

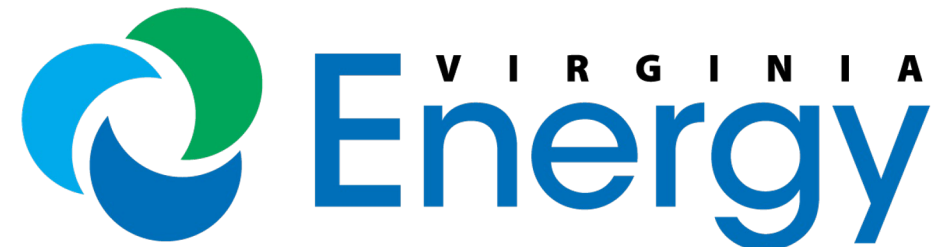
State Perspective on Critical Minerals for Clean Energy

NASEO Annual Meeting 10/13/22

Lorrie C. Skiffington

Overview

1. Who we are and what we do
2. Messaging- Critical Minerals
3. Relationships- Resources for States: AASG, Earth MRI
4. Partnerships- Unconventional Resources





Who we are

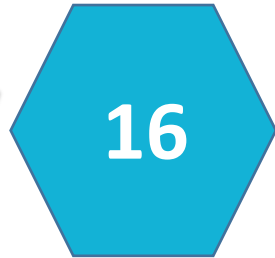


What we do





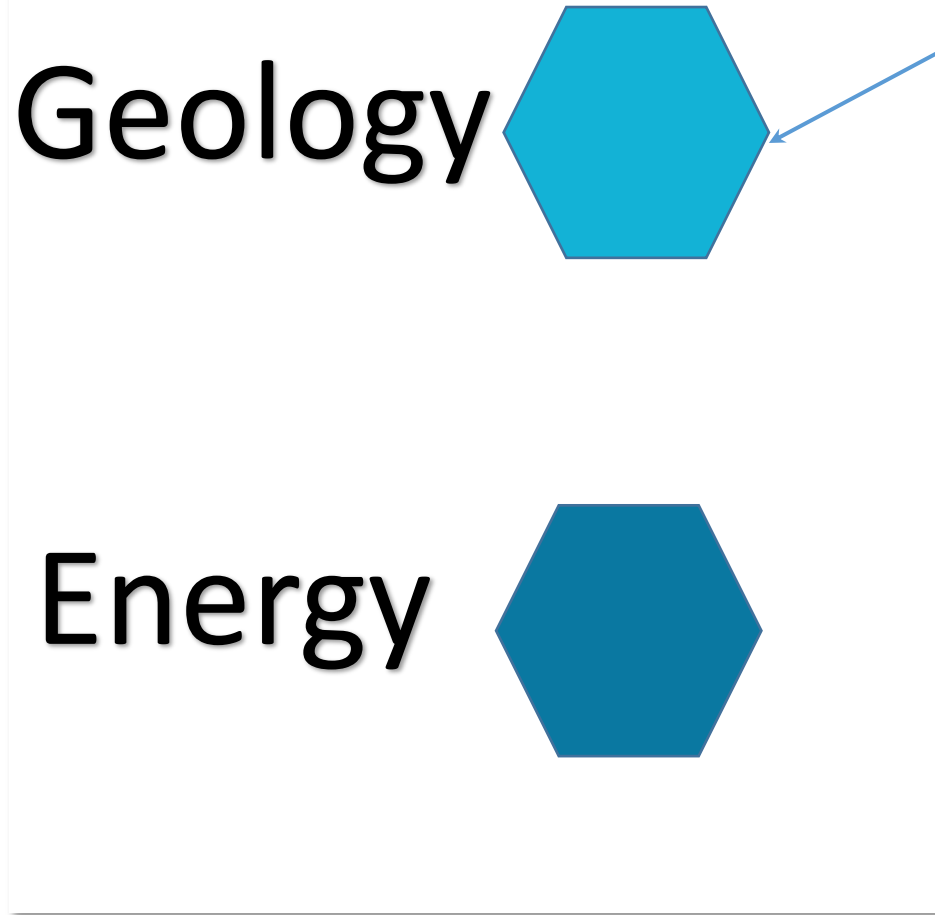
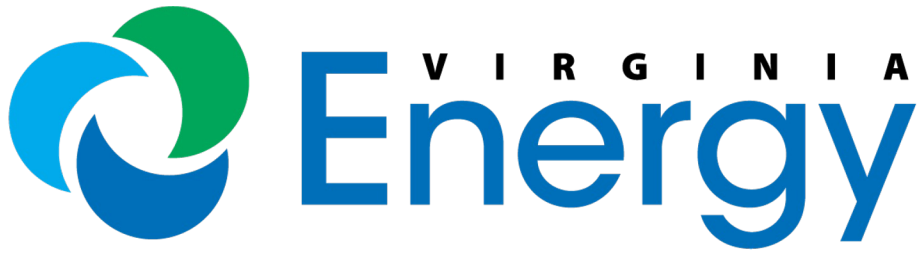
Geology



Number of
Employees

Energy



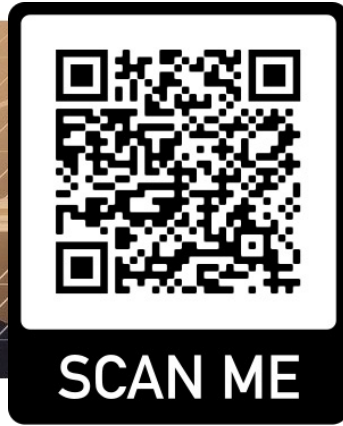


Our Critical Minerals Page



Renewable Energy

Home / Renewable Energy



Virginia's Renewable Energy team serves as support for renewable energy deployment across the Commonwealth. Renewable energy programs focus on ease of deployment, equal access and contributions toward a carbon free electric grid.

Clean Energy Virginia

Expanding Access to Clean Energy and Growing the Clean Energy Jobs of the Future!

The Virginia Clean Economy Act of 2020 set several clean energy goals for the Commonwealth. The Clean Energy Virginia Dashboard was created as a way to measure that progress and make it available for anyone to view. This dashboard is a collaboration between the University of Virginia and Virginia Energy. Click below to learn more about these programs:



Clean Energy Virginia Dash Board

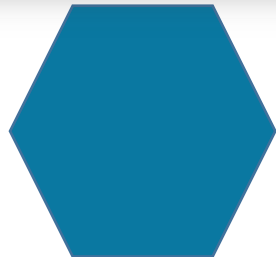


Lead By Example



Energy Workforce

Energy



Energy Efficiency

Home / Energy Efficiency



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NO FARMS
NO FOOD

NO FARMS
NO FOOD

NO MINES
NO ENERGY

Messaging

Critical materials are needed for:

cell phones

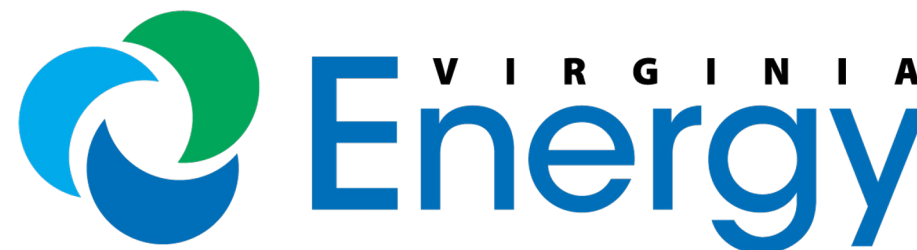
computers

computer chips

electric vehicle batteries

wind turbines

solar power panels



Periodic table of elements highlighting the “critical minerals”

2022 Critical Mineral

2018 List

1 H Hydrogen Nonmetal	2022 Critical Mineral																2018 List																2 He Helium Noble Gas						
3 Li Lithium Alkali Metal	4 Be Beryllium Alkaline Earth Metal	Atomic Number Symbol Name Chemical Group Block																2 He Helium Noble Gas																5 B Boron Metalloid	6 C Carbon Nonmetal	7 N Nitrogen Nonmetal	8 O Oxygen Nonmetal	9 F Fluorine Halogen	10 Ne Neon Noble Gas
11 Na Sodium Alkali Metal	12 Mg Magnesium Alkaline Earth Metal	19 K Potassium Alkali Metal	20 Ca Calcium Alkaline Earth Metal	21 Sc Scandium Transition Metal	22 Ti Titanium Transition Metal	23 V Vanadium Transition Metal	24 Cr Chromium Transition Metal	25 Mn Manganese Transition Metal	26 Fe Iron Transition Metal	27 Co Cobalt Transition Metal	28 Ni Nickel Transition Metal	29 Cu Copper Transition Metal	30 Zn Zinc Transition Metal	31 Ga Gallium Post-Transition Metal	32 Ge Germanium Metalloid	33 As Arsenic Metalloid	34 Se Selenium Nonmetal	35 Br Bromine Halogen	36 Kr Krypton Noble Gas	13 Al Aluminum Post-Transition Metal	14 Si Silicon Metalloid	15 P Phosphorus Nonmetal	16 S Sulfur Nonmetal	17 Cl Chlorine Halogen	18 Ar Argon Noble Gas														
37 Rb Rubidium Alkali Metal	38 Sr Strontium Alkaline Earth Metal	39 Y Yttrium Transition Metal	40 Zr Zirconium Transition Metal	41 Nb Niobium Transition Metal	42 Mo Molybdenum Transition Metal	43 Tc Technetium Transition Metal	44 Ru Ruthenium Transition Metal	45 Rh Rhodium Transition Metal	46 Pd Palladium Transition Metal	47 Ag Silver Transition Metal	48 Cd Cadmium Transition Metal	49 In Indium Post-Transition Metal	50 Sn Tin Post-Transition Metal	51 Sb Antimony Metalloid	52 Te Tellurium Metalloid	53 I Iodine Halogen	54 Xe Xenon Noble Gas	19 K Potassium Alkali Metal	20 Ca Calcium Alkaline Earth Metal	21 Sc Scandium Transition Metal	22 Ti Titanium Transition Metal	23 V Vanadium Transition Metal	24 Cr Chromium Transition Metal	25 Mn Manganese Transition Metal	26 Fe Iron Transition Metal	27 Co Cobalt Transition Metal	28 Ni Nickel Transition Metal	29 Cu Copper Transition Metal	30 Zn Zinc Transition Metal	31 Ga Gallium Post-Transition Metal	32 Ge Germanium Metalloid	33 As Arsenic Metalloid	34 Se Selenium Nonmetal	35 Br Bromine Halogen	36 Kr Krypton Noble Gas				
55 Cs Cesium Alkali Metal	56 Ba Barium Alkaline Earth Metal	72 Hf Hafnium Transition Metal	73 Ta Tantalum Transition Metal	74 W Tungsten Transition Metal	75 Re Rhenium Transition Metal	76 Os Osmium Transition Metal	77 Ir Iridium Transition Metal	78 Pt Platinum Transition Metal	79 Au Gold Transition Metal	80 Hg Mercury Transition Metal	81 Tl Thallium Post-Transition Metal	82 Pb Lead Post-Transition Metal	83 Bi Bismuth Post-Transition Metal	84 Po Polonium Metalloid	85 At Astatine Halogen	86 Rn Radon Noble Gas	55 Cs Cesium Alkali Metal	56 Ba Barium Alkaline Earth Metal	72 Hf Hafnium Transition Metal	73 Ta Tantalum Transition Metal	74 W Tungsten Transition Metal	75 Re Rhenium Transition Metal	76 Os Osmium Transition Metal	77 Ir Iridium Transition Metal	78 Pt Platinum Transition Metal	79 Au Gold Transition Metal	80 Hg Mercury Transition Metal	81 Tl Thallium Post-Transition Metal	82 Pb Lead Post-Transition Metal	83 Bi Bismuth Post-Transition Metal	84 Po Polonium Metalloid	85 At Astatine Halogen	86 Rn Radon Noble Gas						
87 Fr Francium Alkali Metal	88 Ra Radium Alkaline Earth Metal	104 Rf Rutherfordium Transition Metal	105 Db Dubnium Transition Metal	106 Sg Seaborgium Transition Metal	107 Bh Bohrium Transition Metal	108 Hs Hassium Transition Metal	109 Mt Meitnerium Transition Metal	110 Ds Darmstadtium Transition Metal	111 Rg Roentgenium Transition Metal	112 Cn Copernicium Transition Metal	113 Nh Nihonium Post-Transition Metal	114 Fl Flerovium Post-Transition Metal	115 Mc Moscovium Post-Transition Metal	116 Lv Livermorium Post-Transition Metal	117 Ts Tennessine Halogen	118 Og Oganesson Noble Gas	87 Fr Francium Alkali Metal	88 Ra Radium Alkaline Earth Metal	104 Rf Rutherfordium Transition Metal	105 Db Dubnium Transition Metal	106 Sg Seaborgium Transition Metal	107 Bh Bohrium Transition Metal	108 Hs Hassium Transition Metal	109 Mt Meitnerium Transition Metal	110 Ds Darmstadtium Transition Metal	111 Rg Roentgenium Transition Metal	112 Cn Copernicium Transition Metal	113 Nh Nihonium Post-Transition Metal	114 Fl Flerovium Post-Transition Metal	115 Mc Moscovium Post-Transition Metal	116 Lv Livermorium Post-Transition Metal	117 Ts Tennessine Halogen	118 Og Oganesson Noble Gas						
		57 La Lanthanum Lanthanide	58 Ce Cerium Lanthanide	59 Pr Praseodymium Lanthanide	60 Nd Neodymium Lanthanide	61 Pm Promethium Lanthanide	62 Sm Samarium Lanthanide	63 Eu Europium Lanthanide	64 Gd Gadolinium Lanthanide	65 Tb Terbium Lanthanide	66 Dy Dysprosium Lanthanide	67 Ho Holmium Lanthanide	68 Er Erbium Lanthanide	69 Tm Thulium Lanthanide	70 Yb Ytterbium Lanthanide	71 Lu Lutetium Lanthanide																							
		89 Ac Actinium Actinide	90 Th Thorium Actinide	91 Pa Protactinium Actinide	92 U Uranium Actinide	93 Np Neptunium Actinide	94 Pu Plutonium Actinide	95 Am Americium Actinide	96 Cm Curium Actinide	97 Bk Berkelium Actinide	98 Cf Californium Actinide	99 Es Einsteinium Actinide	100 Fm Fermium Actinide	101 Md Mendelevium Actinide	102 No Nobelium Actinide	103 Lr Lawrencium Actinide																							



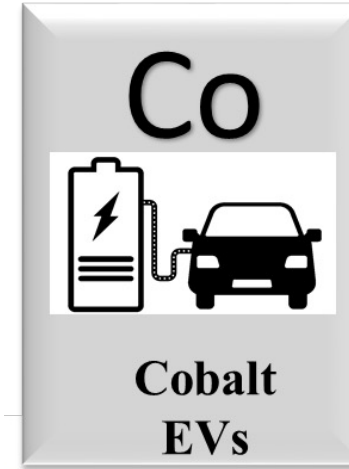
SCAN ME



- Solar: Al, Ge, Ni, Te, Cd, In, Se, Sn, Cu, Fe, Si, Zn, Ga, Pb, Ag

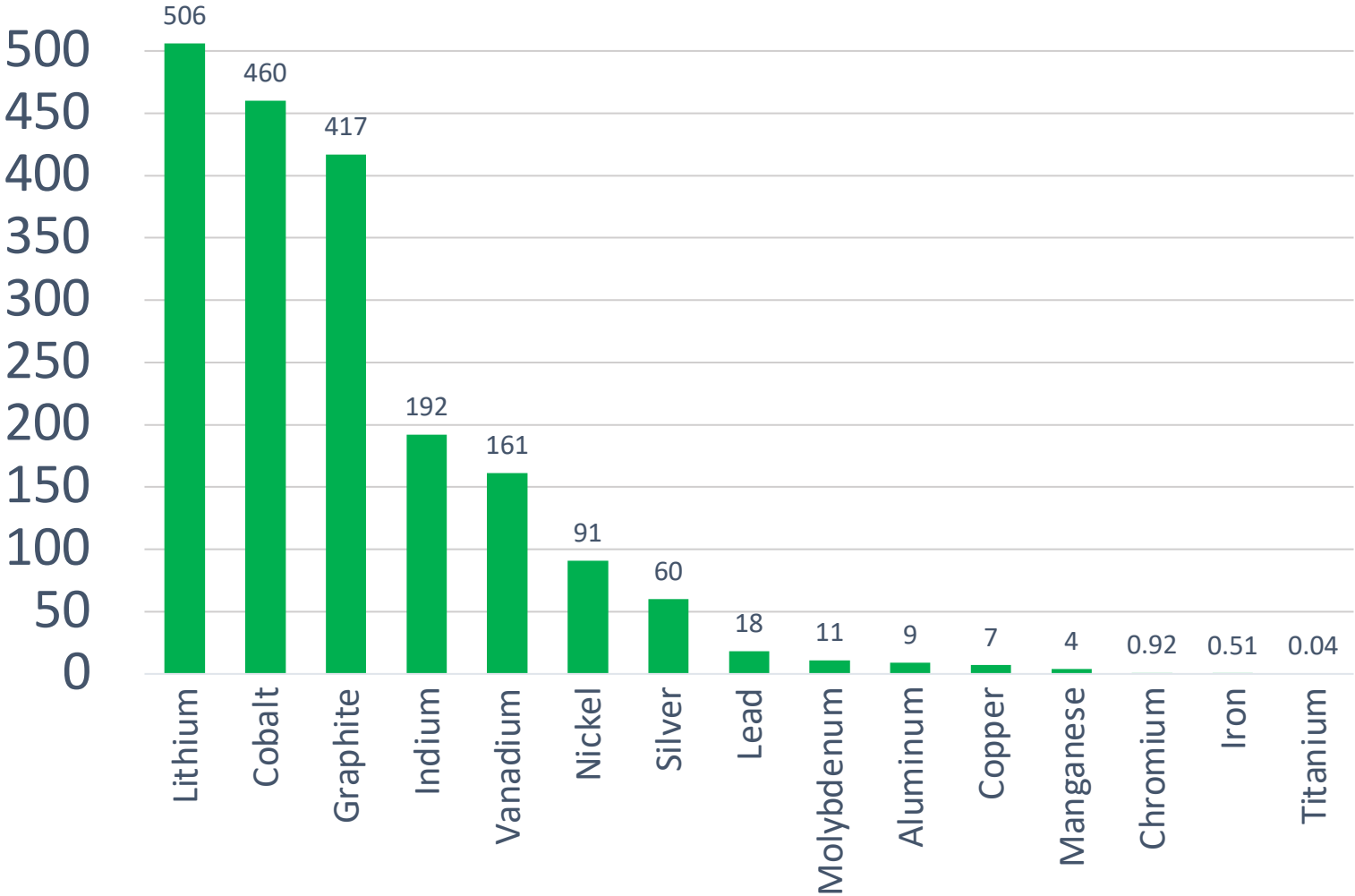
- Wind: Al, Fe, Mo, Cr, Pb, REEs, Co, Mn, Zn, Cu

- eVs & Storage: Al, C, Li, REEs, Co, Fe, Mn, Si, Cu, Pb, Ni, Ti



1 H Hydrogen Nonmetal																	2 He Helium Noble Gas
3 Li Lithium Alkali Metal	4 Be Beryllium Alkaline Earth Metal											5 B Boron Metalloid	6 C Carbon Nonmetal	7 N Nitrogen Nonmetal	8 O Oxygen Nonmetal	9 F Fluorine Nonmetal	10 Ne Neon Noble Gas
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Projected Demand in 2050 for Critical Elements as % of 2020 Production



Graph by L. Skiffington, 2022; 2050 demand projections based on IEA 2DS scenario (steel production excluded by World Bank)

Projected Demand in 2050 for Critical elements as % of 2020 Production

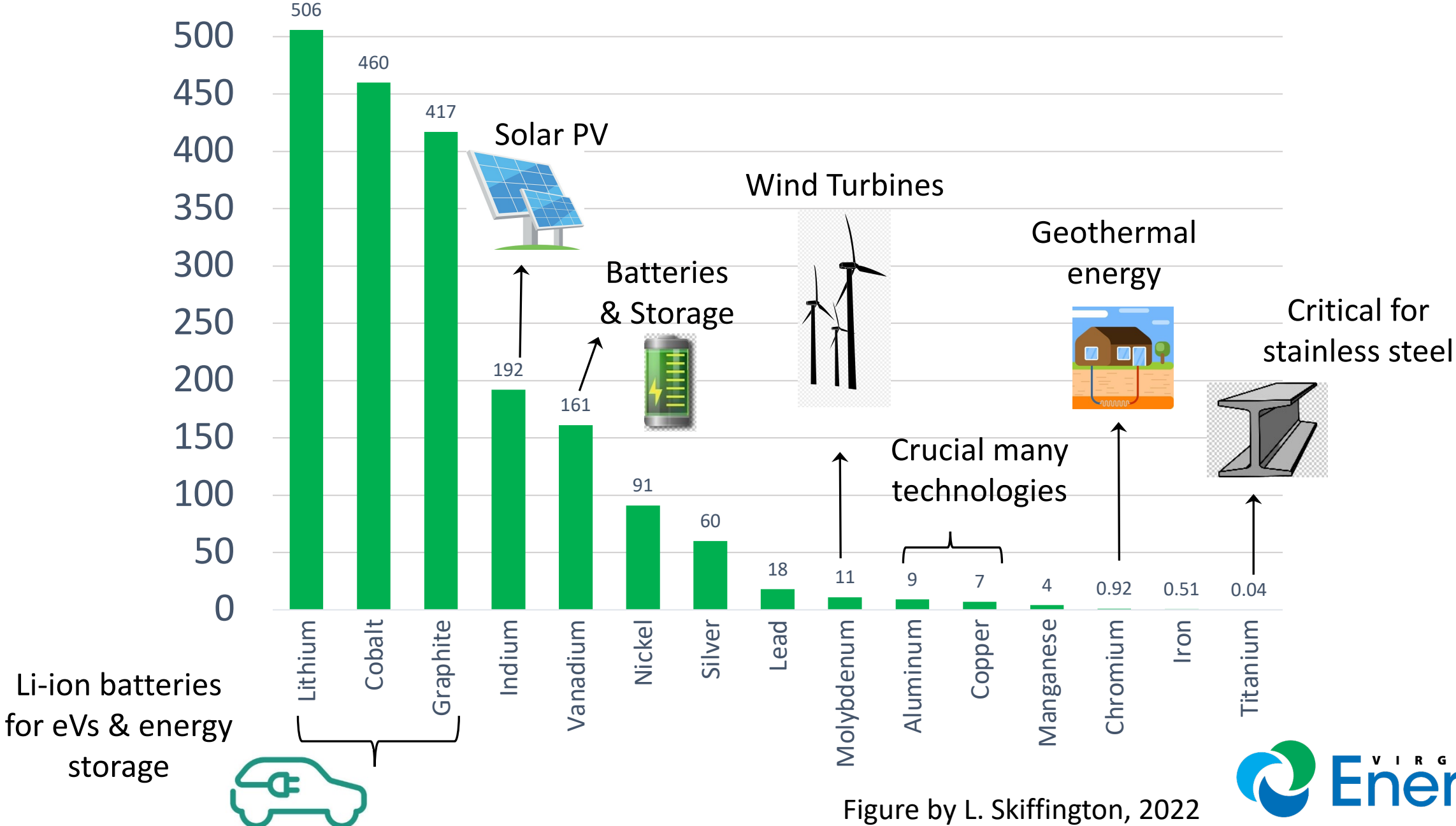
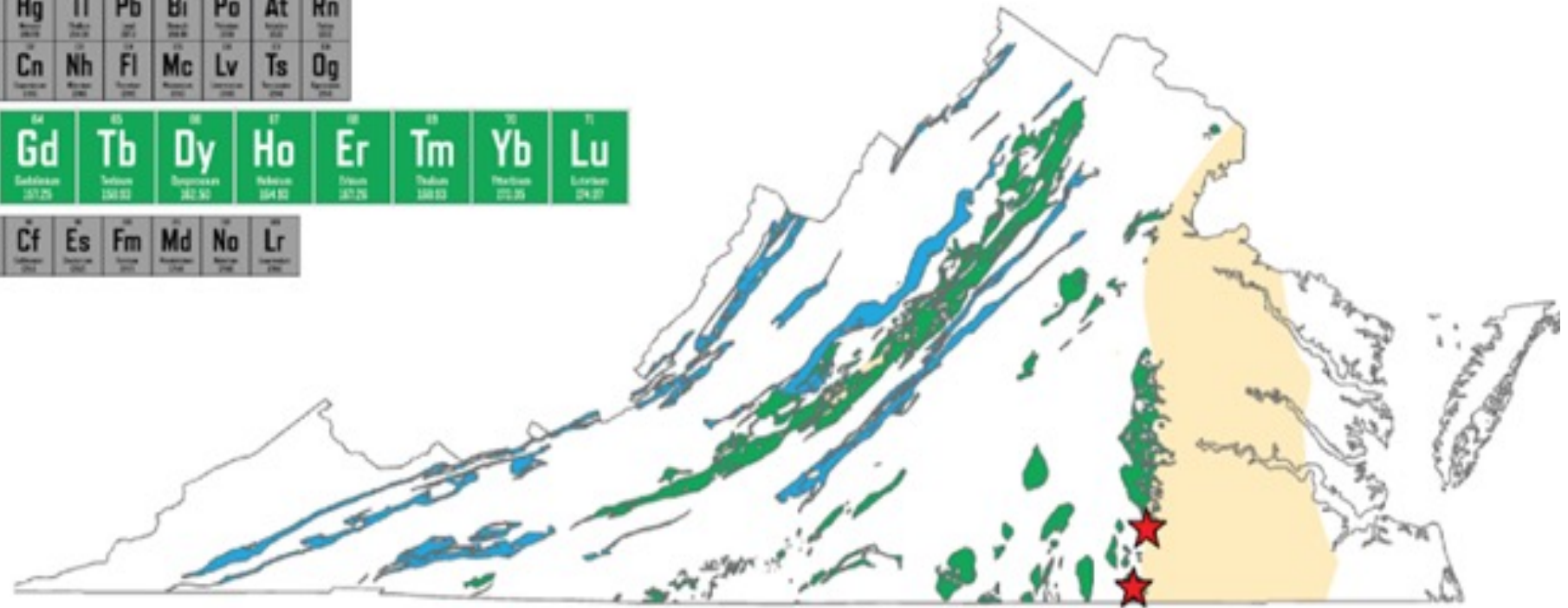
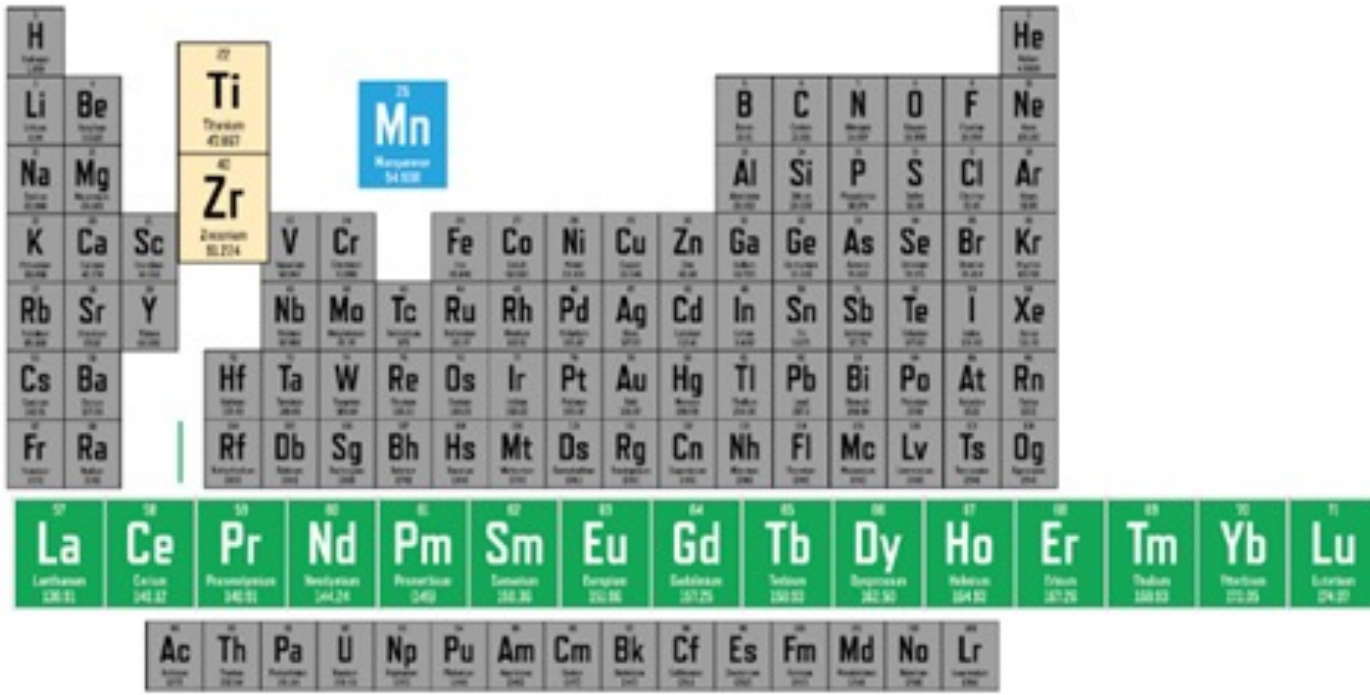


Figure by L. Skiffington, 2022



★ Former Iluka Heavy Mineral Sand Mines

Old Hickory (Dinwiddie County)

Brink Heavy (Greenville County)



Manganese

Rare Earth Elements

Ti and Zr
in Heavy Mineral Sands

Figure by M. Reed, L. Williams,
L. Skiffington @ Virginia Energy- 2022



Our Geologists Harvest Heavy Minerals

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Home > STATE GEOLOGICAL SURVEYS

STATE GEOLOGICAL SURVEYS

Search by State

SEARCH



Alabama

Geological Survey of Alabama - Alabama State Oil and Gas Board
PO Box 869999
Tuscaloosa, Alabama 35486-6999

Alaska

Division of Geological & Geophysical Surveys - Alaska Department of Natural Resources
3354 College Rd.
Fairbanks, Alaska 99709

Arizona

Arizona Geological Survey
1955 East Sixth Street
PO Box 210184
Tucson, Arizona 85721





ENERGY

Mission

AASG standing committees maintain awareness and analysis of key topics; each year, a given committee may or may not be active, as priorities fluctuate, and as special projects arise; the Chair or Co-Chairs recruit committee members as needed

Responsibilities

The Committee: seeks to optimize the state geological survey role in this topic; monitors policy developments; works with Congressional members and staff; supports development of AASG Congressional Testimony as required; monitors and provides input into Federal legislation and regulations; ensures that AASG is represented on related federal advisory committees; monitors and advocates for the federal role, including external grants; facilitates collaboration with federal agencies; collaborates with partners organizations such as NGOs; assists in development and implementation of AASG positions and initiatives; shares pertinent information with the AASG community; updates the AASG Position Statement; helps with AASG annual meeting program planning when asked; and reports to the annual meeting

Current Committee Members

Nick (Berry) H. Tew, Chair
Scott W. Tinker, Chair



U.S. Geological Survey's Earth MRI Program

Project Description



<https://www.usgs.gov/special-topics/earth-mri>

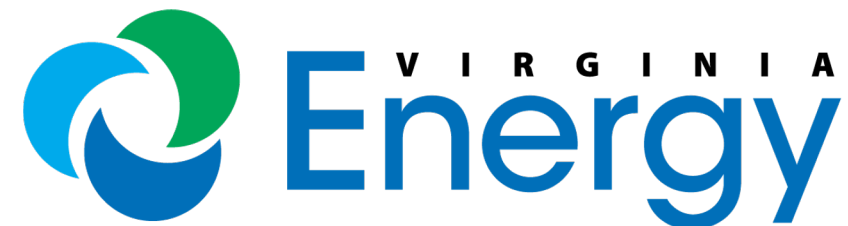
National Map Viewer



<https://ngmdb.usgs.gov/emri/#3/40/-96>

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Evolve Central Appalachia: Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) Initiative for the Central Appalachia Basin (Evolve CAPP)



A pile of waste coal near Clinchco in Dickenson County.

*Photo courtesy of Frank Kilgore from Cardinal News What to Do with Gob 11/9/21 Sarah Wade:
<https://cardinalnews.org/2021/11/09/what-to-do-with-gob/>*



Evolve CAPP looks at coal waste (GOB) for strategic minerals supply



Dr. Karmis & Will Clear

Photo courtesy of Mark Still Mar 17, 2022

<https://energy.vt.edu/research/evolve-capp/in-the-press/evolve-capp0.html>



Evolve CAPP

- Support from several energy companies, engineering firms, and public-private cooperation to evaluate what supplies of recoverable minerals and metals can be found in the region.
- The project will also evaluate and recommend technology and processes to recover materials in an economical and environmentally sound way.
- A coalition of two universities and four community and technical colleges in the region

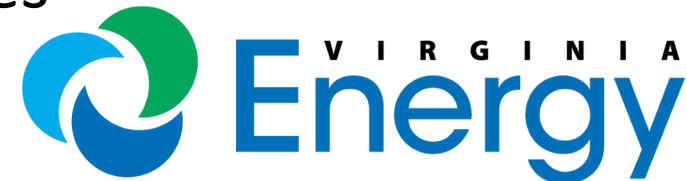
Evolve CAPP-Strengthen Domestic Supply Chain

- The Evolve Central Appalachia project is developing & implementing strategies that enable the region to realize its full economic potential for producing rare earth elements, critical minerals, & high-value, nonfuel, carbon-based products.
- Strategies will be presented to spur economic growth, close supply chain gaps, promote investment in the region, and address workforce education and training opportunities.
- The project aims to show how Southwest Virginia can become a link in federal efforts to strengthen domestic supply chains for rare earth elements and critical minerals for technology uses.

Core CM Evolve CAPP

Project Objectives:

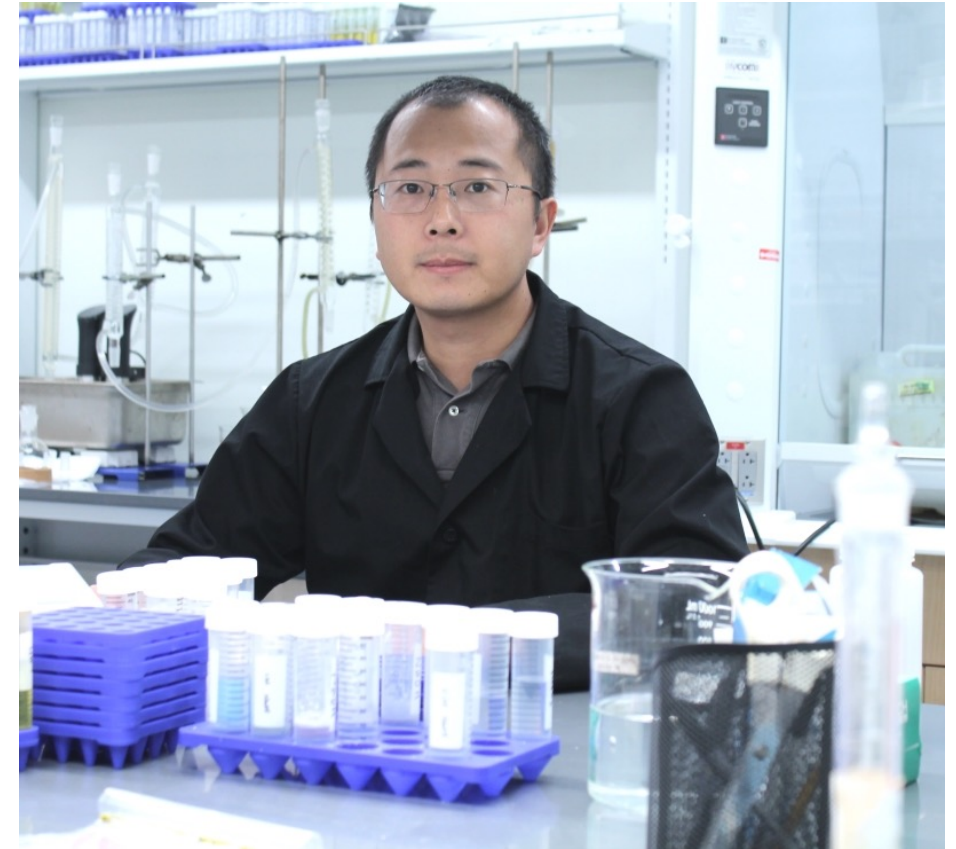
1. Determine the quantity & distribution of resources in the region
2. Formulate strategies to utilize coal waste streams to produce useful fuels & materials
3. Evaluate regional infrastructure & identify industries that may benefit from Rare Earth Element & Critical Mineral production
4. Develop strategies to encourage business development
5. Guide research & development of new technologies
6. Frame plans to establish technology innovation centers
7. Implement stakeholder outreach & education initiatives



Evolve CAPP

- Evolve CAPP program concludes in September 2023
- The aim is not for Department of Energy to produce the material but instead to de-risk the technologies so private companies will have the motivation to license the new processes and produce goods through the commercial sector.
- we can come in and clean up these legacy wastes. And we can create ... almost a new industry in those regions focused on rare earth production and manufacturing.
- You can meet a national security need, and you can supply jobs to regions that are in desperate need of jobs, and you have an opportunity to support better environmental outcomes.

Critical Mineral Extraction



Wencai Zhang is working on the extraction of critical minerals from coal waste and other materials. Randy Walker photo.

IJA

- The Act's funding provisions are aimed at increasing domestic production. First, the bill codifies and funds a US Geological Survey (USGS) effort to compile critical mineral resource location data in the United States. Section 40201 provides \$320 million to the USGS to enhance the Earth Mapping Resources Initiative (Earth MRI), a program of above- and below-ground mapping of mineral resources across the United States. In what could be characterized as a "mining lifecycle approach," Section 40202 prioritizes the mapping of abandoned mine land and mine waste which could be potential sources of multiple critical minerals. The Earth MRI results will be publicly available.
- Second, Section 40204 of the IJA allocates a \$140 million grant to build a Rare Earth Demonstration Facility to develop the commercial feasibility of extracting rare earth elements from acid mine drainage, mine waste, and "other deleterious material," and to separate mixed rare earth oxides into pure oxides of each rare earth element.

https://www.arnoldporter.com/en/perspectives/blogs/environmental-edge/2021/12/domestic-production-of-critical-minerals?utm_source=Mondaq&utm_medium=syndication&utm_campaign=LinkedIn-integration

Questions to Ponder

- What are or can be roles for State Energy Offices or states generally to support and improve critical mineral supply chain? Are there roles and opportunities for states that may not have the geologic resources within their boundaries?
- Mining and processing facilities can engender major concerns over potential adverse environmental and social impacts, including for vulnerable communities? What is or can be done to address such concerns and mitigate adverse impacts?
 - How does potential supply of various critical minerals from unconventional resources, e.g., recovery from coal, byproducts, alternative sources, compare to conventional recovery? What are challenges, opportunities, tradeoffs?
 - What is or will be roles and limitations for reuse and recycling in the shorter and longer term? And for alternatives/substitutes (e.g., battery component formulations)? [*Recycling question: I'm thinking about the timing aspect—at least for batteries, growing demand will far outstrip the supply of used/spent products for recycling but I'd think it important to design products, develop technologies, and plan infrastructure for ease of recycling – circular economy.*]

Thank You