



Combustion Impacts on Particulate Collection

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imagination at work



Combustion Impact on PM Collection

Areas of Impact

- > Particulate Loading to Control Device
- > Flue Gas Flow Rate
- > Flue Gas Composition
- > Particle Size Distribution
- > Carbon Content of Ash
- > Flue Gas Temperature

Particulate Loading

Most particulate enters the system as an inorganic constituent of the fuel. (Not the case for operations such as cement manufacturing)

For power plants, PM mass loading generally proportional to fuel firing rate

Fuel Flow rate controlled by:

- > Power requirements
- > System Efficiencies
 - Chemical to thermal energy conversion
 - Casing thermal losses
 - Stack sensible and latent heat loss
 - Steam turbine losses
 - Electrical generator losses

Particulate Loading

Power Plant Efficiency

Overall efficiency for coal-fired utility ~ 35-40%

Heat Rate ~10,000
Btu/KwHr

Example 240 MWe Plant

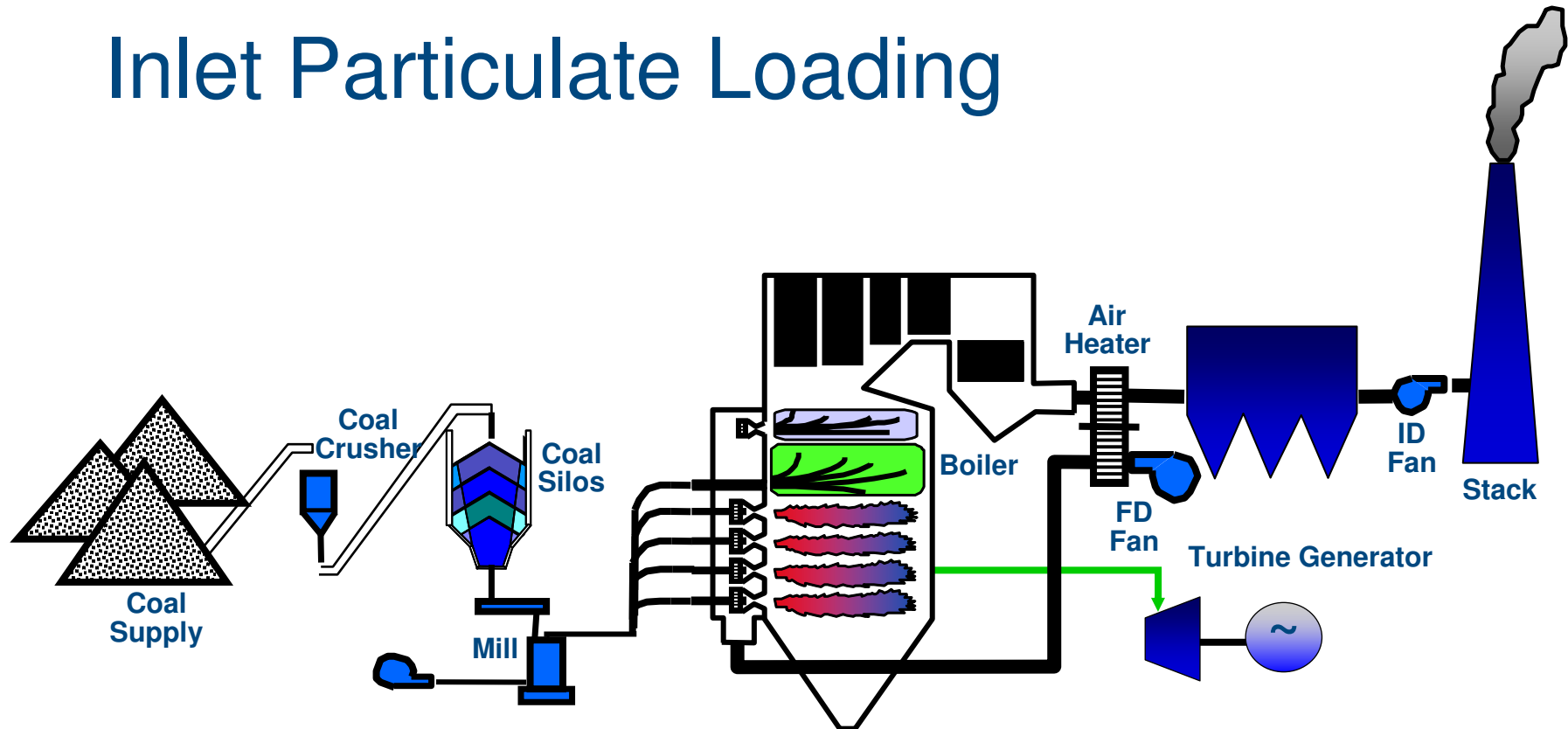
Coal HHV - ~12,000 Btu/lb
(from Proximate Analysis)

Fuel Use = **240,000Kw x
10,000 Btu/KwHr/12,000 Btu/lb /
2000 lb/ton** = 100 tons/hr

Coal Ash Content ~ 10%

PM = 100 tph coal x 10% ash
= 10 tph PM

Inlet Particulate Loading

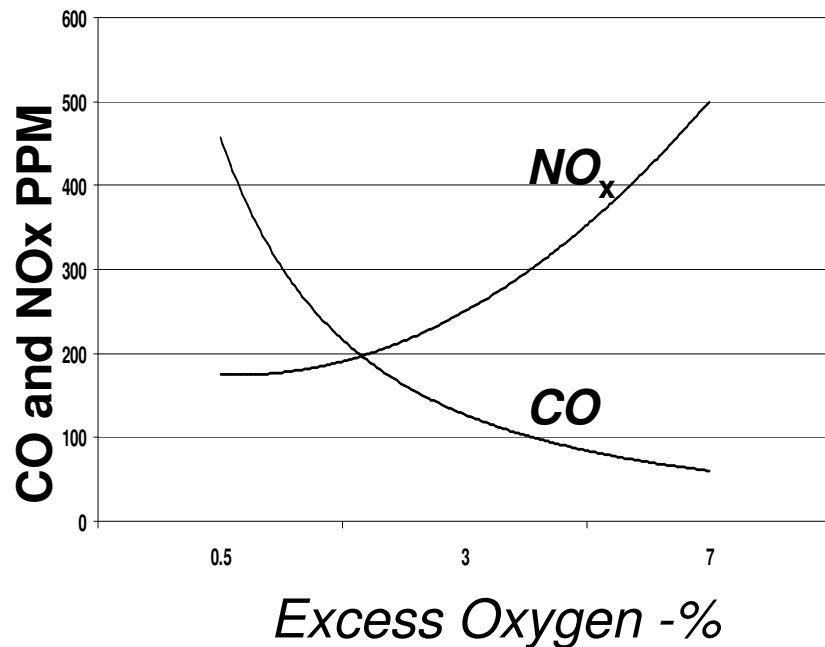


About 20% of Ash Falls out as Bottom Ash

About 80% Passes Through Boiler as Fly Ash

For Typical 240 MWe Plant – 8 Tons/hr Fly Ash

Flue Gas Quantity



Most flue gas mass derived from combustion air and in-leakage

Stoichiometric air defined by fuel composition (Ultimate Analysis)

Excess air required since fuel/air mixing less than perfect

Air in-leakage accounts for significant increase in volume

Flue Gas Quantity

Using Ultimate Analysis

Element	Formula	lb / 100lb	MW	Moles	O2 Multiplier	Stoichiometric O2 demand	Moles CO2	Moles H2O	Moles SO2	Moles N2
Carbon	C	72	12	6.00	1	6.00	6			22.71
Hydrogen	H2	4.4	2	2.20	0.5	1.10		2.2		4.16
Sulfur	S	1.6	32	0.05	1	0.05			0.05	0.19
Nitrogen	N2	1.4	28	0.05	0	0.00				0.05
Water	H2O	8	18	0.44	0	0.00		0.44		0.00
Oxygen	O2	3.6	32	0.11	-1	-0.11				-0.43
Ash		9								
						7.04	6.00	2.64	0.05	26.68
Stoichiometric Demand										
O2						7.04				
N2						26.68				
Moles Combustion Products										
			Stoichiometric	35.38						
			With 3% O2	40.865						
Volume Flue Gas/100 lb fuel				15733	scf					

Rule of Thumb – 12 lbs air per lb coal

Flue Gas Quantity

Example 240 MW_e Power Plant

100 tons/hr fuel

15750 scf/100 Lbs fuel (@3% O₂)

Flue gas flow

$$= 100 \text{ ton fuel/hr} * 2000 \text{ lb/ton} * 157.5 \text{ scfm/lb fuel}$$

$$= 525,000 \text{ scfm}$$

PM Loading

$$= 8 \text{ tons PM/hr} * 2000 \text{ lb/ton} * 7000 \text{ gr/lb} / 60 \text{ min/hr} / 525,000 \text{ scfm}$$

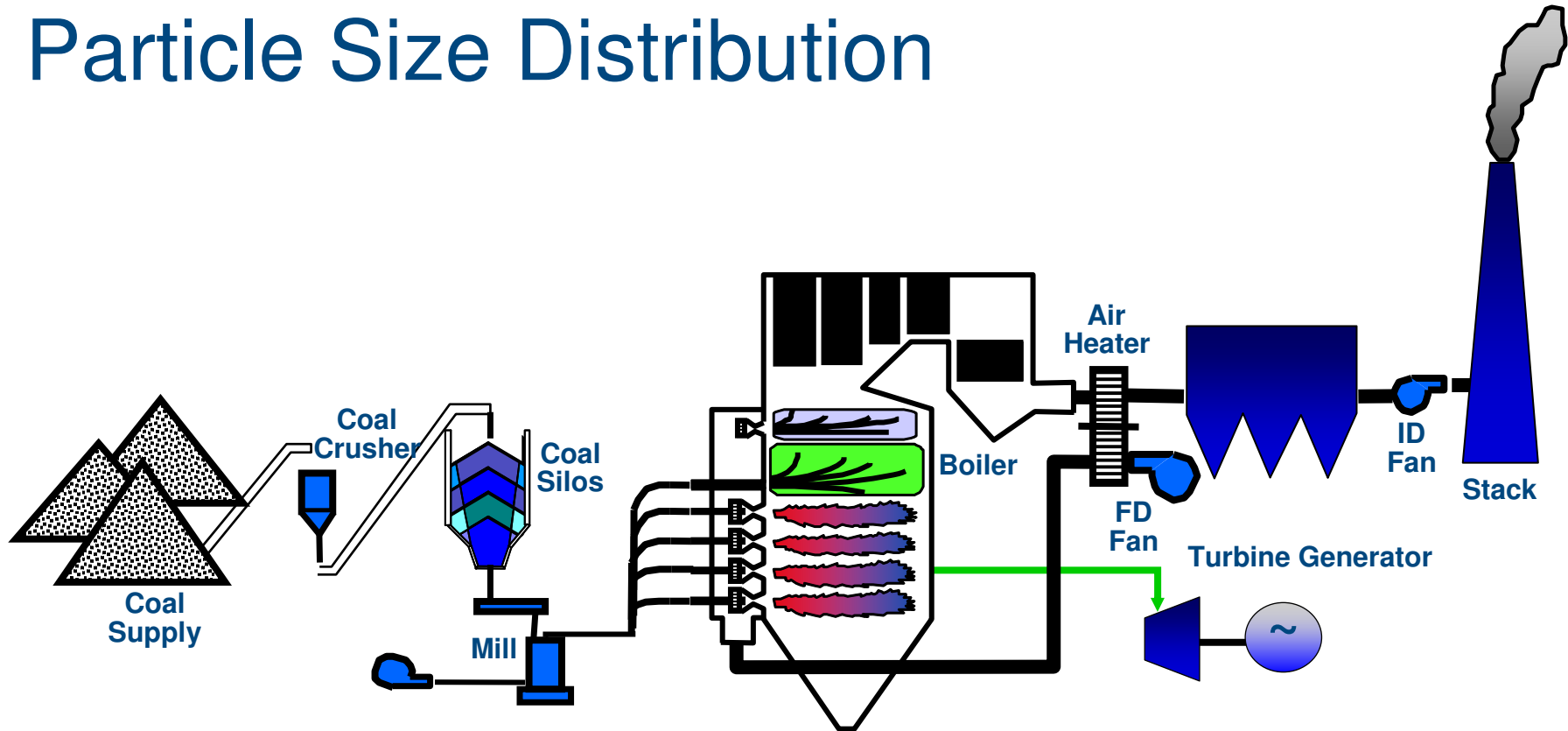
$$= 3.56 \text{ grains/ standard ft}^3$$

Flue Gas Composition

Based On Typical Ultimate Analysis

Flue Gas Species	Moles of Product	Concentration Wet	Concentration Dry
CO2	6	14.7%	15.7%
H2O	2.64	6.5%	0.0%
O2	1.15	2.8%	3.0%
SO2	0.05	1225 ppm	1308.22
N2	31.02	75.9%	81.2%
Total - wet	40.86		
Total - dry	38.22		

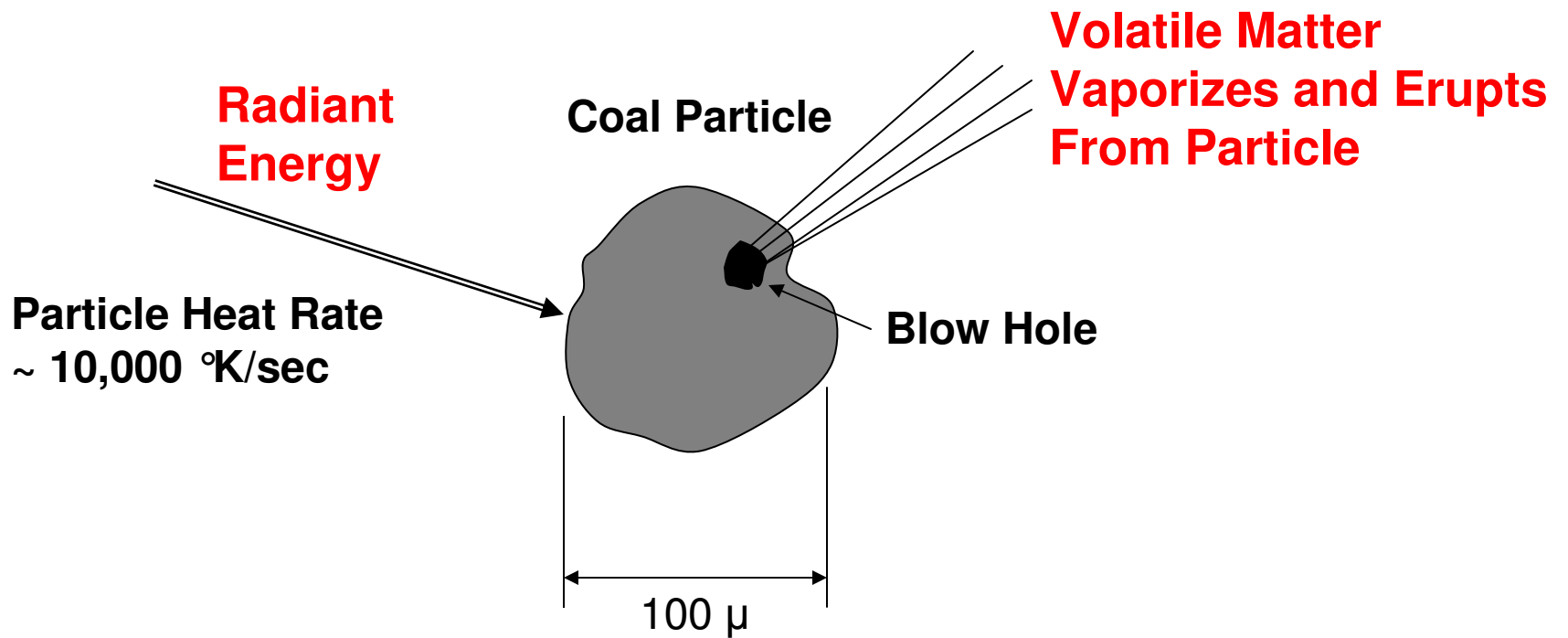
Particle Size Distribution



Crusher ~ 1" "particles"

Mills - 70% through 200 mesh screen – 125 microns

Coal Burning Processes



Particle Size Distribution

Proximate Analysis

- > Percent of coal that is volatile vs “fixed carbon”

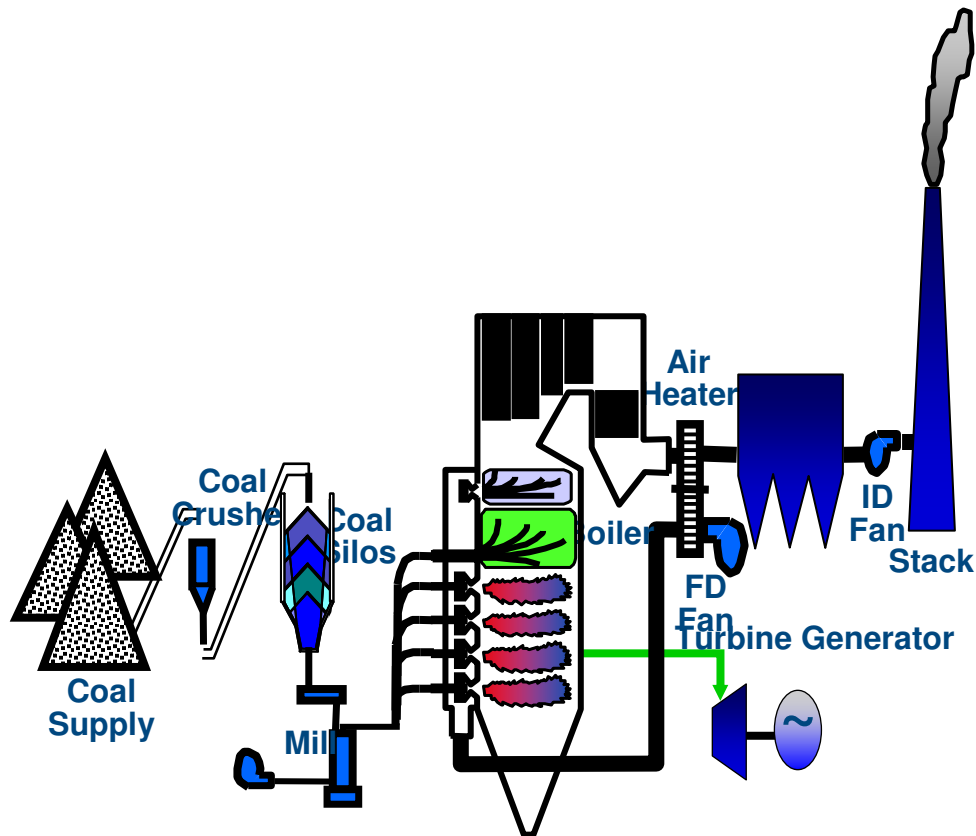
Volatile Matter burns like a gas flame

- > Rapid oxidation but MAY form soot since there can be local oxygen deficiency conditions

Fixed Carbon

- > Often referred to as “Char”
- > Burns by surface reaction - oxygen diffusion
- > End product is a burned out hulk of inorganic material
- > Lattice structure generally broken as they pass through convective sections – these are the “baseballs”

Carbon in Ash



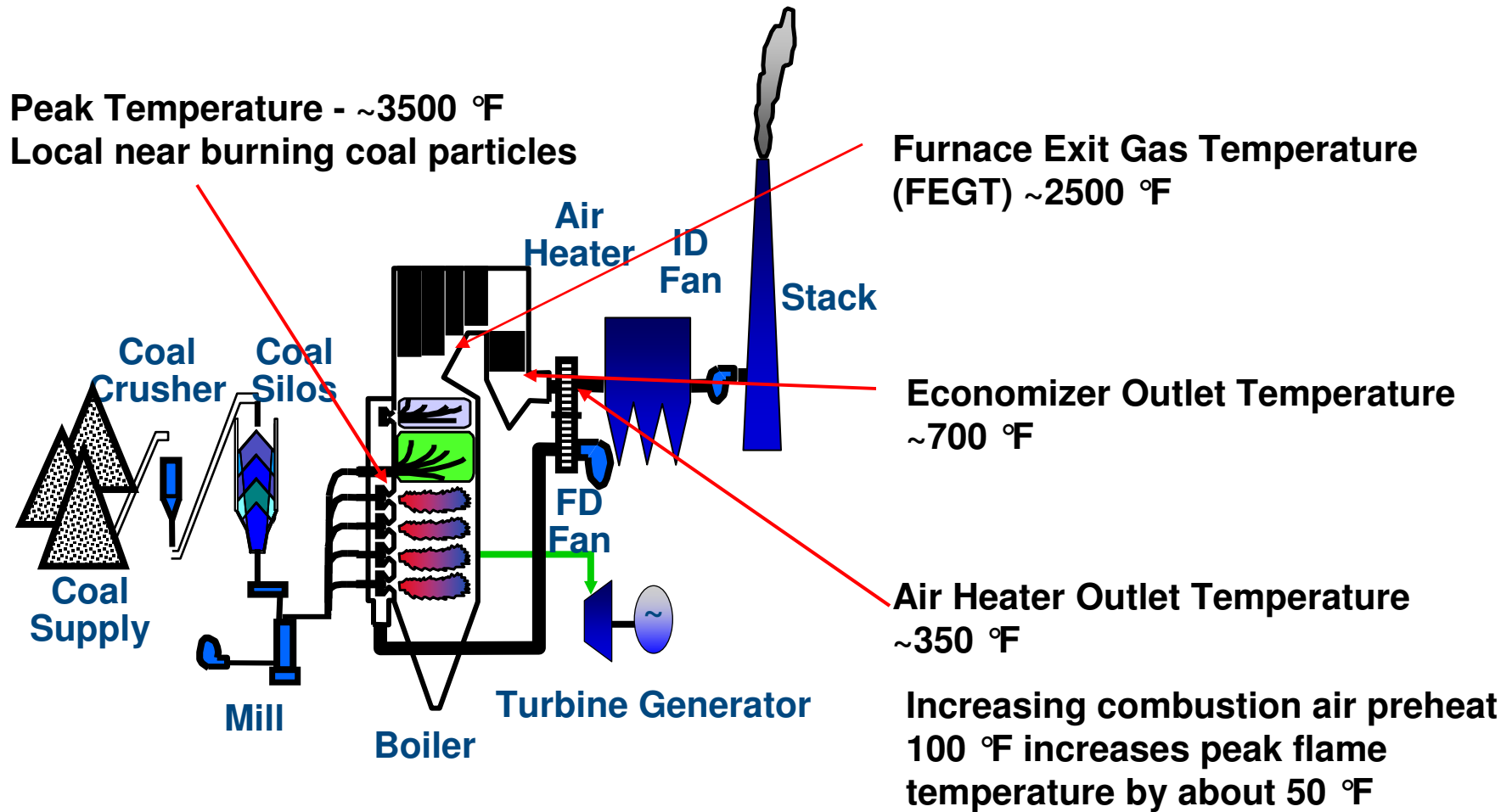
Burnout of Carbon in Char

- > Residence time from burners to nose
- > Effectiveness of fuel/air mixing
- > Reactivity of char

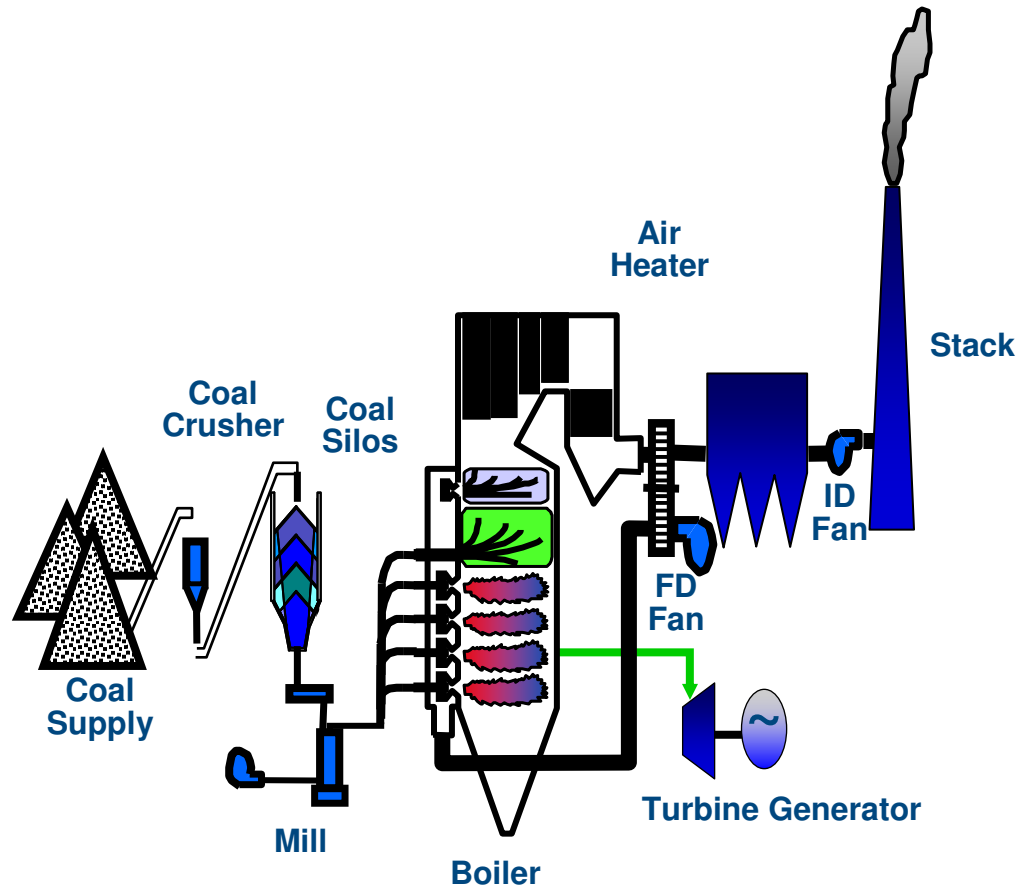
LOI

- > Range from ~ 1 to 20%

Flue Gas Temperature Patterns



Temperature Patterns



Changing air preheat

***Power Cycle efficiency
Slagging in Furnace
Ash resistivity in ESP
Flue gas ACFM***

***SO₃ Dew Point Temp.
~235 to 300°F depending on
moisture and SO₃ level***

Air Pre-heater Coils

***Use of air pre-heaters in
winter increases ESP inlet
temperature***

Summary

Combustion processes control many aspects of ESP operation

- Inlet PM Loading
- Flue gas flow rate (acfm and scfm)
- Particle size distribution
- Flue gas composition and temperature
- Carbon content of ash

Changing combustion conditions that impact ESP performance must be carefully considered. Potential influence on:

- NO_x production
- CO emissions
- Boiler cycle efficiency
- Slagging and fouling
- Boiler tube wastage rates
- Acid precipitation
- LOI