15 September, 2009
Presentation to

Council of Industrial Boiler Owners (CIBO)
Focus Group

Some Factors for Consideration

When Planning a Biomass Project

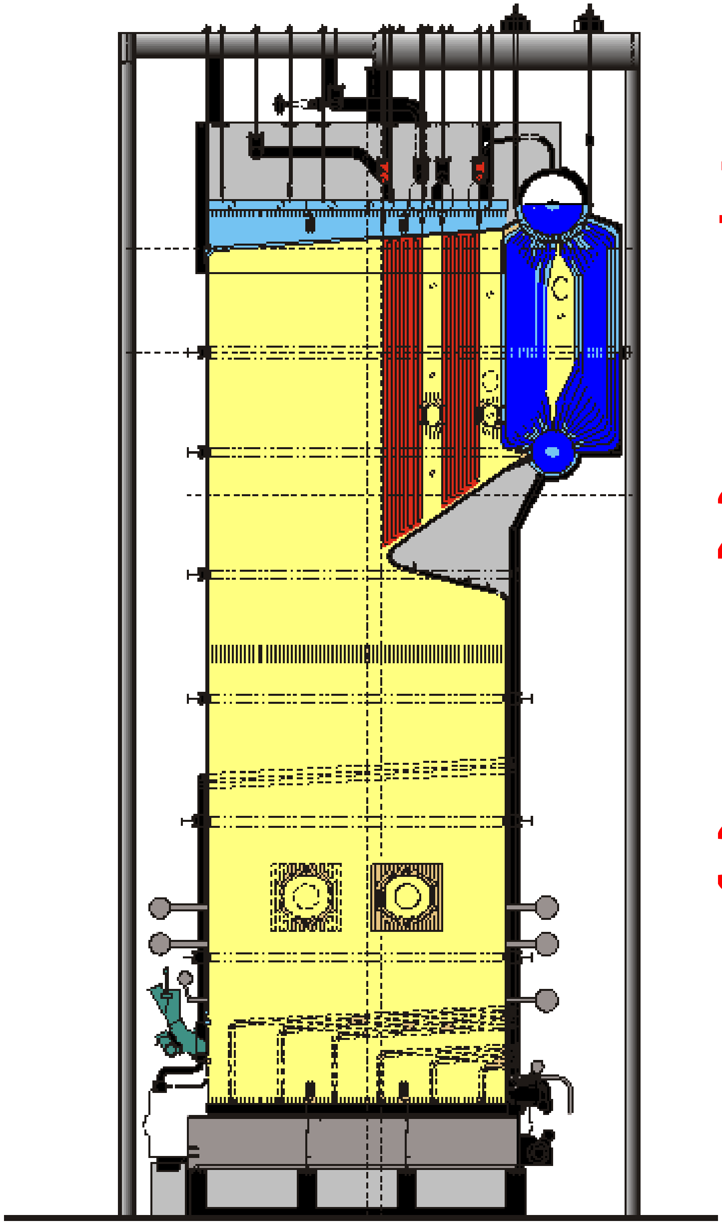
INTRODUCTION

1. Focus on issues specific to biomass.
2. All typical elements of projects using other fuels also present.
    - Fuel availability and quality.
    - Environmental concerns (Air, Liquid, Ash)
    - Land
    - Archeological concerns
    - Power Purchase Agreement (or not)
    - Local Support/Opposition
    - Financing
3. Comparisons- Coal/Biomass
4. Suspension Burning
5. Boiler MACT

EXAMPLES OF BIOMASS FUELS

- Bagasse
- Rice Hulls
- Straw
- Peanut Shells
- Coconut Shells
- Switch Grass
- Wood Waste

BIOMASS PROJECT

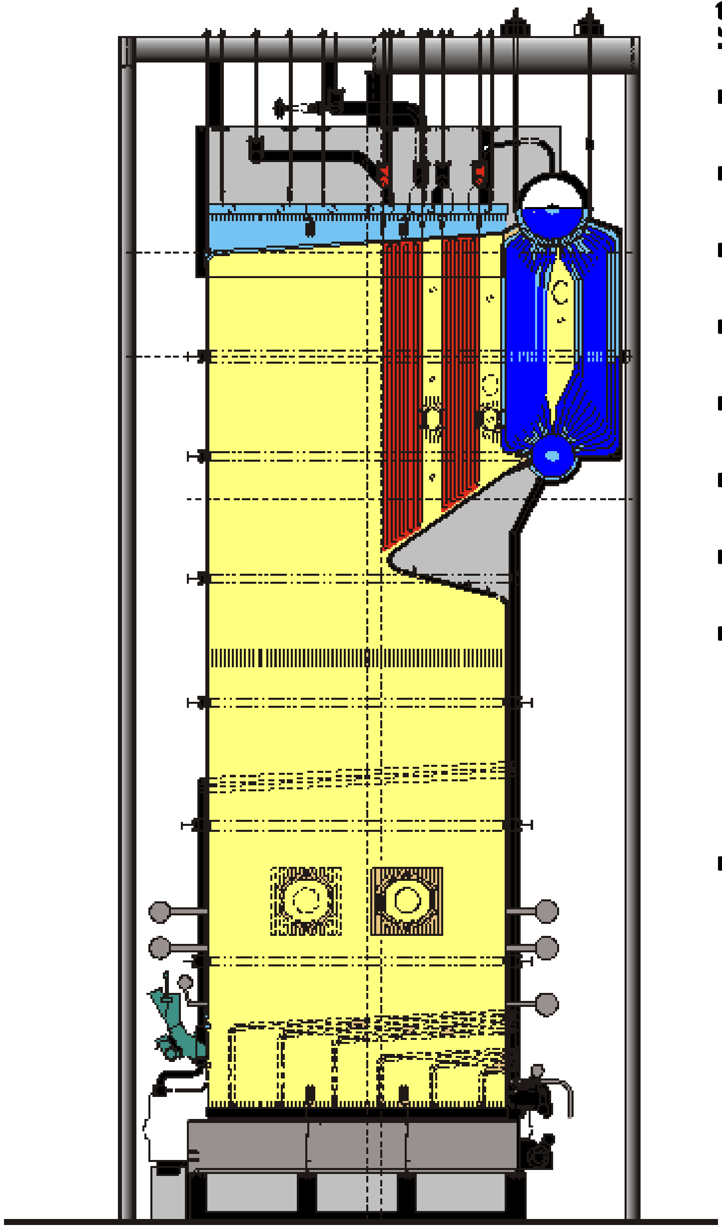


1. Start with the Fuel
2. Performance Requirements
3. Other Factors

FUEL

•The first rule is to start with the fuel. Learn everything there is to know about what you will be burning including ultimate, proximate and detailed mineral ash analysis. If possible get additional information including, if applicable, Hardgrove grindability index (HGI), bulk density and ash fusion temperatures.

BIOMASS PROJECT



Start With The Fuel

- Ultimate analysis
- HHV/LHV
- Moisture content
- Particle size distribution
- Particle morphology
- Friability
- Ash % and elemental analysis
- Bulk Density (usually low)
  - Storage
  - Fuel Handling
- Availability
  - Cost
  - Fuel Coverage Ratio
  - Freight

FUEL ANALYSIS

Fuel Description:	Malt Sprouts	Oat Hulls	Barley Needles	Wood Shavings	Barley Dust/Chaff	DDG's	Rice Husks
Sample Number:	06-0201	06-0198	06-0199	06-0196	06-0197	xx-xxx	CHN-2006-349-21
Condition:	As-Fired	As-Fired	As-Fired	As-Fired	As-Fired		
Proximate Analysis, %:							
Moisture	2.60	7.60	9.80	5.60	8.80	9.1	5.84
Volatile Matter	73.08	69.20	70.02	77.17	63.82	74.69	68.82
Fixed Carbon	18.55	18.01	17.45	16.61	15.60	13.04	7.40
Ash	5.77	5.19	2.73	0.62	11.78	3.17	17.94
Ultimate Analysis, %:							
Hydrogen	6.07	6.25	6.79	6.57	6.16	6.6	4.678
Carbon	42.89	42.08	40.38	47.17	37.18	49.3	36.490
Nitrogen	4.42	0.74	2.08	0.36	0.99	4.32	0.397
Sulfur	0.63	0.21	0.26	0.23	0.12	0.34	0.07
Oxygen	40.23	45.52	47.76	45.05	43.78	27.17	34.585
Ash	5.77	5.19	2.73	0.62	11.78	3.17	17.94
HHV							
Btu/lb	7,882	7,292	7,185	8,510	6,713	8,746	6300
MJ/Kg	18.33	16.96	16.71	19.79	15.61	20.34	14.654
Excess Air %	30	30	30	30	30	n/a	40
NOx Lb/MMBtu	0.343	0.353	0.596	0.171	0.271	n/a	231.5 PPM

ASH ANALYSIS

Elemental Analysis %	DDG's	PRESSINGS from RAPE	RICE HUSKS	BARLEY NEEDLES
SiO2	4.38	1.77	91.80	17.70
Al2O3	0.33	0.08	2.1	1.51
TiO2	0.04	0.04	<0.1	<0.01
Fe2O3	0.53	0.27	0.4	0.33
CaO	4.63	16.70	2.0	3.00
MgO	12.40	10.60	1.5	9.14
Na2O	0.89	0.10	0.4	1.03
K2O	28.10	24.80	0.9	27.80
P2O5	47.79	42.69	0.4	36.19
SO3	0.36	2.34	0.2	1.20
Cl	0.02	0.11	-	1.45
CO2	0.14	0.87	-	-
Total	99.61	100.37	99.80	99.35

ASH FOULING

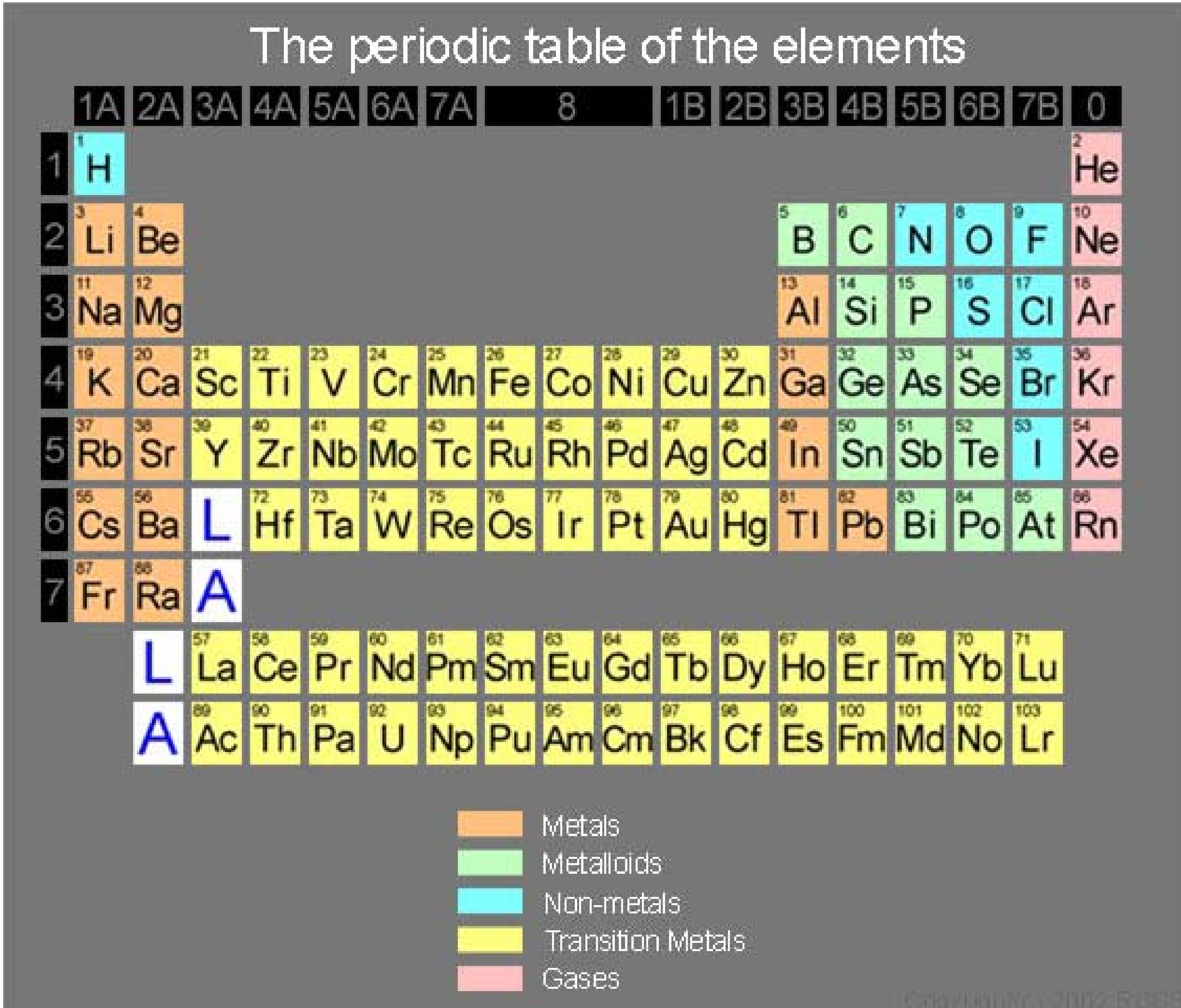
• Eutectic formed between silica and soluble alkalis such as calcium, magnesium, potassium or sodium, that can create a potential problem of slagging in the boiler.

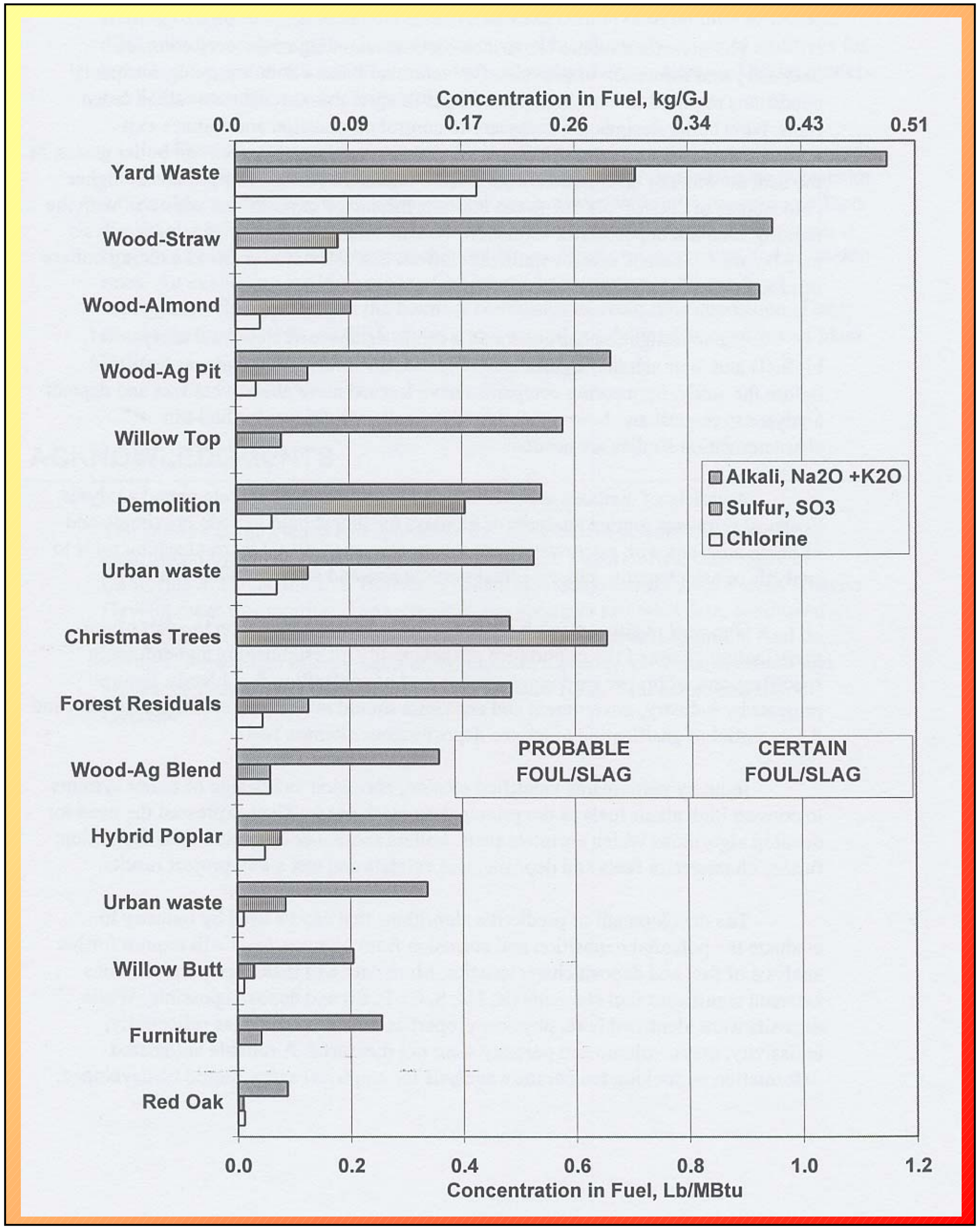
•Chlorides.

•The condensation, adherence and later sintering of volatile ash components on to convection heating surfaces causes fouling and potentially corrosion.

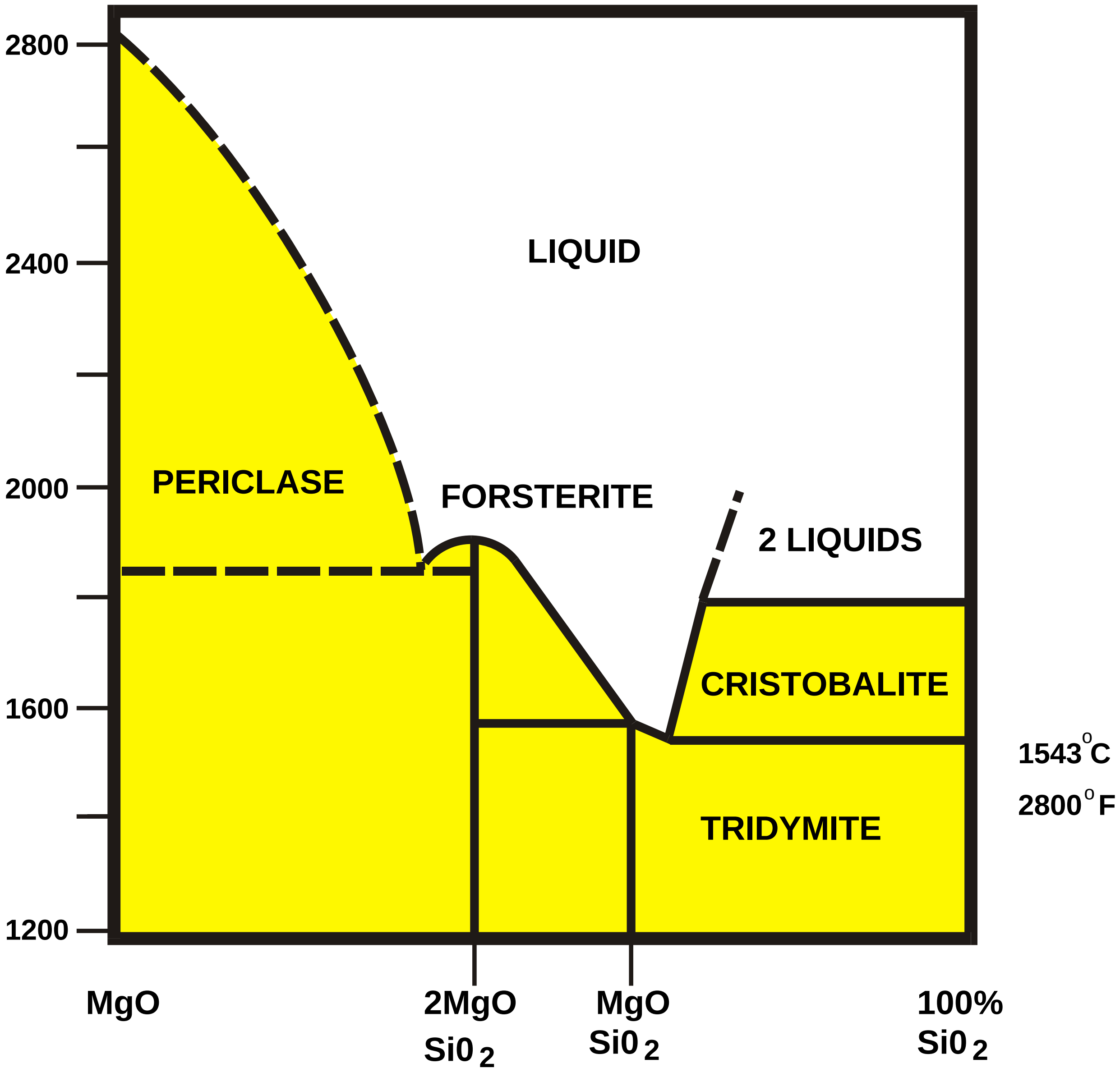
• The volatile ash components are usually the chlorides and the alkali metal oxides (K_2O and Na_2O). Another problem volatile component: P_2O_5

• We recommend using ASTM D 1102 (Test Method for Ash in Wood) which requires 600 degrees C. temperature for calcining the ash.


The periodic table of the elements
1A 2A 3A 4A 5A 6A 7A 8 1B 2B 3B 4B 5B 6B 7B 0
1 H
2 He
3 Li 4 Be 5 B 6 C 7 N 8 O 9 F 10 Ne
11 Na 12 Mg 13 Al 14 Si 15 P 16 S 17 Cl 18 Ar
19 K 20 Ca 21 Sc 22 Ti 23 V 24 Cr 25 Mn 26 Fe 27 Co 28 Ni 29 Cu 30 Zn 31 Ga 32 Ge 33 As 34 Se 35 Br 36 Kr
37 Rb 38 Sr 39 Y 40 Zr 41 Nb 42 Mo 43 Tc 44 Ru 45 Rh 46 Pd 47 Ag 48 Cd 49 In 50 Sn 51 Sb 52 Te 53 I 54 Xe
55 Cs 56 Ba L 72 Hf 73 Ta 74 W 75 Re 76 Os 77 Ir 78 Pt 79 Au 80 Hg 81 Tl 82 Pb 83 Bi 84 Po 85 At 86 Rn
87 Fr 88 Ra A
L 57 La 58 Ce 59 Pr 60 Nd 61 Pm 62 Sm 63 Eu 64 Gd 65 Tb 66 Dy 67 Ho 68 Er 69 Tm 70 Yb 71 Lu
A 89 Ac 90 Th 91 Pa 92 U 93 Np 94 Pu 95 Am 96 Cm 97 Bk 98 Cf 99 Es 100 Fm 101 Md 102 No 103 Lr
Metals
Metalloids
Non-metals
Transition Metals
Gases

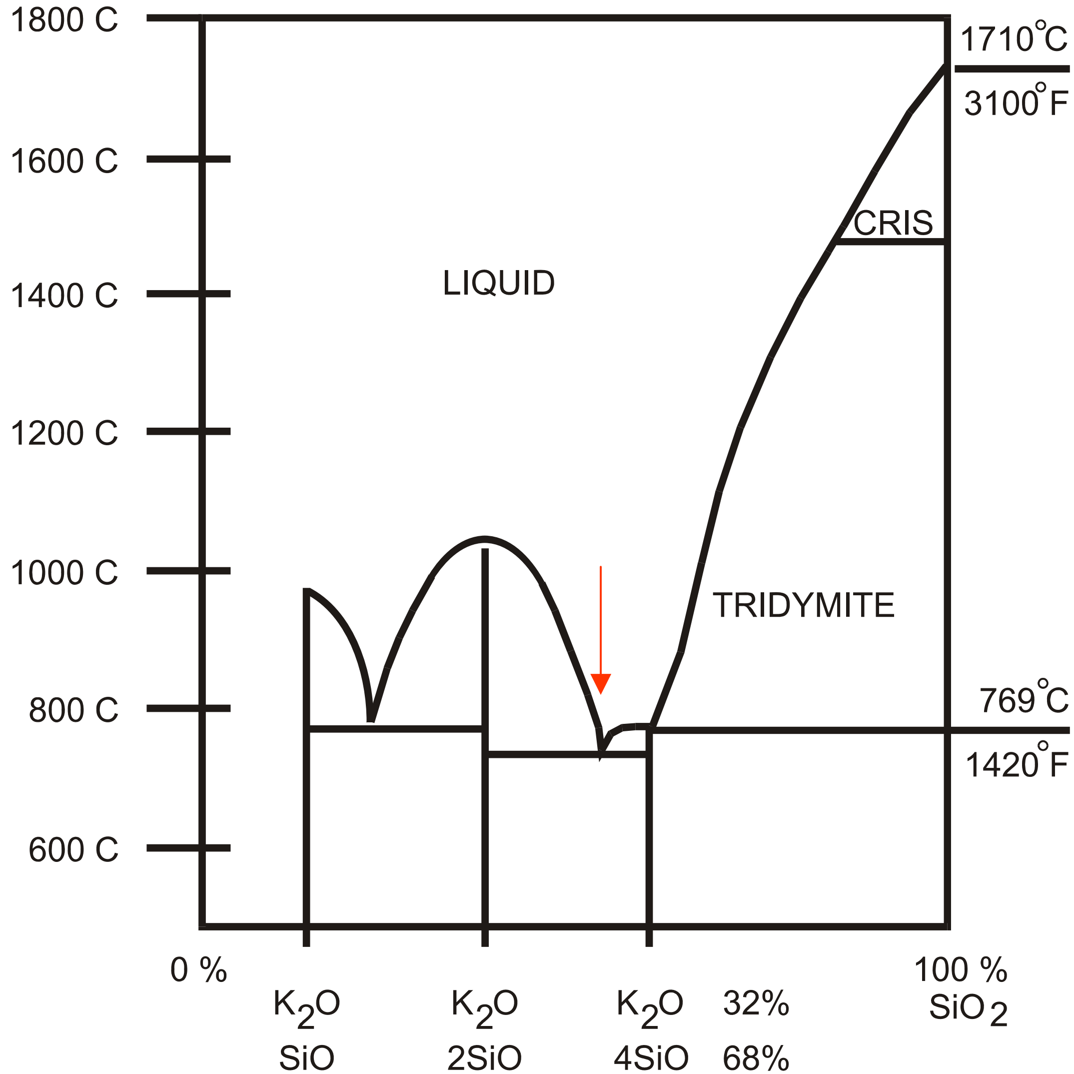


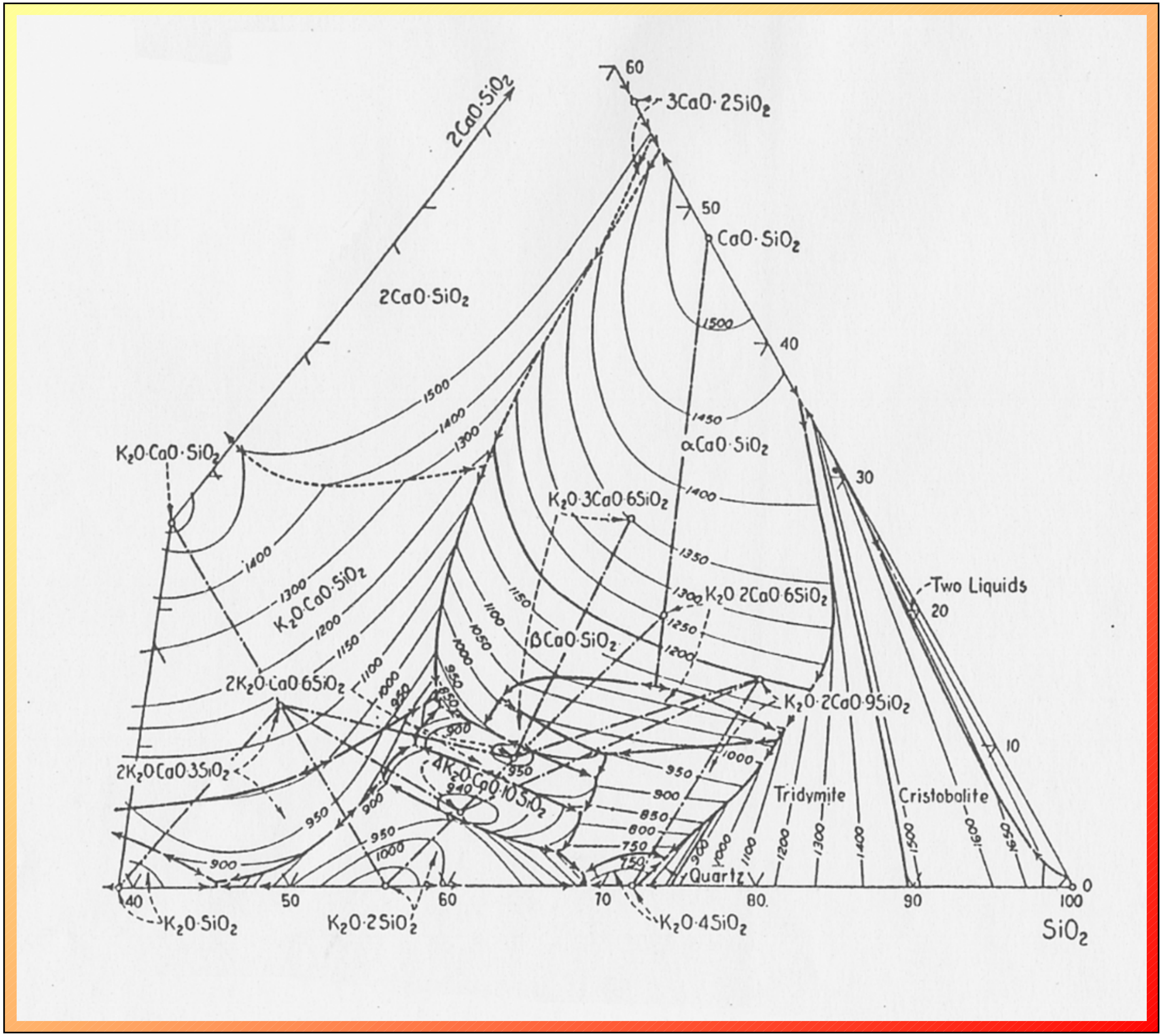
WOOD FUELS WITH HIGH ANNUAL GROWTH ARE ABUNDANT IN ALKALI, SULFUR AND CHLORINE



PHASE DIAGRAM FOR MgO-SiO

Phase Diagram for K_2O-SiO_2





K_2O-CaO-SiO_2SYSTEM

ASH FOULING INDICES

- Eutectic formed between silica and potassium, phosphorus or sodium, that can create a potential problem of slagging in the boiler

- The condensation, adherence and later sintering of volatile ash components on to convection heating surfaces causes fouling.

- The volatile components are usually the alkali metal oxides (K_2O and Na_2O). Another problem volatile component: P_2O_5

- There are two indices, which point to fouling with biomass fuels.

- The ratio of the alkali metal oxides to silica ($(K_2O+Na_2O)/SiO_2$) - AMOS Index

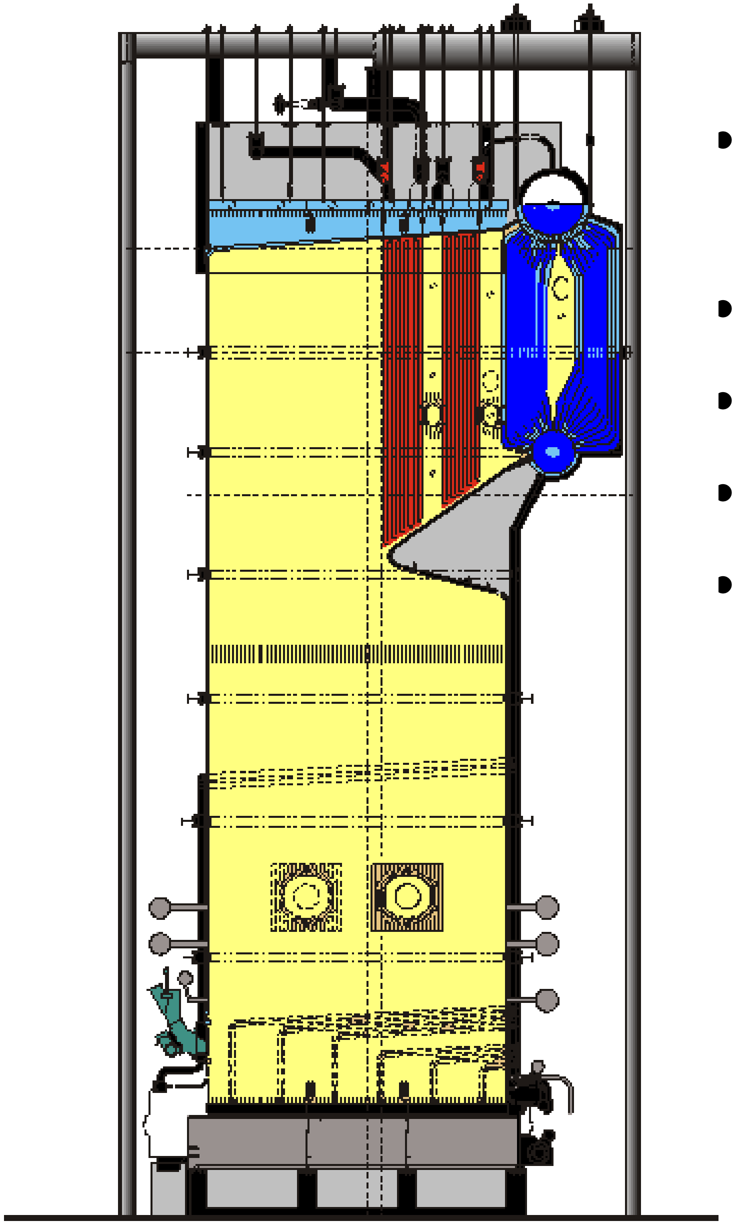
- The ratio of alkali metals to the gross calorific value ((K_2O+Na_2O) x % ash/GCV)) - GCV Index

- Both have been found to be reliable indicators. These two indices supplement each other.

NITROGEN OXIDES

- **Unlike coal, conversion of fuel bound nitrogen form bulk of NO_x generation when burning biomass.**
- **Conversion of fuel bound nitrogen to NO_x minimized and/or NO_x is reduced after formation if the fuel is starved for oxygen at the moment of devolatization. <20% conversion attainable.**
- **Consider N_2 percent when evaluating fuels.**

SYSTEM PERFORMANCE



- Steam capacity, Pressure, Temperature
- Thermal efficiency
- Operations / Maintenance
- Reliability / Redundancy
- Emissions limits (NOx, CO, PM, PM-10, PM-2.5, SO2, VOC)

FURNACE / BOILER DESIGN CRITERIA

- Time, temperature and turbulence in the furnace are optimized for good combustion.
- Low volume heat release rate for sufficient retention time—maximizes carbon burnout and minimizes NOx and CO emissions (longer residence time).
- Longer residence time promotes good burnout and minimizes carryover of air borne fuel particles.
- Low velocities through boiler convection sections to minimize erosion.
- NOx emissions vary directly with fuel bound nitrogen content and excess air.
- CO emissions vary directly with biomass fuel moisture content and excess air.

BOILER/COMBUSTION SYSTEM DESIGN FOR EMISSIONS REDUCTIONS

(Solving Tomorrows Problems with Yesterday's Technology)

- Better Fuel Distribution
- Better Seals
- Improved Overfire Air Systems
- Lower Heat Release Rates
- Sectionalized Undergrate

HEAT RELEASE RATES

Coal – Bituminous

Grate – 750,000 BTU/sq. ft. (approx)

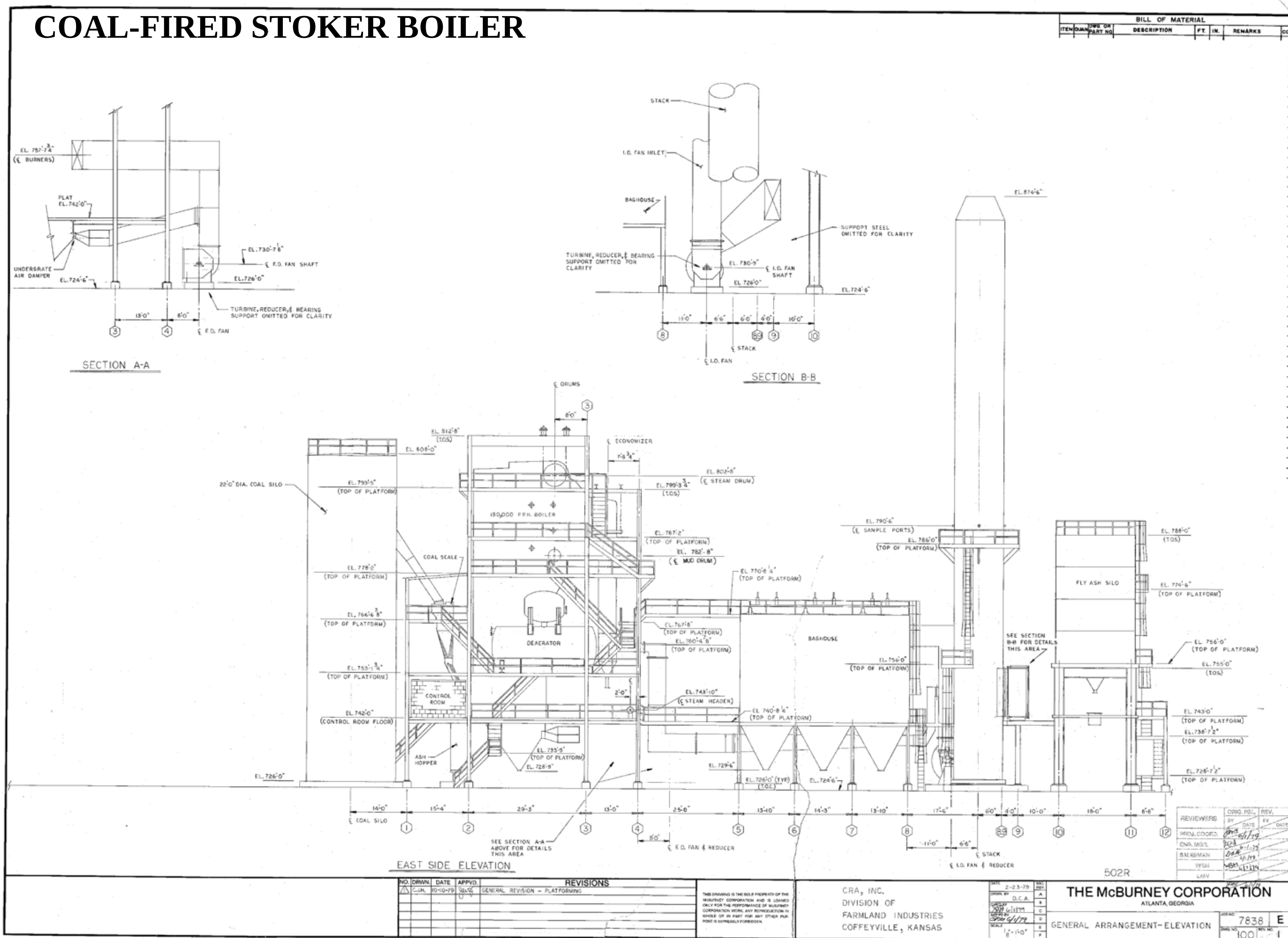
Volumetric – 20,000 – 25,000 BTU/cu. ft.

•Biomass – Wood Wastes

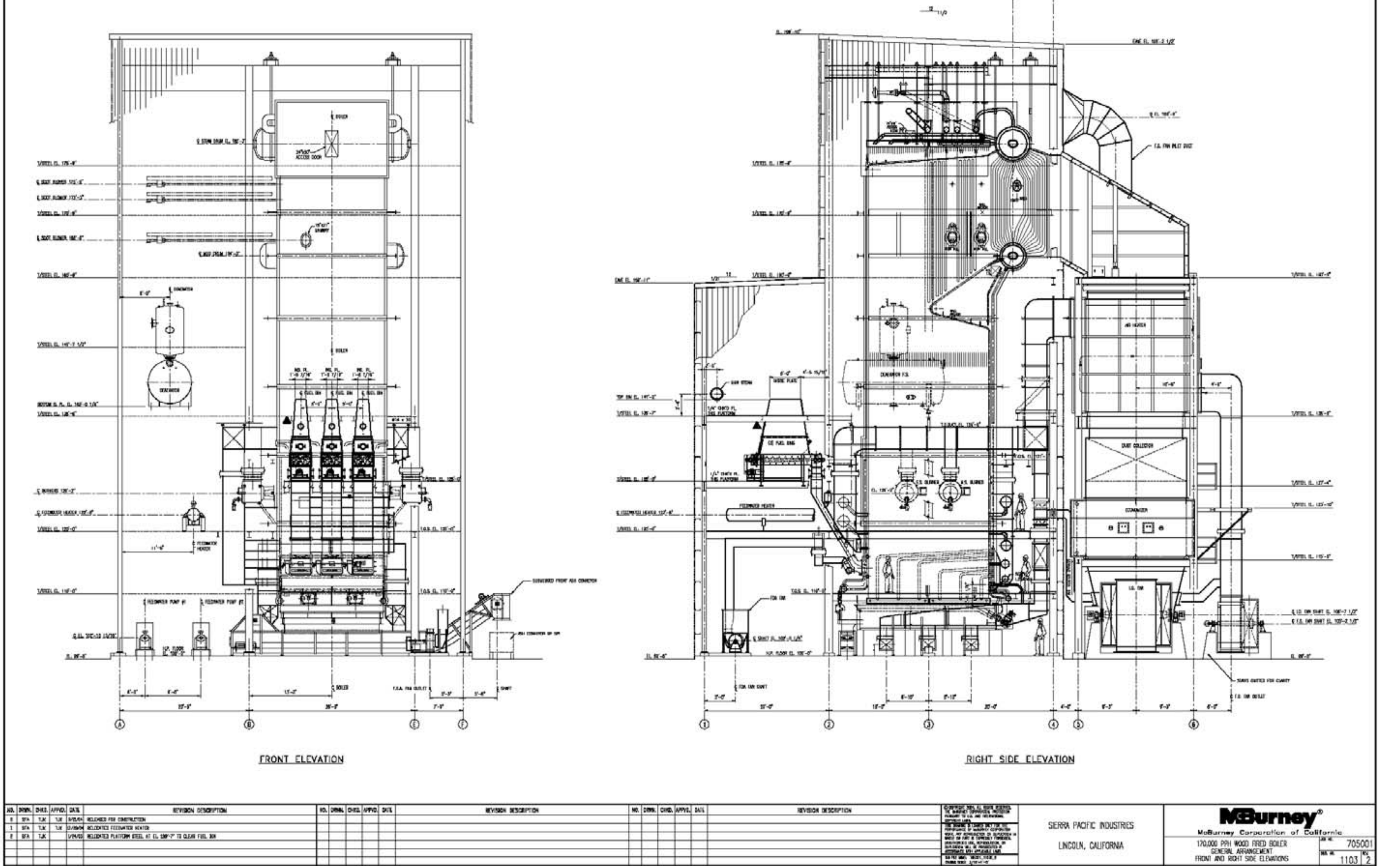
Grate – 850,000 – 1,000,000 BTU/sq. ft.

Volumetric – 15,000 – 20,000 BTU/cu. ft.

COAL-FIRED STOKER BOILER



WOOD-FIRED STOKER & BOILER



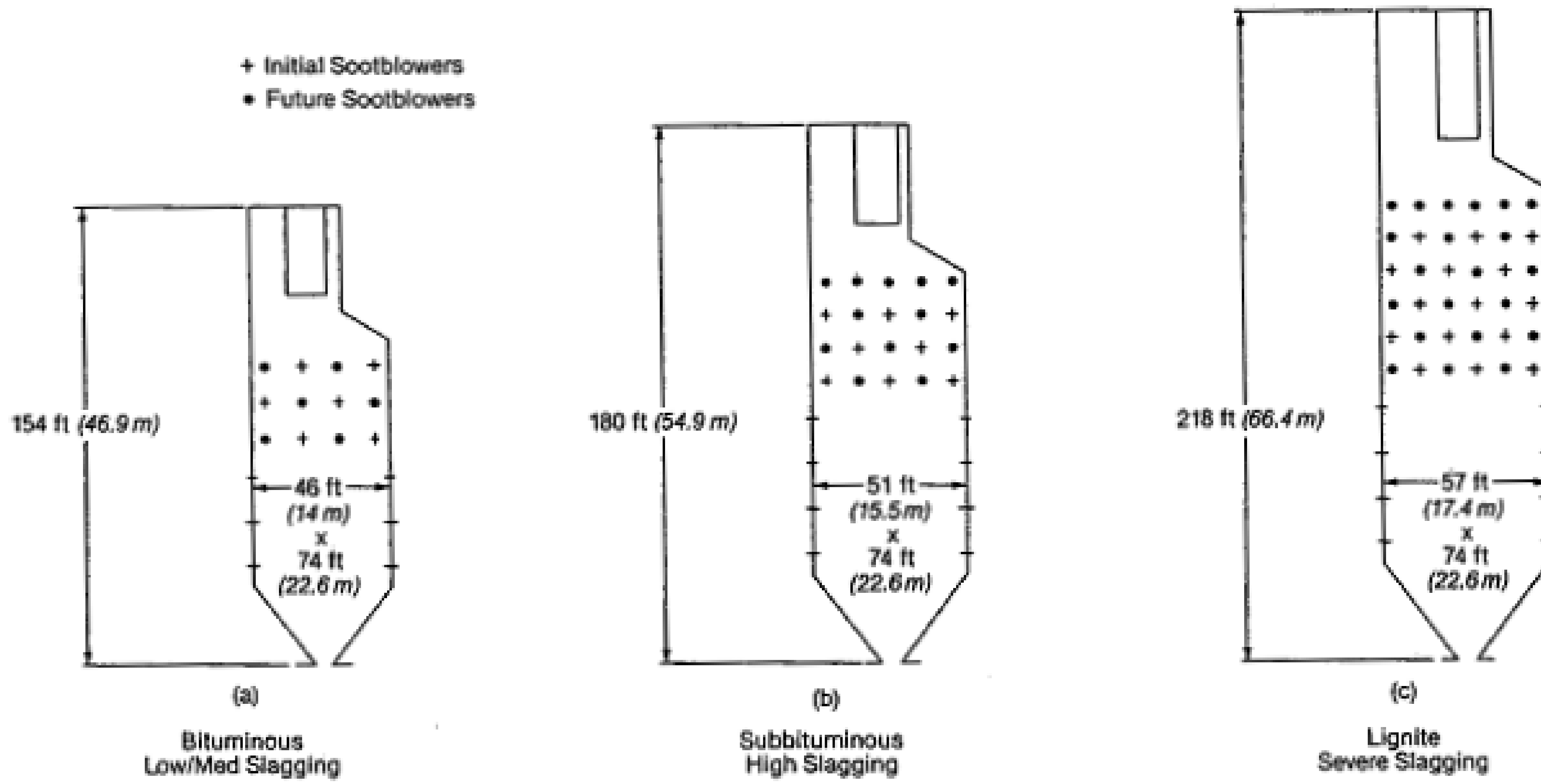


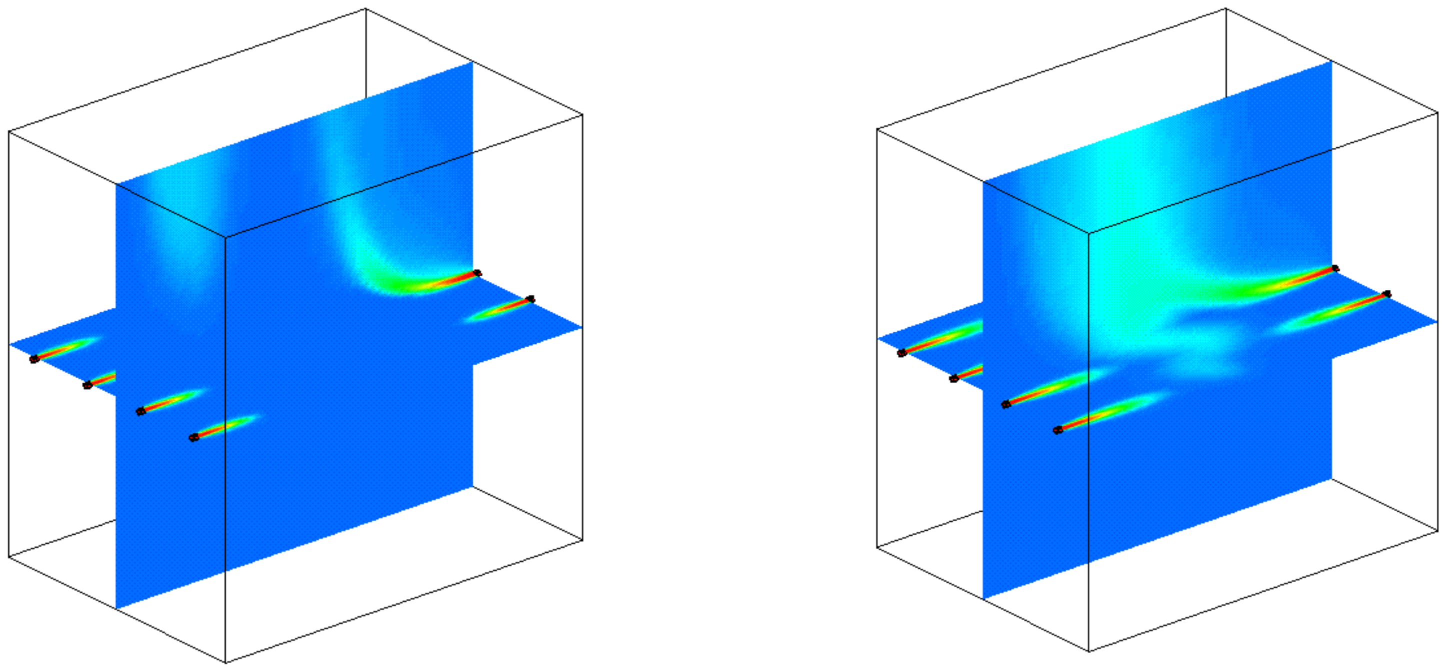
Fig. 19 Influence of slagging potential on furnace size. (See Table 6.)

OVERFIRE AIR

- Proper turbulence in upper furnace assures good fuel/air mixing (minimizes CO and VOC emissions).
- Staged combustion reduces NOx emissions.
- Select Radial and Axial Jet Velocities to Match Vertical Cross Flow and Buoyancy Effects
- Interlaced (Staggered) Design to provide an Effective Curtain of Combustion Air

OVERFIRE AIR—CFD

4” diameter nozzles @ 5” and 20” w.g. pressure



Nozzle Pressure = 5 inches H_2O

Nozzle Pressure = 20 inches H_2O

SUSPENSION FIRING

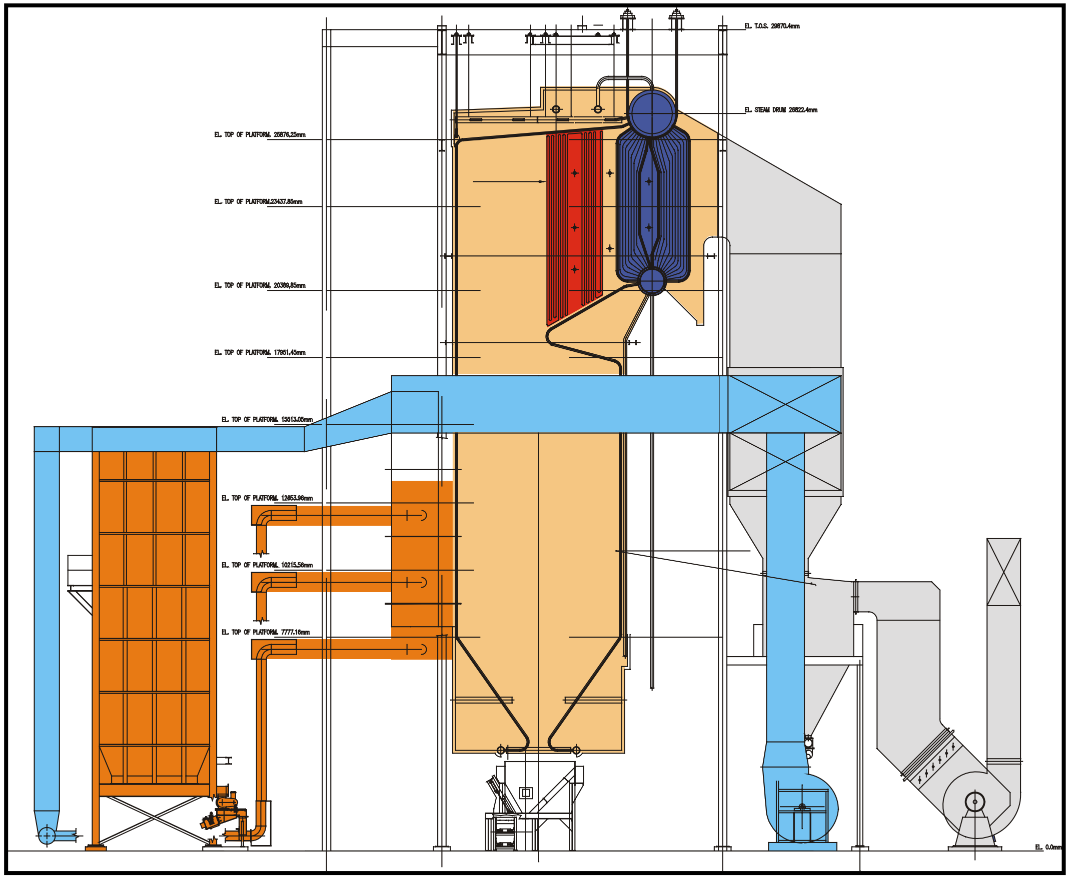
- Best method for dry, small particle size biomass. Smaller particles with lower terminal velocities dry/volatize in suspension.
- Provides better control of fuel air mixing, improving combustion efficiency. Smaller particles are less dense with lower mass of moisture.
- Smaller particles have higher surface area burn quickly, help dry/volatilize higher moisture particles.
- Reduces possibility of furnace pressure excursions.
- Proven method for firing high silica/high ash fuels such as Rice Husks without creation of Cristobalite, *when furnace is properly designed*.
- Low NOx emissions because of lower furnace temperatures.

SUSPENSION BURNERS

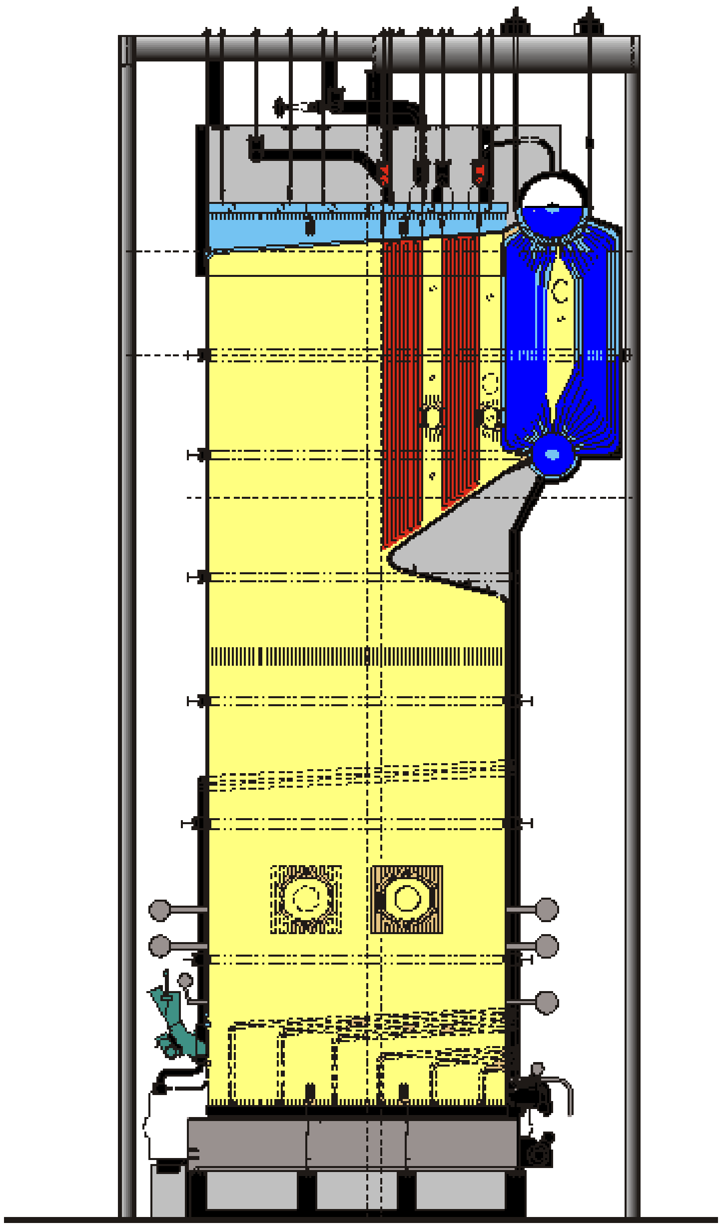
SUSPENSION FIRING

- Biomass fuel may require extensive processing prior to firing.
- Allowable storage time after preparation may be limited to prevent moisture contamination and to limit potential for fires.
- Can also be used for biomass containing high alkali ash
- Ash analysis with careful analysis of slagging indices is imperative.
- Ash removal systems must consider the distinctive properties of the fuel and the firing system.
- May not require the use of a pilot to sustain ignition, depending on boiler firing rate and particle size distribution.

Side View of a Suspension Fired (Rice Husks) Biomass Boiler System



BOILER SYSTEM DESIGN



Other Factors

- Process controls
- Ash Removal
- Auxiliary fuel(s)
- Space limitations
- Future plans
  - Plant expansion
  - Tighter emissions
  - Other fuels

SIERRA-PACIFIC – ABERDEEN, WA

- **Boiler Capacity:**

  72.5 T/hr, (160,000 pph)
- **Steam Pressure:**

  86.2 Bar, (1250 psig)
- **Steam temperature: 537°C, (900°F)**
- **Fuels: Wood, Natural Gas**
- **Detroit Stoker Vibrograte**
- **Emissions Controls:**

  -Multicyclone Collector

  -Electrostatic Precipitator

  -SNCR
- **McB Scope: EPC**
- **Electrical Generation: 16 MW**
- **Project Schedule: 18 mos.**
- **Commercial Operation: March 2003**

AT BIOPOWER- PICHIT, THAILAND

- **Boiler Capacity:**

  90.7 T/hr (200,000 lb/hr
- **Steam Pressure:**

  65.5 Bar (950 psig)
- **Steam Temperature:**

  482°C (900°F)
- **Fuels:**

  Rice Husks, No. 2 Oil
- **Emissions Controls:**

-Staged Combustion, Overfire Air

-Mechanical Collector

-Electrostatic Precipitator

- **McB Scope: Boiler Island Design,**

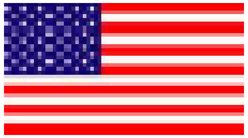
  Combustion System Supply
- **Project Schedule: 24 mos.**
- **Commercial Operation:**

  December 2005

US SUGAR – CLEWISTON, FL

- **Boiler Capacity:**

  226.5 T/hr, 41.4 Bar, 399°C,
  (500,000 lb/hr, 600 psig, 750°F)



- **Fuels:**

  Bagasse & No. 2 Oil

- **Emissions Controls:**

  -Wet Scrubbers

  -SNCR System for NOx

  -Electrostatic Precipitator

- **McB Scope: EPC**
- **Project Schedule: 16 mos.**
- **Commercial Operation:**

  March 2005

SARA LEE – SUFFOLK, VA

- Boiler Capacity: 13.3T/hr (29,325 lb/hr)
- Steam Pressure: 18 Bar (265 psig)
- Steam Temperature: Saturated
- Fuel: Coffee Grounds
- Detroit Stoker Vibragrate
- McBurney Scope – EPC
- Emissions Controls:

  - Multicyclone Collector

  - Electrostatic Precipitator
- Project Schdule:

  16 months

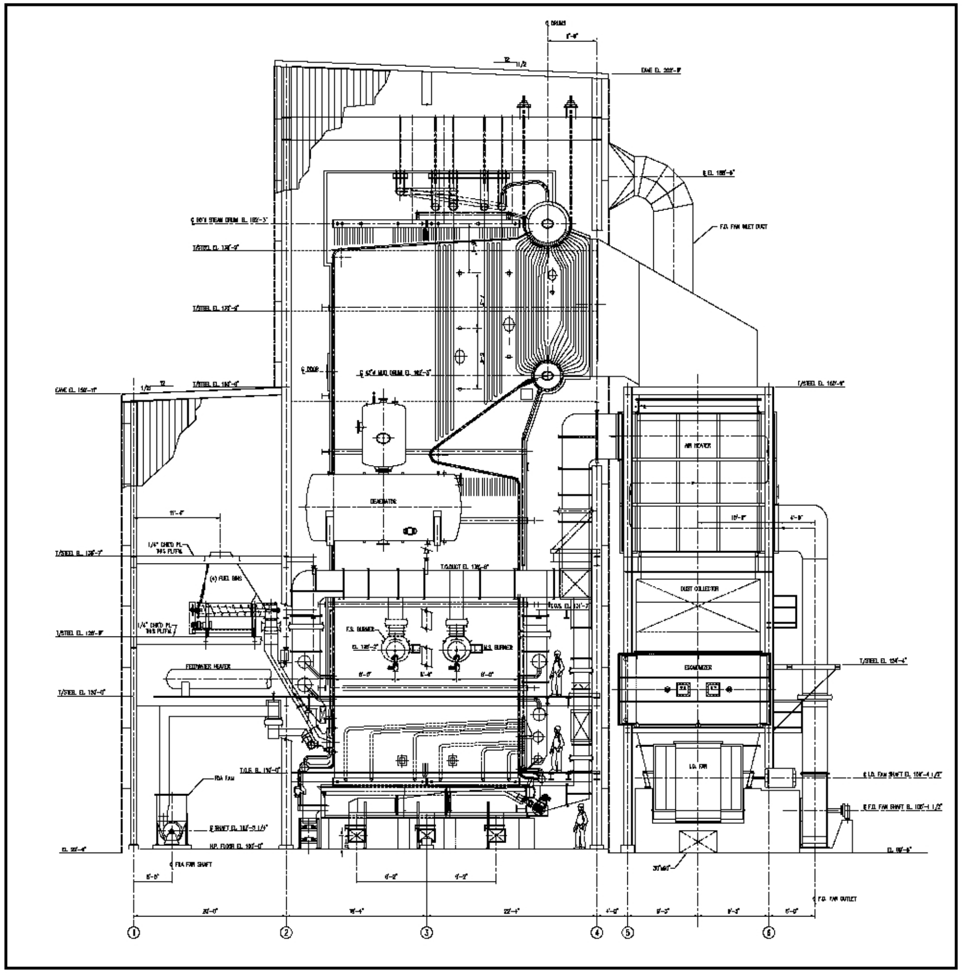
  (two phases combined)
- Commercial Operation: October 2003

KODA ENERGY – SHAKOPEE, MN

- Boiler Capacity: 220,000 pph
- Steam Pressure: 900 psig
- Steam temperature: 900ºF
- Fuels: Oat hulls, barley needles, malt sprouts, natural gas
- McB Tangential Burners
- Emissions Controls:
  - -SNCR system
  - -Multicyclone Collector
  - -ESP
- Electrical Generation:
  - 23 MW (net)
- McB Scope: EPC
- Project Schedule:
  - 18 months
- Commercial Operation:
  - December 2007

SIERRA PACIFIC – BURLINGTON, WA

- Boiler Capacity: 250,000 pph
- Steam Pressure: 900 psig
- Steam temperature: 900ºF
- Fuels: Wood, N. Gas
- Detroit Stoker Vibragrate
- Emissions Controls:
  - -Multicyclone Collector
  - -Electrostatic Precipitator
  - -SNCR
- McB Scope: EPC
- Electrical Generation:
  25 MW
- Project Schedule:
  18 months
- Commercial Operation:
  November 2006



START

WITH THE

FUEL!