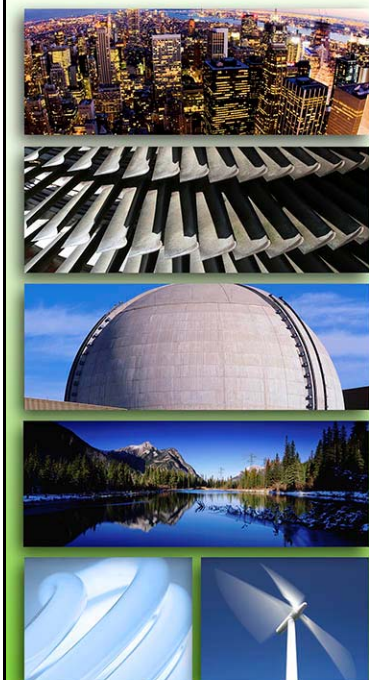

Sustainable Management of Coal Combustion Products

Recent EPRI Research

January 25, 2010

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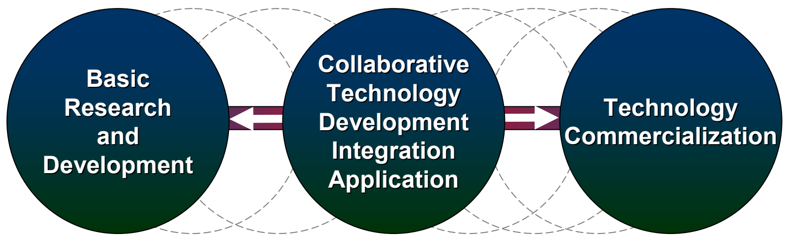
About EPRI

- Founded in 1973 as an independent, nonprofit center for public interest energy and environmental research.
- Objective, tax-exempt, collaborative electricity research organization.
- Participating companies generate over 90% of North American electricity production.
- Broad technology portfolio ranging from near-term solutions to long-term strategic research.

EPRI's Role in Technology Development

Help Move Technologies to the Commercialization Stage…



National Laboratories

Universities

EPRI

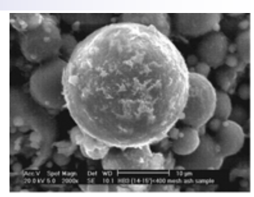
Suppliers

Vendors

Technology Accelerator

EPRI Coal Combustion Product Research

- CCP Research Program initiated in 1980 – 30 years of experience and results
- Provides utilities with information and technologies for management of CCPs
- Provides scientific information to inform policy regulatory decisions
    - Technical findings extensively cited in previous two US EPA determinations
- Current focus is to help ensure sustainable CCP management practices combining environmentally sound disposal and increased beneficial use



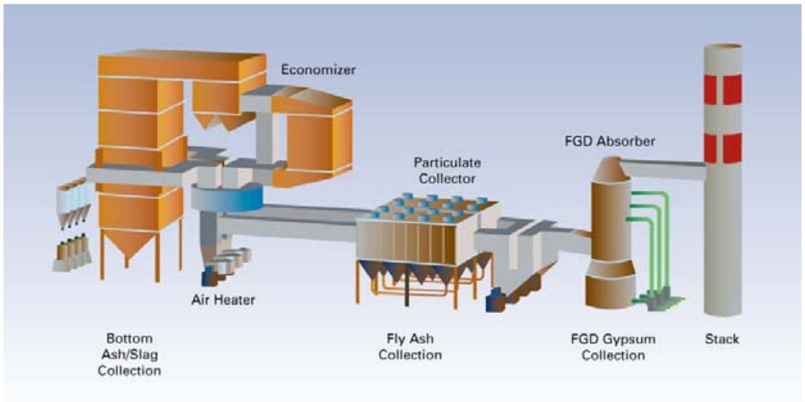
2009 Research

- Series of Fast Track Projects
  - Outreach
  - Comparison of CCPs to Other Materials
  - Risk Evaluations
  - Damage Case Assessments
  - Benefits of CCP Use
  - Cost Impacts on Grid Reliability

Primary Types of Coal Combustion Products

- **Coal Ash**
  - Fly Ash
  - Bottom Ash/ Boiler Slag
- **Wet Flue Gas Desulfurization (FGD) Materials**
  - FGD Gypsum
  - Scrubber Sludge
- **Dry FGD Materials**
  - Spray Dryer Absorber Material
  - Duct/Furnace Sorbent Injection Solids
  - Fluidized Bed Combustion Ash

CCP Generation and Collection

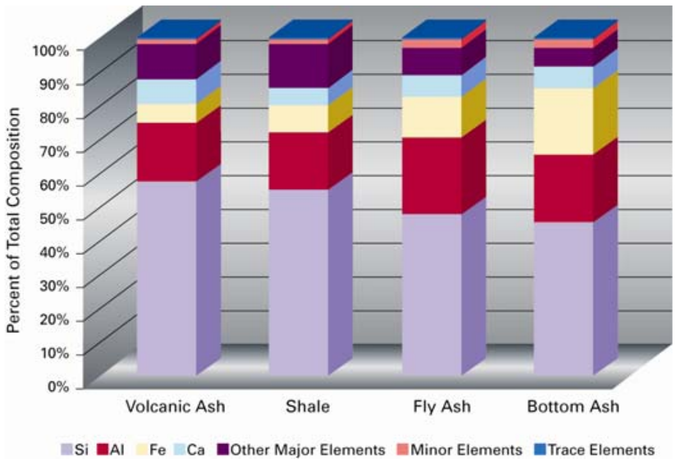


Fly ash and bottom ash make up about 73% of CCPs;
Wet FGD solids (gypsum + scrubber sludge) about 22%

Comparison of Coal Combustion Products to Other Materials

Bulk and Trace Element Composition

Overall Composition of Coal Ash is Similar to Rocks



Data Sources:
Taylor and Lichte, 1980; USGS, 1992; EPRI, 2009a

Trace elements collectively make up less than 1% of the total

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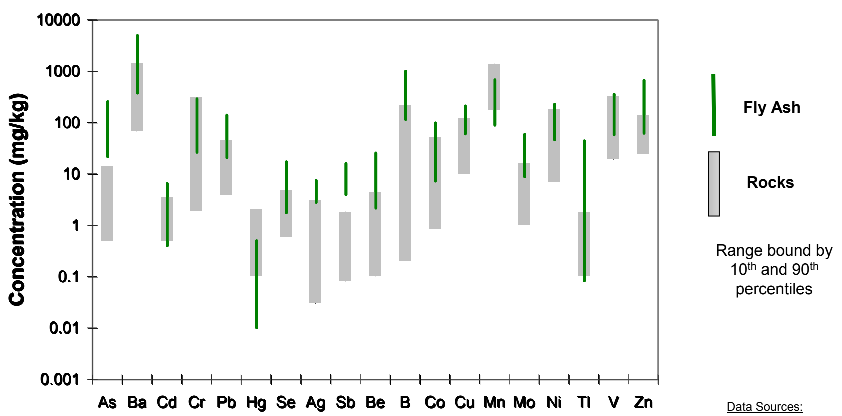
Total Composition of Trace Constituents in Fly Ash are Slightly Enriched Compared to Rocks



Data Sources:
USGS, 2008; EPRI, 2009a

For most trace constituents, only a small fraction of the total composition is leachable

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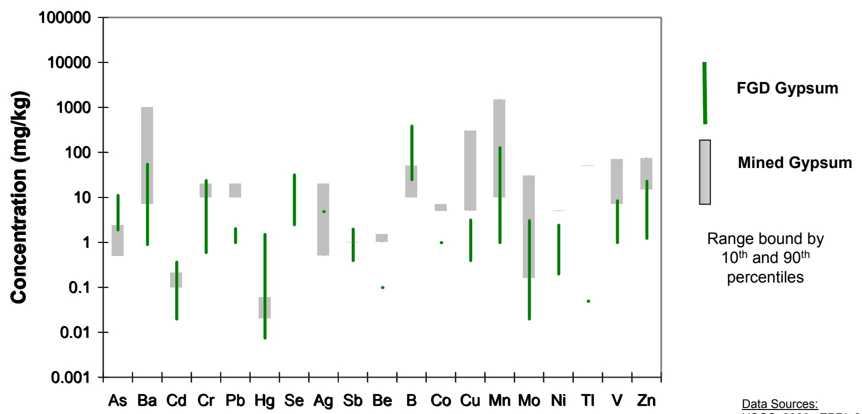
Total Composition of Most Trace Constituents in FGD Gypsum Are Within or Below Ranges in Mined Gypsum



Data Sources: USGS, 2008; EPRI, 2009a

FGD gypsum is relatively pure calcium sulfate

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Trace Element Composition Summary

Material	Fly Ash	Bottom Ash	FGD Gypsum
Rocks	Enriched	=	≤
Soils	Enriched	=	≤
Biosolids	=	=	≤
Metal Slags	=	=	≤
Fertilizers	=	=	≤

Overall, trace elements in fly ash are slightly enriched compared to geologic materials, and similar to other common materials. Trace elements in FGD gypsum are relatively low.

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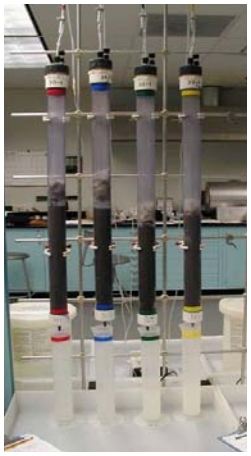
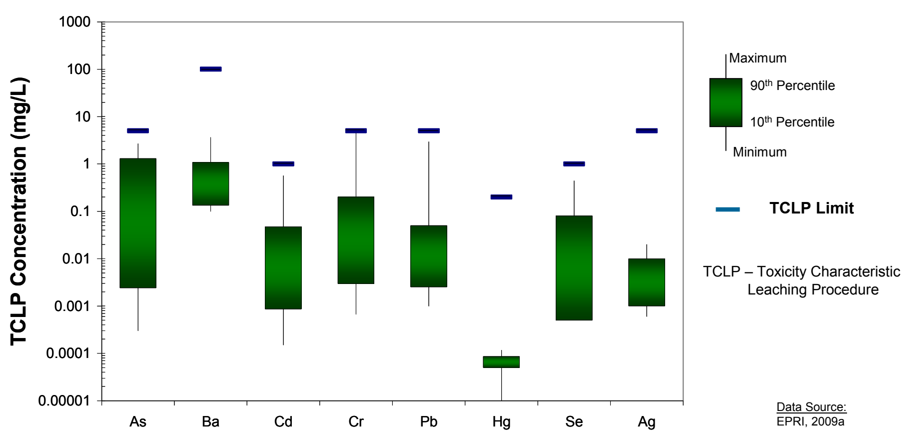


Does CCP Leachate Exhibit Hazardous Waste Characteristics?

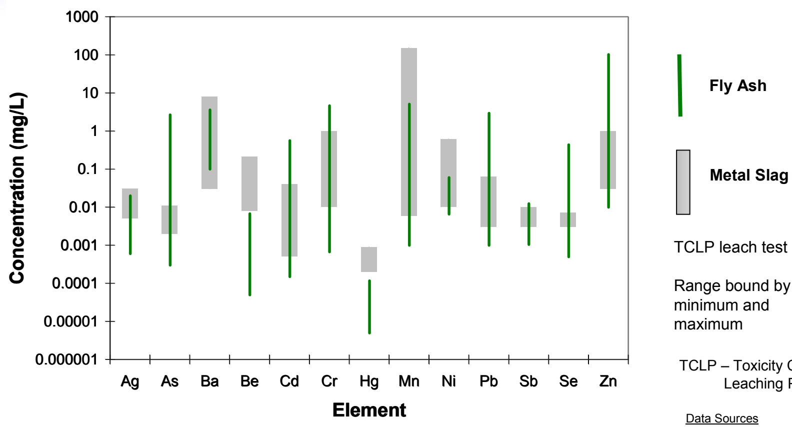
Coal Ash Leachate is Below Hazardous Waste Regulatory Limits



Data Source: EPRI, 2009a

None of 80 fly ash samples from 33 power plants in EPRI database exceeded federal hazardous waste test (TCLP) limits

Coal Fly Ash Leachate is Similar to Non-hazardous Inorganic Waste Leachate



TCLP leach test data

Range bound by minimum and maximum

TCLP – Toxicity Characteristic Leaching Procedure

Data Sources
EPRI, 2009a ; Proctor et al, 2000

Ranges for metal slag and foundry sand leachates are similar to fly ash leachate

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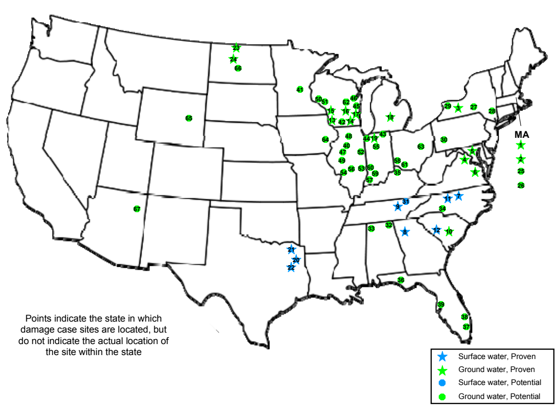
EPA Damage Cases



Total 63 Sites*

- 24 proven, 39 potential
- 9 surface water, 54 groundwater
- 71% on site facilities
- Half landfills, half impoundments

* Does not include 4 oil ash sites

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Groundwater Damage Cases Are Typically Old Sites with Limited Exposure Risk

- **Old Sites**
  - 65% - 90% began operation before 1980
  - No proven cases lined; 18% of potential cases lined
    - EPA/DOE (2006): 98% of new sites lined
- **Low Toxicity Constituents**
  - Exceedances mostly sulfate, manganese, boron
  - Only 3 sites (5%) ➔ off-site exceedances of a maximum contaminant level (MCL) in groundwater
- **Limited Exposure Risk**
  - Only ~ 1/3 sites had potential for groundwater receptors
  - Remediation in progress at 22 of 24 proven damage cases (No information on other two)

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2007 EPA Draft Screening Level Risk Assessment for CCP Disposal Sites

- EPA estimate of potential arsenic risk
  - 245 sites; landfills and ponds; with and without liners
  - Conservative inputs
  - Modeled risks as high as 2×10^{-2}
- EPRI estimate of affected population at the 245 sites
  - 85 with potential for downgradient receptors
  - 8,800 dwellings
  - 23,000 individuals

Risk levels equate to 1 additional person in the US expected to develop cancer over a 70-year lifetime (50th percentile)

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Other Potential Risk Issues Addressed by EPRI Research

Mercury

- Low concentrations, usually less than 1 mg/kg
- Very stable in fly ash at ambient temperatures
- No significant risk to public from beneficial use in wallboard, concrete, or fills

Radioactivity

- Not significantly enriched in ash relative to soil or rocks, or conventional concrete or building materials (USGS, 1997)
- For ash storage site worker, exposure from fly ash is about 2% of background radiation exposure

Windblown Ash

- Easily controlled with wetting and cover materials
- Power plant worker exposure not above health criteria, public exposure significantly less

What Are Some of the Environmental and Economic Implications of Hazardous Waste Regulation?

CCP Use Has Several Important Environmental Benefits

- Energy Savings
- Water Savings
- Reduced CO_2 Emissions
- Reduced Need for Disposal Sites
- Conservation of Natural Resources

Benefits for major uses were quantified using standard life cycle analysis tools

States, CCP marketers, trade groups, utilities, and other organizations assert that hazardous waste designation will reduce or eliminate beneficial reuse options

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Annual Benefits That May Be Lost if CCPs Are Designated a Hazardous Waste

Point of Impact	Annual Savings*	Equivalent to
Energy (trillion Btu)	159	• Annual energy use for 1.7 million households • 47% of annual wind power generation in the U.S.
Water (billion gal)	32	• 31% of domestic water withdrawals of California in 2000
CO_2 equiv. (million tons)	11	• Removal of 1.9 million cars from roadways
Land Space (million yds^3)	51	• More land area than Central Park in New York
Financial (billion $)	5.1-9.7	• Annual full-time salary of 130,000–240,000 average Americans

***Based on 2007 data for beneficial use of CCPs.**

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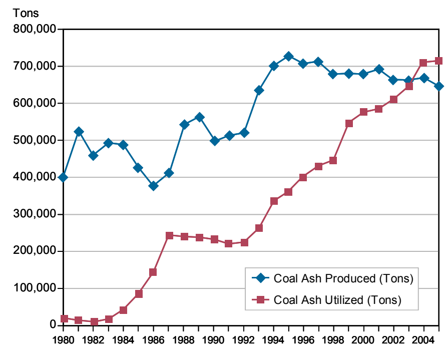
Beneficial Use Can Be Encouraged While Managing CCP Risk: Wisconsin Example

Background

- 11 sites on the damage case list, more than any other state
- Instituted non-hazardous regulation in 1988 and beneficial use regulation in 1997
- Now all active sites have liners and groundwater monitoring

Result

- Virtually eliminated groundwater issues
- Beneficial use increased dramatically



Data courtesy of We Energies

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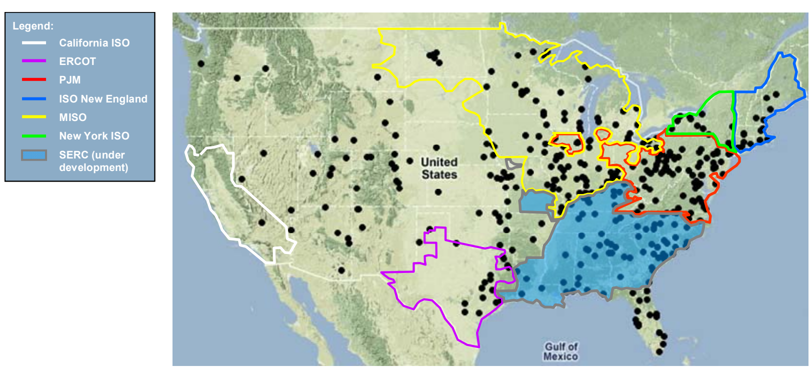
Economic Impact - Regions Modeled



Economic impact was modeled on a unit by unit basis

Regions based on North American Electric Reliability Corp (NERC), Independent System Operator (ISO), and Regional Transmission Organization (RTO) reliability regions

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Summary:
Weighing the Benefits
and the Risks

Summary

- Total Composition
  - Ash composition similar to rocks; trace metals slightly enriched
  - FGD gypsum composition very similar to mined gypsum
- Leaching
  - CCP leachate does not exceed hazardous waste limits (TCLP)
  - Ash leachate similar to non-hazardous inorganic wastes
- Proven/potential damage cases typically old, unlined
  - most pre-1980; only 3 off-site exceedances of an MCL
- Mercury and radioactivity levels in CCPs present little risk in disposal or use

Summary

- Beneficial use of CCPs yields significant savings in energy and water, and reduces CO_2 emissions
  - 2007 savings: 159 trillion Btu, 32 billion gallons, 11 million tons of CO_2e, 51 million cubic yards in land space
  - Hazardous waste designation threatens beneficial use
- High CCP management costs may impact power plant operations
  - Most important in Midwest, Mid-Atlantic, Southeast, Texas

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Together…Shaping the Future of Electricity

www.epri.com/ccp

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