New Generation of Combustion Technologies to Optimize Coal-Fired Boiler Performance

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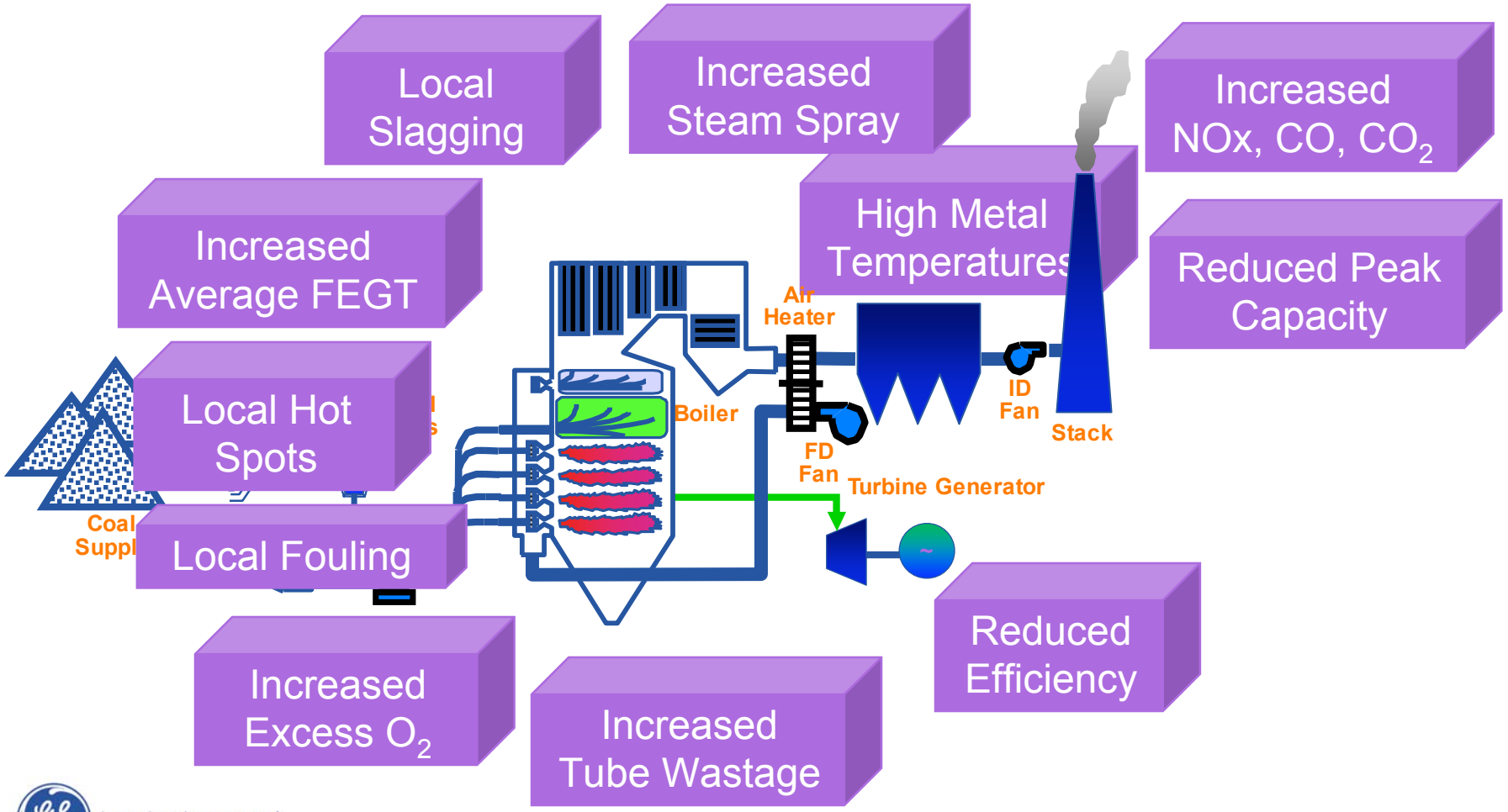
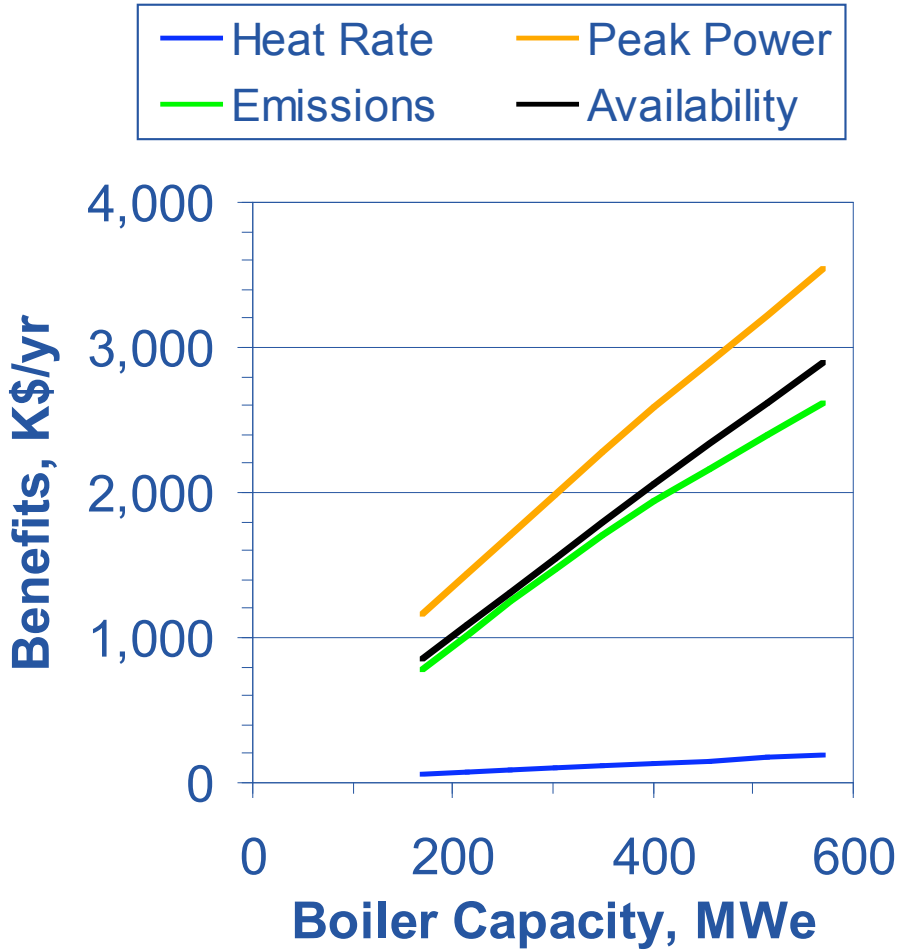
imagination at work

Poor combustion impacts many boiler performance parameters



Combustion optimization has multiple possible saving segments



Performance basis:

- NOx reduction = 15%
- Heat rate decrease = 0.4%
- Output increase = 2.3%
- Outage avoided = 1 week/year

Economic assumptions:

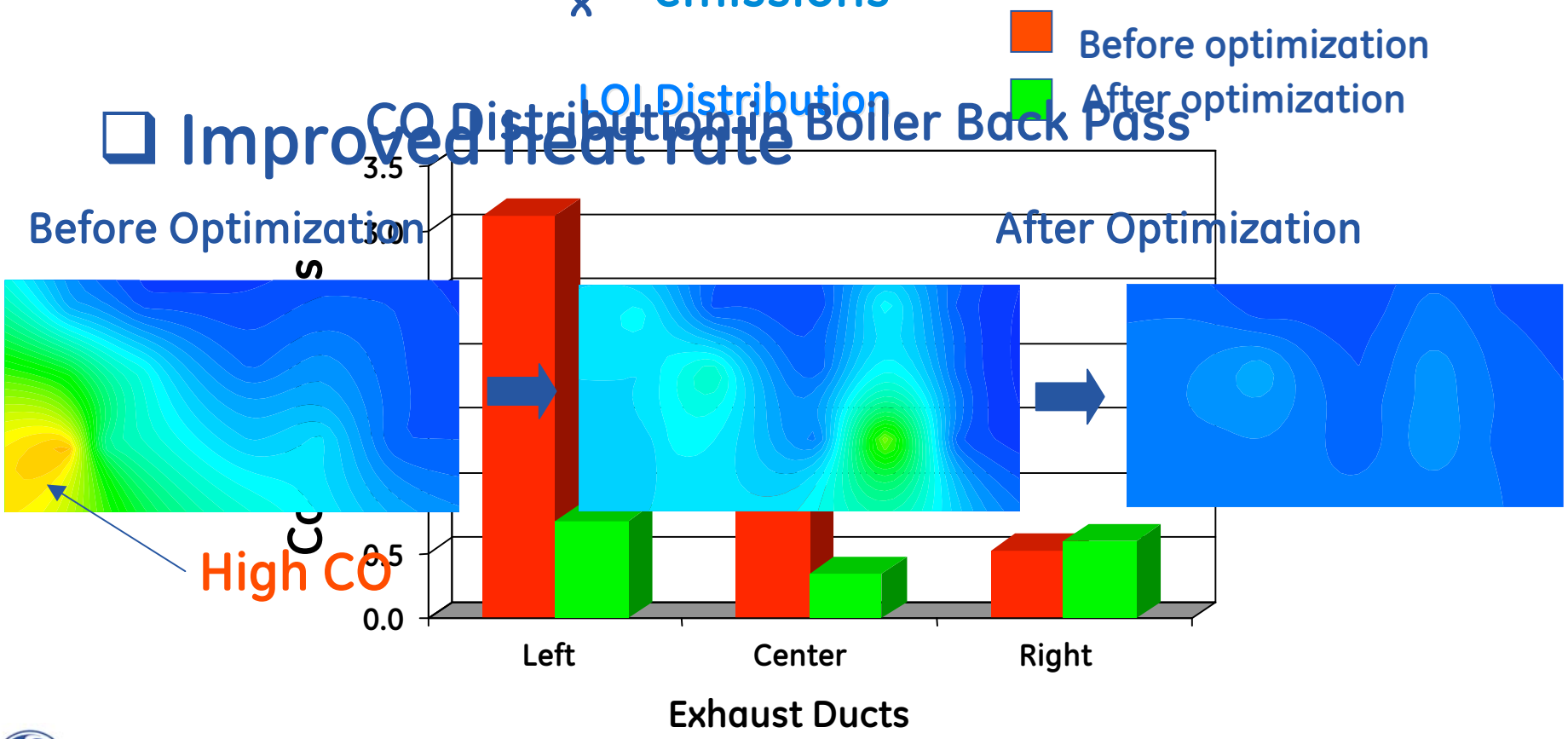
- Baseline NOx = 0.35 lb/MMBtu
- NOx credits = $2,500 per ton
- Fuel cost = 1 $/MMBtu
- Electricity price = 0.03 $/kWhr
- Capacity factor = 0.85

Benefits of combustion optimization

- Reduced NO$_x$ emissions
- Improved heat rate

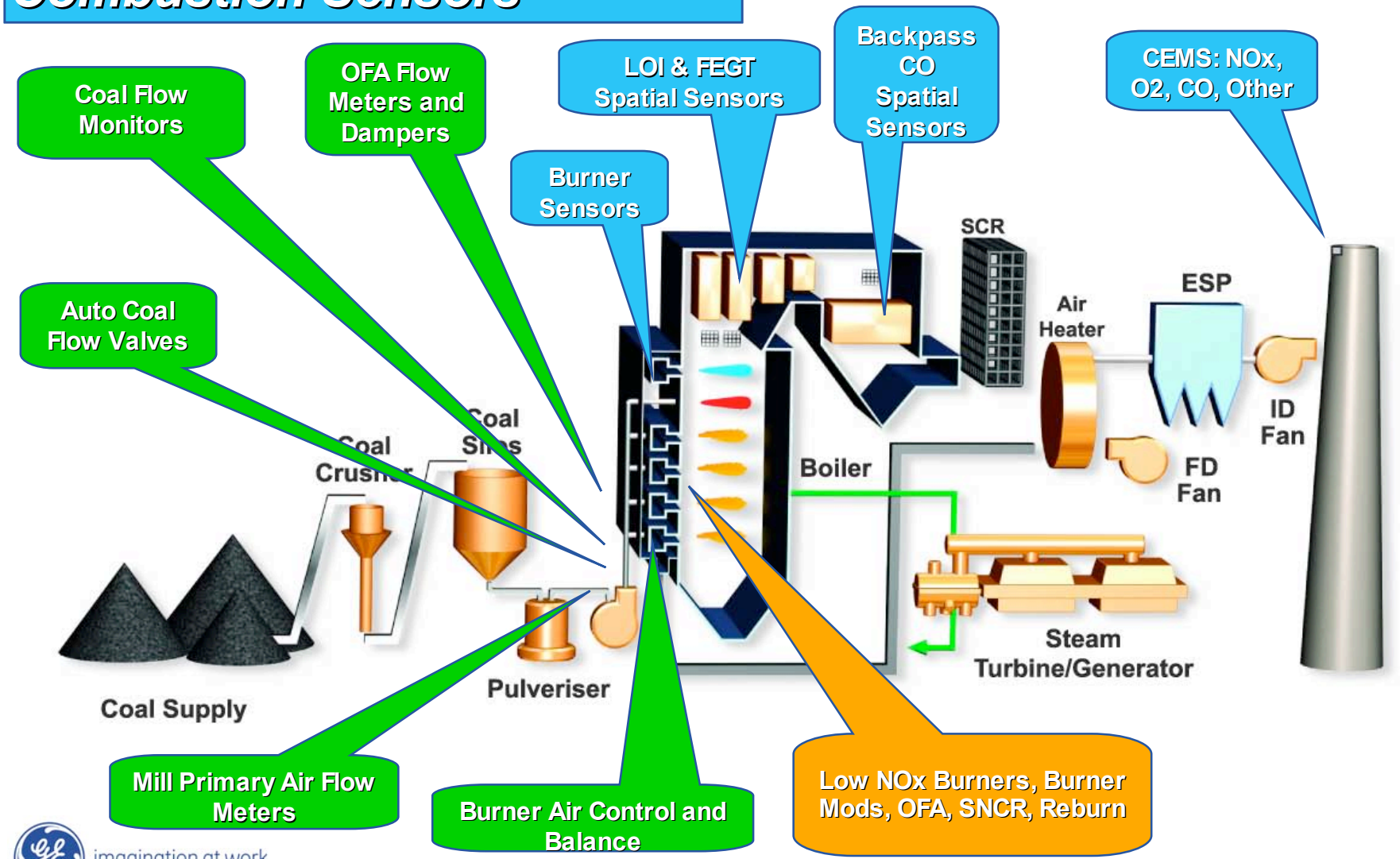
Maintaining deep staging conditions without increase in CO

Reduced LOI and improved mercury removal due to more uniform carbon distribution



Solutions for coal-fired generation

Combustion Sensors



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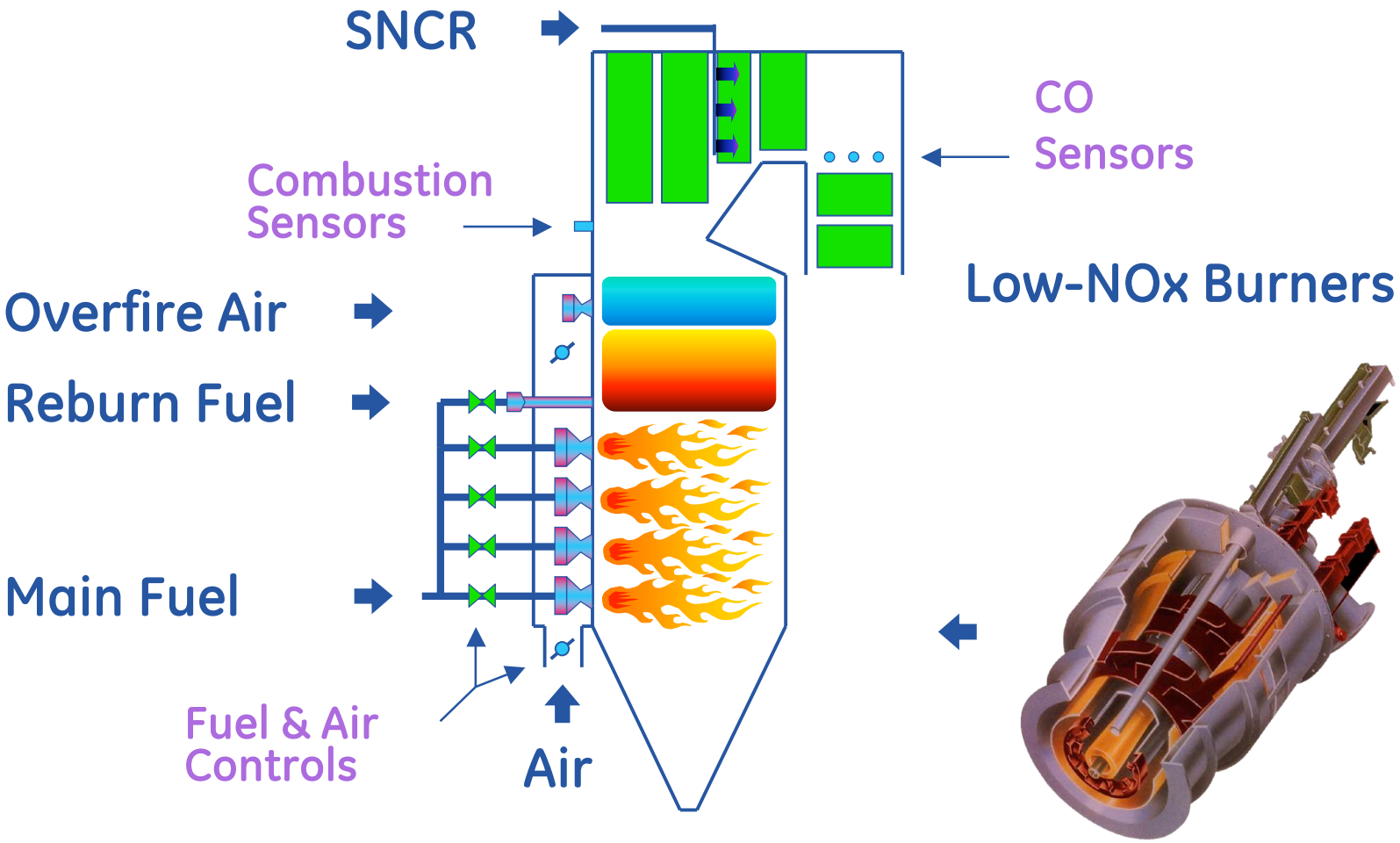
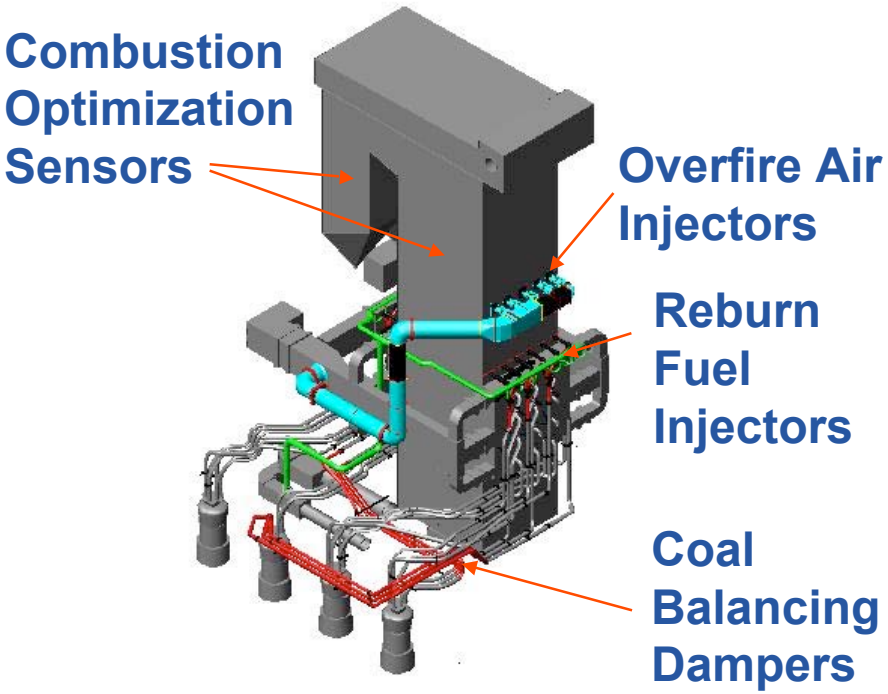
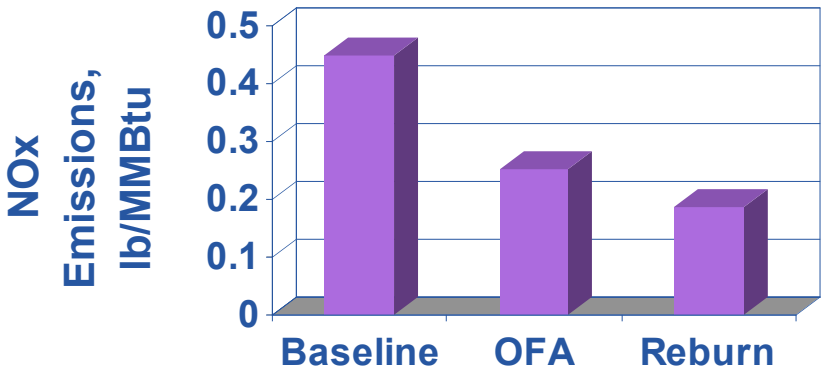
Layering of NO_x emissions control technologies for coal-fired boilers



Coal reburn optimization





Western Kentucky Energy Green Units 1 and 2 in Henderson KY – each 250 MW burning blends of coals and other solid fuels

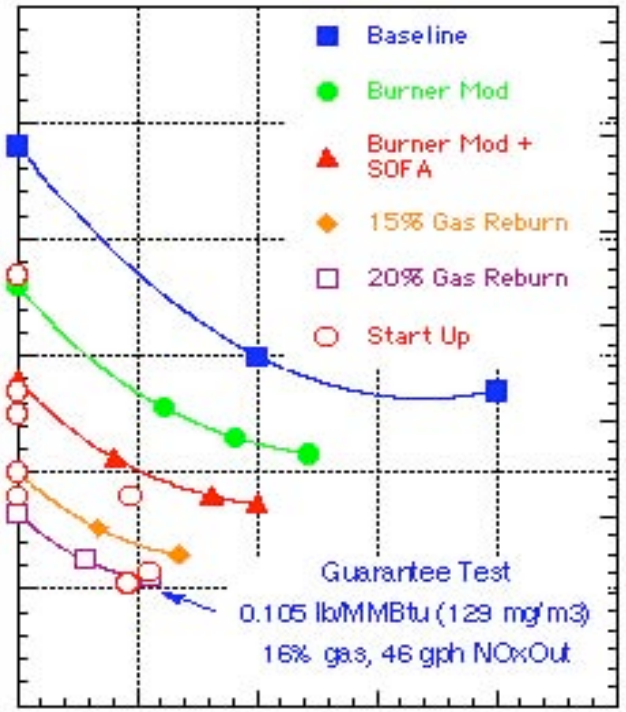
Performance Targets:

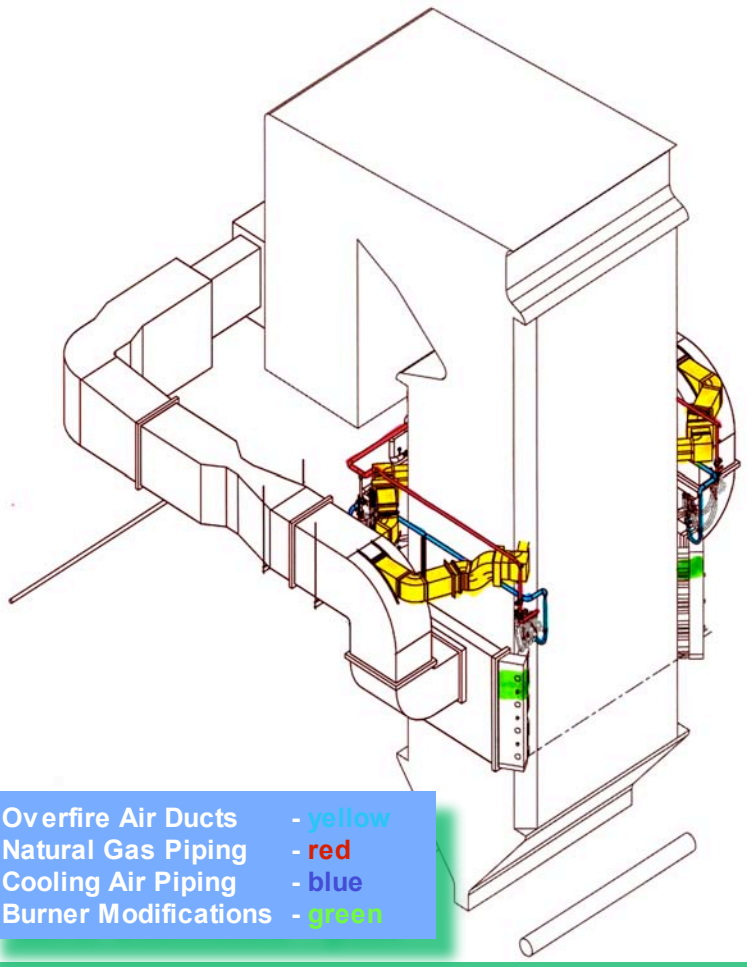
- NOx Emissions = 0.21 lb/MMBtu
- CO Emissions = 120 ppm
- No Impact on Carbon in Ash

Solution: Coal Reburn, Advanced Combustion Sensors, Coal Balancing Dampers

Gas reburn layered approach

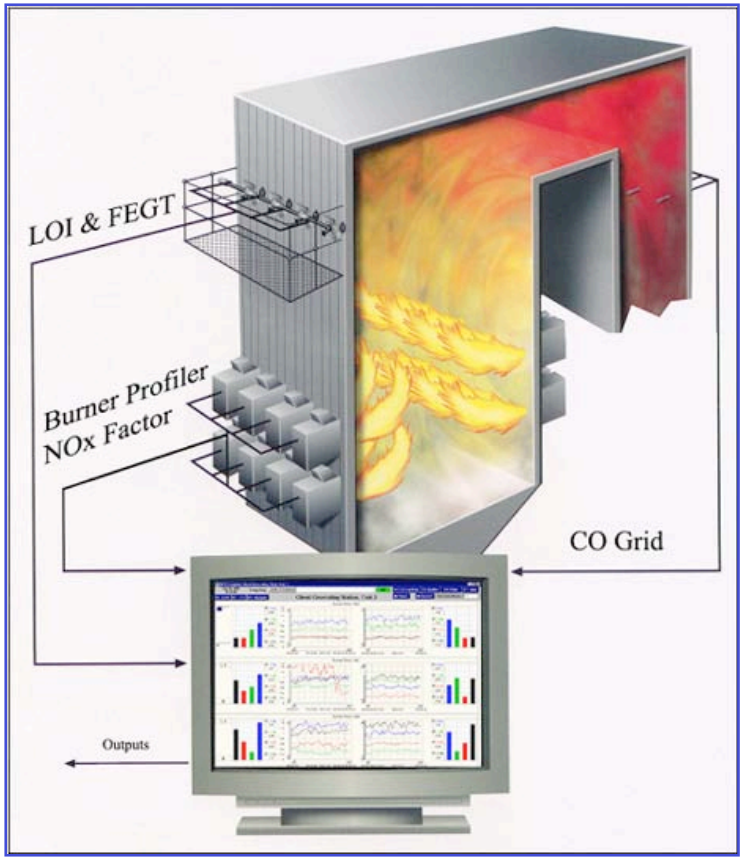
Somerset, 115 MW T-Fired
Burner Mods, SOFA, Gas Reburn, SNCR
0.54 lb/MMBtu => 0.11 lb/MMBtu





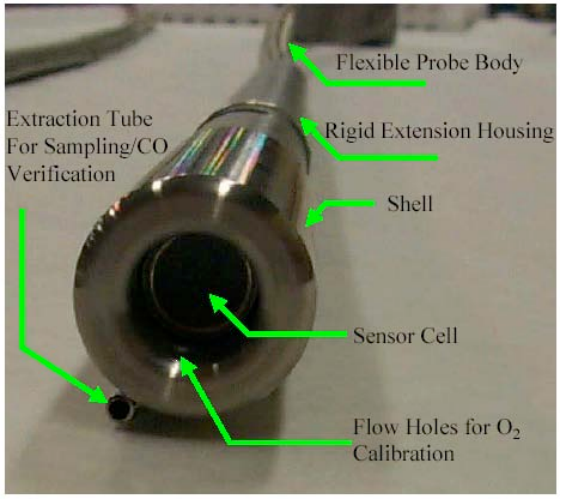
Overfire Air Ducts - yellow
Natural Gas Piping - red
Cooling Air Piping - blue
Burner Modifications - green

Combustion optimization using in-furnace sensors and controls

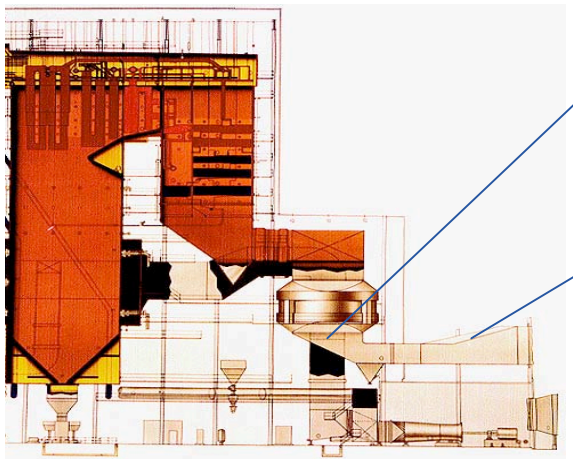


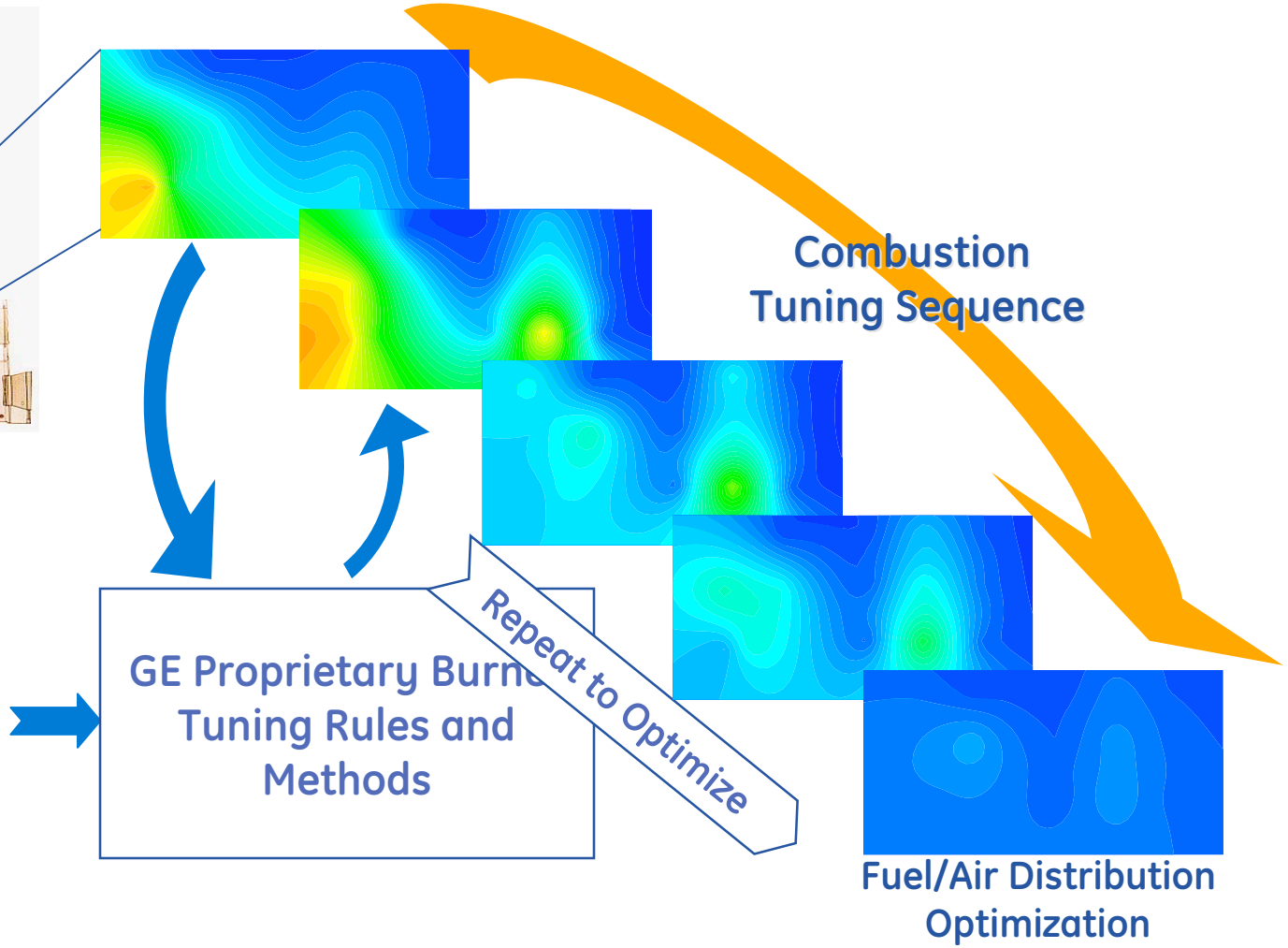
Combustion Trim Control System

CO Sensor

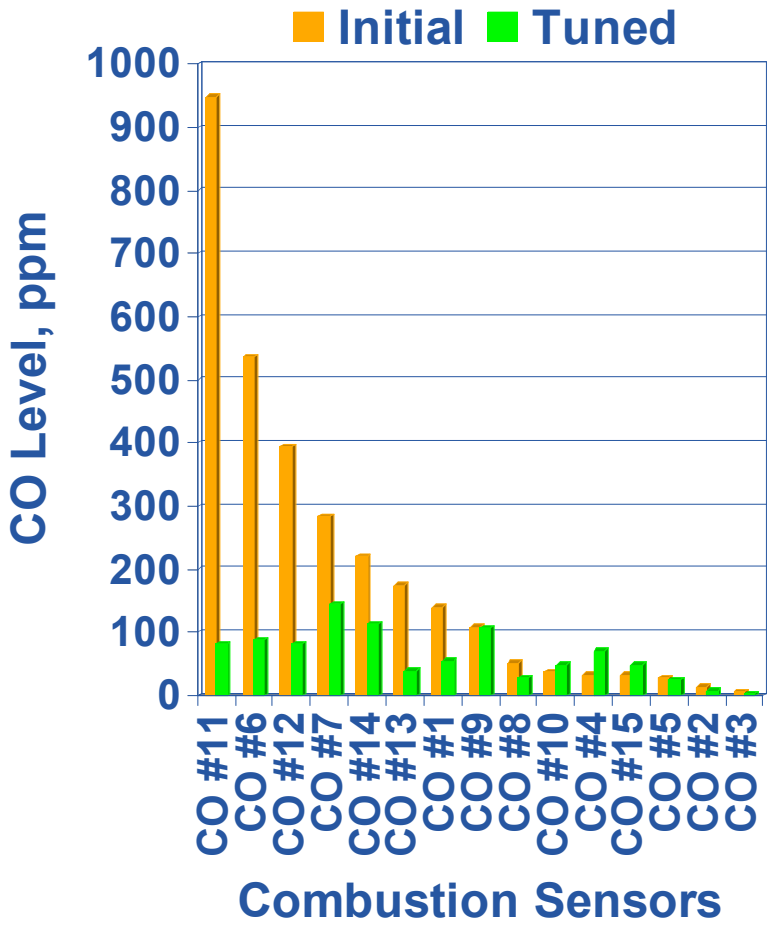


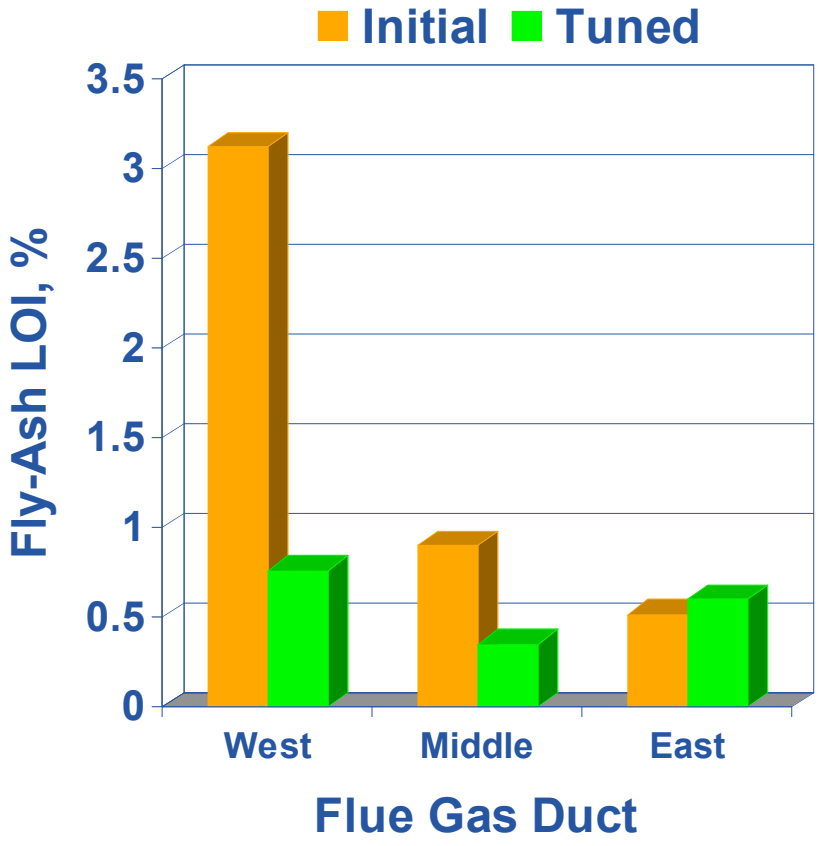
Automatic combustion tuning system involves multiple phases (wall-fired)





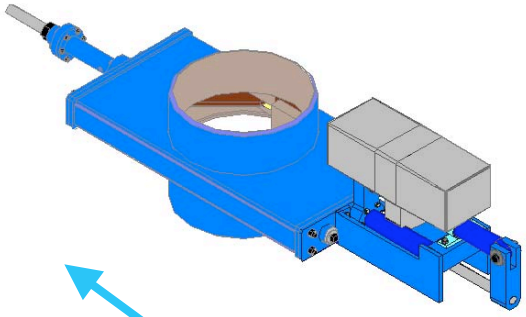
CO trim balances combustion with resulting balance in fly-ash LOI

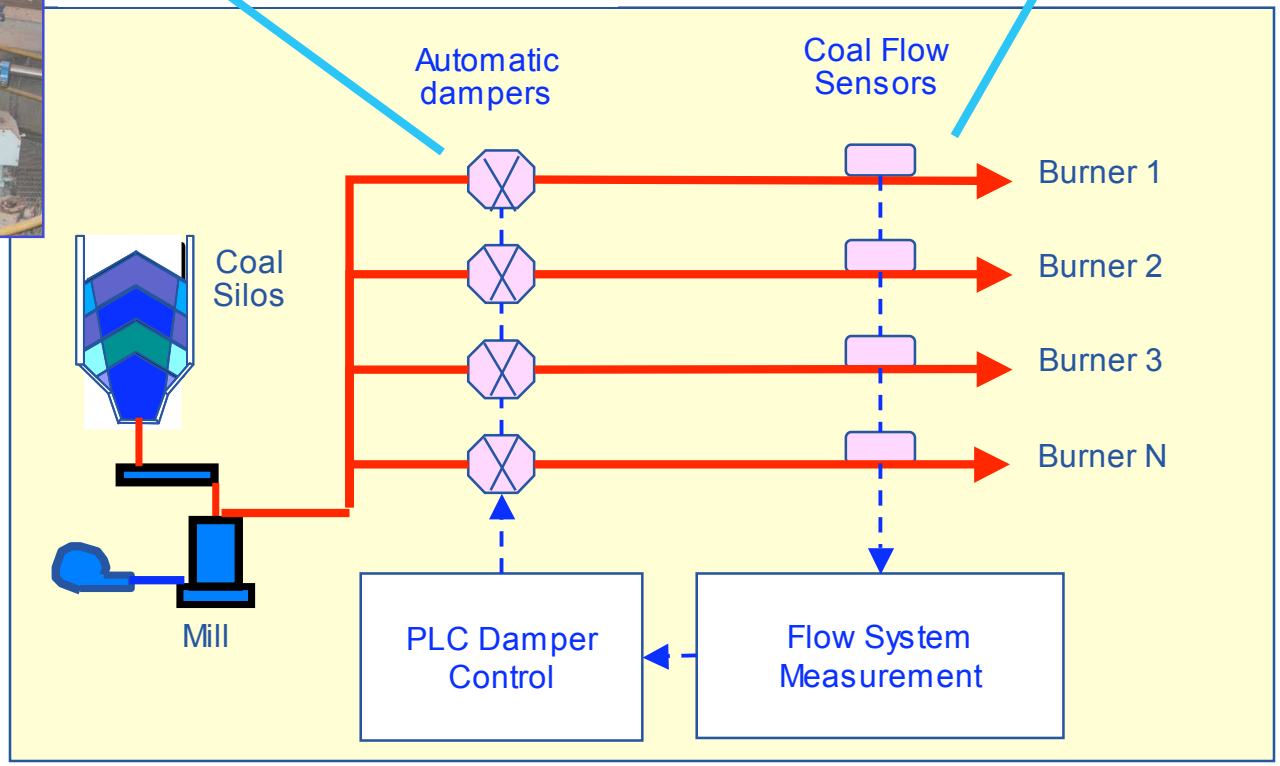




Automatic fuel trim controls improve fuel distribution

Actuated Coal Flow Balancing Damper





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Benefits of fuel trim controls

Improved fuel distribution performance.

Optimized over mill load range.

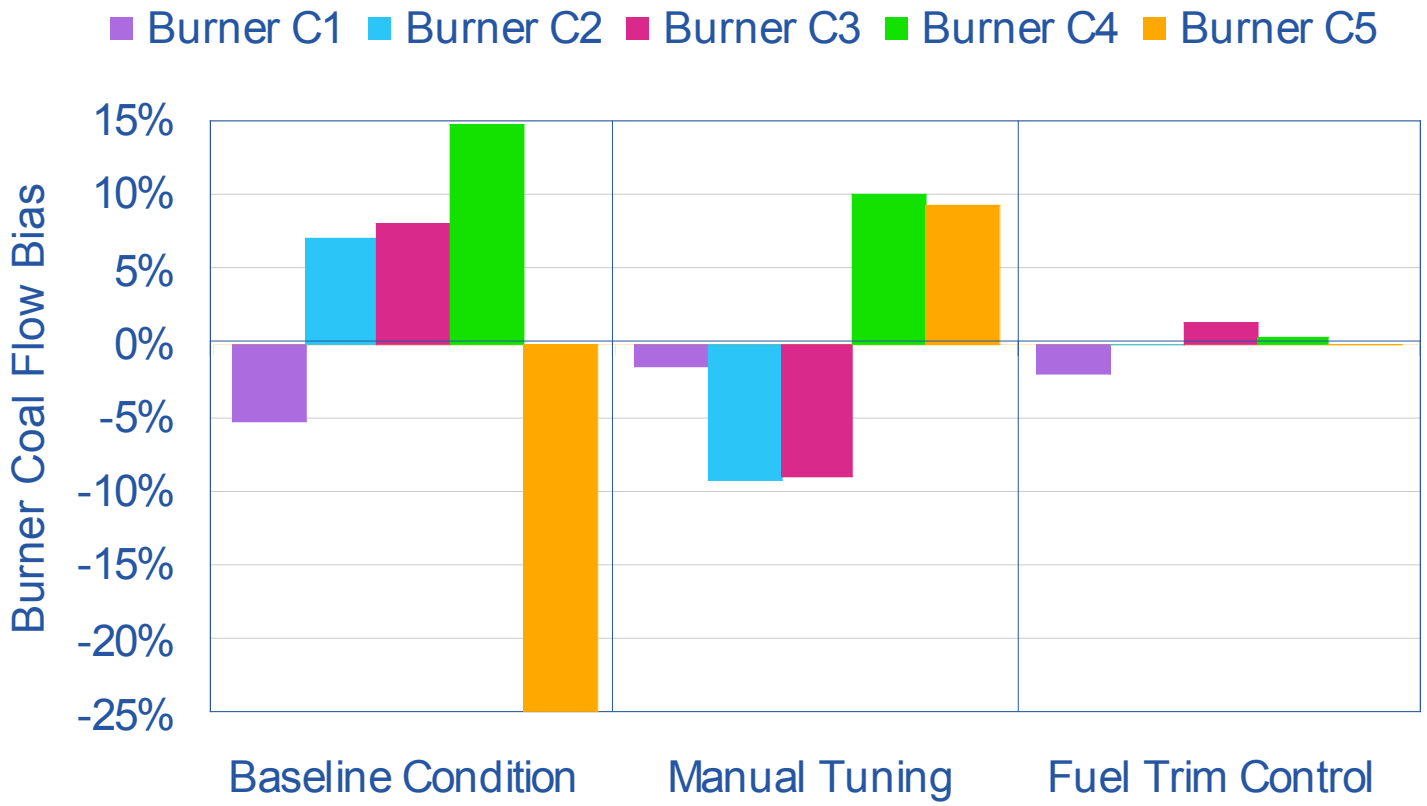
Fuel biasing capability:

- Reduce slagging by affecting temperature and flow imbalances.
- Improve combustion by overcoming burner flow induced furnace air/fuel distribution problems.

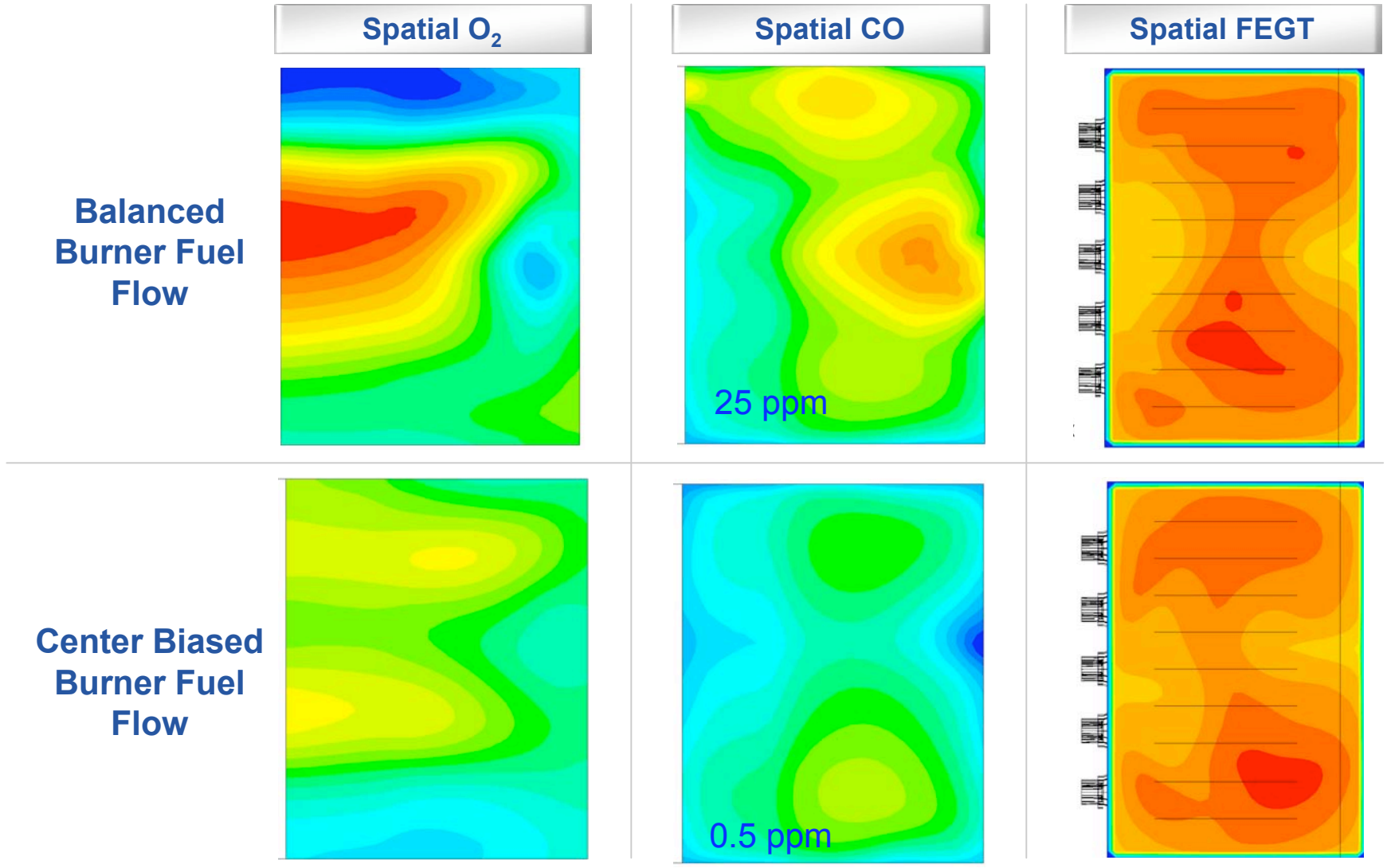
System diagnostics:

- Providing sensor and coal flow diagnostics and alarms.

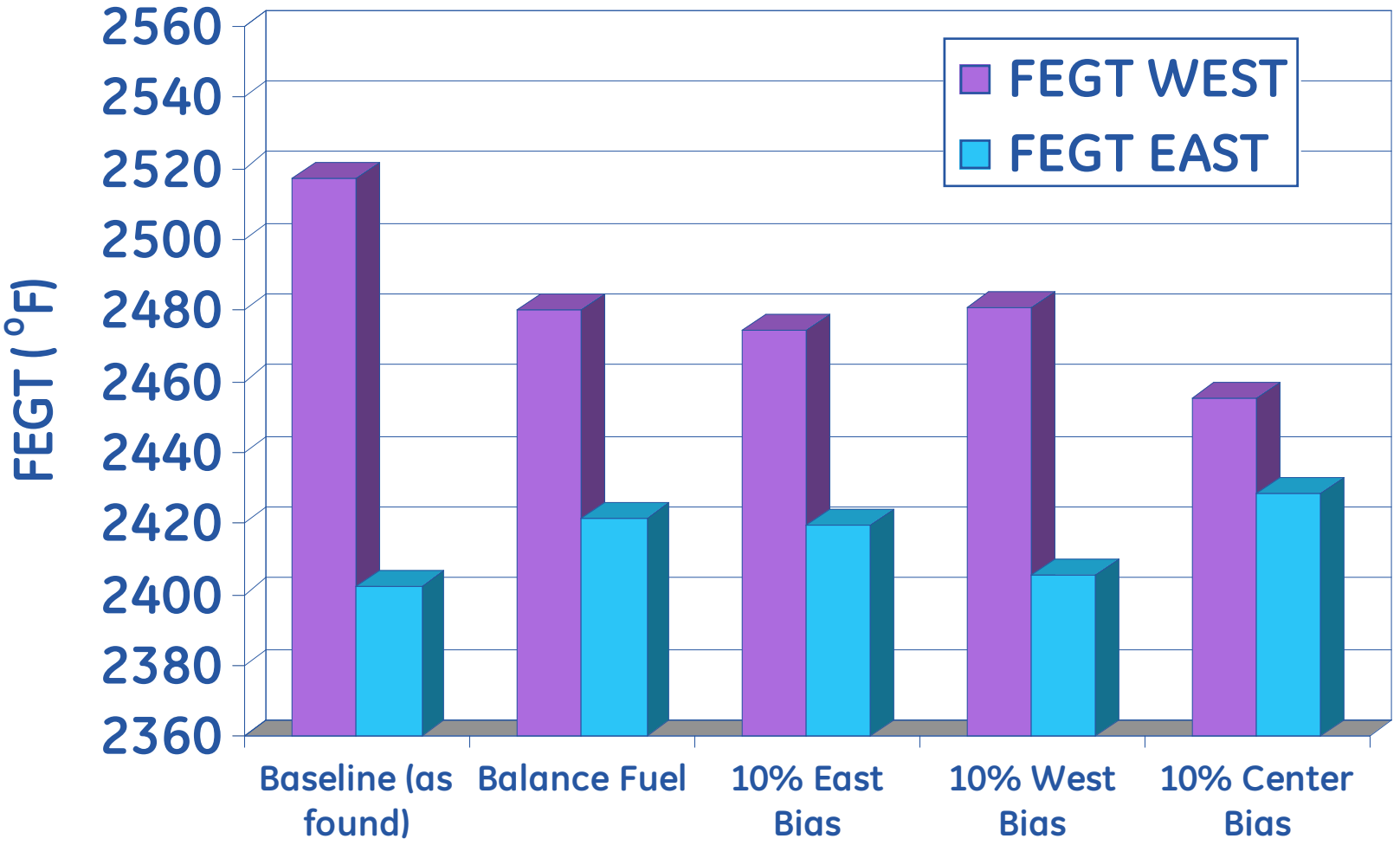
Automatic fuel trim successfully tightens fuel distribution



Projected fuel trim biasing impacts



Coal flow distribution improves FEGT



Corrosion Evaluation

Viewed as a potential problem in many early reburn applications

- Coal fired boilers, High sulfur fuels

Potential for tube wastage

- Corrosion - due to sulfur attack in reducing atmospheres ($Fe+H_2S \Rightarrow FeS$)
- Degradation of protective oxide layer - due to reducing atmosphere

Tube wastage evaluation

- UT analysis and statistical evaluation
- Metallurgical evaluation - destructive testing

Durability results:

Unit	Reburn	Wastage	Metallurgy
Tangential	Gas	No measurable wastage	No change
Wall	Gas	No measurable wastage	No change
Cyclone	Gas	No measurable wastage	No change
Cyclone	Coal	No measurable wastage	No change

Corrosion Evaluation

Cyclone-Fired Unit - 33 MWe - 3.6% S Coal - Gas Reburn

Null Hypothesis Evaluation of Means using t-Distribution

Location	Year	Mean	StDev	#Smpls	Mean Change	Diff. In means @ confidence of 99%
Furnace floor	1991	0.283	0.006	28	0.006	0.003 Acceptable
	1994	0.277	0.008	65		
North wall furnace water wall	1991	0.175	0.005	52	0.009	0.007 Acceptable
	1994	0.166	0.004	69		
West wall furnace water wall	1991	0.170	0.005	33	0.002	0.000 Acceptable
	1994	0.168	0.007	40		
Superheater section east wall	1991	0.171	0.012	40	0.005	0.000 Acceptable
	1994	0.166	0.006	40		
Rear wing wall	1991	0.170	0.008	11	0.004	0.000 Acceptable
	1994	0.166	0.010	11		
Superheater screen tubes	1991	0.172	0.003	23	0.007	0.004 Acceptable
	1994	0.165	0.005	23		
West furnace water wall	1991	0.169	0.020	35	0.006	0.000 Acceptable
	1994	0.163	0.004	30		

*Difference in means above 0.005" considered significant

Summary

Combustion sensors and optimization techniques are advancing the art of combustion tuning.

Automatic burner Fuel Trim controls have proven effective at burner fuel balancing.

The biasing capability of Fuel Trim control is promising for furnace combustion optimization.

Combustion sensors and active tuning controls can address day-to-day combustion imbalance.

Combustion optimization can improve Peak Power, Availability, Heat Rate and Emissions.

Tube wastage can be minimized.