Division of Minerals Sustainability

The Office of Fossil Energy and Carbon Management's (FECM's) Division of Minerals Sustainability is advancing a research, development, and demonstration portfolio geared toward increasing the domestic production and processing of critical minerals and materials in the United States. These efforts support the Biden Administration's strategy on 'Securing a Made in America Supply Chain for Critical Minerals' and have a central role in helping the nation build a clean energy economy and safeguard national security.

America's Need for and Potential to Supply Critical Minerals

Critical minerals and materials, including rare earth elements, are key components of the clean energy technologies we need to achieve our national climate and economic goals. However, the United States is currently highly dependent on foreign sources for many of the critical minerals and materials we need for batteries, wind farms, solar panels, the grid, and other clean energy technologies.

Additionally, the global clean energy market is expected to grow exponentially for the next few decades. Yet currently, even rare earth elements that are mined domestically are shipped overseas for processing before being sold back to the United States in more expensive products.

- More than 95 percent of the U.S. demand for rare earth elements comes from foreign sources.
- More than 50 percent of most critical minerals (43 of 50) come from foreign sources.
- At least 12 critical minerals come exclusively from foreign sources.

Without new domestic raw materials production, refining, and manufacturing capacity, the United States will continue to rely on imports, exposing the nation to supply chain vulnerabilities. Fortunately, the United States has untapped potential to support greater domestic production. A wealth of critical minerals and rare earth elements can be obtained from secondary and unconventional resources, including coal and a wide range of energy and mining waste streams, such as coal waste and ash, acid mine drainage, mine tailings, and produced water from oil and gas production. Across the nation, there are billions of tons of such feedstocks, offering many potential resources for producing a wealth of critical minerals. There is an opportunity to create regional, transparent, robust, and responsible critical mineral supply networks, spurring economic growth and creating enormous job opportunities.

Accelerating the Domestic Production of Critical Minerals and Valuable Carbon Products

The mission of FECM's Division of Minerals Sustainability (the Division) is focused on promoting an environmentally and economically sustainable critical minerals and materials resource recovery industry in the United States.

The Division is working to support the nation's transition to a carbon-free economy and support a domestic clean energy manufacturing industry through the:

1. Development of technology for characterization and assessment of domestic critical minerals and materials from secondary and unconventional sources, including coal, coal wastes, acid mine drainage, oil and gas produced waters, and hard rock mine tailings;
2. Development of advanced resource extraction, processing, and extractive metallurgical, and refining technologies; and
3. Evaluation of the technical and economic potential to co-produce critical minerals from coal and coal wastes.

FECM works to achieve these goals through engagement with industry, academia, technology developers, nongovernmental organizations, communities, and other stakeholders.

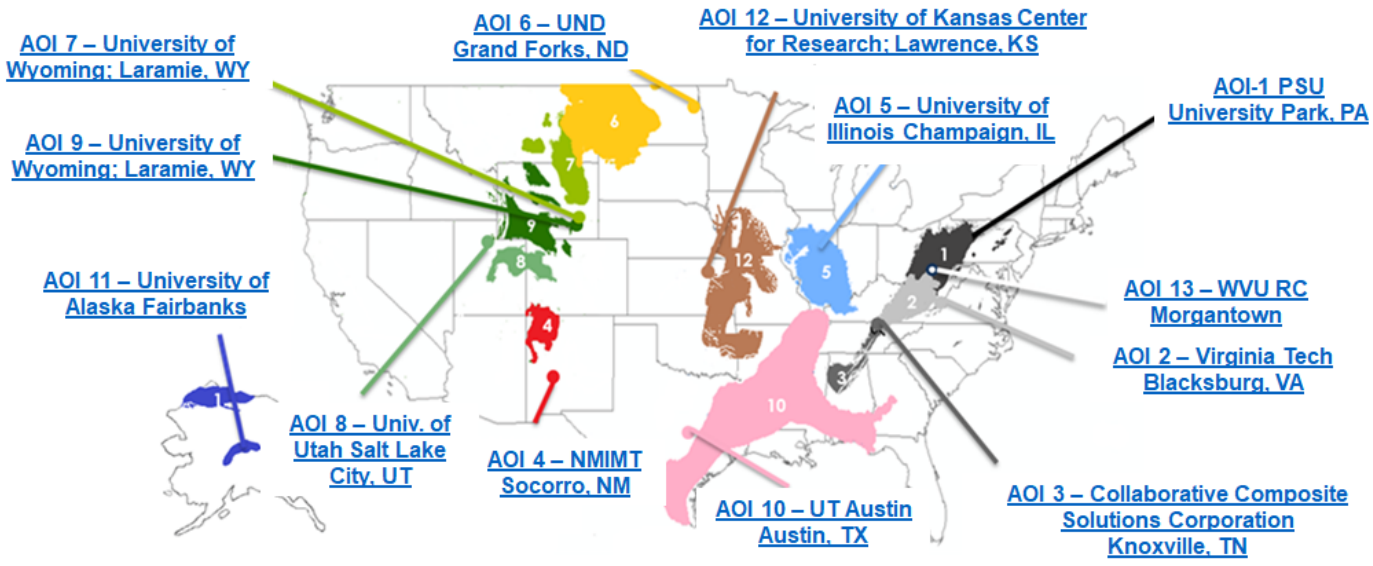
Unconventional and Secondary Sources

Initial estimates suggest that unconventional and secondary sources could provide significant amounts of the rare earth elements and other critical minerals and materials needed to reach the nation's clean energy goals. For example, wastes and byproducts from known fossil fuel reserves and other industries nation-wide currently contain more than 10 million tons of rare earth elements, which is equivalent to more than a 300-year supply at the current rate of U.S. consumption.

The Division is addressing the feasibility of recovering, extracting, separating, purifying, and refining significant quantities of these critical materials. To this end, FECM has established the Carbon Ore Rare Earth and Critical Minerals (CORE-CM) Initiative, which seeks to:

- Build broad-based regional coalition teams, including tribal nations and local communities;
- Investigate regional resources (e.g., materials, facilities, infrastructure, workforce), opportunities, and challenges;
- Catalyze regional economic growth and job creation, while addressing legacy wastes and environmental justice; and
- Enable production of rare earth elements, critical minerals, and high-value, nonfuel, carbon-based products across 13 regions of interest, all falling into active coal regions that are impacted by the energy transition.

Figure 1. CORE-CM: Developing National Prospectus by Assessing Regional Opportunities



AOI: Area of Interest

Mission success also requires demonstrating the ability to upscale the production of high-purity rare earth elements and critical minerals.

Figure 2. The First Small-Scale Projects initiated in 2019

Location: Grand Forks, ND
Feedstock: Lignite
CMM Produced: Mixed rare earth oxides, Germanium (Ge), Gallium (Ga)

Location: Lexington, KY (Physical Separation); Sharon, PA (Chemical Processing)
Feedstock: Post-combustion fly ash from two KY power plants
CMM Produced: Mixed rare earth salts

Location: Mt. Storm, WV
Feedstock: Acid Mine Drainage
CMM Produced: Mixed rare earth oxides, Nickel (Ni), Cobalt (Co), Manganese (Mn)

Location: Webster County, KY
Feedstock: Course Refuse and Lignite
CMM Produced: CMM Produced: Mixed rare earth oxides, Cobalt (Co), Nickel (Ni), Manganese (Mn)

Several small-scale projects (four described above) were designed to demonstrate the technical feasibility to produce rare earth elements and other critical minerals and materials from unconventional sources (lignite, coal ash, acid mine drainage, and coal refuse). The projects were initiated in 2016 and began to produce mixed rare earth oxides (MREO) and some critical minerals and materials by 2019. In the last two years, the projects went from producing grams to kilograms of MREO, while also increasing purity of the MREO to nearly 100 percent.

Results from these small-scale pilot projects informed recently awarded projects, including eight feasibility studies that have been completed and five front-end engineering and design studies that began within the last year.

The front-end engineering and design studies will lead to at least one Bipartisan Infrastructure Law-funded demonstration project that will produce between 1-3 metric tons/day of mixed rare earth oxides, rare earth salts, and other critical minerals. These projects will provide the information needed to inform future full-scale environmentally sustainable production of critical minerals and materials, while optimizing the circuits for co-production and cost reduction.

All of these projects lead toward creating opportunities for the United States to clean up legacy sites and reduce waste from new mining, bring manufacturing back to the country, and provide clean energy jobs. By remediating existing sites and plugging into existing operations, we have the potential to meet substantial demand (perhaps as much as 50 percent) and produce critical materials much faster than the time it takes to begin production from a new mine, which is often more than a decade. However, some new mining will be needed to meet the exponential demand growth that is occurring for these clean energy supply networks.

Advanced Carbon Material Production

The Division of Minerals Sustainability is examining new applications and new markets for carbon from coal. Current research is focused on developing and testing concepts at lab/bench-scale for innovative pathways to produce advanced products derived from coal and coal wastes, particularly clean energy products like graphite for anodes. Research has shown potential in using synthetic graphite from these feedstocks in production of a polymer-derived ceramic to produce commercially viable anodes that can rival the performance of graphite in lithium-ion batteries. Other research focuses on the production of graphene, nanotubes, carbon fibers, and other high-value carbon products.

Future Research Activities

For at least the next few decades, the United States will not be able to produce all its needs through secondary and unconventional sources or recycling. FECM is establishing an Advanced Critical Materials Extraction program that will help develop technologies to substantially decrease the environmental and community impacts of mining by using a more surgical approach. This program will work with experts in drilling, geophysics, chemistry, biology, robotics, artificial intelligence, and other fields to develop technologies that enable precision extraction of critical materials from deep underground without the need for digging giant pits, sending people underground, or significantly impacting the land, water, and air in local communities.

To learn more about the Division of Minerals Sustainability's ongoing efforts, visit FECM's Office of Resource Sustainability website. You can also sign up to receive news alerts to learn about future FECM funding opportunity announcements and project selections.