The Payne Institute for Public Policy
AT COLORADO SCHOOL OF MINES

January 14, 2026

Waste Not: Reimagining Mine Liabilities as Energy Assets

Commentary by Sravan Lavudya and Anna Littlefield

In a year marked by rising geopolitical tensions over critical mineral supply chains, a quiet shift is underway for legacy mine waste. As the US looks to minimize its reliance on foreign critical minerals, we must contend with the implications of increased domestic extraction and processing, neither of which are low impact. Here, we explore how operators are reimagining the pieces of the process, turning mine tailings into assets and repurposing existing mine infrastructure.

A transition to a clean energy economy depends on securing a reliable, domestic source of lithium, cobalt, and rare earth elements, and by extension, new mining operations. Building new mines however, is accompanied by a unique set of environmental and permitting challenges. Thanks to innovative work in the mining industry, the United States is opening access to a vast, previously overlooked domestic source of these very minerals: mine waste (tailings and waste rock).

In October of 2025, a Massachusetts-based startup, Phoenix Tailings, announced a $33 million investment to build a new facility in Exeter, New Hampshire. It's one of the first in the U.S. capable of producing rare earth metals from mining waste, operating without Chinese inputs or technology. The facility, which promises zero toxic byproducts and no direct carbon emissions, will convert refined oxides into magnet-grade metals. With an initial capacity of 200 tons per year and plans to scale to over 1,000, the project is a bold step in reimagining mine tailings not as environmental burdens, but as strategic assets for the clean energy transition.

A Greener Recovery Process

Recovering minerals from tailings is an energy-intensive process. With conventional methods, it risks exacerbating existing emissions problems. A greener recovery process requires integrating **decarbonization technologies** directly into the mineral extraction lifecycle.

The relevance of decarbonization technologies such as Carbon Capture and Storage (CCS) is expanding beyond traditional industrial sectors, underscoring its role as a cross-sector tool. In July 2025, the Electric Power Research Institute (EPRI) and the U.S. Department of Energy (DOE) co-hosted a workshop to explore the use of CCS to reduce the carbon footprint of emerging energy-intensive domains such as data centers. In October of 2025, Google announced the first commercial-scale project at a natural-gas plant to pair heat and power generation with carbon capture and storage. The growing cross-sector relevance reinforces the technology's potential to be integrated into energy-intensive mineral recovery processes, helping the mining industry meet its net-zero goals.
The DOE's Mines & Metals Capacity Expansion Program, backed by $250 million from the IIJA, is funding the deployment of these recovery and repurposing technologies. The program targets pilot-scale facilities that can demonstrate commercially viable recovery from industrial waste streams, with many projects required to include commercialization plans extending to 2030 and to incorporate CCS to reduce carbon intensity.

In parallel, DOE has announced $18.6 million in funding for three National Laboratory-led consortia focused on decarbonizing hard-to-abate sectors such as chemicals, cement, and metals. These include the Decarbonization Alliance for the U.S. Chemical and Refining Industries (DACRI), the C2EMENT Consortium, and the National Consortium for the Decarbonization of the Metals Industry, led by Oak Ridge, Pacific Northwest, and National Renewable Energy Laboratories, respectively. These initiatives aim to accelerate the adoption of low-carbon technologies by developing best practices, decision-support tools, and collaborative forums with industry partners—further reinforcing the federal commitment to industrial decarbonization.

Real-world examples are already emerging. In West Virginia, researchers are piloting carbon capture at coal ash sites to reduce emissions from rare earth extraction. In Wyoming, the Sweetwater Uranium Complex has been selected for fast-track federal permitting to add in-situ recovery (ISR) mining methods, a move designed to accelerate domestic mineral production while minimizing environmental impact.

REE Recovery Research Frontier

Research into recovery and processing methodologies have greatly improved the ability of operators to efficiently extract REEs. These advancements have been supported by research, which continues to identify new techniques for mineral recovery. At the Colorado School of Mines, Dr. Jihye Kim's recent work for example, offers innovative approaches to sustainable recovery of rare earth elements from Bastnaesite ore, reducing waste and improving process efficiency.

In parallel, researchers at Penn State are pioneering new biochemical methods. Joseph Cotruvo Jr., Associate Professor of Chemistry, and his lab have developed a process using a natural protein to selectively recover rare earth elements from industrial waste streams like coal ash and acid mine drainage. Penn State's efforts are part of a broader effort to extract critical minerals from coal waste streams.

A 2025 Nature publication from Mines' professor Elizabeth Holley, shows that a year's worth of American mine waste would be sufficient to fuel 10 million electric cars with lithium and power up as much as 99 million EVs with manganese. These minerals are sitting in tailings piles throughout the United States, waiting to be recovered. The dual outcome of utilizing tailings is a no-brainer: diminished import dependence and lower toxic waste liabilities that require billions of dollars to monitor during and after mining operations.

"We're only producing a few commodities," said Holley, who conducted the research, "The question is: What else is in those rocks?" The answer from her team unearths an industrial opportunity hiding in the light of day, one that could reverse American critical mineral insecurity within five years if policymakers and mining operators converge around practical solutions. Holley's discoveries show that there is enormous value to be had, in shifting the paradigm away from mine waste as an environmental liability and instead viewing mine waste as a strategic national asset for supply chain security.

Together, these contributions reinforce the importance of academic innovation in building a circular, low-emissions future for mineral recovery.

A Second Life for Old Mines: Geothermal Energy

Beyond mineral recovery, legacy mine sites offer a second, distinct opportunity: geothermal energy. Abandoned and water-filled mines maintain stable thermal conditions that can be harnessed for district heating, cooling, or electricity generation. In West Virginia, for instance, the Pittsburgh coal seam alone holds an estimated 1.36 trillion gallons of mine water, a vast resource for geothermal heat pumps.

This potential is being explored through the DOE's Clean Energy Demonstration Program on Mine Lands (CEML). This $500 million program, funded by the IIJA, is designed to support pilot projects in geographically diverse regions. In July 2025, the DOE hosted workshops, including one at the National Renewable Energy Laboratory, to inform the next round of funding opportunities and gather stakeholder input.

Current projects show the breadth of this approach. In Butte, Montana, a former copper mine is being repurposed into a geothermal heating system for local schools and municipal buildings. In Arizona, the MILES HIGH Project is using geothermal heat to recover copper from previously mined material while also installing microgrids and battery storage to improve energy resilience.

Bridging the Gap: From Pilot to Practice

Despite promising pilots, scaling these technologies remains a challenge. Regulator complexity, fragmented permitting processes, and the high capital cost can stall progress and discourage development. Policy coordination is essential. Streamlining permitting for multi-technology projects that combine mineral recovery, CCS, and geothermal could accelerate deployment and reduce administrative burdens.

Public-private partnerships are also key. The DOE's Geothermal Technologies Office (GTO) is funding regional collaborations to advance geothermal deployment, while the Interagency Working Group on Mining Communities is developing frameworks for inclusive planning and tribal consultation. These efforts recognize that technological success depends on social acceptance and equitable benefit-sharing.

Leveraging the Surviving Incentives

The policy landscape has undergone a seismic shift. We must acknowledge that the original, ambitious scope of the IRA is now largely defunct. The Act has been significantly curtailed by the 2025 One Big Beautiful Bill Act (OBBBA), with the long-term runway for consumer-facing incentives (like EV and residential solar tax credits) terminated.

However, this makes the resource-from-waste strategy more critical and viable than ever. The IRA provisions that survived align well with a national security and domestic manufacturing agenda, creating a rare and targeted window of opportunity.

Key Surviving Policy Mechanisms:

The following core IRA provisions remain largely intact and must be strategically applied to overcome the economic challenge of mineral recovery:

Surviving Provision	**Section**	**Strategic Relevance to Mine Waste Recovery**
Advanced Manufacturing Production Credit	§45X	**Crucial Incentive.** Directly applicable to the domestic production of battery components and critical minerals recovered from waste.
Direct Pay and Transferability	Various	**Removes Capital Barriers.** Allows developers (including non-taxed entities) to monetize credits as cash payments, essential for high-upfront-cost projects.
Carbon Capture Credit	§45Q	Supports decarbonizing the energy-intensive processing required for mineral recovery.

This new landscape not defined by the failure of the old IRA, but by the strength of the resilient incentives that remain. These credits can be strategically applied to overcome the economic hurdles Holley and others have identified, making critical mineral recovery from mine waste a commercially attractive enterprise.

Conclusion

The convergence of mineral recovery, carbon capture, and geothermal energy at mine sites represents more than a technical opportunity; it is a paradigm shift. By reimagining waste as a resource and embedding sustainability into every stage of the process, the United States can move closer to its goals of decarbonization, critical mineral security, and energy independence.

Innovators continue to lead the way in testing these processes, but scaling up these processes for meaningful impact on the mining industry and energy transition goals, is not a foregone conclusion. Hurdles exist to individual projects such as high upfront capital costs, a difficult permitting process, and the need to ensure that tribal and local communities see equitable benefits. Proactively addressing these challenges will be necessary in these integrated energy projects, if we hope to capitalize on this opportunity at a commercial scale. This energy-independent and low carbon future will not build itself. It demands coordinated policy, inclusive planning, and a willingness to invest in long-term, integrated solutions.

About the Authors

Sravan Lavudya
Grad Student, Mineral and Energy Economics, Colorado School of Mines

Sravan Lavudya, a mining engineer and Mineral and Energy Economics graduate student at the Colorado School of Mines, focuses on critical minerals and sustainable innovation for a resilient and responsible resource sector.

Anna Littlefield, Payne Institute Geothermal and Low Carbon Energy Technologies Program Manager and Research Associate and PhD Student, Geology and Geological Engineering, Colorado School of Mines

Anna Littlefield is the Geothermal Low Carbon Energy Technologies Program Manager for the Payne Institute at the Colorado School of Mines. As a current PhD student in the Mines geology department, her research focuses on the geochemical impacts of injecting CO2 into the subsurface as well as the overlap of geotechnical considerations with policymaking. Anna joins the Payne Institute with 8 years' experience in the oil and gas industry, where she worked development, appraisal, exploration, new ventures, and carbon sequestration projects. Her academic background is in hydrogeology with an M.S. in geology from Texas A&M University, and a B.S. in geology from Appalachian State University. Anna is passionate about addressing both the societal and technical challenges of future of energy and applying her experience to advance this effort.

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