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CAER -- University of Kentucky, Center for Applied Energy Research

Vol. 8, No. 6, 1997

Energeia

# Disposal of Coal Combustion Byproducts in Underground Coal Mines

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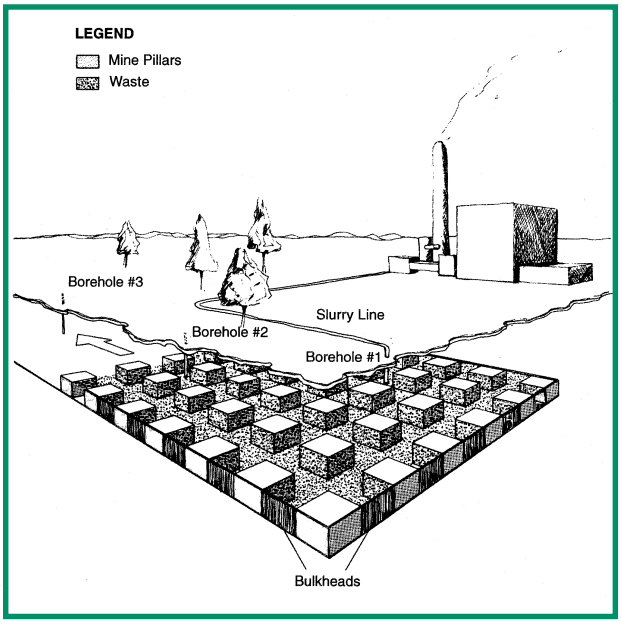
## INTRODUCTION

**Approximately 90 million tons of coal combustion byproducts (CCB) are generated annually by the electric utility industry in the United States. The major byproducts include fly ash (~54%), bottom ash (~16%), boiler slag (~7%), and flue gas desulfurization sludges (~23%). Of the amount generated, about 19 million tons are beneficially used, primarily fly ash as a Portland cement replacement in concrete and concrete products. The remaining, about 71 million tons, is disposed of in impoundments and landfills. The costs for these disposal methods continue to increase due to more stringent environmental regulatory requirements and rising material, labor, and site development costs. As such, these increasing disposal costs are causing the electric utility industry to pursue other disposal and utilization alternatives.**

One alternative to the typical disposal methods is the return and disposal of the byproducts in underground coal mines. This alternative could be economically beneficial to both the coal mining industry and the electric generating industry as well as provide environmental benefit. Since the U.S. Environmental Protection Agency (EPA) determined coal ash to be nonhazardous, this alternative disposal method, which can have numerous benefits, would be consistent with EPA's hope to assist the industry in finding uses for coal ash and promoting resource utilization in lieu of disposal. This article provides an overview of the concept and history of disposal in underground mines, briefly discusses currently allowed practices in several key coal mining states, presents several (but by no means all) key design considerations and environmental concerns / benefits, and discusses several areas for further investigation and research that may result in increased disposal in underground mines.

## HISTORY

The coal industry routinely slurries fine-coal waste from coal preparation and sludge from acid-mine drainage treatment facilities to underground mine workings in lieu of surface impoundment disposal. Therefore, it is not hard to conclude that injection of coal combustion byproducts into underground mines is technologically feasible. One successful project is Duquesne Light Company's hydraulic disposal of fly ash into an abandoned mine located near their Cheswick Power Station to the northeast of Pittsburgh, Pennsylvania. Since 1970, 350 tons per day of fly ash have been slurried into the mine.




*Underground disposal using blind hydraulic flushing*

In addition to this project, several smaller projects document the interest in the concept of disposal in underground mines. For example:

- American Fly Ash has hydraulically injected fly ash into the deep mine workings of Peabody Coal Company's #10 Mine near Springfield, Illinois.
- Dravo Lime Company has disposed of kiln dust waste in deep mine workings at their Cabin Creek lime plant in Maysville, Kentucky.
- The Maryland Department of the Environment is conducting a project to demonstrate the feasibility of disposing coal combustion byproducts in abandoned deep mine workings.
- A permit for injection of CCBs into the mined out areas of an active deep mine has been issued to Mettiki Coal Corporation by the Maryland Department of the Environment.
- In West Virginia a coal ash grout injection project to reduce acid mine drainage from an abandoned deep mine by filling the mine voids is expected to be completed soon. The project is sponsored by the West Virginia Division of Environmental

*(continued, page 5)*

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## Disposal of Coal, continued

Protection and is partially funded by Allegheny Power, Anker Energy, OSM, EPRI, and Consol.

**PRACTICES CURRENTLY ALLOWED**
The complexity of the many federal, state, and local regulations concerning not only mining, but also solid and residual wastes, offers a significant barrier to planning and implementing a project involving the disposal of coal combustion byproducts in underground mines. In addition, the opinions and perceptions of regulatory personnel can also influence potential projects. To gain an understanding of currently allowed disposal practices, the authors polled the state mining and solid/residual waste authorities in the states of Illinois, Indiana, Kentucky, Maryland, Ohio, Pennsylvania, Virginia and West Virginia.

Although the majority of the states polled indicated that underground injection is allowed, the practice of disposing in underground coal mines is not prevalent. This could be attributed to high disposal costs or to prohibitive regulations or perceptions by regulatory personnel. For example, state agency personnel may perceive underground injection as disposal (and the respective solid/residual waste regulations may not allow "disposal" in unlined sites) and not beneficial use; however, the benefits could be seen in subsidence mitigation and acid mine drainage control.

**DESIGN CONSIDERATIONS**
The economics of large volume disposal in underground mines versus continued disposal in impoundments or landfills will obviously dictate future courses of action. Some key design considerations are presented below.

- Proximity of the mine (disposal site) to the generation source will determine the transportation cost for the by-product.
- Conditions of the mine voids will determine the potential storage capacity of the disposal site. Abandoned room and pillar mines offer better opportunities than longwall mines.
- The current by-product handling systems at the source may require modification to prepare the materials for shipment.
- The flowability of the material must be such that it can fill the mine voids. Some byproducts may require modification to improve flowability.
- Large volumes of water are needed for the slurry in hydraulic disposal.
- The depth of the mine and the local hydrogeology will determine the extent of a designed containment.

**ENVIRONMENTAL CONCERNS/ BENEFITS**
Although the EPA determined that coal ash is nonhazardous, environmental liability remains as a key issue. Modification to mine drainage patterns may occur and could affect adjacent property owners. In addition, there is potential for modifying or degrading local groundwater conditions and if dewatering a mine void area prior to filling with coal combustion byproducts is required, subsidence may be induced. However, there are some benefits to underground disposal that should be highlighted.

- Disposal underground reduces the number of surface disposal sites and the environmental, health, safety and social problems associated with them.
- Disposal underground improves mine support and reduces potential for subsidence.
- Alkaline coal combustion byproducts may help to neutralize existing acid mine drainage, provide mitigation of acid mine seeps, and may work to improve groundwater quality.
- Filling the voids in acid producing seams can reduce groundwater contact and acid production.
- Groundwater flow may be impeded, thereby reducing the volume of acid mine seepage.
- Underground disposal may help prevent/control mine fires.

**ADDITIONAL STUDIES/RESEARCH NEEDS**
The technical feasibility of disposing coal combustion byproducts in underground mines has been proven and the selection of this disposal alternative will be decided based primarily on cost and regulatory compliance issues. As such, additional research on the technical issues of injecting coalcombustion byproducts or coal combustion by-product slurries should only be needed in limited special circumstances. On the other hand, more research into the chemical aspect and the interaction of the coal combustion byproducts, mine water, local geology, and groundwater is needed to assess the environmental impact of coal combustion by-product mine injection. Also, many new coal combustion byproducts are being generated and are presenting challenges for surface disposal, let alone for disposal underground. For example, many electric utilities have installed FGD scrubbers to meet the requirements of the 1990 Clean Air Act Amendments. These byproducts are different both physically and chemically from fly ash and require additional research. A pilot study of fixated scrubber sludge injection into an abandoned underground mine was recently performed by the Indianapolis Power and Light Company at their Petersburg Station. No degradation of groundwater was found following the injection at this project.

**SUMMARY**
Although the disposal of coal combustion byproducts in underground coal mines is not widespread, the mine injection disposal alternative has many key attributes. The injection into underground mines reduces the surface area required for disposal sites (landfills and impoundments), eliminates the potential for surface water pollution, eliminates the potential for fugitive dust emission and associated air pollution, reduces the potential for subsidence, and improves the aesthetics of the local area. Also, in acidic coal seams, the injection of coal combustion byproducts can have the additional benefit of reducing the acidity of the mine water. Finally, the concept of waste haulback and disposal in the mine workings may benefit coal companies that can tie these issues into long-term coal contracts.

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## Hower Honored Again

Jim Hower was named the "Outstanding Kentucky Geologist" for 1997 by the Kentucky Section of the American Institute of Professional Geologists at its April 1997 meeting in Lexington. This is the first time the award was presented. He was also given the Distinguished Service Award by the Coal Geology Division of the Geological Society of America at its October 1997 meeting in Salt Lake City.