RE-ENGINEERING
COAL-FIRED GENERATING PLANTS

The CLEAN COMBUSTION SYSTEM
By
CastleLight Energy Corp.
Keith Moore - President

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DISCLAIMER
Information herein is best estimates of the presenters and subject to change.
No guarantees or warrantees implied or given.
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 (SO₂, NOₓ, CO₂, 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 $\text{SO}_2$ and $\text{NO}_x$ 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

\[ SO_2 = \text{FGD} + \text{Limestone}; \quad NO_x = \text{SCR} + \text{Ammonia}; \]
\[ SO_3 = \text{Trona} ?, \quad Hg = \text{Activated Carbon} ? \]
CCS Hybrid Coal-Gasification
SO₂ & NOₓ Control Right in the Combustion Step

<table>
<thead>
<tr>
<th>SO₂ EMISSION REDUCTION</th>
<th>NOₓ</th>
<th>PLANT EFFICIENCY</th>
<th>POWER OUTPUT</th>
<th>PLANT LIFE</th>
<th>INCREMENTAL ELECTRICITY COST</th>
<th>CAPITAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 - 90+ HIGH</td>
<td>No</td>
<td>No Change</td>
<td>No Change</td>
<td>Slight Extension</td>
<td>2-4 MILLS/KWH</td>
<td>$75-110 PER KW</td>
</tr>
</tbody>
</table>

*CONVENTIONAL COAL-FIRED ELECTRIC POWER PLANT
The Clean Combustion System (CCS)
Hybrid of Coal-Gasification / Combustion

CCS Gasification Chamber replaces coal burners & wind box
Typical Coal-Fired Power Plant
Pulverized Coal, Direct-fired
500 MW w/5 Mills @ 58 T/hr (~1 ft⁻³/sec)

FIG. 1    TYPICAL PULVERIZED COAL-FIRED POWER PLANT
CCS Re-Engineered Power Plant
(Indirect-Fired) Each Mill with Coal-Beneficiation Module (CBM)
CCS-Stoker® Gasification Chamber
CCS-Stoker® 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

WITH CCS, NO SCR REQUIRED
CCS Re-Engineered B&W Boiler
Replace PC Burners with 24 new CCS Burners & 6 GC’s
Rockwell International
25 x 10^6 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

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

ESSO LNS-CAP Facility, Cold Lake, Alberta, Canada
CCS-Stoker® Retrofit
30 MW (Thermal) - 125 mmBtu/hr – 5 T/hr Coal
Operation Observations
CCS-Stoker® Furnace Ash Deposits

CCS Walls                         CCS Ceiling

1-28-13
CCS-Stoker® Operation @ MCR
Steam Overboard
# CCS-Stoker® Retrofit Performance

**Preliminary Results – Full Load Operation**

<table>
<thead>
<tr>
<th>Item</th>
<th>Stoker Base Line Test</th>
<th>Preliminary CCS Performance</th>
<th>% Change from Base Line</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SO₂ Stack Emissions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(lb/MMBtu / ppm)</td>
<td>1.80 / 940</td>
<td>0.72 / 440</td>
<td>- 67.0 %</td>
</tr>
<tr>
<td><strong>NOₓ Stack Emissions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(lb/MMBtu / ppm)</td>
<td>0.50 / 370</td>
<td>0.14 / &lt; 88</td>
<td>- 72.0 %</td>
</tr>
<tr>
<td><strong>Boiler Efficiency</strong></td>
<td>77.0</td>
<td>86.9</td>
<td>+ 12.8 %</td>
</tr>
<tr>
<td><strong>CO₂ Emissions - Ton/yr</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GW credits (% Reduction)</td>
<td>94,019</td>
<td>73,720</td>
<td>20,300T/y (- 21.6 %)</td>
</tr>
<tr>
<td><strong>Project Cost Recovery</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(from firing lower cost coal)</td>
<td></td>
<td>~ 3 years</td>
<td></td>
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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 CO₂ 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 SO₂, NOₓ, CO₂, & Hg emission regulations.
Re-Engineered Power Plant with CCS & Coal Beneficiation Processes

Stack Emissions Estimate* firing PRB coals (1.2 lb. SO₂/mm Btu Coal)

- SO₂ = < 0.2 lb./mmBtu (< 105 ppm)
- NOₓ = < 0.10 lb./mmBtu (< 75 ppm)
- CO = < 300 ppm
- LOI = < 1% (high efficiency combustion)
- SO₃ = < 0.1 ppm (condensable particulate)
- CO₂ = ~ 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\textsubscript{2} & NO\textsubscript{x} 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\textsubscript{2} increase!
CCS Summary  
(Key Strategic Issues)

- From Fundamental Combustion Theory to Commercial Operation
- Meets EPA’s new stringent regulations for $\text{SO}_2$ & $\text{NO}_x$
- 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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