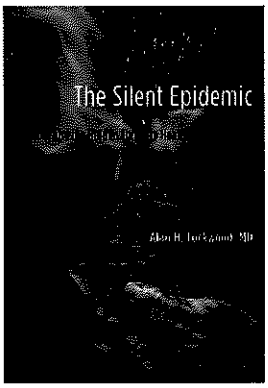
CLEAN AIR AND COAL

Alan H Lockwood MD

Emeritus Professor of Neurology
University at Buffalo

Physicians for Social Responsibility
- Past President
- Co-Chair, Environment and Health Committee
- 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

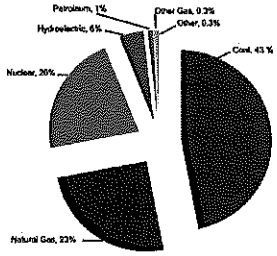
Disclosure: Book Royalties go to PSR, Order via Amazon link on PSR Web Site

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



Source: US Energy Information Administration

Health Effects of Electricity Generation, Various Fuels

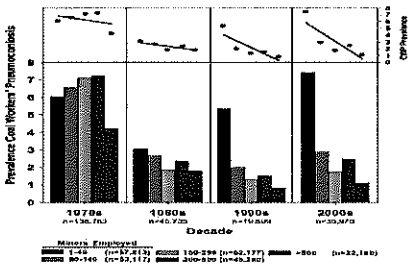
Fuel	Deaths	Serious Illnesses	Minor Illnesses
Lignite	32.6 (8.2-130)	298 (74.6-1193)	17,676 (4,419-70,704)
Other Coals	24.5 (6.1-98)	225 (56.2-899)	13,288 (3,322-53,150)
Oil	18.4 (4.6-73.6)	161 (40.4-645.6)	9,551 (2,388-38,204)
Natural Gas	2.8 (0.70-11.2)	30 (7.48-120)	703 (176-2,813)
Biomass	4.6 (1.16-18.5)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

Based on: Deaths/cases per TerraWh generated electrical power in Europe, 95% confidence intervals.

U.S. generates about 4,000 TWh per year

Source: Markandaya & Wilkinson, Lancet, 2007

Coalworkers Pneumoconiosis Fell for years after 1969 law



Source: AS Laney & MD Attfield, Occup Enviorn Med, 2010

Mine Proximity, West Virginia

- 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)

Source: Hendryx & Ahern, Am J Public Health, 2008

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

Source: Lockwood, AH, The Silent Epidemic, MIT Press, 2012

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 2.5 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

Source: Lockwood AH, The Silent Epidemic, MIT Press, 2012

Kingston spill, December 22, 2008

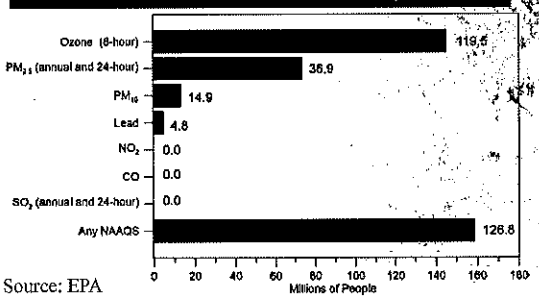
- Dam failed holding back a 84 acre area
- 1.1 billion gallons released
- At dozens of other sites, arsenic and other toxicants have leached into ground water

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
- Respiratory disease – third leading cause in US – 141,075 in 2008
  - Asthma (esp. kids)
  - Emphysema
  - Bronchitis
  - Cancer
- Stroke – Fourth leading cause in US, 133,750 deaths in 2008

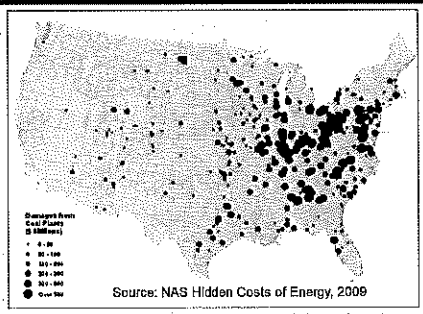
Source: CDC, 2011

People Living In Counties Where NAAQS Not Met, 2007



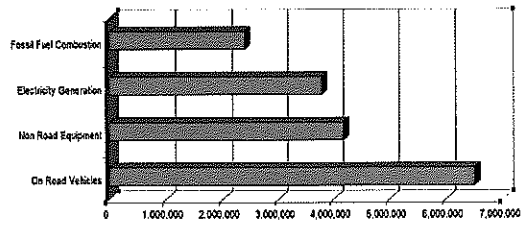
Source: EPA

Air Pollution Damages in 2005 406 Coal Plants: $62 billion



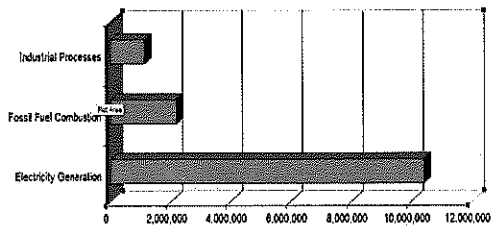
Source: NAS Hidden Costs of Energy, 2009

Oxides of Nitrogen NO_x + Organics + sun = Ozone



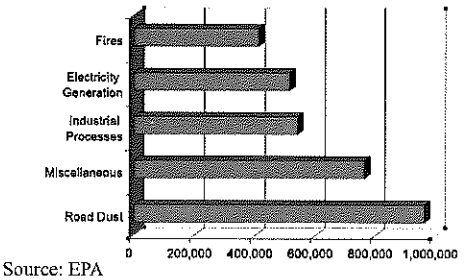
Source: EPA

Sulfur Dioxide Sources



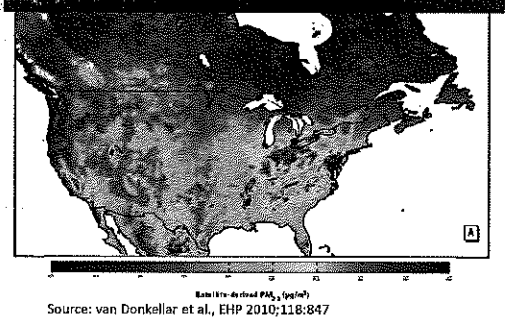
Source: EPA

Small Particles - $PM_{2.5}$



Source: EPA

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

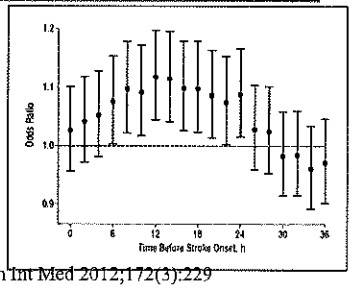
- Korean Study: increased ischemic stroke risk with daily increases in suspended particulates and sulfur dioxide, one day lag nitrogen dioxide, and carbon monoxide, and 3 day lag for ozone
- Taiwan study: on warm days (≥ 20 C) positive association between PM_{10}, NO_2, SO_2, CO, and O_3 for cerebral hemorrhage and ischemic stroke admissions
- Women's Health Initiative: an increase of 10 $\mu g/m^3$ 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

Sources: Hong et al Stroke 2002, Tsai et al Stroke 2003, Miller, et al, NEJM, 2007

Stroke and $PM_{2.5}$

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

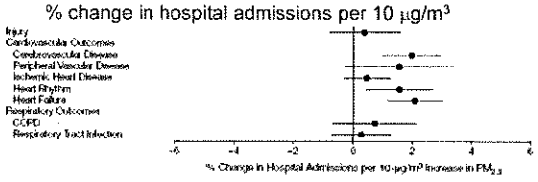
$P = 0.001$



Source: Wellenius Arch Int Med 2012;172(3):229

$PM_{2.5}$ Pollution and Hospital Admissions, 60 Northeast Counties Medicare Data

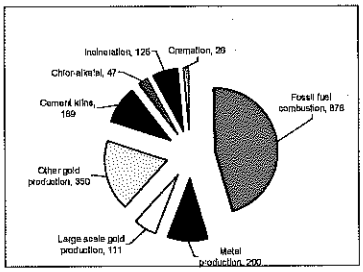
% change in hospital admissions per 10 $\mu g/m^3$



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

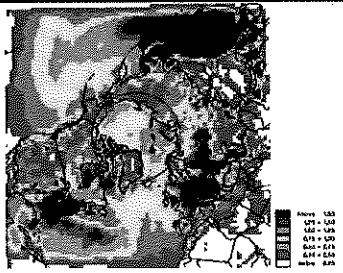
Source: F Dominici et al, JAMA 2006;295:1127-1134

Anthropogenic Mercury Sources (tonnes), 2005



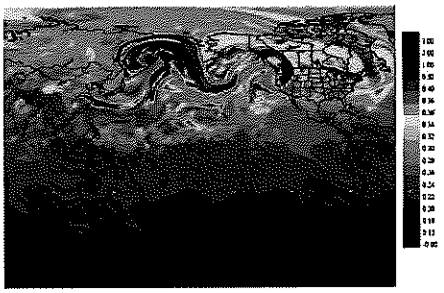
Source: UNEP Global Mercury Assessment, 2008

Worldwide Mercury Deposition

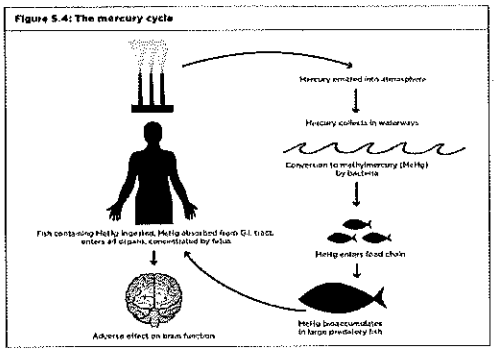


Source: UNEP Global Atmospheric Mercury Assessment, 2008

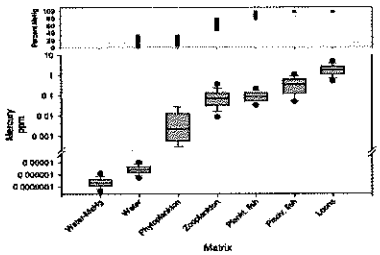
Simulated Mercury Emission From East Asia



Source: UNEP Global Atmospheric Mercury Assessment, 2008



Bioaccumulation of Mercury



Source: Driscoll et al, Bioscience, 2007;57:17-28

Impact of Hg on Child Development

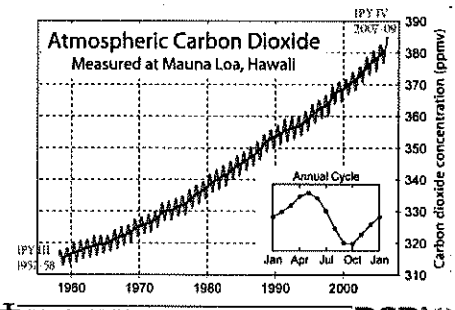
- Doubling of Hg concentration reduces neuro-developmental test scores by 5.7 – 15.9% of a standard deviation.
- Using conservative measures, the annual lost productivity cost due to Hg is $8.7 billion (range $2.2 – 43.8 billion)
- Of this total, $1.3 billion (range $0.1 – 6.5 billion) is attributable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

Sources: Grandjean et al Am J Epidemiol 1999, Trasande et al EHP 2005, EPA

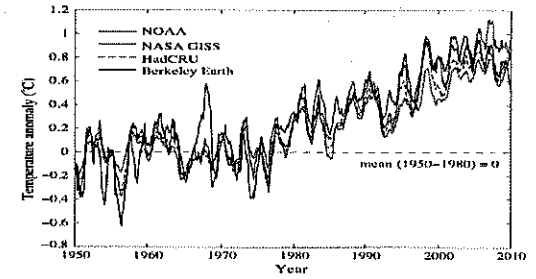
Global Warming

- 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, West Nile, others
  - Pollen, asthma
  - Severe weather events

The Keeling Curve

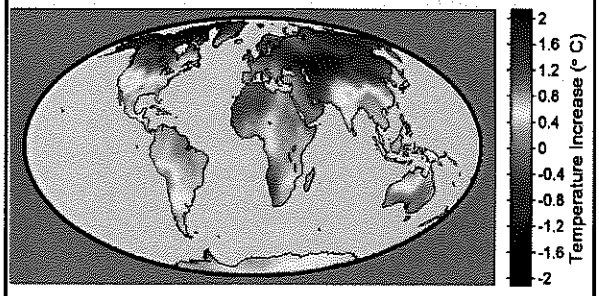


Global Land Temperature estimates, smoothed by 12 month moving average



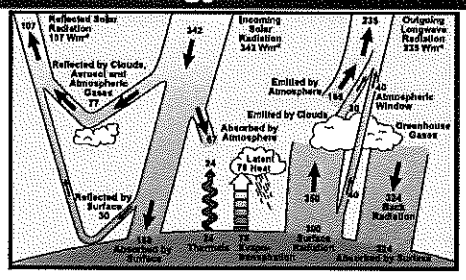
Source: Muller et al, Berkeley Earth

Mean Temperature Change:
Jan 2000-Dec 2010 vs. Jan 1950-Dec 1960



Source: Rohde, et al, Berkeley Earth

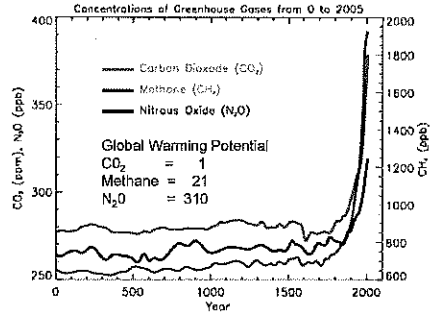
The Earth's Annual Global Energy Balance



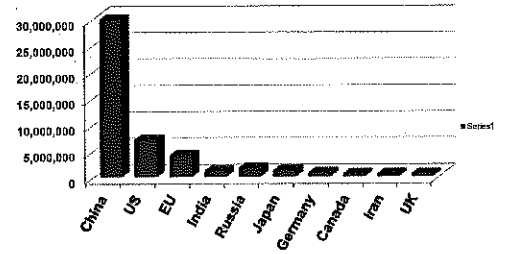
Source: IPCC, Working Group I, 2007

Greenhouse Gases, 0 - 2005

Source: IPCC Fourth Assessment Rpt, Chap 2



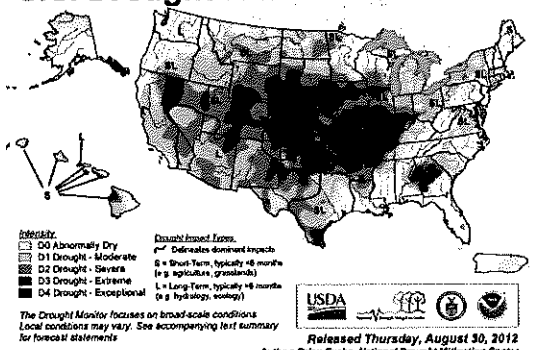
Global Carbon Dioxide Emissions, 2008 (thousands metric tons)



Source: USDOE CO_2 Information Analysis Ctr, on Wikipedia

U.S. Drought Monitor

August 28, 2012
Valid 7 a.m. EDT



Intensity
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional

Drought Impact Types
Delineates dominant impacts
S = Short-Term, typically <6 months (e.g. agriculture, grasslands)
L = Long-Term, typically >6 months (e.g. hydrology, ecology)

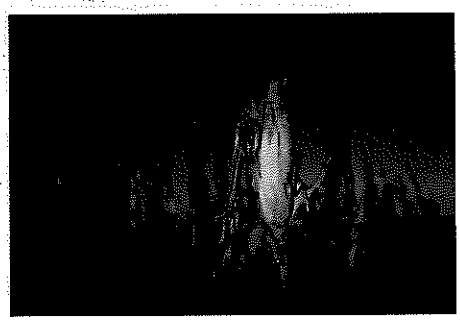
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/

USDA

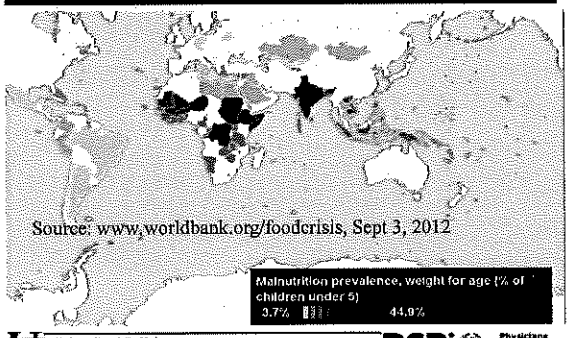
Released Thursday, August 30, 2012
Author: Brian Fuchs, National Drought Mitigation Center

World food prices rose 10% in July, pushed by Midwest drought



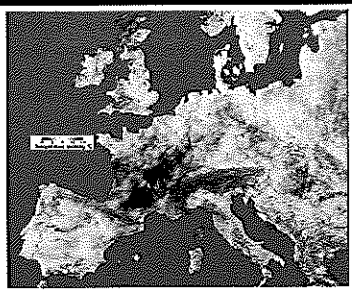
Source: World Bank, August 30, 2012

Childhood Malnutrition, 2007-2011



2003 European Heat Wave June - August

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



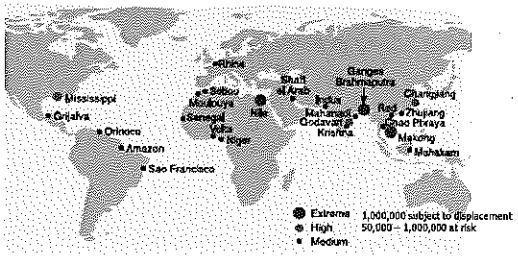
About 52,000 deaths Associated with the Heat wave

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

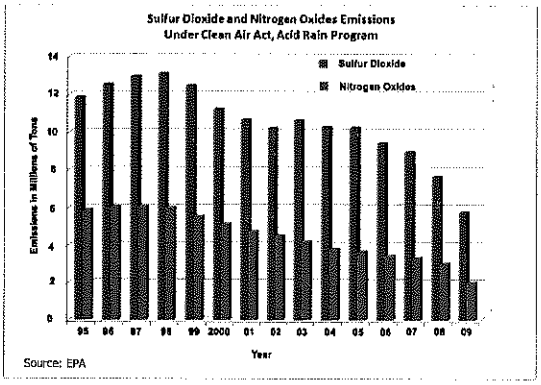
Vulnerability to Delta Flooding 8.7 Million Displaced by 2050



Source: IPCC, Working Group II, 2007

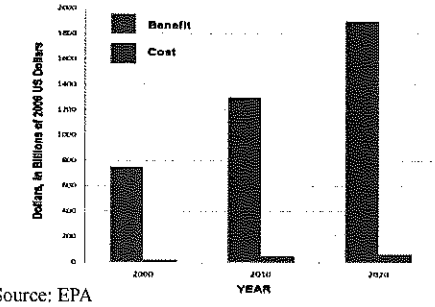
Clean Air Act

- 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



Source: EPA

Annual Cost *vs.* Benefits, Clean Air Act



Source: EPA

Annual Health Effects Avoided: Clean Air Act as Amended

Health Effect	Pollutant(s)	Year 2010	Year 2020
Adult mortality	PM	160,000	230,000
Ozone mortality	Ozone	4,300	7,100
Chronic bronchitis	PM	54,000	75,000
Acute bronchitis	PM	130,000	180,000
Acute myocardial infarction	PM	130,000	200,000
Asthma exacerbation	PM	1,700,000	2,400,000
Hospital admission	PM, Ozone	86,000	135,000
Lost days at work	PM	13,000,000	17,000,000

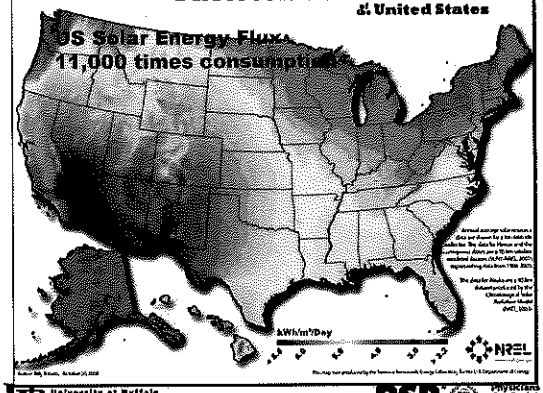
Source: EPA, Second Prospective Report

Sustainable Energy Future

- Improve efficiency
- Use more renewables
- More Wind Energy
- More solar
  - Photovoltaic
  - Sun-powered boilers
  - Now-experimental
    - Artificial photosynthesis
    - Hydrolysis to generate hydrogen

Photovoltaic Solar Resource of United States

US Solar Energy Flux:
11,000 times consumption



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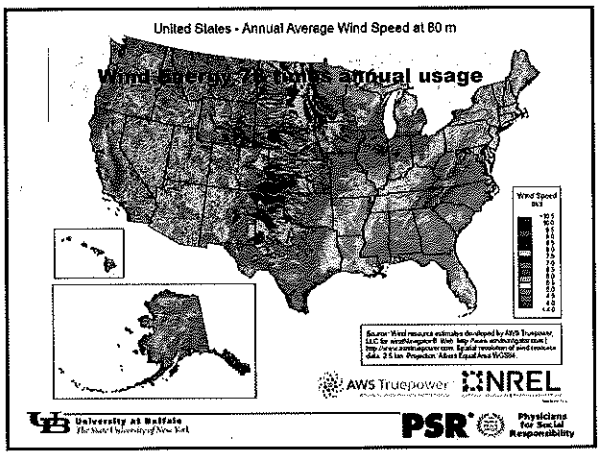

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PSR Physicians for Social Responsibility

What You Do Matters
Take Action

- Ask your legislators 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

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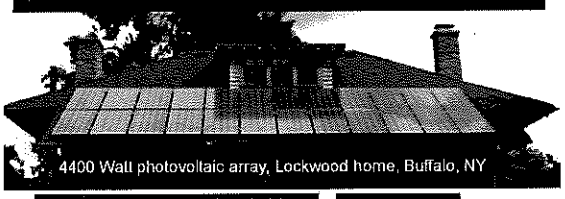
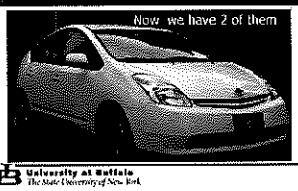
PSR Physicians for Social Responsibility

Thanks !!



4400 Watt photovoltaic array, Lockwood home, Buffalo, NY



We are replacing these with LEDs

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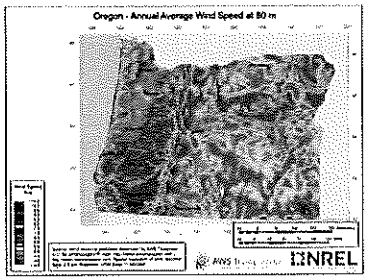
Wind Map Oregon



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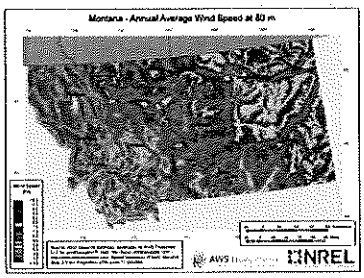
Montana Wind Map



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Pennsylvania, we need your voice!

Please join us in writing a letter to the editor.
For instructions and talking points:

http://action.psr.org/site/LteUser?lte_id=24001

> "Living in a city with two coal plants in the vicinity and 78 in the state, it hit home.... I realize I'm exposed daily to harmful air pollutants as I run along the Schuylkill."
> *- LTE content from Sarab Sodhi, a second-year medical student at Temple University*

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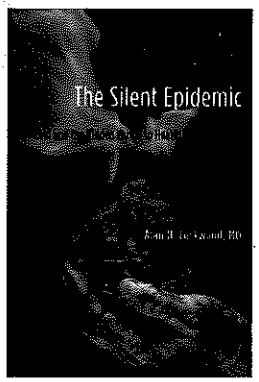

Thanks to:

- Physicians for Social Responsibility
  psr.org
- Earth Justice
- University at Buffalo
- Energy Foundation

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