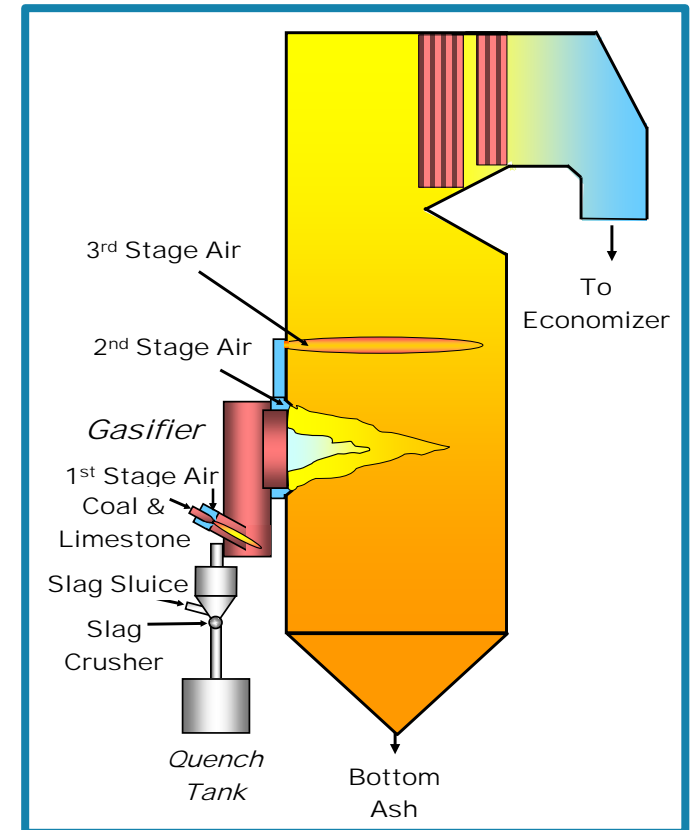


ClearStack Gasifier - Combustor Technology



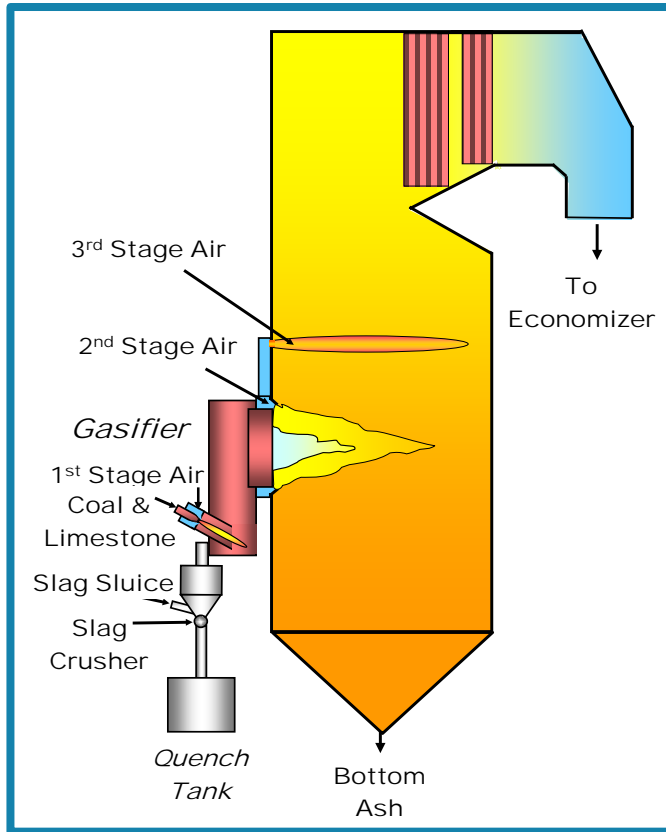
Topics

- ClearStack Technology
 - Pollutant Removal Efficiencies
 - Specific Pollutants
 - Technology Benefits
 - Prior Development
 - Pilot Unit and Commercial Unit
- Summary



ClearStack Technology

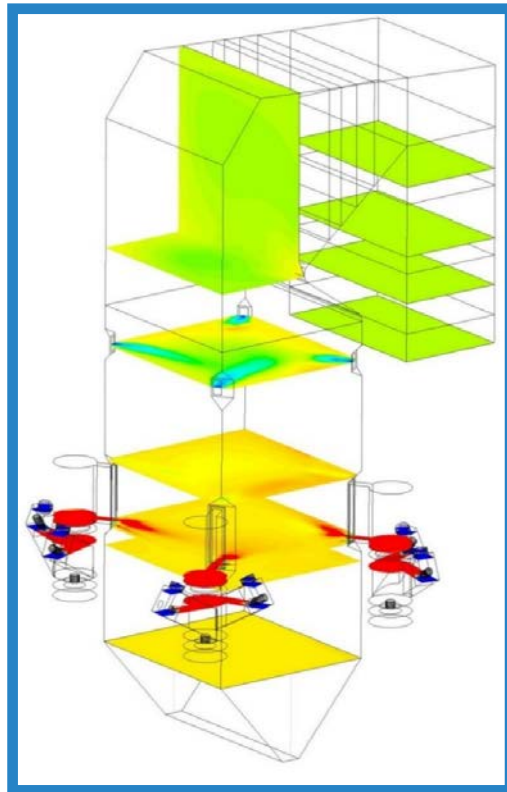
Pre-Combustion Control



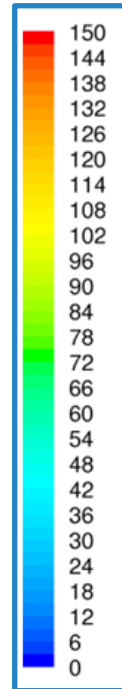
- **Ashworth Gasifier - Combustor**
 - NO_x reduction: +80% (approx. 0.095lb/MMBtu)
 - CO reduction: ~95% (7-8 ppm @ 3% O₂)
- **Fine Limestone**
 - SO₂ reduction: >90%
 - Hg capture in ash near 100%
- **Other**
 - Particulate (PM) emissions reduction: ~95%
 - Other air metal toxics near 80 - 100% capture
 - Acid gas (HCl, HF) reductions
 - Slag and ash passes EPA TCLP tests
 - Minimal auxiliary power demand

ClearStack Technology

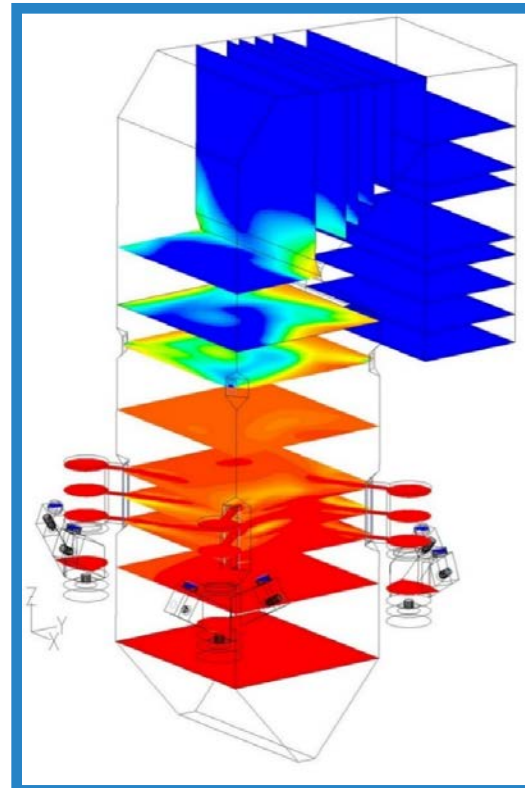
NOx and CO Emissions



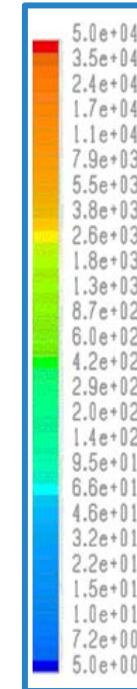
NO_x, ppmv
@ 3% O₂ dry



NO_x = 86 ppmv
0.095 lb/10⁶ Btu



CO, ppmv
@ 3% O₂ dry

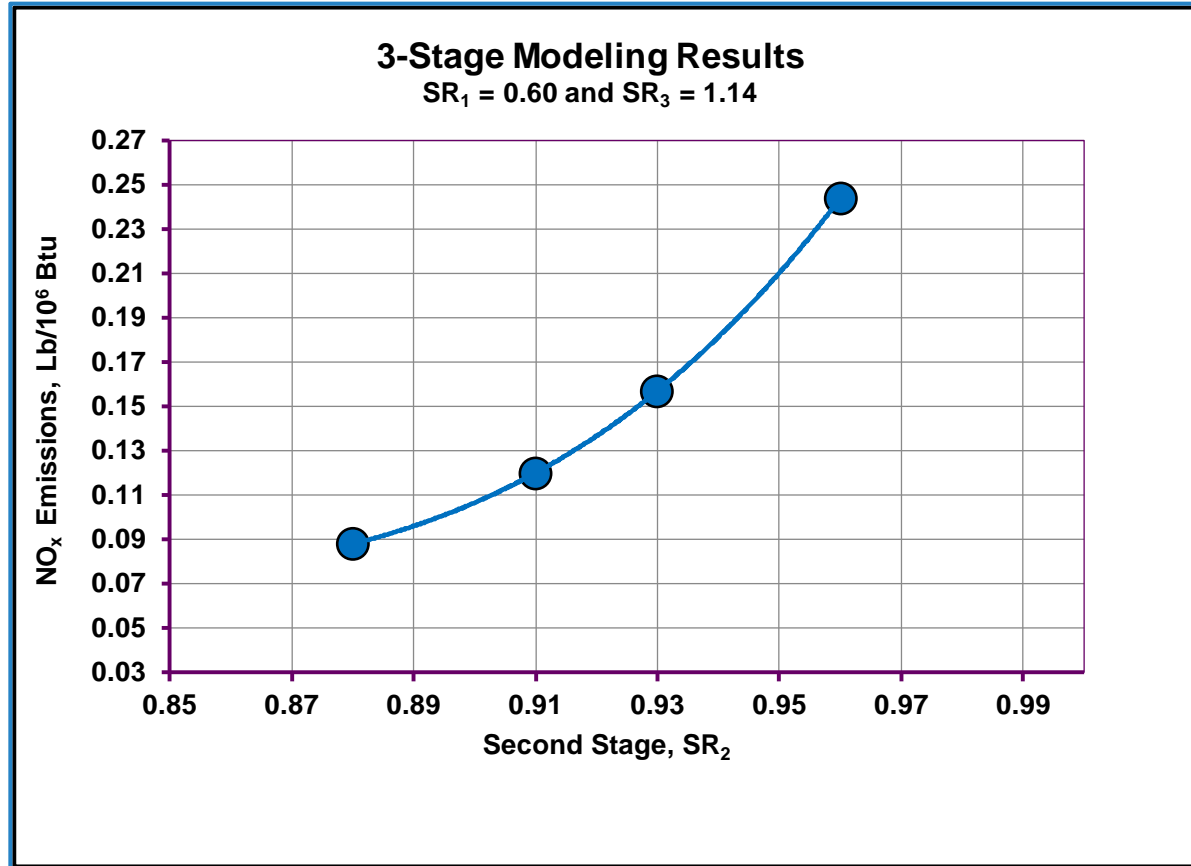


CO = 7- 8 ppmv

**Alstom CFD Modeling
Hutsonville
85 MWe T - Fired
Boiler Firing
Bituminous Coal**

ClearStack Technology

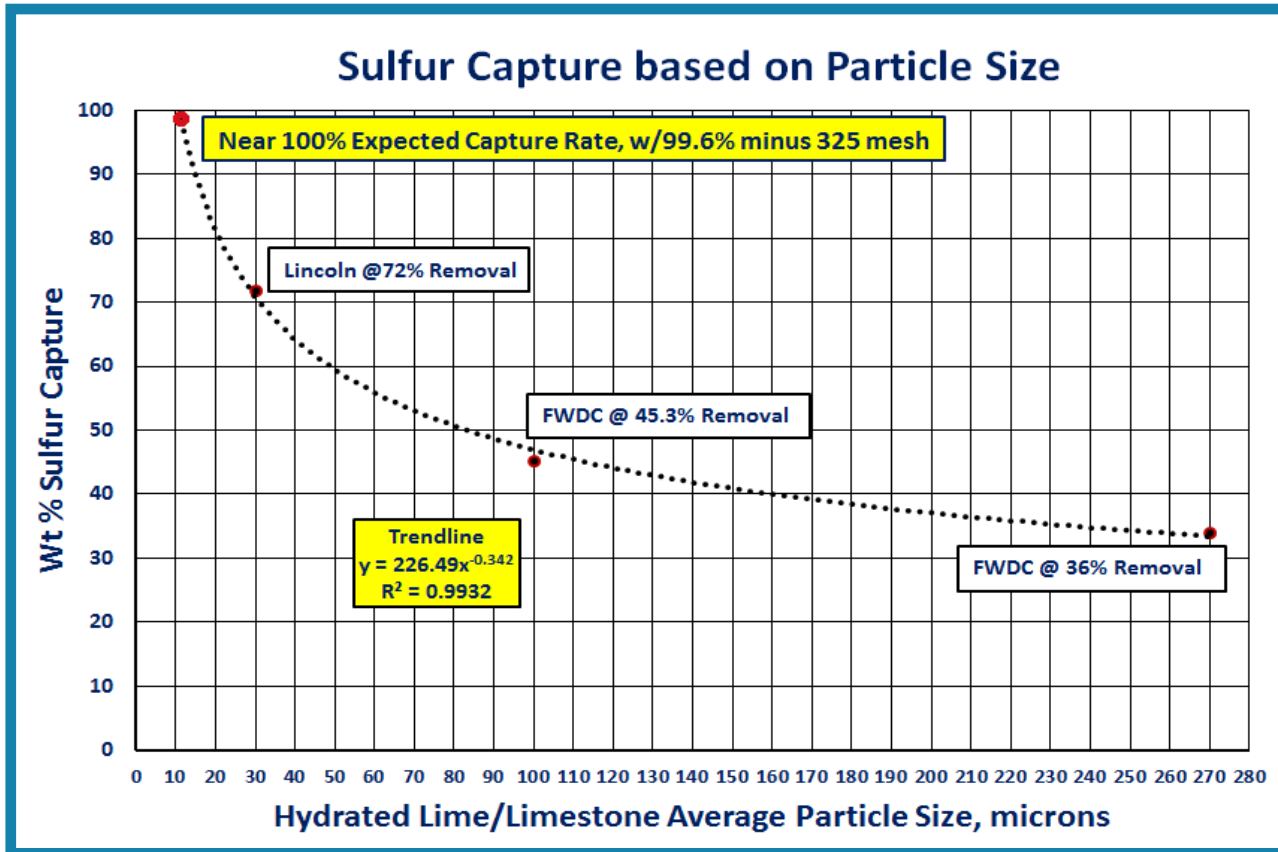
3 Stage Oxidation – NO_x Control (Bituminous Coal)



- GE-EER NO_x modeling
- Low stoichiometric ratio (SR) at initial stages (1 & 2)
- Evaluation of various SR conditions
- Evaluation of impact of steam addition or high moisture coal
- Testing shows SCR equivalent NO_x removal performance

ClearStack Technology

Sulfur Capture



- Reducing atmosphere negates oxidation of Sulfur and Hg
- Forms CaS and Ca-Hg
- Past demonstrations show impact of reagent particle size
- Evaluation of calcium sources

ClearStack Technology

Particulate Emissions

Particle Size	0 - PM ₅	PM ₅ - PM ₁₀	+ PM ₁₀	Overall Efficiency
Gasifier Fly Ash	0.5%	2%	97.5%	99.32%
Conventional Coal Burner Fly Ash	13%	12%	75%	94.96%
ESP Efficiency	65%	99%	99.5%	

- Overall 96% reduction in PM emissions due to slag capture and ESP efficiency
 - 60-80% of particulate removed as slag prior to boiler – lower ESP loading
 - Increases the size of particulate entering boiler that yields 99% ESP efficiency
- Less flue gas velocity and condensable particulate matter

ClearStack Technology

TCLP Air Metal Toxics

Element	Fly Ash	Slag	Regulatory Limit
	mg/L	mg/L	mg/L
Ag	0	0.0002	5
As	0.0334	0.0005	5
Ba	0.548	0.175	100
Cd	0.4842	0.0002	1
Cr	0.1201	0.6335	5
Hg	0	0	0.2
Pb	0.0276	0.008	5
Se	-0.0113	-0.0008	1

All below EPA
Regulatory Limits

Technology Benefits

- A truly multi-pollutant technology
- Lower cost than post-combustion alternatives
- Convert combustion byproducts into potential revenue streams
- Avoid use of costly and hazardous reagents and the corresponding disposal issues
- Eliminate the need for scrubber operation and the corresponding auxiliary power demand, hazardous chemicals, stack corrosion
- Visible vapor plume eliminated - and the impression that "smoke" is coming out of the stacks

Technology Development

➤ **Initial concept**

- Rummel Gasifier (1940's) fired with brown coal to produce fuels and chemicals
- Oxygen entrained gasification
- Captured 70% sulfur in alkaline ash – no limestone required

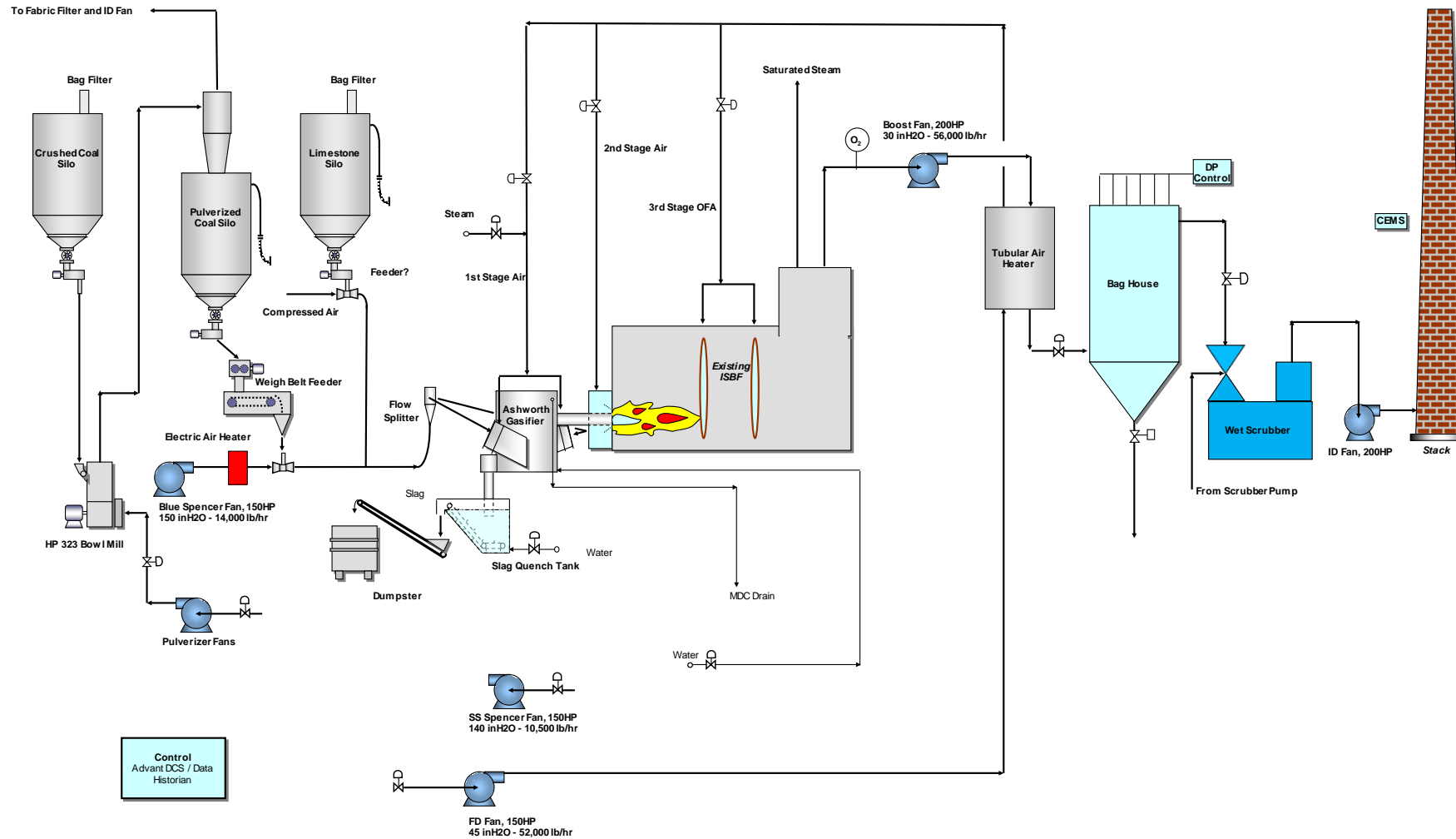
➤ **Florida Power Corporation Pilot Testing**

- 12 MM Btu/hr demonstration in 1984 at Foster Wheeler Development Center
- Air entrained gasification with one stage combustion in boiler
- Captured 45% sulfur and achieved 0.25 lb/MM Btu NOx emissions

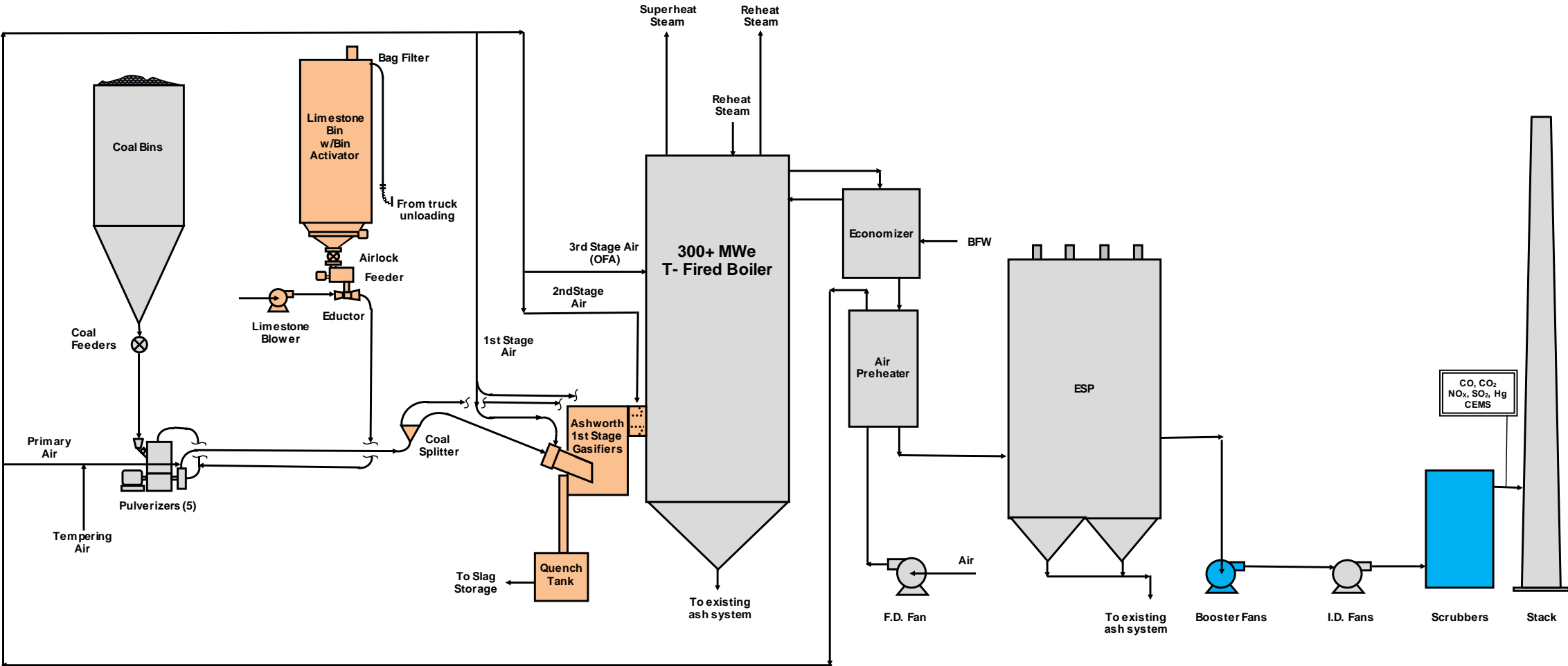
➤ **ClearStack**

- 1998 ClearStack was formed and purchased technology rights from Florida Power
- 40 MM Btu/hr demonstration in 2002-2003 at Lincoln Developmental Center
- Air entrained gasification with two stage combustion in boiler for low NOx
- Achieved 72% sulfur capture and 0.095 lb/MM Btu NOx emissions w/bituminous coal

Pilot Unit Demonstration

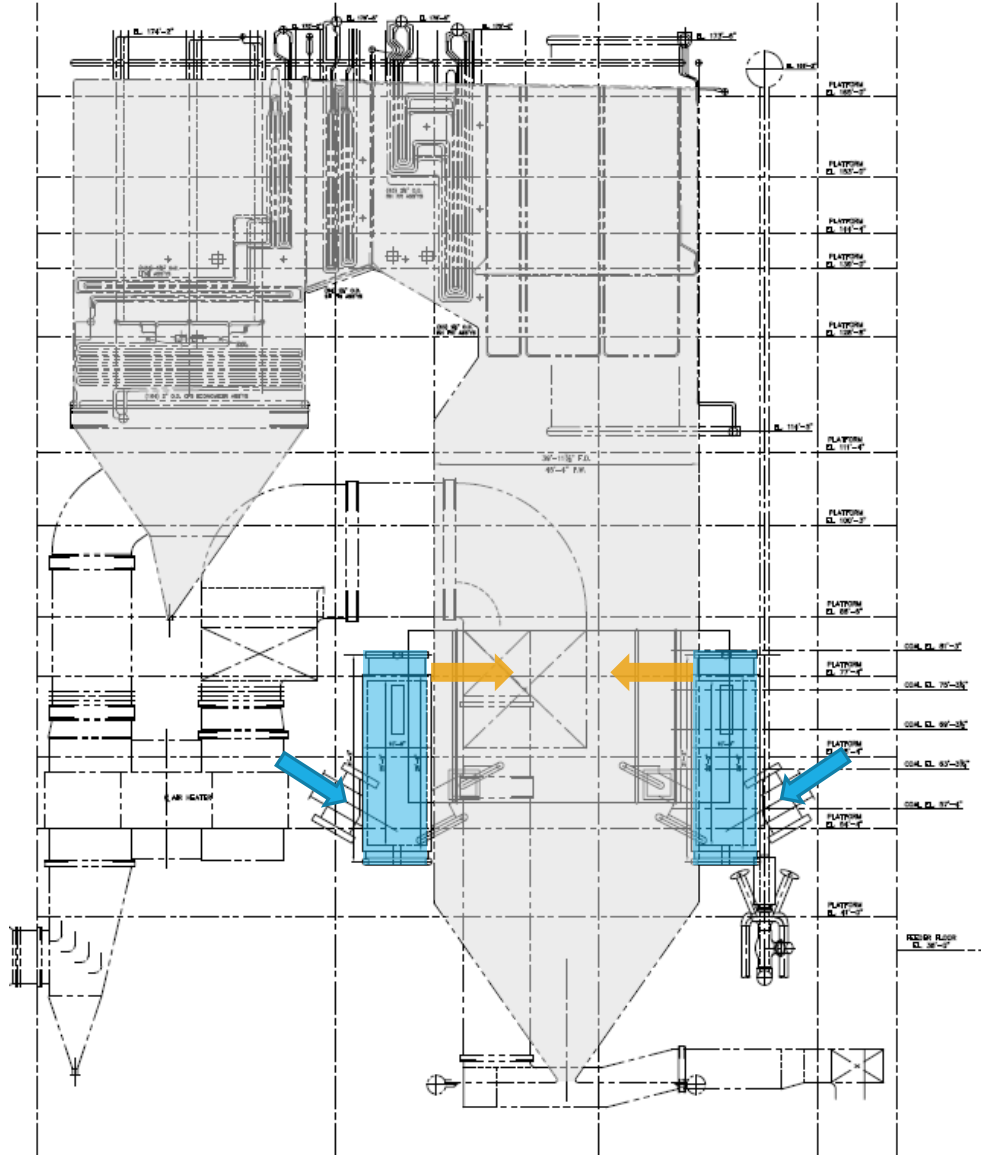


Commercial Demonstration

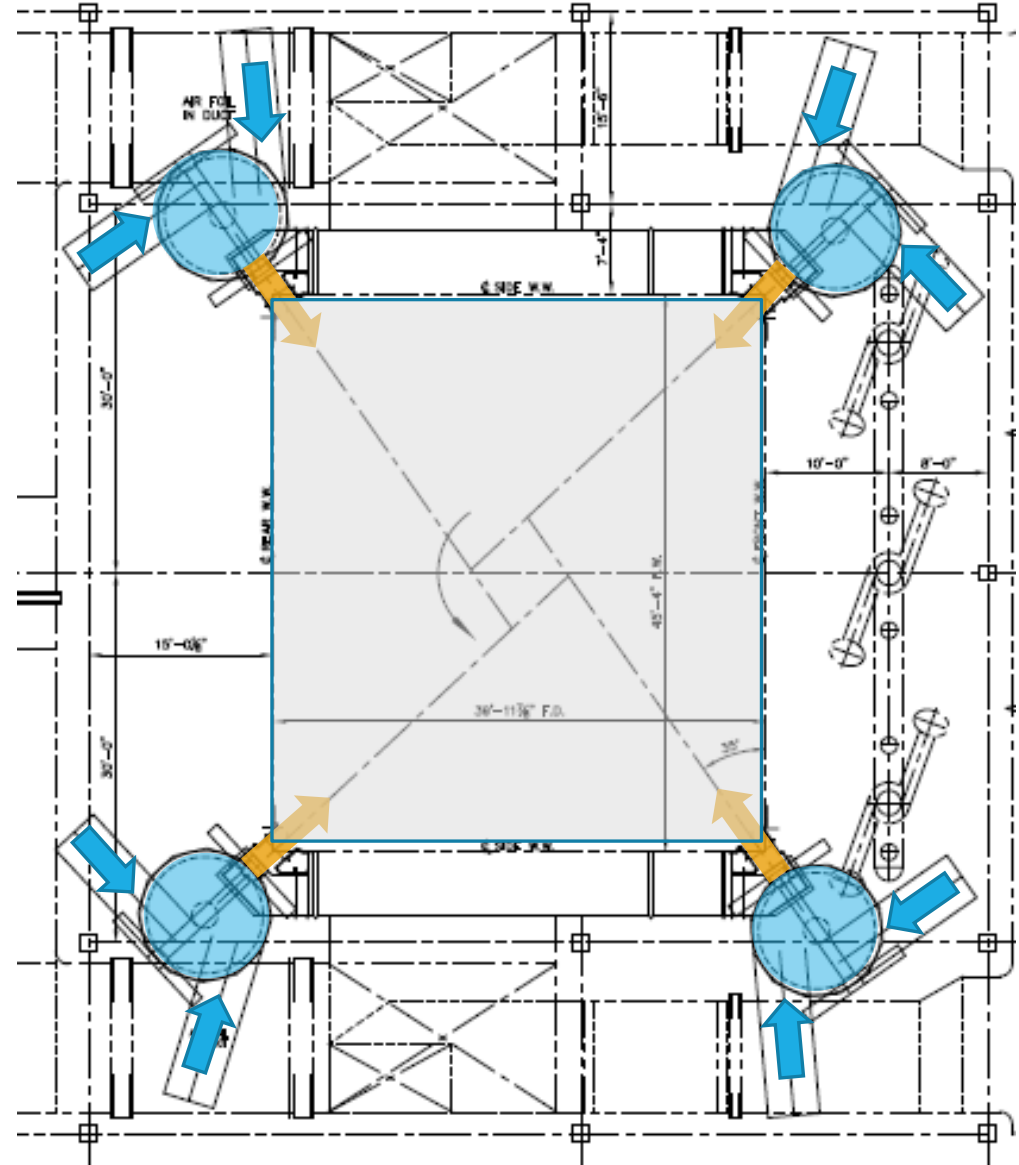


- Gray signifies existing equipment
- Orange signifies new retrofit equipment
- Blue signifies reduced use or bypassed equipment

Side View



Plan View



Summary

- ClearStack provides a low-cost multi-pollutant technology
- Pilot scale demonstration will provide assessment of specific coals
- Commercial scale demonstration will provide verification of performance
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