CLEAN AIR AND COAL

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- Board of Directors
Clean Air and Coal: Goals

- Define Health
- Health and Coal’s Life Cycle
  - Mining
  - Transport
  - Combustion
  - Ash
- Air Pollution
  - SOx, NOx, Mercury, Particulates
  - Health effects
- Global Warming
- Clean Air Act and Economics

Disclosure: Nothing to Declare
What is Health?

Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

World Health Organization
1948
Sources of Energy for Generating Electricity

- Coal, 43%
- Natural Gas, 23%
- Nuclear, 20%
- Hydroelectric, 6%
- Petroleum, 1%
- Other Gas, 0.3%
- Other, 0.3%

Source: US Energy Information Administration
## Health Effects of Electricity Generation, Various Fuels

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Deaths</th>
<th>Serious Illnesses</th>
<th>Minor Illnesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lignite</td>
<td>32.6 (8.2-130)</td>
<td>298 (74.6-1193)</td>
<td>17,676 (4,419-70,704)</td>
</tr>
<tr>
<td>Other Coals</td>
<td>24.5 (6.1-98)</td>
<td>225 (56.2-899)</td>
<td>13,288 (3,322-53,150)</td>
</tr>
<tr>
<td>Oil</td>
<td>18.4 (4.6-73.6)</td>
<td>161 (40.4-645.6)</td>
<td>9,551 (2,388-38,204)</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>2.8 (0.70-11.2)</td>
<td>30 (7.48-120)</td>
<td>703 (176-2,813)</td>
</tr>
<tr>
<td>Biomass</td>
<td>4.6 (1.16-18.5)</td>
<td>43 (10.8-172.6)</td>
<td>2,276 (569-9,104)</td>
</tr>
<tr>
<td>Nuclear</td>
<td>0.052</td>
<td>0.22</td>
<td>...</td>
</tr>
</tbody>
</table>

Based on: Deaths/cases per TerraWh generated electrical power in Europe, 95% confidence intervals. U.S. generates about 4,000 TWh per year

Coalworkers Pneumoconiosis Fell for years after 1969 law

Source: AS Laney & MD Attfield, Occup Environ Med, 2010
As coal production increased, health status worsened and rates of cardiopulmonary disease, lung disease, cardiovascular disease, diabetes and kidney disease worsened.

Example result for COPD: odds ratio and 95% confidence interval

- Less than 4 million tons: 0.969 (0.596 – 1.577)
- More than 4 million tons: 1.559 (1.069 – 2.272)

Coal Transport

- About 70% of all rail traffic is related to coal transport
- Rail accidents are much more common per ton-mile than road traffic
- Diesel locomotives emit particulates that are harmful to health
- Trucks produce particulates from diesel engines and wear and tear of roads

Two Killed in Coal Train Derailment, August 12, 2012
Hazardous Air Pollutants (HAPS) Released by Coal Combustion (from over 60)

- Oxides of sulfur
- Oxides of nitrogen
- Arsenic
- Beryllium
- Cadmium
- Chromium
- Mercury
- Nickel
- HCl
- HF
- Acreolin
- Dioxins
- Formaldehyde
- Uranium and Thorium

Source: EPA Report to Congress, publication 453/R-98-004a
Air Pollutants

- Criteria Air Pollutants: harmful to health and environment, have National Ambient Air Quality Standards (NAAQS)
  - Carbon Monoxide
  - Lead
  - Nitrogen Dioxide
  - Particulates (10 and 2.4 micron aerodynamic diameter)
  - Ozone
  - Sulfur Dioxide
- Mercury
Coal Ash

- We burn about 1 billion tons of coal each year
- This produces about 100 million tons of coal combustion waste
- As pollution control devices become more efficient as mandated by the Clean Air Act, the ash becomes more toxic
- Ash is largely unregulated and often stored under substandard conditions

Kingston spill, December 22, 2008

- Dam failed holding back a 84 acre area
- 1.1 billion gallons released
- At dozens of other sites, arsenic and other toxicants have leached into ground water
Air Pollution and Leading Causes of Death in Americans

- Heart Disease – leading cause in US - 617,527 in 2008
  - Myocardial Infarct
  - Congestive Heart Failure
  - Fatal Arrhythmia
- Malignant neoplasms – Second leading cause in US, 566,137 deaths in 2008

  - Asthma (esp. kids)
  - Emphysema
  - Bronchitis
  - Cancer

- Stroke – Fourth leading cause in US, 133,750 deaths in 2008

Source: CDC, 2011
People Living In Counties Where NAAQS Not Met, 2007

- Ozone (8-hour): 119.5
- PM$_{2.5}$ (annual and 24-hour): 36.9
- PM$_{10}$: 14.9
- Lead: 4.8
- NO$_2$: 0.0
- CO: 0.0
- SO$_2$ (annual and 24-hour): 0.0
- Any NAAQS: 126.8

Source: EPA
Air Pollution Damages in 2005

406 Coal Plants: $62 billion

Source: NAS Hidden Costs of Energy, 2009

FIGURE 2-6  Air pollution damages from coal generation for 406 plants, 2005 (2007 USD). Damages related to climate changes effects are not included.
Oxides of Nitrogen
$\text{NO}_x + \text{Organics} + \text{sun} = \text{Ozone}$

Source: EPA
Sulfur Dioxide Sources

Source: EPA
Small Particles - PM$_{2.5}$

Source: EPA
PM$_{2.5}$ 1999-2000 and Life Expectancy

Source: Pope, CA, NEJM 2009;360:376-386
Satellite Derived PM$_{2.5}$ Concentration 2001 - 2006

Source: van Donkellar et al., EHP 2010;118:847
PM and Cardiovascular Disease

- Harvard 6 Cities Study: 26% increase mortality in most versus least polluted cities
- ACS Cancer Prevention Study: each 10 $\mu$g/m$^3$ increase in PM$_{2.5}$ associated with increases of 4% in all cause and 5% cardiopulmonary mortality
- Other studies: show increases in acute myocardial infarct, defibrillator discharges, myocardial ischemia during stress test

Source: Cited by Brook et al Circulation 2004
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/m$^3$ 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.

Stroke and PM$_{2.5}$

Increase in odds ratio for stroke comparing 25$^{th}$ with 75$^{th}$ percentile increase (6.4 $\mu$g/m$^3$)

$P = 0.001$

Source: Wellenius Arch Int Med 2012;172(3):229
PM$_{2.5}$ Pollution and Hospital Admissions, 60 Northeast Counties Medicare Data

% change in hospital admissions per 10 μg/m$^3$

Injury
Cardiovascular Outcomes
Cerebrovascular Disease
Peripheral Vascular Disease
Ischemic Heart Disease
Heart Rhythm
Heart Failure
Respiratory Outcomes
COPD
Respiratory Tract Infection

ANOVA shows East significantly higher than West for all outcomes except heart failure and COPD

Source: F Dominici et al, JAMA 2006;295:1127-1134
Anthropogenic Mercury Sources (tonnes), 2005

- Cremation, 26
- Incineration, 125
- Chlor-alkalai, 47
- Cement kilns, 189
- Other gold production, 350
- Large scale gold production, 111
- Metal production, 200
- Fossil fuel combustion, 878

Source: UNEP Global Mercury Assessment, 2008
Worldwide Mercury Deposition

Source: UNEP Global Atmospheric Mercury Assessment, 2008
Figure 5.4: The mercury cycle

Mercury emitted into atmosphere

Mercury collects in waterways

Conversion to methylmercury (MeHg) by bacteria

MeHg enters food chain

MeHg bioaccumulates in large predatory fish

Fish containing MeHg ingested, MeHg absorbed from G.I. tract, enters all organs, concentrated by fetus

Adverse effect on brain function
Bioaccumulation of Mercury

Source: Driscoll et al, Bioscience, 2007;57:17-28
Impact of Hg on Child Development

- Doubling of Hg concentration reduces neuro-developmental test scores by 5.7 – 15.9% of a standard deviation.
- Using conservative measures, the annual lost productivity cost due to Hg is $8.7 billion (range $2.2 – 43.8 billion)
- Of this total, $1.3 billion (range $0.1 – 6.5 billion) is attributable to coal-fired power plants
- EPA indicates that among the most highly exposed individuals in US, Hg may reduce IQ by about 7 points.

US Solar Energy Flux
11,000 times consumption
Wind Energy 78 times annual usage

Global Warming

- Is it real?
  - Four studies say YES

- Is it caused by humans? YES
  - Correlated with fossil fuel use, greenhouse gas concentration
  - Keeling curve and correlation with $O_2$
  - Isotope data - $C^{12}:C^{13}$ ratio

- Health effects
  - Drought and starvation
  - Heat-related illness
  - Rise in sea level
  - Disease: malaria, dengue, cholera, Hanta virus, others
  - Severe weather events
Global Land Temperature estimates, smoothed by 12 month moving average

Source: Muller et al, Berkeley Earth
Mean Temperature Change:

Source: Rohde, et al, Berkeley Earth
The Earth’s Annual Global Energy Balance

Greenhouse Gases, 0 - 2005

Source: IPCC Fourth Assessment Rpt, Chap 2

Global Warming Potential

$\text{CO}_2 = 1$

Methane = 21

$\text{N}_2\text{O} = 310$
Global Carbon Dioxide Emissions, 2008 (thousands metric tons)

Source: USDOE CO₂ Information Analysis Ctr, on Wikipedia
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/
World food prices rose 10% in July, pushed by Midwest drought

Source: World Bank, August 30, 2012
Childhood Malnutrition, 2007-2011


Malnutrition prevalence, weight for age (% of children under 5)
3.7%    44.9%
2003 European Heat Wave
June - August

Image created from Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA’s Terra satellite

About 52,000 deaths Associated with the Heat wave
Hanta Virus, Yosemite

- 10,000 who camped in Curry Village warned about Hanta virus
- 6 known cases
- 2 known deaths

Source: Daily Beast, Sept 3, 2012, National Park Service
Vulnerability to Delta Flooding
8.7 Million Displaced by 2050

Source: IPCC, Working Group II, 2007
Clean Air Act

Signed in 1970
- Established EPA
- EPA mission: to protect human health and the environment
- Established NAAQS

Amended in 1990
- Established Acid Rain Program
- Gave EPA authority to regulate sources
  - Point sources
  - Mobile sources
Sulfur Dioxide and Nitrogen Oxides Emissions Under Clean Air Act, Acid Rain Program

Source: EPA
Annual Cost vs. Benefits, Clean Air Act

Source: EPA
### Annual Health Effects Avoided: Clean Air Act as Amended

<table>
<thead>
<tr>
<th>Health Effect</th>
<th>Pollutant(s)</th>
<th>Year 2010</th>
<th>Year 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult mortality</td>
<td>PM</td>
<td>160,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Ozone mortality</td>
<td>Ozone</td>
<td>4,300</td>
<td>7,100</td>
</tr>
<tr>
<td>Chronic bronchitis</td>
<td>PM</td>
<td>54,000</td>
<td>75,000</td>
</tr>
<tr>
<td>Acute bronchitis</td>
<td>PM</td>
<td>130,000</td>
<td>180,000</td>
</tr>
<tr>
<td>Acute myocardial infarction</td>
<td>PM</td>
<td>130,000</td>
<td>200,000</td>
</tr>
<tr>
<td>Asthma exacerbation</td>
<td>PM</td>
<td>1,700,000</td>
<td>2,400,000</td>
</tr>
<tr>
<td>Hospital admission</td>
<td>PM, Ozone</td>
<td>86,000</td>
<td>135,000</td>
</tr>
<tr>
<td>Lost days at work</td>
<td>PM</td>
<td>13,000,000</td>
<td>17,000,000</td>
</tr>
</tbody>
</table>
What You Do Matters
Take Action

- Ask your candidates if they support EPA’s current clean air and carbon dioxide emission standards.
- Speak to your friends, family, and colleagues about the importance of clean air and protecting our health.
- Join Physicians for Social Responsibility
go to: www.psr.org
The Silent Epidemic
Coal and the Hidden Threat to Health

Alan H. Lockwood, MD

Thanks to:
- Physicians for Social Responsibility
  psr.org
- Earth Justice
- University at Buffalo
- Energy Foundation
Thanks !!

4400 Watt photovoltaic array, Lockwood home, Buffalo, NY

Now we have 2 of them

We are replacing these with LEDs