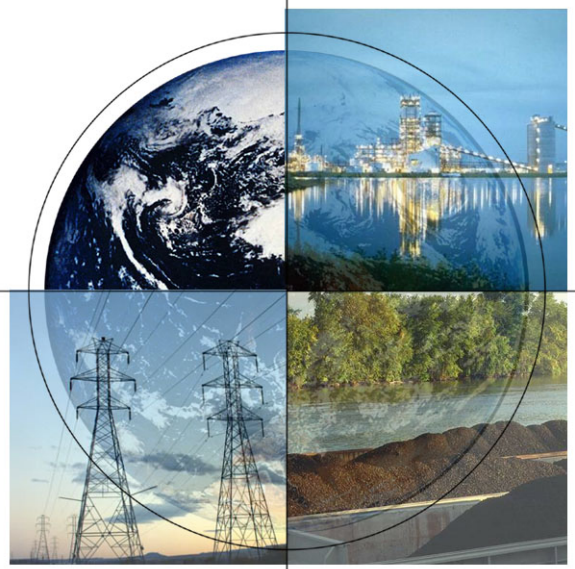
Recycling and Beneficial Use of Coal Utilization Byproducts (CUBs)



AWMA 2006 Waste Management Meeting

Arlington, VA
January 18, 2006

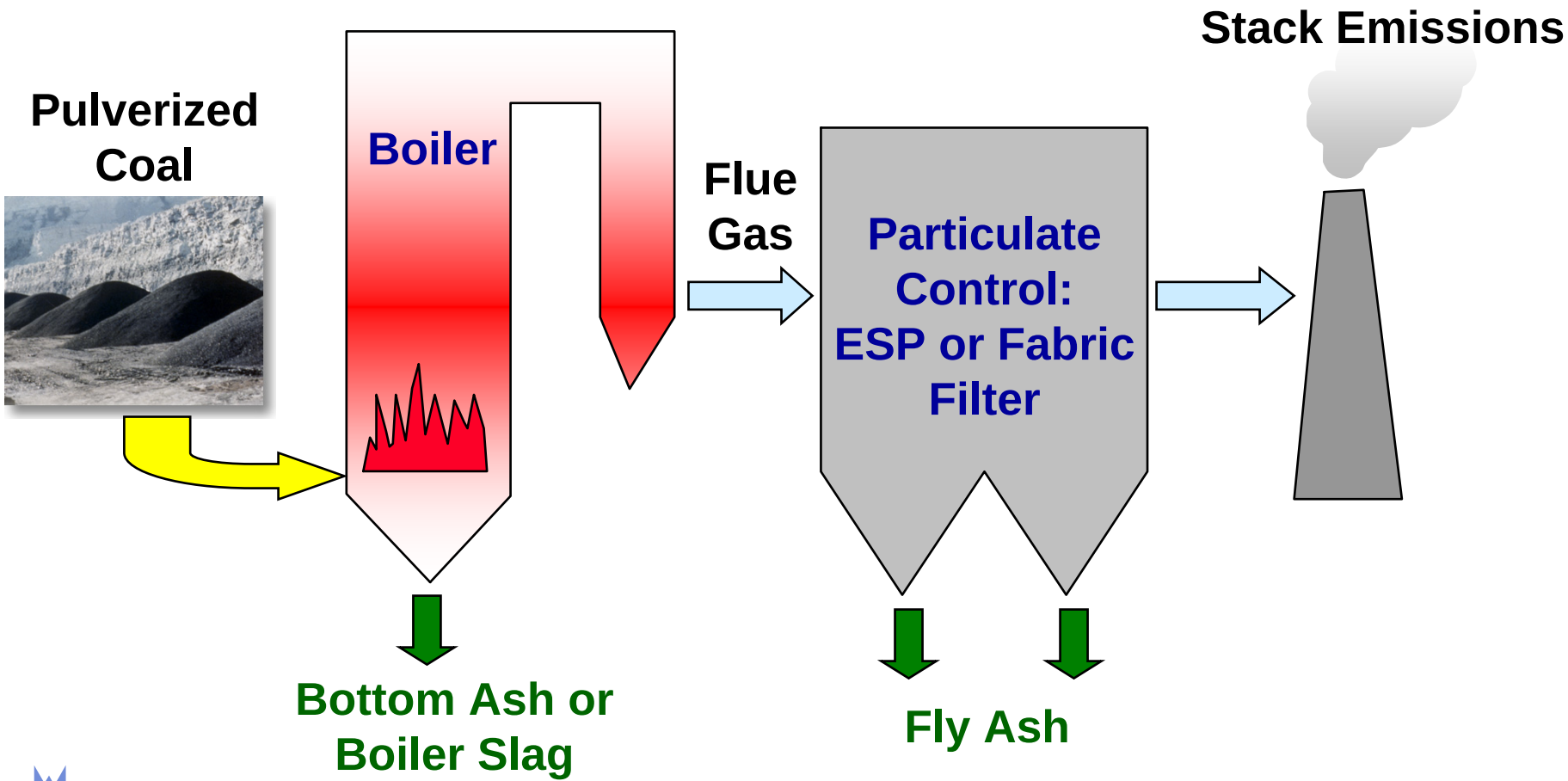
William W. Aljoe, Project Manager
U.S. Department of Energy, National Energy Technology Laboratory

CCPs (Industry) = CUBs (DOE)

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

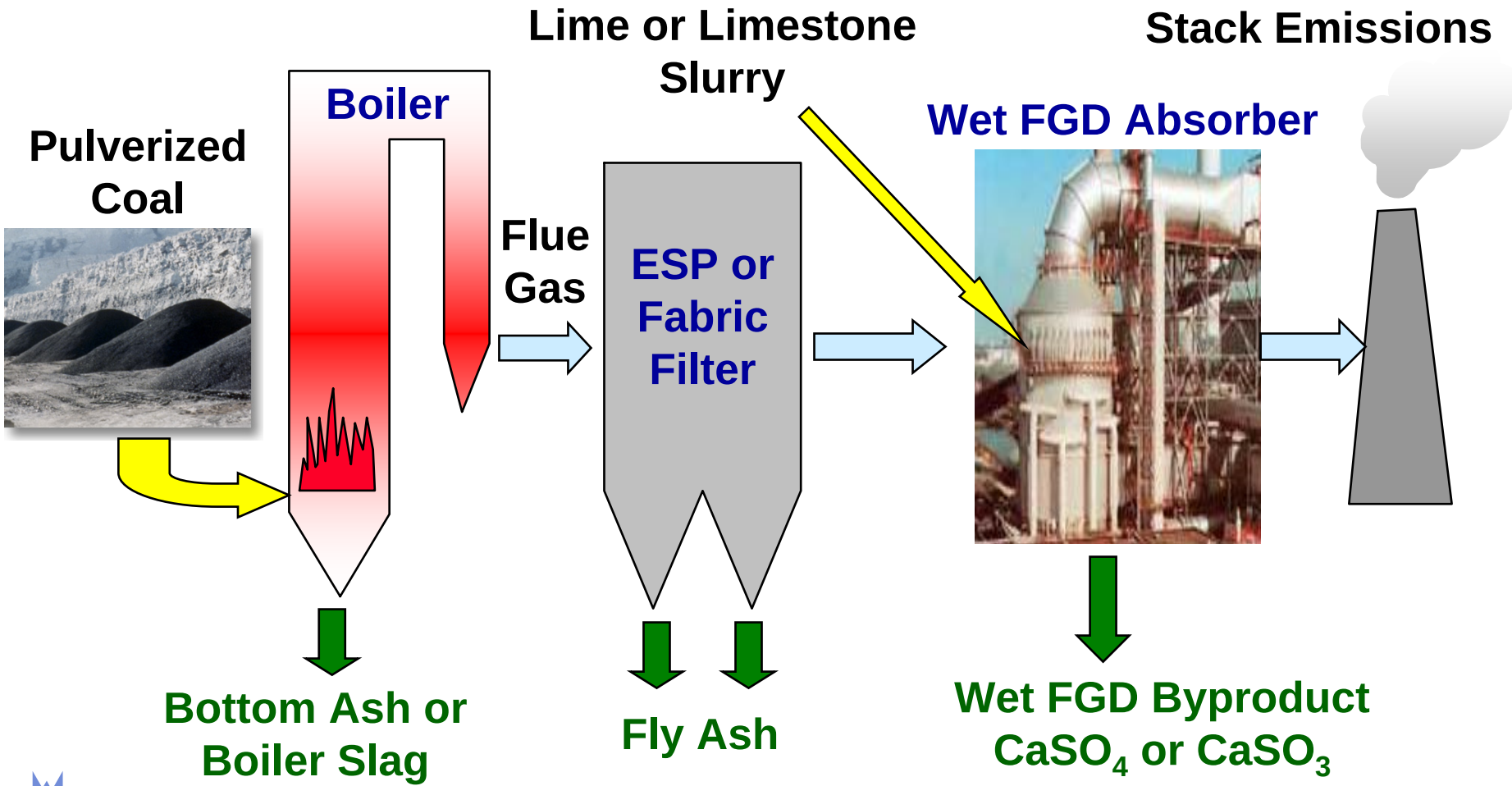
CUBs from Electric Utility Boilers

Pulverized Coal without Flue Gas Desulfurization



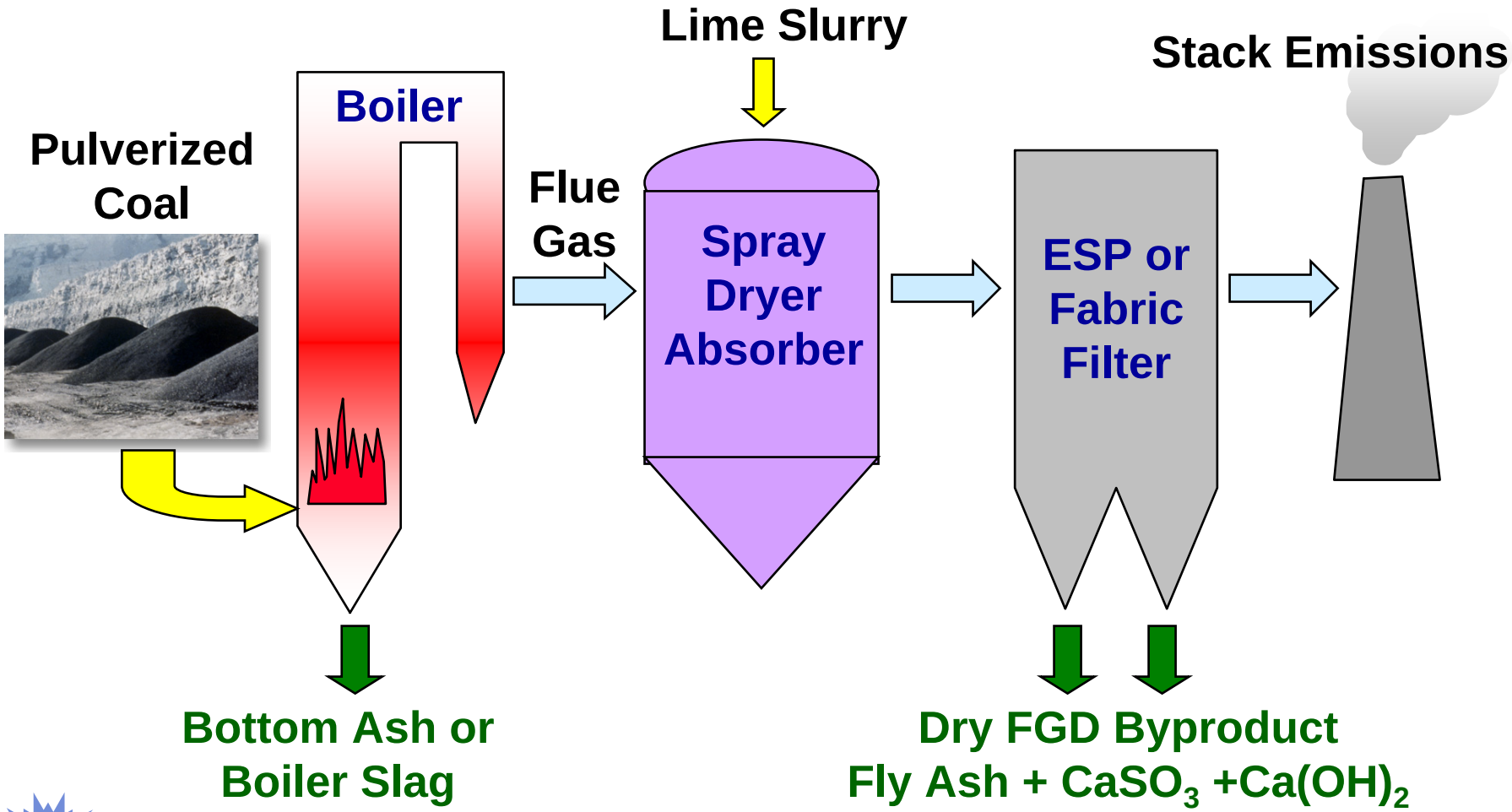
CUBs from Electric Utility Boilers

Pulverized Coal with Wet Flue Gas Desulfurization

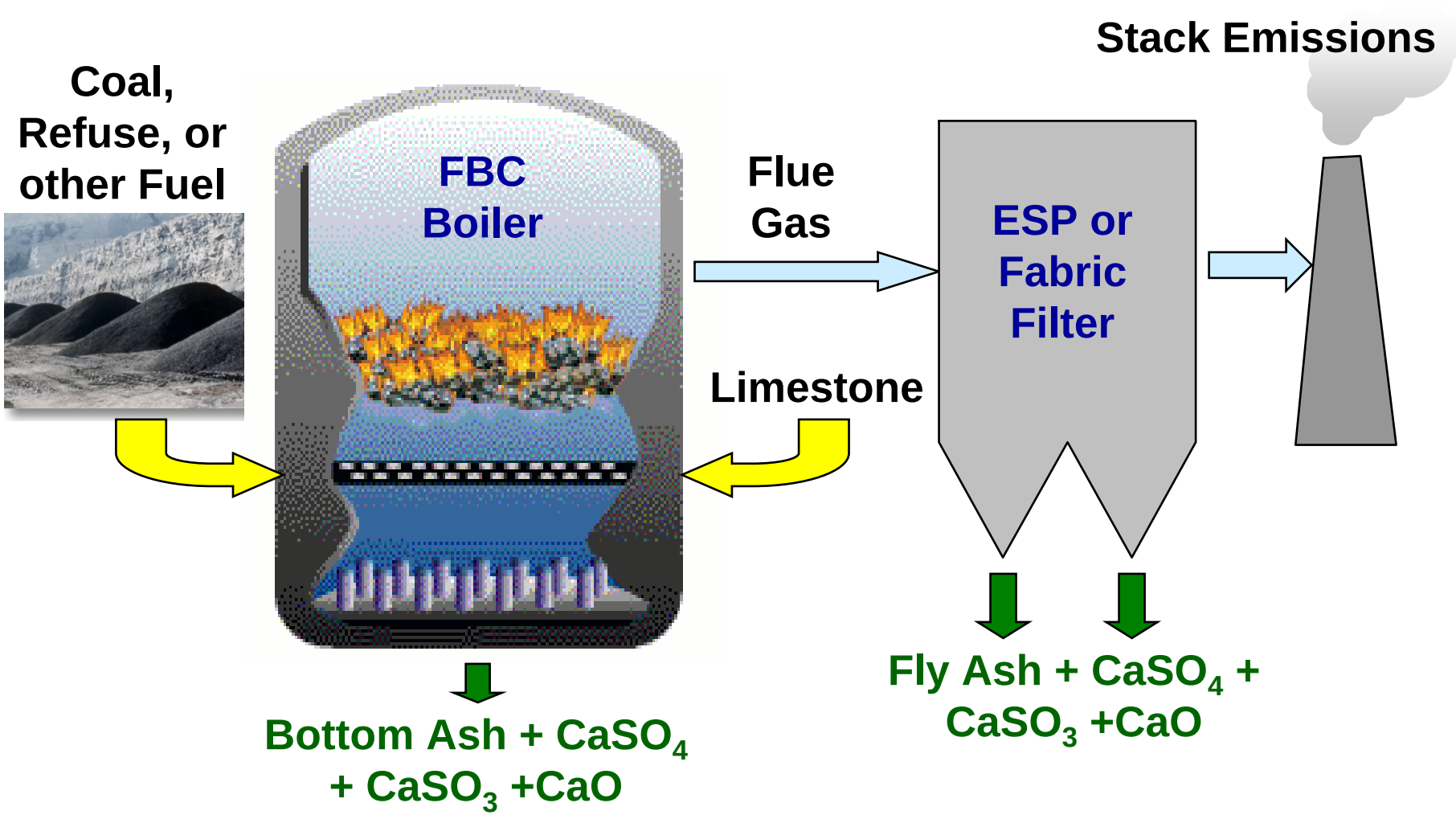


CUBs from Electric Utility Boilers

Pulverized Coal with Dry Flue Gas Desulfurization (FGD)



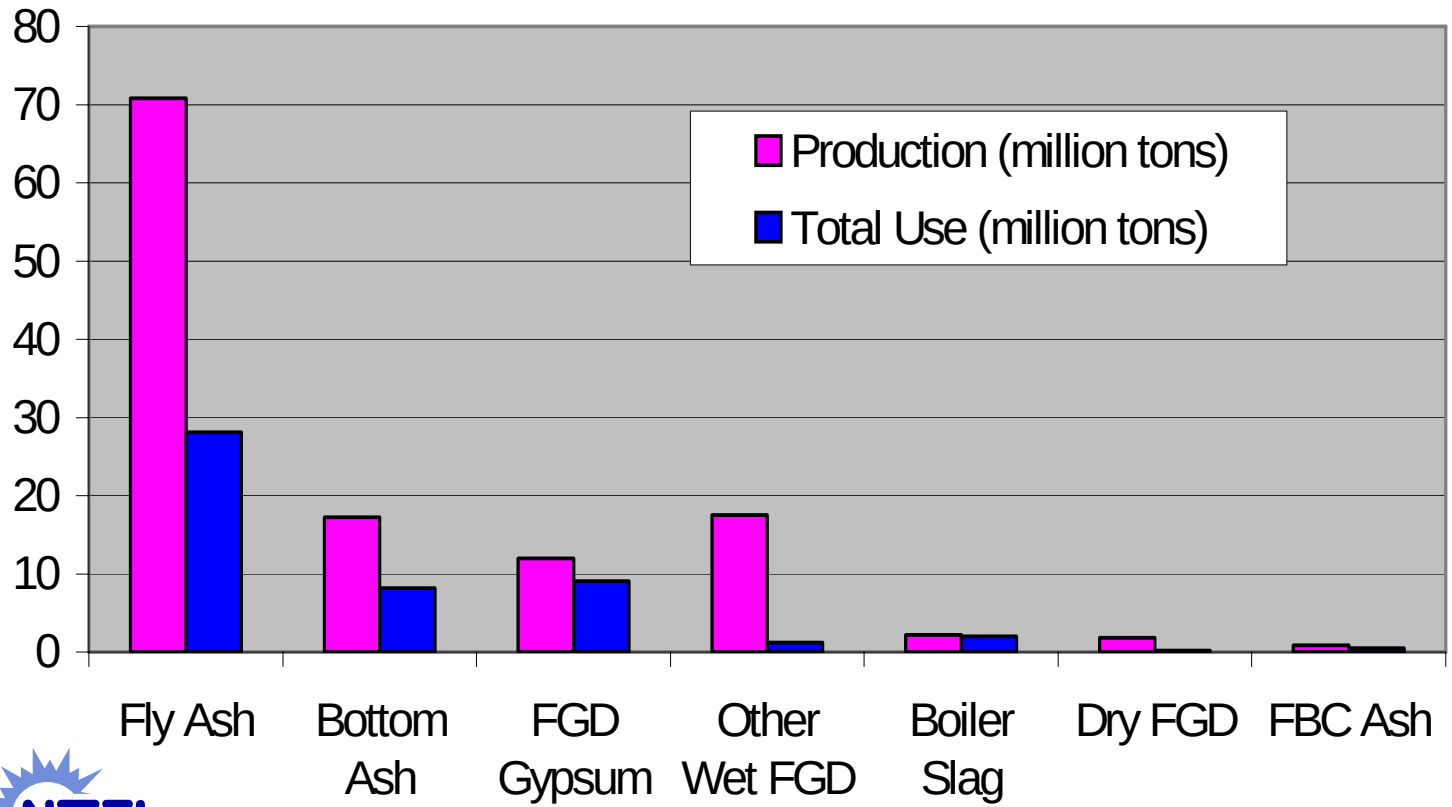
CUBs from Fluidized Bed Combustion (FBC)



U.S. CUB Production and Use – 2004

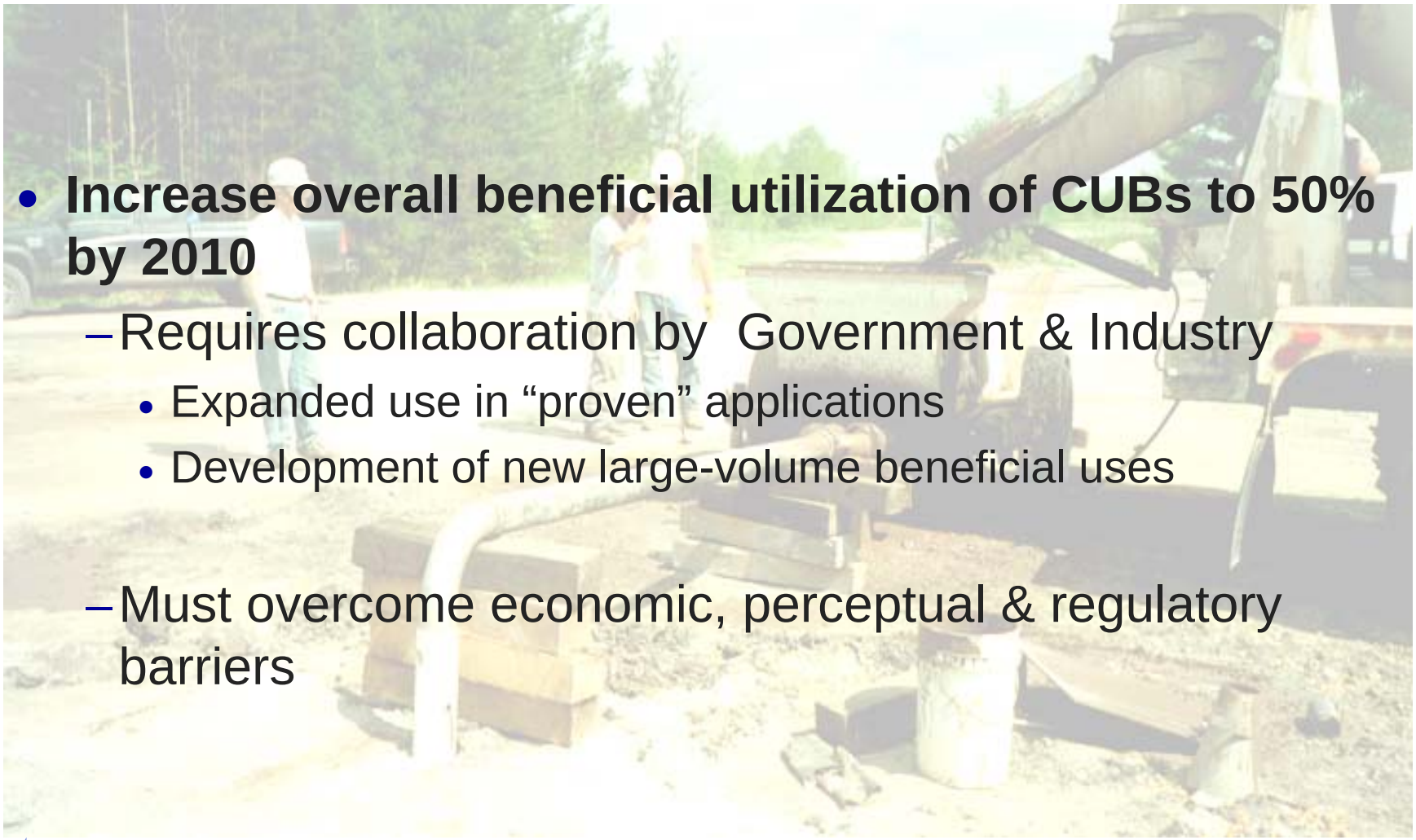
(*Data from American Coal Ash Association)*

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

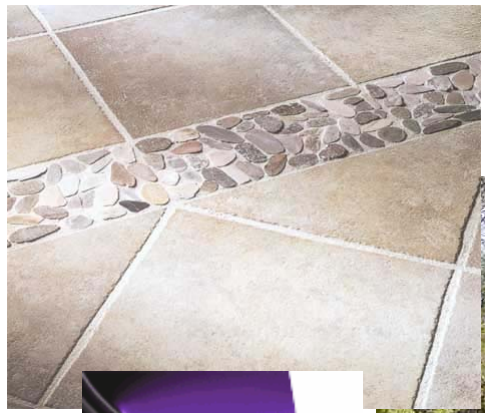
Near-term Goal for CUB Beneficial Use



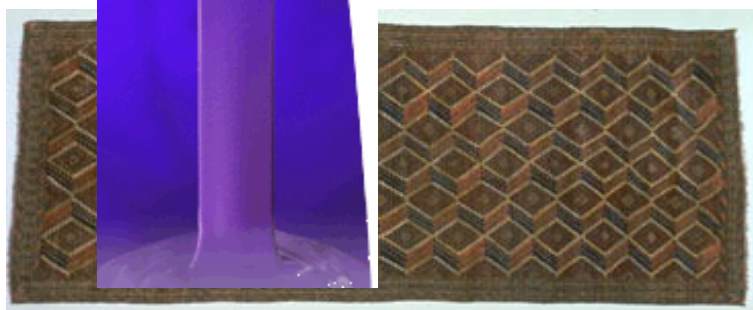
- **Increase overall beneficial utilization of CUBs to 50% by 2010**
  - Requires collaboration by Government & Industry
    - Expanded use in “proven” applications
    - Development of new large-volume beneficial uses
  - Must overcome economic, perceptual & regulatory barriers

Many Uses for Coal Utilization Byproducts

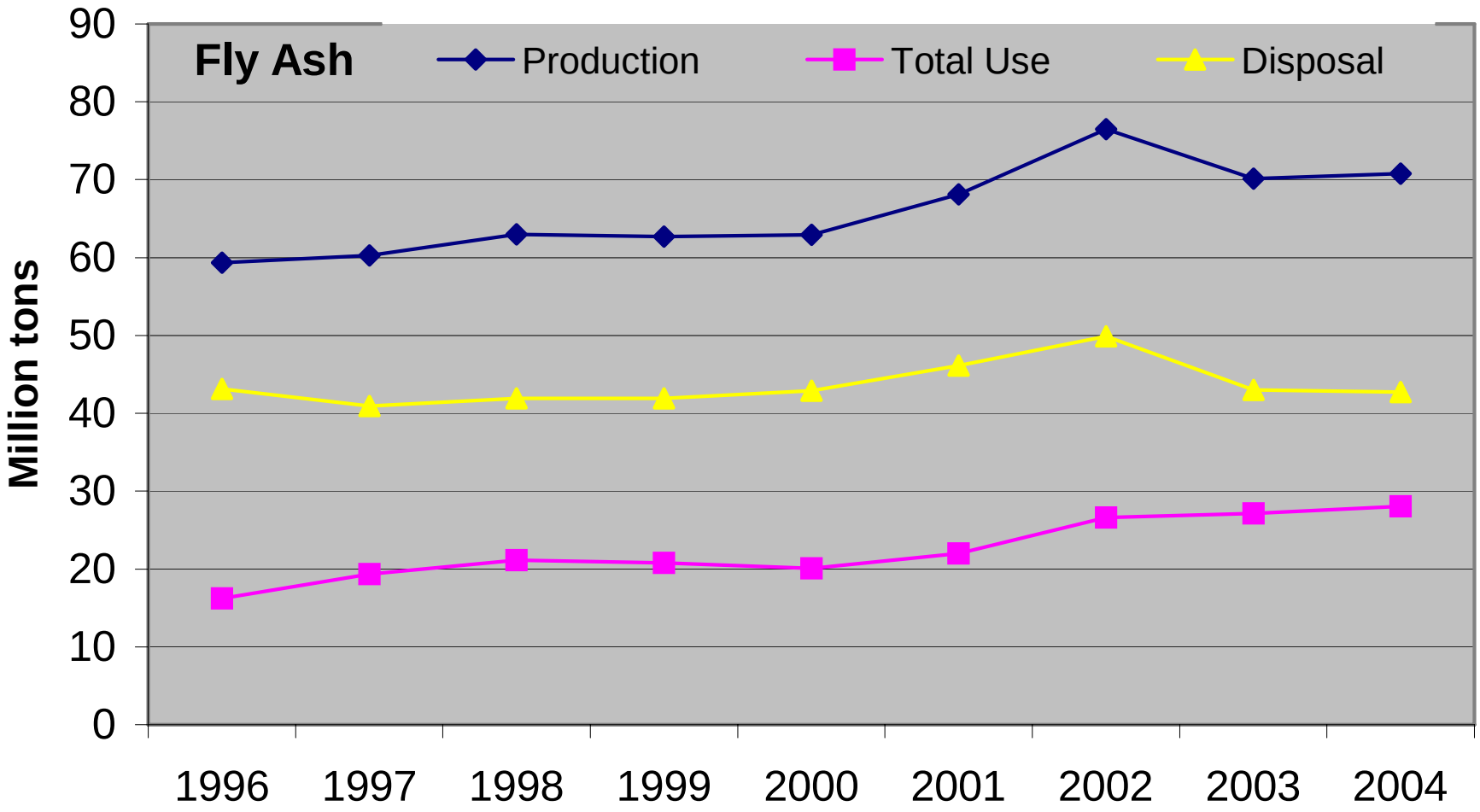
- Drywall (Gypsum)
- Cement & Concrete
- Structural fill
- Road base
- Anti-skid
- Soil amendments
- Bowling balls
- Wall paints
- Carpeting
- Synthetic tiles
- AMD control



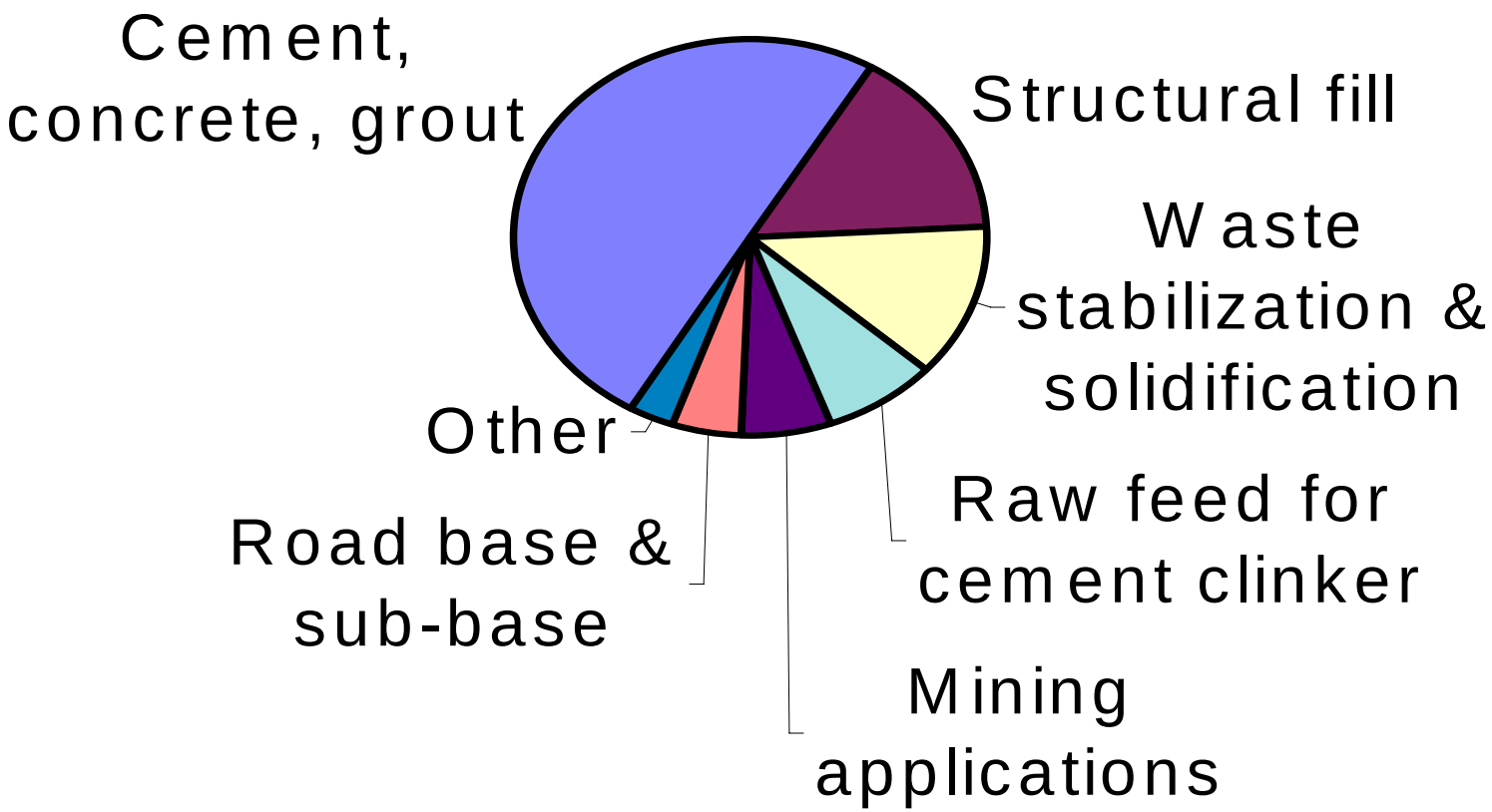
Fort Mandan Visitor Center



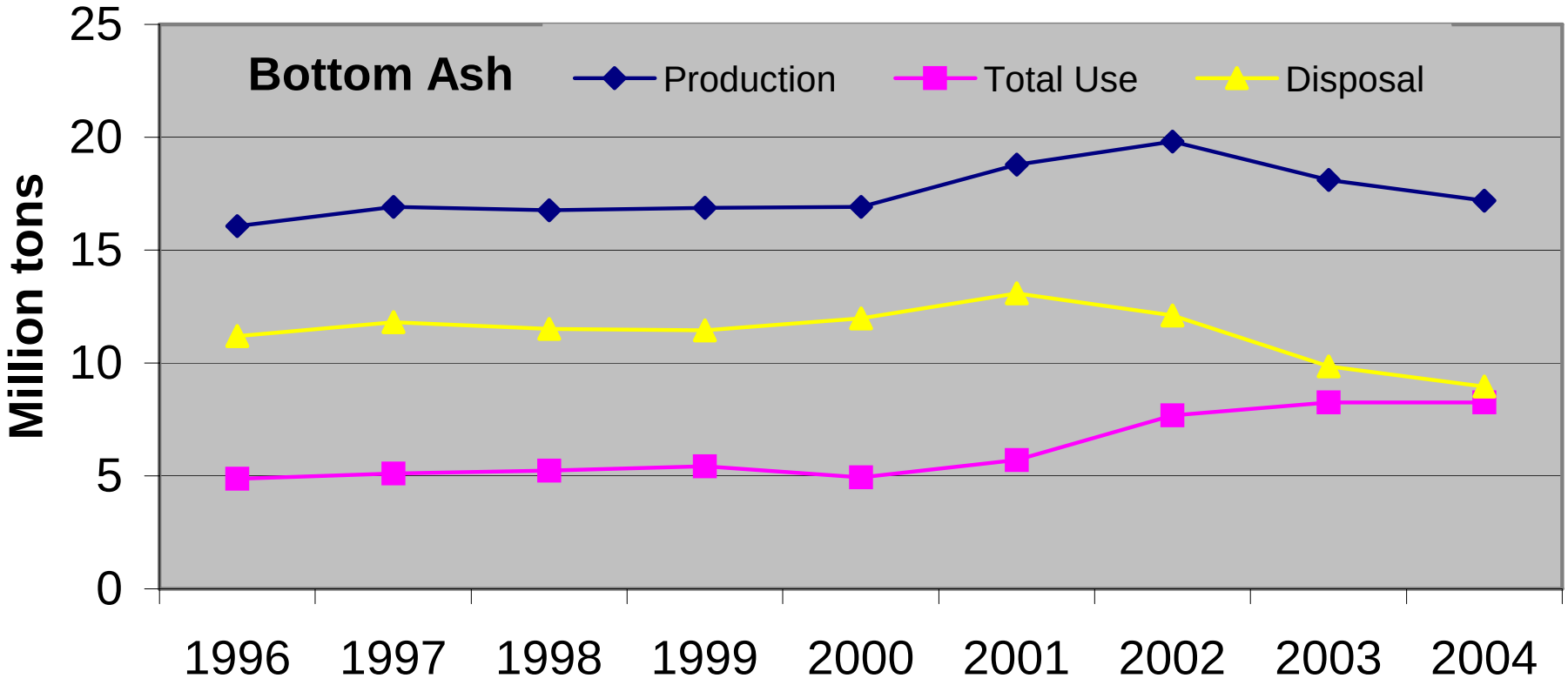
Trends in Fly Ash Production & Use



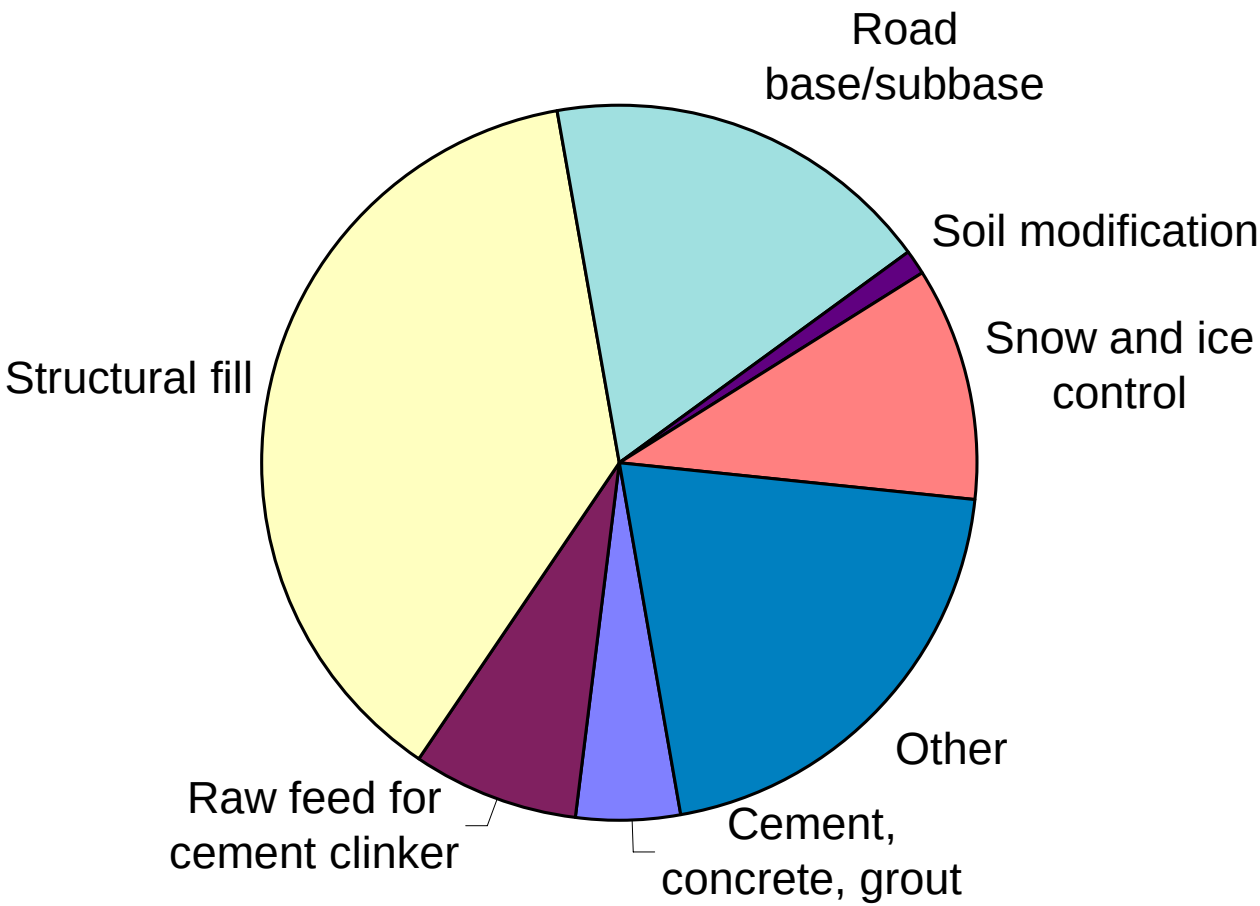
Types of Fly Ash Utilization



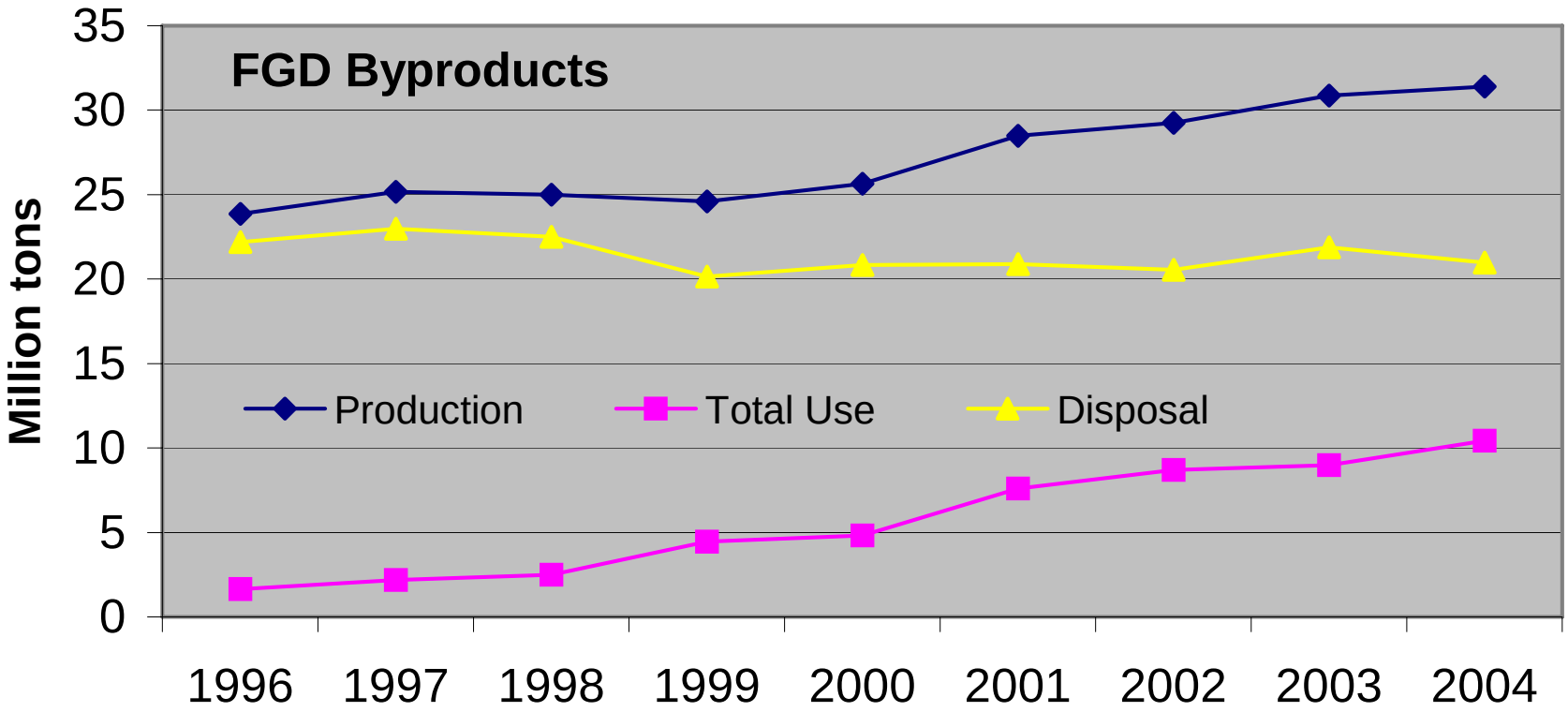
Trends in Bottom Ash Production & Use



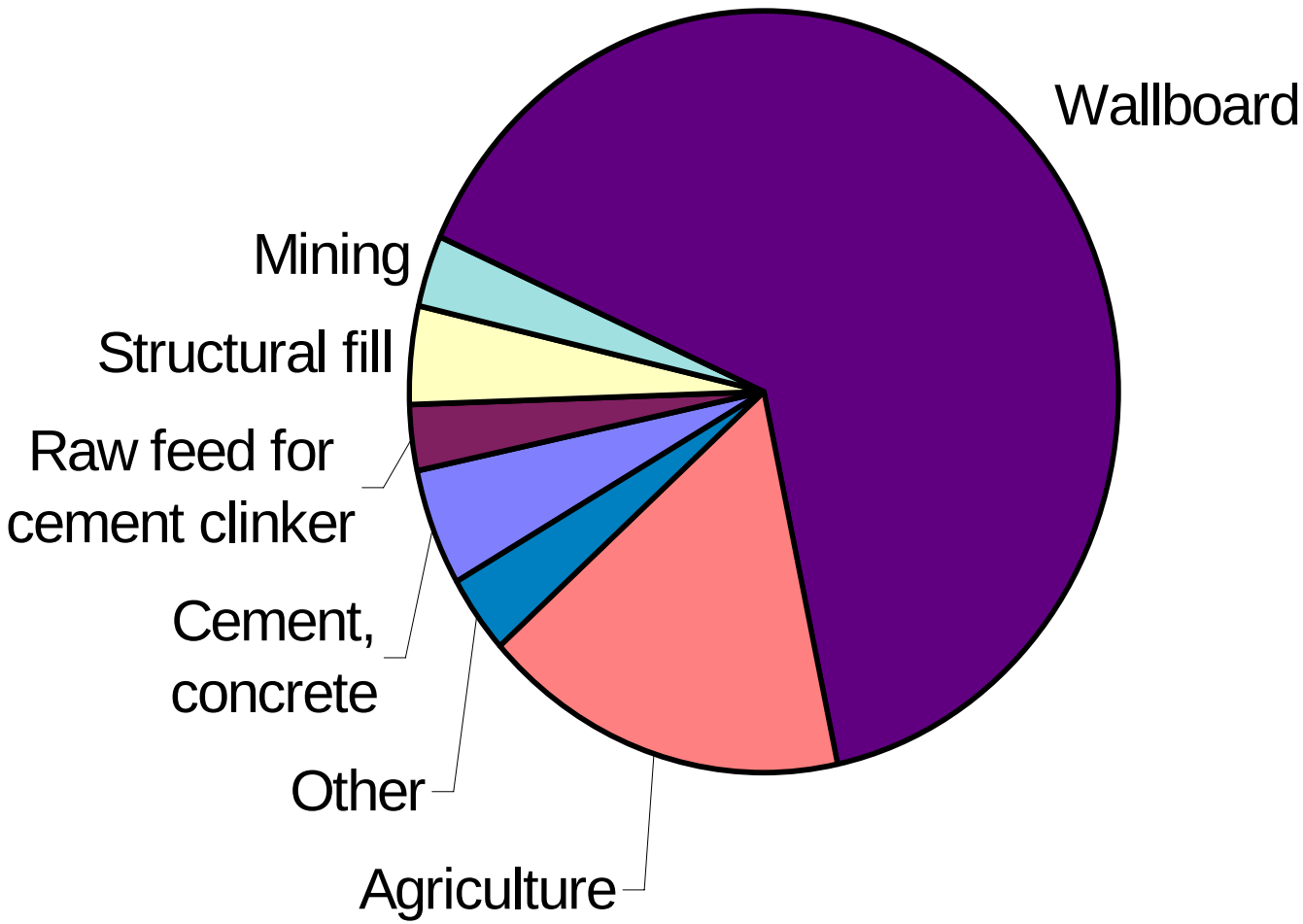
Types of Bottom Ash Utilization



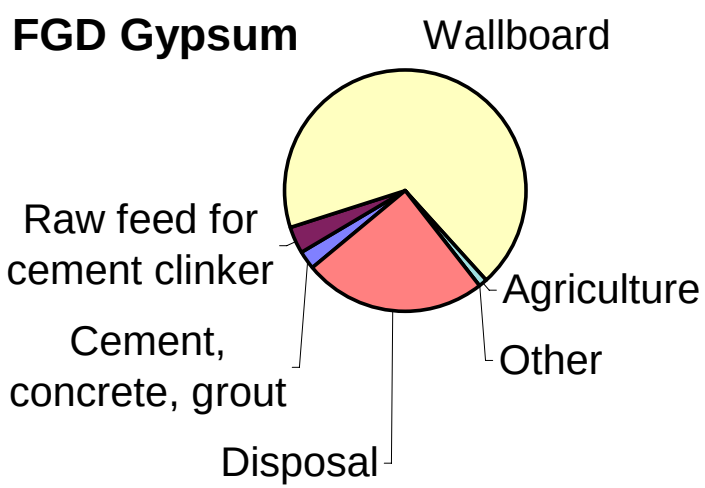
Trends in FGD Byproduct Production & Use

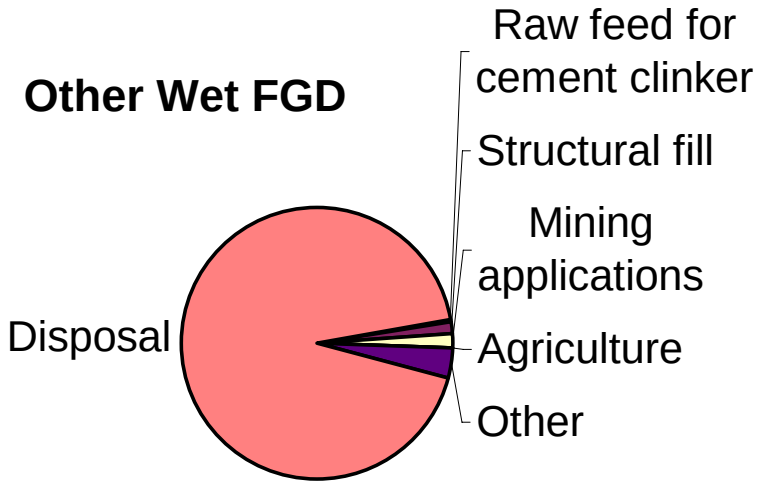


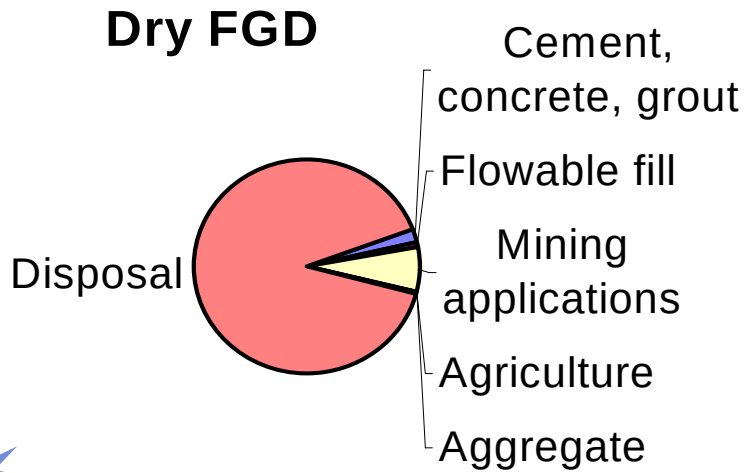
Types of FGD Byproduct Utilization

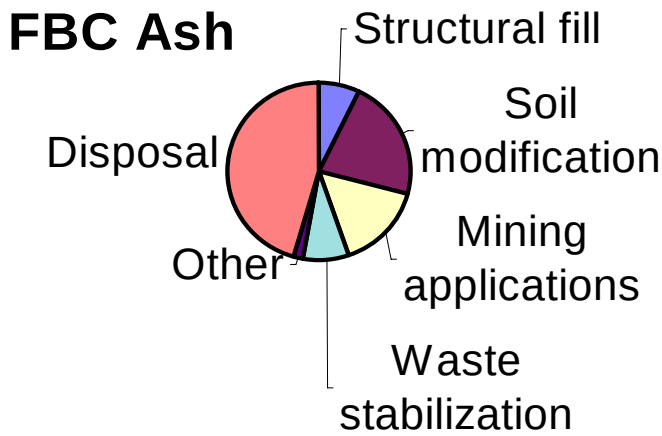


FGD Byproducts: Use by Type (2004)









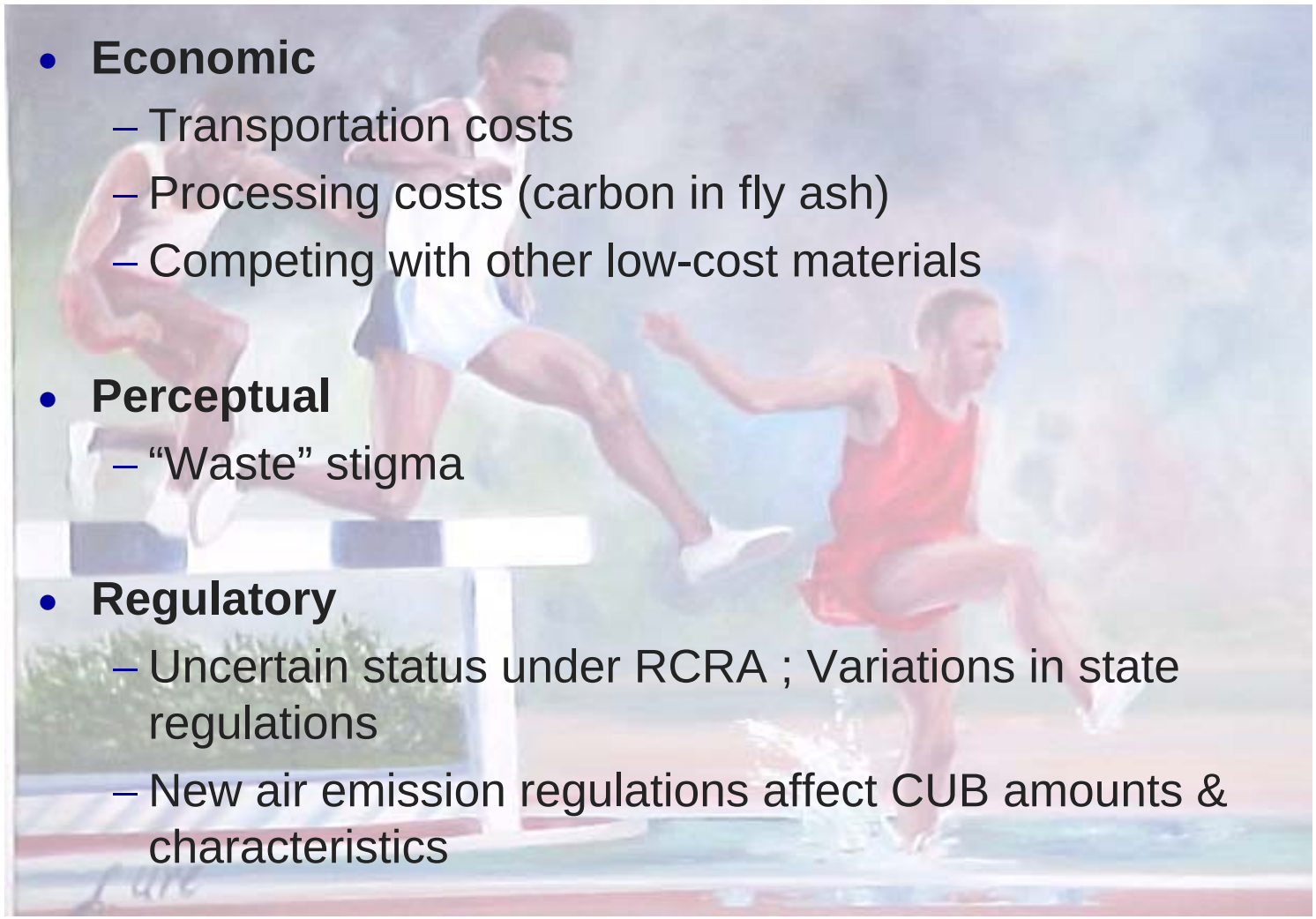
Multiple Benefits of Using CUBs

- **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

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

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?
    - Western coal plants = 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)

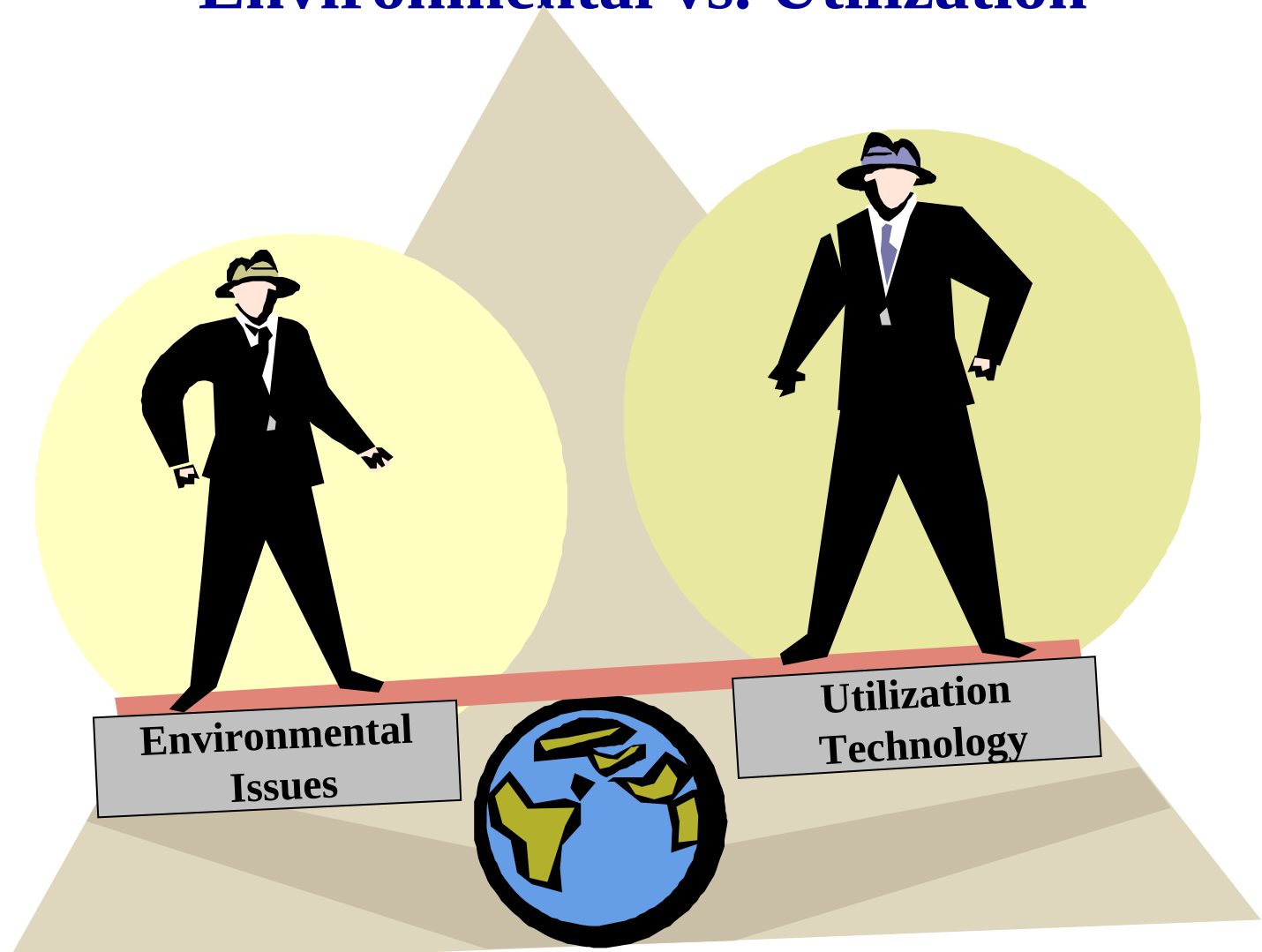
- **Government-Industry partnership to promote the beneficial use of Coal Combustion Products (CCPs)**
  - Led by U.S. EPA Office of Solid Waste
    - U.S. Agency Charter Members: DOE and FHWA
    - Industry: American Coal Ash Association, Utility Solid Waste Activities Group
- **Major Activities**
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

CUBs in Fossil Energy's R&D Programs

- **Innovations for Existing Plants (IEP) Program**
  - Basic and Applied R&D (Bench & pilot scale)
  - DOE funding: typically $100k - $1M per project

- **Clean Coal Technology Demonstration Program**
  - Full-scale field demonstrations
  - PPII: Power Plant Improvement Initiative
    - 1 project, ~ $7M DOE Funding
  - CCPI: Clean Coal Power Initiative
    - 1 Project: ~$4M DOE Funding

CUB R&D Priorities for IEP Program: Environmental vs. Utilization



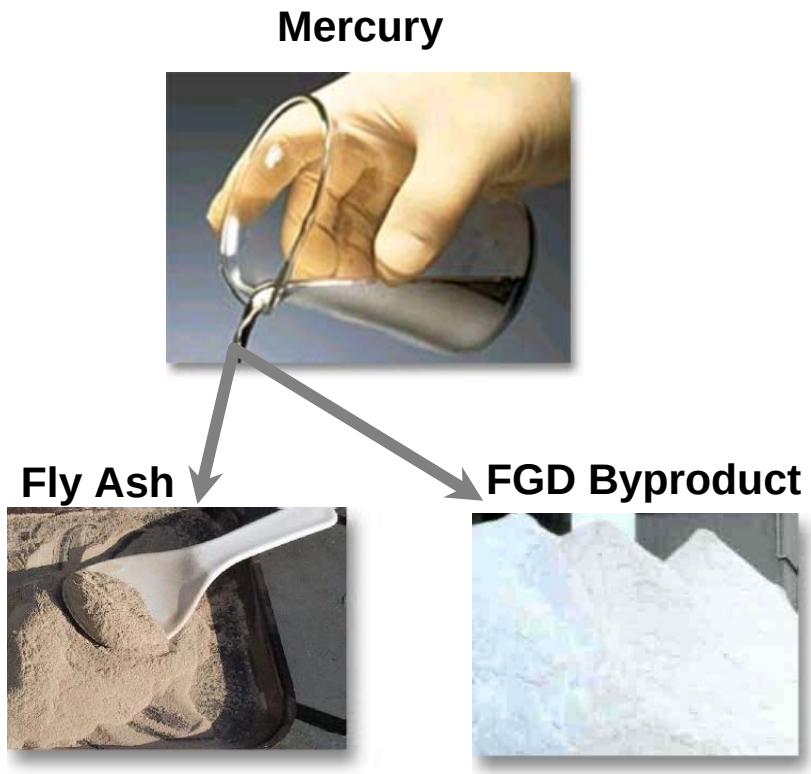
Potential Impact of Power Plant Mercury Emission Regulations on CUBs

Fly Ash

- **Loss of all reuse applications**
  ~ $908 M/yr impact

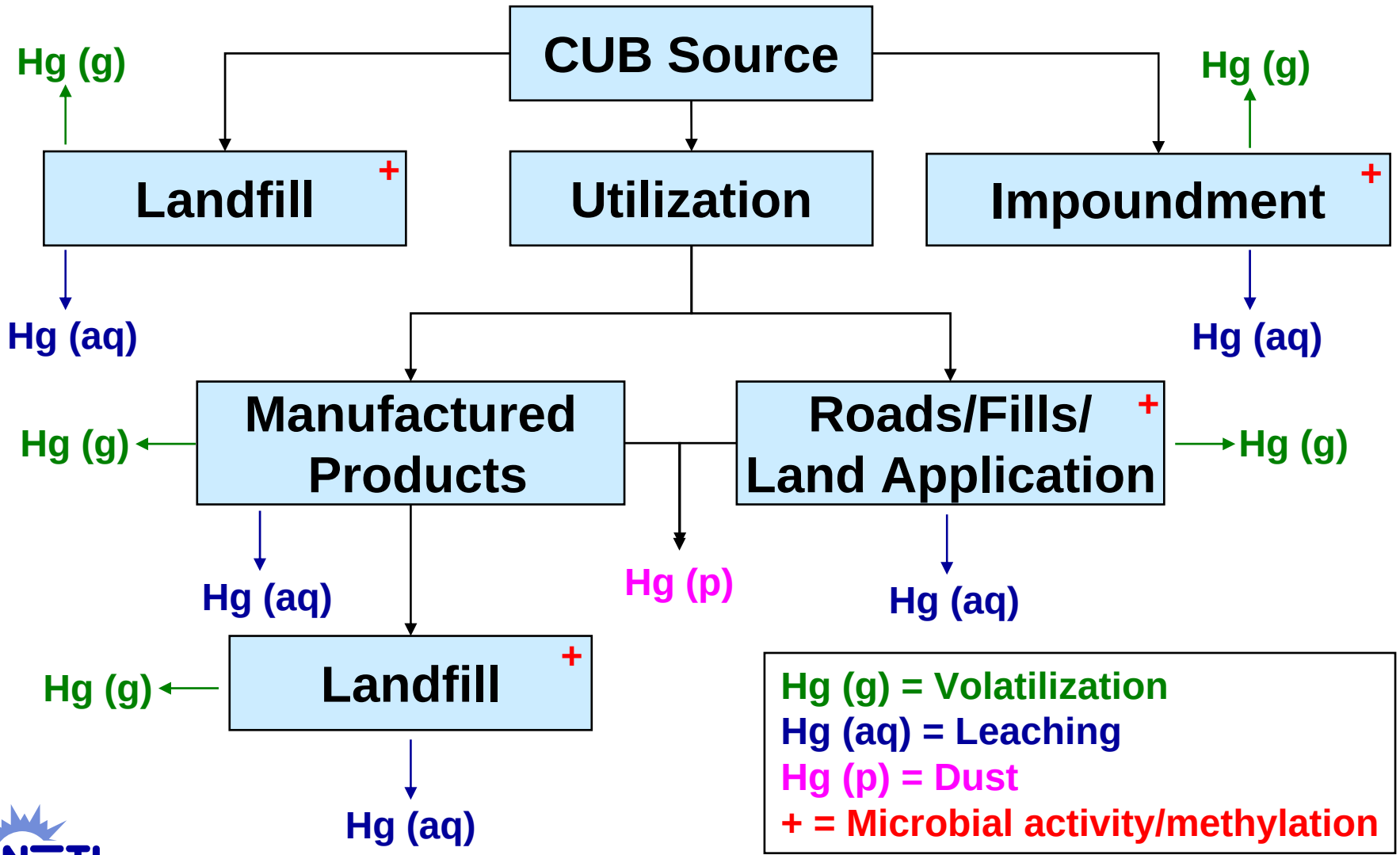
FGD Solids

- **Loss of all reuse applications**
  ~ $213 M/yr impact



Hazardous designation of all CUBs could cost more than $11 billion/year

Environmental Release of Hg from CUB



Hg Release from CUB via Leaching

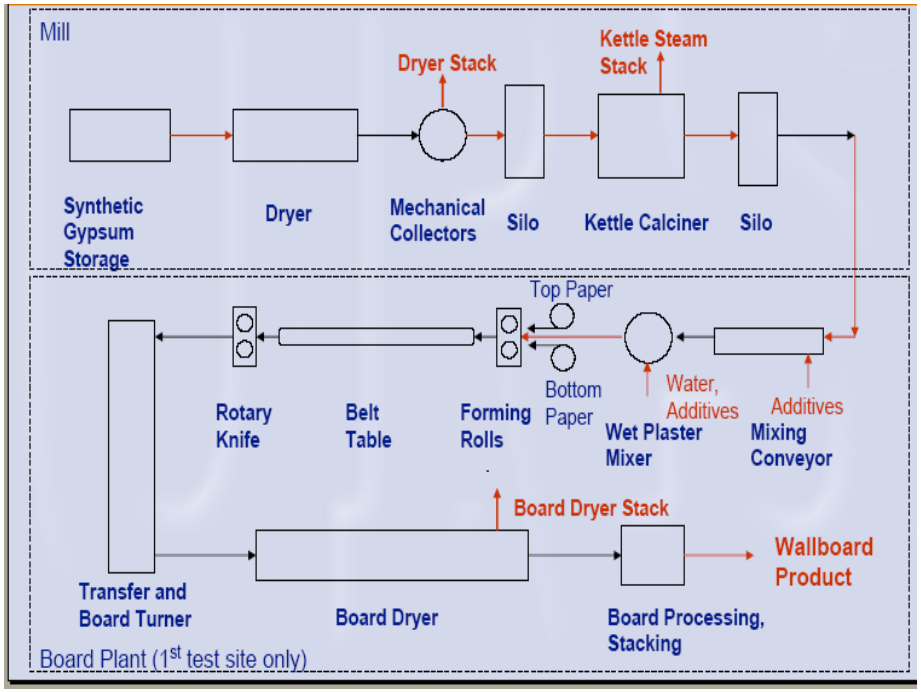
- **Preliminary results for fly ash: Hg generally <u>does not leach</u> in landfills and beneficial use environments**
  - >99.9% of Hg stays in solid

Drywall ready for landfill

- **Preliminary Results for FGD Byproducts:**
  - 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

Fate of Mercury in Synthetic Gypsum Used for Wallboard Production

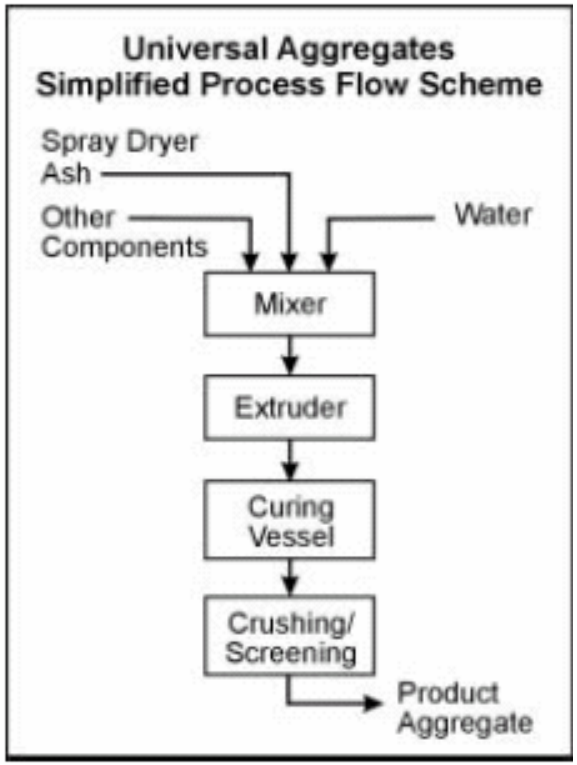
- **Measure Hg releases and perform mass balances at 3 operating wallboard manufacturing plants (USG Corp.)**



Combustion Byproducts Recycling Consortium (CBRC)

- **Cooperative Agreement with West Virginia University (1999 – 2007)**
- **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/**

PPII Project: Manufacture of Lightweight Aggregates Using Spray Dryer Ash

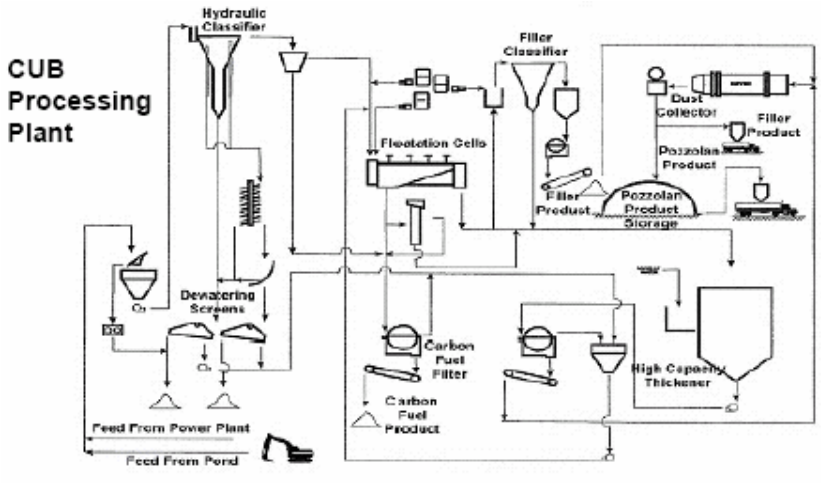


Birchwood Power Partners
King George County, VA

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

CCPI Project: 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/