

THE CLEAN COMBUSTION SYSTEM™

"Burns Coal as Clean as Natural Gas"



Hybrid Coal-Gasification Retrofit of Power Boilers for SO₂ & NO_x Control and Improved Efficiency

Presentation Dated August 19, 2010

by

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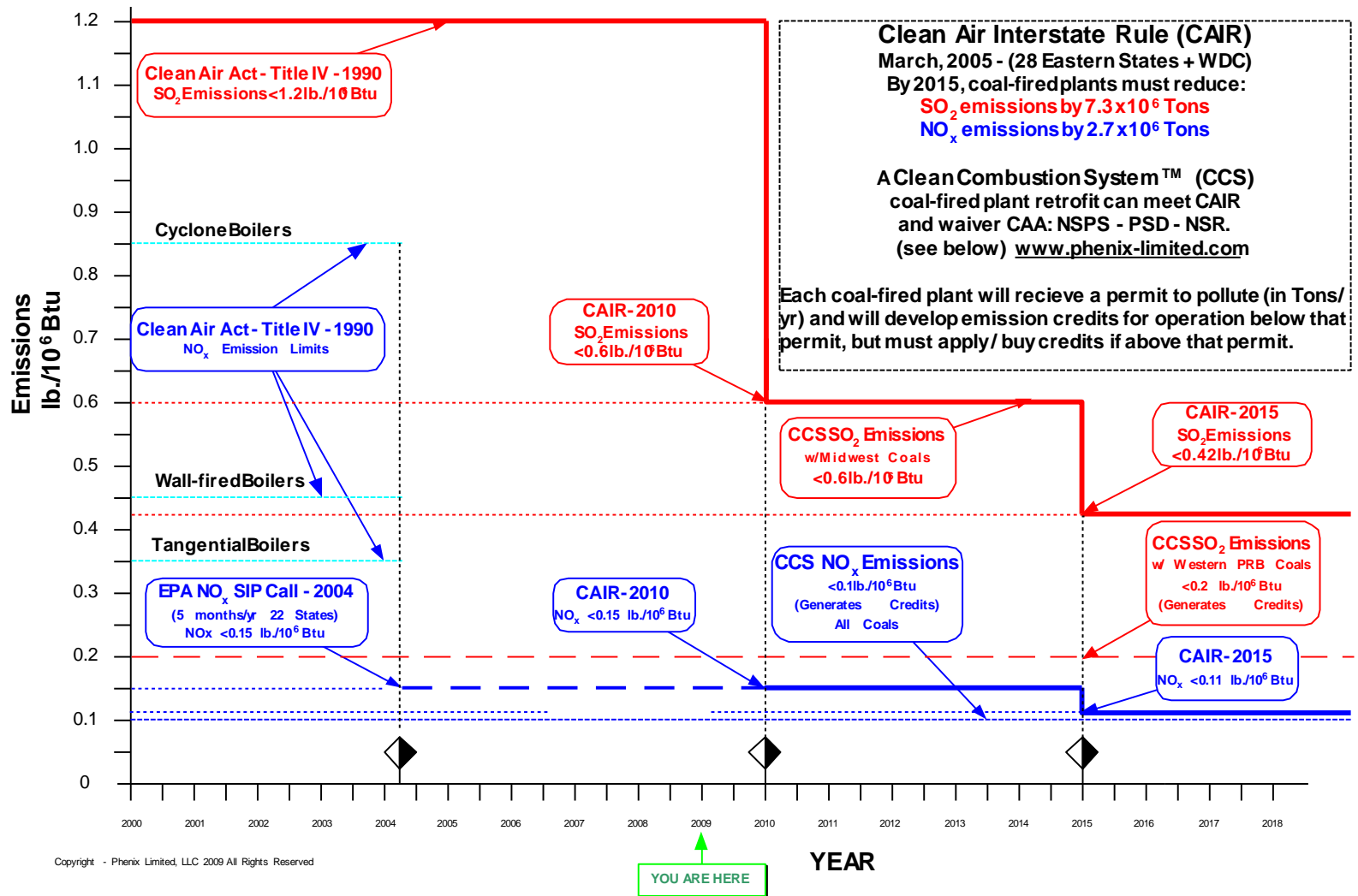


Castle Light PR Corp.

The Clean Combustion System™ (CCS)

- CCS provides SO₂ and NO_x emission control in combustion with improved efficiency
 - **Retrofits all boiler types; Cyclone, Wall-fired, T- fired, Stoker**
 - **Oxy-fuel Plants; low-cost control of corrosive sulfur compounds**
 - **May convert gas & oil-fired boilers to coal firing**
- **Castle Light PR Corp.** Provides Technology Management & Licensing
 - evolved from rocket engine programs at Rockwell International in the 1980's
 - CCS application studies, top level system design, CFD analysis
 - Engineering, Hardware, Equipment Supply, Warrantee; Client installs
- Our subsidiary, **Phenix Limited, LLC** conducts the CCS engineering tasks
- **CCS Objectives:**
 - Retrofit of older, smaller (<300MW) power boilers for 20 or more years of competitive dispatch
 - Meet EPA's Clean Air Interstate Rules (CAIR)
 - Low-cost SO₂ and NO_x control with improved efficiency
 - Reduced operating cost
- **New CCS Developments:**
 - Control Mercury,
 - Fire low-cost waste coals (high moisture ,high ash)

EPA's "Clean Air Interstate Rule"

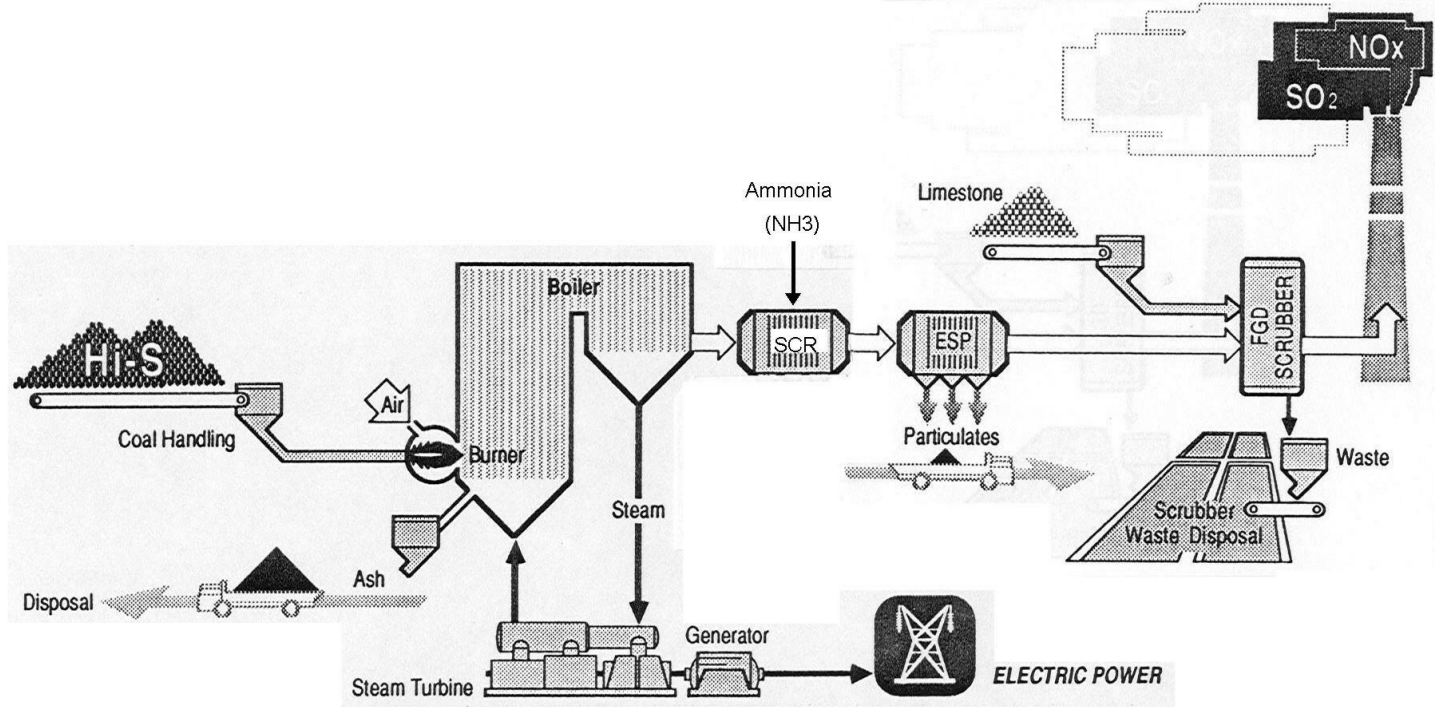


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Conventional Emission Controls

$\text{SO}_2 = \text{FGD} + \text{Limestone}$; $\text{NO}_x = \text{SCR} + \text{Ammonia}$;
 $\text{SO}_3 = \text{Trona ?}$, $\text{Hg} = \text{Activated Carbon ?}$



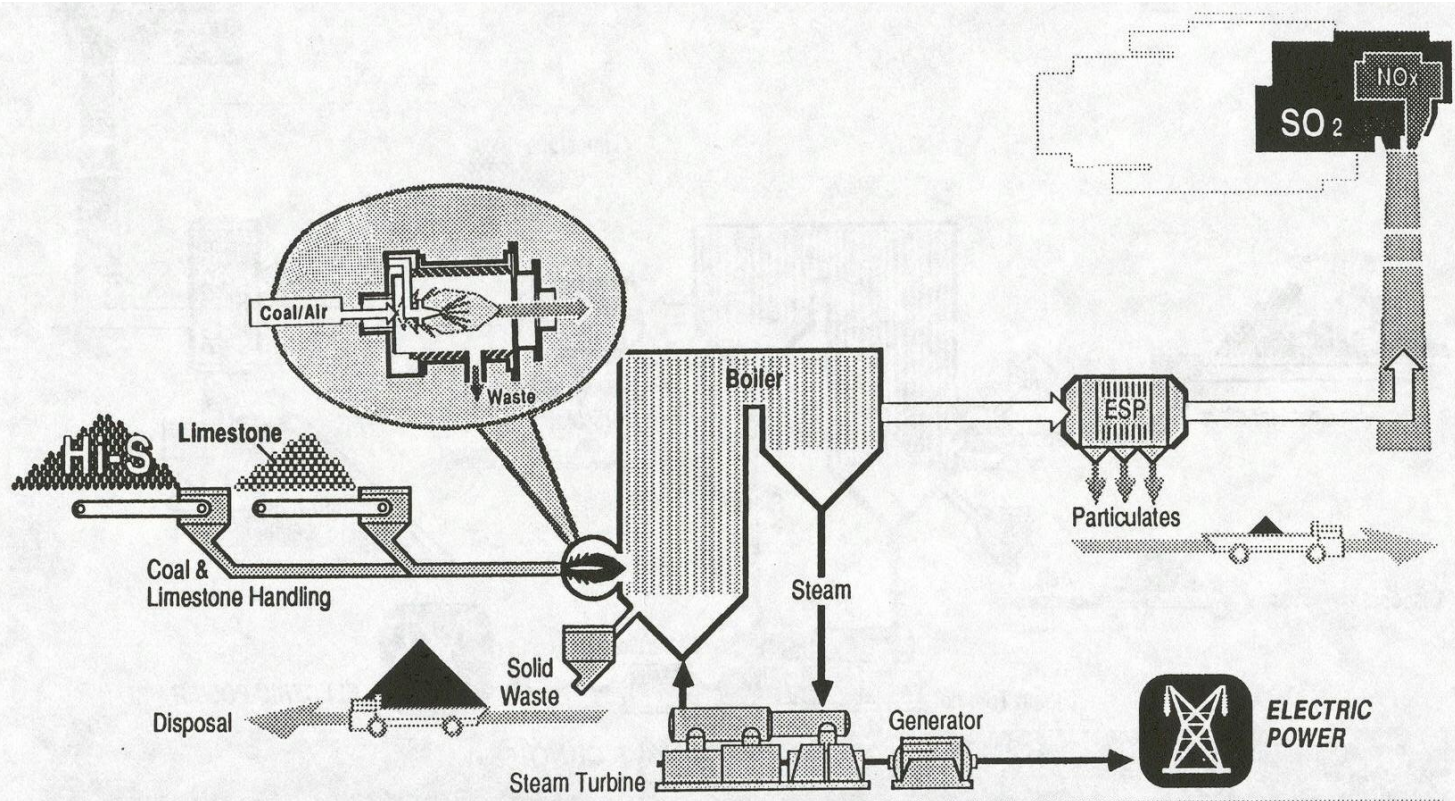
COMPARED WITH CONVENTIONAL TECHNOLOGY*

SO_2 EMISSION REDUCTION	NO_x EMISSION REDUCTION	PLANT EFFICIENCY	POWER OUTPUT	PLANT LIFE	INCREMENTAL ELECTRICITY COST	CAPITAL COST
90% AND HIGHER	90% AND HIGHER	2+% Decrease	2+% Decrease	No Change	11 - 15 MILLS/KWH	\$280 - 300 PER KW

* CONVENTIONAL COAL-FIRED ELECTRIC POWER PLANT

CCS Hybrid Coal-Gasification

SO₂ & NO_x Control Right in the Combustion Step



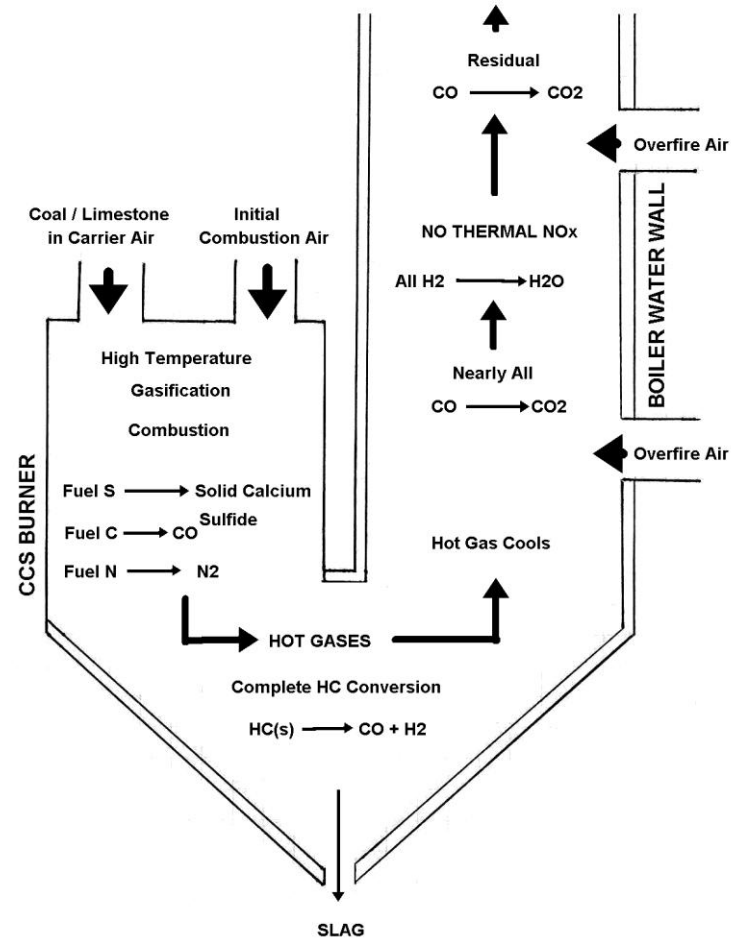
COMPARED WITH CONVENTIONAL TECHNOLOGY*

SO ₂ EMISSION REDUCTION	NO _x	PLANT EFFICIENCY	POWER OUTPUT	PLANT LIFE	INCREMENTAL ELECTRICITY COST	CAPITAL COST
75 - 90+	HIGH	No Change	No Change	Slight Extension	2-4 MILLS/KWH	\$75-110 PER KW

* CONVENTIONAL COAL-FIRED ELECTRIC POWER PLANT

Hybrid Gasification Schematic

The Clean Combustion System (CCS)



Rockwell International

25 x 10⁶ Btu/hr (1 ton/hr) Test Facility (1990)



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LNS-CAP Facility

ESSO Site, Cold Lake, Alberta Canada

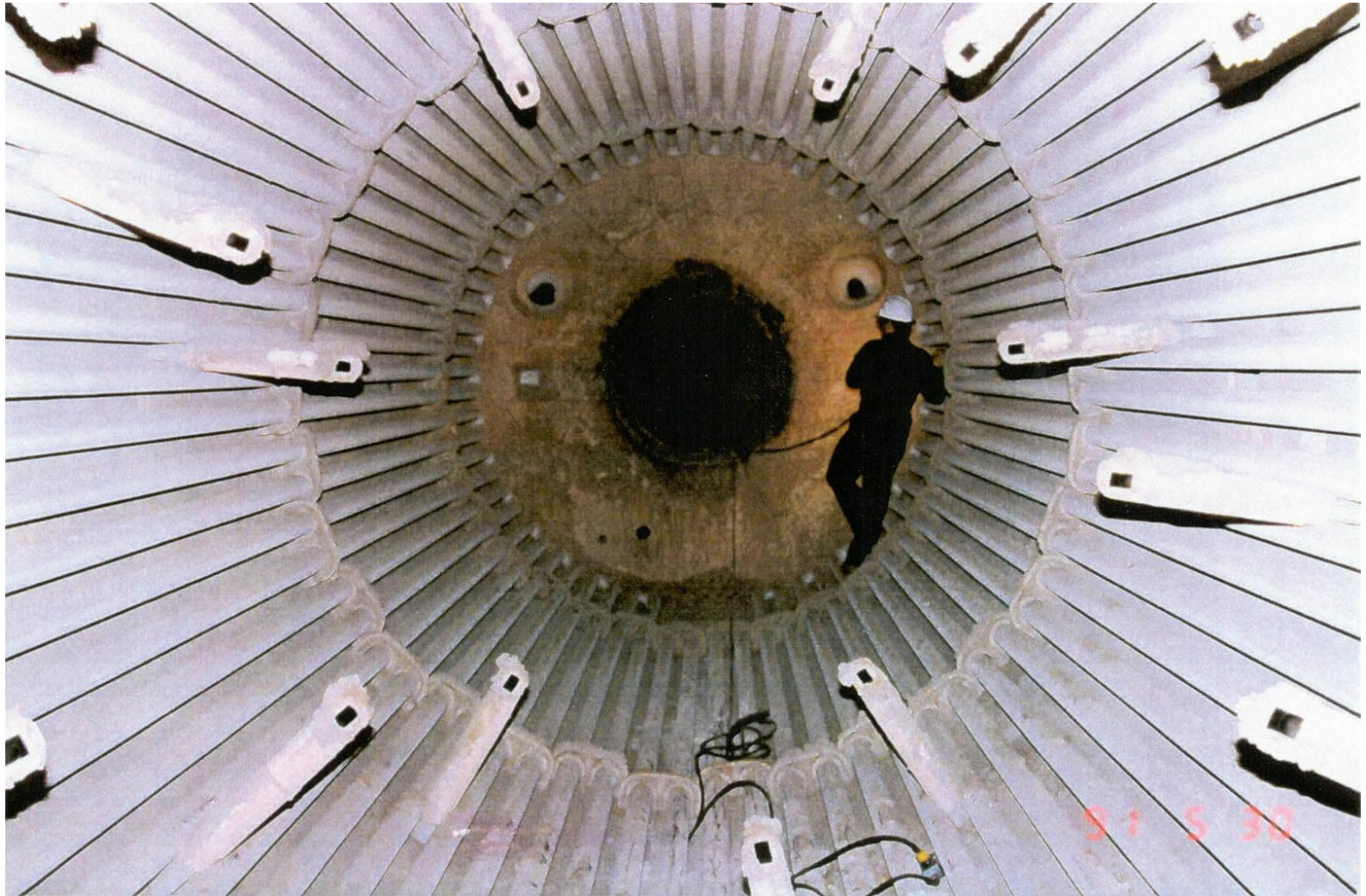


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Boiler Radiant Section

View Forward to Burner

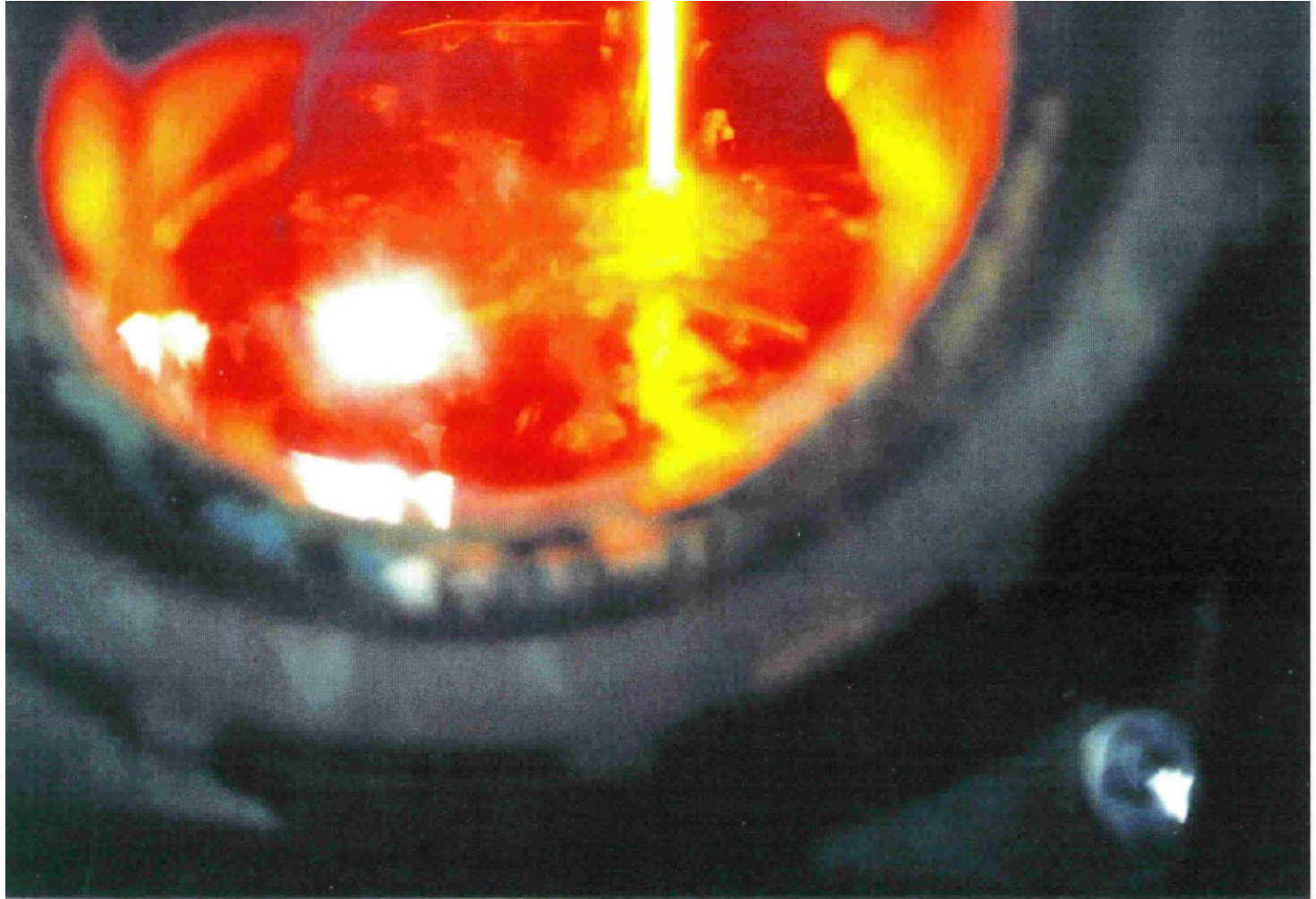


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LNS-CAP

Slag to Water Trough



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LNS-CAP

Gasification Chamber Inspection



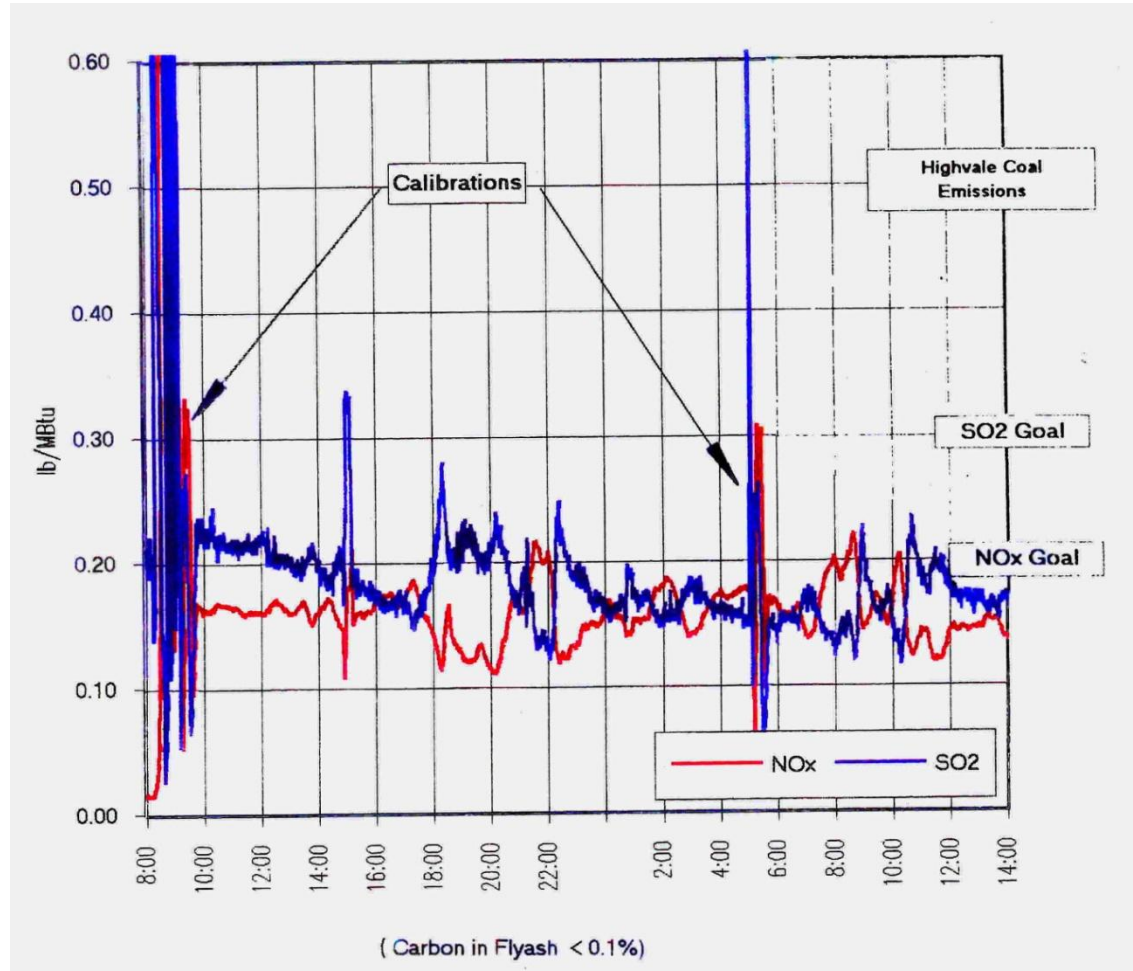
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Demonstrated Emissions

SO₂ - 0.2 lb./mmBtu & NO_x - 0.15 lb./mmBtu

ESSO LNS-CAP Facility, Cold Lake, Alberta, Canada



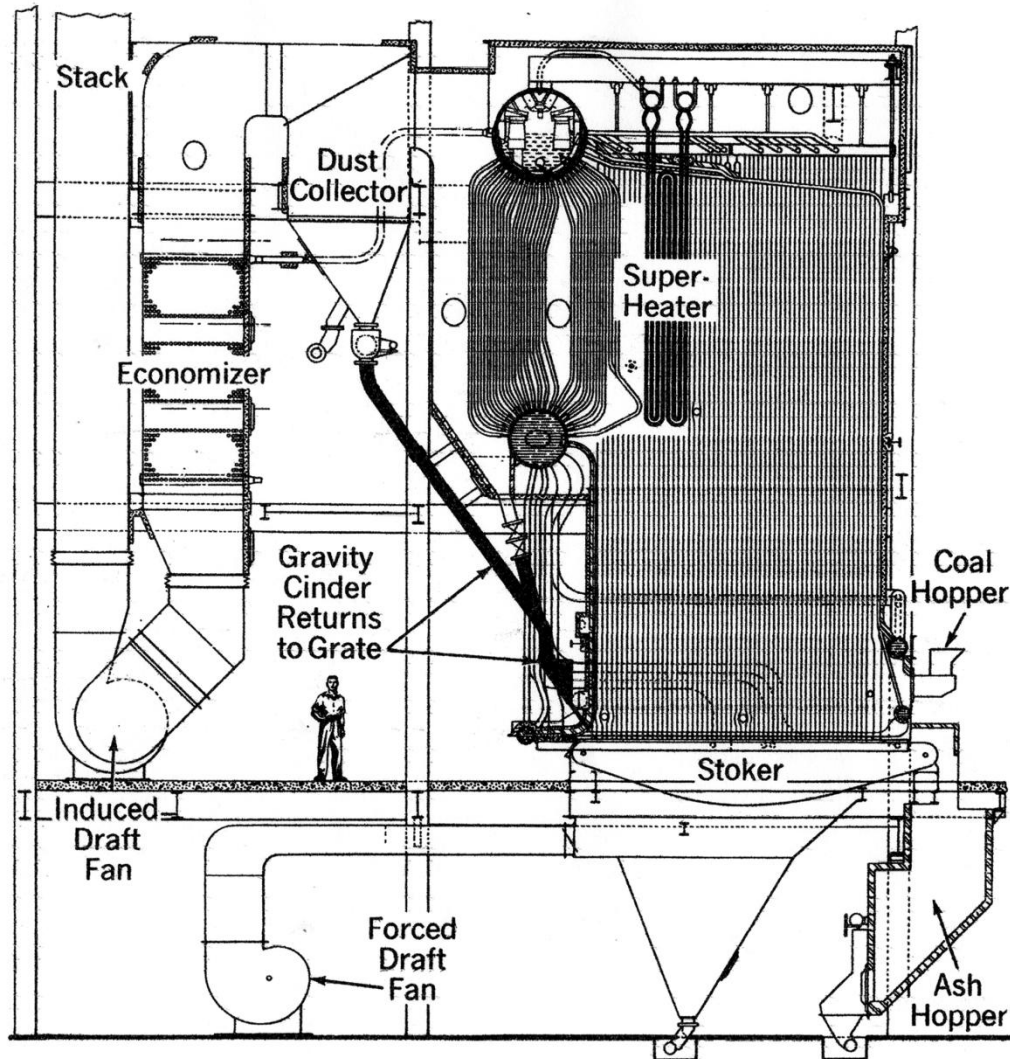
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CCS-Stoker[®] Project Description

- **Objective:**
 - Reduce operating cost by half (switch to low-cost high-sulfur Illinois coal – 2.5 lb. SO₂/mmBtu)
 - Construction Permit w/ waiver NSPS, PSD; no NSR
 - Emissions Warrantee: <0.9 lb. SO₂/mmBtu, <0.25 lb. NO_x /mmBtu
- **Project Initiated:** Oct 2005,
Commissioning: Jan 2007
- **Phenix Scope** : Process Design & Engineering;
 - Supply all equipment, hardware, electrical, instrumentation / controls
 - Provide Commercial Warrantee & License
- **Client Scope:** Site Construction Management;
 - Equipment Installation,
 - Commissioning & Start-up
- **Project Support:** In part, by the Illinois Department of Commerce and Economic Opportunity through the Illinois Clean Coal Institute and the Office of Coal Development.

Coal-Fired Stoker Boiler (typical)



CCS Retrofit

Demo:

Stoker, ash pit, brick over grate

New Equipment:

CCS Burner,
Gasification Chamber,
Boiler Instruments,
APH, Mill, FD fan,
BM & Combustion Sys,
HMI & PLC Controls

Replace:

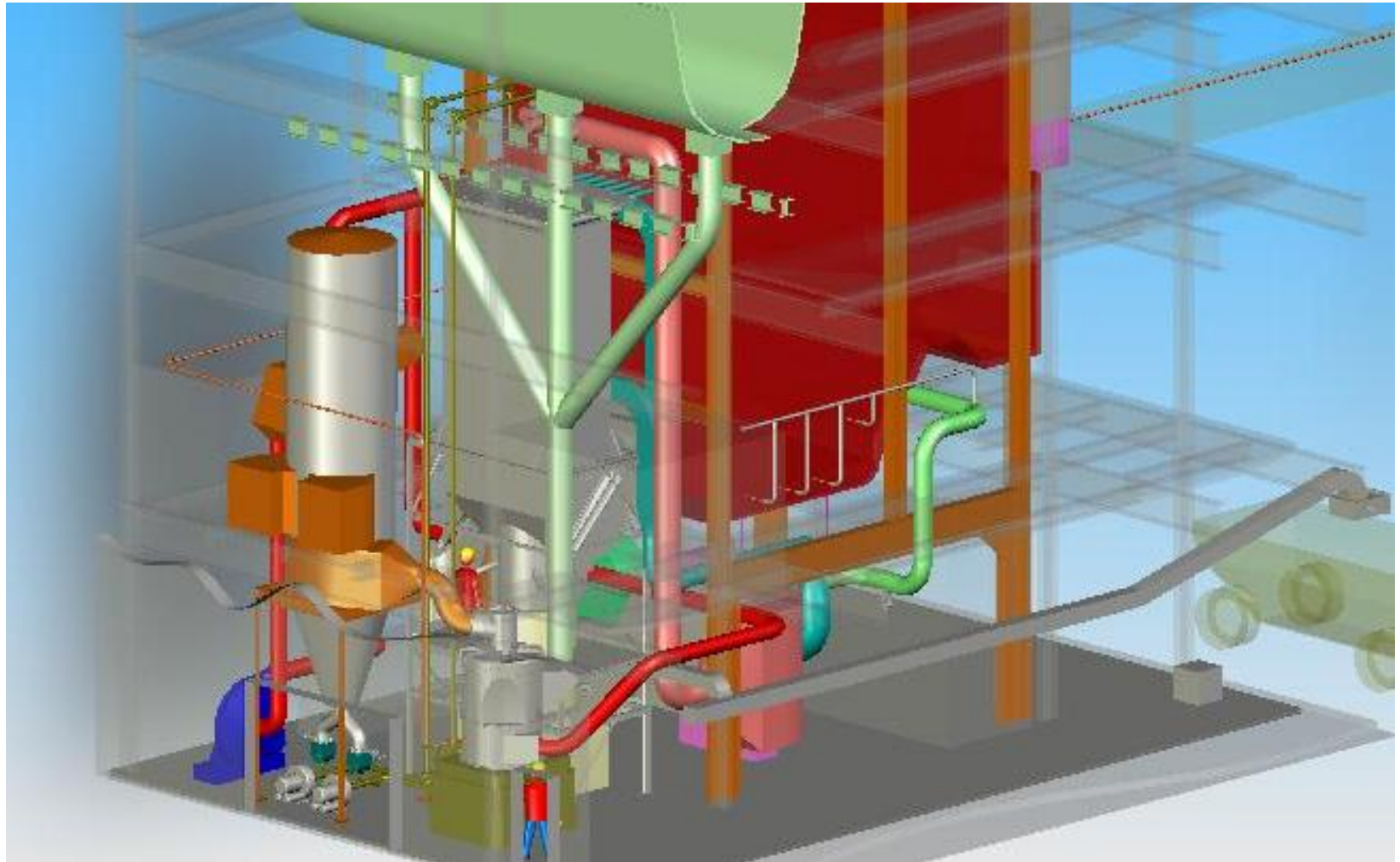
MCC,
Control Panel

Operator Training:

From cold start to
automatic full load
operation in 5 hrs.

CCS-Stoker[®] Retrofit

125 mmBtu/h



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Gasification Chamber Installation



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CCS-Stoker[®] Equipment Stack Up

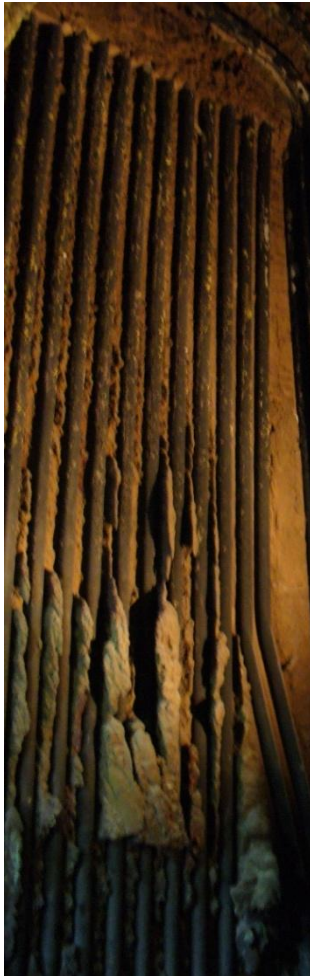


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Stoker Boiler Furnace Deposits

Typical Examples



Wall Ash Deposits



Exit Fouling Deposits

CCS-Stoker[®] Operation Observations

Very Little Ash Deposits on Furnace Tubing

No Plugging or Fouling of Back Pass Section



Furnace Walls



Furnace Ceiling

CCS-Stoker[®] Retrofit Performance

Preliminary Results – Full Load Operation

Item	Stoker Base Line Test	Preliminary CCS Performance	% Change from Base Line
SO ₂ Stack Emissions (lb/MMBtu)	1.80	0.72*	- 67.0 %
NOx Stack Emissions (lb/MMBtu)	0.50	0.14 (88 ppm)	- 72.0 %
Boiler Efficiency	77.0	86.9	+ 12.8 %
CO ₂ Emissions - Ton/yr GW credits (% Reduction)	94,019	73,720	20,300T/y (- 21.6 %)
Project Cost Recovery (from firing lower cost coal)		~ 3 years	

*Nearly meets CAIR (Clean Air Interstate Rules)

CCS-Stoker[®] Operation Observations

Operation @ MCR – Steam Overboard



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CCS Features

Improved Operability, Availability & Reliability

- All equipment off-the-shelf & familiar to the Operators
 - Safe, stable operation,
 - Same startup, shutdown and turndown as a PC burner
- Bottom Ash (slag) removed before furnace
 - low particulate/ash load; clean furnace, less soot blowing
- Sulfur removed from furnace gases - near-zero SO₃:
 - Allows for lower furnace exit temperatures
 - Minimize water-wall wastage & corrosion,
 - Can use hot boiler exhaust for pulverizer sweep air:
 - Dry the coal – reject moisture
 - Improves coal pulverizer safety from fire & puffs (low O₂)
- Improved Boiler Efficiency (2 to +10%)
 - Reduce CO₂ emissions
 - High combustion efficiency (LOI < 1%)
- Limestone is only “chemical” required
- No waste water for disposal



CCS Summary

(Key Strategic Issues)

- From Fundamental Combustion Theory to Commercial Operation
- Fire lower cost coals - reduce plant operating cost
- Meets EPA's new stringent CAIR initiatives for SO₂ & NO_x
- Allow power plant upgrade with waiver of NSPS & PSD - No NSR
- May generate CO₂ – SO₂ – NO_x emission credits
- Low Retrofit Cost; maintain older, smaller power boilers competitive - improve capacity factor & dispatch
- Fits within Plant & Boiler Site Footprint
- No waste water discharge
- Ash products have value (sell bottom ash & fly ash)
- No Hazardous or Toxic Chemicals Required

It's ADVANCED COAL GASIFICATION TECHNOLOGY!



Castle Light PR Programs

- Advanced environmental engineering consulting services.
- Convert / upgrade gas, oil and coal-fired plants:
 - To burn coal with reduced operating cost
 - Extend competitive life for 20 or more years
 - And meet stringent new EPA emission regulations.

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