2024

EMISSIONS CONTROL

PROJECT PORTFOLIO

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

DISCLAIMER

This project was funded by the United States Department of Energy, National Energy Technology Laboratory, in part, through a site support contract.

CONTENTS

INTRODUCTION

The U.S. Department of Energy's (DOE) Emissions Control Program develops technological improvements and solutions for control of non-CO_2 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_2 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: DOE is seeking innovative conceptsfor treating 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 compact 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 toward 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 public health and safety.

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

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

Performer	**Illinois Institute of Technology**
Award Number	FE0031931
Project Duration	10/01/2020 – 03/31/2024
Total Project Value	$ 1,244,344
Focus Area	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.

Emissions Control

Performer	**National Energy Technology Laboratory (NETL)**
Award Number	FWP-1022479
Project Duration	04/01/2021 – 03/31/2024
Total Project Value	$ 464,989
Technology Area	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 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 residuals (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.

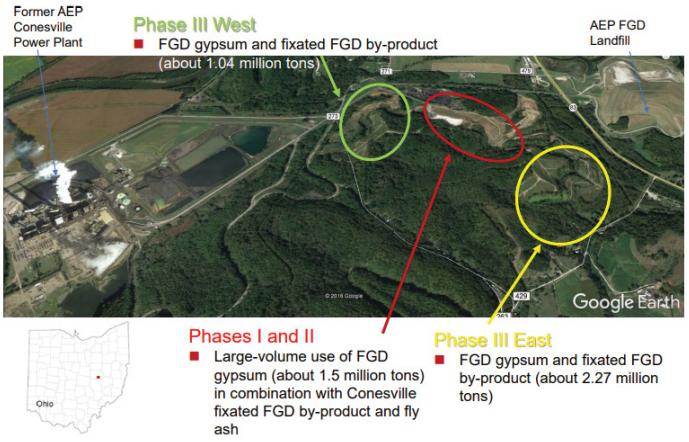
Beneficial Use of Harvested Ponded Fly Ash and Landfilled FGD Materials for High-Volume Surface Mine Reclamation

Performer	**Ohio State University**
Award Number	FE0032038
Project Duration	07/06/2021 – 07/05/2024
Total Project Value	$ 1,273,996
Focus Area	Ash Beneficial Use

The focus of this project is on the viability of beneficial use of harvested coal combustible residuals (CCRs), especially ponded 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 project has been 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 ponded 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 two 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 conducted 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.

A Data-Driven Multiscale Phytotechnology Framework for Identification and Remediation of Leached-Metals-Contaminated Soil Near Coal Ash Impoundments

Performer	**Virginia Polytechnic Institute and State University**
Award Number	FE0032184
Project Duration	10/01/2022 – 09/30/2025
Total Project Value	$ 400,000
Focus Area	Ash Beneficial Use

The project objectives are to integrate satellite remote sensing, machine learning and image processing, geological engineering models, and soil science and plant pathology to 1) identify potential leaching of metals from coal ash impoundments (Phase I), and 2) propose locally adaptable phytoextraction approaches to remediate contaminated regions (Phase II). The analyses will consider potentially contaminated areas surrounding coal combustion product impoundments of southern West Virginia, south-west Virginia, eastern Kentucky, eastern Tennessee, and North Carolina. The project will develop a locally adapted phytoremediation design including a database of phytoremediation potential of different hyperaccumulating plants, an environmental justice screening to prioritize areas with high environmental justice impact, and a machine learning informed model that outputs a ranked list of suggested plant species for each candidate site.

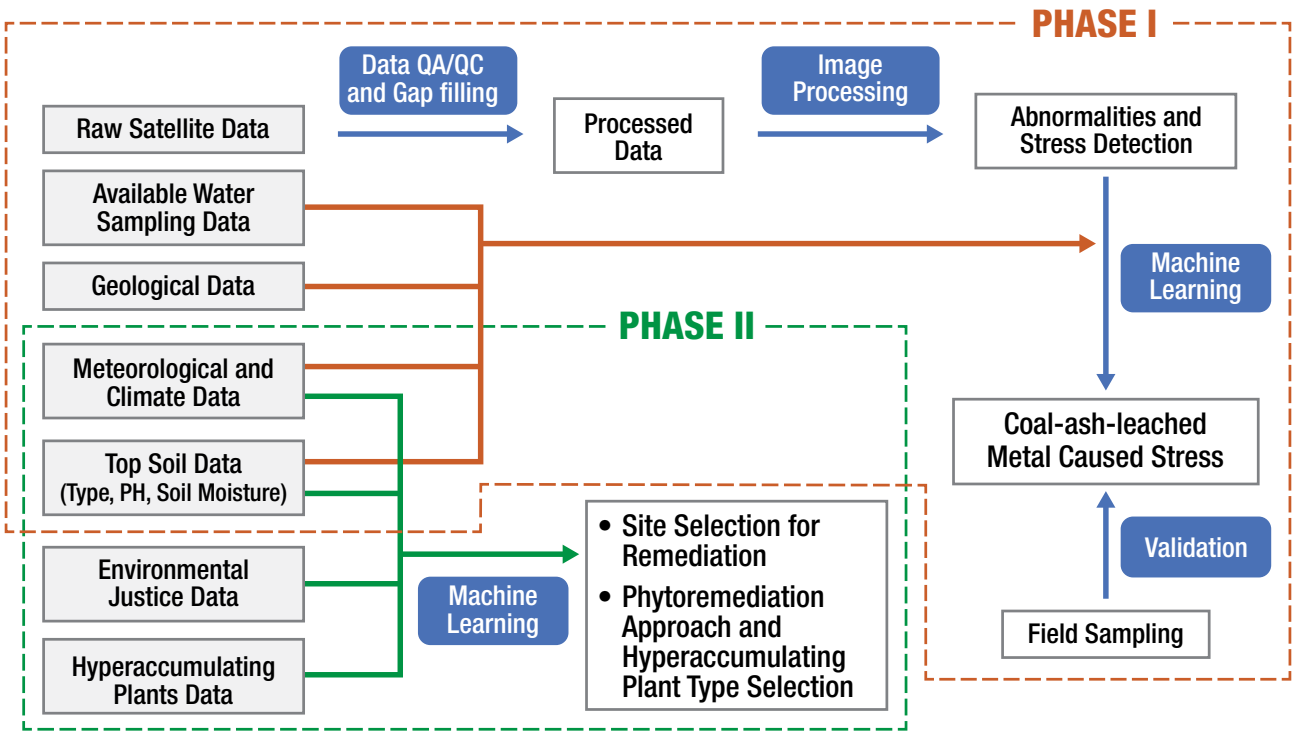


Diagram of phases 1 (identify potential leaching of metals from coal ash impoundments) and 2 (propose locally adaptable phytoextraction approaches to remediate contaminated regions) of the project.

Surface Modified Fly Ash for Value Added Products (SuMo Fly Ash)

Performer	**University of Illinois**
Award Number	FE0032039
Project Duration	08/01/2021 – 01/31/2024
Total Project Value	$ 1,230,015
Focus Area	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. The encapsulated fly ash particles will be demonstrated to improve the 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 the Environmental Protection Agency's 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 due to their improved mechanical properties and lower cost compared to traditional organic filler.

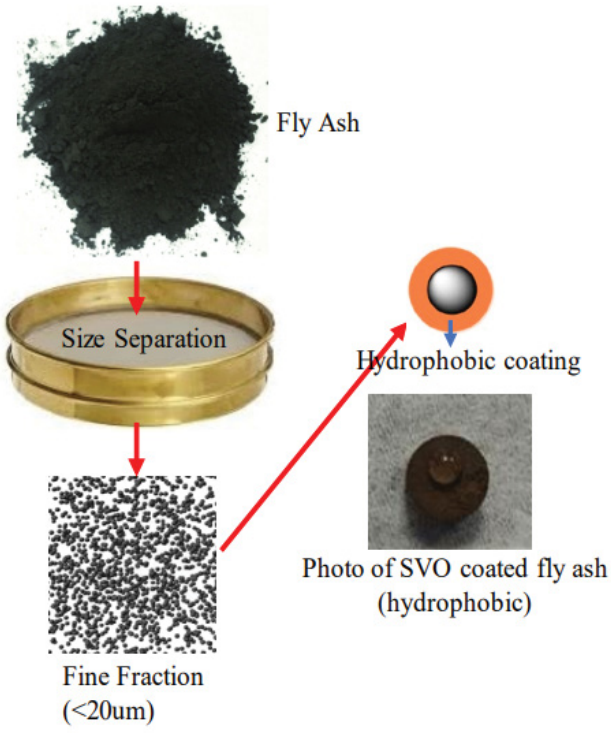


Diagram of the method used to process coal fly ash into coated fly-ash particles.

Sustainable and Cost-Effective Phytoremediation Technologies in the Management of Contaminated Soils Adjacent to Coal Combustion Product Impoundment

Performer	**Nevada System of Higher Education**
Award Number	FE0032195
Project Duration	03/06/2023 – 03/05/2026
Total Project Value	$ 396,835
Technology Area	Ash Beneficial Use

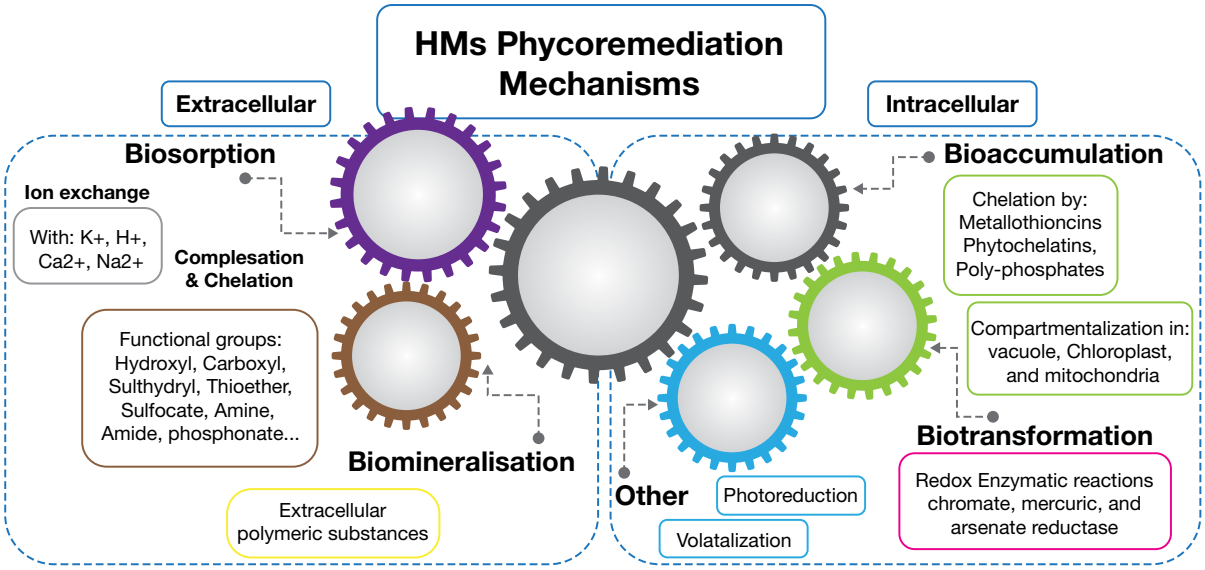
The goal of the project is to mitigate the environmental burdens associated with coal combustion product (CCP) ponds at the North Valmy power plant by finding native plants and establishing a vegetation cover to phytoextract the toxic heavy metals from ponds and phytostabilize the ultrafine particles of residues. Therefore, developing a sustainable technology to remediate such affected sites is the primary goal of this proposed study.

This project proposes to develop low-cost phytoremediation methods to indicate whether a storage facility is keeping contaminants within its storage boundary, and to advance environmentally friendly technologies that can remediate affected sites.

Innovative Biomonitoring and Remediation of Heavy Metals Using Phytotechnologies at the Savannah River Site Coal Combustion Product Impoundment Sites

Performer	**Florida A&M University**
Award Number	FE0032198
Project Duration	01/25/2023 – 01/24/2025
Total Project Value	$ 399,528
Technology Area	Ash Beneficial Use

The objective of this work by Florida A&M University project is to utilize algal- and cyanobacterial-based phycotechnologies to address pervasive heavy metal contamination from coal combustion product (CCP) impoundments at the Savannah River Site. Novel bioindicators to gauge the potential for phytoremediation to restore legacy impoundment sites will be developed. The objective will be achieved by conducting an environmental diagnostic assessment of ash pond sites, using metagenomics to identify taxonomic composition and gene functions of algal communities in sites with heavy metal contamination, developing an environmental health index of ash pond sites to predict the success of remediation strategies, isolating algal-cyanobacterial taxa and screening them against heavy metals to confirm heavy metal resistance and/or hyperaccumulation, and populating artificial intelligence models to develop an iterative remediation strategy. Phytotechnology could be a low-technology solution to remediate legacy coal ash impoundments. If the project demonstrates its effectiveness, algae and cyanobacteria could be applied to reduce the heavy metals concentration at other impoundments and reduce the risk of metals exposure to nearby communities and ecosystems.



Mechanisms for phycoremediation of heavy metals.

ABBREVIATIONS

AI/ML .....artificial intelligence/machine learning

CCP .....coal combustion product

CCR .....coal combustible residuals

COPC..... constituents of potential concern

FGD..... flue gas desulfurization

SuMo ..... surface-modified

NOTES

CONTACTS

David K. Lyons
Technology Manager
Emissions Control

304-285-4379

K.Lyons@netl.doe.gov

Seth Lawson
Team Supervisor
Integrated Carbon Management Team

304-285-0578

seth.lawson@netl.doe.gov

WEBSITES:

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

ACKNOWLEDGMENTS

The Emissions Control Portfolio was developed with the support of many individuals. Key roles were played by principal investigators, federal project managers, the technology manager, the team supervisor, and National Energy Technology Laboratory site-support contractors.

NATIONAL ENERGY TECHNOLOGY LABORATORY

1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochran Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

Program staff are also located in
Houston, TX and **Anchorage, AK**.

Visit us: **www.NETL.DOE.gov**

@NationalEnergyTechnologyLaboratory

@NETL_DOE

@NETL_DOE

U.S. DEPARTMENT OF ENERGY

April 2024