The Risks, They Just Keep On Coming

( Impacts of Environmental Bills in Congress )

GAMS Anniversary Seminar
September 19, 2003

Lloyd R. Kelly
Vice President & Partner
Hill & Associates, Inc.

(410) 263-6616 ext.104 / L.Kelly@hillandassoc.com
HAPPY BIRTHDAY, ALEX
Order of Presentation

1. How Our Models Work

2. Results of Modeling Current Bills In Congress

3. Discussion of the Risk Implications

4. Conclusions
**Hill and Associates, Inc.**  
Electric Generation, Coal and Emissions Forecasting System

**National Power Model™**  
- Dispatch Economics  
- 90+ Control Areas  
- Seasonal/TOD Prices, Flow & Gen.

**Demand Model**  
- GDP  
- Weather  
- Electric Intensity

**Regional Emission Limits**  
- SO₂, CO₂, NOₓ

**Transmission**  
- Bi-Directional Simultaneous Flows  
- Seasonal Limits  
- Time-of-Day Rates

**Plant/Area by TOD**  
- Generation  
- Power Flows  
- Marginal Prices  
- Emissions

**Coal Plant Energy Demand**

**Utility Fuel Economics Model**  
- Fuel Switching  
- Clean-up Equip Choices  
- Allowance Trading

**Generation Database (all units)**

**Generation Cost Supply Models**  
- New Build  
- Gas & Oil Forecast

**Generation Database (coal units)**

**Coal Plant Costs & Emissions Forecast**

**Coal Plant Costs and Emissions Forecast**

**Strategies for**  
- SO₂  
- NOₓ  
- Particulates

**Utility Fuel Economics Model**  
- Coal Supply Curves  
- Cash Cost by Mine  
- All Regions  
- By Coal Type

**Demand**  
- Industrial  
- Commercial  
- Residential
Three Factors Differentiate Us

• Our Coal Mining Cost Curves By Detailed Type of Coal

• The Feedback Loop With Dispatch, Coal Choice and Equipment Decisions Co-Dependent

• Simultaneous Interplay of Pollutant Limits
## Multi-Emission Limits

|----------|-------------|-------|-------------------------------------------------|--------------------------|
| SO2      | 12.0 million tons | 4.35 mm in '10 | 4.5 mm in '10  
3.0 mm in '18 | 4.5 mm in '08  
3.5 mm in '12  
2.25 mm in '15 |
| NOx      | 7.1 million tons | OTC Stepdown '03  
21-State SIP Call '05 | 2.1 mm in '08  
(1.582 mm East/0.538 mm West)  
1.7 mm in '18  
(1.162 mm East/0.538 mm West) | 1.7 mm in '12 |
| Mercury  | 48.6 tons | None | 26 tons in '10  
15 tons in '18 | 24 tons in '08  
5-16 tons in '12 (EPA set cap) 10 tons (H&A) |
| CO2      | 2.19 billion tons | None | None | ~2.6 billion in '08 (2005 levels)  
~2.3 billion in '12 (2001 levels) |
Last Year’s Outlook

Total U.S. Steam Coal
Including "Snapshot" Results

<table>
<thead>
<tr>
<th>Year</th>
<th>Million Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>800</td>
</tr>
<tr>
<td>2004</td>
<td>850</td>
</tr>
<tr>
<td>2006</td>
<td>900</td>
</tr>
<tr>
<td>2008</td>
<td>950</td>
</tr>
<tr>
<td>2010</td>
<td>1,000</td>
</tr>
<tr>
<td>2012</td>
<td>1,050</td>
</tr>
<tr>
<td>2014</td>
<td>1,100</td>
</tr>
<tr>
<td>2016</td>
<td>1,150</td>
</tr>
<tr>
<td>2018</td>
<td>1,200</td>
</tr>
<tr>
<td>2020</td>
<td>1,250</td>
</tr>
</tbody>
</table>

NAQ
CO2 Snapshot
Bus
Gas Price Sens.

HILL & ASSOCIATES INC.
This Year’s Study

Total U.S. Coal Production

Million Tons


$4.30 Gas $3.80 Gas $2.80 Gas $2.30 Gas

NAQ SKY CAP Gas Price Sens.
Different Types of Risk for Coal

• The Risk of the Carper Bill Being Passed (Or Any Other Form of Fixed CO2 Limits)

• The (Mercury + Gas Price) Risk
  – More Insidious (Looks OK from One Angle)
  – Coal Tonnage Alone Doesn’t Tell Whole Story

• Risks Not Reflected In Our Modeling
CO$_2$ Impact: It Ain’t Rocket Science

- Starting Point: 3.904 Billion MWH

- If Grows 2.5%/yr for 25 Years = 7.238 Bln

- Assume 20% Is Hydro, Relicensed Nuc.s, etc (Remaining 80% Is Fossil-Fired = 5.790 Bln)

- Even If ALL Fossil-Fired Is Natural Gas, Result is CO$_2$ Emission of 2.29 Billion Tons (vs Carper Bill Limit of 2.3 Bln – No Coal!)
Current Global Mercury Emissions

- Total of Natural, Anthropogenic & Oceanic = 5500 tons

- U.S. Anthropogenic = 158 tons (2-3%)

- U.S. Power Plants = 48.6 tons (<1%)

- Geologists’ Anecdote: 1 Volcano Erupting…
Measurement of Hg Emissions

• Dispute Over Whether They Can Be (And Are Being) Measured Accurately

• SO$_2$ and NO$_x$ Range 2-12 million tons/year

• Hg : 50 tons/yr (<1mm, <1k, <100)

• SO$_2$ and NO$_x$ in Coal: lb./million Btu

• Hg in Coal: lb./trillion Btu
  (i.e., one-millionth the level of other pollutants)
But Isn’t Mercury Poisoning Especially Bad?

- State of Hawaii – Continuous Simmering Volcanic Emissions + Occasional Eruptions … Why don’t we hear about a lot of mercury deaths there?

- EPA Administrator Browner’s Official Basis:
  “There is a ‘plausible link’ between man-caused emissions of mercury and the possible bioaccumulation in the food chain and the possibility that the level could become high enough to adversely affect the health of women of childbearing age and young children.”
Mercury Impact:
Highly Volatile w/ Gas Prices

• Unlike CO₂ This Is Economic Trade-Off

  – A Brand-New Gas-Fired Combined Cycle Plant Simply Wins The Dispatch Competition vs Many Coal-Fired Plants

  – The Balance Point Changes, Obviously, With Natural Gas Price
Hg-Surviving Coal vs Gas Price

- Gas Price ($/mmBtu)
- Million Tons

Graph showing the relationship between gas price and the surviving coal in million tons.
2015 SKY Sensitivity, GAS -$100

Dispatch Cost $/MWh

COAL
GAS
What’s The Point Here On Mercury?

• Don’t Focus As Much On The Single “Correct” Answer As On The RISK!
  
  – If Supply/Demand Balance For Natural Gas Shifts (Drilling, LNG, Trans-AK and/or Trans-Canada Pipeline, etc), Then Much Of Coal Industry Gets Killed Under Hg Limits
  
  – Remember, U.S. Utilities’ Hg Is Less Than 1% Of The Global Atmospheric Load !!!
But Coal Tonnage Alone Doesn’t Tell The Whole Story

• Mercury Allowance Price of About $150,000 per lb. \( \times \) 52,000 lb = $7.8 bln

• In Fact, For 2010:
  – NAQ Sum (Mwh * Disp_Cost) = $92 bln
  – SKY Sum (Mwh * Disp_Cost) = $78 bln

  ( $14 billion per year extra cost to generate )
Other Risks Not Shown By Our Modeling

• We Traditionally Choose To Use Identical Electric Demand Across Scenarios (i.e., No Price Elasticity of Electric Demand)
  – Utility Generation Would Suffer At These Levels
  – U.S. Economy Would Get A Huge “Hit”

• Our Models Are Currently Set Up To Assume Any Gas Infrastructure Needed Would Arrive
  – But Carper Case (w/ CO₂ Lim.) Goes To 42 TCF!
CONCLUSIONS

• Our Models Aren’t Perfect, But We Are Probably Getting Closer Than Many Others (especially Government analyses)

• The Threat Is Real! (and Risk Affects Capital Availability)

• Key Decision-Makers Are Starting To Realize This May Be An Unacceptable Risk
BACKUP SLIDES
Some Mercury Technology

• 3 Forms of Mercury (Hg)
  – Elemental (gas at boiler temperatures) – Hg °
  – Ionic (gas) – Hg ++
  – Solid Particles (Predominantly HgCl₂)

• 2 Forms of Capture
  – Gaseous Hg adsorbed onto porous particles (PAC), then collected with ESP’s or Bag Houses (PM collection)
  – The predominant Hg solid compounds are soluble in wet scrubber solutions & captured by wet FGD

• Elemental Hg is hardest to capture, but can be oxidized to Ionic (belief that SCR promotes this)
  – PRB coal high in elemental form
Eastern Bituminous Coal – Mercury Modeling
(1.0 lb Hg Basis)

1.0 lb Hg

HgCl$_2$
(Solid)

Hg$^{++}$
(Ionic Gas)

0.60 lb Hg

0.10 lb Hg

Hg$^+$
(Elemental Gas)

0.30 lb Hg

Max. Cleanup Equip. (Scrub, SCR & PAC)

0.120 lb Hg
(or, 88.0% Removal)
PRB Coal – Mercury Modeling
(1.0 lb Hg Basis)

1.0 lb Hg

HgCl₂ (Solid)

Hg⁺⁺ (Ionic Gas)

0.15 lb Hg

0.10 lb Hg

0.75 lb Hg

Hg° (Elemental Gas)

Max. Cleanup Equip.
(Scrub, SCR & PAC)

0.292 lb Hg
(or, 70.8% Removal)
Coal Basins Losing/Gaining Tonnage via Mercury Limits
Generic WV All Mines Cost Curve

Cash Cost ($/Ton)

Cumulative Capacity (MMTPY)
Simplified Generic Cost Curve

Cumulative Capacity (MMTPY)

Cash Cost ($/Ton)

0 5 10 15 20 25 30

0 10 20 30 40
Cost Curve Movement Over Time

Cumulative Capacity (MM TPD)

Cash Cost ($/Ton)

- Base Yr
- Base Yr+5
- Base Yr+10
- Base Yr+15
Illinois Basin Coal Production

Million Tons


NAQ  SKY  CAP
Colorado, Utah, New Mexico Coal Production

Million Tons


NAQ SKY CAP