An Update of Proposed CO$_2$ Regulations for Coal- and Gas-Fired Power Plants

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Summary of EPA Greenhouse Gas New Source Performance Standard*

• All new generation must meet an emission standard of 1,000 Lb CO$_2$/MWh
  – Uncontrolled coal ~ 1,675 Lb CO$_2$/MWh

Greenhouse Gas New Source Performance Standard

NSPS is a formidable challenge for coal to remain in the energy mix…

- **Existing Subcritical PC**
- **New Supercritical PC**

- **Year 0 – 10, No Capture**
- **Year 11 – 30, 65% Capture**

**Lb CO₂/MWh**
- Year 0 – 10, No Capture
- Year 11 – 30, 65% Capture

**NATIONAL ENERGY TECHNOLOGY LABORATORY**

U.S. GDP Strongly Linked to Fossil (Coal and Gas) Generation

GDP grew while fossil generation fell, but the growth was not sustainable: housing bubble and economic stimulus spending!

Sources: EIA, Annual Energy Review; BEA: NIPA Table 1.1.6
From 2002 to 2011, actual price was, on average, 64% higher than what AEO’02 predicted.
Global Natural Gas Price Comparison*

What is the likelihood that natural gas prices will remain at historic lows?

Gap between Henry Hub, global prices will shrink as export markets (LNG) open up

Spark spread shrinks quickly as domestic gas price reaches a global equilibrium

CO₂ Capture-Ready Coal Units

A continued investment in coal R&D via CO₂ capture-ready units can provide the following returns...

1. **Keeps a proven fossil resource in play:** Power generation and U.S. economic growth directly linked. New generation needed to drive economic growth, and capture-ready coal units in compliance with EPA’s proposed GHG NSPS.

2. **Capital Cost savings:** Capture-ready coal has a 60% capital cost savings over other baseload options, e.g. nuclear.

3. **Insurance Policy:** A mechanism to keep natural gas prices in check through promotion of energy diversity. Also, a proven way to serve baseload, as spark spreads* shrink due to a global natural gas price equilibrium.

*Spark spread = Theoretical gross profit margin of gas-fired generation from selling a unit of electricity, given a specific fuel price.*
CO₂ Capture-Ready Definition

CO₂ Capture-Ready Supercritical PC:
- Extra real estate
- Space in pipe racks, cable trays
- Design allowance for change in cooling load
- Control systems for CO₂ capture
- Intelligent steam turbine design

Note: Block Flow Diagram is not intended to represent a complete material balance. Only major process streams and equipment are shown.
Design Strategy

- Minimize cost of electricity by keeping capital costs low, or maximizing power output

\[
COE(\frac{\$}{MWh}) = \frac{(TOC \times CCF) + OC_{fixed} + (Cap.Fac. \times OC_{var})}{Cap.Fac. \times MWh}
\]
Capture-Ready 30-Year CO₂ Emission Schedule

30 Year Average Emission Rate (65% CO₂ Capture)
Capital Cost Results ($/kW)

<table>
<thead>
<tr>
<th>Case</th>
<th>1st Generation CO₂ Capture</th>
<th>Post CO₂ Capture</th>
<th>Capture Ready Plant</th>
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Capture-ready coal has 50-60% capital cost savings over other baseload options, e.g. nuclear.

1. 2012 Annual Energy Outlook, EIA
LCOE’s for Capture-Ready Coal and Uncontrolled NGCC

33% decrease in natural gas price is an attractive return on investment for coal R&D!

- **Capture-Ready Coal, 1st Gen CCUS**
  - LCOE = \$11.50/mmBtu

- **Capture-Ready Coal, 2nd Gen CCUS, $25/ton CO₂ EOR**
  - LCOE = \$9.75/mmBtu

- **Capture-Ready Coal, 2nd Gen CCUS, $75/ton CO₂ EOR**
  - LCOE = \$8/mmBtu

1st Gen CCUS
- Gas ~ \$11.50/mmBtu
- \( \text{LCOE}_{\text{coal}} = \text{LCOE}_{\text{NGCC}} \)

2nd Gen CCUS
- Gas ~ \$9.75/mmBtu
- \( \text{LCOE}_{\text{coal}} = \text{LCOE}_{\text{NGCC}} \)

- Gas ~ \$8/mmBtu
- \( \text{LCOE}_{\text{coal}} = \text{LCOE}_{\text{NGCC}} \)
Final Thoughts

Understanding project risk and market dynamics are critical:

• **Project Risk**: Industry needs assurance that either 1) CCUS will be available at the end of the first decade, or 2) they won’t be penalized if it isn’t. Without this, there is little incentive for developers to take the risk on capture-ready units.

• **Market Dynamics**: Current gas prices, regulatory burden on coal (MATS, CSAPR/CAIR, NSPS) make NGCC the likely choice for new generation. However, given the large difference between domestic and global spot prices, and pending regulations on fracking, gas prices will almost surely increase. In addition, nuclear is ~100–150% more costly than capture-ready coal and is therefore not an economic baseload alternative.
Greenhouse Gas New Source Performance Standard

Recent Developments…

- EPA missed an April 13, 2013 deadline to finalize GHG NSPS
- Considerations:
  - Coal and gas combined into the same category, an unprecedented approach by EPA
Regulation of CO$_2$ from Existing Coal Plants

- EPA has consistently downplayed any regulation of CO$_2$ from existing coal units, but it is widely believed to be forthcoming.

1. Encouraging states to burn more gas than coal to meet state-specific CO$_2$ budgets
2. Retirement after ~50 years of operation
3. Coal plant efficiency improvements
4. Phased-in CO$_2$ reductions over time, finally ending in deployment of carbon capture and sequestration

- Will EPA make a determination that CCS is the "best system of emission reduction?"