Coal, Carbon, and the Future of the Global Energy Mix

By Richard Morse

Woods Institute Energy Seminar
March 4, 2009
Agenda

1. Background

2. Fundamentals of the Global Trade

3. Coal in the West: Impact of Carbon on Coal

4. China’s Coal Market

5. Coal and CO₂ Mitigation
Coal under siege?

“Coal-fired power stations are death factories. Close them. [...] coal is the single greatest threat to civilization and all life on our planet.” – Dr. James Hansen of NASA

“If somebody wants to build a coal fired power plant they can, its just that it will bankrupt them because they are going to be charged a huge sum for all that greenhouse gas that’s being emitted.” – Barack Obama to SF Chronicle

“Coal is my worst nightmare.” – Steve Chu (pre-DOE)
Or coal renaissance?

Coal is the world’s fastest growing fossil fuel

Increase in primary demand, 2000 – 2007 (IEA)

- Coal: 4.8% (1000 Mtoe)
- Oil: 1.6%
- Gas: 2.6%
- Renewables: 2.2%
- Nuclear: 0.8%

% = average annual rate of growth

Shares of incremental energy demand Reference Scenario, 2006 – 2030 (IEA)

- Non-OECD
  - Coal: 40%
  - All other fuels: 60%
- OECD
  - Coal: 40%
  - All other fuels: 60%

Source: IEA WEO 2008
Emissions from coal outpace all other energy sources

IEA Projection of Energy Related Emissions to 2030

Source: IEA WEO 2008
Asia’s massive growth of coal-fired generation capacity

Drivers

• Cheap cost of energy fuels development

• Energy security: wide distribution of reserves and suppliers

Planned additions to coal-fired capacity in Asia

<table>
<thead>
<tr>
<th>Country</th>
<th>MW</th>
<th>Implementation phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>77 770</td>
<td>2008 – 2017</td>
</tr>
<tr>
<td>Pakistan</td>
<td>19 710</td>
<td>2006 – 2030</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>4 100</td>
<td>2007 – 2016</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>2 400</td>
<td>2008 – 2016</td>
</tr>
<tr>
<td>Thailand</td>
<td>4 000</td>
<td>2008 – 2018</td>
</tr>
<tr>
<td>Laos</td>
<td>1 800</td>
<td>2008 – 2014</td>
</tr>
<tr>
<td>Cambodia</td>
<td>4 510</td>
<td>2008 – 2020</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>116 000</td>
<td>2007 – 2025</td>
</tr>
<tr>
<td>Malaysia</td>
<td>2 670</td>
<td>2007 – 2014</td>
</tr>
<tr>
<td>Indonesia</td>
<td>50 000</td>
<td>2007 – 2026</td>
</tr>
<tr>
<td>Philippines</td>
<td>4 360</td>
<td>2008 – 2016</td>
</tr>
<tr>
<td>China</td>
<td>280 500</td>
<td>2009 – 2020</td>
</tr>
<tr>
<td>Korea, Rep. of</td>
<td>8 450</td>
<td>2005 – 2020</td>
</tr>
<tr>
<td>Japan</td>
<td>2 940</td>
<td>2006 – 2016</td>
</tr>
</tbody>
</table>

Total: 579.21 GW
20% realization = ~400 million tons of coal new demand annually

Source: ABARE
PESD’s work on coal

**Goal:** How will country-level political economy factors affect global patterns of coal production, trade, and use under different scenarios?

**Two Part Study:**
1. Global Coal Trade Model (DIW Berlin)
2. Political Economy Case Studies
Agenda

1. Background

2. Fundamentals of the Global Trade

3. Coal in the West: Impact of Carbon on Coal

4. China’s Coal Market

5. Coal and CO₂ Mitigation
Distribution of global reserves

Worldwide distribution of hard coal reserves (Bt)

Ritschel, Schiffer 2007
Steam coal trade has increased dramatically
The global market: trade flows

Main trade flows in hard coal traffic by sea, 2006 [in Mt]

Global hard coal production: 5.4 Bt
Maritime trade: 782 Mt
Incl. 595 Mt steam coal
187 Mt coking coal

* from Vietnam to China
** Incl. 3 from Indonesia and 1 from South Africa

Source: VDKI, Hamburg 2007
Ritschel, Schiffer 2007
Price formation is increasingly linked in the international market

Source: Reuters
Domestic markets are increasingly linked to international markets

Spot price of Qinghuangdao (QHD) and Newcastle

USD/ton

Source: Newcastle data from Reuters; Qinhuangdao Data from CCTD converted with exchange rate data from NY Fed.
Newcastle coals are 6700 kc/kg, QHD coals are 5800 kc/kg
Agenda

1. Background

2. Fundamentals of the Global Trade

3. Coal in the West: Impact of Carbon on Coal
   a) Europe
   b) USA

4. China’s Coal Market

5. Coal and CO₂ Mitigation
Power generation economics favor coal
The German power market

Coal is More Profitable

Carbon Starts to Close the Gap

Source: Reuters
Carbon markets to 2012

Post 2012? NO REAL MARKET – Huge policy uncertainty creates big risks for coal investment

Source: Reuters, EEX
Agenda

1. Background

2. Fundamentals of the Global Trade

3. Coal in the West: Impact of Carbon on Coal
   a) Europe
   b) USA

4. China’s Coal Market

5. Coal and CO₂ Mitigation
Lurking cap and trade

The risk is real but not much else...

Obama’s budget assumes roughly $14 / ton in 2012 with full auctioning.

<table>
<thead>
<tr>
<th>Contract</th>
<th>Open</th>
<th>High</th>
<th>Low</th>
<th>Settle</th>
<th>Change in Price</th>
<th>Volume</th>
<th>Open Interest (2009-02-27)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar09</td>
<td>$2.34</td>
<td>$2.35</td>
<td>$2.15</td>
<td>$2.31</td>
<td>0.03</td>
<td>319</td>
<td>2,417</td>
</tr>
<tr>
<td>Apr09</td>
<td>$2.35</td>
<td>$2.35</td>
<td>$2.35</td>
<td>$2.32</td>
<td>0.03</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>May09</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$2.33</td>
<td>0.03</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Jun09</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$2.34</td>
<td>0.03</td>
<td>-</td>
<td>47</td>
</tr>
<tr>
<td>Jul09</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$2.35</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sep09</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$2.37</td>
<td>0.03</td>
<td>-</td>
<td>74</td>
</tr>
<tr>
<td>Dec09</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$2.40</td>
<td>0.03</td>
<td>-</td>
<td>614</td>
</tr>
<tr>
<td>Mar10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$2.43</td>
<td>0.03</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Jun10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$2.47</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dec10</td>
<td>$2.53</td>
<td>$2.63</td>
<td>$2.40</td>
<td>$2.55</td>
<td>0.02</td>
<td>103</td>
<td>2,210</td>
</tr>
<tr>
<td>Jan13</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$11.25</td>
<td>0.25</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dec13</td>
<td>$12.00</td>
<td>$12.00</td>
<td>$12.00</td>
<td>$12.00</td>
<td>-0.25</td>
<td>10</td>
<td>197</td>
</tr>
<tr>
<td>Dec14</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$12.75</td>
<td>-0.48</td>
<td>-</td>
<td>29</td>
</tr>
<tr>
<td>Dec15</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$13.50</td>
<td>-</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>442</td>
<td>5,611</td>
</tr>
</tbody>
</table>
Political tolerance for carbon prices are likely to constrain carbon’s impact on coal

<table>
<thead>
<tr>
<th>Re-dispatch from 10 mmBtu/MWh Coal to 7 mmBtu/MWh Gas Combined Cycle</th>
<th>Gas price ($/mmBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
<td></td>
</tr>
<tr>
<td>Coal Price ($/mmBtu)</td>
<td>$6.44</td>
</tr>
<tr>
<td>Mid-Atlantic</td>
<td></td>
</tr>
<tr>
<td>$55/ton</td>
<td>$2.30</td>
</tr>
<tr>
<td>$35.80</td>
<td>$76.21</td>
</tr>
<tr>
<td>ComEd</td>
<td></td>
</tr>
<tr>
<td>$1.54</td>
<td>$48.13</td>
</tr>
<tr>
<td>West</td>
<td></td>
</tr>
<tr>
<td>$1.97</td>
<td>$41.15</td>
</tr>
<tr>
<td>South</td>
<td></td>
</tr>
<tr>
<td>$2.43</td>
<td>$33.69</td>
</tr>
<tr>
<td>$74.10</td>
<td></td>
</tr>
</tbody>
</table>

Regional politics are likely to dictate the amount of carbon permits that are initially sold vs. given away for free (allocations vs. auctions)

Source: PJM
Mass vs. EPA signals looming CO$_2$ regulation

- Regulation is being used to stop coal plant permitting and is likely to have a greater impact than carbon price signals for the foreseeable future.
The environmental movement poses a serious challenge to coal

Source: Sierra Club Coal Campaign
Agenda

1. Background

2. Fundamentals of the Global Trade

3. Coal in the West: Impact of Carbon on Coal
   a) Europe
   b) USA

4. China’s Coal Market

5. Coal and CO₂ Mitigation
Coal is Dominant Energy for China

70% of China Primary Energy from Coal

81% Electricity Generated by Coal
Source: 2008 data from China Electricity Council
Uneven reform of the Chinese energy sector creates erratic market behavior

Sources: McCloskey's, China NRDC
Agenda

1. Background

2. Fundamentals of the Global Trade

3. Coal in the West: Impact of Carbon on Coal

4. China’s Coal Market

5. Coal and CO$_2$ Mitigation
The state of clean coal for power generation

Vattenfall’s 30 MW demo plant at Schwarze Pumpe, Germany
Efficiency gains represent huge mitigation potential in the near term

CCS: Green Gen 400 MW demo plant to be fully operational by 2020...

Efficiency investment may represent the greatest CO₂ mitigation potential in the near term

Source: IEA Clean Coal Center
Agenda

1. Background
2. Fundamentals of the Global Trade
3. Coal in the West: Impact of Carbon on Coal
4. China’s Coal Market
5. Coal and CO₂ Mitigation

Conclusions:

1. Large growth in coal demand ahead
2. Cap and trade has some impact in the West when carbon prices are strong, but regulation and policy risk could play a larger role in the near term
3. Asian development currently depends on coal
4. Need to understand China (and Asia’s) coal markets and evaluate all possible mitigation options

Contact: rkmorse@stanford.edu
US coal pricing

Source: Reuters
Long term generation outlook: capacity shortage will need to be filled

Development of the European Power Plant Portfolio from 2005 to 2030

* EU.
Source: RWE
Coal’s carbon exposure is complex

Key Cap and Trade Issues from Coal’s Perspective

• Political tolerance for strong carbon prices?
• Will we reach a meaningful switching point?
  – Customer First proposal
    • AEP, Duke, Progress Energy, Southern Company back 100% free permits
Policy uncertainty is the biggest threat to investment in new coal capacity

Carbon Post 2012:

• Indecision on Kyoto offset provisions, CER quantity and quality, EC favors tightening

• Long term prices could reach meaningful switching points

• Possible increase to from 20% to 30% Kyoto reduction target

• Coal Emissions Performance Standard?

Renewables Threaten Coal Utilization Rates and Favor Gas:

• Renewables target 20% by 2020, could be exceeded (IEA 27%)
  
  • Decreases coal utilization rates, creates uncertain economics

  • Increasingly favors gas for balancing power
What we know about EU ETS beyond 2012: auctions vs. allocations

**EU ETS Phase III:**

1. Regional discrepancies in the cost of emissions permits split coal economics
   - Full auctioning in the West
   - The East ramps up auctioning slowly, reaching full auctioning in 2020

2. Impacts:
   - RWE cancels all coal plants in western Europe
   - Are we seeing an East / West split for coal economics?

Implications for US cap and trade?