Indiana Center for Coal Technology Research

Basic Mercury Data & Coal Fired Power Plants

CCTR Basic Facts File #2

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Complexity of Mercury Controls

DOE Example

If the Houston Astrodome were filled with ping-pong balls representing the quantity of flue gas emitted from coal-fired power plants in the U.S. each year, 30 Billion (30,000,000,000) ping pong balls would be required. Mercury emissions would be represented by 30 colored ping pong balls & ***the challenge by industry is to remove 21 of the 30 colored balls (for 70% compliance) from among the 30 Billion***

Source: “Coal Energy Systems”, Bruce G. Miller, 2005, p369

Three Forms of Mercury from Power Plants

The mercury emitted from power plants is measured as three forms:

Elemental, Hg^{o}
Oxidized, Hg^{+2}
Condensed on ash particles, Hg_p

In the natural environment mercury can go through a series of chemical transformations to convert to a highly toxic form, **methylmercury, CH_3Hg** which is concentrated in fish and birds

Almost no mercury from the soil is taken into the shoots of plants

Source: “Coal Energy Systems”, Bruce G. Miller, 2005, p.109

Mercury Types From Power Plants

- **40%** of Hg from power plants is **Oxidized Hg**
  60% of Hg from power plants is **Elemental Hg**
- Most of the Oxidized Hg and all of the Elemental Hg is carried away by the wind
- **Oxidized Hg is water-soluble**. A small amount of the oxidized Hg ends up in water and may be formed into an organic form called **Methylmercury**. This is the Hg type eaten by fish

Source: http://www.epa.gov/nrmrl/pubs/600r01109/600R01109chap9.pdf#search=%22mercury%20in%20coal%20slag%22

Mercury Emissions from Power Plants

Use of Coal Combustion By-Products (CCB) varies globally with **56% of CCBs being profitably used in Europe (1999) compared with about 30% in the U.S**. Countries such as **Canada, India, & Japan utilize 27%, 13% & 84%** of their CCBs, respectively

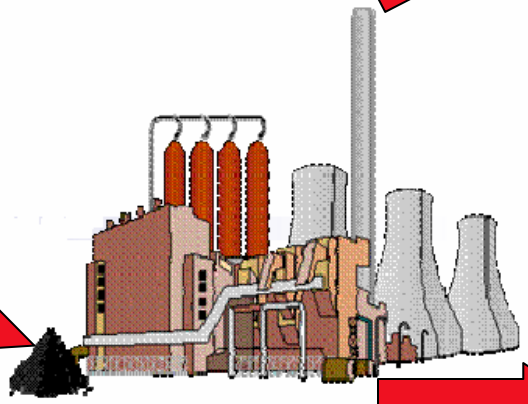
Coal from China's Guizhou Province has mercury concentration of 55ppm which is about 200 times the **average mercury concentration in U.S. coals, 0.275ppm**

Source: "Coal Energy Systems", Bruce G. Miller, 2005,

U.S. Mercury Data for Power Plants

Coal washing removes 30% Hg

100%



75 Tons Hg per year from U.S. power plants

66%

50 Tons Hg emitted to the air *< 1% of Hg globally emitted to the atmosphere per year*

34%

25 Tons Hg reduction through existing pollution controls such as **scrubbers for SO2, SCRs for NOx, and PM fabric filters**

22%

17 Tons Hg to land fills

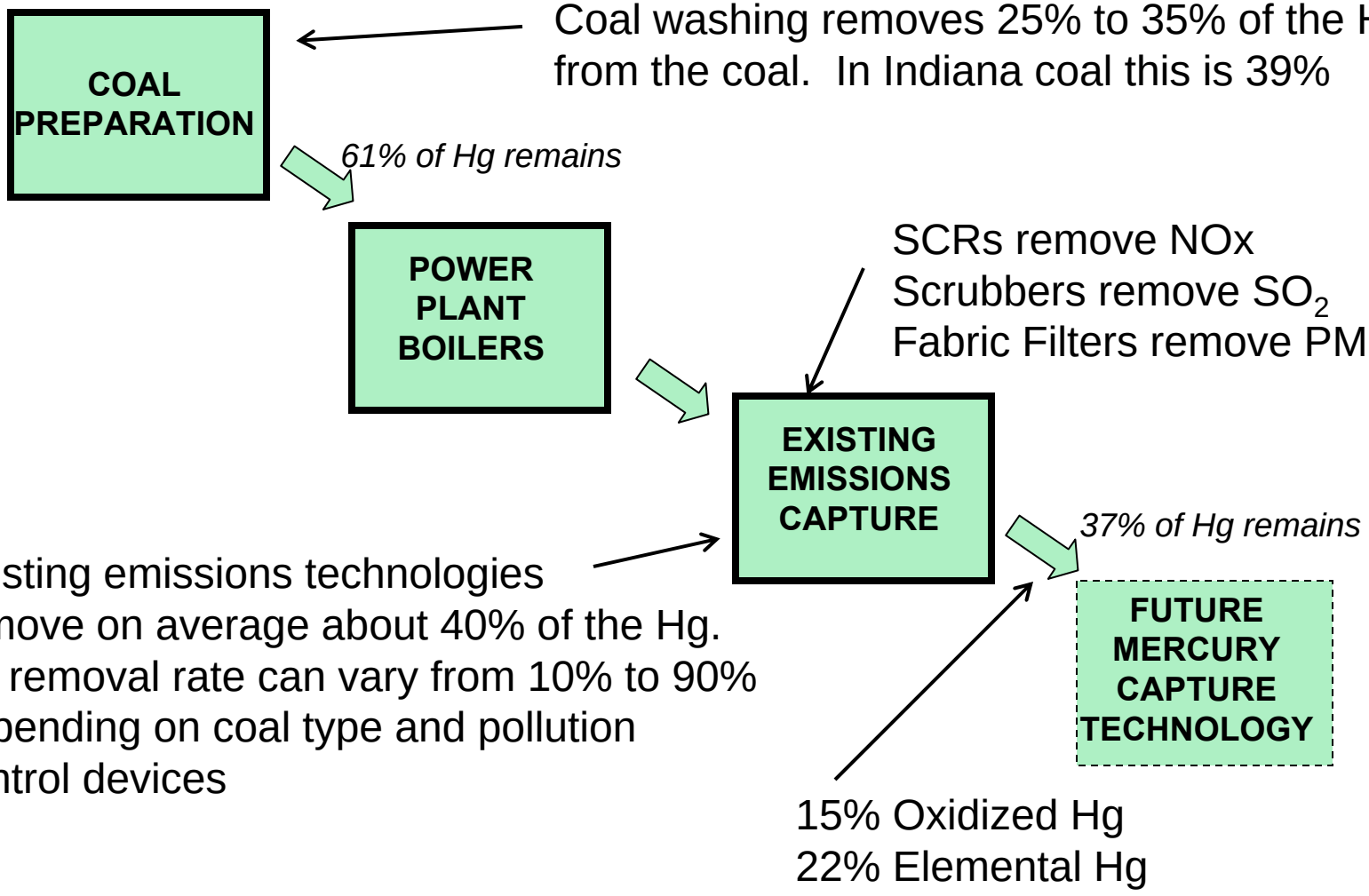
8 Tons Hg commercial use 12%

4%

8% **30% to concrete**

70% to roofing, agriculture, wallboards, blasting grit, road base, drainage, fillers etc

Mercury Extraction Process



U.S. Mercury Emissions

TABLE 1. National Air Emissions Estimates for Mercury[3]

Source Category	1990 (tons)	1999 (tons)[f]	% reduction
Utility Coal Boilers[b]	51.1	47.9[a]	6%
Industrial Boilers[b]	12.0	12.0	0%
Medical Waste Incinerators	49.7	1.6	97%
Municipal Waste Combustion	56.7	4.9	91%
Hazardous Waste Incinerators[b]	6.6	6.6	0%
Chlorine Production	10.0	6.5	30%
Electric Arc Furnaces[c]	6.9	NA	NA
Gold Mining	3.4[d]	11.5	NA
Other[e]	23.5	21.6	6%
Total	219.9	112.6	45%

About 50 Tons per year of Hg is emitted from U.S. power plants

Massive Hg reductions have been achieved at medical and municipal sites

Source: /www.epa.gov/mercury/pdfs/I_HgReleases.pdf

Mercury from U.S. Power Plants

Majority of coal arriving at power plants has been washed and 25% to 35% of the Hg removed (Indiana = 39%)

Approximately **75 Tons of Hg** are found in the coal delivered to power plants each year and about two thirds of this Hg is emitted to the air, resulting in about **50 Tons being emitted annually**. This 25 Ton reduction is achieved in the power plant boilers and through existing pollution controls such as **scrubbers for SO2, SCRs for NOx, and PM fabric filters**

Source: http://www.epa.gov/mercury/control_emissions/index.htm

1999 U.S. Commercial Uses Of Coal Combustion By-Products, CCBs

About **70% of the CCBs are land-disposed** & the other **30% are reused or recycled** for commercial uses

33 Million Tons (MTons) of CCBs commercially used
~ **3% of the total tonnage of coal produced** in the U.S. (coal produced is 1100 Million Tons per year)

10 MTons of CCBs are used for concrete
~ **the greatest current use of CCBs**

Source: http://www.epa.gov/nrmrl/pubs/600r01109/600R01109chap9.pdf#search=%22mercury%20in%20coal%20slag%22

Mercury Concentrations in Coal Combustion By-Products

CCB	Parts per Million ppm
Fly Ash	0.330
Bottom Ash	0.067
Boiler Slag	0.042
Wet FGD scrubber solids/sludges	0.200

The Fly Ash contains over half of all the Hg emitted from coal fired power plants

Source: http://www.epa.gov/nrmrl/pubs/600r01109/600R01109chap9.pdf#search=%22mercury%20in%20coal%20slag%22

U.S. Coal Combustion Residues

Coal Combustion Residue	Description	Average Quantity Generated Per Ton of Coal Burned [a]	Total Nationwide Quantity Generated in 1999 [b]
Fly ash	Fine, powdery non-combustible mineral matter in the boiler flue gas and collected by electrostatic precipitator or fabric filter	160 lb/ton	63,000,000 tons
Bottom ash	Dark gray, granular, porous non-combustible mineral matter heavier than fly ash and collected in bottom of the boiler furnace.	40 lb/ton	17,000,000 tons
Boiler slag	Coarse, black, glassy mineral matter that forms when molten bottom ash contacts quenching waters in wet-bottom furnaces.	100 lb/ton	3,000,000 tons
Wet FGD scrubber solids/sludges	Solid material or sludge generated by scrubbing processes used to remove sulfur from the flue gases.	350 lb/ton	25,000,000 tons

108 MTons

108 MTons of total CCR

~ 9.8% of total U.S. coal tonnage production

Source: http://www.epa.gov/nrmrl/pubs/600r01109/600R01109chap9.pdf#search=%22mercury%20in%20coal%20slag%22

1999 U.S. Commercial Uses of CCBs

Commercial Application or Use	Coal Combustion Residue								Nationwide Total (tons)
	Fly ash		Bottom ash		Boiler slag		Wet FGD solids/sludges		
	tons	%	tons	%	tons	%	tons	%	
Concrete/grout	10,000,000	49	700,000	13	11,000	0.5	290,000	6.5	11,000,000
Waste stabilization/solidification	1,900,000	9.3	69,000	1.3	0	0	16,000	0.4	2,000,000
Structural fill	3,200,000	15	1,400,000	26	52,000	2.2	580,000	13	5,200,000
Mining applications	1,500,000	7.3	150,000	2.8	10,000	0.4	230,000	5.2	1,900,000
Raw feed for cement clinker	1,300,000	6.1	160,000	2.9	0	0	0	0	1,500,000
Road base/subbase	1,200,000	5.9	1,100,000	20	5,500	0.2	17,000	0.4	2,300,000
Flowable fill	850,000	4.1	13,000	0.2	0	0	0	0	860,000
Other	460,000	2.2	450,000	8.3	76,000	3.2	180,000	4.1	1,200,000
Mineral filler	160,000	0.8	63,000	1.2	12,000	0.5	0	0	240,000
Soil modification	78,000	0.4	17,000	0.3	13,000	0.5	2,100	<0.1	110,000
Agriculture	78,000	0.4	43,000	0.8	0	0	80,000	1.8	200,000
Snow and ice control	3,200	0.1	1,100,000	20	51,000	2.2	0	0	1,200,000
Blasting grit/roofing granules	0	0	160,000	2.9	2,100,000	90	0	0	2,300,000
Wallboard	0	0	0	0	0	0	3,100,000	69	3,100,000
Nationwide Total [a]	21,000,000	100	5,400,000	100	2,300,000	100	4,500,000	100	33,000,000

Source: http://www.epa.gov/nrmrl/pubs/600r01109/600R01109chap9.pdf#search=%22mercury%20in%20coal%20slag%22

Mercury Emissions from Utilities in 2000

State	Hg Emissions (Tons)	Hg Rank
TX	5.13	1st
PA	5.12	2nd
OH	3.83	3rd
IL	3.41	4th
IN	**2.63**	**5th**

Indiana Coal has 5.2 lb Hg per TBtu = 5.2 lb Hg x 10^{-6} per MBtu

(1lb = 16 oz, 1 Ton of Indiana coal has about 22 MBtu)

= 5.2 x 10^{-6} x 16 x 22 = 0.0018 oz Hg per Ton Coal

≈ 1/500th oz of Hg per Ton of coal

Sources: http://www.epa.gov/cleanenergy/egrid/index.htm

http://www.eia.doe.gov/cneaf/coal/page/acr/table26.html

Indiana Emissions By Sector (1000 Tons)

Mercury

	2002			2001			2000			
	SO_2[1]	NOx[1]	CO_2	SO_2	NOx	CO_2	SO_2	NOx	CO_2	Hg
Utilities	901	279	148,000[3]		358	145,000[3]	878	346	142,653	0.003
Transportation	19	318	64,348*		349	63,043*		365	62,023*	0[2]
Other	93	119	109,391*		210	107,174*		250	105,439*	0.002
Total	1,013	716	321,739*		917	315,217*	982	961	310,115*	0.0044[2]

Source: 1-Per Email March 9th, 2005 IDEM

2-1999 Value Per Email March 10th, 2005 IDEM

3-Based on Average Increase of 3 Million Tons/YR Increase For 1990-2000, EIA

http://www.in.gov/idem/soe2004/air/chart.html#isd

http://www.state.in.us/idem/soe/98report/air6.html

EPA eGRID2002 Version 2.01 State File (Year 2000 Data)

http://www.epa.gov/cleanenergy/egrid/index.htm

*Values base on 1998 data showing relative percentage to Utilities

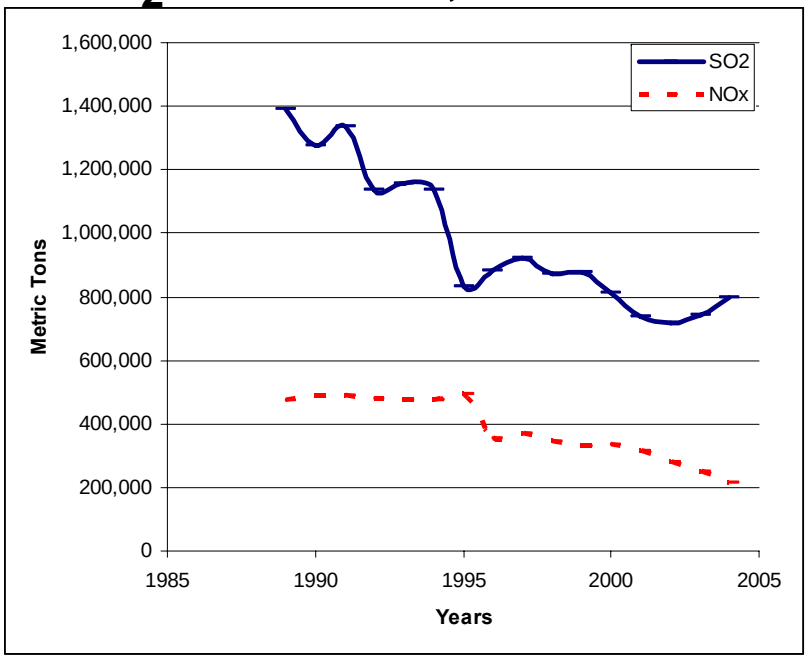
Mercury from 10 Largest Indiana Power Stations in 2000 (1.99 Tons)

Station	Utility	Hg Emission in 2000 (pounds)	% IN coal of total coal used	% WY coal of total coal used	Percentage MW Scrubbed
1. Gibson 3131 MW	Duke	640	79%	0%	43%
2. Rockport 2600 MW	IMPCo	1109	16%	84%	
3. R M Schahfer 1780 MW	NIPSCo	406	21%	58%	48%
4. Petersburg 1672 MW	IPL	284	100%	0%	100%
5. Clifty Crk. 1209 MW	IKECorp	518	22%	78%	
6. Cayuga 1096 MW	Duke	224	64%	36%	
7. Merom 1000 MW	Hoosier	118	100%	0%	100%
8. Tanners Crk. 980 MW	IMPCo	299	92%	5%	
9. Harding St. 924 MW	IPLCo	177	100%	0%	
10. Wabash R. 918 MW	Duke	201	100%	0%	

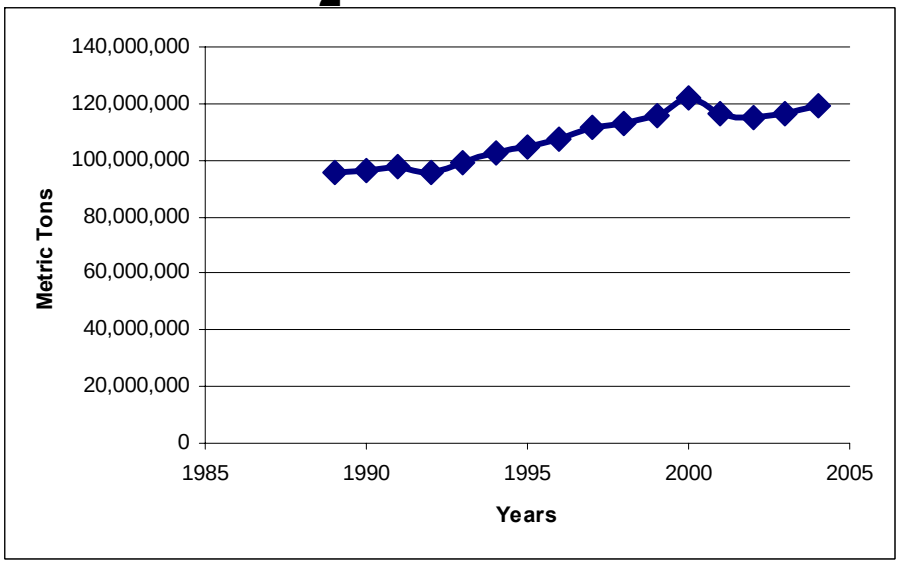
*Note: * Schahfer has 2 of its 6 units, 155MW, using Natural Gas*
Cayuga has 1 of its 3 units, 99MW, using Natural Gas
Harding St has 3 of its 8 units, 322MW, using Natural Gas
Wabash River has 1 of its 7 units as an IGCC & 2 units using Natural Gas
Source: Form EIA 767, 2003

Other Emissions from Indiana Power Plants

SO_2 and NOx, 1990-2004



CO_2, 1990-2004



Mercury is a Global Problem

While coal-fired power plants are the largest remaining source of human-generated **Hg emissions in the U.S. they contribute very little to the global Hg pool**

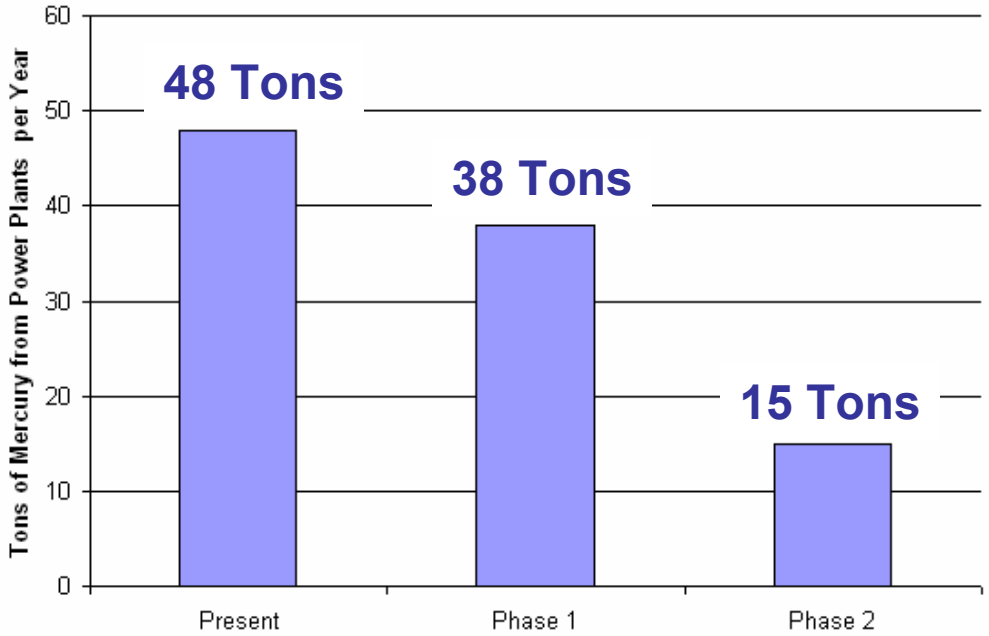
2005 estimates of annual total global mercury emissions from all sources, natural & human-generated, range from roughly 4,400 to 7,500 Tons/year

Human caused U.S. Hg emissions are estimated to account for roughly 3 % of the global total, & U.S. coal-fired power plants are estimated to account for only about 1 %

http://www.epa.gov/camr/basic.htm

Clean Air Mercury Rule, CAMR

CAMR establishes “standards of performance” limiting Hg emissions from new & existing coal-fired power plants & creates a market-based cap-and-trade program that will **reduce nationwide utility emissions of Hg (48 Tons) in two distinct phases**



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http://www.epa.gov/camr/basic.htm

Clean Air Mercury Rule, CAMR

Phase 1

A cap of 38 Tons on Hg emissions by taking advantage of "co-benefit" reductions – that is, Hg reductions achieved by reducing sulfur dioxide (SO2) & nitrogen oxides (NOx) emissions under CAIR

Phase 2

Due in 2018, coal-fired power plants will be subject to a second cap, which will reduce emissions to **15 Tons upon full implementation**

Source: http://www.epa.gov/nrmrl/pubs/600r01109/600R01109chap9.pdf#search=%22mercury%20in%20coal%20slag%22

http://www.epa.gov/camr/basic.htm

Mercury Summary

Over 60% of Hg in the air in the U.S. **comes from international sources**, not U.S. sources

When fully implemented, the U.S. CAMR rules will reduce utility emissions of Hg from 48 Tons a year to 15 Tons, **a reduction of nearly 70 %**

Mercury vapor in the atmosphere **can drift for over a year**

Indiana coal possesses **about 1/500 oz of Hg in each Ton** (2.6 Tons Hg annually from all power plants in the state)

Source: http://www.epa.gov/nrmrl/pubs/600r01109/600R01109chap9.pdf#search=%22mercury%20in%20coal%20slag%22
http://www.epa.gov/camr/basic.htm