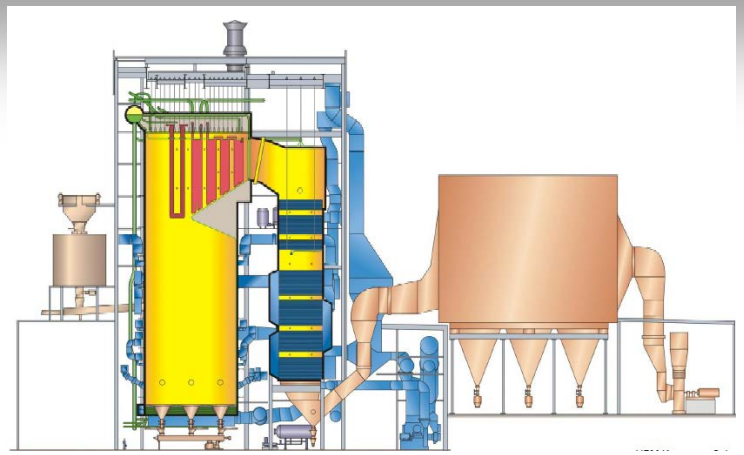
Foster Wheeler BFB Boilers

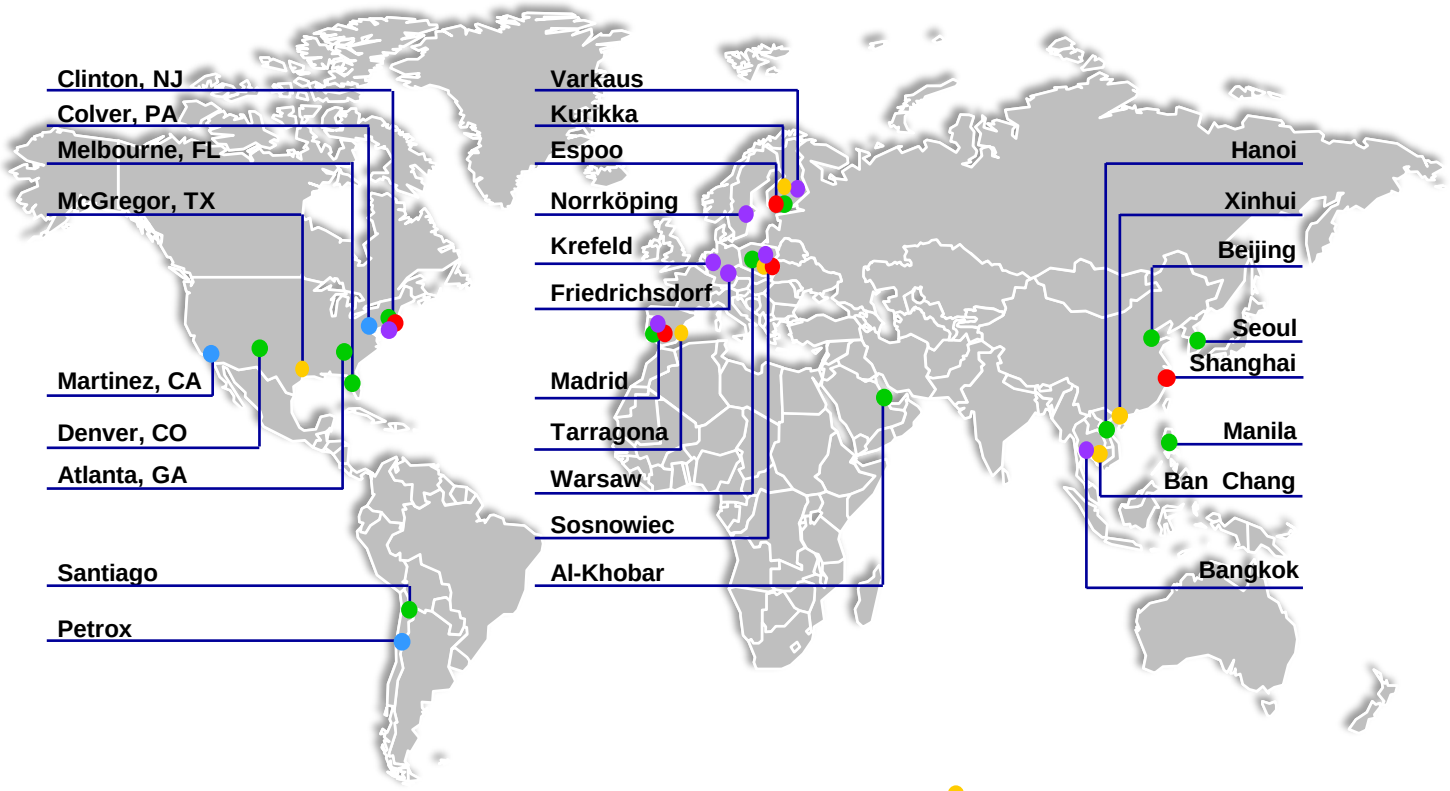
Licensee Expertise for Brazilian Markets

October 29, 2014



Foster Wheeler Global Power Group Offices

A global business with approximately 3,000 highly-skilled people



- Operating unit HQs and/or main engineering centre
- Regional/local engineering centre
- Sales offices
- Manufacturing facilities (GPG)
- Power plant operation

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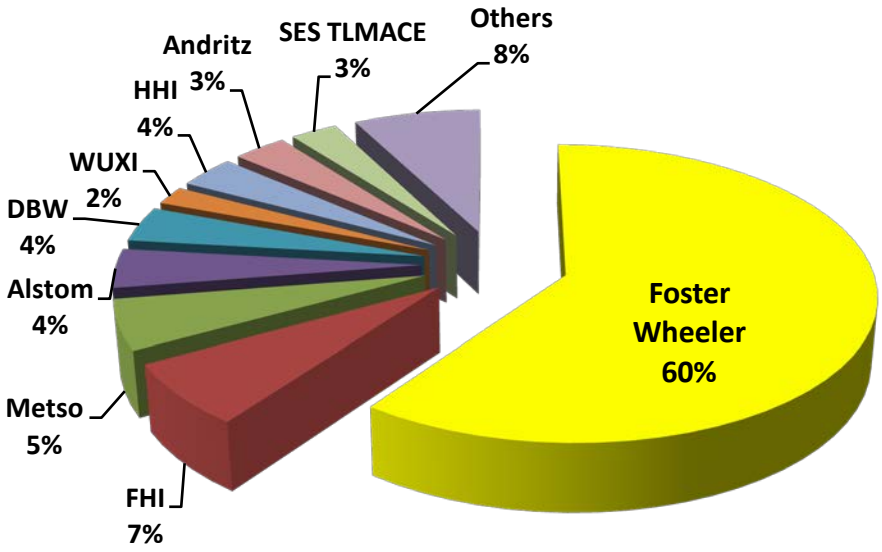
FW is the Leading Global Supplier of FB Technology

- Over 570 Fluidized Bed Units Sold
  - > 28,000 MWe Subcritical Units in Operation
  - 460 MWe Supercritical Unit in Operation
  - 5 Supercritical Units in Construction
    - 4 x 550 MWe + 1 x 330 MWe
- Total Fleet logged over 30 Million Hours of Operation
- Widest Fuel Experience in Industry
- High Availability Demonstrated

World CFB Market

GPG Served Market

Orders Over 2004-2013 Period



Source: FW Competitor Database 061214, CFB Boiler Type. All sizes. Excludes domestic orders provided by domestic suppliers in China, India, and Japan. Other includes suppliers with less than 1% of the market share. Market share based on GWe.

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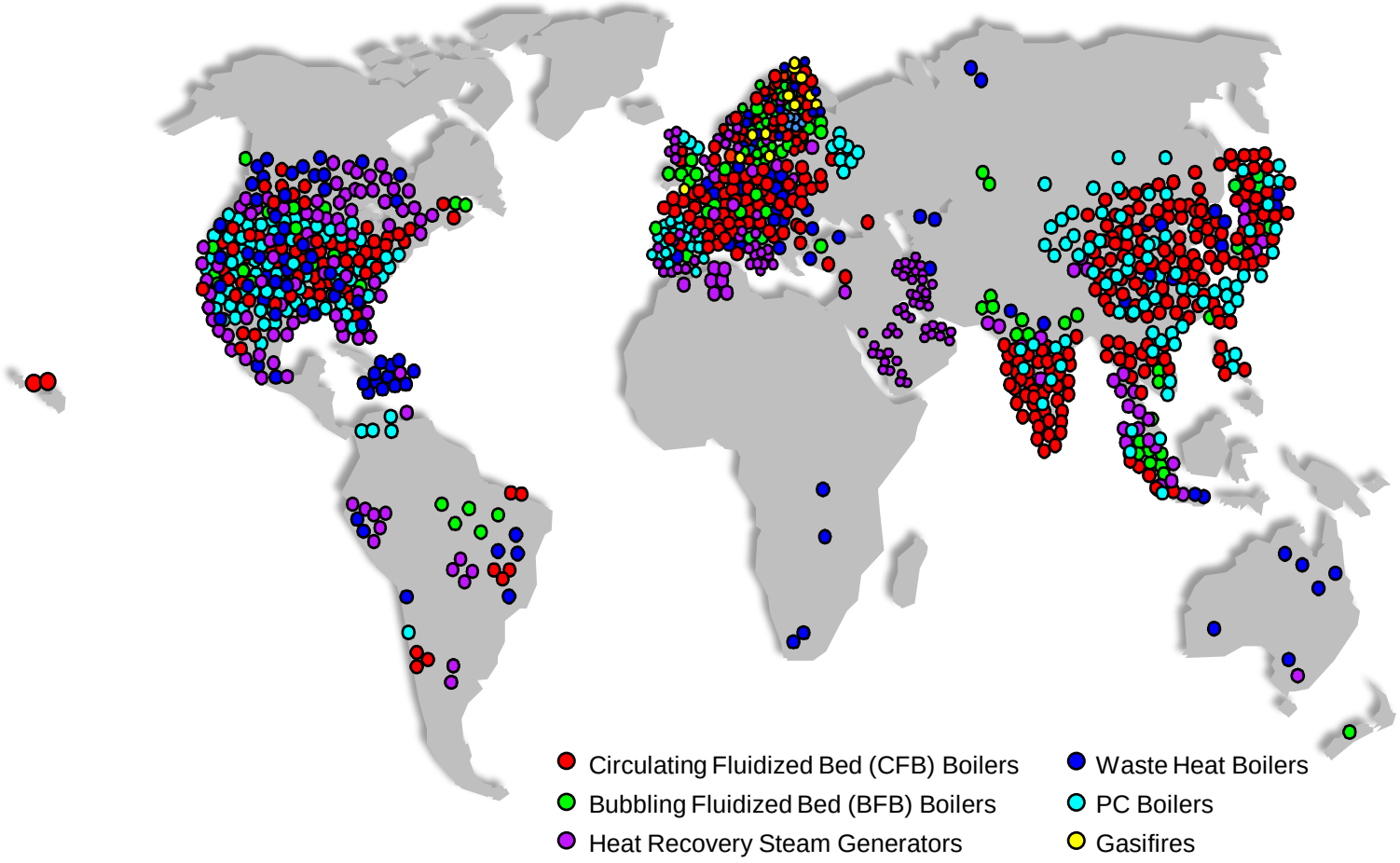
Foster Wheeler Global Power Group References



Successful BFB Operating Experience

1st Foster Wheeler BFB unit in operation in 1970's

- 100 Greenfield BFB boilers
- 36 BFB conversions / retrofits
- Operating availability very high

Salmi Voima Oy, Finland

Äänevoima Oy, Finland

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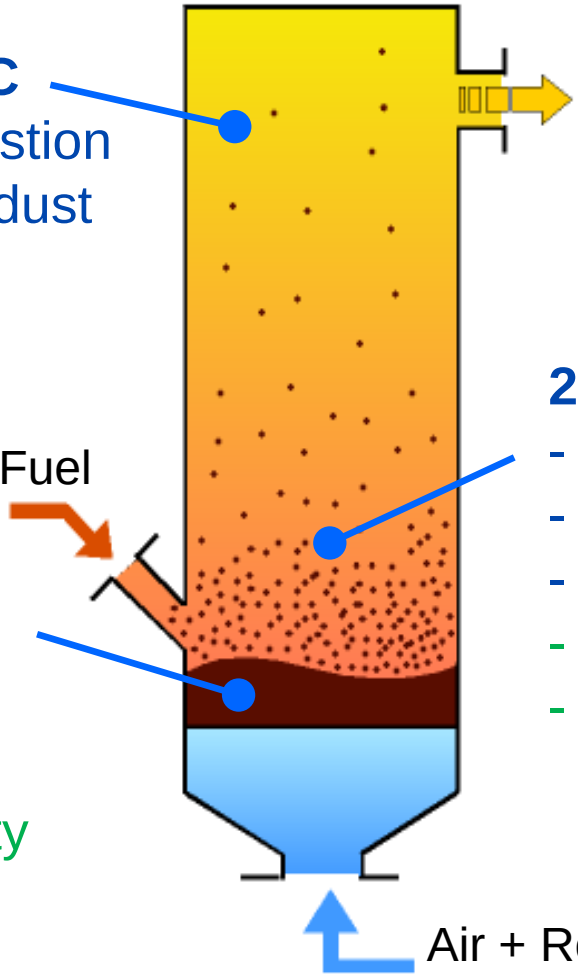
Fluidized Bed Combustion

Main principles: BFB conditions

3. Exit 900 - 1000°C
- Completed combustion
- Low carry-over of dust
- Minimized fouling



2. Over-bed combustion
- 1000-1200°C
- Secondary air levels
- Over-stiochiometry
- Volatiles combustion
- CO & NOx control

1. Bubbling Bed
- ≈ 800 – 850 °C
- Velocity < 1.5 m/s
- Sub- stoichiometry
- Sand > 97%
- Fuel < 3%
- Operational flexibility
- Low agglomeration

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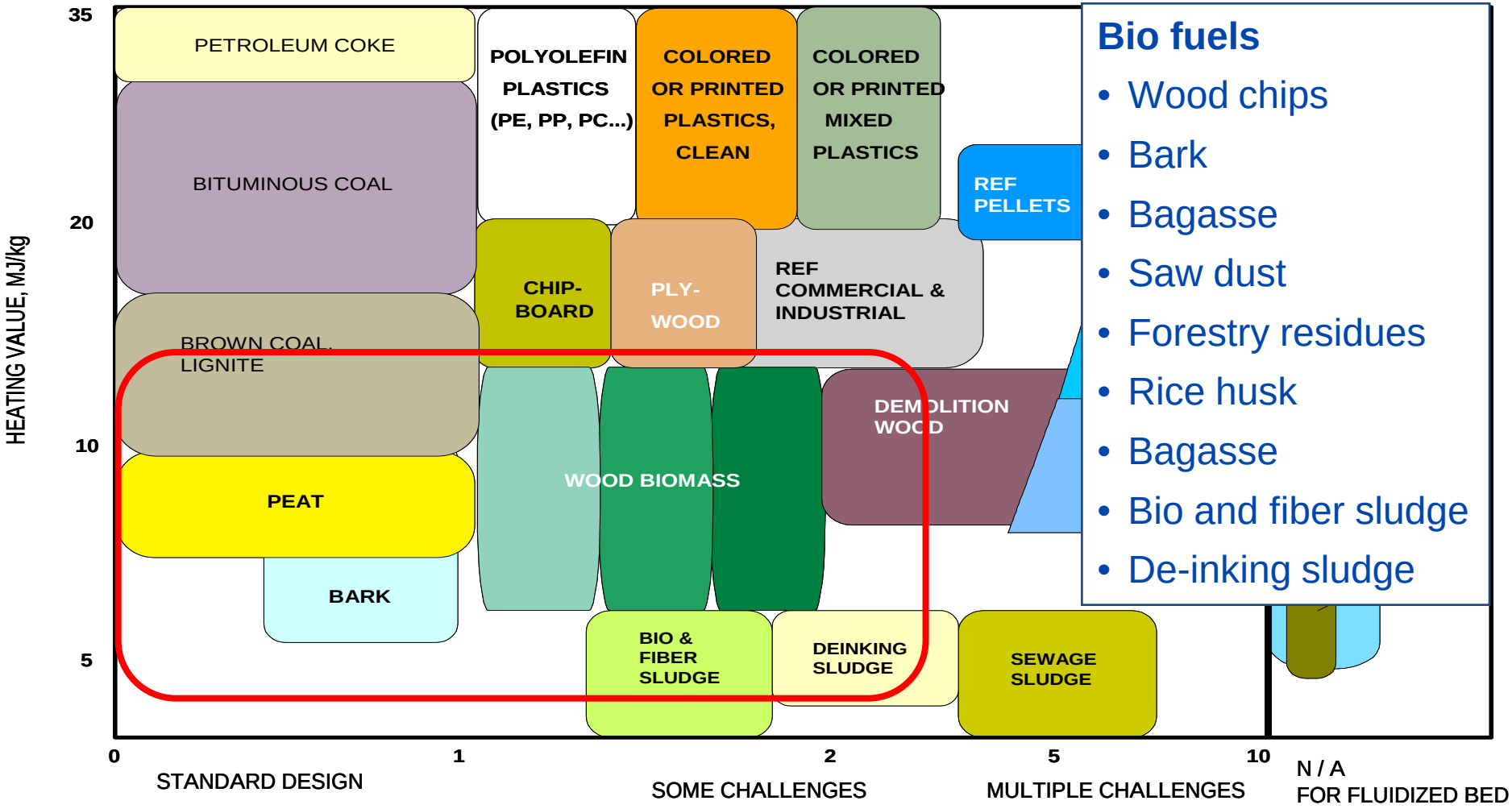
Fuels for BFB Boilers

Good Fuel Flexibility



Bio fuels

- Wood chips
- Bark
- Bagasse
- Saw dust
- Forestry residues
- Rice husk
- Bagasse
- Bio and fiber sludge
- De-inking sludge

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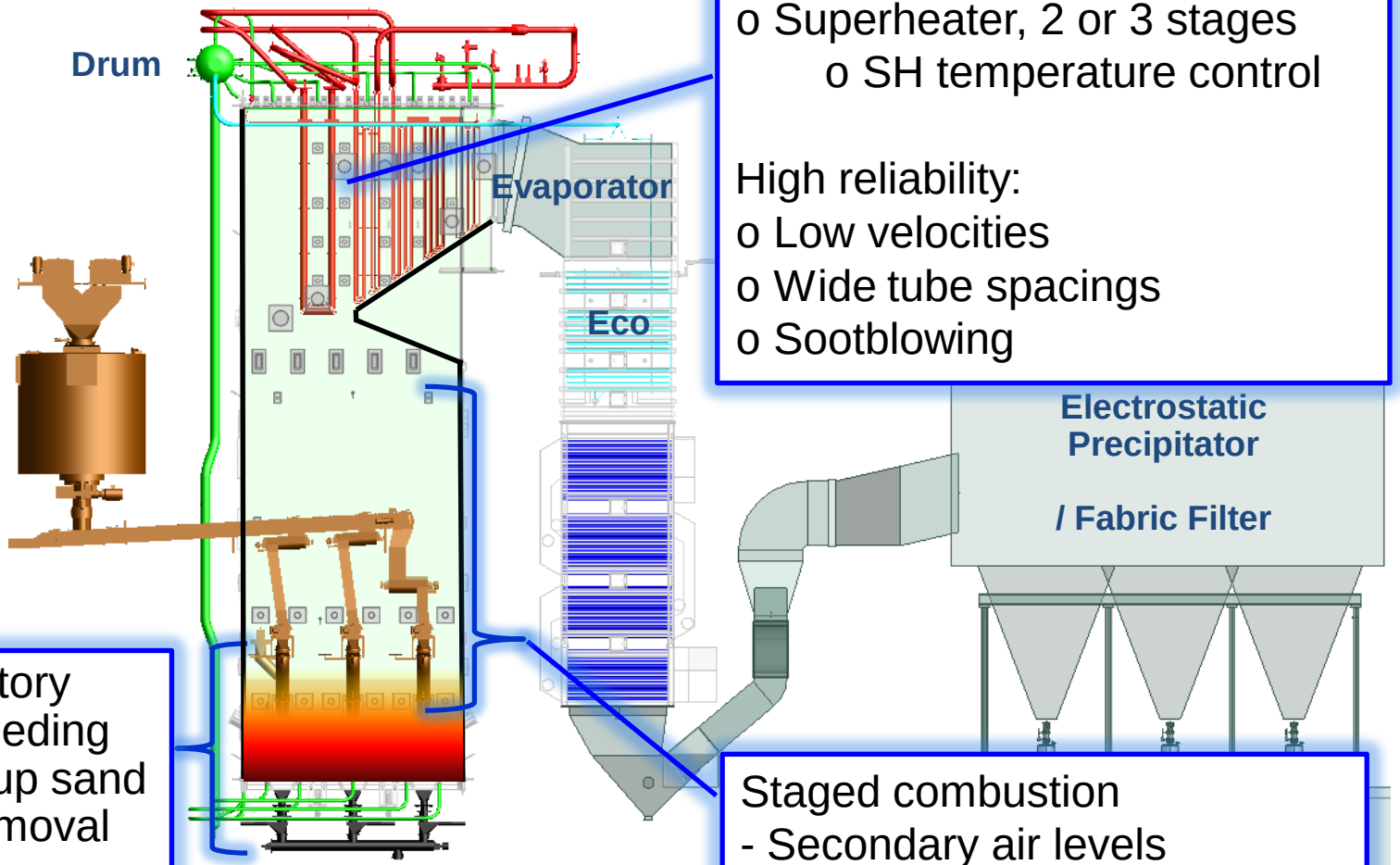
FW BFB Boiler: Design Features



o Superheater, 2 or 3 stages
o SH temperature control

High reliability:
o Low velocities
o Wide tube spacings
o Sootblowing

o Refractory
o Fuel feeding
o Make-up sand
o Ash removal (large particles, agglo merates)

Staged combustion
- Secondary air levels
- Good mixing
- Load burners

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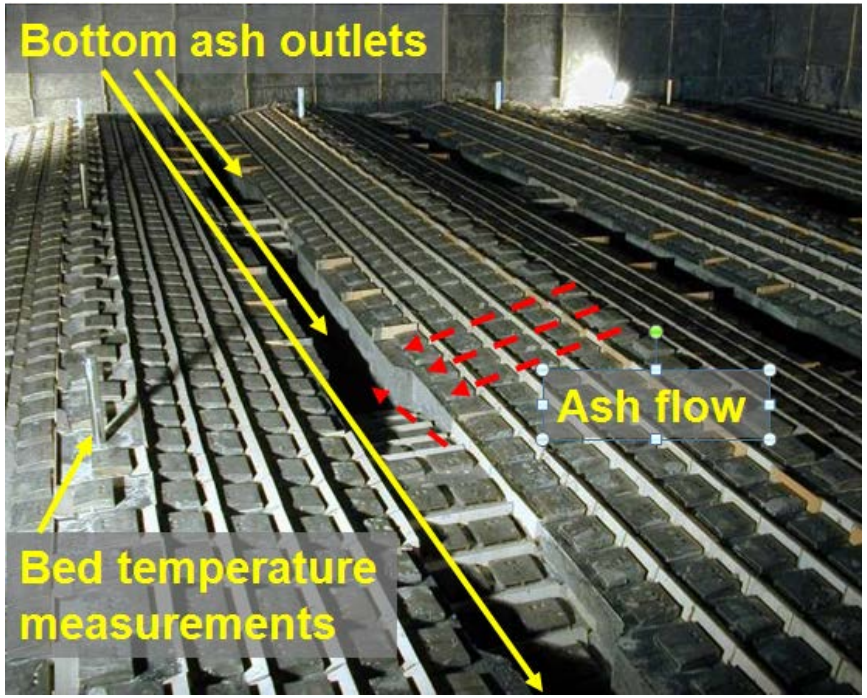
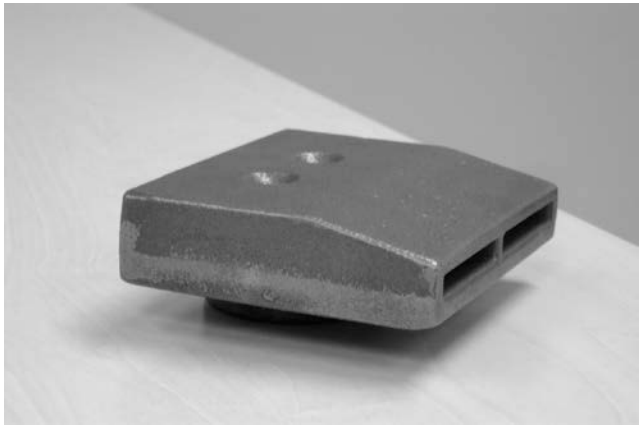
FW BFB Step Grid

Managing Difficult Fuels



- Large ash valleys
- Directional nozzles
  - No blockages
  - Easy maintenance
  - Even air distribution
- 14 Step Grids in BFBs



BFB vs Grate: PERFORMANCE

FW BFB: Stable Operation

Feature	BFB	Grate / Stoker
Turn-down ratio	Bio 1:4 ... 1:5 - Bed temp control with recirculation gas	Typically < 1:3
Fly ash ratio	80 – 90 % - Lower ash heat loss	< 20 %
Unburned fuel (LOI)	0.3 – 0.7 weight-%	2.5 – 3.5 weight-%
Boiler Efficiency	Up to > 90 %	< 90 %
Excess air	> 20 %	> 30 %
Combustion control	Flexible - Air staging with multiple air levels	Constrained - More fixed air feeding

BFB vs Grate : EMISSIONS

FW BFB: Flexibility for future requirements

Feature	BFB	Grate / Stoker
NOx	Wood, bark, bagasse < 300 mg/m3n, 8% O2 dry	Higher NOx (Peak temp 1200 – 1600 °C)
SNCR	Up to 50% NOx reduction	SNCR + SCR
CO	Low < 170 mg/m3n, 8% O2 dry	High - More uneven combustion
SO2	Reduction is possible in bed - CaO in ash or limestone	No sorbent in furnace (Scrubber may be needed)
Particles	ESP or Baghouse Very low emission achievable.	ESP or Scrubber (UBC is challenge)

BFB vs Grate: ECONOMY

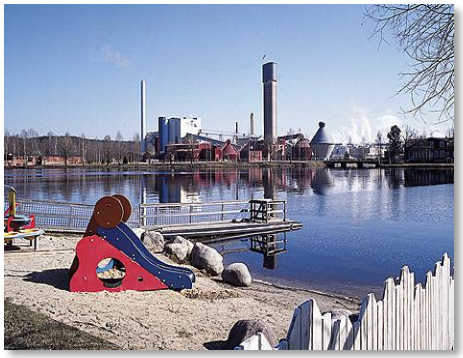
FW BFB: Low operation costs

Feature	BFB	Grate / Stoker
Investment cost	Higher	Lower
Maintenance & Availability	Better - High availability - Annual maintenance - Low erosion	Poorer - Grate - Scrubber
Fuel Economy	Good - Cheaper fuels possible - Fuel Moisture > 60%	Low - Very limited fuels - Biomass Moisture <50%
Boiler Efficiency	Up to > 90 %	< 90 %
Utilities consumption	Sand for bed make-up	

Technology Selection

		PRICE FUEL FLEXIBILITY		
		Lower	**Medium**	**Higher**
o **Fuel K, Cl** o **Maintenance cost** o **Emissions**	**High**	Grate	Grate	N/A
	Medium	BFB	BFB	CFB
	Low	BFB	BFB	CFB
		Lower	**Medium**	**Higher**

o **STEAM CAPACITY**
o **STEAM TEMPERATURE**
o **EFFICIENCY**
o **AVAILABILITY**



FW BFB in Brazil

- Recognition of Customer's needs
  - Fuel mixtures – wide experience
  - Increased efficiency
  - Increased reliability
  - Meeting future emission limits

  - Conceptual design and optimization

FW is a Proven Supplier of Biomass Boilers

FW BFB in Brazil

- High Value for Biomass Energy Solutions
  - Proven Technology
    - New BFBs
    - Conversions to BFB
  - Excellent quality
  - Service support
  - Technology support

FW is a Proven Supplier of Biomass Boilers

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HIGH PERFORMANCE
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TEAMWORK
OUR CORE VALUES
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OF BEHAVIOR FOR
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