Indiana Center for Coal Technology Research

Coal Utilization By-products

CCTR Basic Facts File #6

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Coal Residues Produced in U.S.

More than 120 Million Tons (MTons, 2005) of coal related residues are generated in the U.S. by coal-burning power plants each year

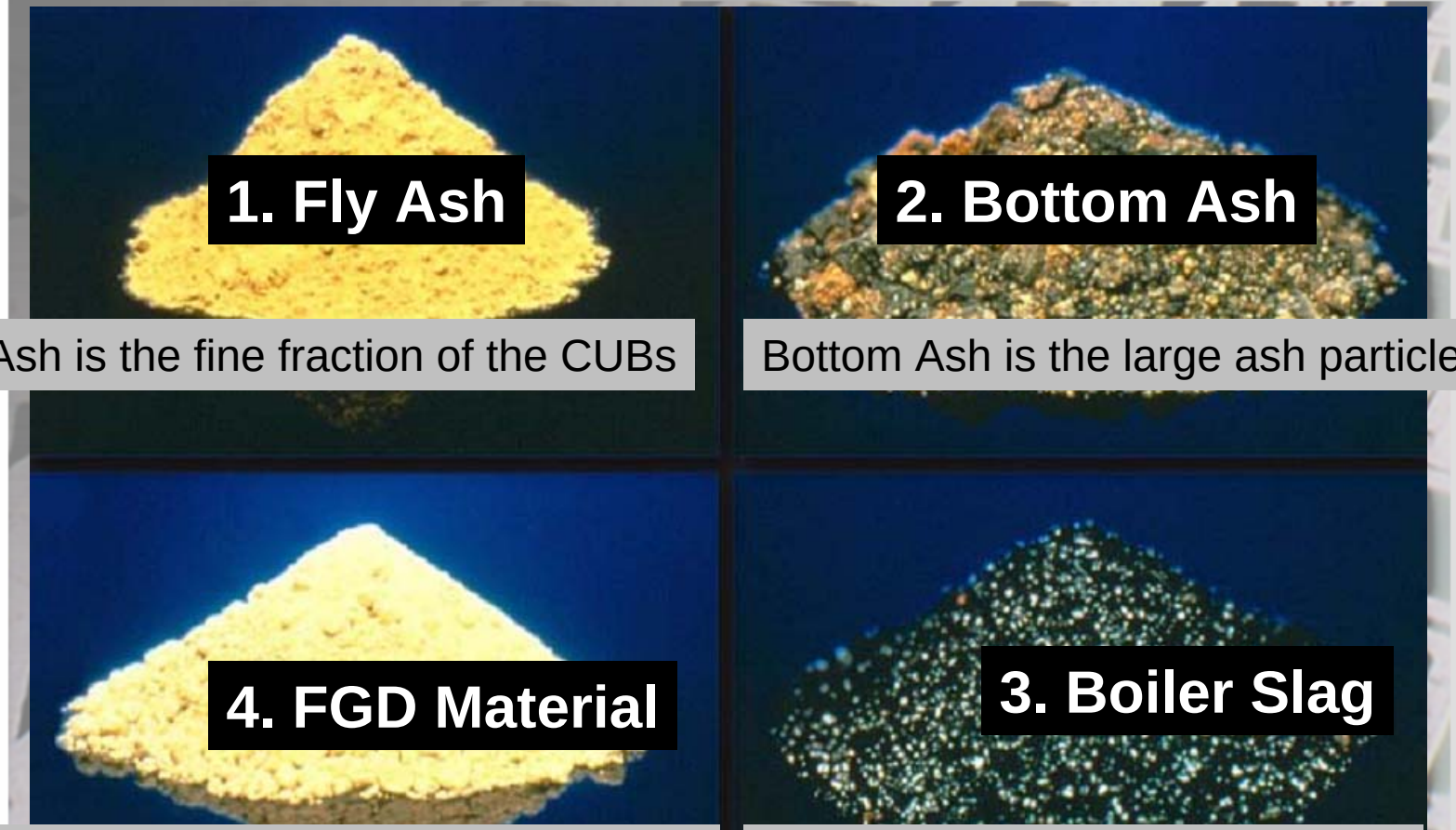
Coal Residues CUB, CCB, CCP, & FFCW

Same things but different names:

- DOE now calls them Coal Utilization By-products, CUBs (includes gasification) At one time DOE called them Coal Combustion By-products, CCB
- Utility industry tends to use the term Coal Combustion Products, CCP
- EPA tends to use the term Fossil Fuel Combustion Wastes, FFCW

Residues are products when utilized & wastes when disposed of

Coal Utilization By-Products, CUBs



Fly Ash is the fine fraction of the CUBs

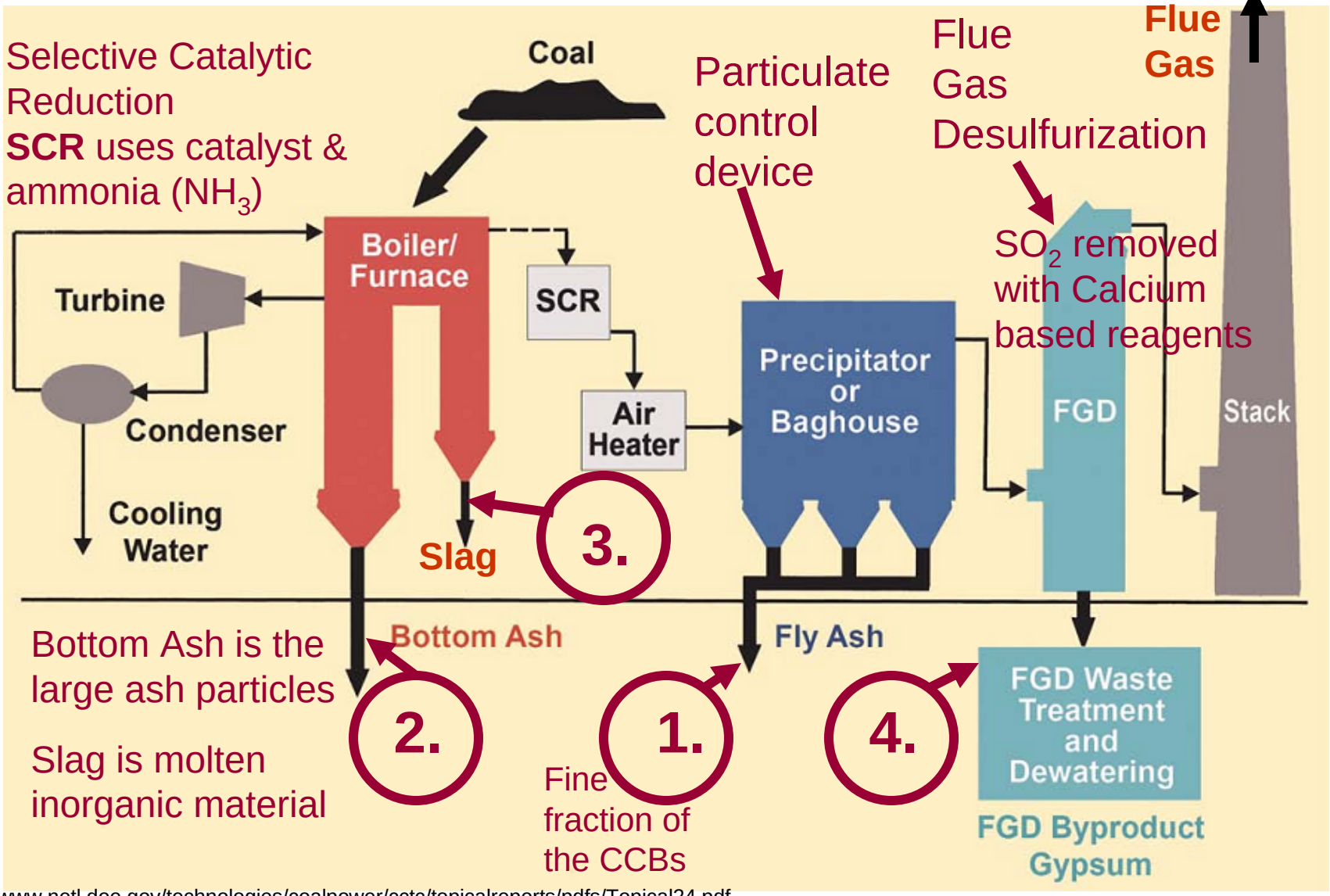
Bottom Ash is the large ash particles

Flue Gas Desulfurization material is Synthetic Gypsum, a mixture of gypsum ($CaSO_4$) and calcium sulfite ($CaSO_3$)

Slag is molten inorganic material

Source: http://www.fossil.energy.gov/programs/sequestration/publications/programplans/2006/2006_sequestration_roadmap.pdf

Typical Coal-Fired Steam Generating System



Source: http://www.netl.doe.gov/technologies/coalpower/cctc/topicalreports/pdfs/Topical24.pdf

CUBs in the U.S.

2005		
CUB	MTons	% of Total
1. Fly Ash	71.1	57.7%
2. Bottom Ash	17.6	14.3%
3. Boiler Slag	2.67	1.6%
4. FGD Material	31.1	25.3%

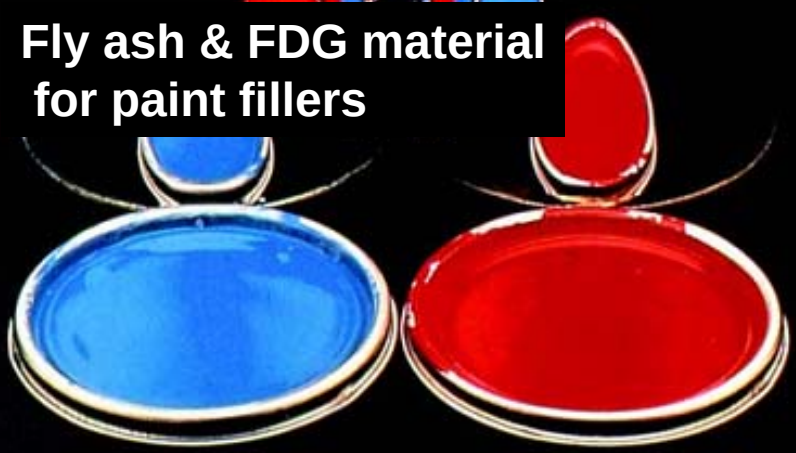
Most common & economical use of fly ash is the manufacture of concrete & concrete products

Sources: http://www.netl.doe.gov/technologies/coalpower/cctc/topicalreports/pdfs/Topical24.pdf
http://www.acaa-usa.org/PDF/2005_CCP_Production_and_Use_Figures_Released_by_ACAA.pdf
http://www.fossil.energy.gov/programs/sequestration/publications/programplans/2006/2006_sequestration_roadmap.pdf

Fly Ash in manufacture of pre-cast concrete pipes

FGD Material, Synthetic Gypsum for production of wallboard

Fly ash & FDG material for paint fillers



Most common use of boiler slag roofing granules

Source: http://www.netl.doe.gov/technologies/coalpower/cctc/topicalreports/pdfs/Topical24.pdf

Global Usage of CUBs

1999 Percentages

United States	30%
Canada	27%
Europe	56%
Japan	84%
India	13%

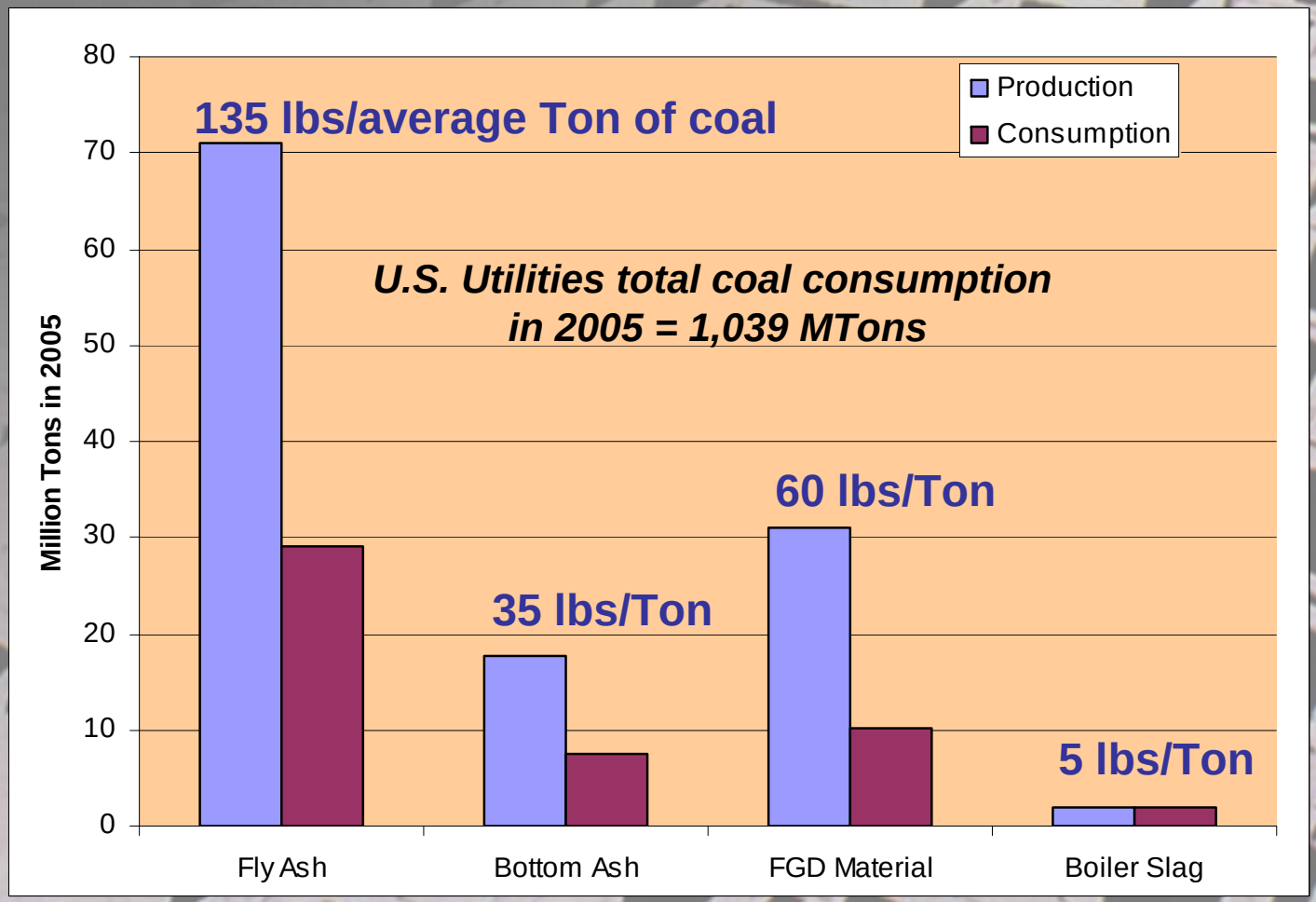
Europe - Material shortages & state regulations

Japan - High cost of disposal

India - Large amounts & high ash content

Source: http://www.fossil.energy.gov/programs/sequestration/publications/programplans/2006/2006_sequestration_roadmap.pdf

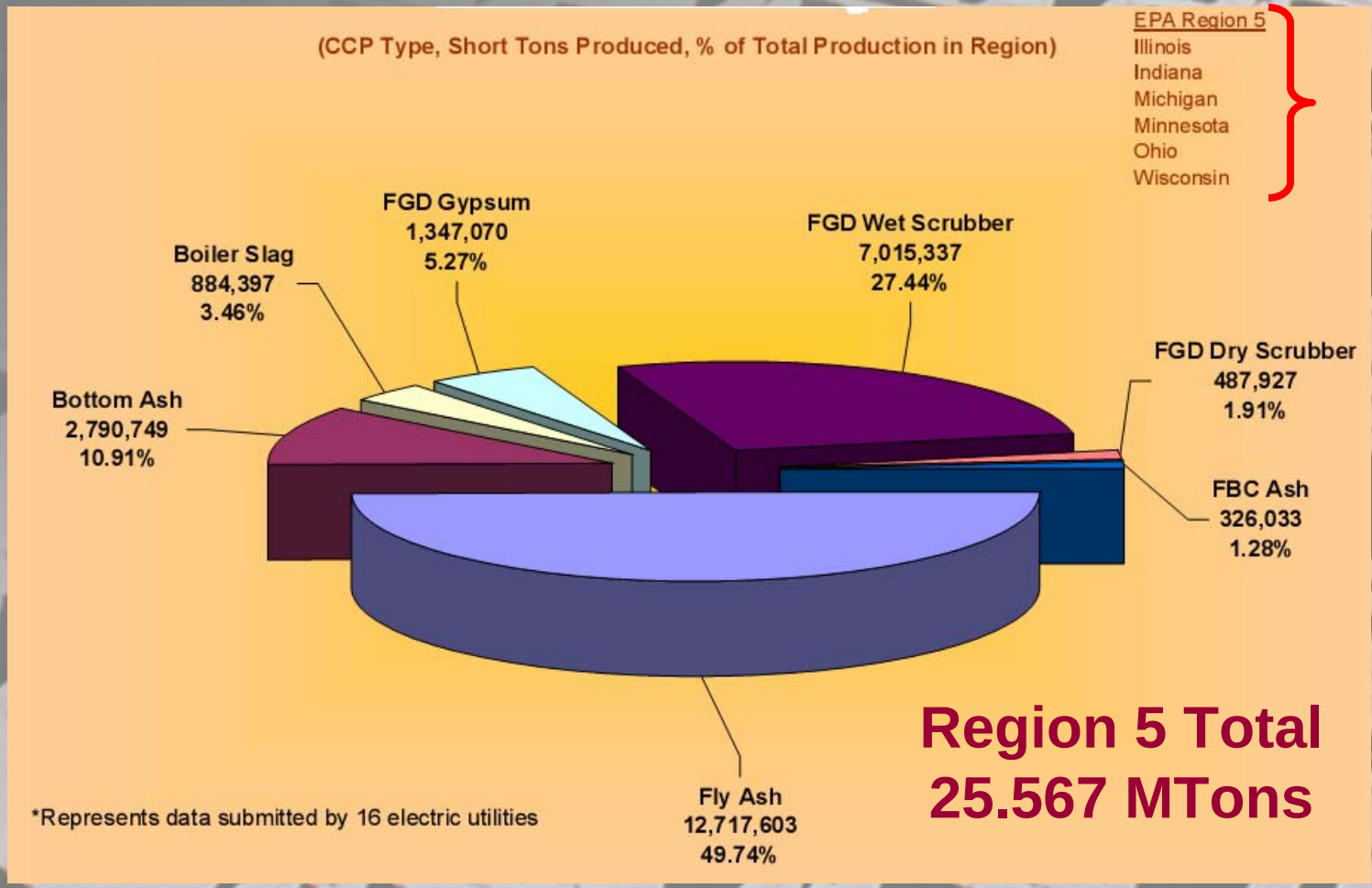
U.S. CUBs Produced & Consumed, 2005



http://www.acaa-usa.org/CCPSurveyShort.htm http://www.eia.doe.gov/emeu/aer/txt/stb0703.xls

http://www.fossil.energy.gov/programs/sequestration/publications/programplans/2006/2006_sequestration_roadmap.pdf

Midwest CUBs Produced, 2004 EPA Region 5



http://www.acaa-usa.org/PDF/Charts_Ash_Production_EPA_Rgns_1-10.pdf

http://www.fossil.energy.gov/programs/sequestration/publications/programplans/2006/2006_sequestration_roadmap.pdf

Indiana's CUBs Produced & Consumed 1999

CUB	Production MTons	Consumption MTons	Percentage Consumed
Fly Ash	3.287	1.130	34%
Bottom Ash	1.162	0.497	43%
FGD Materials	3.779	1.839	49%
Total	**8.229**	**3.466**	**42%**

Compared with 30% national average

Source: Maria Mastalerz, "Characteristics of Indiana's Coal Resource", August 2004

http://www.fossil.energy.gov/programs/sequestration/publications/programplans/2006/2006_sequestration_roadmap.pdf

Boilers & Ash By-Products

In general, there are 3 types of coal-fired boiler furnaces used in the electric utility industry

They are referred to as:

1. **Dry-bottom boilers**
2. **Wet-bottom boilers**
3. **Cyclone furnaces**

http://www.fossil.energy.gov/programs/sequestration/publications/programplans/2006/2006_sequestration_roadmap.pdf

Boilers & Ash By-Products

The most common type of coal burning furnace is the dry-bottom boiler with fly ash constituting the major ash component at 80-90% with bottom ash in the range of 10-20%

Wet bottom boilers yield molten ash, or slag from furnace bottom which drops into a water-filled hopper

Mercury in CUBs

About 75 Tons of Hg are found in coal delivered to U.S. power plants/year & about two thirds is emitted to the air, resulting in 50 Tons of Hg emissions. The 25 Ton reduction is achieved in the power plant through existing pollution controls such as:

Scrubbers for SO_2
SCRs for NOx
& PM fabric filters

Three Forms of Mercury Emissions

Mercury is present in the flue gas in varying percentages of the three general forms: (1) Particulate-bound mercury, (2) Oxidized mercury (primarily Mercuric Chloride – $HgCl_2$), & (3) Elemental mercury

Oxidized Hg is water-soluble. A small amount of the oxidized Hg ends up in water & may be formed into an organic form called **Methylmercury -** type eaten by fish

http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/pdf/mercury_%20FGD%20white%20paper%20Final.pdf

EPA & Non-Hazardous CUBs

In its 1999 Report to Congress, the EPA determined that CUBs did not generally exhibit any of the four characteristics of a hazardous waste:

- **Corrosivity**
- **Reactivity**
- **Ignitability**
- **Toxicity**

This regulatory categorization is an important factor in minimizing the cost of disposal & to marketability

http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/pdf/mercury_%20FGD%20white%20paper%20Final.pdf

Mercury Capture Across Existing Devices

Hg capture across existing air pollution control devices (APCD) can vary significantly based on many factors:

- **Hg speciation**
- **Coal properties**
- **Fly ash properties**
- **Specific APCD configurations**

Level of control ranges from 0% to more than 90%

http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/pdf/mercury_%20FGD%20white%20paper%20Final.pdf

Mercury Removal with SCR & FDG

Selective Catalytic Reduction (SCRs) for NOx controls are effective in converting elemental Hg to oxidized Hg that can subsequently be captured in a downstream FGD absorber

The average Hg removal without SCR operation was 48% while average Hg removal with SCR operation was 89% (DOE/NETL 2006)

http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/pdf/mercury_%20FGD%20white%20paper%20Final.pdf

Mercury Oxidation at SCR

DOE & EPRI show that more than 70% of the Hg at the Selective Catalytic Reduction (SCR) device outlet can be oxidized if the coal Chlorine content is greater than about 500 ppm

http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/pdf/mercury_%20FGD%20white%20paper%20Final.pdf

Summary

The 1999 regulatory status of non-hazardous residues from coal-fired power plants is a very significant factor that impacts the cost of waste disposal & the CUBs marketability