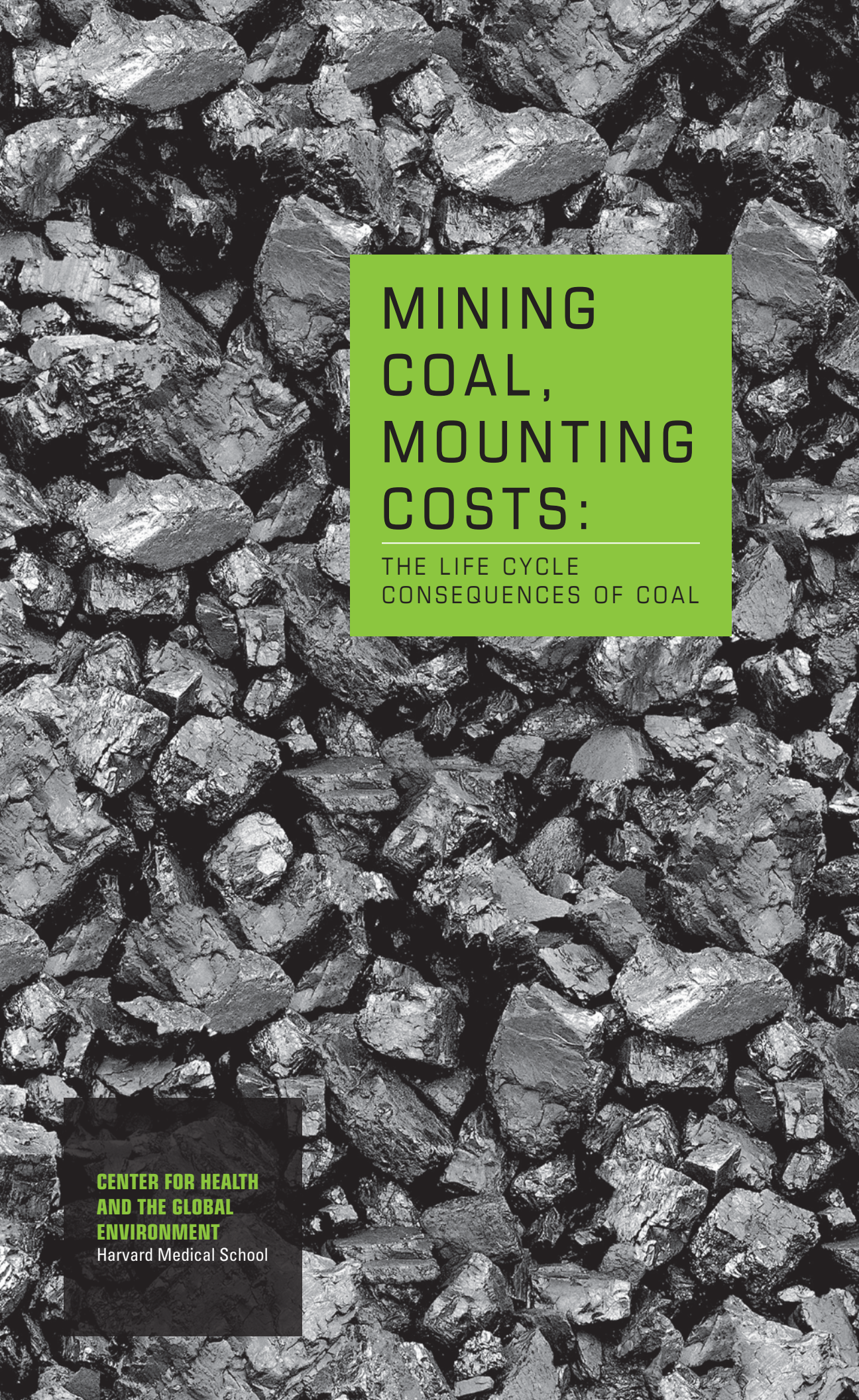


MINING COAL, MOUNTING COSTS:

THE LIFE CYCLE CONSEQUENCES OF COAL

CENTER FOR HEALTH AND THE GLOBAL ENVIRONMENT
Harvard Medical School

Energy is essential to our daily lives, and for the past century and a half we have depended on fossil fuels to produce it. But, from extraction to combustion, coal, oil and natural gas have multiple health, environmental and economic impacts that are proving costly for society.

Coal carries a heavy burden. The health and environmental hazards stem from exploration, extraction, processing, transport and combustion, and the large waste stream of air and water pollutants generated. Coal combustion, in over 600 U.S. power plants, also contributes to global warming. The proposed technology of carbon capture and storage (CCS) addresses climate-altering carbon dioxide (CO_2) emissions – one of coal's by-products – but comes with its own set of costs and risks.

This pamphlet is an executive summary of an extensive publication on the true costs of coal. The images are intended to convey the full scope of the impacts. There are: a) measurable effects, b) economically-evaluated impacts,[1] and c) qualitative consequences from each life cycle stage of coal. We focus on Appalachia, though coal is mined in other regions of the U.S. and is burned throughout the world.

[1]The calculations make use of the Value of Statistical Life (VSL), an estimate expressing the benefits of reducing mortality risk in monetary terms. VSL = $7.5 million; all figures in 2008 U.S. dollars.

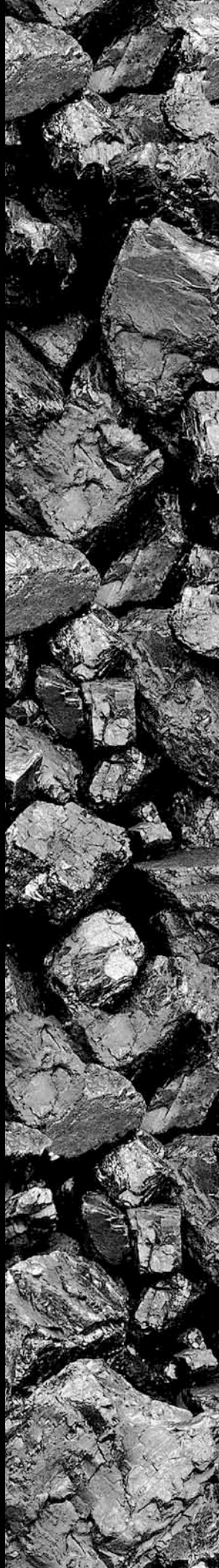
The Annual Economically-Quantifiable Costs of Coal

	Estimated Costs in 2008 (USD)		
	Low	Best	High
Land Disturbance: Carbon & Methane	$738M	$2.2B	$10.2B
Public Health Burden in Appalachian Communities	$74.6B	$74.6B	$74.6B
Fatalities Among the Public Due to Coal Transport by Rail	$1.8B	$1.8B	$1.8B
Emissions of Air Pollutants from Combustion	$65.1B	$187.5B[2]	$187.5B
Mercury Impacts	$414.8M	$5.5B	$29.3B
Subsidies	$3.2B	$3.2B	$5.4B
Abandoned Mine Lands	$8.8B	$8.8B	$8.8B
Climate Contribution from Combustion	$20.6B	$61.7B	$205.8B

Total Annual Cost Estimates in $Billions (2008 USD), and Cents per kWh Above Current Market Prices for Coal-Fired Electricity (Round Numbers)

	Estimated Costs in 2008 (USD)		
	Low	Best	High
Totals	$175B	$345B	$523B
Added Costs in ¢/kWh	9¢	18¢	27¢

[2]A 2010 Clean Air Task Force report, with Abt Associates consulting, lists 13,000 premature deaths due to air pollution from all electricity generation in 2010, a decrease in their estimates from previous years. They attribute the drop to 105 scrubbers installed since 2005, the year in which we based our calculations. We were pleased to see improvements reported in air quality and health outcomes. There is, however, considerable uncertainty regarding the actual numbers. Using the epidemiology from the "Six Cities Study" implies up to 34,000 premature deaths in 2010. Thus our figure of 24,000 is mid-range while those of the CATF represent the most conservative of estimates.



THE MEASURABL

M = **Measurable**
E = **Economic**
Q = **Qualitative**

COAL MINING

1 Underground

M: Since 1900, accidents have killed over 100,000 U.S. miners; over 200,000 have died from black lung disease.
E: These deaths and illnesses are reflected in wages and workers' comp, costs considered internal to the coal industry, but long-term support often depends on state and federal funds.
Q: Family and community tragedies, disabilities and losses.

2 Mountain Top Removal (MTR)

M: 500 Appalachian summits removed, transforming 1.4 million acres. Over 2,000 miles of streams buried; 2,500 miles of polluted streams in Kentucky alone.
E: Methane and carbon due to land disturbance (from all mining) contribute to climate change: $2.2 billion per year.
Q: Blasting; physical vulnerabilities (boulders, downed trees and mudslides) in surrounding communities (especially after heavy rains, more frequent with climate change); drinking water contamination; plant and animal populations harmed and lost.

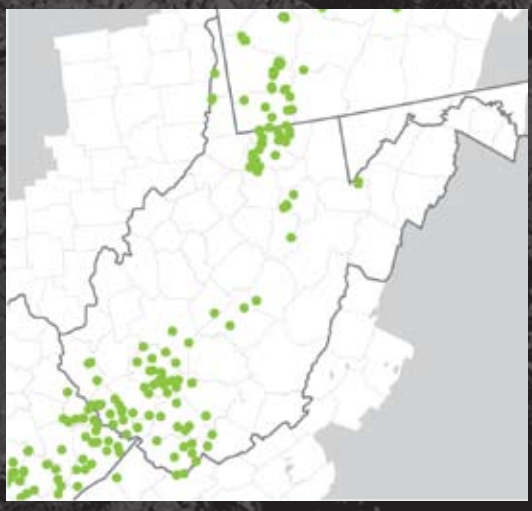
3 Sludge, Slurry and "Fly Ash" Ponds

M: Thousands of sludge and slurry ponds lie near coal mines and processing plants; 1,300 coal combustion waste ("fly ash") impoundments are adjacent to coal-fired plants, receiving 130 million tons of waste annually: 53 publicized spills, 1972-2008.
E: Cleanup costs and direct damages inadequately assessed.
Q: Risk of property damage, injuries and deaths; air and water contamination with toxins, heavy metals and radioactive elements.

4 Coal-Mining Regions

M: 11,000 excess deaths annually from lung cancer, heart, respiratory and kidney disease; highest health burden in heavy coal mining areas.
E: Lives lost evaluated at $74.6 bn/yr; includes impact of carcinogens: $11.8 bn/yr.
Q: Reproductive disorders, increased cancer rates, social and environmental losses.

SLUDGE, SLURRY AND "FLY ASH" PONDS
This map shows the locations of the major impoundments in West Virginia and adjacent states. Thousands of sludge and slurry ponds surround MTR sites. Leaks and releases contaminate ground water.



Source: Hope Childers, Wheeling Jesuit University

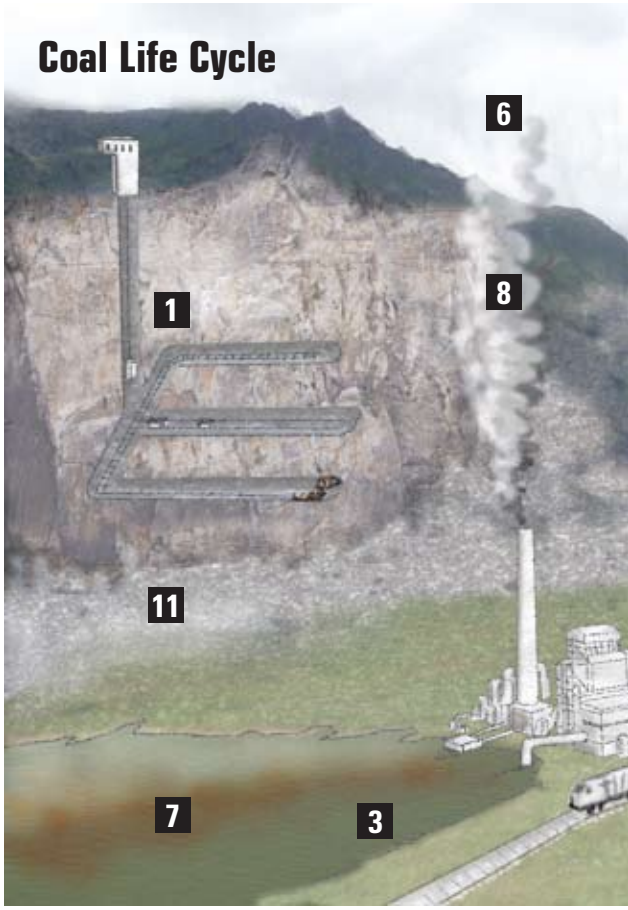
LE, ECONOMIC, A

5 Rail Transport
M: Deaths in RR accidents: 246/yr.
E: Lives lost assessed at $1.8 bn/yr.
Q: 70% of U.S. rail traffic dedicated to shipping coal. Diesel trucks also deliver coal to processing and power plants.

COAL COMBUSTION

6 Air Pollution
M: Lung disease: Particulates and oxides of nitrogen and sulfur kill over 24,000 people[2] annually, including 2,800 from lung cancer (2005). Heart disease: 38,200 non-fatal heart attacks annually.
E: Lives lost evaluated at $187.5 bn/yr.
Q: Air pollution also damages trees, crops and property.

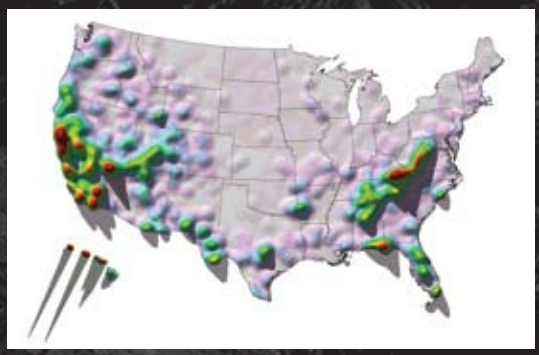
7 Nitrogen (N)
M: Land: Acid rain leaches calcium from forest soils. Water: Appx. 2/3 of the N deposited in U.S. East Coastal waters comes from coal burning. N "fertilization" contributes to the 350 "dead zones" globally and Harmful Algal Blooms (red tides) that lead to illness, shellfish bed closures, and harm to the seafood industry



ECOLOGY

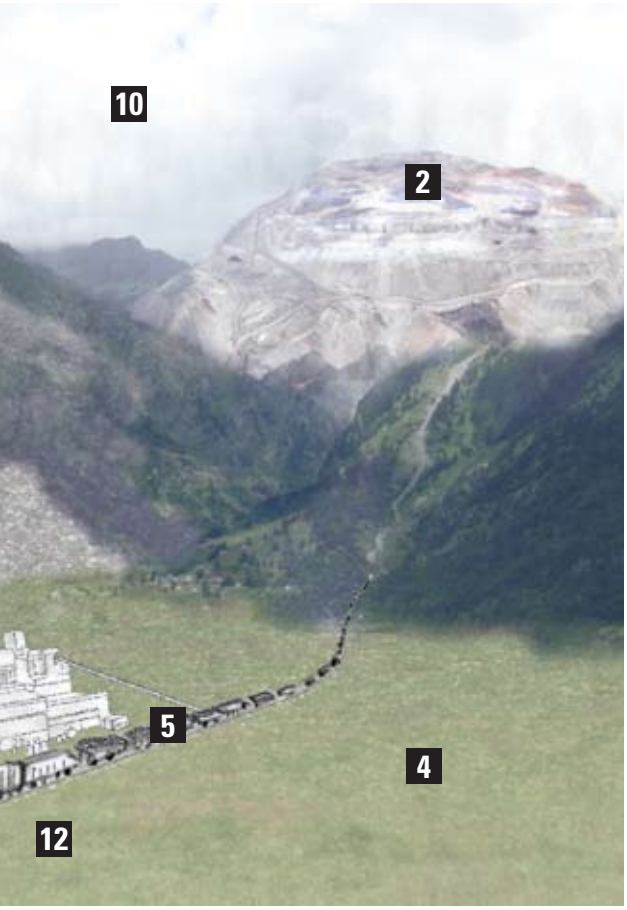
The highlights on this map show U.S. regions rich in biodiversity.

- The Appalachian Mountains are a treasure of plant and animal biological diversity. Drainage from Mountain Top Removal (MTR) mining alters stream conductivity, harming insect and amphibian life even at low levels of mining.
- Appalachian watersheds are being damaged to a degree far beyond the impacts of urbanization.
- Carcinogens are present in many regional drinking water supplies, as are heavy metals, including aluminum, antimony, arsenic, barium, beryllium, cadmium, iron, lead, manganese, selenium, thallium, and the radioactive elements uranium and thorium.



Source: The Nature Conservancy

ND QUALITATIVE



and tourism.
E: HABs (linked with N from multiple sources) >$82 mn/yr (U.S. events).
Q: Degraded forests, fisheries and waterways.

8 Mercury
M: Retardation and cardiovascular disease.
E: Health impacts and lost productivity evaluated at $5.5 bn/yr.
Q: Restricted consumption of fish (otherwise healthy); seafood and allied industries losses.

9 Subsidies
Federal subsidies and benefit payments estimated at $3.2 bn to $5.4 bn/yr. KY state subsidies to the coal industry yield a net loss of $115 mn/yr to taxpayers.

10 Climate Change
M: Coal generates almost half of the nation's electricity, but 4/5 of utility sector greenhouse gases. Coal burning produces 1½ times more CO_2 than oil and 2 times that from natural gas. Black carbon (soot), methane and ozone also warm the atmosphere.
E: Composite impacts: $61.7 bn/yr (range: $20.6 bn to $205.8 bn, depending on evolving

ABANDONED MINE LANDS
Shown here are abandoned mine lands and reclamation sites from Alabama to Pennsylvania, Indiana and Illinois. In Centralia, PA, a fire that started in 1962 still burns through old coal mines and veins under the town and surrounding hillsides in several directions. Other abandoned mines have been used to dump toxic petrochemicals. Many communities are virtually abandoned when coal is exhausted.

Source: Hope Childers, Wheeling Jesuit University

costs of climate change).
Q: Warming, stronger hurricanes and more heatwaves, floods, droughts and wildfires; food insecurity and damage to life support systems; health, environmental and economic impacts.

11 Abandoned Mine Lands

M: Slag heaps, persistent underground fires, degraded land and abandoned communities.1/5 of slurry, and some chemical industry toxins, are injected into abandoned mines.
E: Lost value of land and reclamation costs: $8.8 bn/yr.
Q: Water contamination; land degradation; community impoverishment.

OTHER PROCESSES

12 Carbon Capture and Storage (CCS)

M: Land needed: 11,600 square miles to reduce 1/5 of coal's CO_2 emissions by 2050. Extensive infrastructure, high construction costs and an "energy penalty" = 1.25 to 1.4 times as much coal burned (depending on technology) to produce an equal amount of energy, increasing diesel transport and liquid waste locally, and all upstream activities and costs.
E: CCS would almost double the cost of electricity per kilowatt hour (kWh) at the plant.
Q: Risks of CCS include:

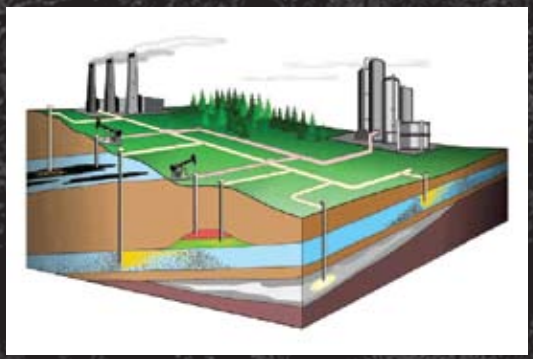
- Acidification of saline aquifers, leaching heavy metals into ground water.
- Acidification and fractures of limestone ($CaCO_3$).
- Release of highly-concentrated CO_2, toxic to plants, wild animals and humans.
- Alteration of microbial communities possible, releasing other gases.
- Increased pressures raise risks of leaks and releases.
- Increased pressures may destabilize faults, causing earthquakes.
- Significant investment and insurance liabilities likely.

Note on Peak Coal

The U.S. Geological Survey (USGS) has, in the past, estimated a 200-year supply of coal in U.S. The latest USGS and Energy Information Administration estimates of economically-recoverable coal may reduce the planning horizon for moving beyond coal to 20-30 years.

CARBON CAPTURE AND STORAGE (CCS)

Carbon capture and storage is a proposed means for reducing CO_2 emissions. The process involves: a) separating the CO_2, b) compressing it to a liquid, c) pumping it into pipelines, and d) storing it underground, under sea beds or in the deep ocean. Catalytic converters scrub other chemicals, metals and particles that are then pumped into "fly ash" ponds nearby power stations.



Source: Alberta Geological Society

CONCLUSION

We estimate that the life cycle impacts of coal and the waste stream generated are costing the U.S. public a third to over one half a trillion dollars annually. Accounting for the damages conservatively doubles to triples the price of electricity from coal per kWh generated, making wind, solar, and other forms of non-fossil fuel power generation, along with investments in efficiency and electricity conservation methods, economically competitive.

Beyond dollar evaluations, qualitative impacts include harm to air quality, watersheds, land, plants, animals, families and communities. The proposed technology of CCS is costly and risky, and is projected to magnify the ecological and health footprint of coal.

RECOMMENDATIONS

Local:

- Alternative industrial and farming policies for coal-field regions.
- Manufacture and install solar, wind and small-scale hydro.
- Manufacture technologies for efficient, self-regulating "smart" grids.
- Complementary inter-regional development (e.g., with the Rust Belt).
- End mountain top removal (MTR) mining.
- Reclaim all MTR sites and abandoned mine lands.
- Meet water quality standards.

National:

- Electric vehicles, plugged into cleanly-powered smart grids, and healthy cities programs, with cities connected by light rail.
- Realign federal and state regulations and incentives to stimulate manufacture of and markets for clean and efficient energy systems.

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"Full Cost Accounting for the Life Cycle of Coal," with relevant references, appears in the January 2011 issue of the *Annals of the New York Academy of Sciences* (www.nyas.org).

In support of our commitment to the environment, this pamphlet was printed on New Leaf Reincarnation paper. This paper is 100% recycled using 50% post-consumer fiber, and processed chlorine-free using certified renewable energy.

DESIGN: SHEILA ERIMEZ

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