VIRGINIA CENTER FOR COAL AND ENERGY RESEARCH

EVOLVE CAPP

Evolve Central Appalachia

PROJECT UPDATE

VCCER SPRING ADVISORY BOARD MEETING

RICHARD BISHOP
PRINCIPAL INVESTIGATOR
MAY 18, 2023

ACKNOWLEDGEMENT

This material is based upon work supported by the Department of Energy under Award Number DE-FE0032055.

DISCLAIMER

BACKGROUND – CRITICAL MINERALS

- USGS 2022 Critical Minerals Report includes 50 Mineral Commodities
- Classification based on share of import & countries of origin
- World Bank estimated that "energy critical minerals" (Lithium, Cobalt) **need to increase by 500% by 2050!**

https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action

Criticality Usually Includes:

1. Dependence on Imports
2. Country Origin of Mineral Producer

+ *Responsible Sourcing Practices*

Europium	100%	Phosphors, nuclear control rods
Fluorspar	100%	Manufacture of aluminum, cement, steel, gasoline
Gadolinium	100%	Medical imaging, steelmaking
Gallium	100%	Integrated circuits, LEDs
Graphite	100%	Lubricants, batteries
Holmium	100%	Permanent magnets, nuclear control rods
Indium	100%	Liquid crystal display screens
Lanthanum	100%	Catalysts, ceramics, glass, polishing compounds
Lutetium	100%	Scintillators for medical imaging, cancer therapies
Manganese	100%	Steelmaking, batteries
Neodymium	100%	Medical, industrial lasers
Niobium	100%	Steel, superalloys
Praseodymium	100%	Permanent magnets, batteries, aerospace alloys
Rubidium	100%	Research, development in electronics
Samarium	100%	Cancer treatment, absorber in nuclear reactors
Scandium	100%	Alloys, ceramics, fuel cells
Tantalum	100%	Electronic components, superalloys
Terbium	100%	Metal alloys, lasers
Thulium	100%	Metal alloys, lasers
Ytterbium	100%	Catalysts, scintillometers, lasers, metallurgy
Yttrium	100%	Ceramic, catalysts, lasers, metallurgy, phosphors
Iridium	?**	Coating of anodes for electrochemical processes
Rhodium	?**	Catalytic converters, electrical components
Ruthenium	?**	Electrical contacts, chip resistors in computers
Beryllium	11%	Alloying agent in aerospace, defense industries
Aluminum	13%	Power lines, construction, electronics
Zirconium	25%	High-temperature ceramics production
Palladium	40%	Catalytic converters
Germanium	50%	Fiber optics, night vision applications
Lithium	50%	EV rechargeable batteries
Magnesium	50%	Car seats, luggage, laptops
Nickel	50%	Stainless steel, rechargeable batteries
Tungsten	50%	Wear-resistant metals
Barite	75%	Hydrocarbon production
Chromium	75%	Stainless steel
Tin	75%	Coatings, alloys for steel
Cobalt	76%	Rechargeable batteries, superalloys
Platinum	79%	Catalytic converters
Antimony	81%	Lead-acid batteries, flame retardants
Zinc	83%	Metallurgy to produce galvanized steel
Titanium	88%	White pigment or metal alloys
Bismuth	94%	Medical, atomic research
Tellurium	95%	Solar cells, thermoelectric devices
Vanadium	96%	Alloying agent for iron, steel
Arsenic	100%	Semi-conductors, lumber preservatives, pesticides
Cerium	100%	Catalytic converters, ceramics, glass, metallurgy
Cesium	100%	Research, development
Dysprosium	100%	Data storage devices, lasers
Erbium	100%	Fiber optics, optical amplifiers, lasers

Source: Visual Capitalist

RESEARCH TEAM

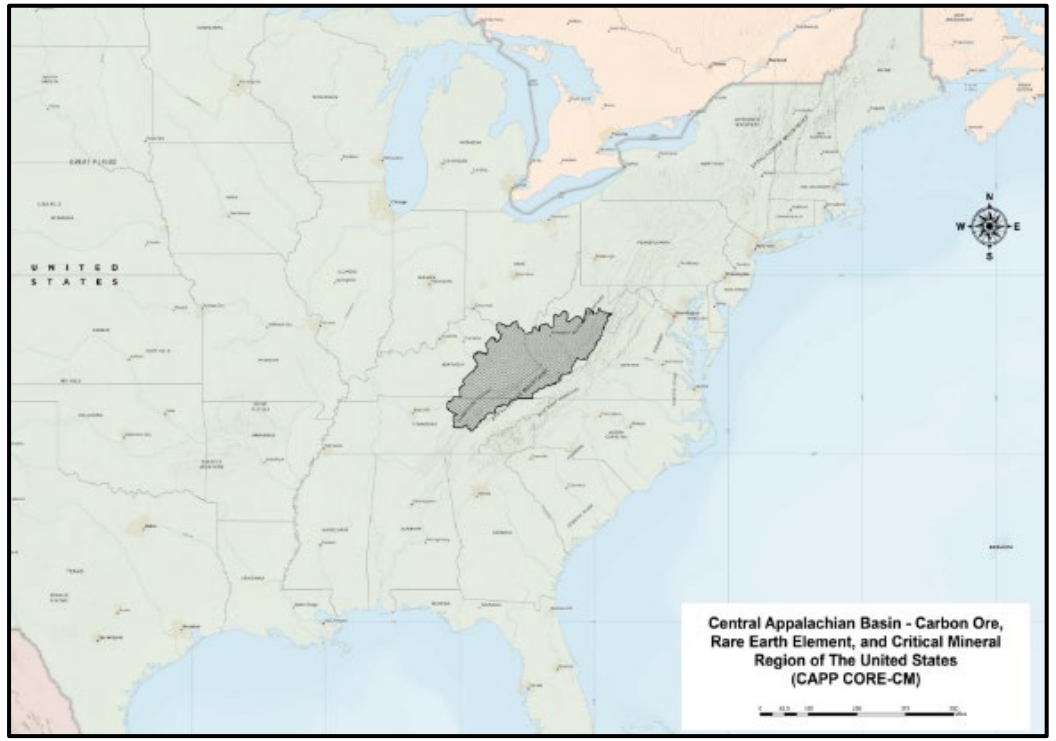
West Virginia University Mining Engineering	**Virginia Tech VCCER & Mining Engineering**	**University of Kentucky Mining Engineering**
Marshall Miller & Associates	**Gray Energy Technologies**	**Oak Ridge National Laboratory**
Advanced Resources Intl.	**Chmura Economics**	**U. S. Geological Survey**
Crescent Resource Innov.	**Southern States Energy Board**	**Virginia Dept of Energy**

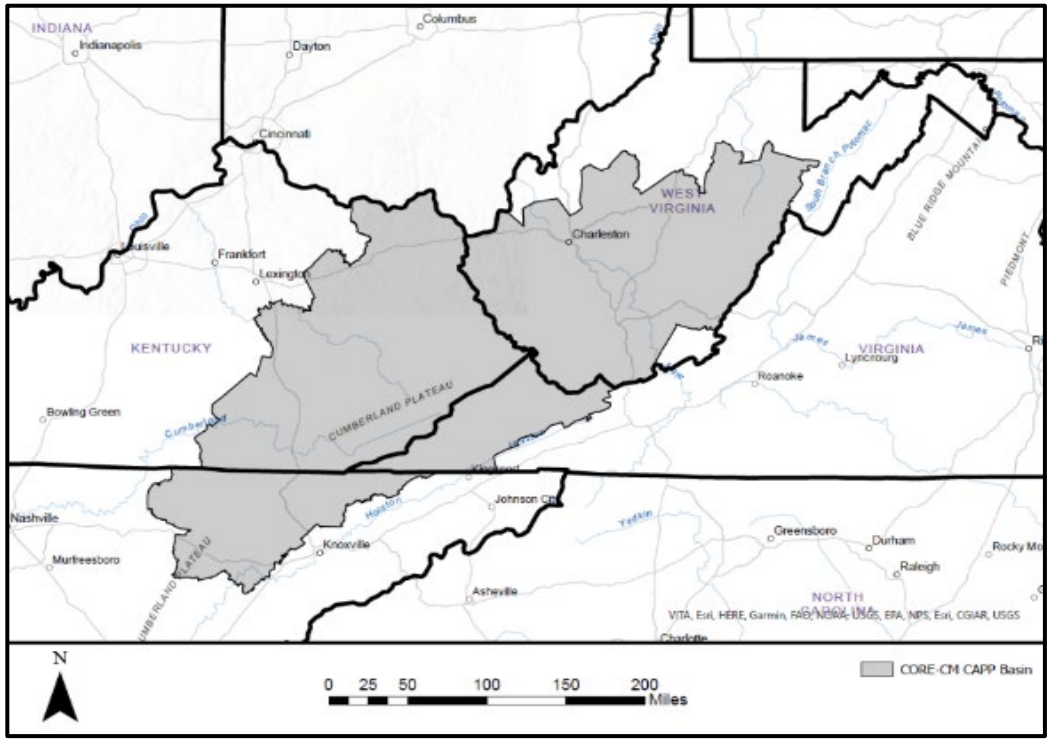
Mountain Empire Community College Coalition

- Mountain Empire Community College (MECC), VA
- Roane State Community College (RSCC), TN
- Southeast Kentucky Community & Tech. College (SKCTC)
- Southern West Virginia Comm. & Tech. College (SWVCTC)

PROJECT OVERVIEW

- *Investigating the Rare Earth & Critical Minerals potential of the Central Appalachian (CAPP) basin*
- *Project Dates: October 1, 2021 – September 30, 2023; Funding: $1,584,999 DOE + $526,492 cost share*
- *Extension for Resource Characterization: Oct 1, 2023 – Mar 31, 2024: $500K DOE + $125K cost share*





EVOLVE CAPP

PROJECT TIMELINE

Task Number	Task Name	2021			2022												2023												2024			
														Q5			Q6			Q7			Q8			Q9			Q10			
		10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1.0	**Project Management & Planning**	A	B											D												H						I
1.1	Summary of Environmental Justice Considerations																															
1.2	Summary of Economic Revitalization & Job Creation Outcomes																															
1.3	EHS Analysis for Products ... from CORE-CM Resources					C																										
2.0	**Basinal Assessment of CORE-CM Resources**									E																						
2.1	Preliminary Basinal Resource Assessment																															
2.2	Basinal Resource Gap Analysis																															
2.3	Characterization & Data Acquisition Plan																															
3.0	**Basinal Strategies for Reuse of Waste Streams**																															
3.1	Assessment of Mining Refuse & CCR Waste Streams																															
3.2	Assessment of Other Waste Streams																															
3.3	Waste Stream Gap Analysis																															
3.4	Waste Stream Utilization Roadmap																															
4.0	**Basinal Strategies for Infrastructure, Industries & Business**																															
4.1	Regional Infrastructure, Industry & Business Assessment																															
4.2	Strategies to Spur Economic Growth																															
4.3	Infrastructure Needs, Economic Challenges & Supply Chain Gaps																															
5.0	**Technology Assessment, Development & Field Testing**																															
5.1	Technology Assessment - Mining																															
5.2	Technology Assessment - Separation Processes																															
5.3	Technology Assessment - Carbon Products																															
5.4	Technology Assessment & Testing																															
5.5	Technology Gap Analysis & Field Testing																															
6.0	**Technology Innovation Centers (TIC)**																															
6.1	TIC Location																															
6.2	Commercial Acceleration																															
7.0	**Stakeholder Outreach & Education**																															
7.1	Initial Stakeholder Outreach & Education Plan									F																						
7.2	Stakeholders Advisory Committee					G																										
7.3	Workforce Readiness & Development																															
7.4	Public Outreach, Education & Engagement																															

PROJECT MILESTONES

Milestones:

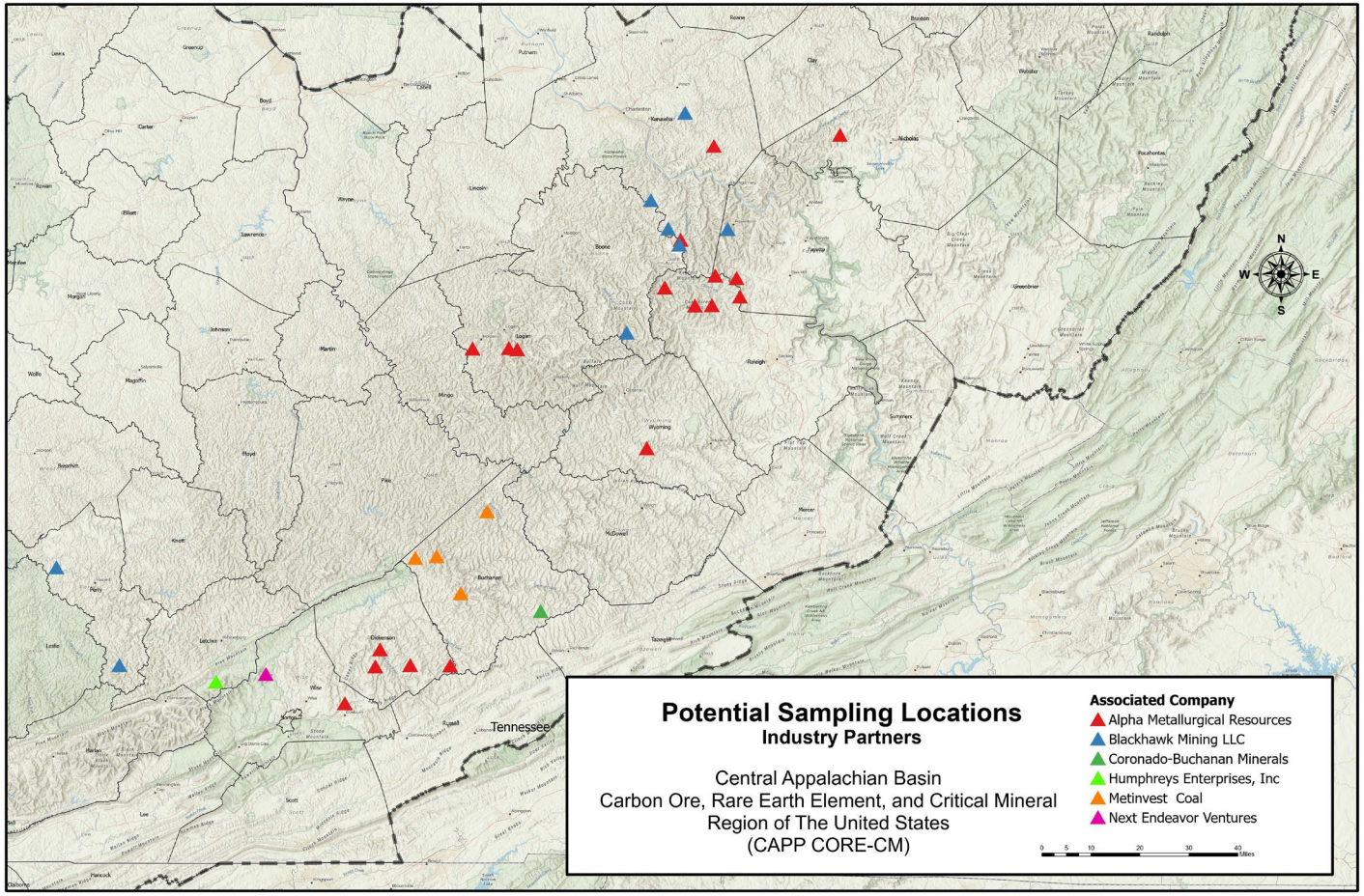
- ✓ (A) Project Kick-off Meeting
- ✓ (B) Project Management Plan
- ✓ (C) EH&S Workshop
- ✓ (D) Interim Report
- ✓ (E) Preliminary Sampling Plan
- ✓ (F) Initial Outreach & Education Plan
- ✓ (G) Stakeholder Advisory Committee
- ❑ (H) Interim Report #2
- ❑ (I) Final Report

ASSESSMENT OF CORE-CM RESOURCES

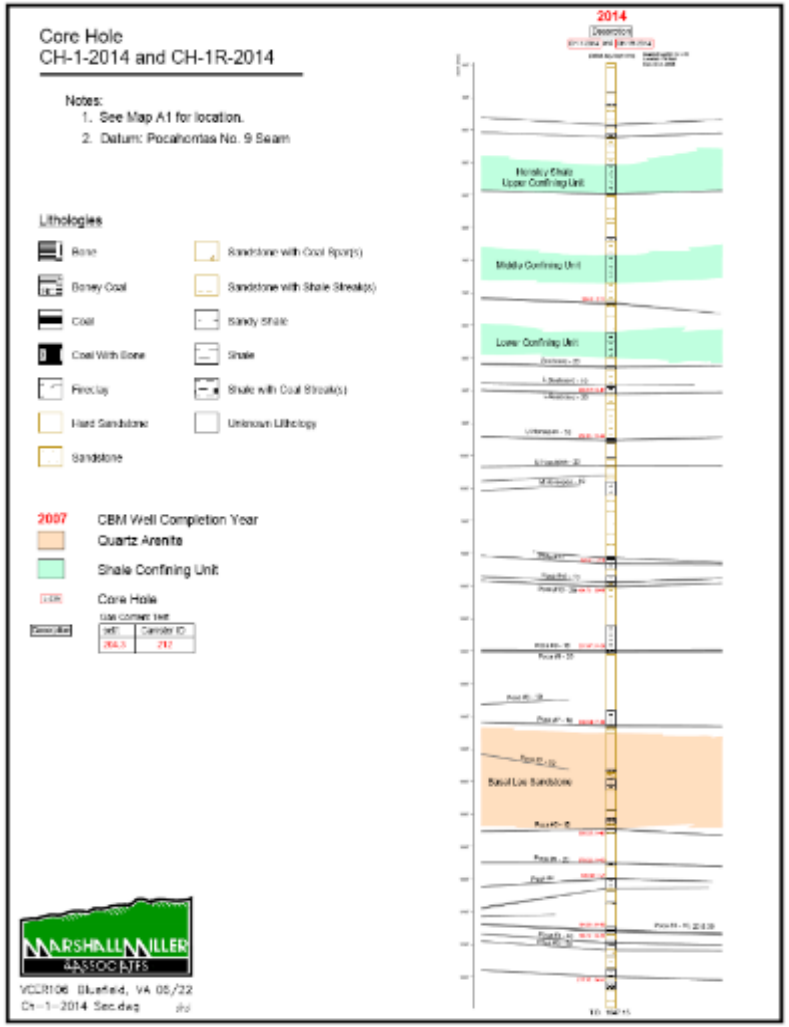
- *Characterization & Data Acquisition Plan*
  - *Initial list of sampling locations:* ***June 2022***
- *Assessment of Mining Refuse & CCR Waste Streams*
  - *CCR sampling commenced* ***September 2022***
  - *Produced water sampling commenced* ***December 2022***

POTENTIAL FUTURE SAMPLING LOCATIONS

- Targeting resource gaps
- Confirming historical sampling



P-XRF SCREENING & LAB ANALYSIS OF DRILL CORE



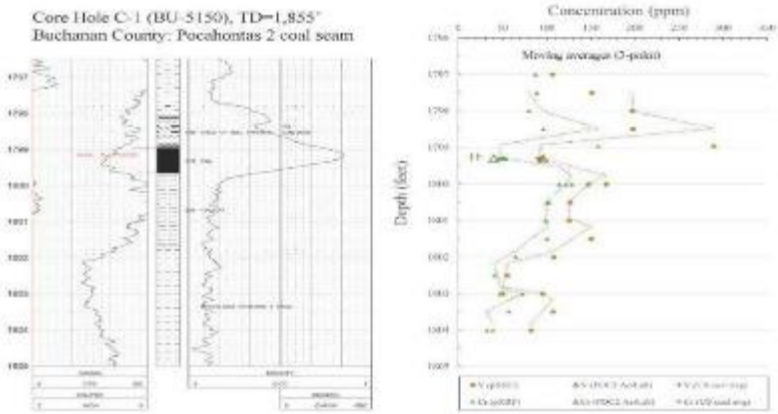
Plan:

- Analyze Core Hole for REE-CMs
- Compare pXRF to ICP-MS

Status:

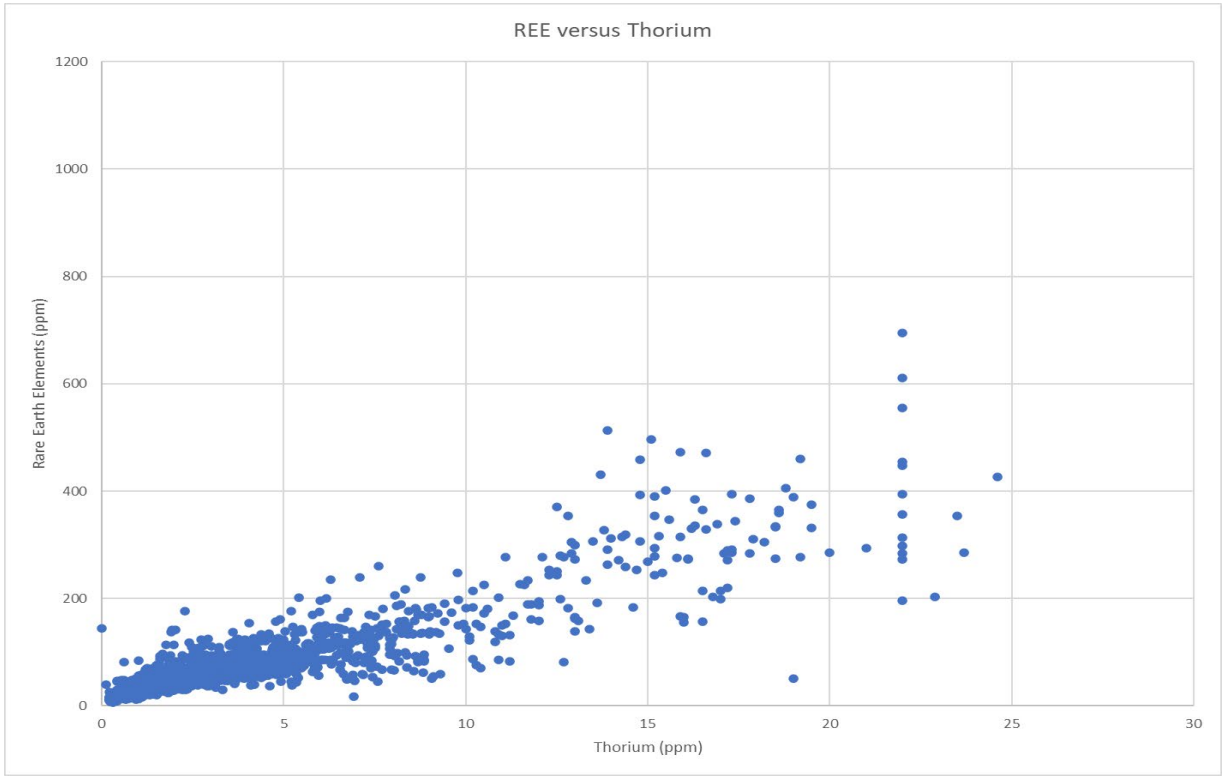
✓ pXRF complete

✓ **19** samples analyzed w/ ICP-MS



GEOPHYSICS – SPECTRAL GAMMA

- Spectral Gamma – continuously measures % rays from Thorium vs Uranium vs Potassium rock
- Relationship between Thorium / REE & Uranium / REE



MM&A Downhole Geophysical Logging Truck

SAMPLE ANALYSIS – COLLECTED SAMPLES

Fly Ash

Bed Ash

Landfill Bed Ash

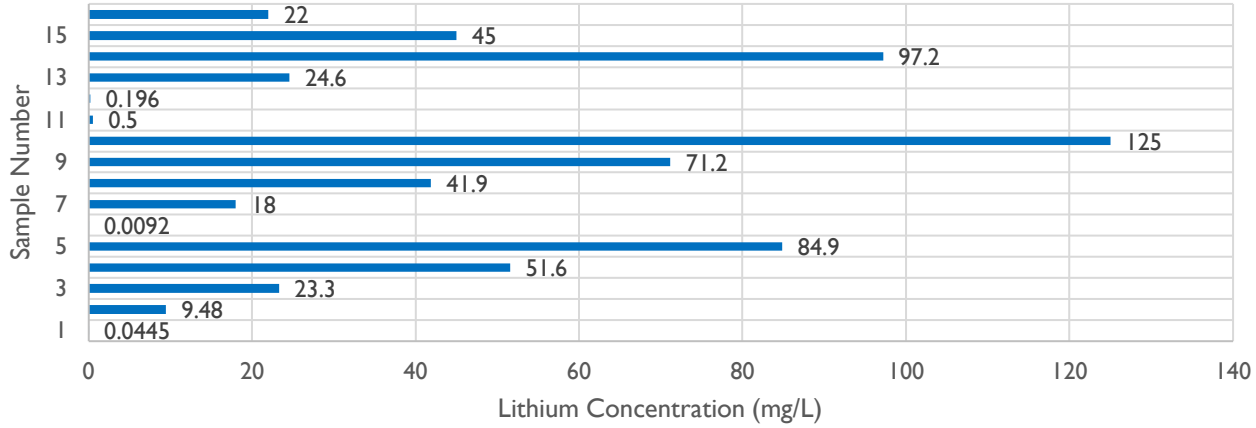
Landfill Fly Ash

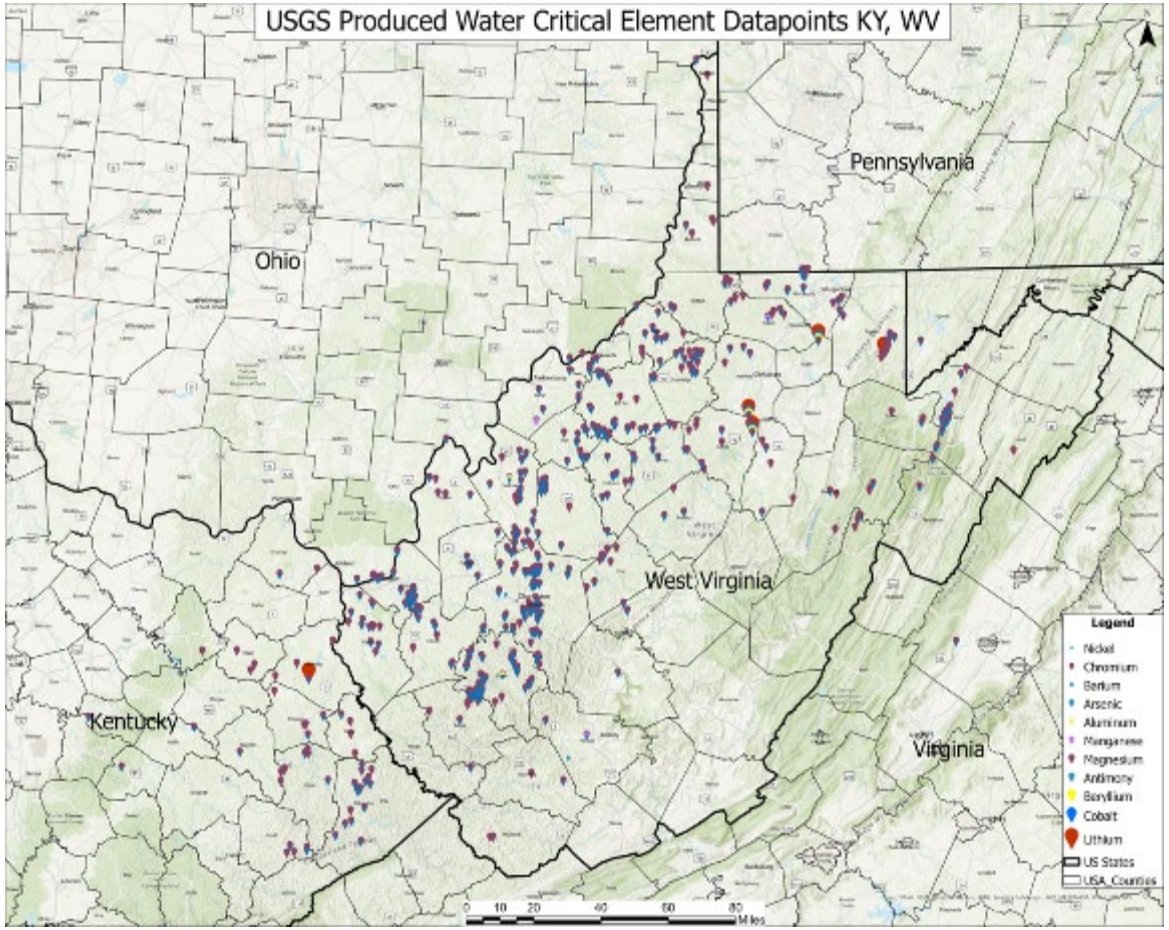
Core Samples

- ✓ Coal combustion ash & core samples collected
- ✓ Analyzed w/ ICP-MS
- ✓ Developing protocols for future sampling

USGS PRODUCED WATER DATABASE

- 1280 samples were identified for KY & WV
- No REE data present within database across study area
- Subset of 11 critical elements present include:
  - Antimony (Sb) – 14
  - Beryllium (Be) – 14
  - Cobalt (Co) – 14
  - Lithium (Li) – 16 (see below)
  - Magnesium (Mg) – 715
  - Manganese (Mn) – 19
  - Aluminum (Al) – 16
  - Arsenic (As) – 14
  - Barium (Ba) – 430
  - Chromium (Cr) – 14
  - Nickel (Ni) – 14



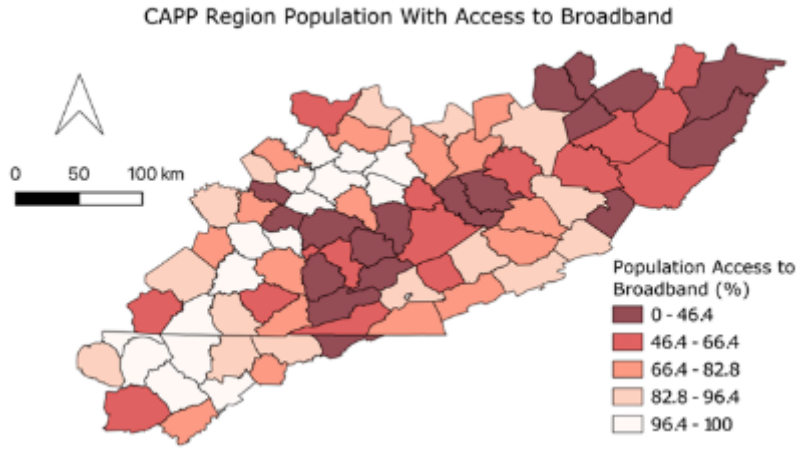


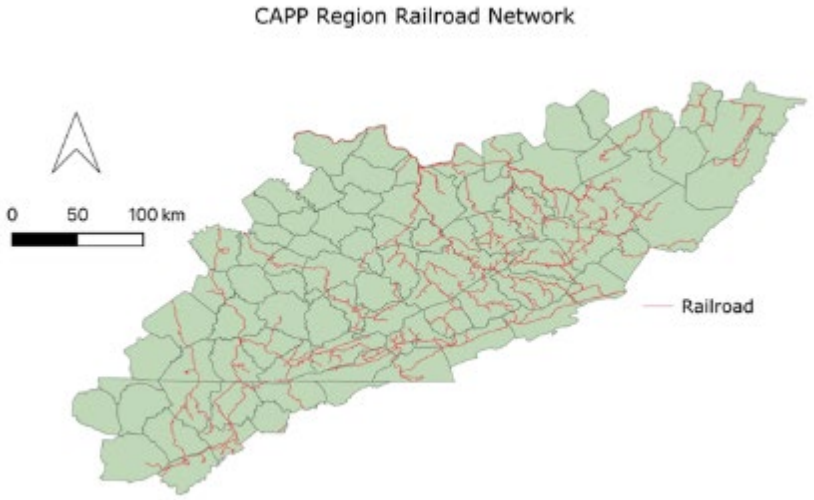
Blondes, M. S., Gans, K. D., Engle, M. A., Kharaka, Y. K., Reidy, M. E., Saraswathula, V., Thordsen, J. J., Rowan, E. L., & Morrissey, E. A. (2019). U.S. Geological Survey National Produced Waters Geochemical Database v2.3 [Data set]. U.S. Geological Survey. https://doi.org/10.5066/F7J964W8

INITIAL INFRASTRUCTURE ASSESSMENT

Screening for various metrics, including:

- Cheapest source of electricity
- Primary & secondary roads
- Power generation
- Railroad networks
- Commercially navigable waterways
- Fly ash pond locations
- Population with access to broadband
- Educational opportunities
- Etc.





TECHNOLOGY ASSESSMENT, DEVELOPMENT & FIELD TESTING

- Mining (primary, co-products, re-mining)
- Separation Processes
- Carbon Products
- Technology Assessment
- Field-Testing
- Gap Analysis

WORKFORCE READINESS & DEVELOPMENT

- Workforce Readiness Plan
- Workshops & Forums
  - Engage stakeholders/entrepreneurs, public, future workforce personnel
  - Identify & assess skillsets & employment opportunities
  - Offer programs, certifications & skills training to match needs of projects in basin

Workforce Readiness Plan

Step 1
Assess the Workforce

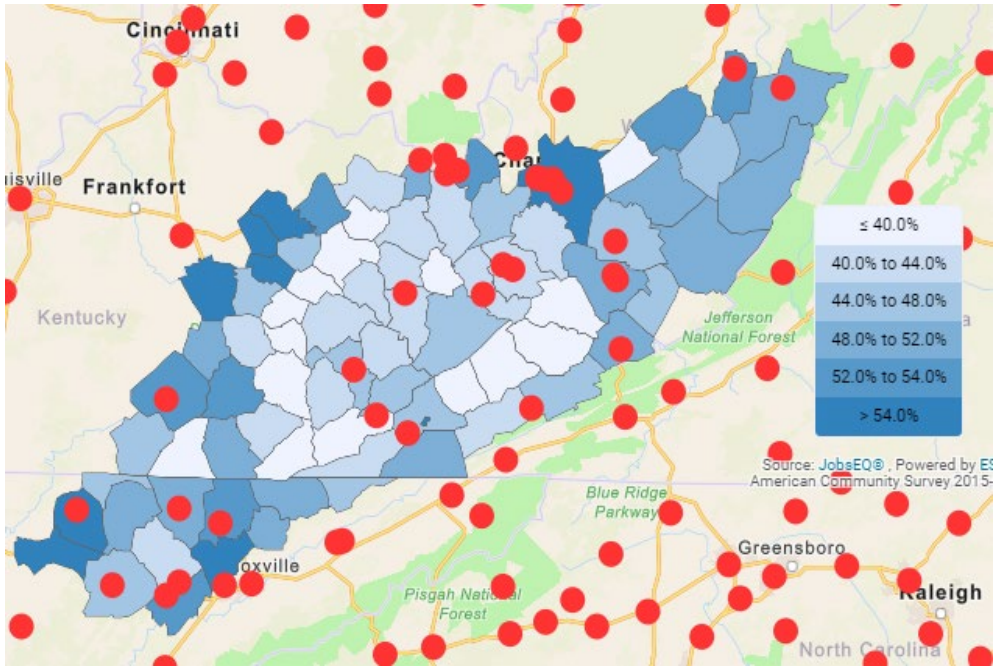
→

Step 2
Identify Supporting Organizations

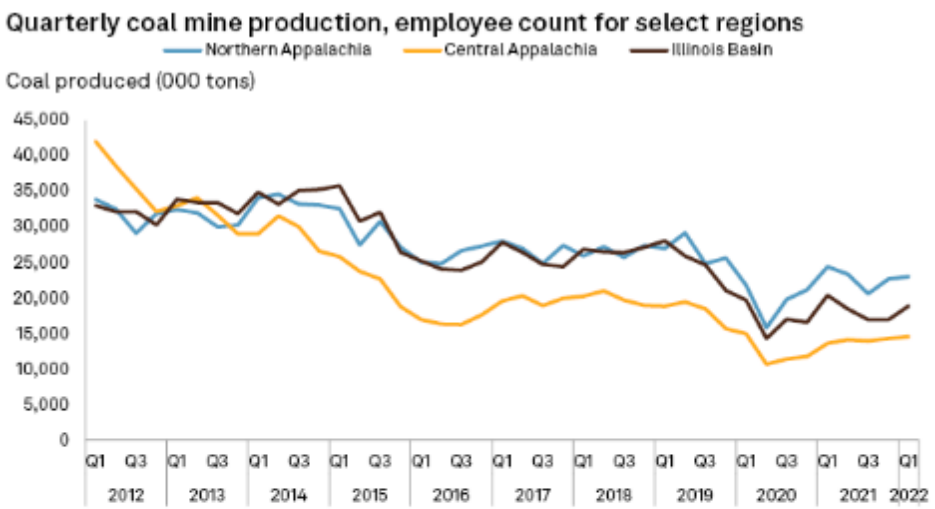
→

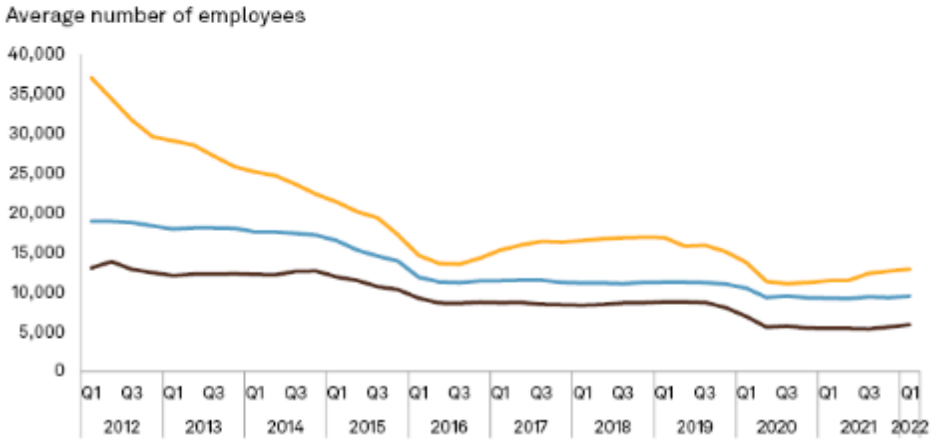
Step 3
Develop the Workforce

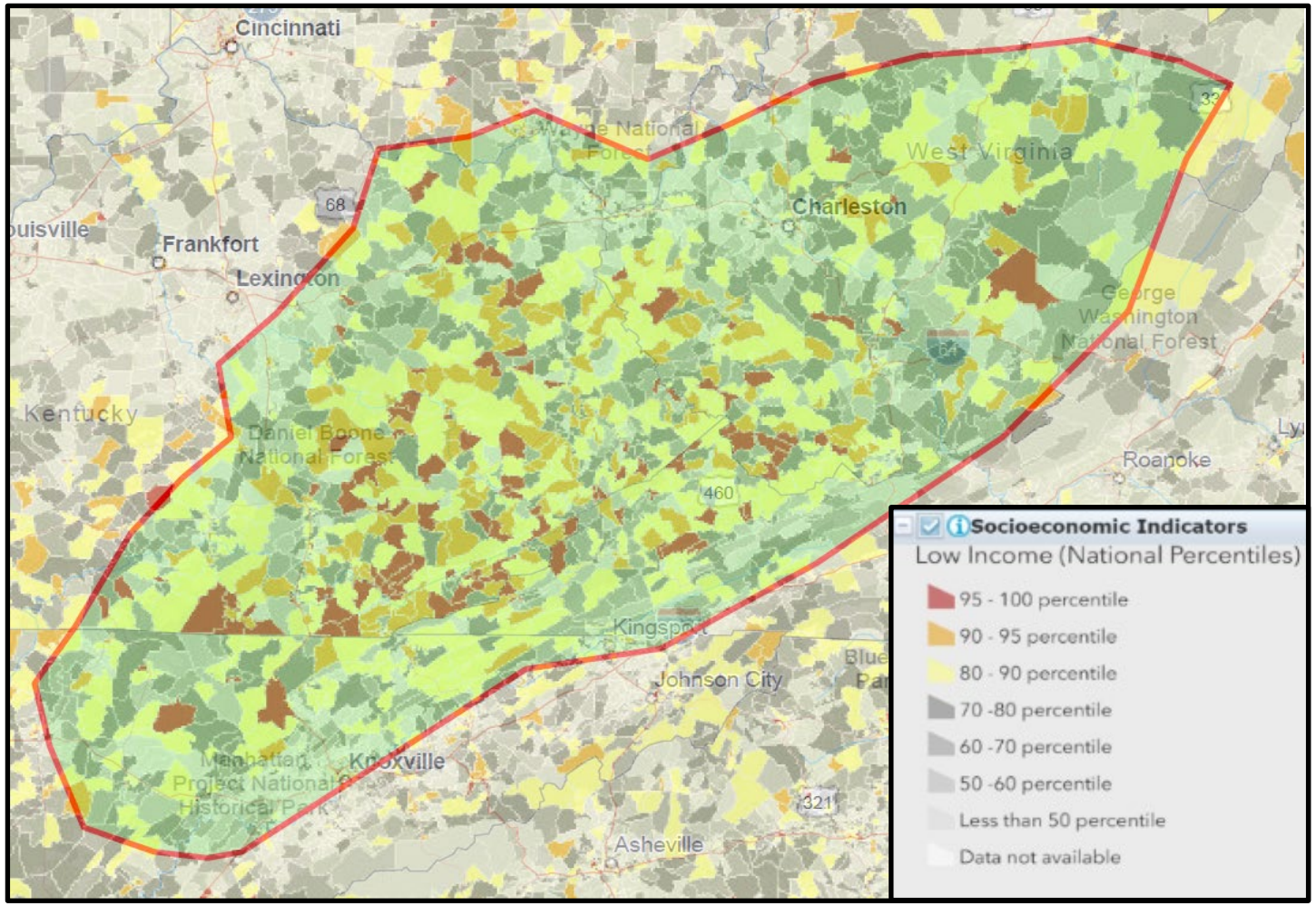
Labor Force Participation Rate with locations of Public 2-year or Less Training Facilities



CAPP EMPLOYMENT TRENDS & SOCIOECONOMIC INDICATORS





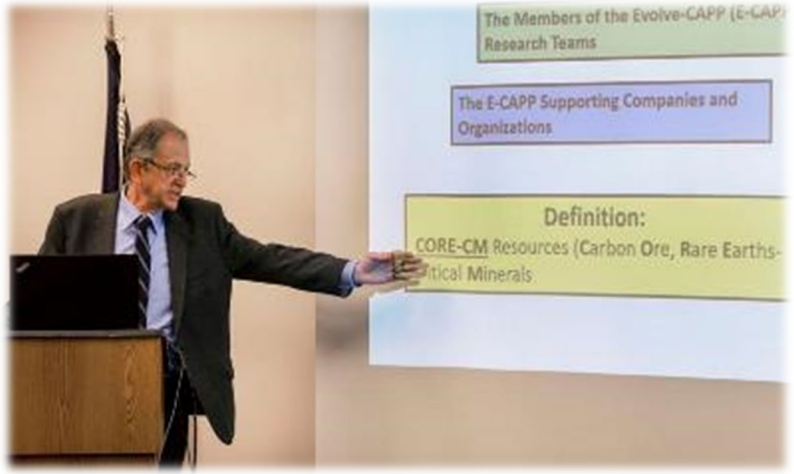


Source: S&P Global Market Intelligence (May 2022)

STAKEHOLDER OUTREACH & EDUCATION

- *Open Public Session, Stakeholders Advisory Committee:* ***March 2022*** ✓
- *Initial Stakeholder Outreach & Education Plan:* ***June 2022*** ✓
- *Public Outreach, Education & Engagement:* ***14 presentations..***

➢ ***MCPA, USEA, SSEB, Open Session, SME-CAS, FL-SME, SME, etc.***

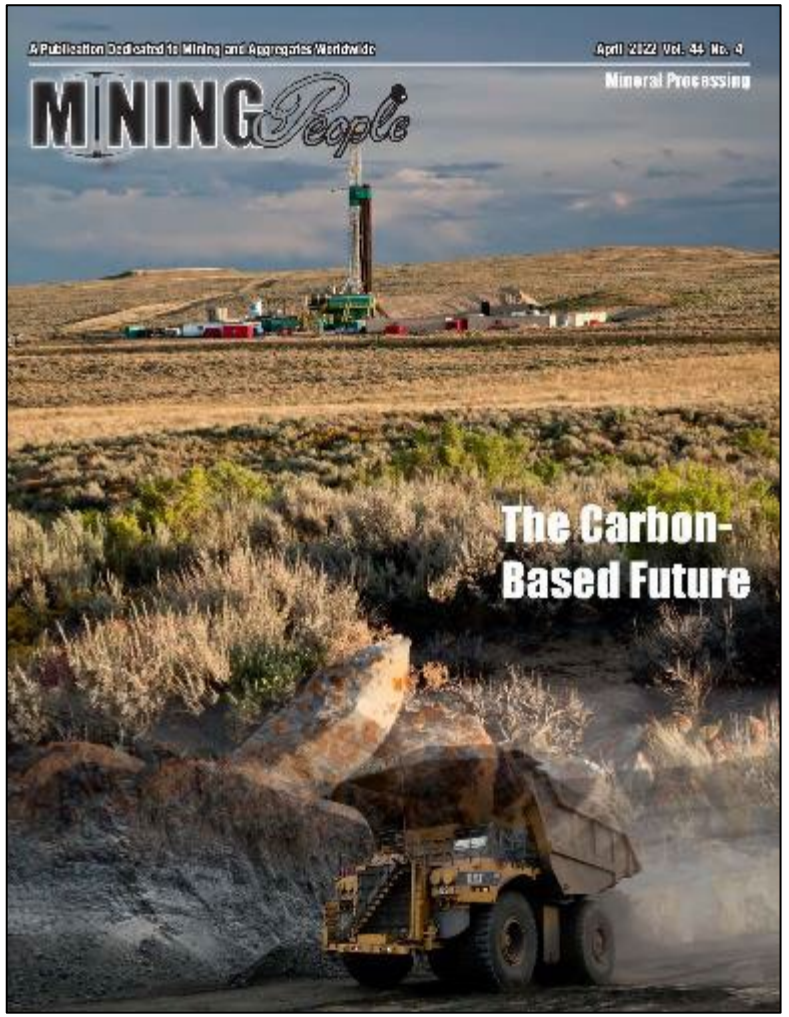


ADDITIONAL OUTREACH

- ✓ Open Session Public Outreach event on March 16th, 2022 in Abingdon, VA
- ✓ 1st Stakeholder Advisory Committee (SAC) meeting - March 16th, 2022 in Abingdon, VA
- ✓ Multiple regional news agencies reporting on Evolve CAPP after Open Session
- ✓ 2022 SME-FL Regional Mining Conference presentation on October 12th
- ✓ 2nd Stakeholder Advisory Committee (SAC) meeting – December 1st, 2022 in Lexington, KY
- ✓ Central Appalachian SME Section Spring Meeting in Julian, WV on April 14th
- ✓ SME-NYC Mining Finance Conference in Manhattan on May 9th – 10th

- ➢ Metallurgical Coal Producers Association (MCPA) Conference in Roanoke, WV on May 20th
- ➢ Planning 3rd Stakeholder Advisory Committee (SAC) meeting in West Virginia on August 4th

IN THE MEDIA..



Carbon-Based Future continued

There's also a hope of eventually bringing something that can be in short supply in rural communities: good-paying jobs, ideally utilizing existing local skillsets.

"The very same fossil fuel communities that have powered our nation for decades can be at the forefront of the clean energy economy by producing the critical minerals needed to build electric vehicles, wind turbines, and so much more," said Secretary of Energy Jennifer M. Granholm (left), according to DOE's funding announcement last year.

"By building clean energy products here at home, we're securing the supply chain for the innovative solutions needed to reach net-zero carbon emissions by 2050 – all while creating good paying jobs in all parts of America."

That's a hope discussed eagerly in regions that have historically relied upon coal mining for employment, such as Wyoming and parts of Appalachia.

"We basically put together a large team of experts with a variety of backgrounds," says Richard Bishop (right), principal investigator for Evolve Central Appalachia (CAPP), a project based at Virginia Polytechnic Institute and State University (Virginia Tech) where he says they're currently engaged in "desktop due diligence" to collect all the data.

"Initially the focus is putting together all the existing information that's out there, so what information has already been sampled in the region… but also where those gaps are [and] what kind of sampling program we need to really identify a resource in our region, whether it be from coal waste or in situ in the ground," Bishop says.

"We're coming up with strategies to utilize existing infrastructure that is in place but also to really move these projects forward in a safe and environmentally friendly way."

Once the resource is identified, he says, they'll be reviewing the various processing methods available to recover the minerals they're looking for. He says there's been a lot of research done in the area over the last five years or so – and there's also the potential to learn about processing methods from other industries.

There also seems to be a lot of technologies showing up on conference agendas this year, some of them already at pilot or even small commercial scale – from techniques to chemically screen ever-smaller particles to improved dewatering processes to a system for grinding coal to separate impurities from the hydrocarbons.

In several of the DOE-funded projects, the possibility of using coal waste – whether mine drainage, old coal waste piles, or power plant ash – as a source of rare earth elements and critical minerals – is one that's being looked at heavily.

It may be a particularly relevant option in Appalachian states with a long history of mining – and literally hundreds of waste piles left behind by companies that operated generations ago, before current processing technologies and reclamation capabilities were in place.

Often, those waste piles contain a lot of usable coal. In Virginia, some of it has even been burned in a power plant designed to handle the material, which has enabled the cleanup of a few longstanding waste sites in recent years. But a lot more remain.

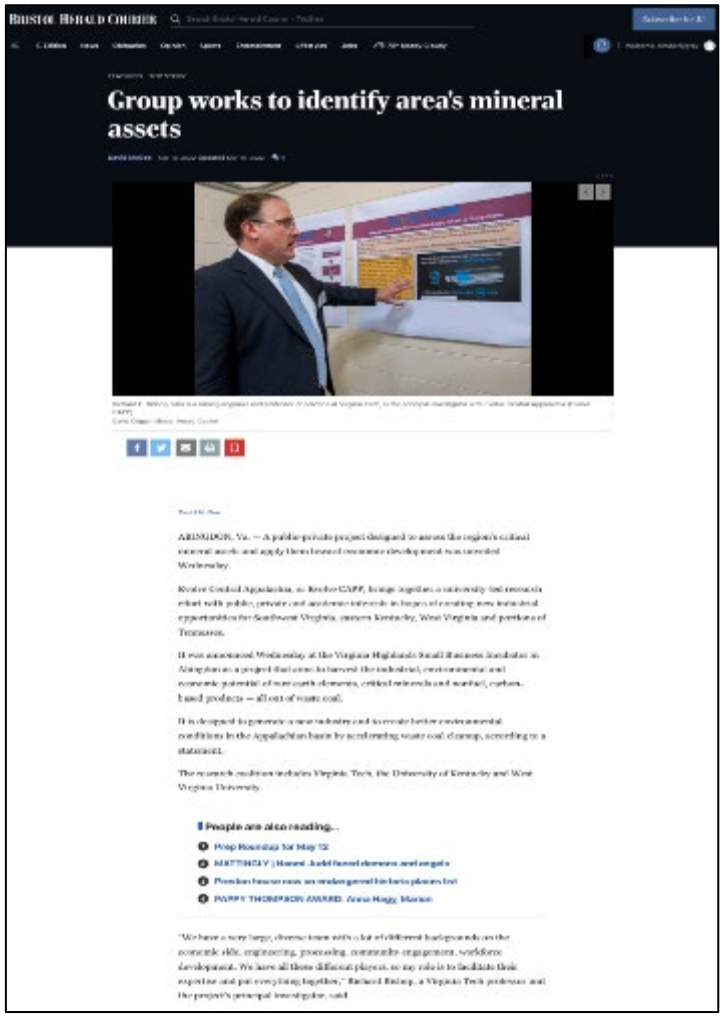
Now, those waste sites are being eyed for the materials that could be extracted – and the win-win that could occur if funding available to help clean up the piles can also help to advance research efforts.

In the western U.S., the University of Wyoming is overseeing two of the DOE-funded projects, covering two regions: the Powder River Basin of Wyoming and Montana, a production powerhouse that contains the nation's largest coal mines; and the Wind River Basin, which includes parts of Colorado and Wyoming.

In Wyoming, where the coal region is branding itself as "Carbon Valley" – a name inspired by aspirations to follow in the footsteps of California's "Silicon Valley" technology hub – these DOE-funded projects are only part of the energy around finding new uses for coal. Wyoming, which reportedly produces

continue

Above: Research lab at the University of Wyoming. Right: Coal core sample for rare earth elements.



Bristol Herald Courier

Group works to identify area's mineral assets

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"We have a very large, diverse team with a lot of different backgrounds on the economic side, engineering, processing, community engagement, workforce development. We have all these different players, so my role is to facilitate their expertise and put everything together," Richard Bishop, a Virginia Tech professor and the project's principal investigator, said.

IN THE MEDIA..

Group works to identify Appalachia's mineral assets

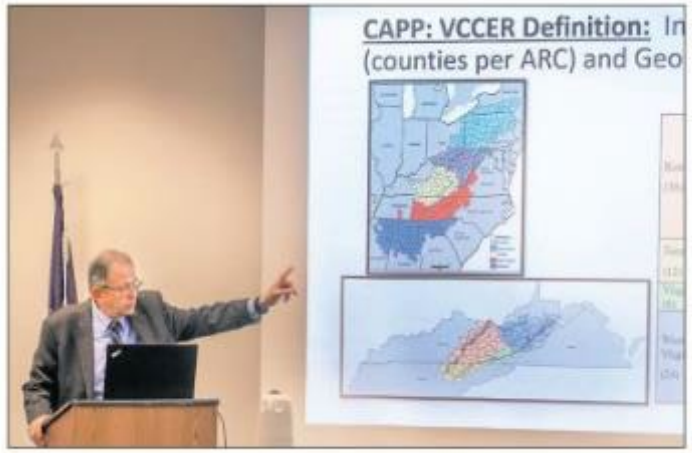
BY DAVID MCGEE
BRISTOL HERALD COURIER

ABINGDON, Va. — A public-private project designed to assess the region's critical mineral assets and apply them toward economic development was unveiled Wednesday.

Evolve Central Appalachia, or Evolve CAPP, brings together a university-led research effort with public, private and academic interests in hopes of creating new industrial opportunities for Southwest Virginia, eastern Kentucky, West Virginia and portions of Tennessee.

It was announced Wednesday at the Virginia Highlands Small Business Incubator in Abingdon as a project that aims to harvest the industrial, environmental and economic potential of rare earth elements, critical minerals and nonfuel, carbon-based products — all out of waste coal.

It is designed to generate a new industry and to create better environmental conditions in the Appalachian basin by accelerating waste coal cleanup, according to a statement.



DAVID CRIGGER/BRISTOL HERALD COURIER

Michael Karmis, original principal investigator, talks about the purpose of Evolve Central Appalachia (Evolve CAPP).

The research coalition includes Virginia Tech, the University of Kentucky and West Virginia University.

"We have a very large, diverse team with a lot of different

See **CAPP**, Page A4

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ECONOMY

Tech scientists see rare opportunity in Appalachia

Rare earth elements, extracted from coal waste, could help build a new industry.

by Randy Walker
September 14, 2022

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QUESTIONS?

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Evolve Central Appalachia

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https://energy.vt.edu/research/evolve-capp.html