

# **RE-ENGINEERING COAL-FIRED GENERATING PLANTS**



## **The CLEAN COMBUSTION SYSTEM**

**By**

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### **DISCLAIMER**

Information herein is best estimates of the presenters and subject to change.  
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# Problem Statement

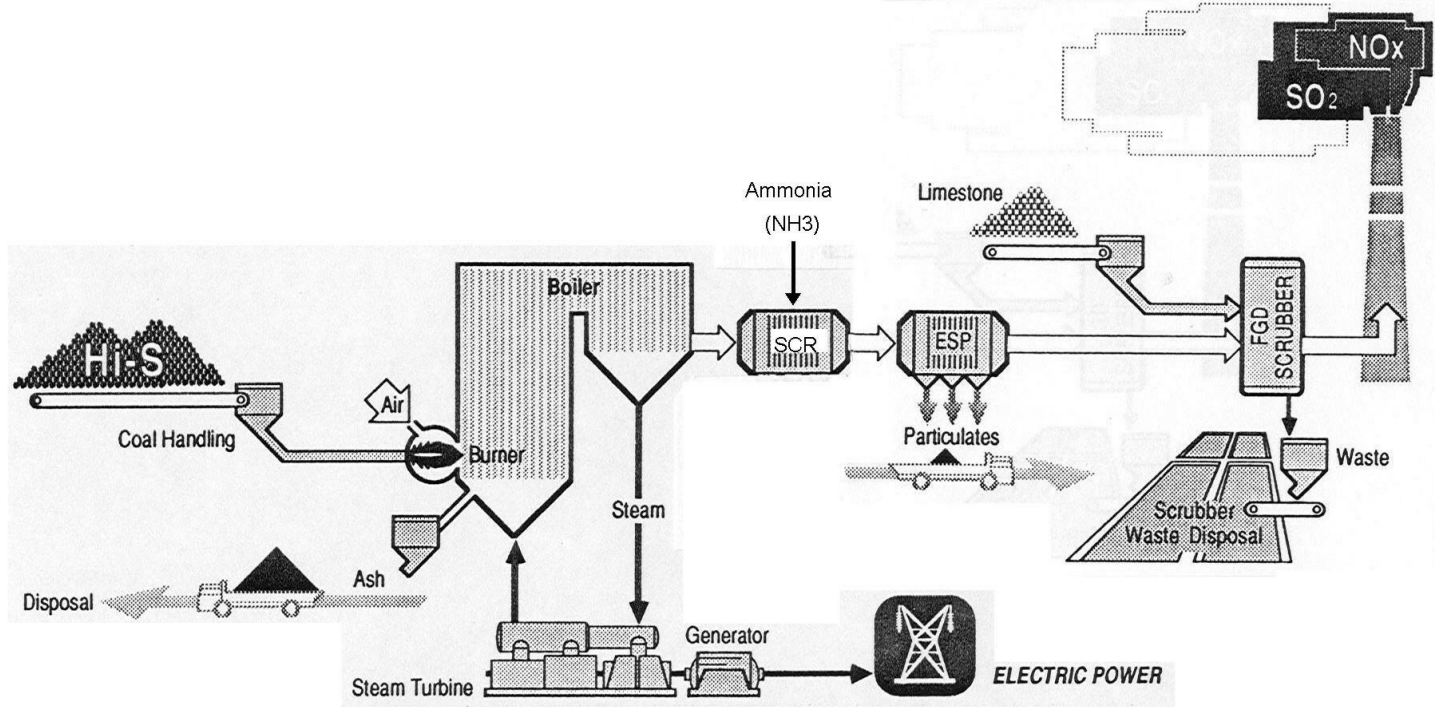
- EPA's interpretation of New Source Review (NSR) severely limits / prohibits modifications to power plants!
- Some 600 older, smaller (<400MW) coal-fired power plants are at risk of being mothballed or abandoned!
- However, an Emissions Reduction program (SO<sub>2</sub>, NO<sub>x</sub>, CO<sub>2</sub>, mercury) can provide waivers of NSPS, PSD, with no NSR.
- **Objective:**  
Re-engineer the coal-fired power plants with affordable technology to meet EPA's air quality regulations and reduce operating cost.

# CastleLight Energy Corp.

- Technology manager for the **Clean Combustion System™ (CCS)**
  - A Hybrid of Coal-Gasification and Combustion
  - Evolved from the 1980's rocket engine programs
  - Strong in-combustion control of SO<sub>2</sub> and NO<sub>x</sub> emissions.
  - Field Demonstrated
- Developer of **Advanced Coal Beneficiation (ABC)** process;
  - Improves coal quality: remove **water , ash, mercury, and**
  - Produce an **oil product for sale from the coal!**
- When combined: CCS + ABC technology to provide older power plants 20 or more years of very competitive dispatch!

# Conventional Emission Controls

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



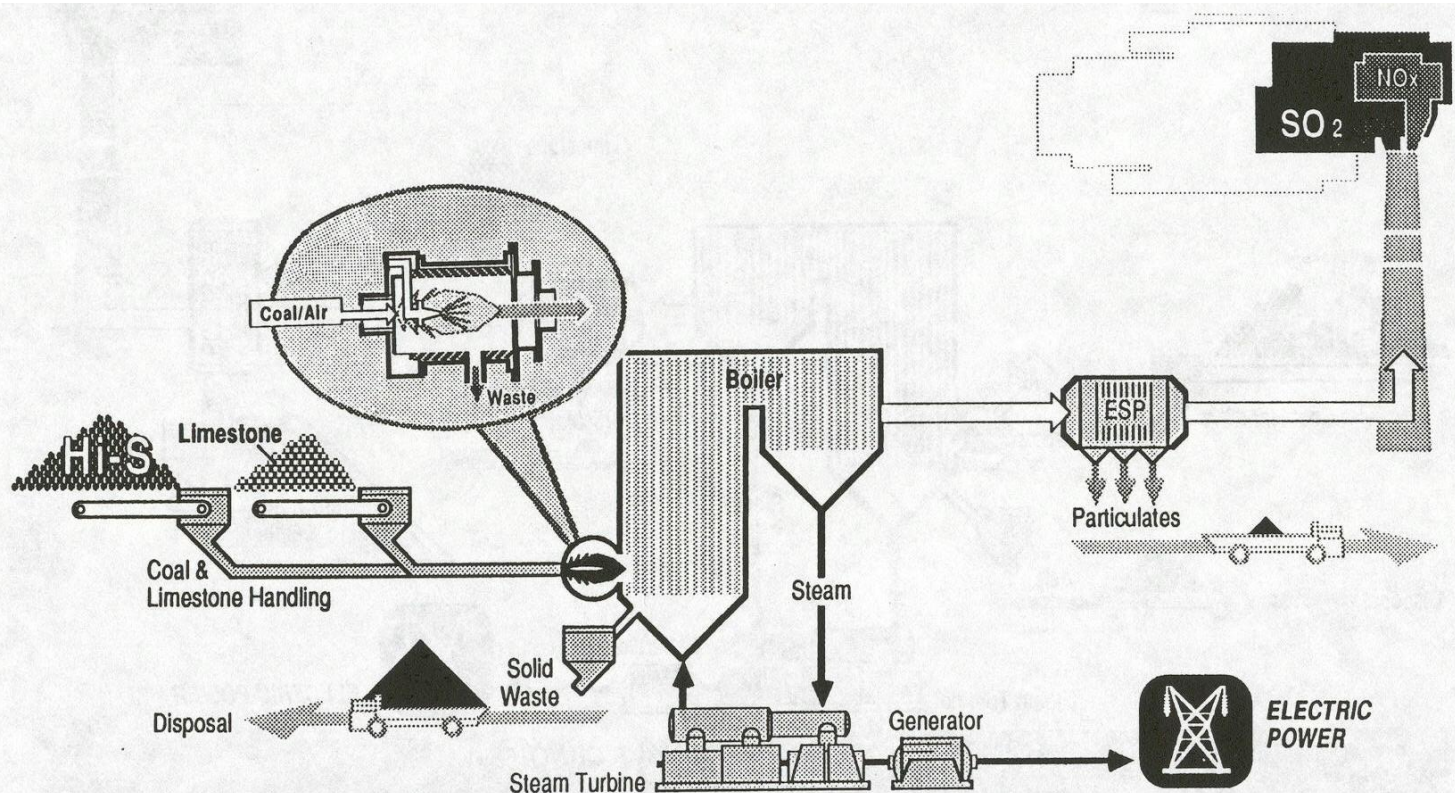
**COMPARED WITH CONVENTIONAL TECHNOLOGY\***

$\text{SO}_2$ EMISSION REDUCTION	$\text{NO}_x$ EMISSION REDUCTION	PLANT EFFICIENCY	POWER OUTPUT	PLANT LIFE	INCREMENTAL ELECTRICITY COST	CAPITAL COST
<b>90% AND HIGHER</b>	<b>90% AND HIGHER</b>	<b>2+% Decrease</b>	<b>2+% Decrease</b>	<b>No Change</b>	<b>11 - 15 MILLS/KWH</b>	<b>\$280 - 300 PER KW</b>

\* CONVENTIONAL COAL-FIRED ELECTRIC POWER PLANT

# CCS Hybrid Coal-Gasification

## SO<sub>2</sub> & NO<sub>x</sub> Control Right in the Combustion Step



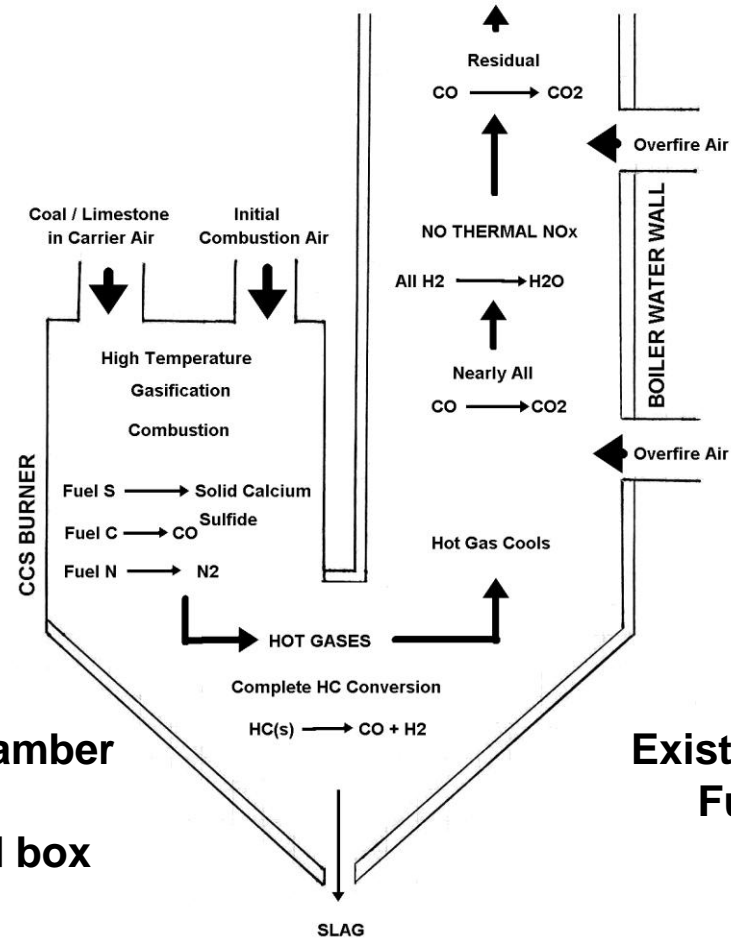
**COMPARED WITH CONVENTIONAL TECHNOLOGY\***

SO <sub>2</sub> EMISSION REDUCTION	NO <sub>x</sub> EMISSION REDUCTION	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

# The Clean Combustion System (CCS)

## Hybrid of Coal-Gasification / Combustion



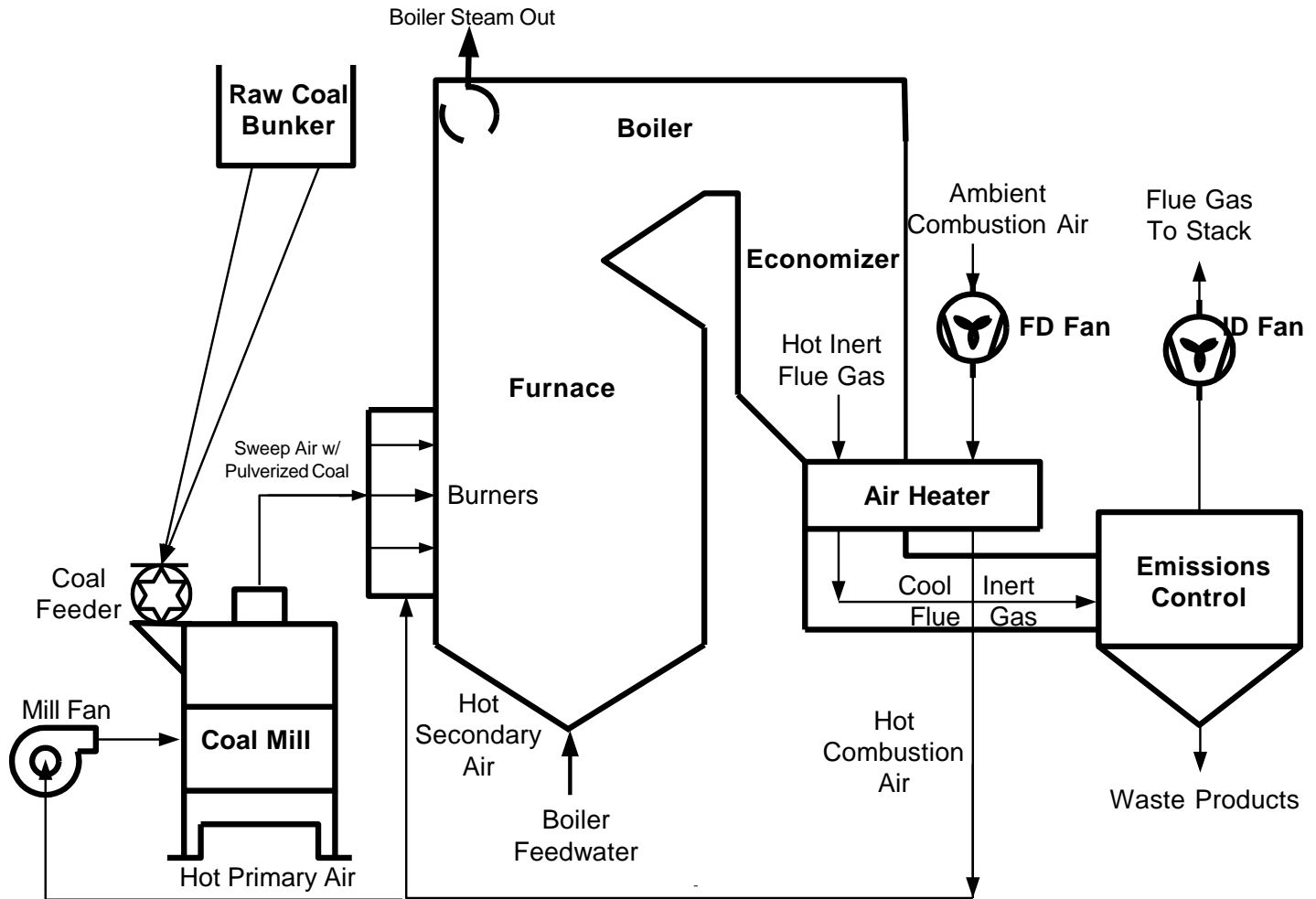
**CCS Gasification Chamber  
replaces  
coal burners & wind box**

**Existing Boiler  
Furnace**

# Typical Coal-Fired Power Plant

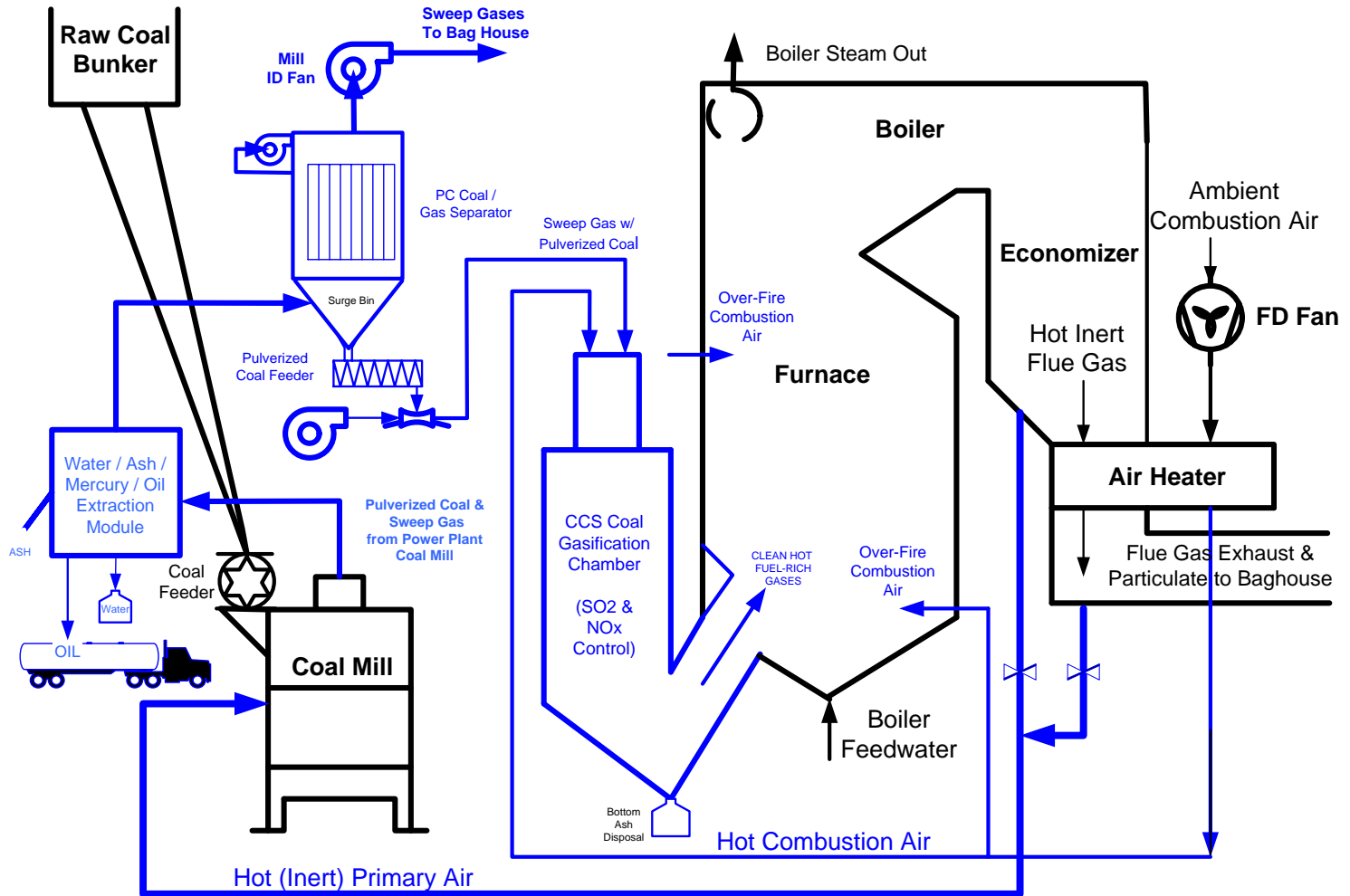
Pulverized Coal, Direct-fired

500 MW w/5 Mills @ 58 T/hr ( $\sim 1 \text{ ft}^3/\text{sec}$ )



# CCS Re-Engineered Power Plant

## (Indirect-Fired) Each Mill with Coal-Beneficiation Module (CBM)





# CCS-Stoker<sup>®</sup> Gasification Chamber



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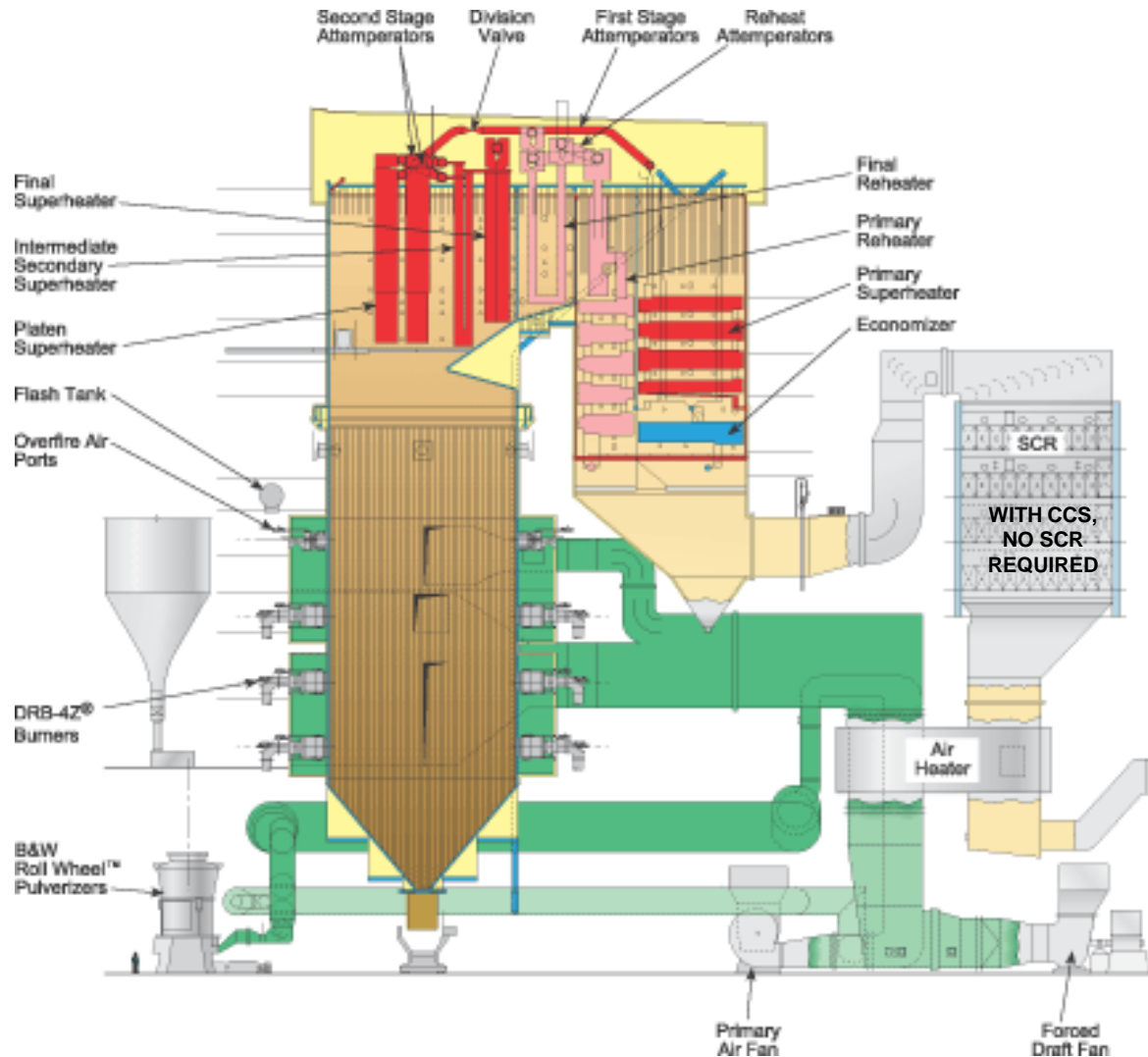
# CCS-Stoker<sup>®</sup> Gasification Chamber Installation

- Shop fabricated membrane wall, studded and refractory lined construction
- Replaces boiler PC Burner and wind-box
- Connected to the boiler drums for natural circulation water cooling



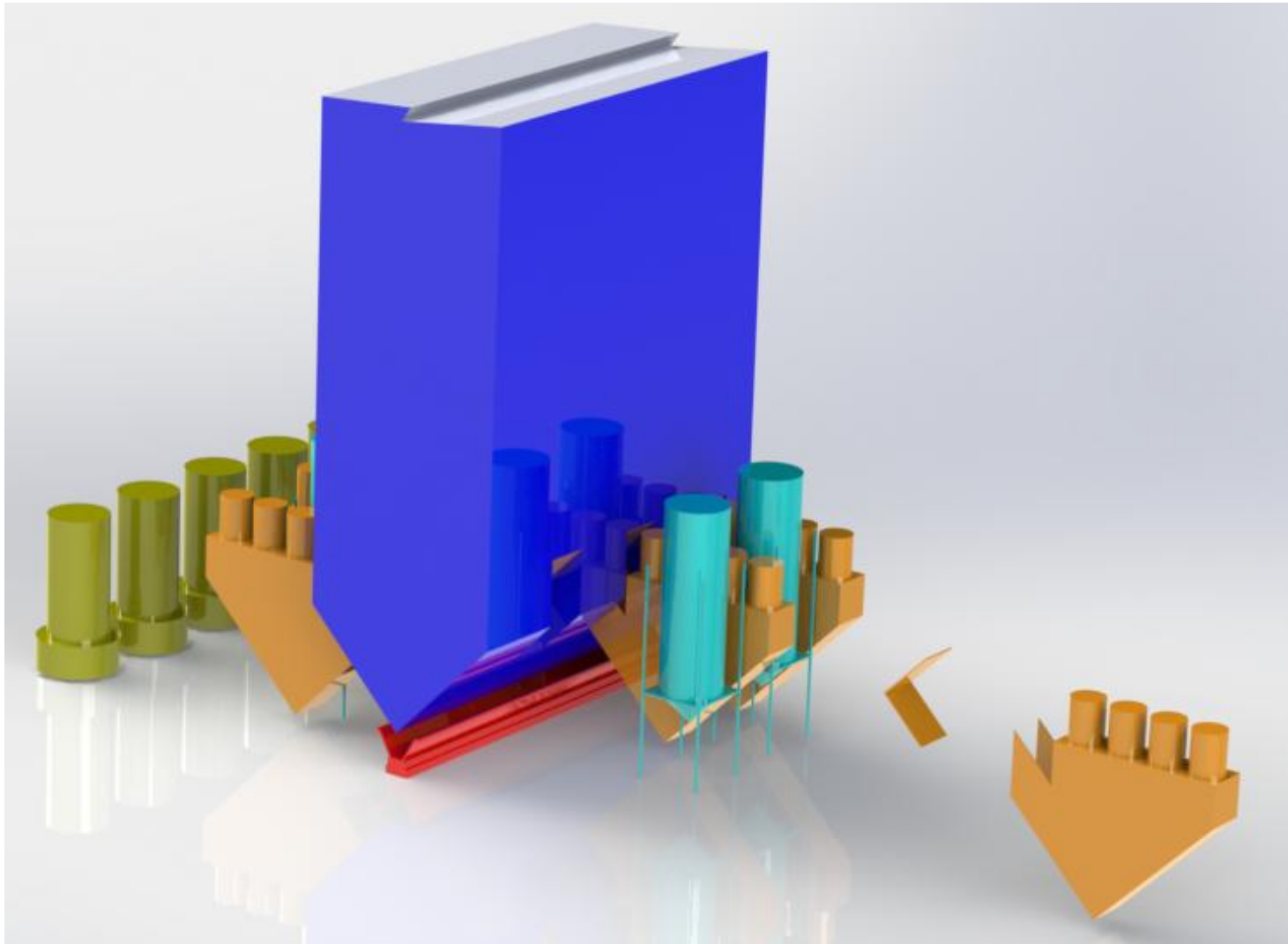
# B&W Opposed-Wall Fired Boiler

## 500 MW – 24 Wall-Fired PC Burners



# CCS Re-Engineered B&W Boiler

Replace PC Burners with 24 new CCS Burners & 6 GC's



# Rockwell International

25 x 10<sup>6</sup> Btu/hr (1 ton/hr) Test Facility (1990)



# LNS-CAP Facility

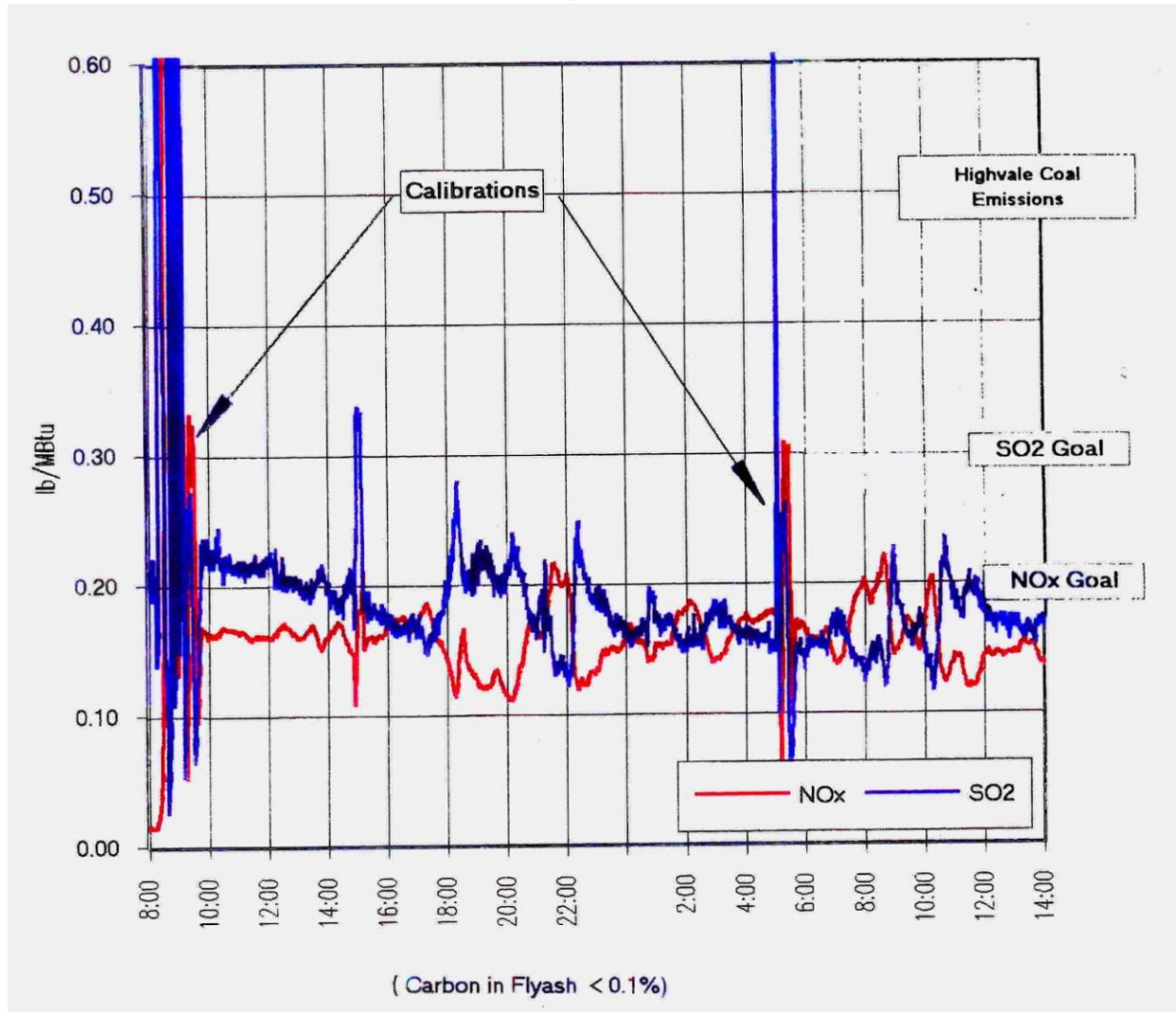
ESSO Site, Cold Lake, Alberta Canada  
50 mmBtu/hr – 3T/hr PRB Coal



# Demonstrated Emissions

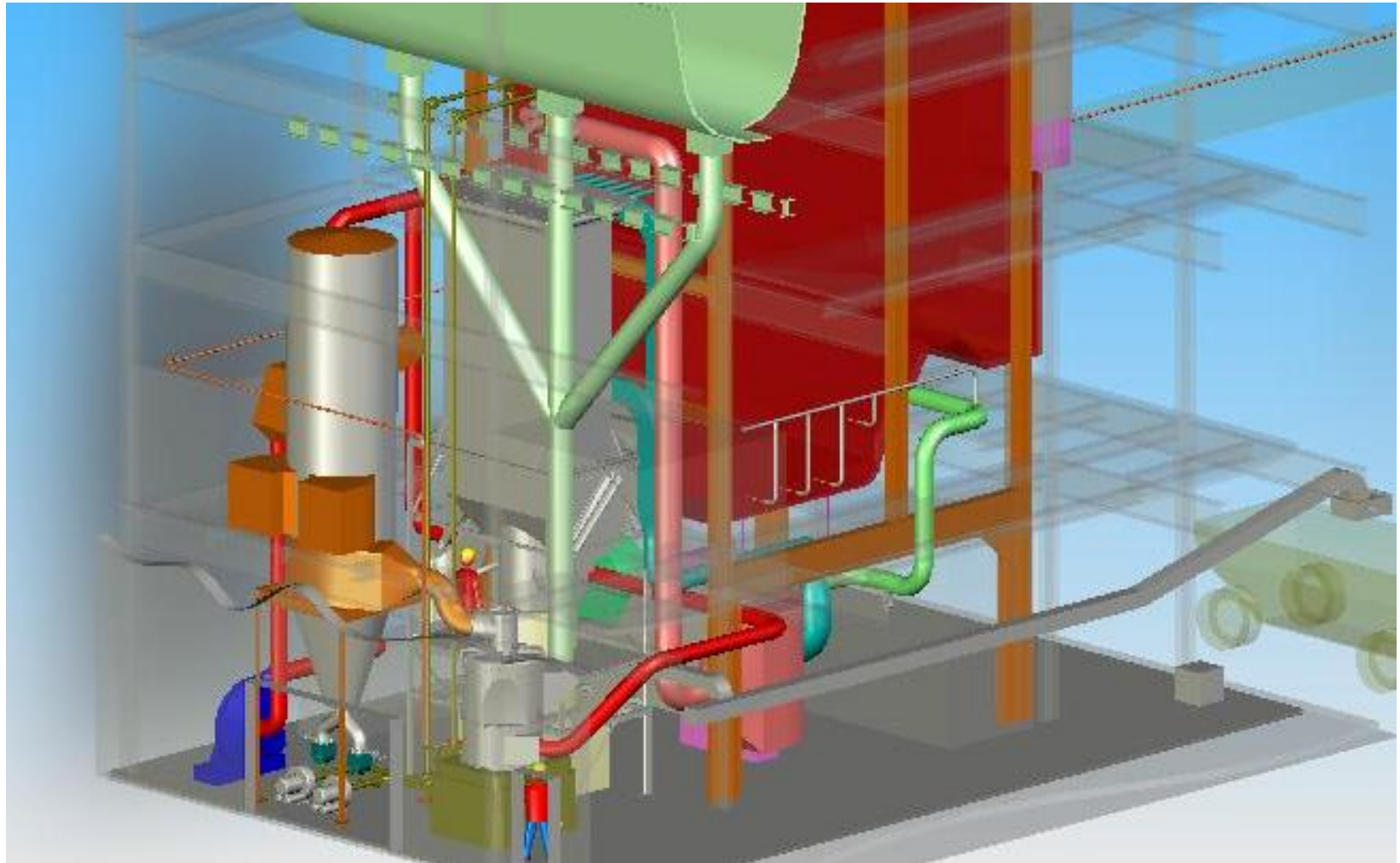
SO<sub>2</sub> - 0.2 lb./mmBtu & NO<sub>x</sub> - 0.15 lb./mmBtu

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



# CCS-Stoker<sup>®</sup> Retrofit

30 MW (Thermal) - 125 mmBtu/hr – 5 T/hr Coal





# Operation Observations

## CCS-Stoker<sup>®</sup> Furnace Ash Deposits



CCS Walls



CCS Ceiling

# CCS-Stoker<sup>®</sup> Operation @ MCR

## Steam Overboard



# CCS-Stoker<sup>®</sup> Retrofit Performance

## Preliminary Results – Full Load Operation

Item	Stoker Base Line Test	Preliminary CCS Performance	% Change from Base Line
SO <sub>2</sub> Stack Emissions (lb/MMBtu / ppm)	1.80 / 940	0.72 / 440	- 67.0 %
NO <sub>x</sub> Stack Emissions (lb/MMBtu / ppm)	0.50 / 370	0.14 / < 88	- 72.0 %
Boiler Efficiency	77.0	86.9	+ 12.8 %
CO <sub>2</sub> 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	



# Coal-Beneficiation Module

## “oil well in the coal pile”

- CastleLight Energy Corp. is in development of a “flash” coal-pyrolysis module for coal-fired electric generating plants – one for each coal mill.
- CB Module extracts water, ash, mercury, and OIL from the coal.
  - Processes coal as fast as it is pulverized.
  - Water recovered from coal moisture – for plant use.
- Supplies a high quality coal fuel to the power plant
  - improves plant efficiency.
- Carbon neutral process = No CO<sub>2</sub> increase!
- **Oil Sales – Off set Plant’s coal supply cost!**
- **Example:**
  - 500-MW power plant (process 10,000 T/day PRB coal)
  - Produces ~2400-barrels / day oil (pays ~½ of coal cost!)
  - Fires ~5,600 T/day high quality coal for low-cost electricity
  - Meets EPA’s SO<sub>2</sub>, NO<sub>x</sub>, CO<sub>2</sub>, & Hg emission regulations.



# Re-Engineered Power Plant with CCS & Coal Beneficiation Processes

**Stack Emissions Estimate\* firing PRB coals (1.2 lb. SO<sub>2</sub>/mm Btu Coal)**

- SO<sub>2</sub> = < 0.2 lb./mmBtu (< 105 ppm)
- NO<sub>x</sub> = < 0.10 lb./mmBtu (< 75 ppm)
- CO = < 300 ppm
- LOI = < 1% (high efficiency combustion)
- SO<sub>3</sub> = < 0.1 ppm (condensable particulate)
- CO<sub>2</sub> = ~ 17% reduction (improved combustion efficiency)
- Mercury = < 40 ppb
- Particulate = < 0.03 lb./mmBtu (bag house)
- Boiler Efficiency = 2 – 10% increase
  - Preliminary estimates of performance, measured after bag house – no guarantees
- **MEETS proposed EPA CSAPR & CAMR  
for Existing Power Plants**



# Strategic Business Opportunity?

## Acquire Abandoned Coal-fired Power Plants

- **Re engineer PC Electric Generation Plant with CCS;**
  - Provides SO<sub>2</sub> & NO<sub>x</sub> emissions control,
  - Waiver of NSPS, PSD, & no NSR
- **Integrate a CBM on each coal Mill**
- **Improved power plant performance**
  - improves boiler heat rate/efficiency - less fuel fired
- **Very competitive dispatch;**
  - **“paid for”** fuel = low cost electricity
- **Can show carbon neutral process = No CO<sub>2</sub> increase!**



# CCS Summary

## (Key Strategic Issues)

- From Fundamental Combustion Theory to Commercial Operation
- Meets EPA's new stringent regulations for SO<sub>2</sub> & NO<sub>x</sub>
- Allow power plant upgrade with waiver of NSPS & PSD - No NSR
- Low Retrofit Cost; maintains older, smaller plants competitive
- Lower operating cost from oil sales
- Improve plants capacity factor & dispatch
- Fits within plant & boiler site footprint
- Ash products have value (sell bottom ash & fly ash)
- No hazardous or toxic chemicals required

**It's ADVANCED COAL GASIFICATION TECHNOLOGY!**



# CastleLight Energy Corp Re Engineering Programs

- CastleLight Energy Corp. provides 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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