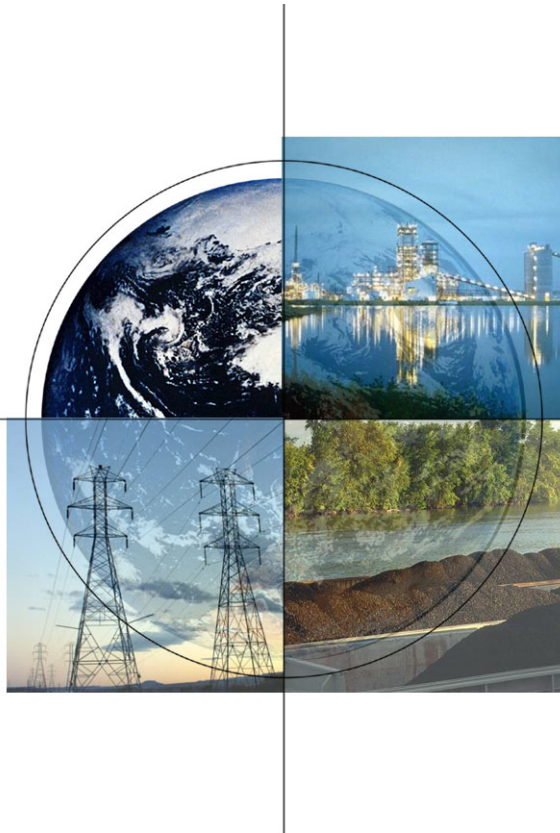


# Recycling and Beneficial Use of Coal Utilization Byproducts (CUBs)



**AWMA 2006 Waste  
Management Meeting**

**Arlington, VA  
January 18, 2006**

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

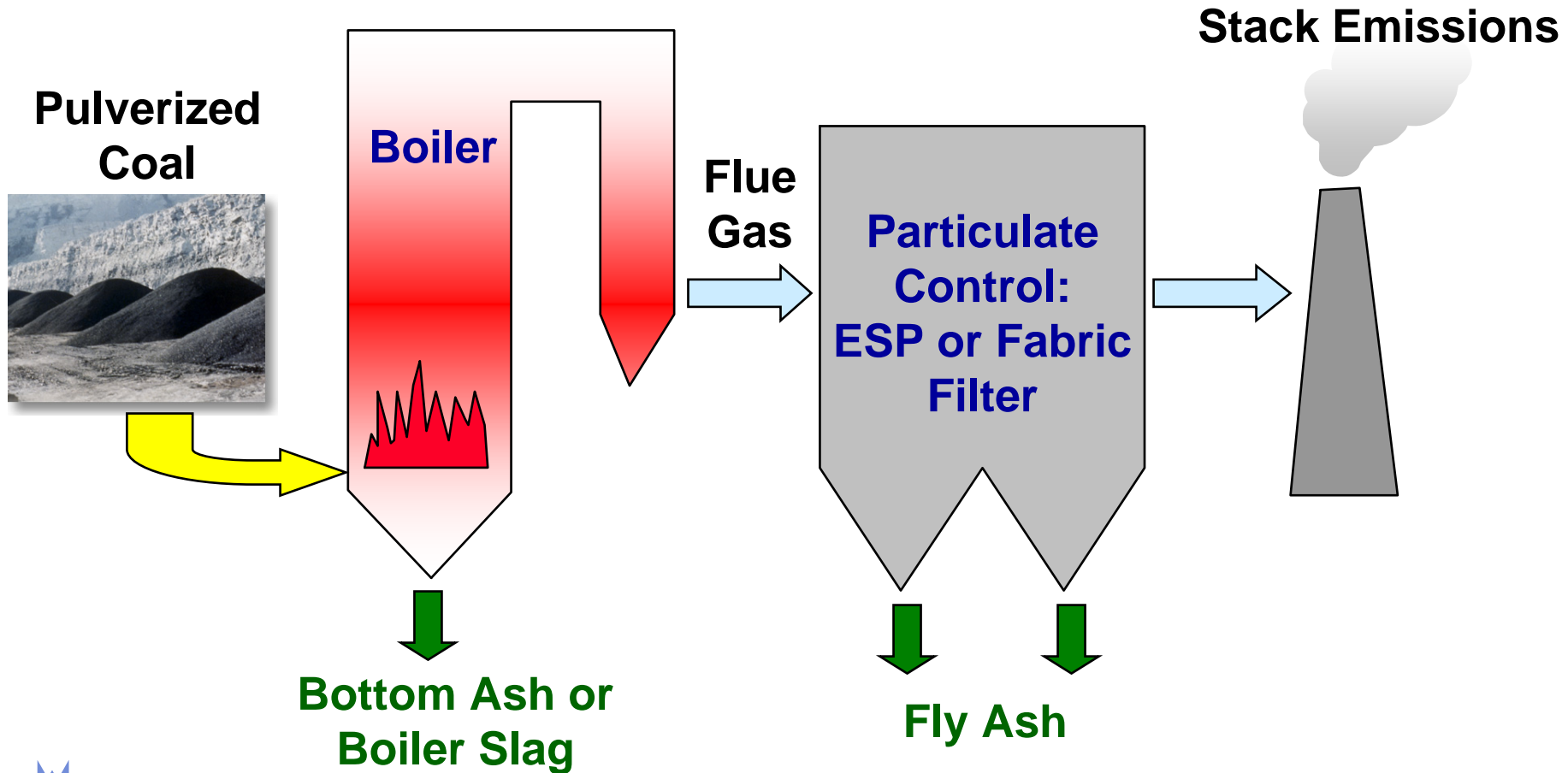


# CCPs (Industry) = CUBs (DOE)

- **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

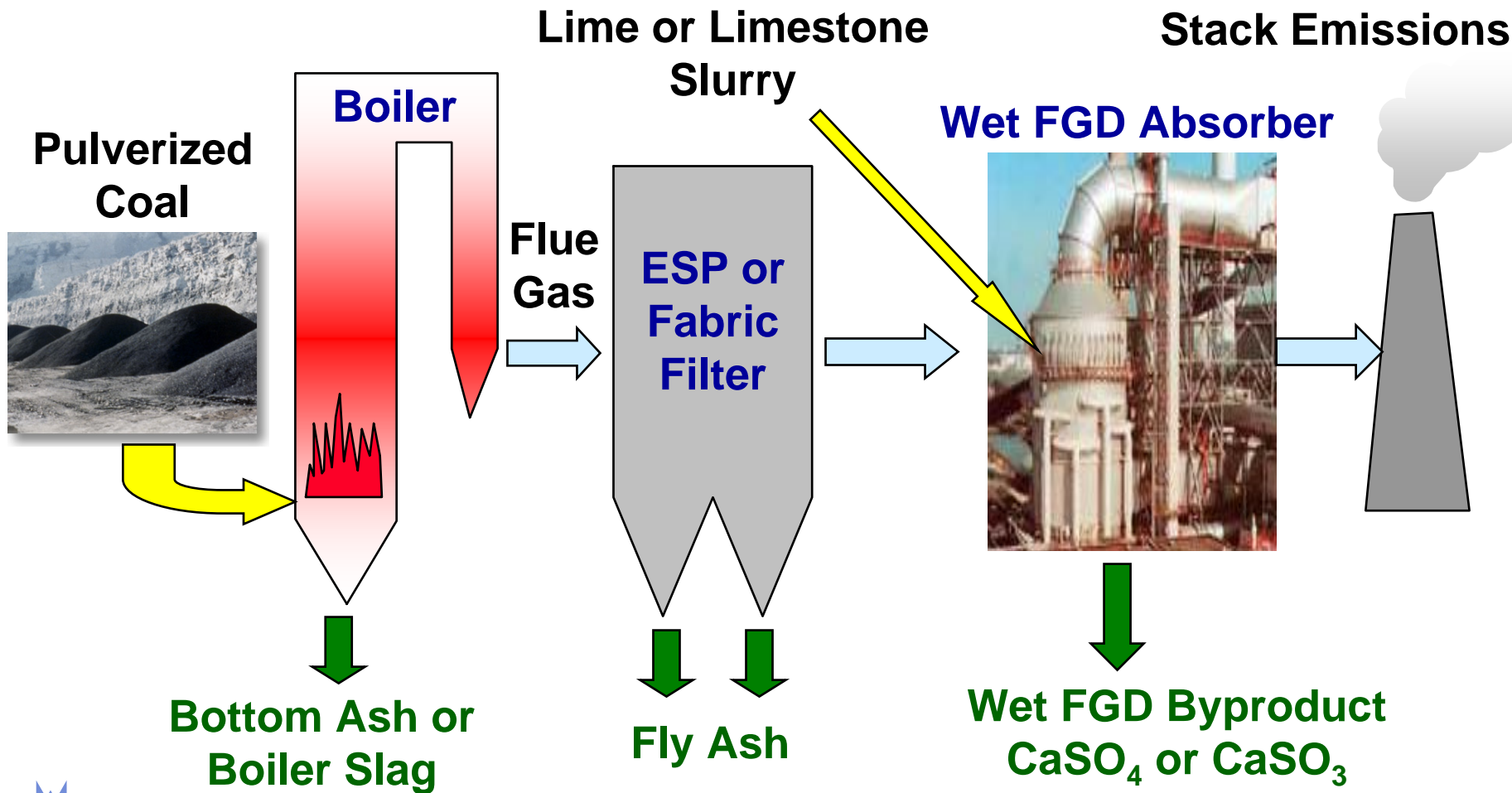
# CUBs from Electric Utility Boilers

*Pulverized Coal without Flue Gas Desulfurization*



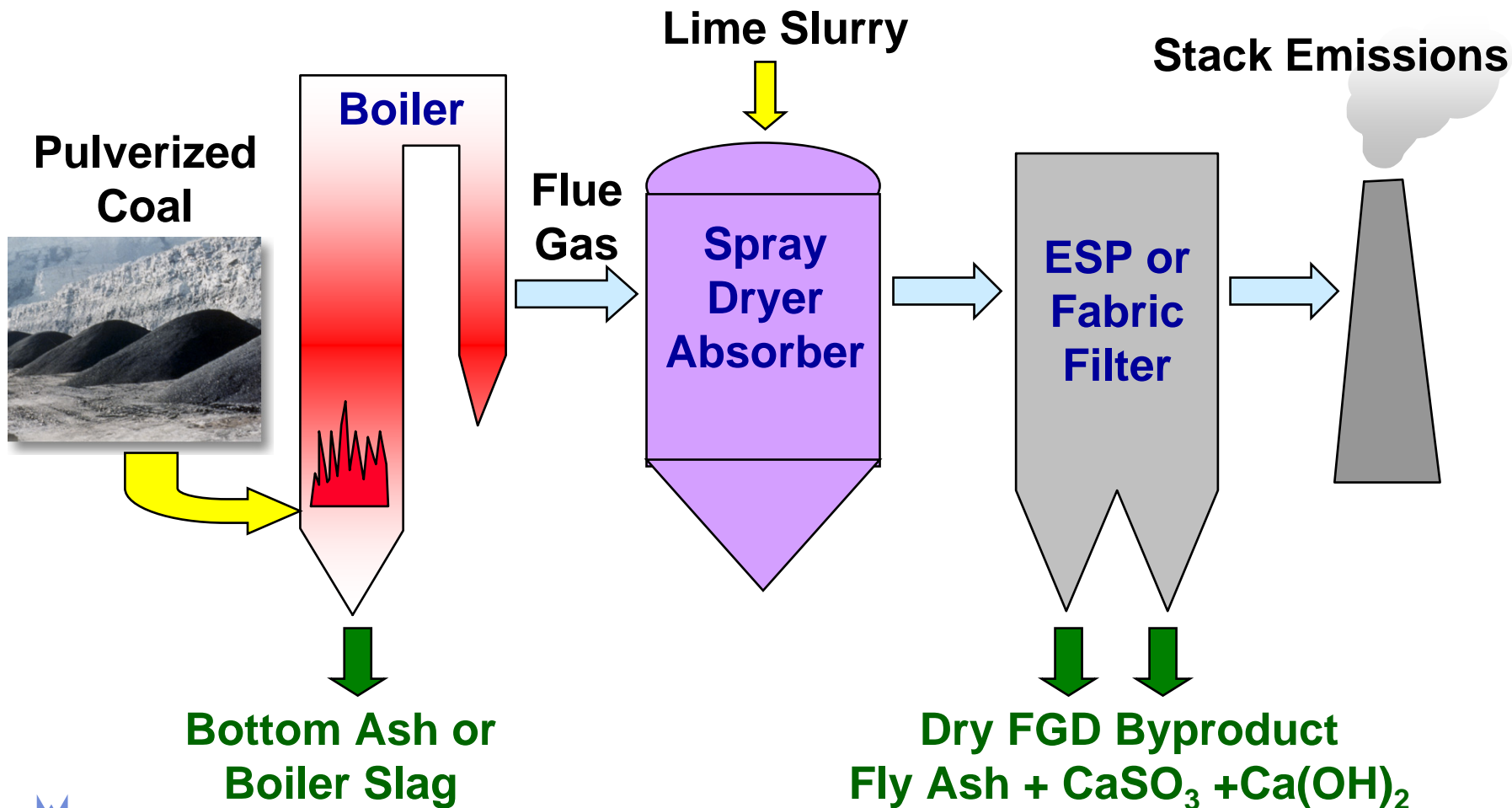
# CUBs from Electric Utility Boilers

*Pulverized Coal with Wet Flue Gas Desulfurization*

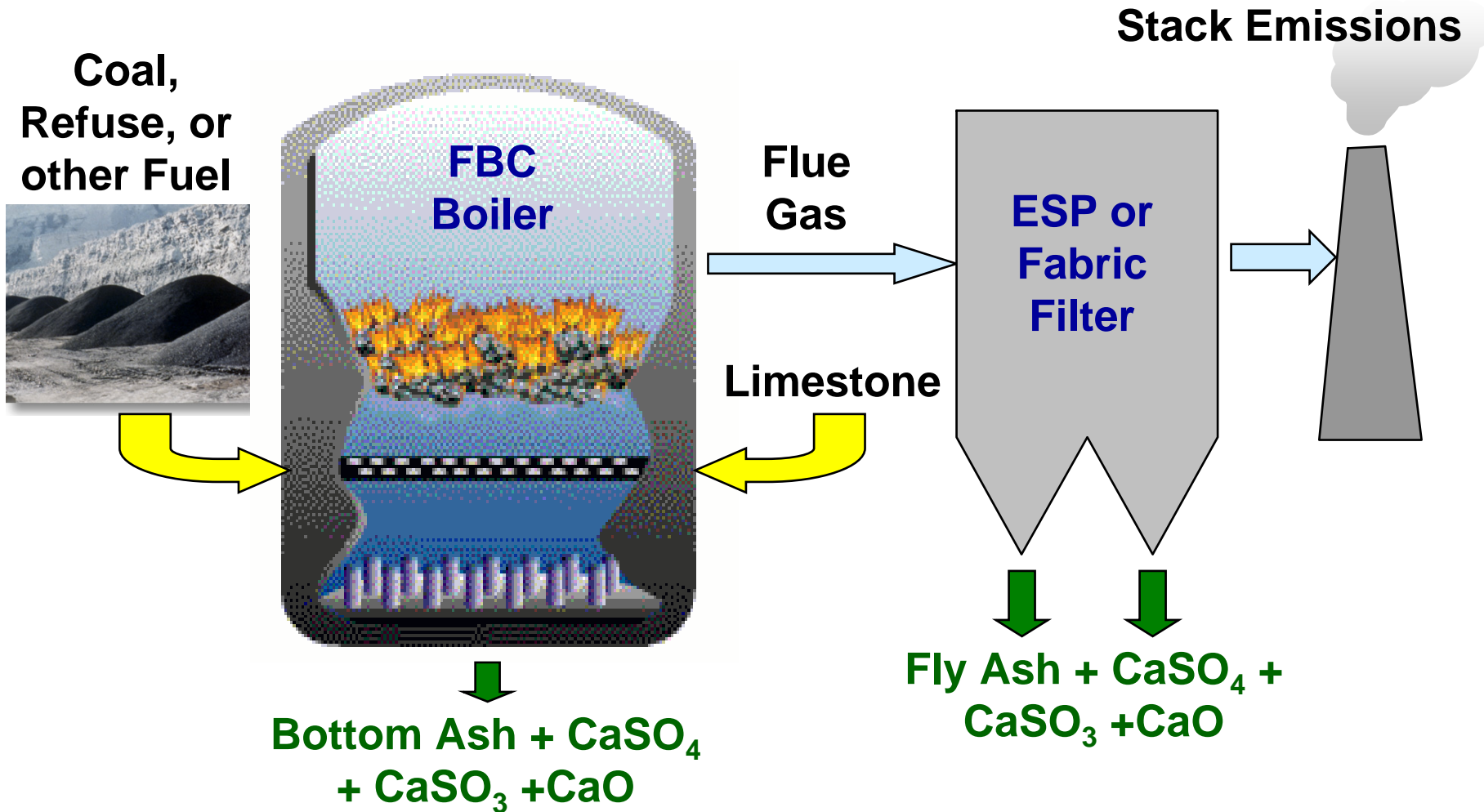


# CUBs from Electric Utility Boilers

*Pulverized Coal with Dry Flue Gas Desulfurization (FGD)*



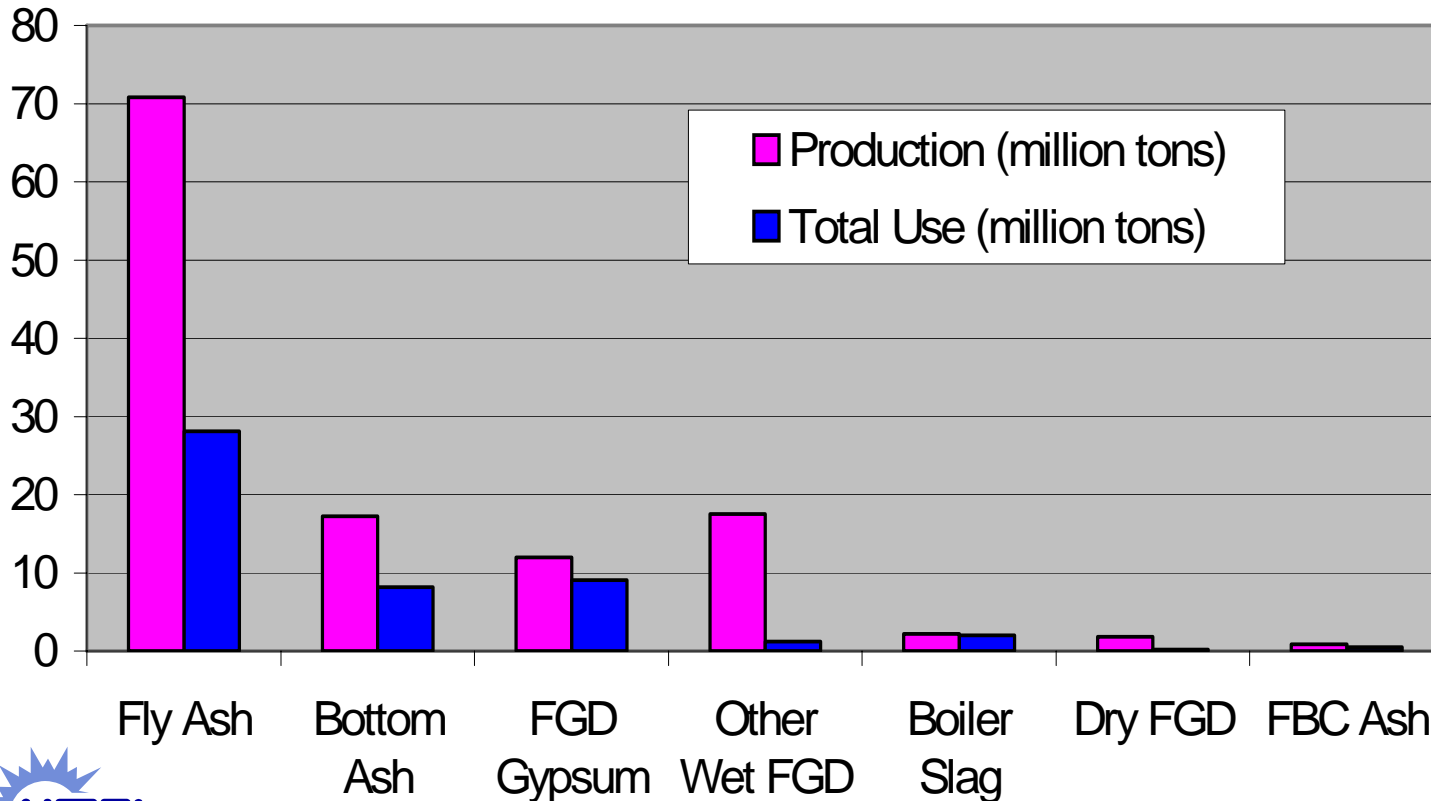
# CUBs from Fluidized Bed Combustion (FBC)



# 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

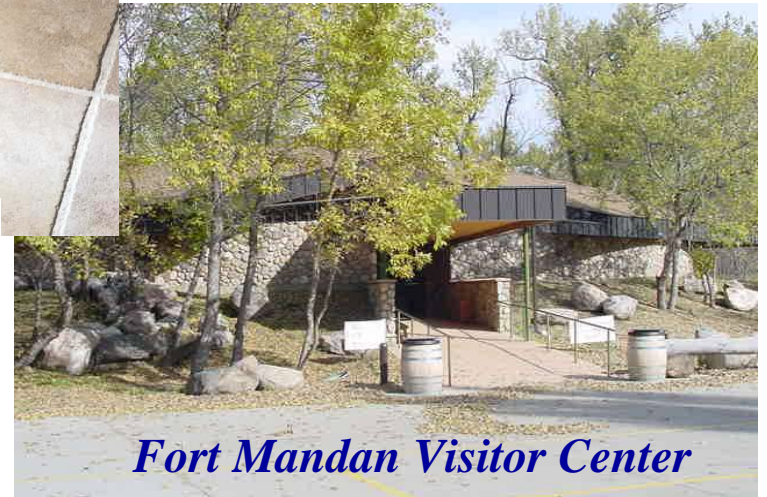
- **Increase overall beneficial utilization of CUBs to 50% by 2010**
  - Requires collaboration by Government & Industry
    - Expanded use in “proven” applications
    - Development of new large-volume beneficial uses
  - Must overcome economic, perceptual & regulatory barriers



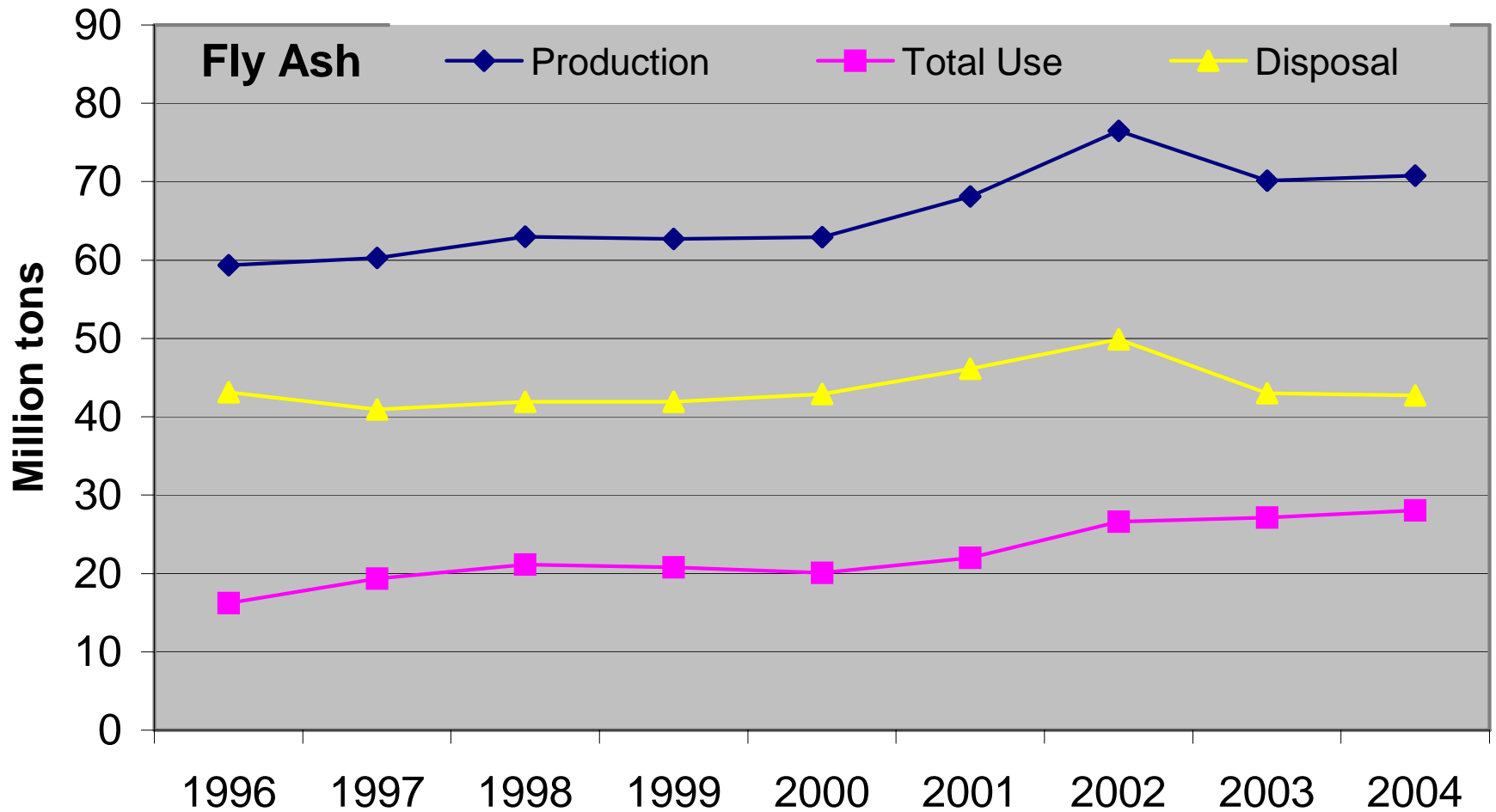


# Many Uses for Coal Utilization Byproducts

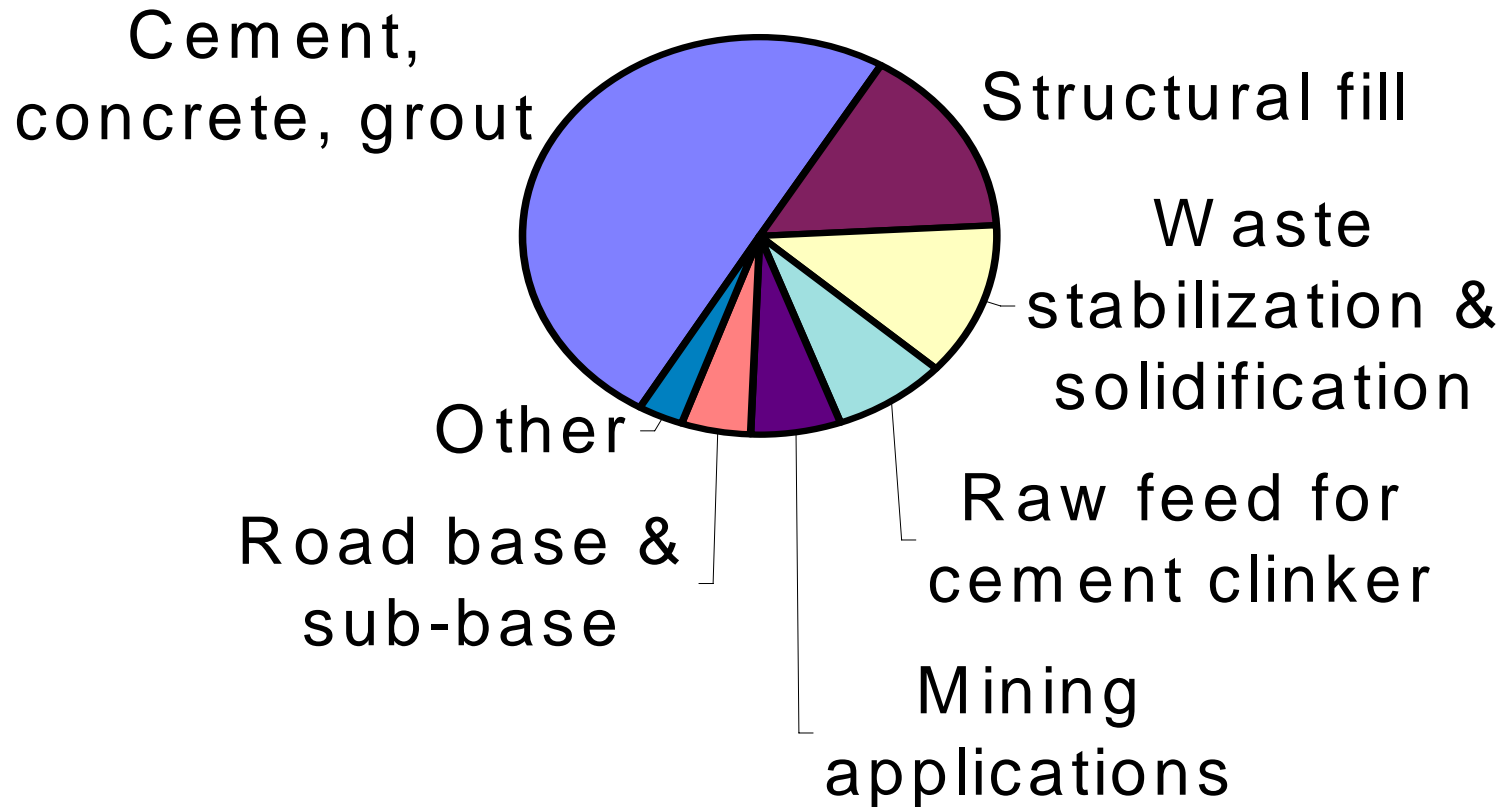
- Drywall (Gypsum)
- Cement & Concrete
- Structural fill
- Road base
- Anti-skid
- Soil amendmets
- Bowling balls
- Wall paints
- Carpeting
- Synthetic tiles
- AMD control



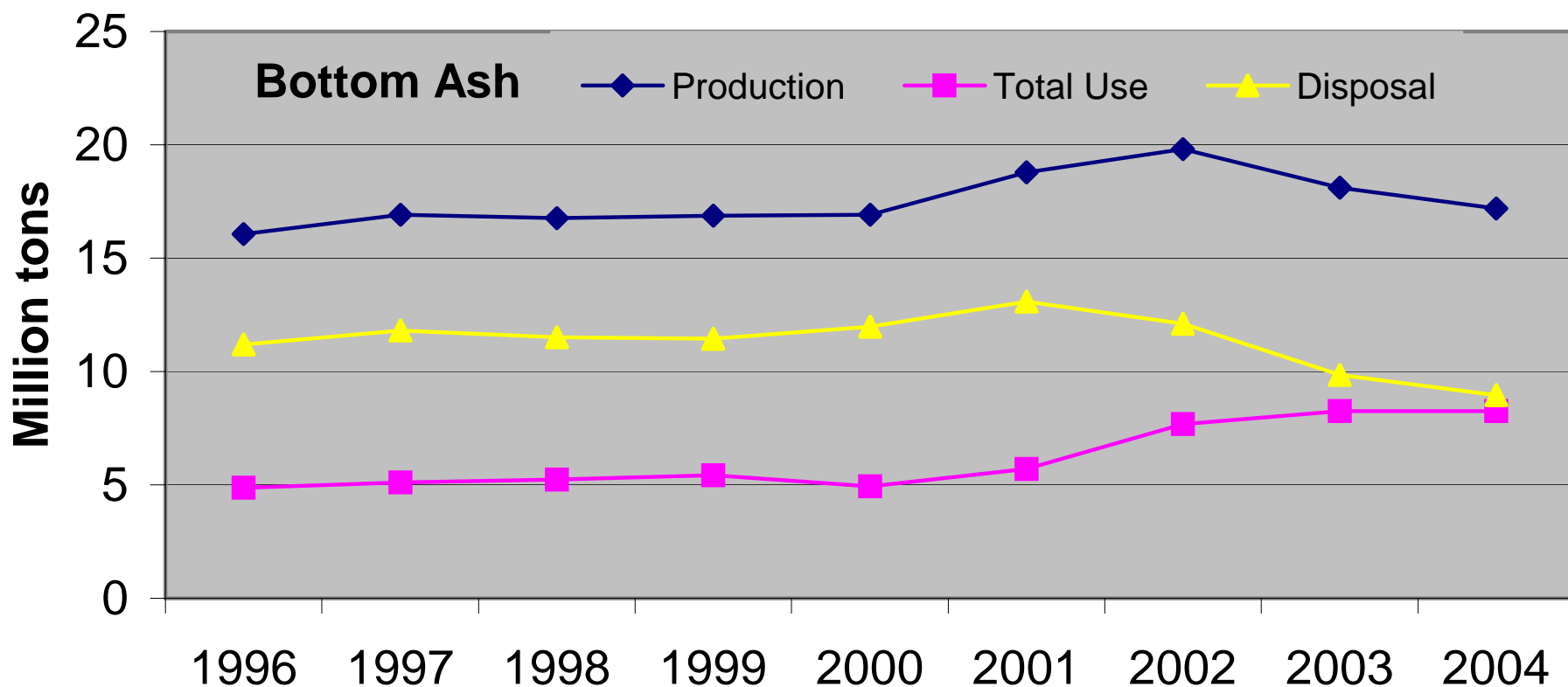
# Trends in Fly Ash Production & Use



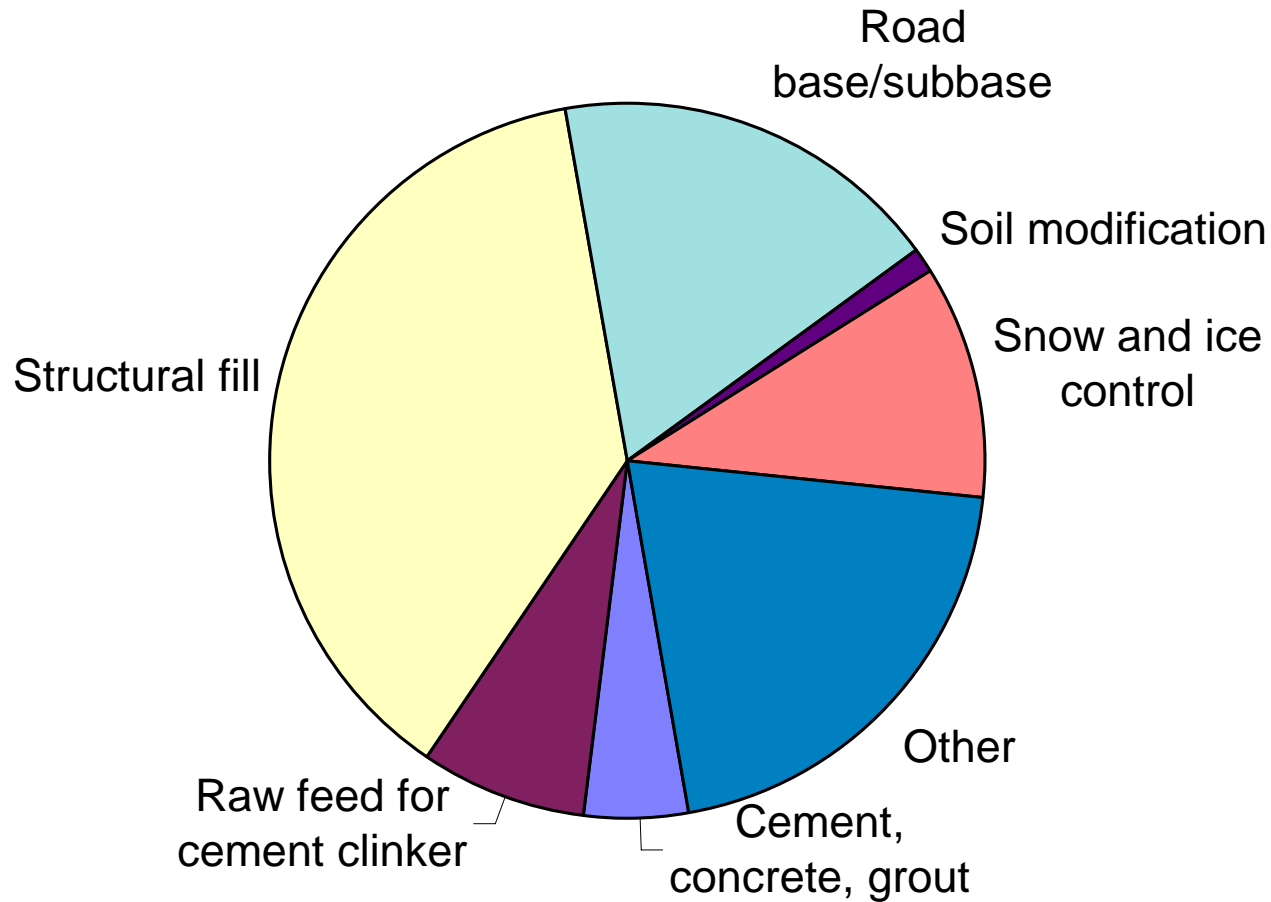
# Types of Fly Ash Utilization



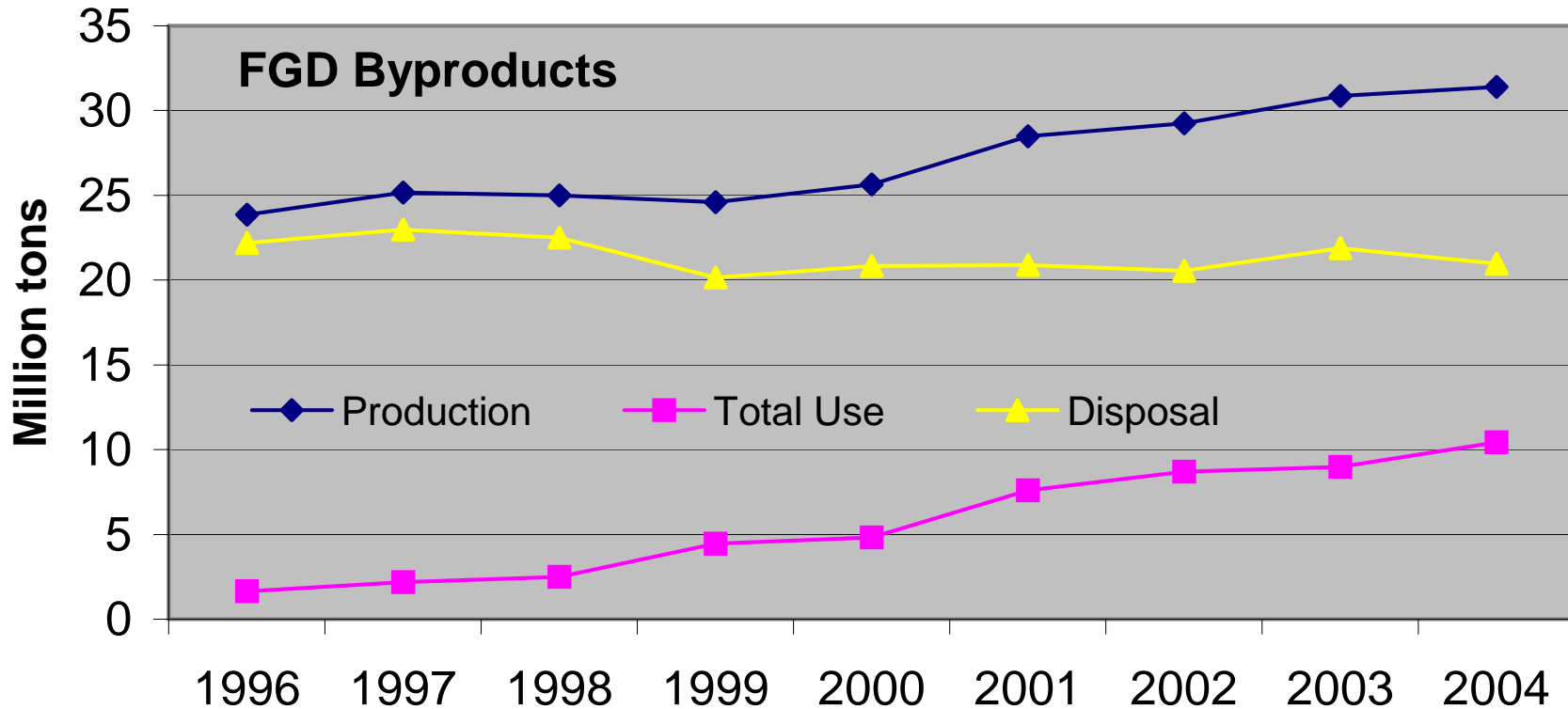
# Trends in Bottom Ash Production & Use



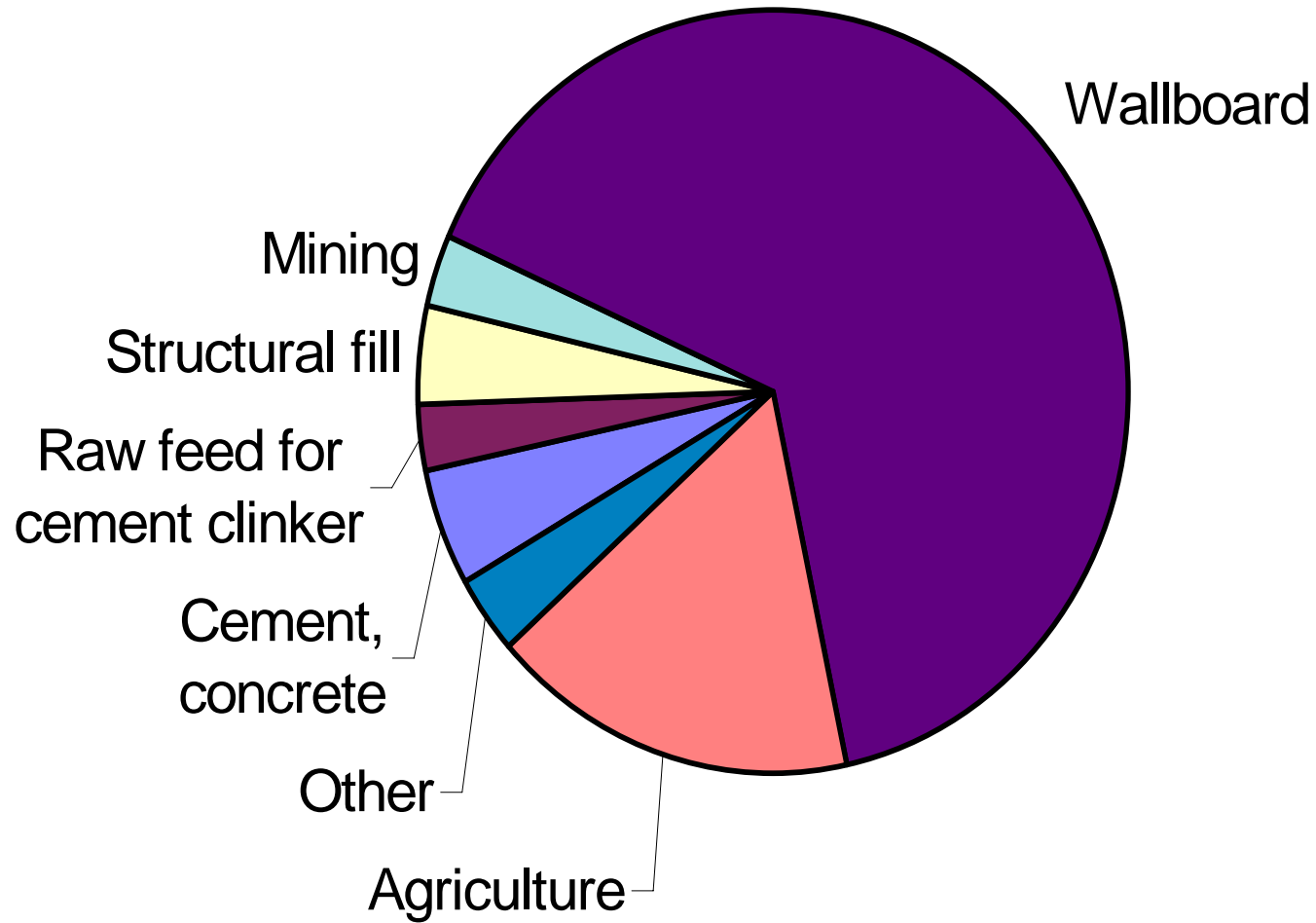
# Types of Bottom Ash Utilization



# Trends in FGD Byproduct Production & Use

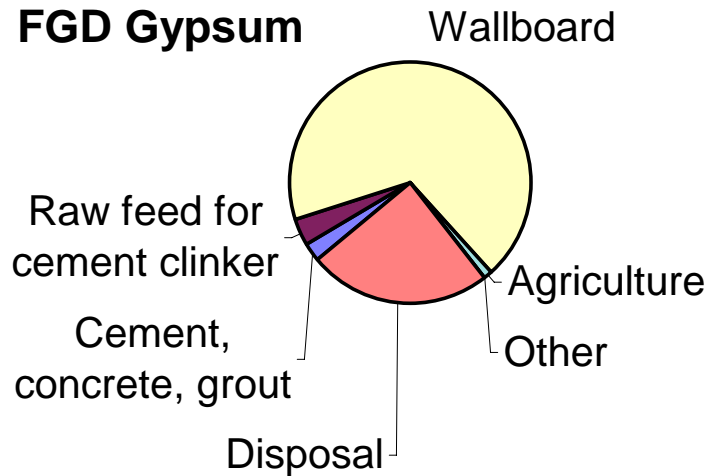


# Types of FGD Byproduct Utilization

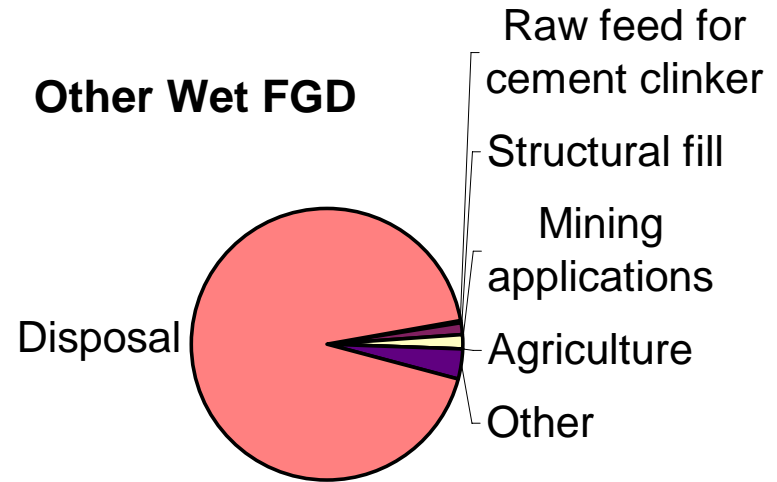


# FGD Byproducts: Use by Type (2004)

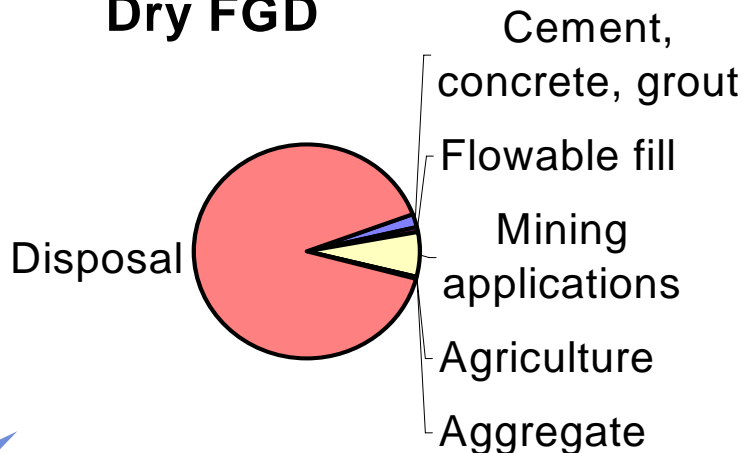
**FGD Gypsum**



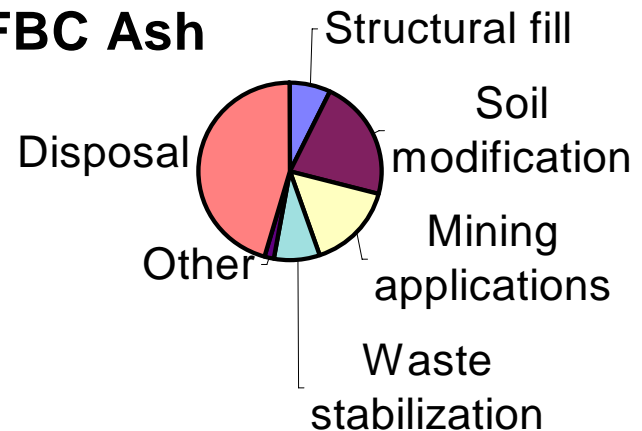
**Other Wet FGD**



**Dry FGD**



**FBC Ash**





# Multiple Benefits of Using CUBs

- **Environmental**

- Reduced greenhouse gas emissions
  - 1 ton of fly ash as cement replacement = 0.8 tons of CO<sub>2</sub> avoided
- Reduced land disposal requirements



- **Economic**

- Avoid disposal costs
- Revenue from sale of byproducts

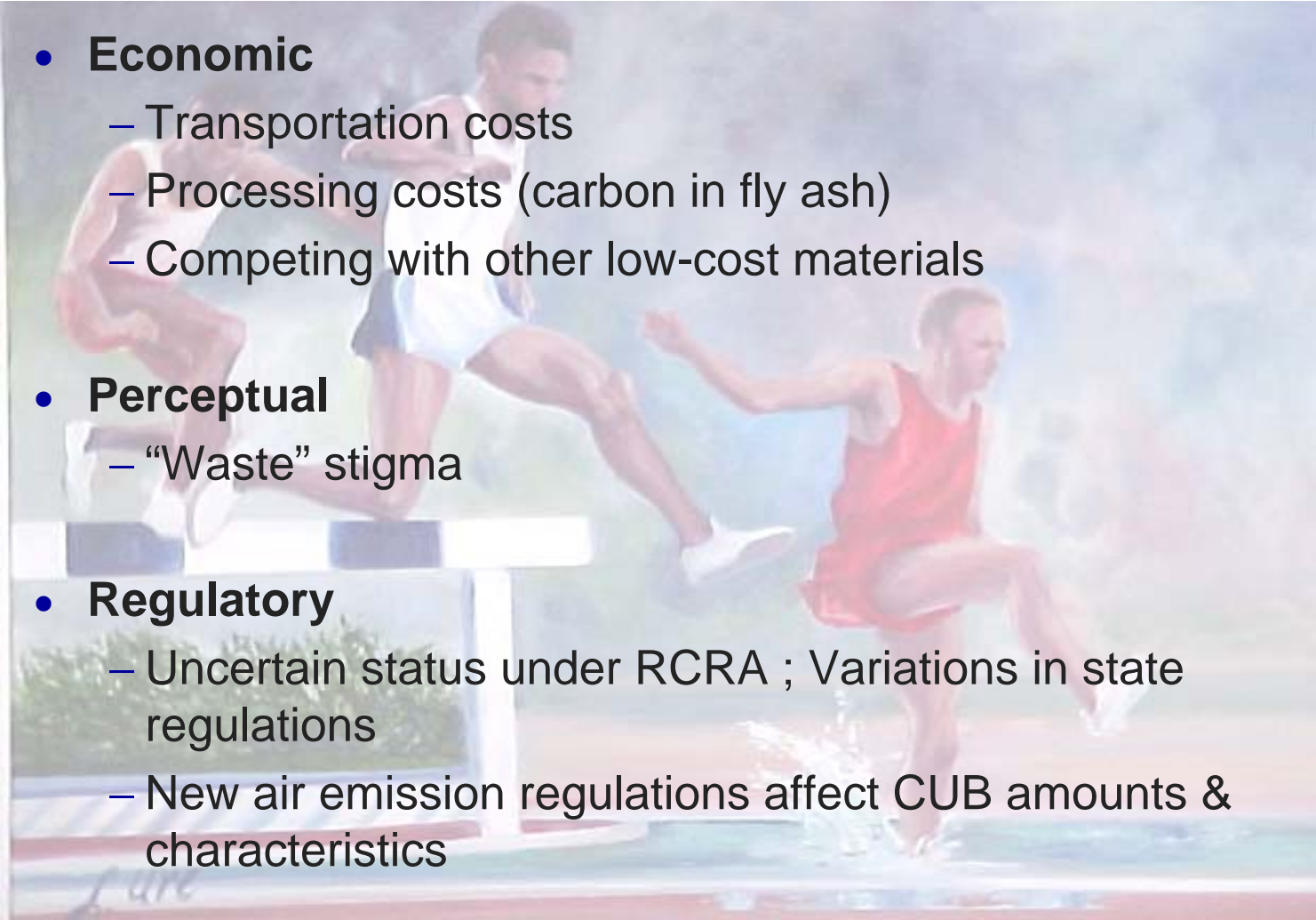


- **Performance**

- 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<sub>3</sub> in fly ash disrupt or prevent expansion of current cement/concrete markets?
- **CAMR: Additional Hg in CUBs**



# Coal Combustion Products Partnership (C<sup>2</sup>P<sup>2</sup>)

- **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<sup>2</sup>P<sup>2</sup> 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

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FOSSIL ENERGY NEWS SPOTLIGHT

**Jeffrey Jarrett to Lead Fossil Energy Office**  
Jeffrey D. Jarrett was sworn in as the 10th Assistant Secretary for Fossil Energy after being confirmed by the Senate on December 17, 2005. Jarrett brings more than 30 years of energy and environmental experience to the job. [Read more >](#)

**12:06:05 :: FutureGen Project Launched**  
The Energy Department has signed an agreement with the FutureGen Industrial Alliance to build FutureGen, a prototype of the fossil-fueled power plant of the future. The nearly \$1 billion government-industry project will produce electricity and hydrogen with zero emissions. [Read more >](#)

**12:23:05 :: DOE Extends Public Comment Period on Natural Gas Supply and Demand to January 19, 2006**  
Public and stakeholder comments are being sought on the outlook for natural gas supply and demand, as requested by Congress and the National Energy Policy Act. [Read More >](#)

**12:20:05 :: Novel Coal-Fired Heating Systems Proves Successful at Ohio Greenhouse**  
Using a Department of Energy-funded coal-fired technology, a greenhouse in northeast Ohio is saving more than \$1,000 a day in heating costs. [Read More >](#)

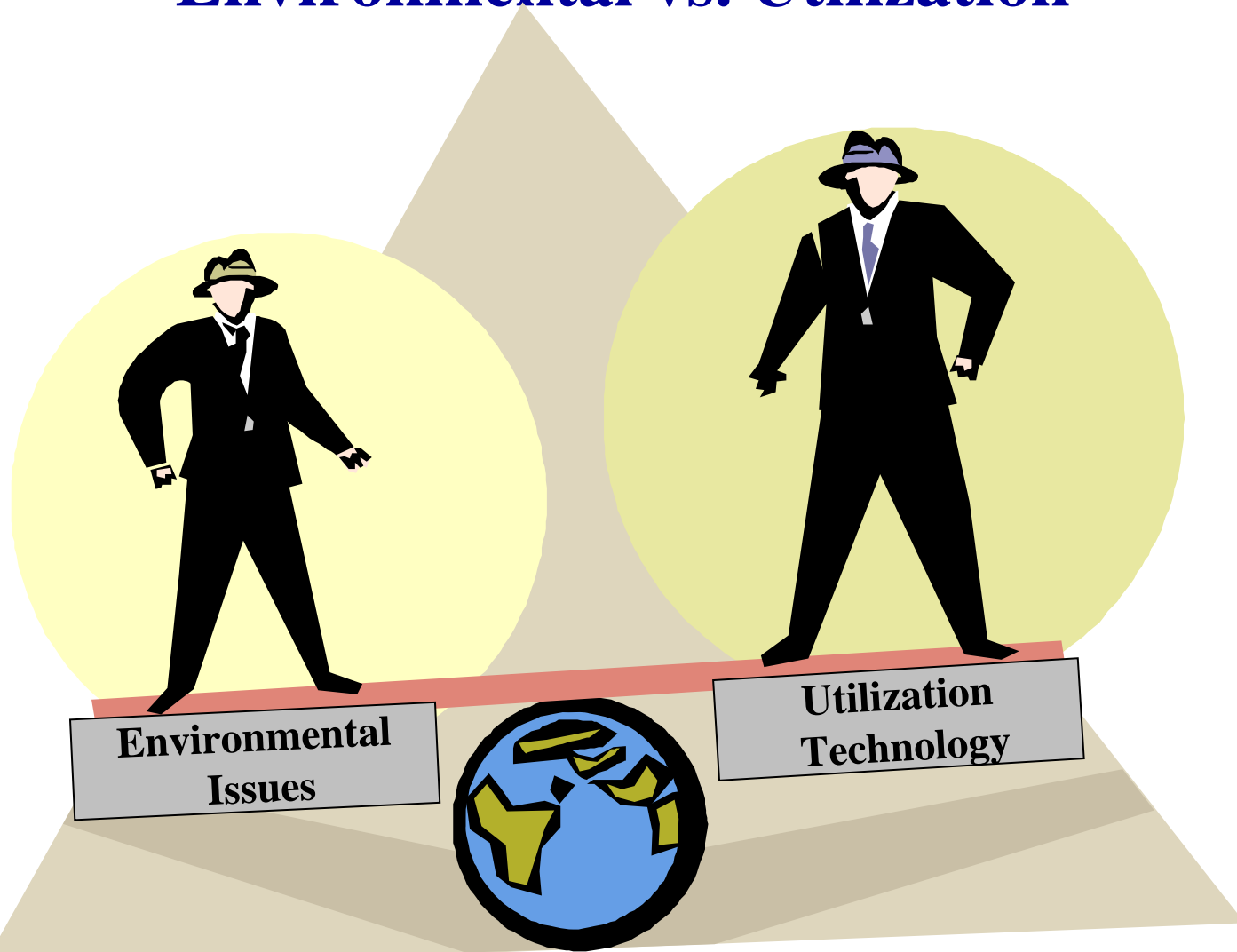
OFFICE OF FOSSIL ENERGY  
Ensuring that we can continue to rely on clean, affordable energy from our traditional fuel resources is the primary mission of DOE's Office of Fossil Energy. Fossil fuels supply 85% of the nation's energy, and we are working on such priority projects as pollution-free coal plants, more productive oil and gas fields, and the continuing readiness of federal emergency oil stockpiles.

Read more about:

- Fossil Energy Organization
- Business & Funding Opportunities
- Upcoming Fossil Energy Events
- Topics/Opportunities for Students & Teachers



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



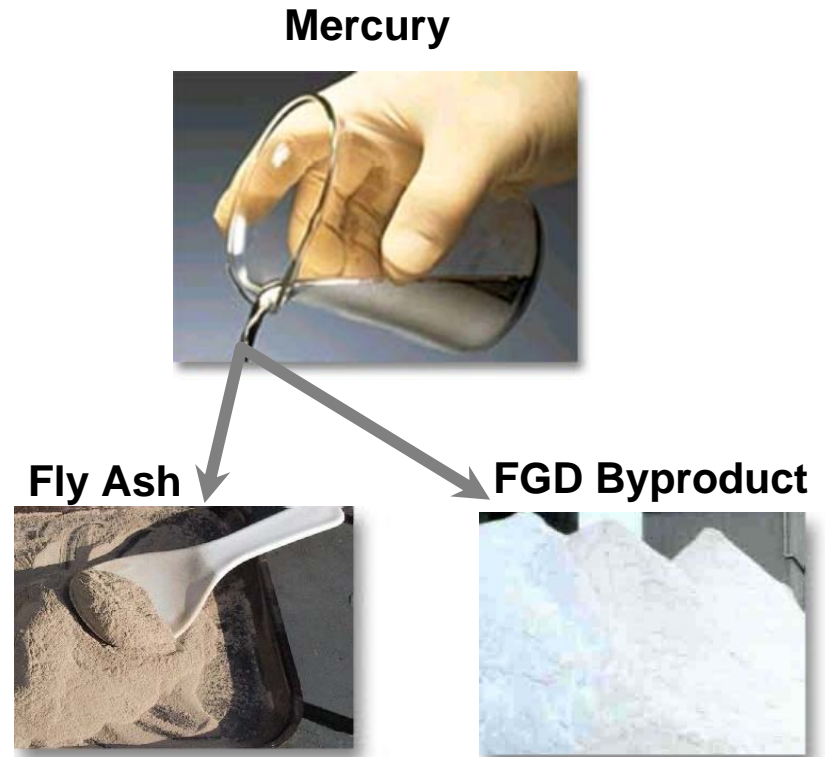
# Potential Impact of Power Plant Mercury Emission Regulations on CUBs

## Fly Ash

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

## FGD Solids

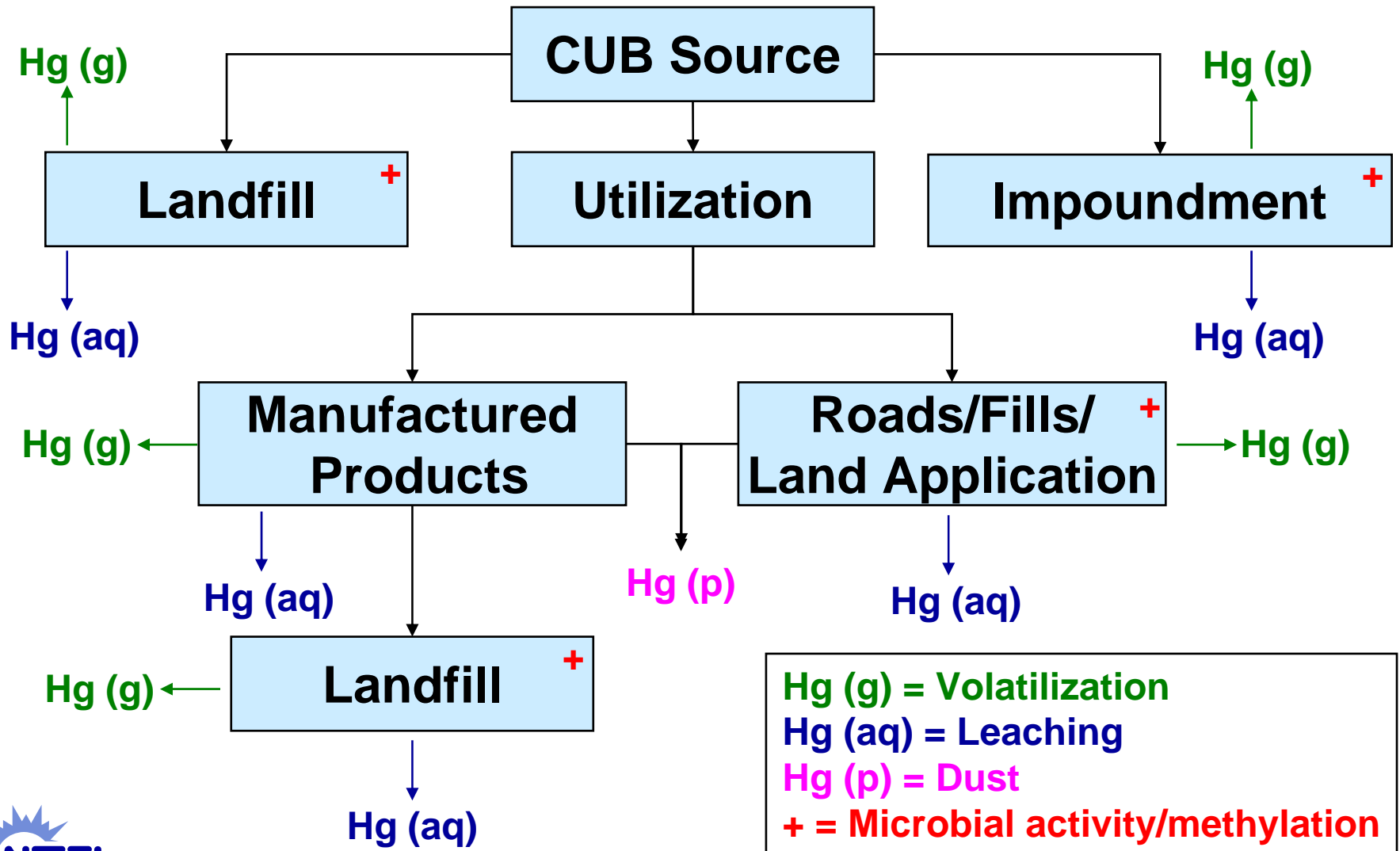
- Loss of all reuse applications  
~ \$213 M/yr impact



**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 does not leach in landfills and beneficial use environments
  - >99.9% of Hg stays in solid

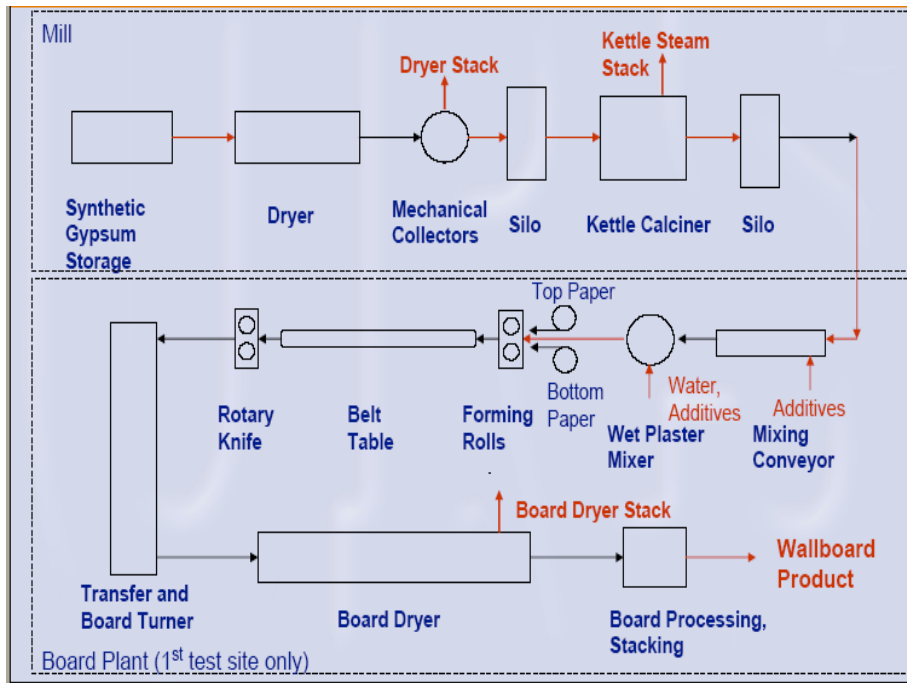


*Drywall ready for landfill*

- 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.)

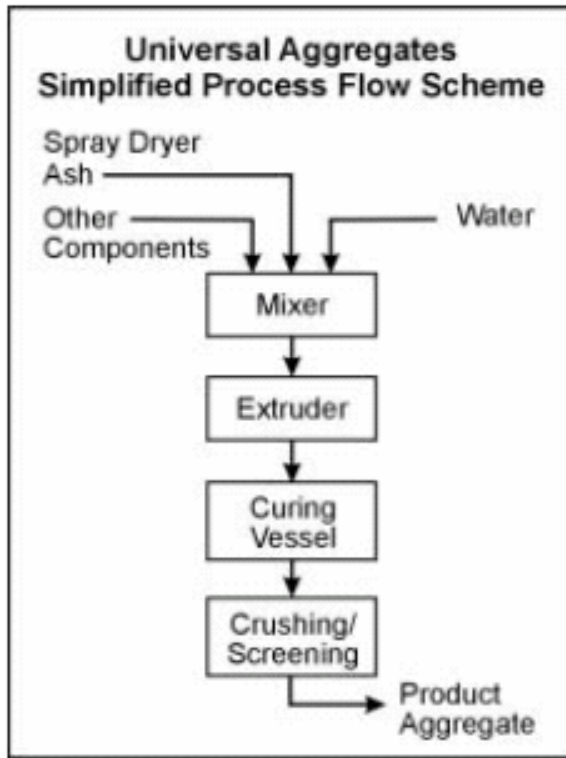


# Combustion Byproducts Recycling Consortium (CBRC)

- **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://www.wri.nrcce.wvu.edu/CBRC/>**



# PPII Project: Manufacture of Lightweight Aggregates Using Spray Dryer Ash



**Birchwood Power Partners  
King George County, VA**

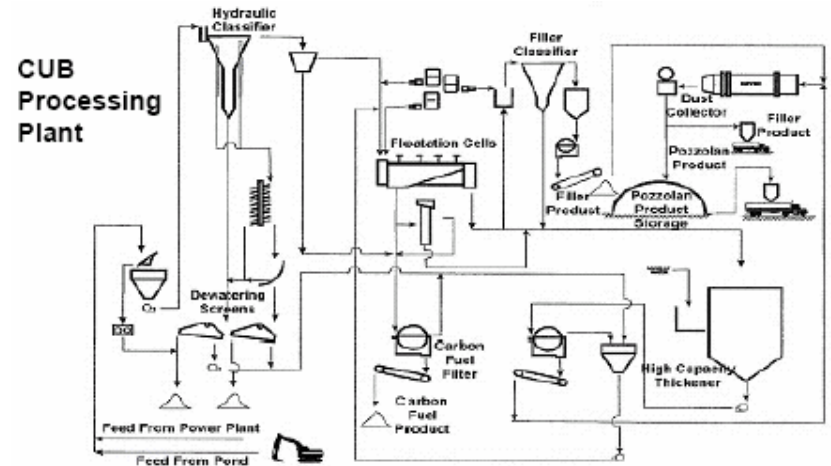


- 115,000 tpy ash → 167,000 tpy aggregates
- Aggregate properties tailored toward end-use markets
- Operation began in Spring 2004



# 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<sup>2</sup>P<sup>2</sup>)**
  - <http://www.epa.gov/c2p2/>
- **Combustion Byproducts Recycling Consortium**
  - <http://wwwri.nrcce.wvu.edu/CBRC/>

