Coal’s Assault on Human Health

Coal: The Economy, Electricity, Political Power, and Health

- In 2007, the U.S. consumed 4,159,514 gigawatt-hours (GWh) of electricity, a 2.3-percent increase from 2006.
- 48.6% of U.S. electricity is produced by burning coal.
- Pollution from coal-fired power plants may cause as many as 49,000 deaths and 450,000 serious illnesses each year.
- “External Costs” of burning coal are about $62 billion per year
- The US has about 500 billion tons of proven coal reserves, a 250 year supply.
- Coal companies and electrical utilities are politically powerful with well funded lobbies.

Sources: Edison Electrical Institute, Markandaya & Wilkinson, Lancet, 2007 National Research Council, 2009

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Power Plant Energy Sources, 2006
4,064,702,000 Megawatt Hours

Source: US Energy Information Agency

Life Cycle of Coal

Mining: a dangerous profession, leaching of elements, e.g. arsenic, affects water supply
Transportation: substantial emissions by locomotives and watercraft
Washing: slurry contains elements that affect health
Combustion: the major problem
Fly Ash: storage, escape of toxins into water supply, transportation

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RESPIRATORY EFFECTS

Pollutants Released by Burning Coal

Over 60 pollutants have been identified in coal plant emissions

SOx - Oxides of Sulfur: Affects children and adults with respiratory disease including asthma, contributes to PM formation

NOx – Oxides of Nitrogen: Patients with respiratory diseases, contributes to secondary PM formation

PM – Particulate Matter: classified by size and method of formation, contributes to respiratory, cardiovascular, and nervous system diseases (e.g., stroke, MI)

Hg – Mercury: A naturally occurring element found in coal, bioaccumulates in food chain, especially fish, affects brain function

CO₂ – Carbon Dioxide: a major greenhouse gas and contributor to global warming
Coal Pollutants: Irritants

Healthy Airway  Inflamed Airway

Size of Typical Particles

PM$_{2.5}$ particles < 2.5 μm each

PM$_{10}$ particles < 10 μm each

Human Hair 50 μm

Finest Beach Sand 90 μm

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Pollutants from Coal Combustion Linked to

Asthma: especially acute exacerbations, may be triggered by inhalation of pulmonary irritants, including SOx and Ozone, children vulnerable

Chronic Obstructive Pulmonary Disease: COPD, chronic bronchitis and emphysema

Lung Cancer: linked to increases in PM concentration in ambient air

Effects on Respiratory System: Asthma Prevalence by State

Source: Centers
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CARDIOVASCULAR EFFECTS

PM and Cardiovascular Disease

Source: Brook et al, Air Pollution and Cardiovascular Disease
Circulation 2004;109:2655-2671
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Cardiovascular Disease

Percent Change in Hospitalization Rate
Per 10 μgram/m³ PM$_{2.5}$

<table>
<thead>
<tr>
<th>Disease</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischemic heart disease</td>
<td>0.44</td>
</tr>
<tr>
<td>Heart rhythm disturbance</td>
<td>0.57</td>
</tr>
<tr>
<td>Congestive Heart Failure</td>
<td>1.28</td>
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</tbody>
</table>

Source: Domenici et al JAMA 2006

Air Pollution and Stroke

- **Korean Study**: increased ischemic stroke risk with daily increases in suspended particulates and sulfur dioxide, one day lag nitrogen dioxide, and carbon monoxide, and 3 day lag for ozone
- **Taiwan study**: on warm days (> 20 C) positive association between PM$_{10}$, NO$_2$, SO$_2$, CO, and O$_3$ for cerebral hemorrhage and ischemic stroke admissions
- **Women’s Health Initiative**: an increase of 10 μg/m³ in the PM$_{2.5}$ concentration was associated with a 24% increase in the risk for a cardiovascular event and an increased risk for a cerebrovascular event
- **Medicare study**: 2.33 % increase in ischemic stroke in comparing quartiles of PM$_{10}$

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NEUROLOGIC EFFECTS

The Mercury Cycle

- Mercury emitted into atmosphere
- Mercury collects in water/steam
- Coal-burning converts to methylmercury (MeHg)
- MeHg bio accumulates in large predatory fish
- Humans eat fish, accumulate MeHg in brain

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Anthropogenic Mercury Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Tons/year</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustion</td>
<td>137.9</td>
<td>86.9</td>
</tr>
<tr>
<td>Utilities</td>
<td>52.0</td>
<td>32.8</td>
</tr>
<tr>
<td>Muni Incinerator</td>
<td>29.6</td>
<td>18.7</td>
</tr>
<tr>
<td>Industrial Boilers</td>
<td>28.4</td>
<td>17.9</td>
</tr>
<tr>
<td>Medwaste Incinerator</td>
<td>16.0</td>
<td>10.1</td>
</tr>
<tr>
<td>Other Manufacturing</td>
<td>15.8</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Source: Mercury Study Report to Congress, EPA, 1997

Mercury Health Effects

Predominantly nervous system, may also affect kidneys
- brain development *in utero* and after birth.
- paresthesias (peripheral neuropathy)
- incoordination (writing, speech, gait)
- impaired hearing
- mental disturbances

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Impact of Hg on Child Development

• Cord blood Hg levels 70% higher than maternal level

• 1999 – 2000 NHANES data indicate that 15.7% of women of childbearing age have Hg levels ≥ 3.5 μg/L.

• 630,000 children born annually in USA with cord blood Hg levels ≥ 5.8 μg/L

Sources: National Research Council, 2000; Stern & Smith EHP 2003, Mahaffey et al, EHP 2004

Figure 5.1: IQ Distribution

Figure 5.2: Change in IQ Distribution with 3 Point Decrease
Coal: Global Warming Culprit

Global Warming and Health

- Flooding due to rising sea level
- Alterations in ability to grow food at different latitudes
- Increases in heat-related illness
- Increases in vector-borne illnesses (malaria, dengue, etc.)
- Increases in extreme weather events
- Reduced water quality and increased water-borne illnesses
- Reduced air quality and increased in pollution-related morbidity and mortality
- Ecosystem destruction and reduced biodiversity

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