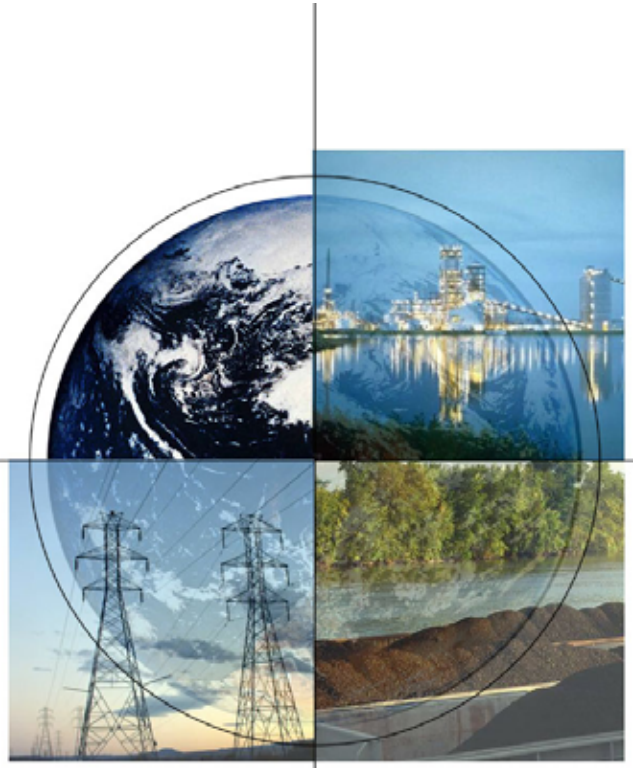
DOE Coal Utilization Byproduct (CUB) R&D Program



U.S.-India Coal Working Group
Washington, D.C.

November 18, 2005

William W. Aljoe, Project Manager
National Energy Technology Laboratory

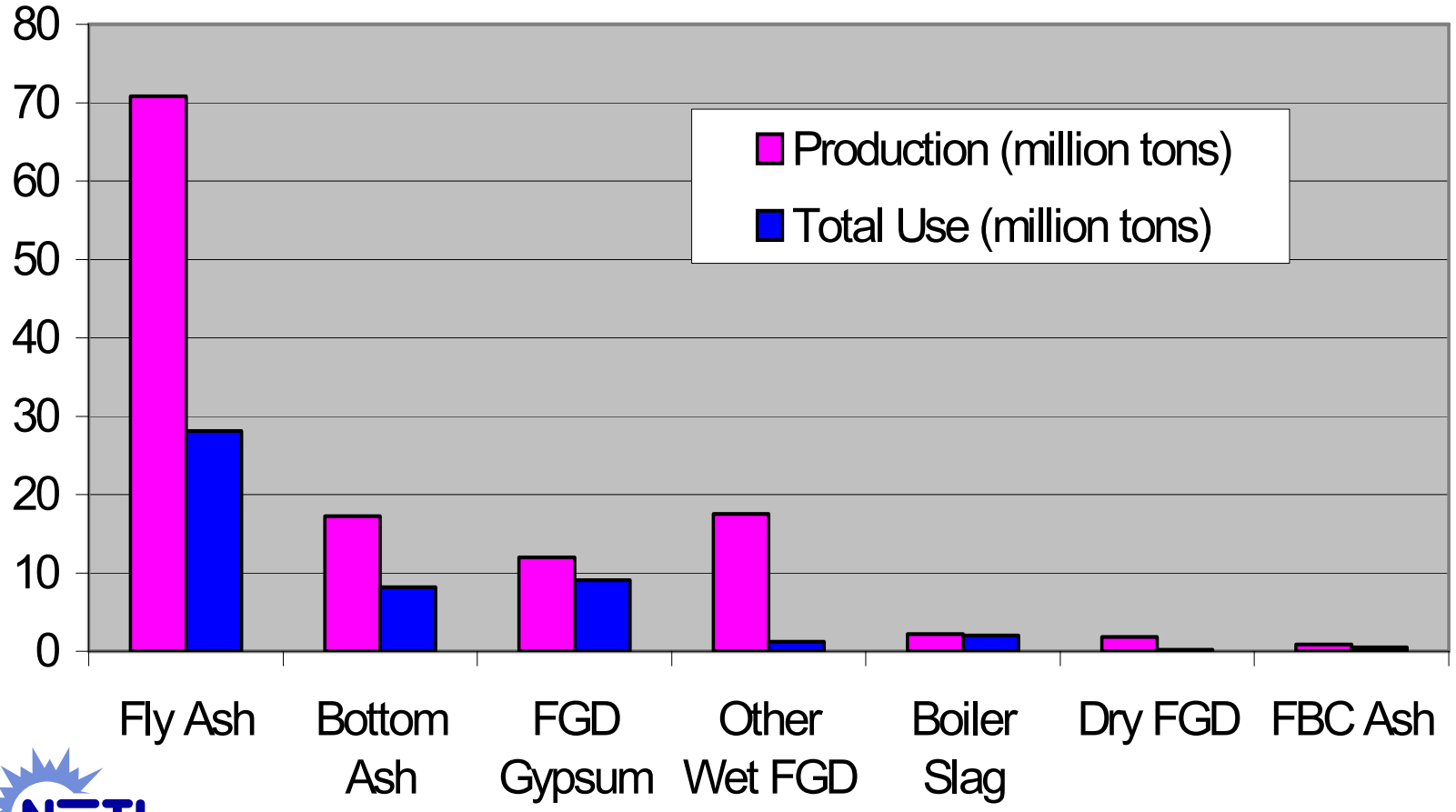
What are CUBs?

- **Coal Utilization Byproducts**
  - Includes Fly ash, Bottom ash, FGD solids
  - Many other acronyms: CCBs, CCPs, CCW, FFCW, CCR ...
- **Utilization includes:**
  - Combustion
  - Gasification & Hybrid systems
- **Byproducts because:**
  - $ from electricity sales >> $ from CUB sales
  - “Products” when sold or beneficially used
  - “Wastes” when sent to a permanent disposal site
    - Can still become “products” after disposal

U.S. CUB Production and Use – 2004

(Data from American Coal Ash Association)

2004	Fly Ash	Bottom Ash	FGD Gypsum	Other Wet FGD	Boiler Slag	Dry FGD	FBC Ash	Total
Production (million tons)	70.8	17.2	12.0	17.5	2.2	1.8	0.9	122.5
Total Use (million tons)	28.1	8.2	9.0	1.2	2.0	0.2	0.5	49.1
Percent of production utilized	39.6%	47.4%	75.7%	6.8%	89.6%	9.7%	54.6%	40.1%



>40% Overall Utilization in 2004

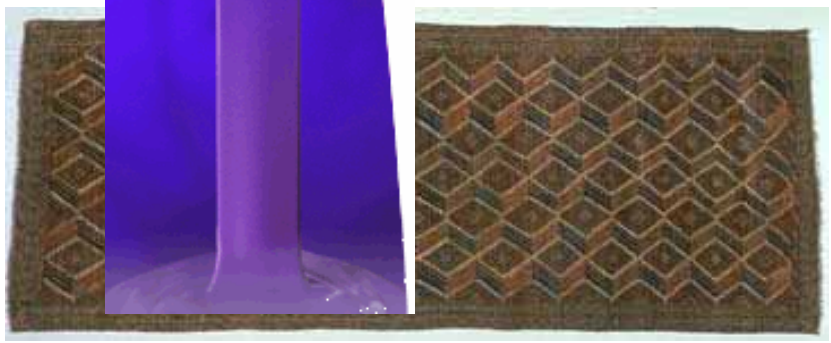
Near-term Goal for CUB Utilization

- **Increase overall beneficial utilization of CUBs to 50% by 2010**
  - Will require collaborative effort by Government & Industry
  - Must overcome economic, perceptual & regulatory barriers

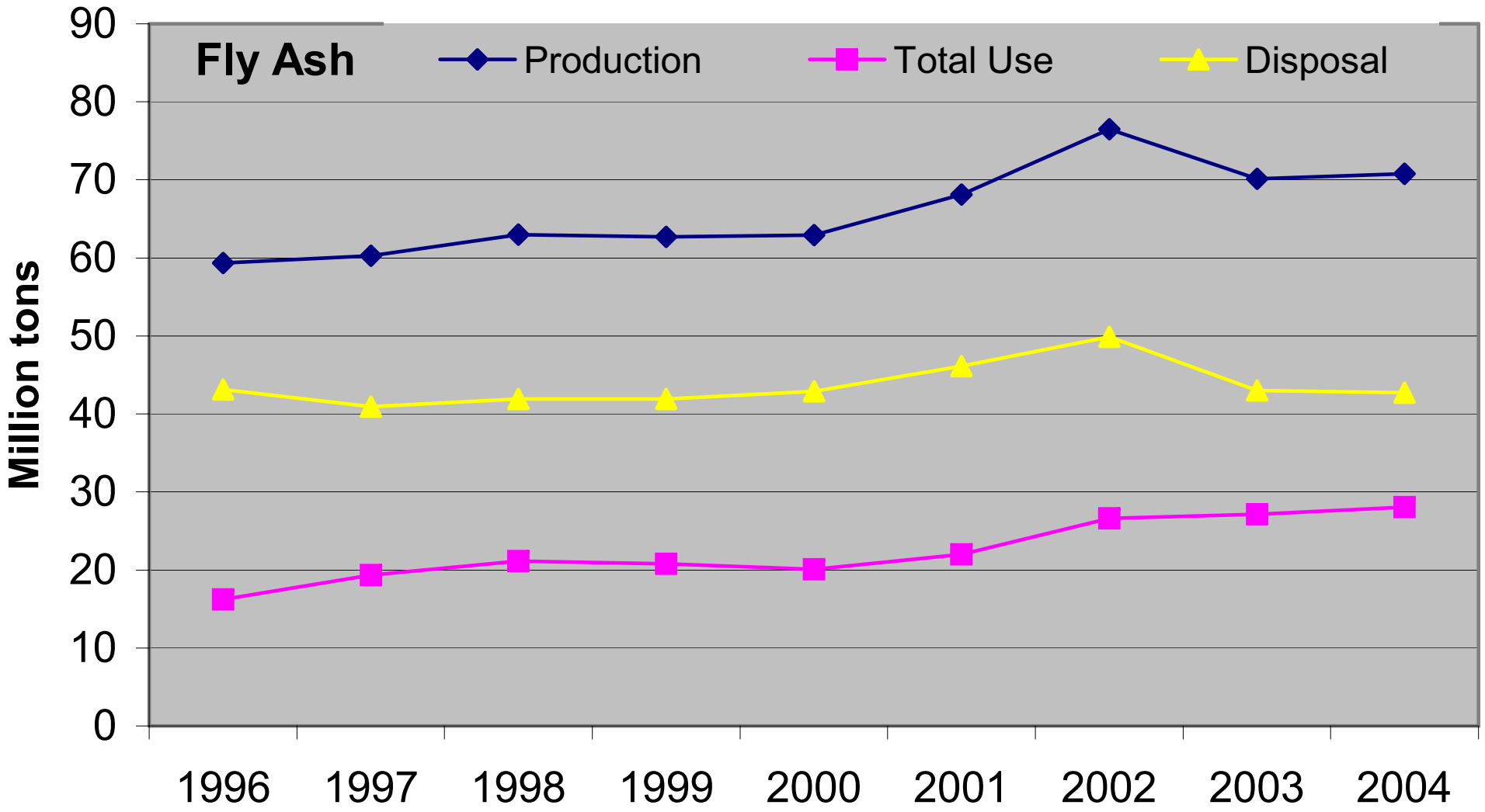
Many Uses for Coal Utilization Byproducts

- Drywall
- Cement & Concrete
- Structural fill
- Bowling balls
- Wall paints
- Carpeting
- Synthetic tiles
- AMD control
- Soil amendments

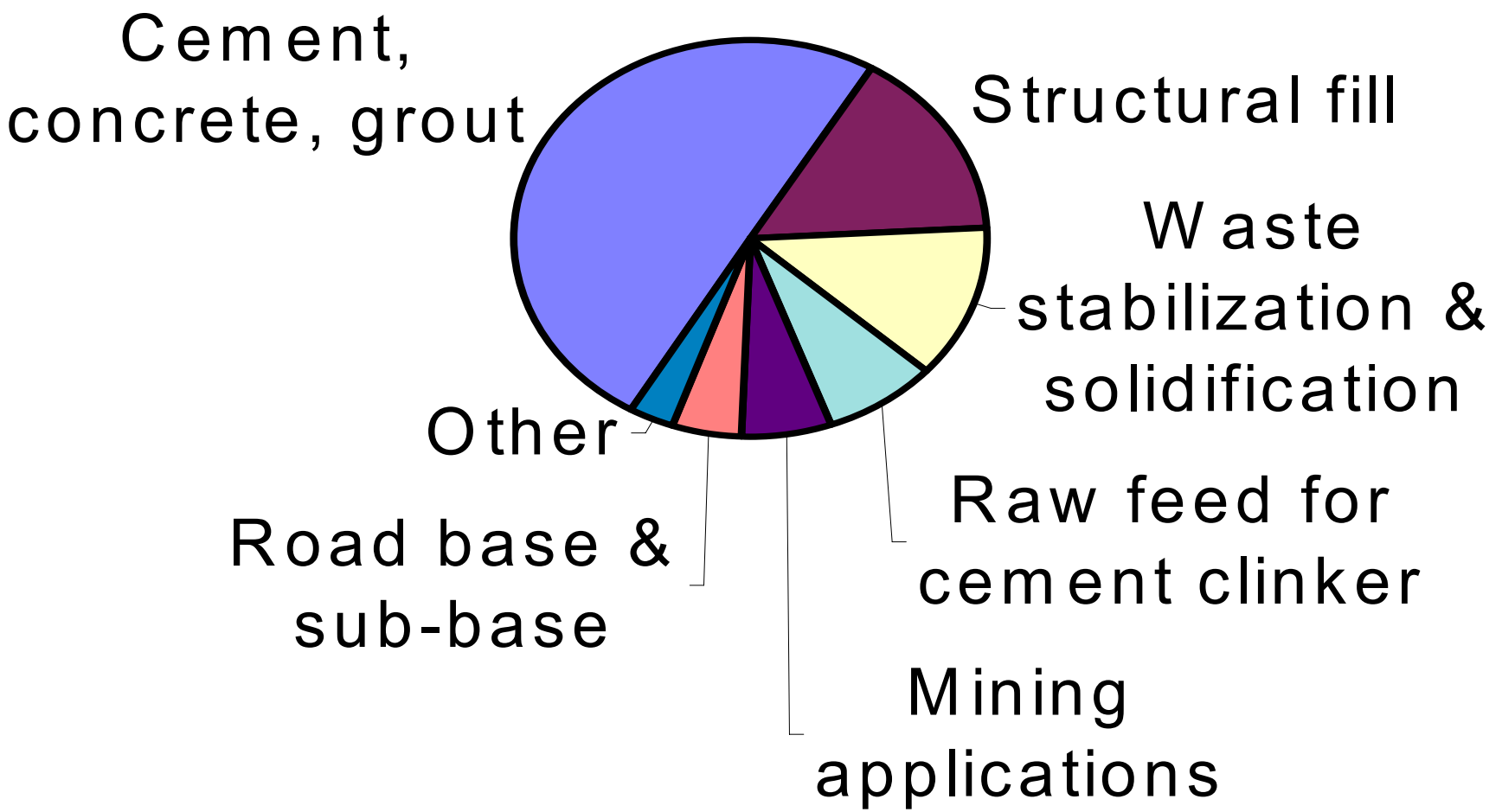
Fort Mandan Visitor Center



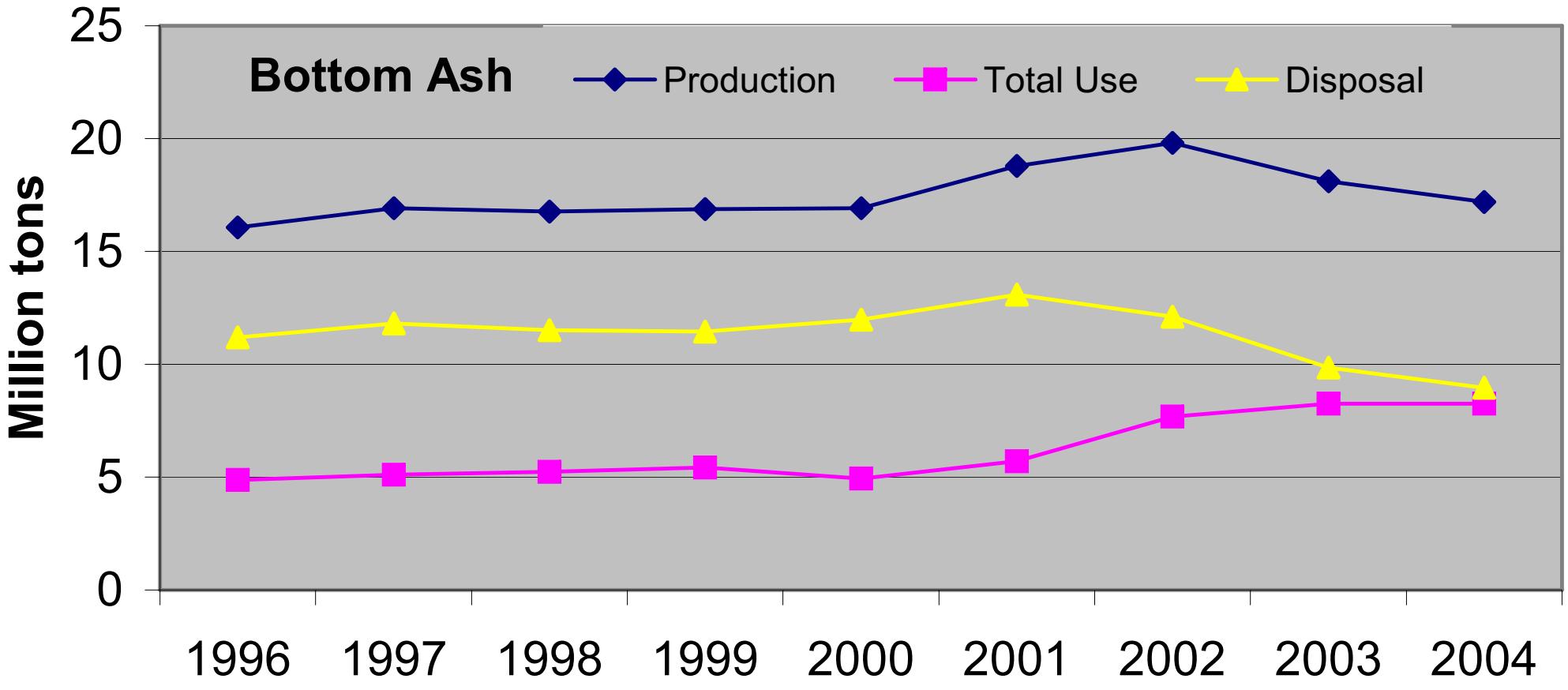
Trends in Fly Ash Production & Use



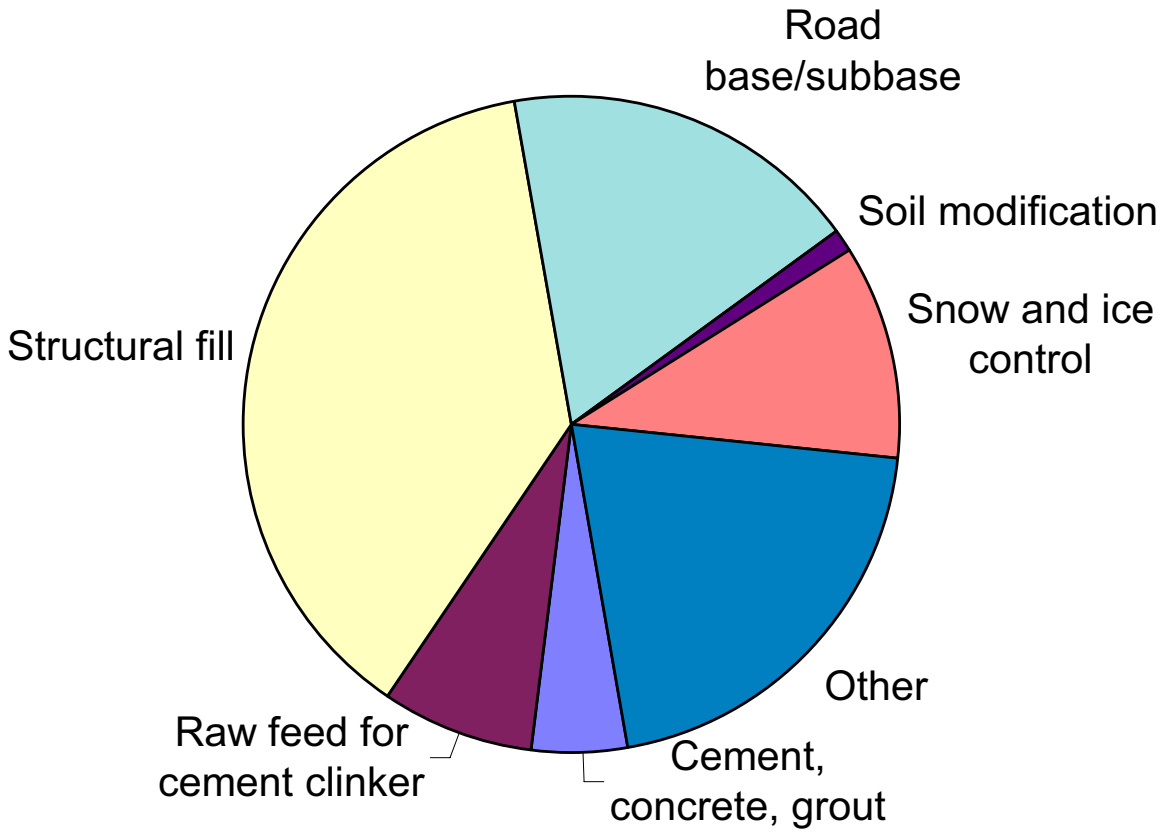
Trends in Fly Ash Production & Use



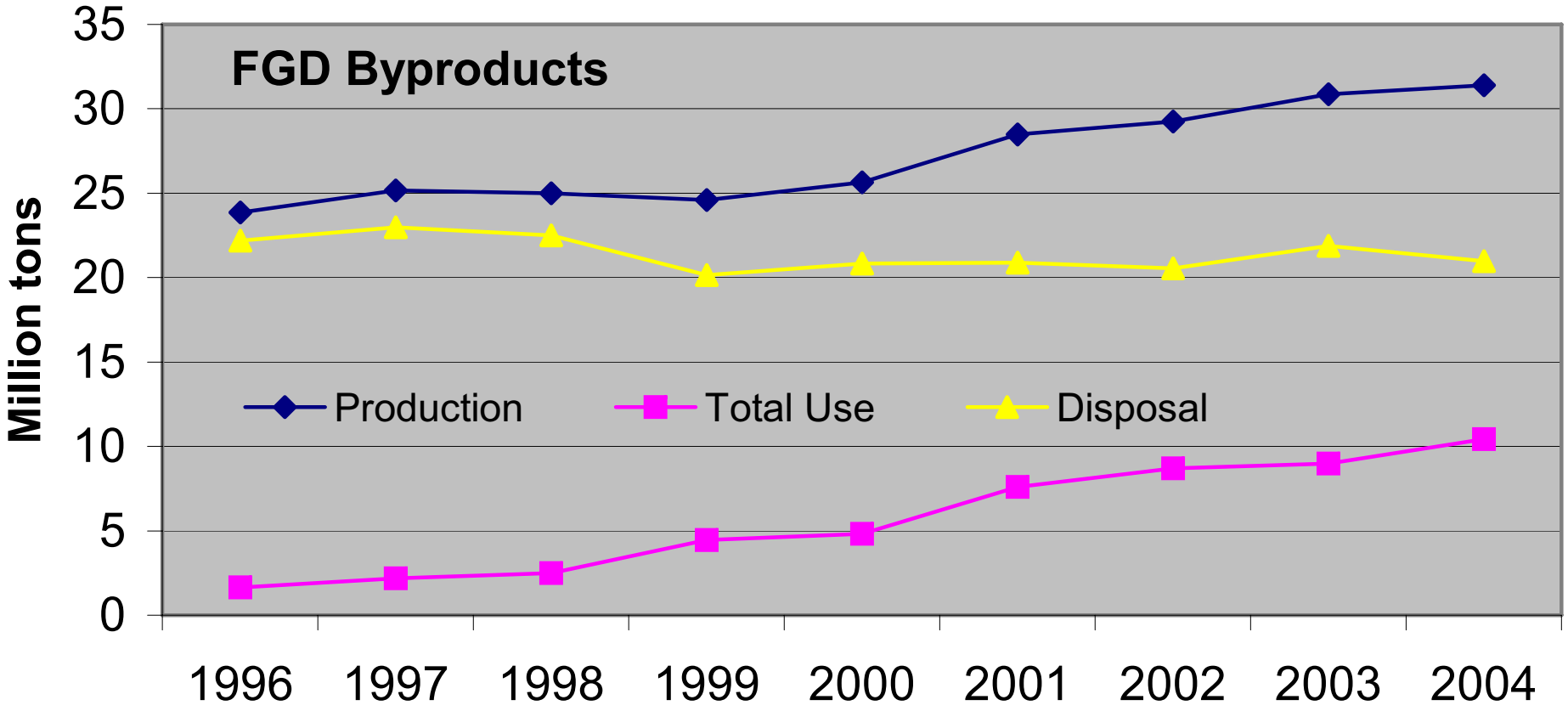
Trends in Bottom Ash Production & Use



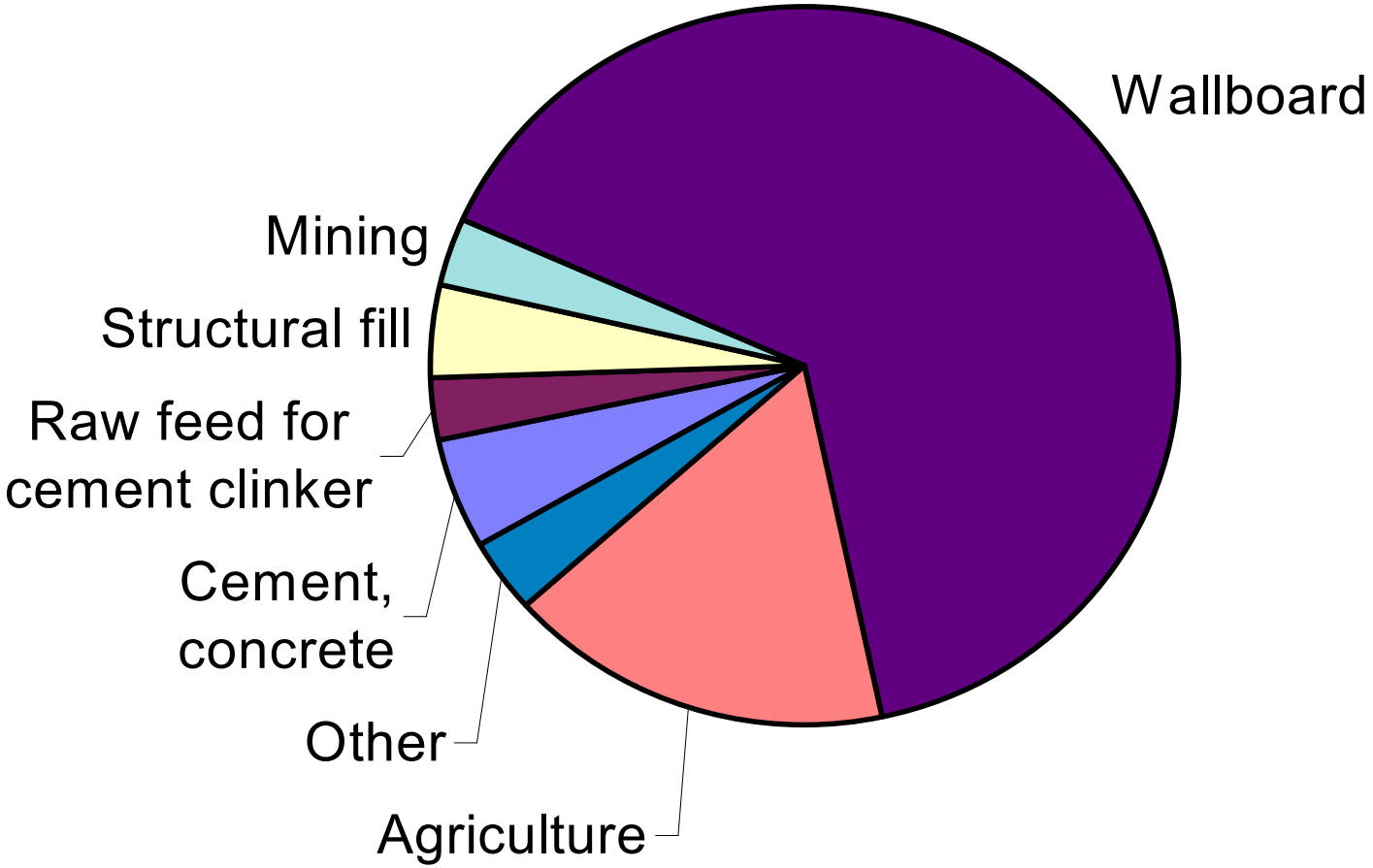
Trends in Bottom Ash Production & Use



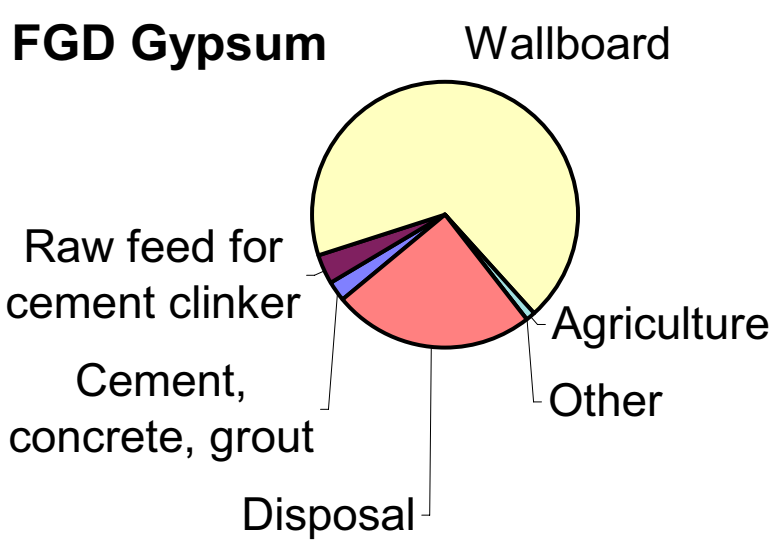
Trends in FGD Byproduct Production & Use

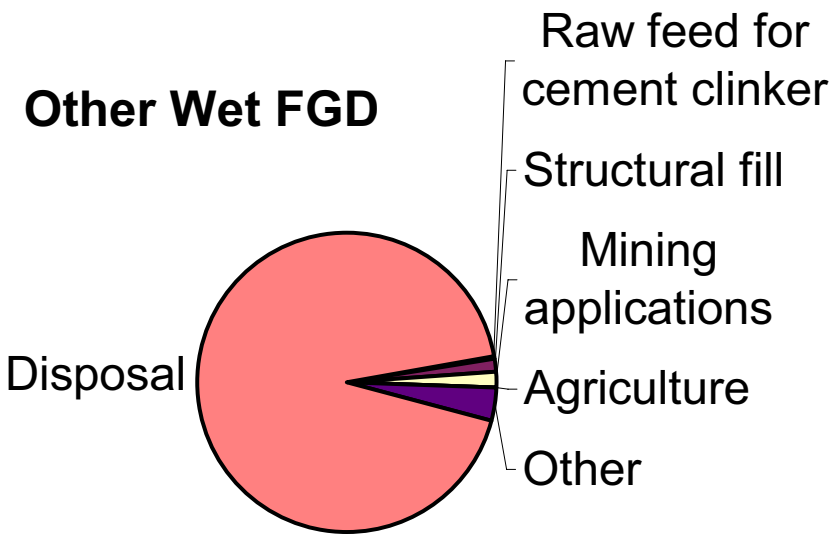


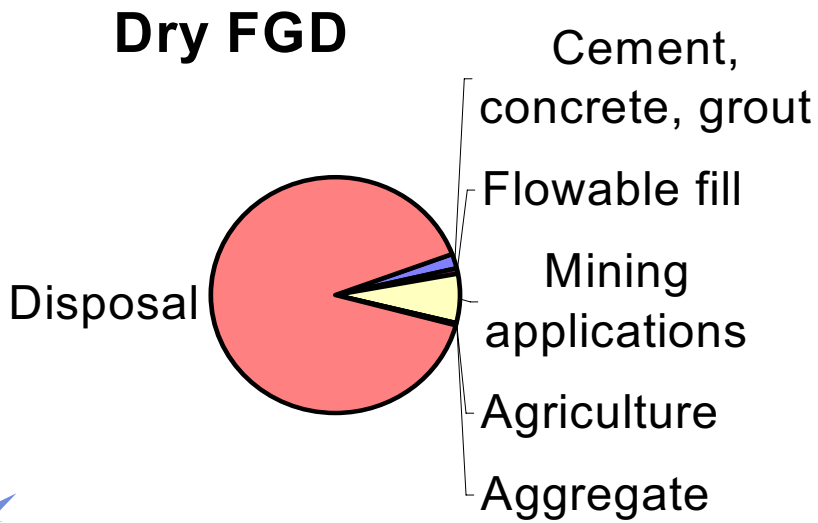
Trends in FGD Byproduct Production & Use

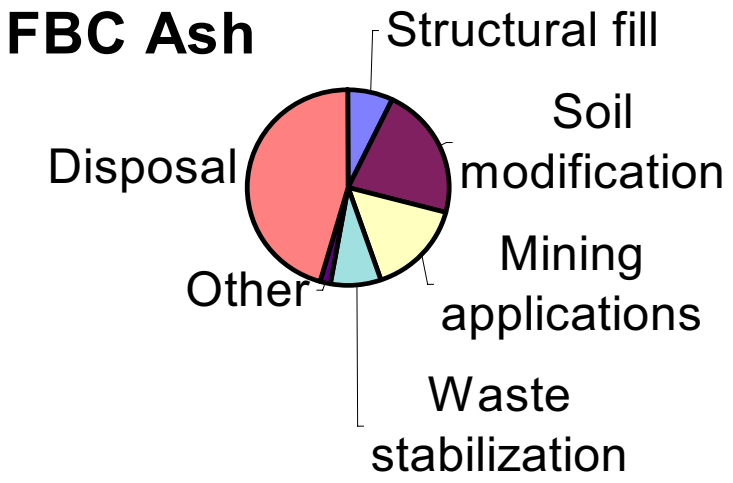


FGD Byproducts: Use by Type (2004)









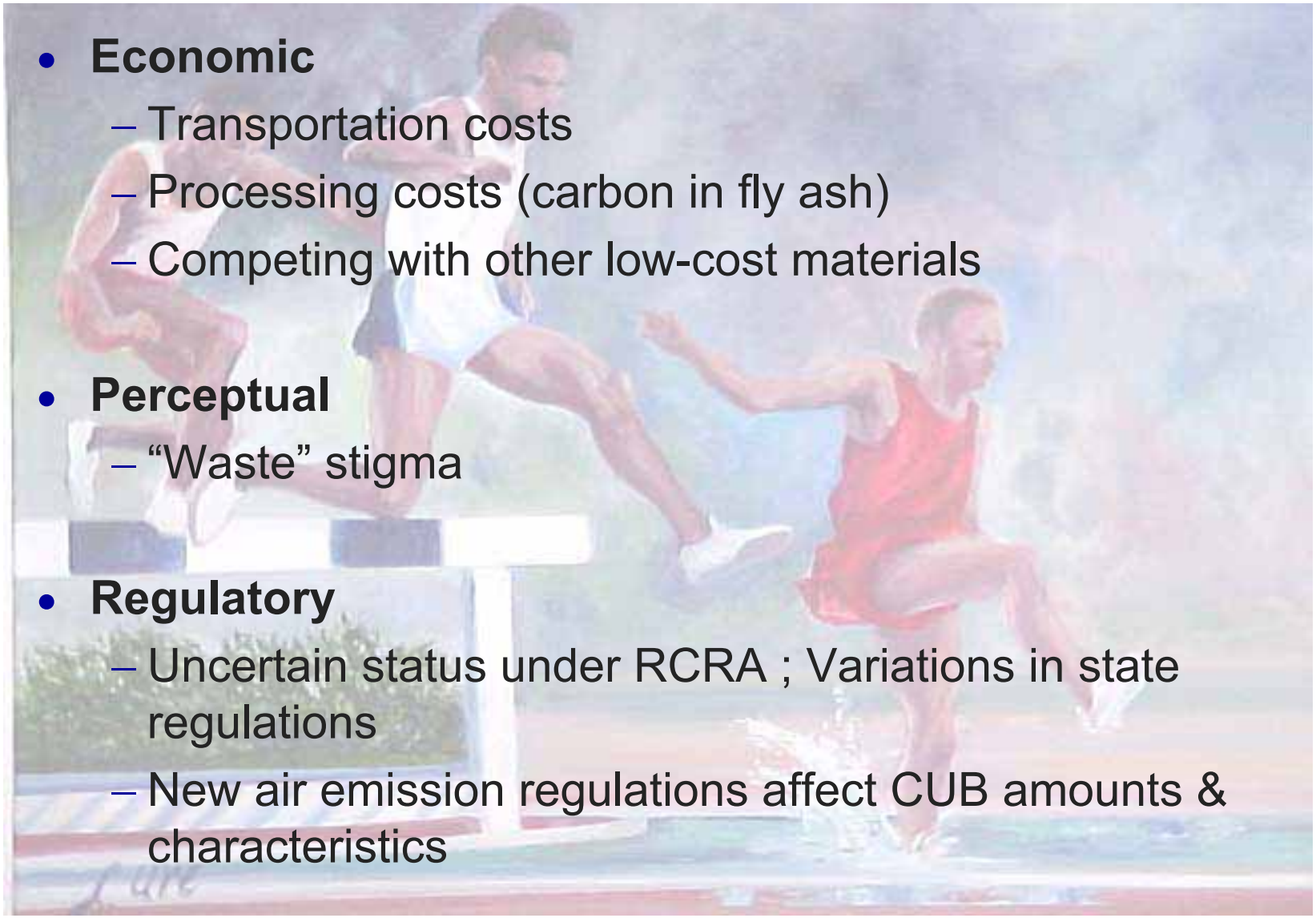
Multiple Benefits of Using CUBs

- **Environmental**
  - Reduced greenhouse gas emissions
    - 1 ton of fly ash as cement replacement = 0.8 tons of CO_2 avoided
  - Reduced land disposal requirements

- **Economic**
  - Avoid disposal costs
  - Revenue from sale of byproducts

- **Performance**
  - Enhance physical and chemical characteristics, e.g., increased strength, improved workability

Barriers to CUB Utilization



- **Economic**
  - Transportation costs
  - Processing costs (carbon in fly ash)
  - Competing with other low-cost materials
- **Perceptual**
  - "Waste" stigma
- **Regulatory**
  - Uncertain status under RCRA ; Variations in state regulations
  - New air emission regulations affect CUB amounts & characteristics

EPA Regulations Introduce Additional Challenges to CUB Utilization

- **RCRA Subtitle D Rules (Landfills, impoundments)**
- **Minefill: is it Utilization or Disposal? (NAS Study)**
- **CAIR = More FGD Byproducts**
  - Will wallboard market continue to absorb excess?
  - Can new large-volume markets be developed?
    - PRB coal = dry FGD (unsuitable for wallboard)
- **CAIR = More Low-NOx burners, SCR, SNCR**
  - Will additional carbon/NH_3 in fly ash disrupt or prevent expansion of current cement/concrete markets?
- **CAMR: Additional Hg in CUBs**

Coal Combustion Products Partnership (C^2P^2)

- **Government-Industry partnership to promote the beneficial use of Coal Combustion Products (CCPs)**
  - Led by U.S. EPA Office of Solid Waste
    - U.S. Agency Charter Members: DOE and FHWA
    - Industry: American Coal Ash Association, Utility Solid Waste Activities Group
- **Major Activities**
  - Awards program: "C^2P^2 Partners"
  - Regional Workshops
- **Website: http://www.epa.gov/c2p2/**

CUB Reuse: Economics 101

- **Producer (Utility) Perspective:**
  - Recycling occurs when cost of reuse < Cost of disposal
    - In theory: new technology reduces cost of reuse
    - In practice: reuse becomes “economical” when disposal costs rise

- **User Perspective:**
  - Recycling occurs when cost of reuse < cost of alternative materials
    - Need specifications for reuse (not always available)
    - Need consistent supply and quality of material
    - Need support from material supplier

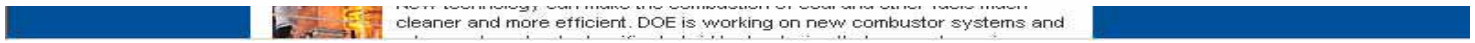
CUBs in Fossil Energy's R&D Programs

Clean Coal Technology & the President's Initiative

DOE is implementing President Bush's $2 billion, 10-year initiative to develop an improved generation of coal-based electric power and pollution control technologies that will be environmentally superior to the technologies used in today's power plants. Read More > **Large-scale Demonstrations**

Pollution Control Innovations for Today's Power Plants

With the President's *Clear Skies Initiative* calling for major reductions in power plant air emissions, DOE is developing new pollution control technologies that can meet tighter standards without resulting in major cost increases for ratepayers. Read More > **Basic and Applied R&D (small scale)**

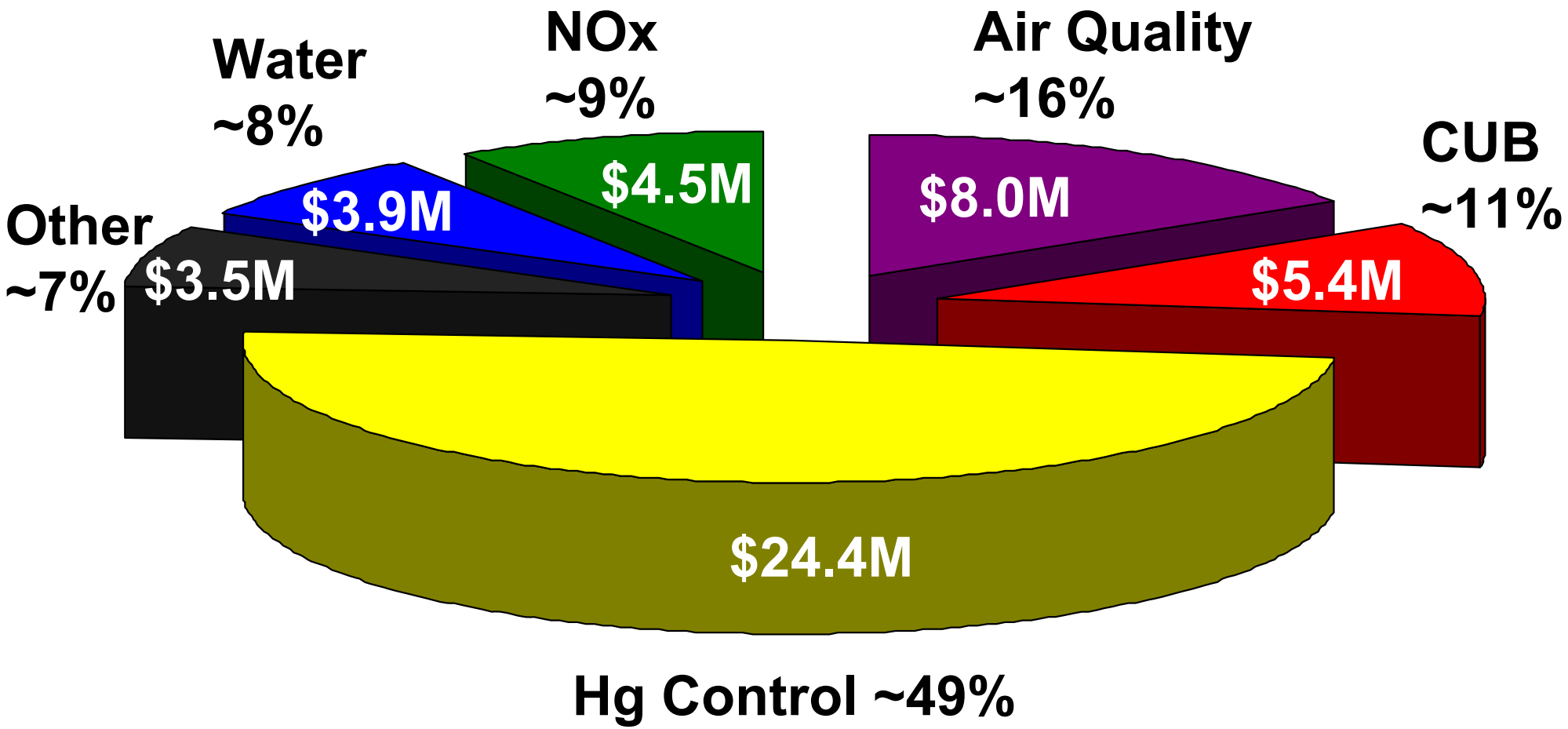


Program Implementation: National Energy Technology Laboratory (NETL)

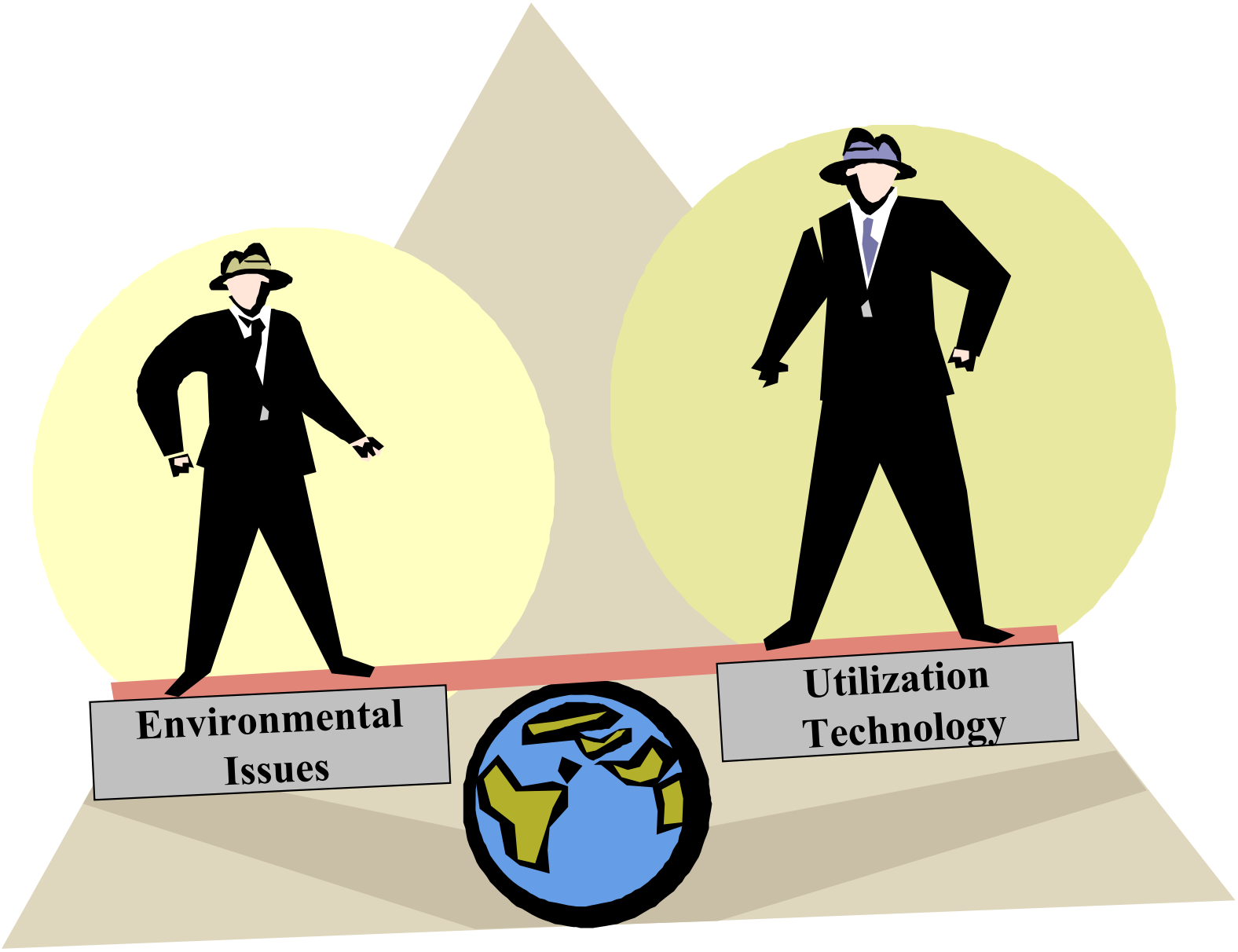
- **One of DOE's 17 national labs**
  - Government owned / operated
- **Funding: DOE Office of Fossil Energy**
  - Other Federal agencies & private collaborators
- **Sites in PA, WV, OK, AK**
- **R&D Implementation**
  - External contracts & grants
  - In-house research

Innovations for Existing Plants

Extramural Funding, FY03–05 ~ $49M

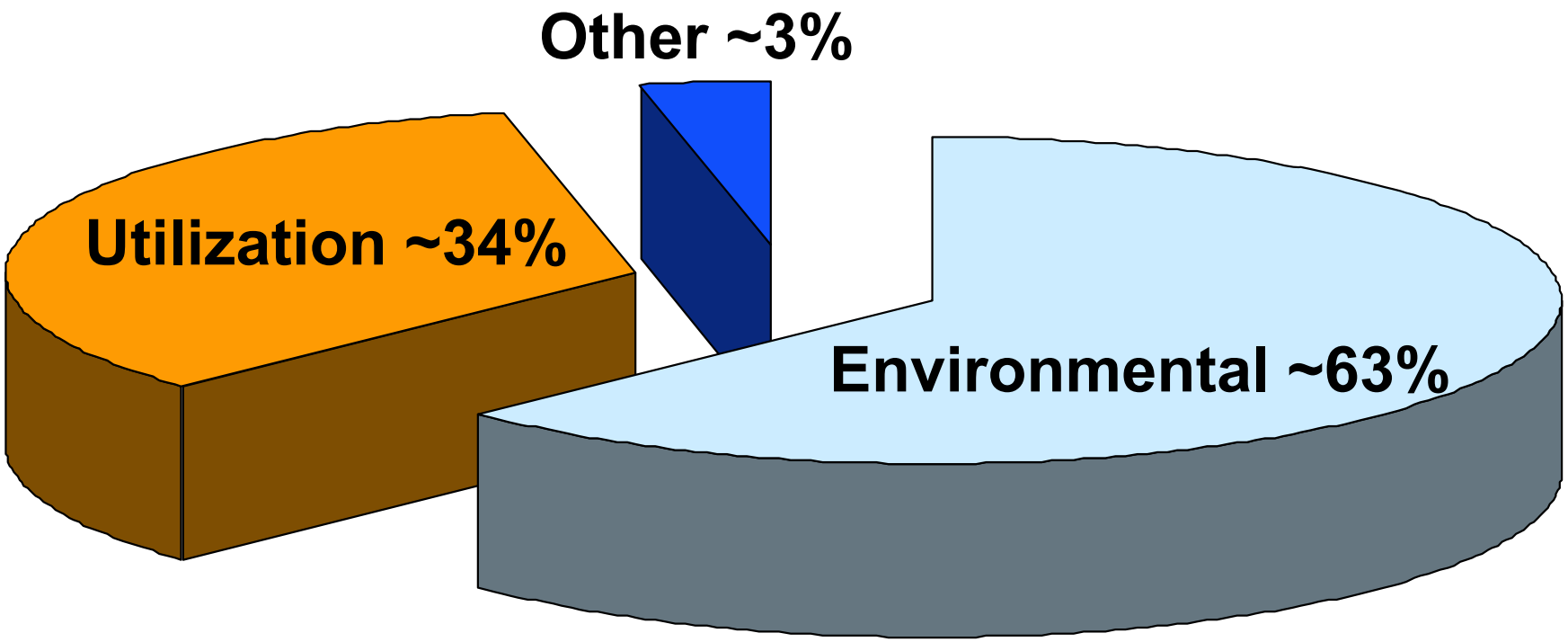


CUB R&D Priorities: Environmental vs. Utilization



NETL IEP-CUB Funding, FY03-05

Environmental vs. Utilization



* Does not include In-house or CBRC Projects

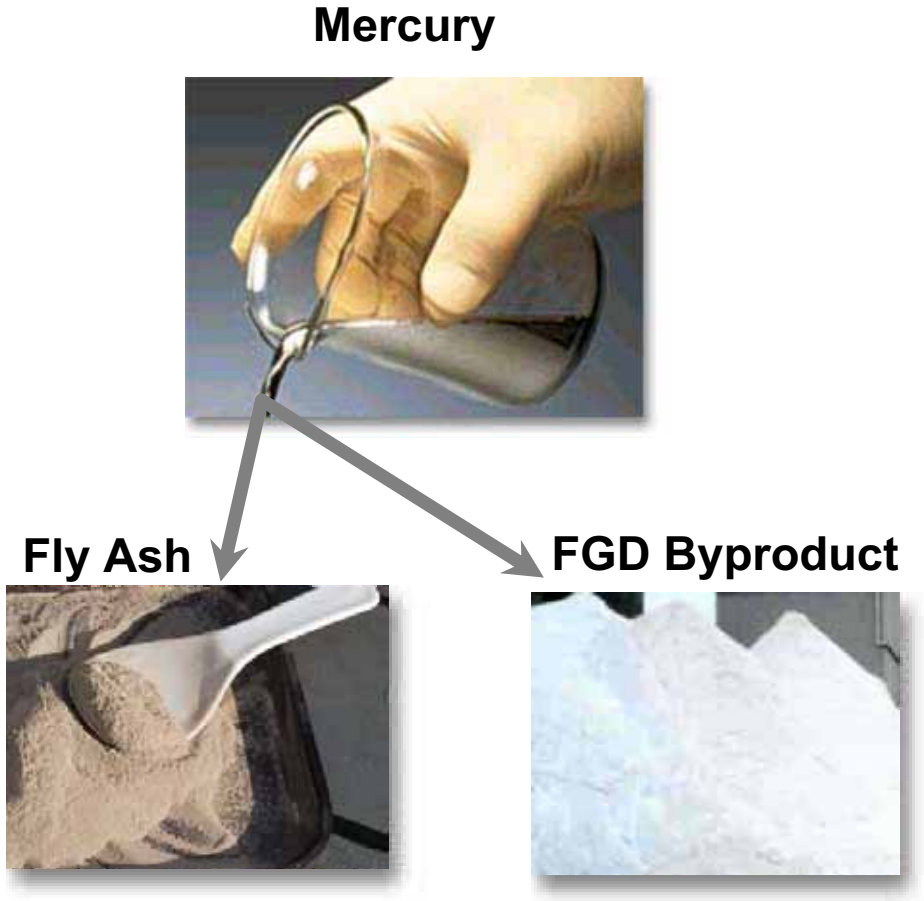
Potential Impact of Power Plant Mercury Emission Regulations on CUBs

Fly Ash

- Loss of all reuse applications
  ≤ $908 M impact

FGD Solids

- Loss of all reuse applications
  ≤ $213 M impact



Hazardous designation of all by-products could cost more than $11 billion/year

Mercury Partitioning Across Coal Power Plants

(Annual Nationwide Estimates based on 1999 EPA ICR Data)

After Coal Cleaning

Typical Control Technologies

Sorbent Injection

Enhanced Scrubbing

Boiler

Particulate Control

FGD System

15T Hg
CAMR Phase II

48T Hg

Pre-CAMR: ~75T Hg

Bottom Ash ~5T Hg

Fly Ash

FGD Byproduct

~22T Hg

Stack

In 2018: ~94T Hg

~6T Hg

~73 T Hg

Environmental Release of Hg from CUBs

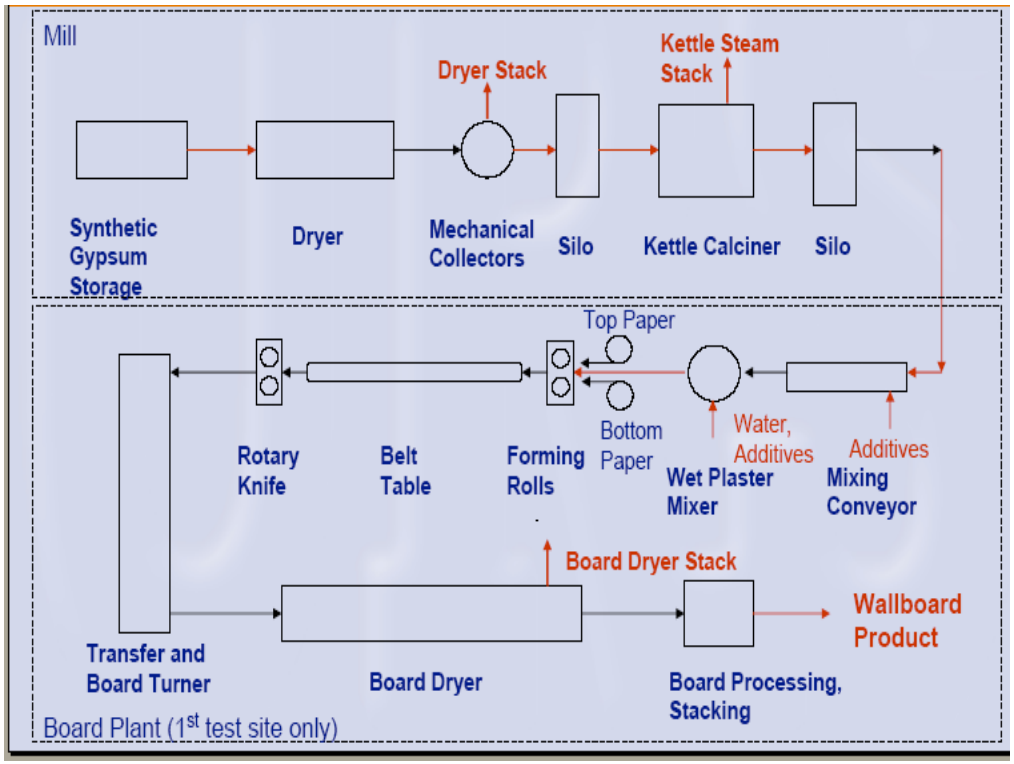
NETL Extramural R&D Projects

- **Complete list of projects and relevant reports can be found on the NETL CUB Web site:**
  - http://www.netl.doe.gov/coal/E&WR/cub/

Project Title	Lead Organization
CUB Analysis from ACI Mercury Control Field Testing	ADA-ES and Reaction Engineering
Characterization of Coal Combustion By-Products for the Re-Evolution of Hg into Ecosystems	CONSOL Energy
Hg and Air Toxics Element Impacts of Coal Combustion By-product Disposal and Utilization	UNDEERC
Fate of Hg in Synthetic Gypsum Used for Wallboard Production	US Gypsum
Characterization of CUBs from Phase II Hg Control Field Testing	Frontier GeoSciences Inc.

Fate of Mercury in Synthetic Gypsum Used for Wallboard Production (USG Corp.)

- **Measure mercury concentrations in solid, liquid, and gaseous streams at 3 operating wallboard manufacturing plants**



Estimated Nationwide Hg Emissions from FGD-Wallboard Industry

- **Based on ACAA 2004 CCP Production and Use Survey**
  - 8,148,078 Tons of FGD Gypsum Used in Wallboard Production

Task	Mercury Emitted in grams per ton of dry gypsum processed	Estimated Industry Release (pounds/yr) based on Task results
Plant A (w/SCR)	0.045	808.49
Plant A (w/o SCR)	0.083	1491.22
Plant B	0.09	1616.99
Plant C	Below	Below

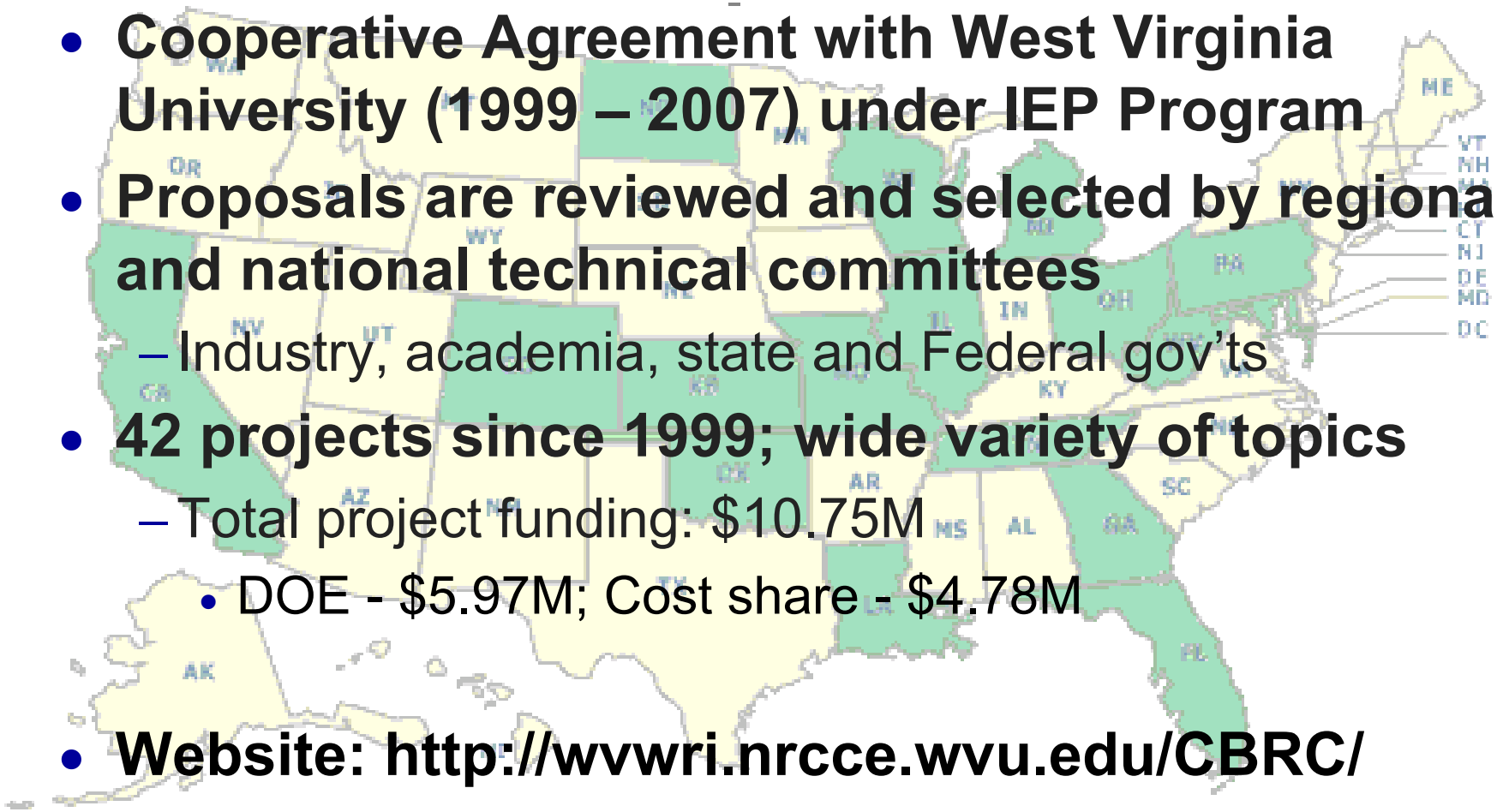
NETL In-House Research: Hg Release from CUB

- **Determine the stability of Hg and other metals in CUB under simulated end-use environments**
- **Explain the chemistry underlying metal stability**

Drywall ready for landfill

- **Preliminary Results:**
  - All Hg in FGD gypsum remains in iron-rich residues
  - Iron-containing phase, probably introduced to FGD via limestone, is responsible for Hg sorption & retention in disposal environments

Utilization Research: Combustion Byproducts Recycling Consortium (CBRC)



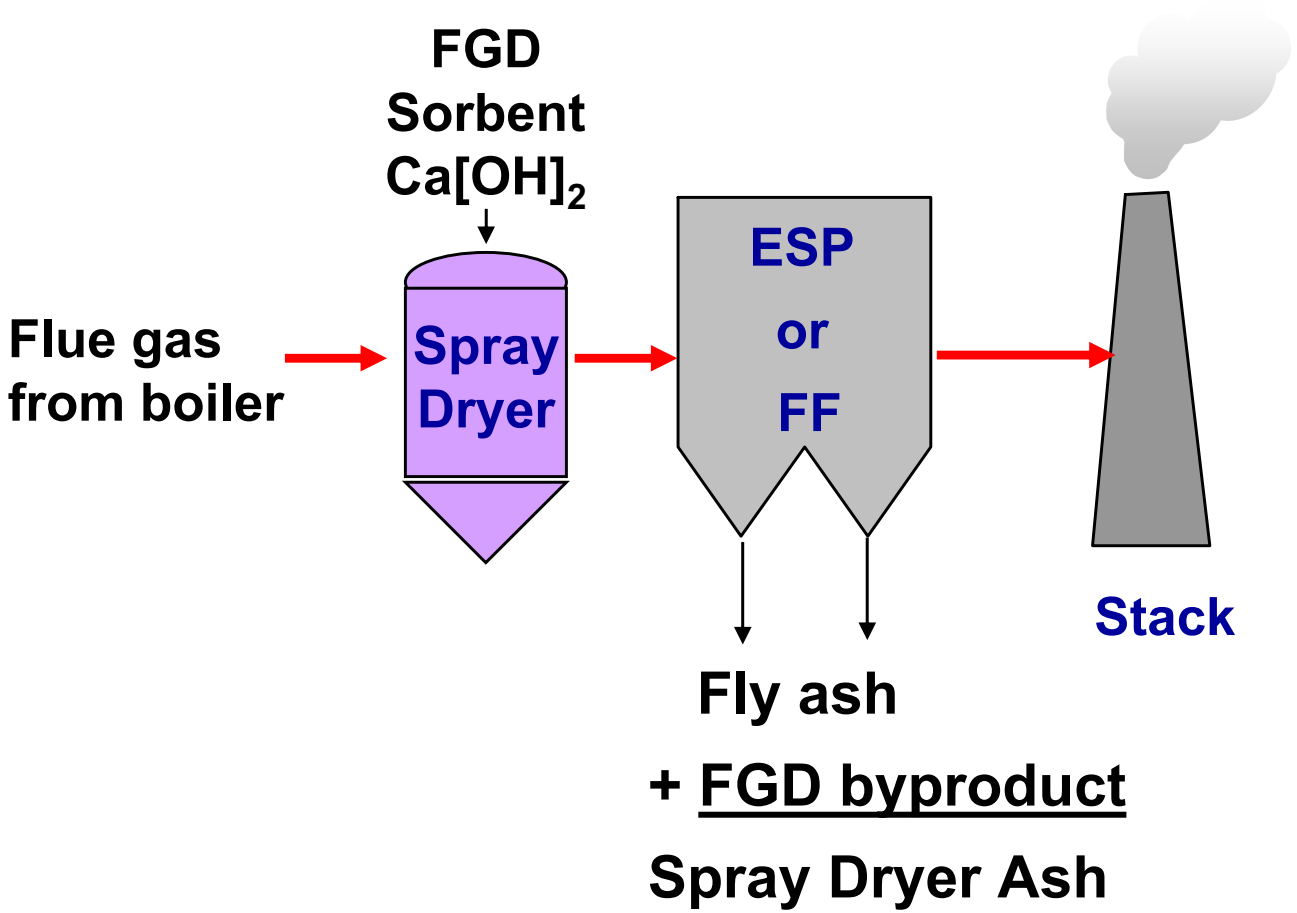
- **Cooperative Agreement with West Virginia University (1999 – 2007) under IEP Program**
- **Proposals are reviewed and selected by regional and national technical committees**
  - Industry, academia, state and Federal gov’ts
- **42 projects since 1999; wide variety of topics**
  - Total project funding: $10.75M
    - DOE - $5.97M; Cost share - $4.78M
- **Website: http://wvwri.nrcce.wvu.edu/CBRC/**

Clean Coal Technology Demonstration Projects

- **Manufacture of Lightweight Aggregates Using Spray Dryer Ash**
  - Awarded in November 2002 to Universal Aggregates, LLC
  - Total project funding: $19.58M
    - DOE - $7.22M; Cost share - $12.36M

- **Multi-product CUB Processing Plant**
  - Awarded in November 2004 to University of Kentucky Research Foundation
  - Total project funding: $8.98M
    - DOE - $4.48M; Cost share - $4.50M

Manufacture of Lightweight Aggregates Using Spray Dryer Ash



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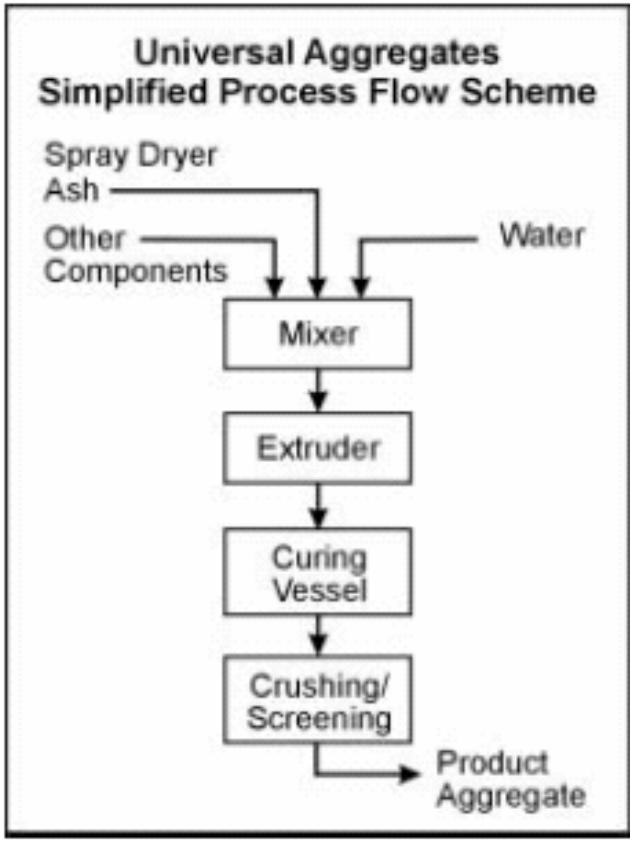


Birchwood Power Partners
King George County, VA

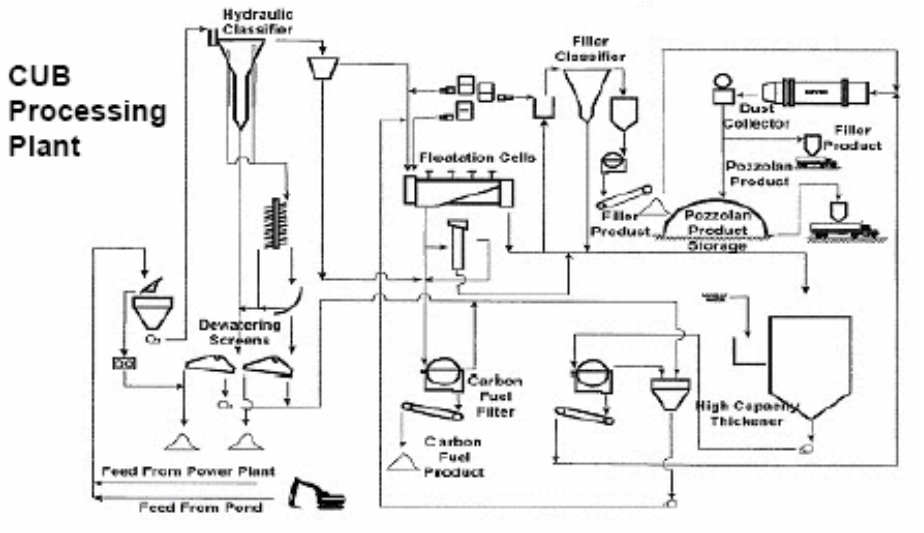
- 115,000 tpy ash → 167,000 tpy aggregates
- Aggregate properties tailored toward end-use markets
- Operation began in Spring 2004

Multi-product CUB Processing Plant

- **Uses fly & bottom ash from disposal ponds at Ghent Power Station, Ghent, KY**

- **Hydraulic classification & froth flotation used to create multiple products:**
  - Pozzolan for Portland cement replacement
  - Lightweight aggregate
  - Graded sand = construction fill
  - Unburned carbon = supplemental boiler fuel
  - Ultrafine spheres = polymer filler

- **Startup: scheduled October 2007**



For More Information

- **DOE Office of Fossil Energy: Coal & Natural Gas Electric Power Systems**
  - http://fossil.energy.gov/programs/powersystems/
- **DOE-FE Innovations for Existing Plants Program**
  - http://www.netl.doe.gov/coal/E&WR/cub/
- **DOE-FE Clean Coal Power Initiative**
  - http://www.netl.doe.gov/coal/CCPI/
- **Coal Combustion Products Partnership (C^2P^2)**
  - http://www.epa.gov/c2p2/
- **Combustion Byproducts Recycling Consortium**
  - http://wvwri.nrcce.wvu.edu/CBRC/