THE COAL INDUSTRY AND MERCURY POLLUTION IN WEST VIRGINIA

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INTRODUCTION

Coal is an important part of the economy both in West Virginia and on the national level. In West Virginia, the coal industry currently provides about 40,000 direct jobs, which includes miners, contractors, and supporting industries, such as supply and repair. Mining jobs provide 30% of the total employment and total earnings in West Virginia. The combined direct and indirect contributions of the coal industry to West Virginia's economy are more than $13 billion a year. Ninety-nine percent of all electricity used in West Virginia is generated by use of coal (West Virginia Coal Mining Facts, 2005).

However, coal mining industries and coal-burning power plants today are facing major challenges in addressing public concerns of environmental damages. West Virginia coal is prized for its high BTU value, which averages about 12,500 BTU's per pound; however, it has impurities with average of 0.19 ppm mercury, 1.6% sulfur, and 17.13 ppm arsenic. Trace elements, such as mercury, that are present in coal are released into the atmosphere when coal is burned. Total mercury emissions in West Virginia were 2.38 tons in 2001. Mercury, especially methyl mercury, damages the human neurological system. Its effect is more pronounced in young and unborn children whose nervous systems have not yet fully developed. To reduce the health risks caused by mercury emissions, the United States Environmental Protection Agency (USEPA) has recently issued the Clean Air Mercury Rule (CAMR) to permanently cap and reduce mercury emissions from coal-fired power plants. Based on the new regulation, a first phase cap of 38 tons per year (tpy) will become effective in 2010 and a second phase cap of 15 tpy will become effective in 2018. This new regulation has significant financial implications for coal-fired power plants, because of high costs associated with mercury removal.

Developing innovative technologies for cost effective mercury emission control is therefore critical to coal-burning power plants, and it plays an important role in sustaining and promoting coal usage as an integrated component of the Nation's energy policy and ensuring the Nation's energy security. The main purpose of this paper is to provide background information on the West Virginia coal industry, its economic importance to the state and mercury emissions from the state. Mercury emission control technologies are also discussed in this paper.

1. COAL PRODUCTION AND ECONOMIC IMPORTANCE IN WEST VIRGINIA

1.1 Mining Companies

According to Dave Kessler of the West Virginia Department of Miners Health and Safety, there were 285 active underground coal mines and 207 active surface mines in West Virginia, as of September 10, 2005 (Kessler, September 10, 2005). In 2004, the total number of coal miners in West Virginia was 16,037, of which approximately 10,500 were underground miners, the rest being surface miners. There were 315 underground and 230 surface mines actively operating in West Virginia in 2004 (West Virginia Office, 2004). The ten largest surface mines and ten largest underground mines in West Virginia are listed in Tables 1 and 2.

Table 1: Ten Largest Surface Mines in WV Ranked by Production – 2004.

Rank	Company Name	County	Production (tons)	Employees
1	Catenary Coal Company	Kanawha	4,907,961	302
2	Alex Energy, Inc.	Nicholas	4,144,650	217
3	Hobet Mining, Inc.	Boone	4,122,253	292
4	Independence Coal Company	Boone	3,808,256	214
5	Fola Coal Company	Clay	3,786,080	132
6	Arch of W.V., Inc.	Logan	2,820,673	199
7	Evergreen Mining, Inc.	Webster	2,717,365	221
8	Coal-Mac, Inc.	Mingo	1,869,962	126
9	Elk Run Coal Company, Inc.	Boone	1,649,712	87
10	Bluestone Coal Corp.	McDowell	1,646,096	66

Source: West Virginia Office of Miners Health Safety and Training, June 2004

Table 2: Ten Largest Underground Mines in WV Ranked by Production – 2004.

Rank	Company Name	Mine	Production (tons)	Employees
1	McElroy Coal Company	McElroy Mine	8,357,059	660
2	Consolidation Coal Company	Robinson Run #95	6,245,830	488
3	Consolidation Coal Company	Blacksville #2	5,705,567	488
4	Consolidation Coal Company	Loveridge	4,970,513	493
5	Eastern Associated Coal Corp.	Federal #2	4,889,905	484
6	Speed Mining, Inc.	American Eagle Mine	3.704,294	134
7	Consolidation Coal Company	Shoemaker	3,689,310	427
8	Eastern Associated Coal Corp.	Harris #1	3,067,565	311
9	Rockspring Development, Inc.	Camp Creek Mine #1	3.063,594	256
10	Performance Coal Company	UBBMC Montcoal Eagle	2,780,843	196

Source: West Virginia Office of Miners Health Safety and Training, June 2004

1.2 Economic Importance of Coal in West Virginia

The amount of taxes collected from the coal industry is considerable. Severance taxes pump approximately $214 million into West Virginia’s economy and although mining takes place in only 26 of West Virginia’s 55 counties, all 55 counties receive Coal

Severance Tax funds. Twenty-four million dollars of the Coal Severance Tax collected each year goes directly into the Infrastructure Bond Fund, which provides financial assistance for projects that foster economic development, such as road construction. Coal companies and utility companies that generate electricity using coal account for over 60% of all business taxes paid in West Virginia (West Virginia Coal Mining Facts, 7 July 2005). The average annual coal mining salary in 2004 was $53,100 (Coal Facts, 2004). The coal industry payroll in West Virginia is nearly $2 billion per year (West Virginia Coal Mining Facts, 7 July 2005). Coal is responsible for $3.6 billion annually in the gross state product (West Virginia Coal Mining Facts, 7 July 2005). In addition to state and local taxes, the Federal government collects more than $11 billion in taxes and fees from the coal industry (CARE, 2005). Mining jobs provide 30% of the total employment and total earnings in West Virginia. The combined direct and indirect contributions of the coal industry to West Virginia's economy are more than $13 billion a year.

1.3 Quantity

West Virginia leads the nation in underground production and is second only to Wyoming in total production. In 2004, West Virginia produced over 151 million tons of coal, which accounts for about 15% of coal production nationwide (West Virginia Coal Mining Facts, 2005). West Virginia has an estimated 52,997,786,227 tons of recoverable coal reserves (WV Coal History, 2004).

1.4 Quality

The quality of coal is primarily measured by how much heat it emits when it burns and how much ash and impurities are left behind. West Virginia coal is prized for its high BTU value and, particularly for coal from the Southern coalfields(Coal, n.d.). The BTU content per pound of Western coal ranges from 8,000 to 11,000, with most around 8,500. West Virginia coal ranges from 10,500 to 15,000 BTUs per pound, with most around 12,500 BTU (Eia, n.d.). Western coals tend to be lower in sulfur, averaging 0.3% sulfur (Gsa, 2003), compared with an average of 1.6% sulfur in West Virginia coal. The ash content in West Virginia coal averages about 10.5 %, compared to an average of about 5 % for Western coal (Trace, 2004) (Smtc, 2002). The mean whole coal mercury content of West Virginia coal is 0.19 p.p.m.. This is higher than the mean whole mercury contents of coal from other regions of the United States (see Table 3); however, West Virginia coal is generally higher in BTU content than coal from other regions.

1.5 Breakdown of Impurities

Coal is made up primarily of organic elements (carbon, hydrogen, oxygen and nitrogen) and inorganic elements (primarily silicon, aluminum, iron, calcium, magnesium, titanium, sodium, potassium, and sulfur). Organic elements comprise the combustible body of the coal, whereas the non-combustible inorganic elements present in coal largely form the ash when the coal is burned. Trace elements are defined as elements present in coal in amounts of less than 1 percent by weight. Most trace elements in West Virginia coal are present at levels of 10 to 100 p.p.m. or less (Trace, 2004).

Table 3: <u>Values for Mercury Concentration and Calorific Value for Coal from Selected Regions of the United States.</u>

[No. = number of analyses]

Coal-producing region	Mercury (ppm)			Calorific value (Btu/lb)		
	Median	Mean	No.	Median	Mean	No.
Appalachian, northern	0.19	0.24	1,613	12,570	12,440	1,506
Appalachian, central	.10	.15	1,747	13,360	13,210	1,648
Appalachian, southern	.18	.21	975	12,850	12,760	969
Eastern Interior	.07	.10	289	11,510	11,450	255
Fort Union	.08	.10	300	6,280	6,360	277
Green River	.06	.09	388	9,940	9,560	264
Gulf Coast	.13	.16	141	6,440	6,470	110
Pennsylvania Anthracite	.10	.10	51	12,860	12,520	39
Powder River	.06	.08	612	8,050	8,090	489
Raton Mesa	.05	.09	40	12,500	12,300	34
San Juan River	.04	.08	192	9,340	9,610	173
Uinta	.04	.07	253	11,280	10,810	226
Western Interior	.14	.18	286	11,320	11,420	261
Wind River	.08	.15	42	9,580	9,560	42

Source: United States Geological Survey, September 2001

The geographic distribution in Figure 1 illustrates the distributions of mercury according to geographic region. The stratigraphic distribution in Figure 2 illustrates the distribution of mercury in each coal seam. Most of the concentrations of mercury occur in the Lower Kittanning through Harlem coal seams, which are thin and generally considered unmineable (Trace, 2004).

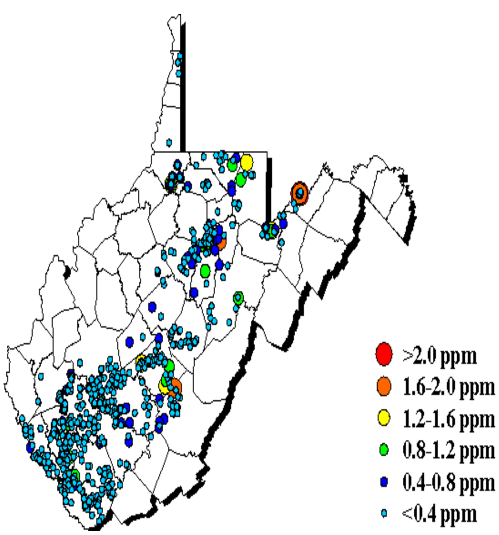


Figure 1: Geographic Distribution of Mercury in all WV Coals (*West Virginia Geological Survey, September 28, 2005*)

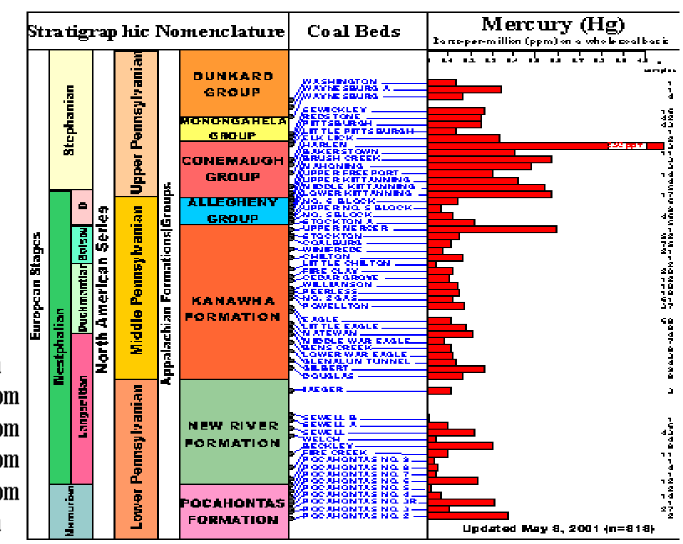
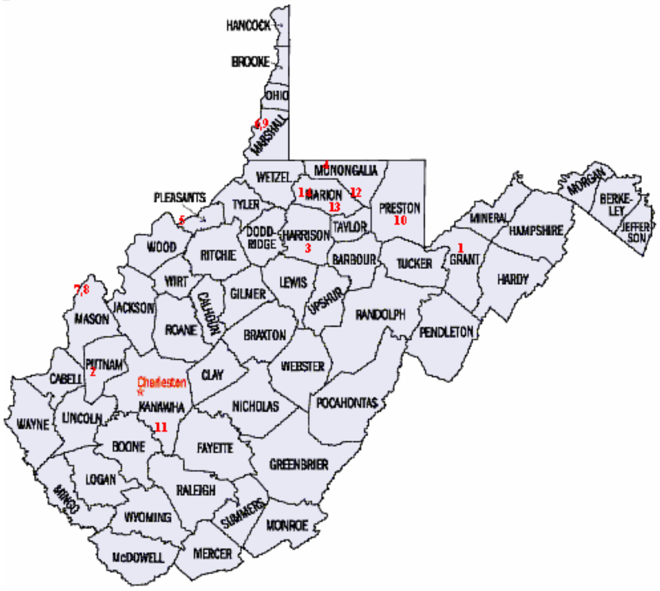


Figure 2: Stratigraphic Distribution of Mercury in WV Coals by Seam (*West Virginia Geological. Survey, September 28, 2005*)

2. COAL BURNING POWER PLANTS IN WEST VIRGINIA

2.1 Number and Location of Plants

As of 2001, there were fourteen coal-burning power plants in West Virginia. Figure 3 below shows the locations of the coal-fired power plants in the state. The majority of the plants are located in the north-central section of the state and near rivers.



1. Mount Storm Power Station, Grant County
2. John E. Amos Power Plant, Putnam County
3. Harrison Power Station, Harrison County
4. Fort Martin Power Station, Maidsville, Monongalia County
6. Mitchell Power Plant, Marion County
7. Mountaineer Plant, Mason County
8. Phillip Sporn Plant, Mason County
9. Kammer Plant, Moundville, Marshall County
10. Albright Power Station, Preston County
11. Kanawha River Plant, Kanawha County
13. Rivesville Power Station, Marion County
14. American Bituminous Power Partners, Granttown, Marion County

Figure 3: West Virginia Coal Burning Power Facilities.
Source: Clear the Air (cta), n.d.

2.2 Energy Generated

Table 4 below lists the coal-fired power plants in West Virginia that produce more than two million megawatt-hours of energy per year. The total energy generated by these major power plants is 69,237,328 MWH. (Net Generation, 2005).To produce this electrical energy, West Virginia power plants use more than 36 million tons of coal per year (American Coal Foundation, 2003).

Table 4: Energy Generated by the Major Coal-Fired Power Plants in WV. (All Plants Generating More Than Two Million MWH)

Plant	**Owner**	**Megawatt-Hours**
John E. Amos	Appalachian Electric Power	16,379,771
Harrison	Allegheny Electric	13,584,254
Mount Storm	Virginia Electric Power	11,631,825
Mountaineer (1301)	Appalachian Electric Power	8,267,917
Fort Martin	Allegheny Electric	7,669,881
Pleasants	Allegheny Electric	6,042,881
Phillip Sporn	Central Power	5,660,799
	Total	**69,237,328**

Source: Environmental Integrity Project, 2004

3. MERCURY POLLUTION FROM COAL-BURNING POWER PLANTS

3.1 Pollution Produced by Coal-Burning Power Plants

When coal is burned, wastes are created in two principle forms. The first is the solid waste left behind after combustion, called ash, which is comprised mostly of metal oxides and alkali. The second is in the form of air emissions, which are comprised primarily of carbon dioxide, sulfur dioxide, nitrogen oxides, particulate matter and some trace elements found in the coal, including mercury. Each of these pollutants has its own particular effect on the environment. The solid wastes, which are often deposited in landfills and abandoned underground mines, can leach toxins into the surrounding soil and water. The air emissions present a greater problem because, due to their airborne nature, they are more difficult to remove and spread over very wide ranges. Carbon dioxide, one of the gases released during coal combustion, is the predominant gas contributing to the greenhouse effect. Sulfur dioxide and nitrogen oxides are primary contributors to acid rain. In high concentrations, sulfur dioxide can aggravate the conditions of people suffering from respiratory diseases, such as asthma, bronchitis and emphysema. Particulate matter emitted from coal combustion can damage lung tissue and has been linked to cancer and premature death. The average emission rates in the United States from coal-fired generation are: 2,249 lbs/MWH of carbon dioxide, 13 lbs/MWH of sulfur dioxide, and 6 lbs/MWH of nitrogen oxide (Electricity, 2005).

Mercury is released in power plant emissions in three forms; particulate, ionized and elemental. The particulate and ionized forms are more easily captured and removed from power plant emissions with present technology. On the other hand, the elemental form is harder to remove. In the environment the elemental mercury can undergo a series of chemical transformations that convert it into the highly toxic organic form known as methyl mercury. The process by which elemental mercury is converted to methyl mercury is a complex bacterial conversion that occurs when the elemental mercury is consumed by certain microorganisms present in soil and water (Frequent, 2005). When animals higher in the food chain consume these microorganisms, they also take in the methyl mercury. This process is known as bioaccumulation. Animals higher in the food chain, such as larger fish and animals that eat them have increasingly larger concentrations of methyl mercury. Humans are mainly exposed to mercury in the form of methyl mercury by eating contaminated fish and shellfish (Frequent, 2005).

Mercury, especially methyl mercury, damages the human neurological system, causing impairment of the peripheral vision; disturbances in sensations; lack of coordination of movements; impairment of speech, hearing, walking; and muscle weakness. Its effect is even more pronounced in young and unborn children whose nervous systems have not yet fully developed (Frequent, 2005).

To combat mercury emissions, on March 15, 2005, the EPA issued the first-ever federal rule to permanently cap and reduce mercury emissions from coal-fired power plants. This rule, called the Clean Air Mercury Rule, builds on the EPA's Clean Air Interstate Rule (CAIR) and makes the United States the first country in the world to regulate mercury emissions from coal-fired power plants. The first phase cap is 38 tons and emissions will be reduced by taking advantage of "co-benefit" reductions – that is, mercury reductions achieved by reducing sulfur dioxide and nitrogen oxides emissions under CAIR. In the second phase, due in 2018, coal-fired power plants will be subject to a second cap, which will reduce emissions to 15 tons upon full implementation (Frequent, 2005).

3.2 Mercury Generated in West Virginia and in the Nation

Mercury emissions from coal power plants are a problem nationally. In 2001, more than 91,000 pounds of mercury was produced by coal-fired power plants in the United States. Texas, Pennsylvania, Ohio, and Indiana, all produced greater mercury emissions (by weight) than West Virginia. Total mercury emissions in West Virginia increased from 2.18 tons in 1999 to 2.38 tons in 2001. West Virginia ranked highest in mercury emissions per area in 2001. Table 5 lists the emissions for each of West Virginia's fourteen power plants in 1999 and 2001. The greatest mercury emission increase from 1999 to 2001 took place at the Mount Storm Power station, increasing 62%. While five of the power plants reduced their emissions, emissions increased at nine plants, increasing the total mercury emissions from 1999 to 2001 by nine percent (Mercury Emissions, 2001).

Table 5**:** Mercury Emissions from Coal-Fired Power Plants in West Virginia.

Plant Name	Estimated Mercury Emissions in 1999 (pounds)	Mercury Emissions in 2001 (pounds)
Mt. Storm Power Station	864	1400
John E Amos	838	630
Philip Sporn	478	300
Fort Martin	390	400
Mitchell (WV)	390	300
Mountaineer	359	300
Harrison	303	400
Krammer	241	210
Pleasants & Willow Island	227	340
Kanawha River	112	140
Albright	103	180
Rivesville	31	46
Morgantown Energy Facility	15	120
Total	**4,357**	**4,766**

Source: Clear the Air (cta), 2001

3.3 Technologies for Removing Mercury from Power Plant Emissions

As important as coal is to West Virginia and the nation, the future of coal depends upon finding new, innovative and clean ways to use it. Public opinion on the use of fossil fuels and the national political climate can have a significant effect on the use of coal. Developing innovative technologies for cost effective mercury emission control is therefore critical to coal-burning power plants. The most researched technology is

Activated Carbon Injection (ACI). A Powdered Activated Carbon Sorbent (PAC) is injected into a flue gas at a location in the duct before the particulate matter control device (electrostatic precipitator or fabric filter). The PAC sorbent binds with mercury in flue gas while in the duct and filter. The mercury is later captured in the particulate matter control device (Controlling Power Plant Emissions, 2005). Of the two particulate matter control devices, the fabric filter has shown better results because of enhanced gas particle contact in filter cakes on the surface of the bags in the filter fabric. The activated carbon's performance is dependent upon its chemical and physical properties. Surface area, pore size distribution, and particle size distribution determine how much mercury can be captured. As the surface area and pore volume increase so does the capacity for mercury to be captured. The pores of the carbon sorbent must be large enough to provide free access to internal surface area while avoiding excessive blockage by previously absorbed reactants. As particles sizes decrease, access to the internal surface area of the particle increase along with potential adsorption rates. The temperature, concentration of mercury in the flue gas, and the flue gas composition are other factors that determine the amount of mercury captured. The selection of a carbon for a given application should take into considerate the total concentration of mercury, the flu gas composition, and the methods of capture, an electrostatic precipitator, a fabric filter, or a dry scrubber (Controlling Power Plant Emissions, 2005). Table 6 lists the various controls and the effectiveness of removal using active carbon injection. As one can see from Table 6, the most effective control classes are the spray dryer/fabric filter and the fluidized bed combustion fabric filter, although the spray dryer/fabric filter has a wider range of results, 0 to 99 percent. The fluidized bed combustion fabric filter also gave good results, ranging from 66 to 99 percent removal. The control classes using a fabric filter had better results than those that used the electrostatic precipitator or venturi scrubbers. The estimated cost for PAC injection is 0.003 to 3.096 $mill/kWh. The higher end of the range of costs is associated with plants that use spray dryers and electrostatic precipitators (ESP's) or plants that use hot ESP's. However, very few plants currently use these technologies, so the majority of plants' costs range between 0.003 and 1.903 $mill/kWh (Srivastava, 2005).

A pilot test program is being sponsored by Powerspan Corp. to develop a process called photochemical oxidation. The process requires elemental mercury removal in a downstream SO2 scrubber, wet electrostatic precipitator, or baghouse, and uses 254-nm ultraviolet light from a mercury lamp. The use of the ultraviolet light causes an excited state of the mercury in the flue gas, which leads to the oxidation of the elemental mercury. Photochemical oxidation has shown promising results. Preliminary testing has shown greater than 90% oxidation and removal of elemental mercury. This process has great potential to serve as a low cost option for coal fired power plants as well as waste incinerator flue gases. (Granite, 2005)

Table 6: Types of Controls and Percentages of Mercury Removal

Control Class	% Mercury Removal		% Elemental Mercury	
	Minimum	Maximum	Minimum	Maximum
Electrostatic Precipitator (cold)	0	55	12	85
Electrostatic Precipitator (cold) & Flue gas desulfurization (wet)	24	70	81	98
Electrostatic Precipitator (hot)	0	27	34	91
Electrostatic Precipitator (hot) & Flue gas desulfurization (wet)	4	65	80	99
Fluidized bed combustion Fabric Filter	66	99	44	68
Fluidized bed combustion & Flue gas desulfurization (wet)	79	96	45	84
Spray Dryer/Electrostatic Precipitator	5	25	91	98
Spray Dryer/Fabric Filter	0	99	64	99
Fabric Filter	40	85	3	33
Venturi Scrubber	3	24	86	96

Source: U.S. Environmental Protection Agency, March 2004

CONCLUSION

Coal is an important part of the economy both in West Virginia and in the national level. In West Virginia, the coal industry currently provides about 40,000 direct jobs. Ninety-nine percent of all electricity used in West Virginia is generated by use of coal. Nationally, coal accounts for 55% of all electricity generated in the U.S. The demand for electricity has increased 136% since 1970, and will increase a projected additional 24% by 2020, in turn increasing the demand for West Virginia Coal (WV Mine Coal Mining Facts, 2005). There were 285 active underground coal mines and 207 active surface mines in West Virginia. In 2004, West Virginia produced over 151 million tons of coal, about 15% of production nationwide, exports over 50 million tons to 23 other countries, leading the nation in coal exports. There are fourteen coal-burning power plants in West Virginia. The majority are located in the north-central section of the state. The total energy generated by the major power plants (those generating more than two million megawatts) is 69,237,328 megawatts. Mining jobs provide 30% of the total employment and total earnings in West Virginia. The combined direct and indirect contributions of the coal industry to West Virginia's economy are more than $13 billion a year.

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