



# 2023

## EMISSIONS CONTROL



## PROJECT PORTFOLIO



U.S. DEPARTMENT OF  
**ENERGY**



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## INTRODUCTION

The U.S. Department of Energy's (DOE) Emissions Control Program develops technological improvements and solutions for control of non-CO<sub>2</sub> emissions (liquids, gases, and solids) associated with carbon capture, plus management, disposition, and remediation of coal combustion residuals (CCRs) and CCR storage sites. The next-generation concepts and advanced technologies on which the National Energy Technology Laboratory (NETL) and partners are working are intended to address the urgent need to safely manage and disposition aging inactive/legacy CCR impoundments, control emissions associated with those impoundments, and control non-CO<sub>2</sub> emissions that may occur with more widespread implementation of carbon capture and decarbonization. These technological advancements will help foster environmental justice as they underpin remediation of legacy harms of fossil fuel use, reduction of the volume of CCRs for disposal, and address any pollution issues that might emerge in the large-scale implementation of carbon capture. Specifically:

### **Advanced Concepts and Technologies to Increase the Beneficial Use of Coal Combustion Residuals**

Research and development (R&D) in this area will advance technology applicable to increasing the beneficial utilization of coal combustion residuals (CCR) via:

- Innovative technology and concepts to increase beneficial utilization: R&D will to be directed at (1) the fraction of coal combustion products that are not currently being recycled or beneficially reused at high levels such as non-gypsum, wet and dry flue gas desulfurization materials and bottom ash and/or (2) materials used in current CCR facilities that may be negatively impacted by new CCR regulations.
- Innovations for improved cost and performance of CCR beneficiation/upgrading technologies: R&D to focus on improvements in the performance and cost of beneficiation/upgrading of technology associated with high-volume reuse materials (i.e., fly ash and synthetic gypsum).
- Innovative technology and processes for utilizing CCR in storage impoundments: Advanced cost-effective approaches for removing, upgrading, and beneficially recycling CCR from active and inactive storage impoundments are sought.

### **Advanced Concepts and Technologies for Managing Inactive and Legacy CCR Impoundments**

R&D in this area will advance technologies applicable to improving the management or closure of active and inactive CCR disposal sites. The approaches being pursued are:

- Innovative technologies, concepts, and processes for managing and/or closing-in-place inactive or legacy storage impoundments: Approaches that provide a cost-efficient and environmentally sound alternative to the physical removal of the material are of interest. R&D is sought for innovative technologies, concepts, and processes to stabilize, neutralize, and/or encapsulate trace metals and other contaminants in unlined or inadequately lined inactive or legacy disposal sites.
- Innovative technologies, concepts, and processes for CCR impoundment leachates: innovative concepts are sought that will treat leachates and related discharges from both active and inactive (legacy) unlined or inadequately lined CCR impoundments and ponds with a particular focus on arsenic and selenium. These treatment technologies should be relatively small and modular in design with the assumption that further development could allow them to be mobilized.

Technologies developed under the Emissions Control program will responsibly divert coal CCR towards beneficial reuse, improve the operation and management of existing and legacy CCR impoundments, and reduce the volume of CCR needed to be disposed of in impoundments while protecting the environment and the health and safety of the public.

# ADVANCED CONCEPTS AND TECHNOLOGIES TO INCREASE THE BENEFICIAL USE OF COAL COMBUSTION RESIDUALS

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## Facilitating Implementation of High-Volume Fly Ash use in Precast Concrete Construction to Increase Beneficial Utilization

<b>Performer</b>	Illinois Institute of Technology
<b>Award Number</b>	FE0031931
<b>Project Duration</b>	10/01/2020 – 09/30/2023
<b>Total Project Value</b>	\$ 1,244,344
<b>Focus Area</b>	Ash Beneficial Use

The main goal of this project is to increase the beneficial use of fly ash as a supplementary cementitious material for precast concrete applications. The major focus of this project is to develop balanced concrete mix design strategies which collectively satisfy the following objectives: (1) increase fly ash beneficial use by at least 15% in the precast concrete industry, (2) maintain or exceed stringent structural property requirements (e.g., compressive strength at initial prestress, modulus of rupture, etc.), (3) exhibit little or no additional cost relative to conventional mixtures, and (4) mitigate detrimental environmental consequences

inadvertently caused by increased beneficial use.

Anticipated outcomes of this project include significantly increased beneficial use of fly ash in the concrete industry via the precast construction sector, revised design guidelines and code provisions for sustainability requirements for concrete mix designs, diversion of large quantities of fly ash from landfills or impoundments, and establishing a framework for incorporating lesser-used coal combustion residual materials (e.g., fly ash which does not meet applicable specification requirements) in concrete construction practices.



Development of a high-volume fly ash implementation framework for precast concrete construction will encompass (a) participation from a coal-fueled power generation facility and fly ash distributor, (b) cutting-edge concrete materials science research, and (c) fabrication and experimental testing of (d) full-scale precast components.

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<b>Performer</b>	National Energy Technology Laboratory (NETL)
<b>Award Number</b>	FWP-1022479
<b>Project Duration</b>	04/01/2021 – 03/31/2024
<b>Total Project Value</b>	\$ 464,989
<b>Technology Area</b>	Ash Beneficial Use

Sorbents are widely employed for the clean-up of fluids (such as coal-derived flue gas, drinking water, and gas masks), and have over 10 billion dollars in sales annually in the United States. A proof-of-concept artificial intelligence/machine learning (AI/ML) methodology will be developed to design optimum promoted zeolite sorbents for the treatment of ash impoundment leachate. Zeolites can be readily synthesized from materials contained within the coal combustion ash impoundments and can be promoted or cation exchanged to enhance capacity and reactivity. An additional rationale for development of this methodology is that sorbents are

typically developed through laborious, expensive, and time-consuming experiments, often taking years for commercial development. The proposed methodology will promote U.S. leadership in sorbent development, creating domestic jobs and reducing time and effort for the sorbent formulation. Benefits of this work would include: remediation of domestic ash impoundments, generation of beneficial byproducts from coal combustion residual (CCR), and development of a proof-of-concept AI/ML methodology for rapid design of sorbents tuned to specific ash impoundment and/or landfill requirements.

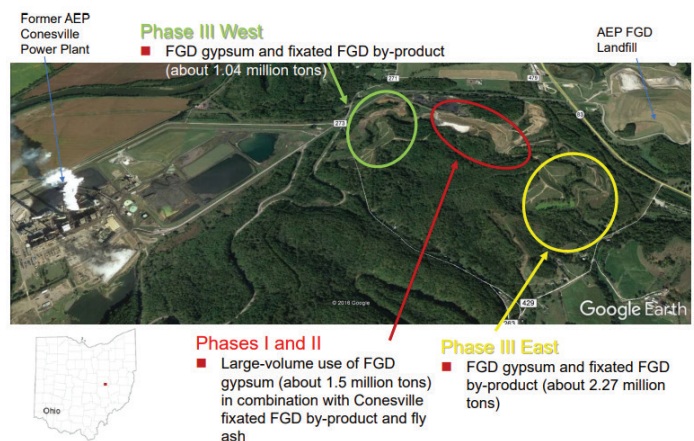
## Beneficial Use of Harvested Pondered Fly Ash and Landfilled FGD Materials for High-Volume Surface Mine Reclamation

<b>Performer</b>	Ohio State University
<b>Award Number</b>	FE0032038
<b>Project Duration</b>	07/06/2021 – 07/05/2023
<b>Total Project Value</b>	\$ 1,273,996
<b>Focus Area</b>	Ash Beneficial Use

The focus of this project will be on the viability of beneficial use of harvested coal combustible residuals (CCRs), especially pondered fly ash and landfilled flue gas desulfurization (FGD) by-products. The project will take place at three sites represented by circles in the adjacent graphic. The proposed project is designed to demonstrate laboratory- as well as bench-scale testing and construction methods that can be applied to a wide variety of ash ponds, closed FGD landfills, and abandoned coal mine sites in the United States. The major tasks for this project are:

1. Geotechnical and environmental testing and evaluation using an existing bench-scale facility of harvested pondered fly ash and landfilled FGD material at the former Conesville, Ohio power plant. Successful completion of the lab- and bench-scale testing will lead to Task 2 - Conesville Full-Scale Demonstration.
2. About 2 million tons of harvested CCR materials from an inactive fly ash pond and an adjacent old FGD landfill will be used to fully reclaim a nearby partially abandoned surface coal mine. Site monitoring will be carried out during the project.
3. Numerical models leveraging the rich set of data collected from the Conesville site will be used to analyze risks for high-volume surface mine reclamation with harvested CCRs. Transport simulators and geochemical reaction models will be integrated, calibrated, and validated. Sensitivity analysis of the temporal evolution and significance of the factors involved in the process will be performed to determine significant risk factors and drivers.

The project could result in reduced by-product liability and disposal costs for coal-fired utilities in a manner that is economically viable and beneficial to the environment, the public's health and safety, and the power-generating companies. Also, the results of this project could provide owners, design engineers, and regulatory agencies with specific information about the technical feasibility and probable cost of using these methods for remediation and reclamation of abandoned coal mine sites across the United States, especially in eastern and midwestern coal mining regions.



Locations of Conesville Five Points reclamation projects.



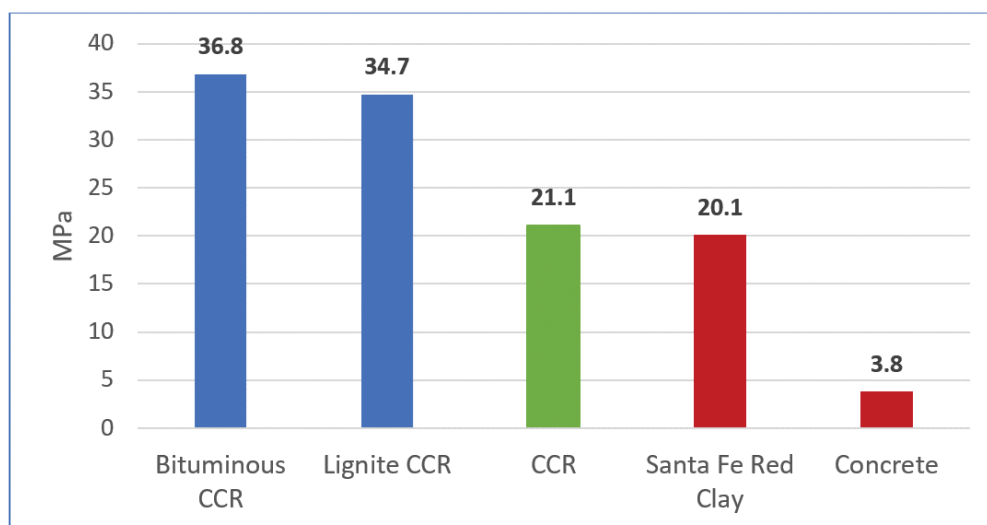
## High Strength, Encapsulated, Commercially Useful Components and Particles Made from Coal Combustion Residuals

<b>Performer</b>	Semplastics EHC, LLC
<b>Award Number</b>	FE0031932
<b>Project Duration</b>	10/01/2020 – 09/30/2023
<b>Total Project Value</b>	\$ 1,407,585
<b>Focus Area</b>	Ash Beneficial Use

Semplastics aims to demonstrate the effectiveness of their Coal Combustion Residuals (CCR) encapsulation technology. Samples of the selected CCR will be encapsulated and undergo leach testing to show reduction of toxic element leaching by more than 80%. The project team will mold test plates from CCR and a number of inorganic resins, which will be cut into test specimens for microstructural, mechanical, and physical property analysis. The process developed in making the test plates will be used for scale-up to make bulk demonstration parts. The team will optimize the scaled-up process to produce large-scale support columns (approximately 9" diameter). The team will develop two predictive models—one for encapsulated CCR in high-CCR-loaded bulk parts, and one for encapsulated CCR as filler in polypropylene. By the end of the project, the team plans to demonstrate that encapsulated CCR improves the

strength and modulus of polypropylene by 30-50% and can be used in structural components to provide a strength five to ten times that of concrete.

If successful, it will result in a feasible, high-volume method of mitigating the effects of CCR leaching into the environment and enable the use of virtually all CCR including previously non-viable CCR for commercial applications. This work will also provide at least two routes to utilize large volumes of CCR in materials that are commercially viable with high-volume markets. Expected beneficiaries of this work include owners of current and formerly operational coal-based power plants, who will be able to leverage a new use for their current and past waste products; the construction industry, who will have access to new high-strength, fast-hardening support structures, and the plastics industry, who will gain new high-performance plastics at polypropylene prices.



Initial results show CCR-based materials have up to 10x higher flexure strength than concrete.

## Surface Modified Fly Ash For Value Added Products (SuMo Fly Ash)

<b>Performer</b>	University of Illinois
<b>Award Number</b>	FE0032039
<b>Project Duration</b>	08/01/2021 – 07/31/2023
<b>Total Project Value</b>	\$ 1,230,015
<b>Focus Area</b>	Ash Beneficial Use

The primary objective of this project is to develop a technology to encapsulate coal fly ash particles in sulfurized vegetable oil to enhance its physical and mechanical properties by inherently reducing its metal leaching potential, for use as novel fillers in multi-polymeric matrices such as plastics and elastomers. It will be demonstrated that these encapsulated fly ash particles will improve functional properties of plastics and elastomers and have comparable or improved environmental release of constituents of potential concern (COPC) compared to non-CCR (coal combustible residuals)

products, thereby meeting EPA evaluation criteria for CCR encapsulated beneficial use.

If successful, surface-modified (SuMo) fly ash will overcome some of the inherent barriers to fly ash utilization, such as regional and seasonal imbalances in supply and demand and transportation and beneficiation costs. Additionally, sulfurized vegetable oil-coated fly ash particles could provide both economic and functional benefits as a polymer filler, as they have improved mechanical properties and lower cost in comparison to traditional organic filler.

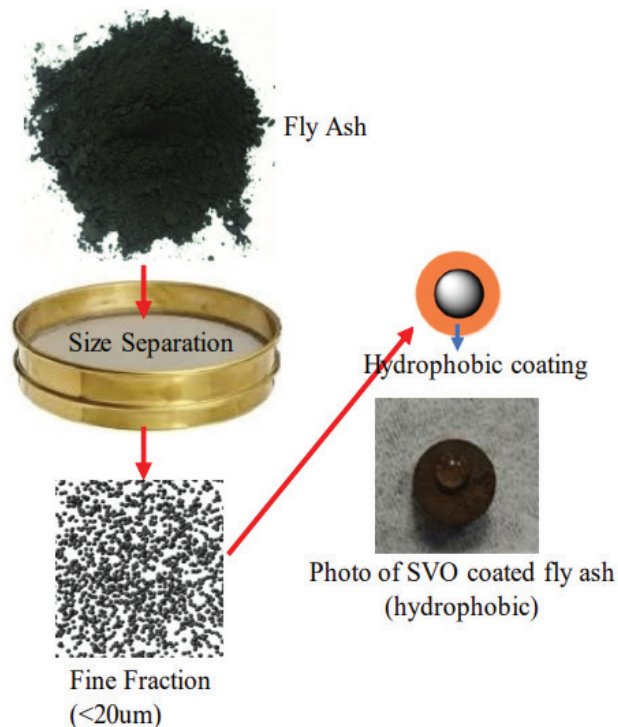


Diagram of the method used to process coal fly ash into coated fly-ash particles.

## ABBREVIATIONS

AEP ..... American Electric Power  
AI/ML ..... artificial intelligence/machine learning  
CCR ..... coal combustibles residuals  
CO<sub>2</sub> ..... carbon dioxide  
COPC ..... constituents of potential concern  
DOE ..... United States Department of Energy

EPA ..... United States Environmental Protection Agency  
FGD ..... flue gas desulfurization  
NETL ..... National Energy Technology Laboratory  
R&D ..... research and development  
SuMo ..... surface-modified  
SVO ..... sulfurized vegetable oil

# NOTES

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<https://netl.doe.gov/carbon-capture/emissions-control>

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