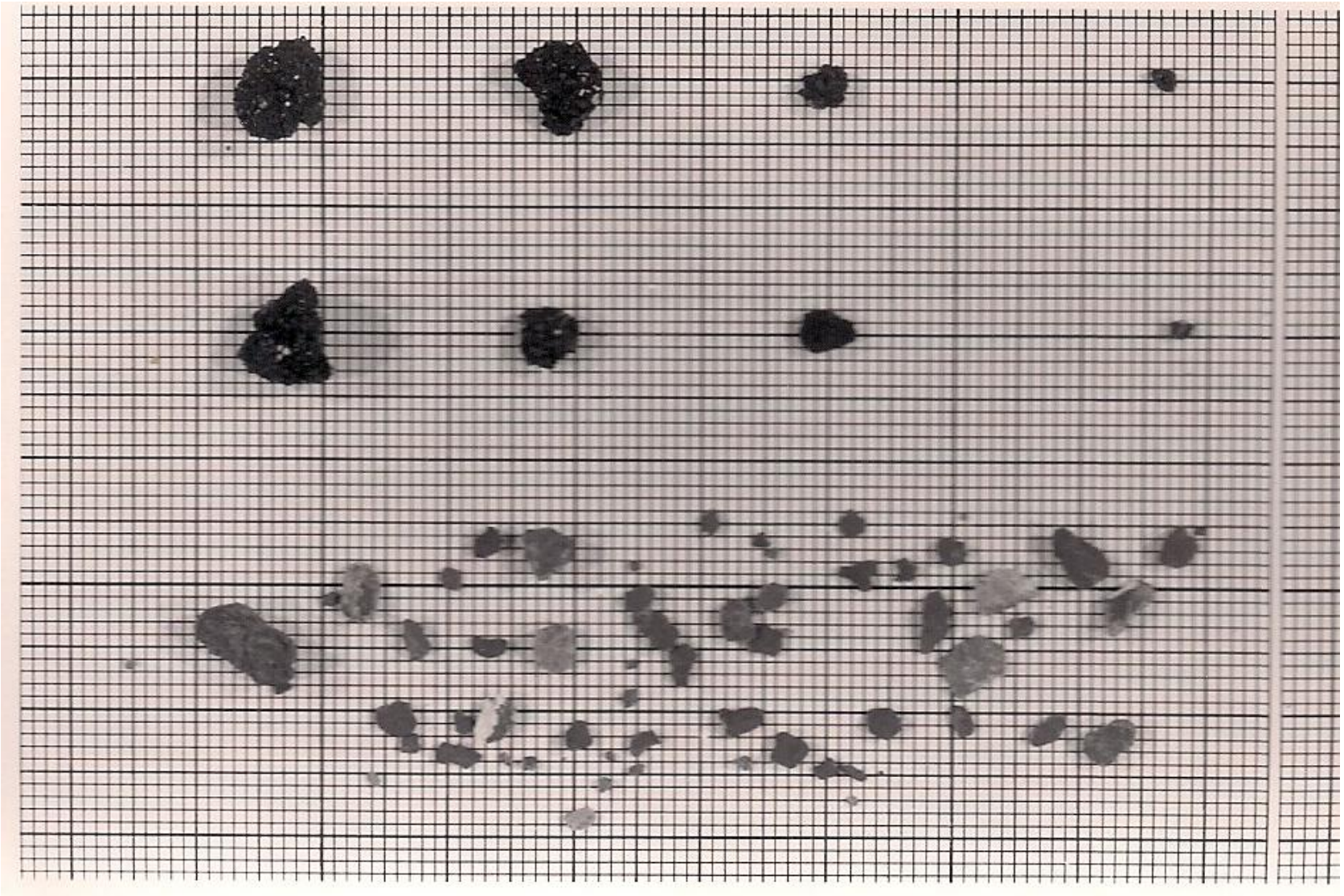
Slurry Combustion – Char-Sand Agglomerates

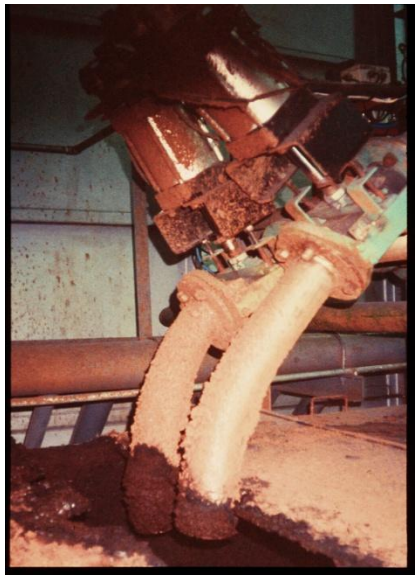


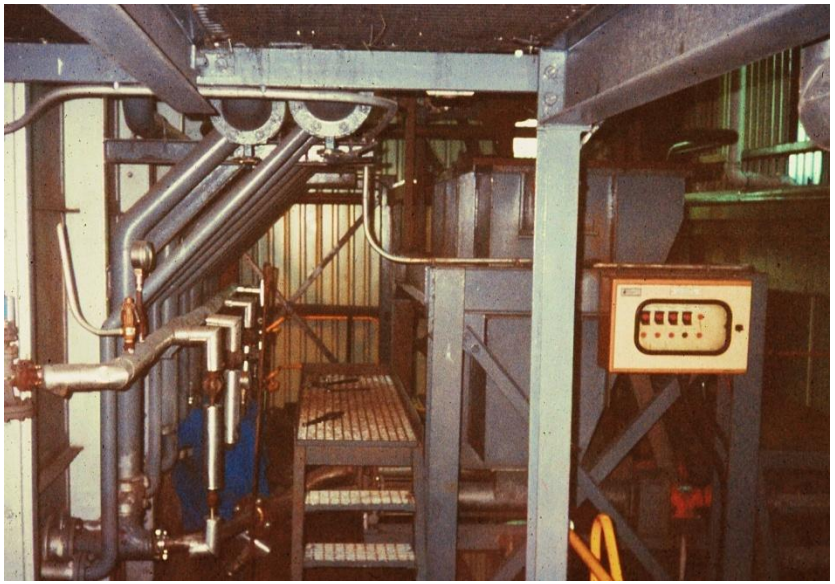
Biomass Sludge Co-fired with Coal

- 26 tph of steam required
- 12 tph of sludge at 85% water content
- Co-fired with coal
- Effective moisture content in fuel 71%
- Proven through calculation and pilot plant test work
- Demonstrated at industrial scale

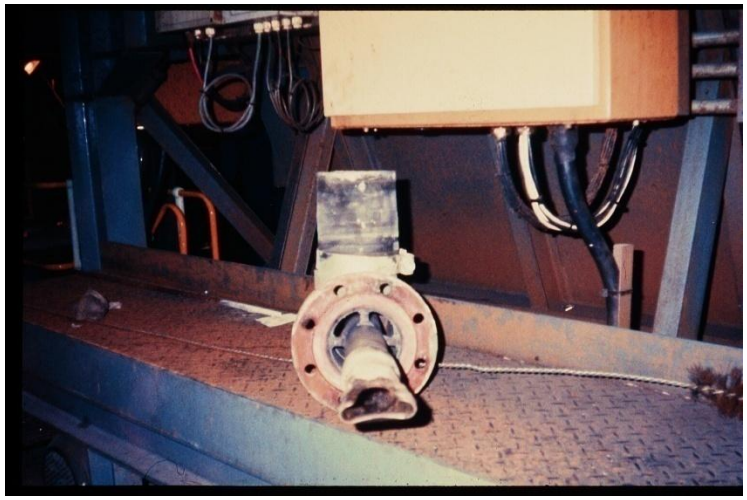
Biomass and Sludge co-firing

Sludge delivery

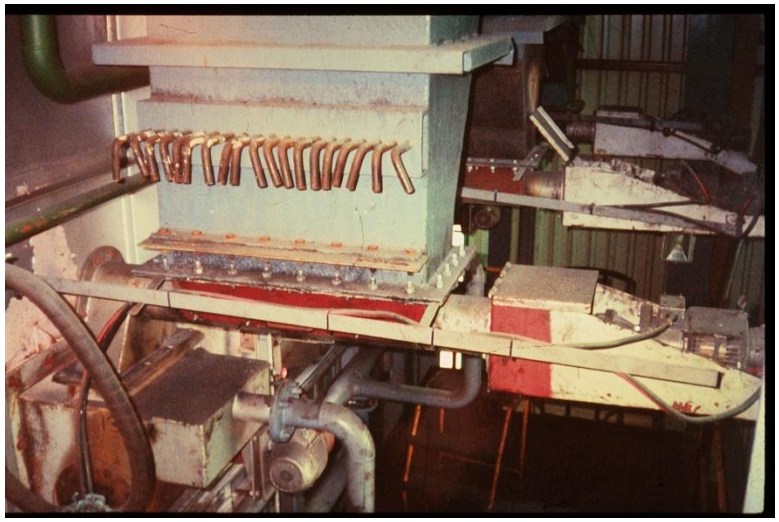




Buffer tanks

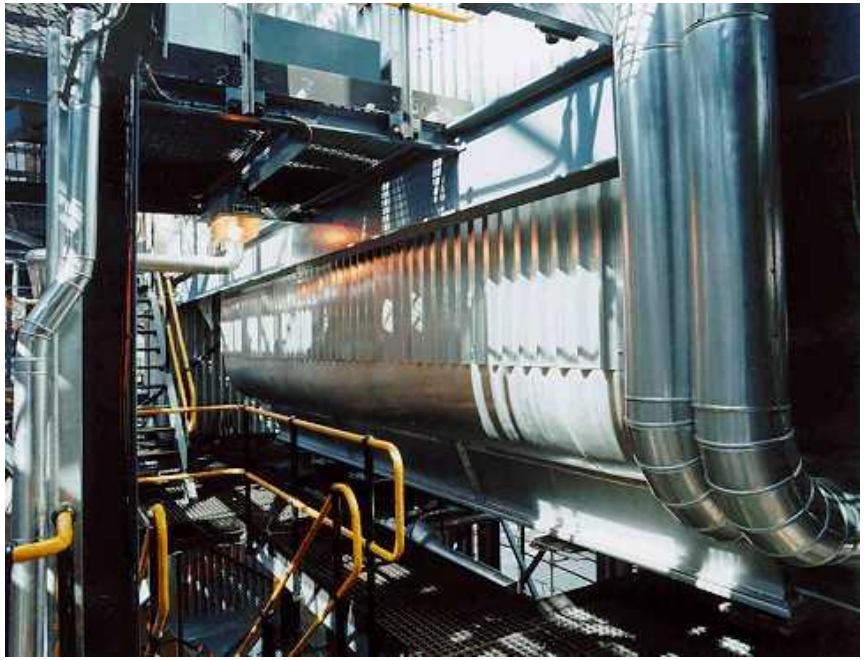


Sludge nozzle



Coal feeders

Biomass and Sludge co-firing

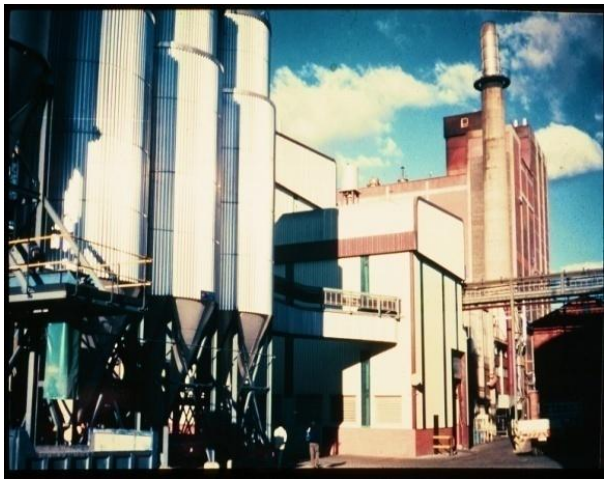


Waste heat boiler

View of plant

Fluidised Bed Industrial Applications

Duff-fired HGG



Co-fired Boiler

HSP Incinerator

Deodoriser

Conclusions

- FBC can utilise a wide range of “problem” (or “opportunity”) fuels
- Discard coal can be burnt at good thermal and combustion efficiencies
  - Crushing to < 6 mm required
  - Sulphur capture required (and proven), sorbent choice
- Anthracite discards are problematic, low combustion efficiency achieved

Conclusions (Contd)

- Duff (fine) coal can be utilised – Features required:
  - Grit refiring
  - Low fluidising velocities
  - Expanded freeboard
- Coal Slurries can be utilised
  - Inherent low thermal efficiency due to water content
  - Combustion efficiency higher than parent coal would suggest, and can be improved upon
  - Boiler design (in-bed HX) important – Excess air

Conclusions (Contd)

- Biomass wastes, including sludge, can be utilised
  - Co-firing can be beneficial wrt fouling and agglomeration
  - Dry waste autothermal
  - Wet waste can be co-fired with coal
  - For wet sludges, control complicated but possible,

    in-bed HX design critical (Excess air)
  - In-flight drying and inbed combustion need to be “balanced”
  - Deep bed assists in sludge dispersal

Important Issues

- Economics – you might be able to burn it, but does it make sense? Centralised vs decentralised
- Consider coal cost in R/GJ delivered and sorbent cost in R/t S removed
- De-watering of high moisture content fuels – CAPEX vs OPEX
- Possible operational problems with biomass (Na, K)
- BFBC vs CFBC (size does count)

Benefits from this research to the coal and boiler industries

- Technical viability of utilising a range of waste coals proven.
- Data available on combustion and thermal efficiencies (BFBC) on which to base economic decisions
- Design features highlighted, FBC is not “one size fits all”
- Reduction in the amount of coal discarded on the surface, thereby reducing a visible eye-sore
- Extending the lifetime of our finite coal reserves

Benefits from this research to the coal and boiler industries (contd)

- Minimising the emissions of greenhouse and acid gases formed by spontaneous heating and combustion of coal discard piles
- Eliminating the ground water pollution often found with discard coal dumps
- Providing energy from materials that are currently discarded and have already been mined/recovered, thereby eliminating the energy required to mine new coal for utilisation

Utilisation of Low Grade Fuels in Fluidised Bed Combustors

Thank You

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