



NARUC

National Association of Regulatory Utility Commissioners

R&D Spotlight: The Wyoming Innovation Center and New Market Opportunities for Coal Resources

October 11, 2-3 PM ET

Moderator: Hon. Mary Throne, Wyoming

Panelists:

Cindy Edwards, Area Director, Economic Development Administration for the U.S. Dept. of Commerce

Dr. Holly Krutka, Executive Director of University of Wyoming's School of Energy Resources

Dr. Christina Lopano, Geochemist, Research and Innovation Center, National Energy Technology Laboratory

Opening Remarks

Hon. Mary Throne, WY



Panelists

- **Cindy Edwards**, Economic Development Administration
- **Dr. Holly Krutka**, University of Wyoming School of Energy Resources
- **Dr. Christina Lopano**, Research and Innovation Center, National Energy Technology Laboratory



UW School of Energy Resources

Prepared for
NARUC Webinar

October 11, 2022



UNIVERSITY
OF WYOMING

School of
Energy Resources

THE WORLD NEEDS MORE COWBOYS.

Topics

- Wyoming Innovation Center
- SER mission and pillars
- Centers of Excellence Model
- Carbon Engineering Program

Wyoming Innovation Center (WylC)

Focus on Advanced Carbon Technologies – Using coal as a source of carbon for manufacturing



Wyoming Innovation Center (WylC)

- Rare earth elements
- Critical minerals
- Activated carbon
- Carbon fiber
- Graphene
- Asphalt
- Agricultural char
- Much more



Wyoming Innovation Center (WylC)

- Partners in the WylC project
 - UW School of Energy Resources
 - Campbell County
 - City of Gillette
 - Governor's office
- Local Contractor
 - Powder River Construction
- Architect
 - Arete – Sheridan
- Subcontractors
 - APEX
 - Scott Brothers



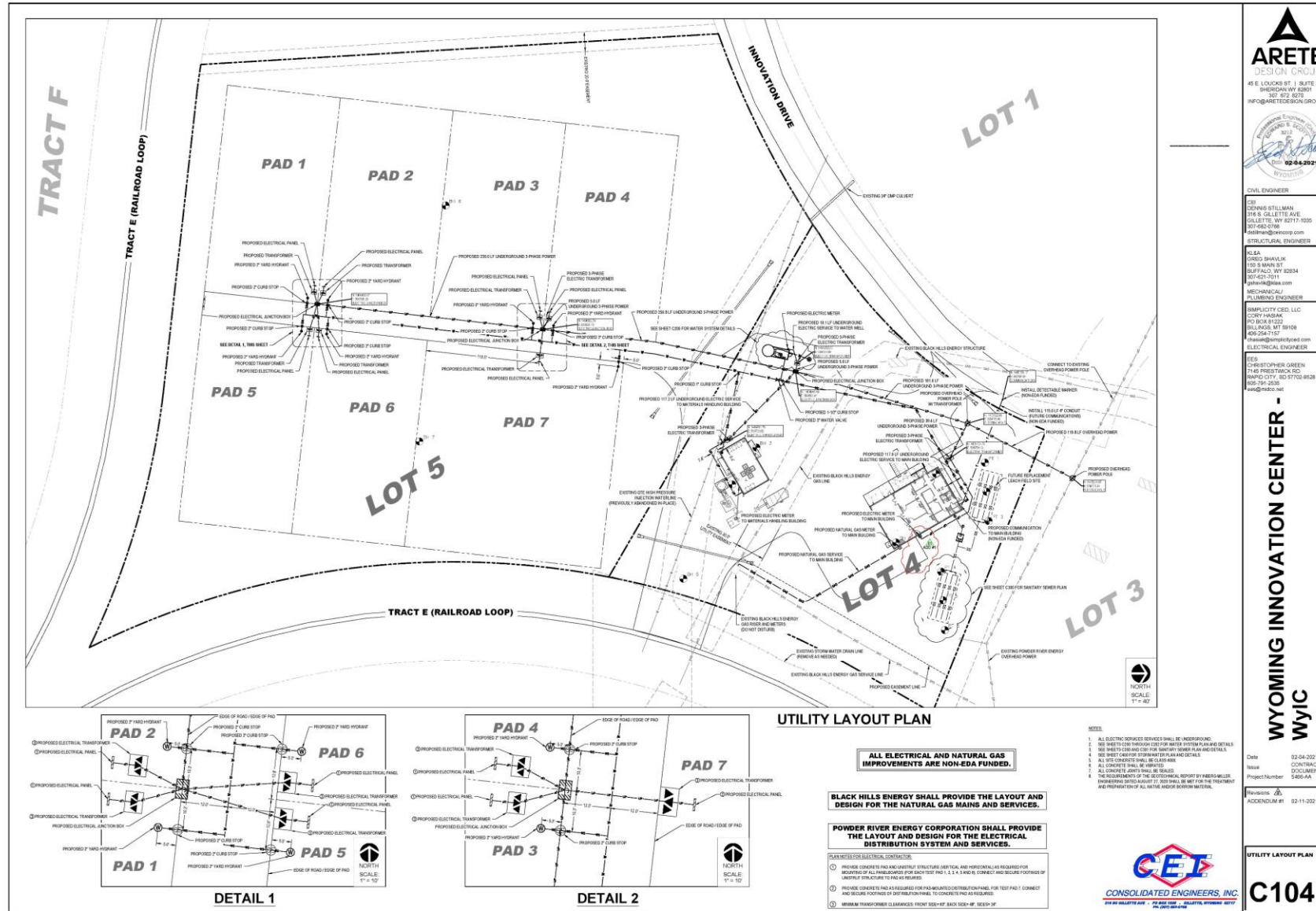
Wyoming Innovation Center (WylC)

Completed March 2022



Wyoming Innovation Center (WylC)



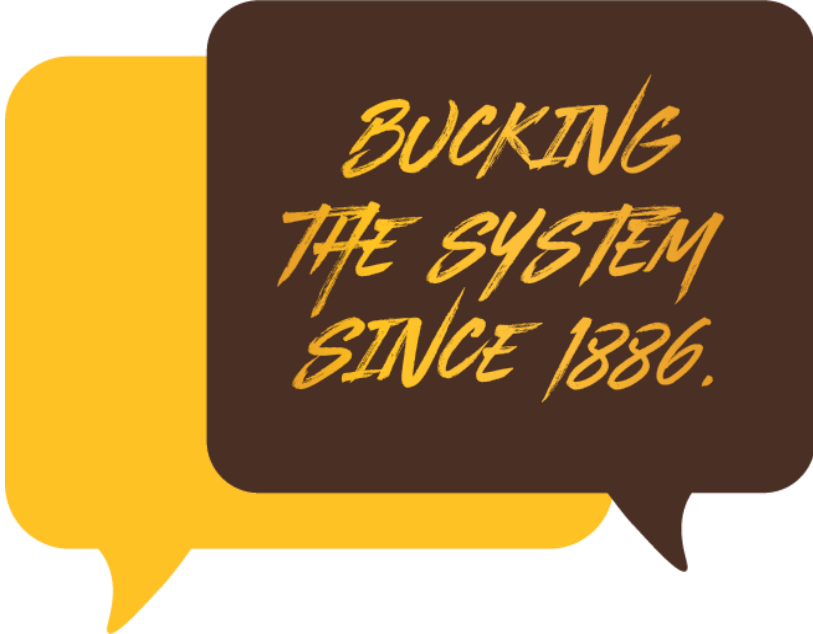


SER Mission and Pillars

*THE WORLD NEEDS MORE
ADVENTUROUS SPIRIT.*

SER's Mission:

Energy-driven economic
development for
Wyoming



*BUCKING
THE SYSTEM
SINCE 1886.*

SER Pillars

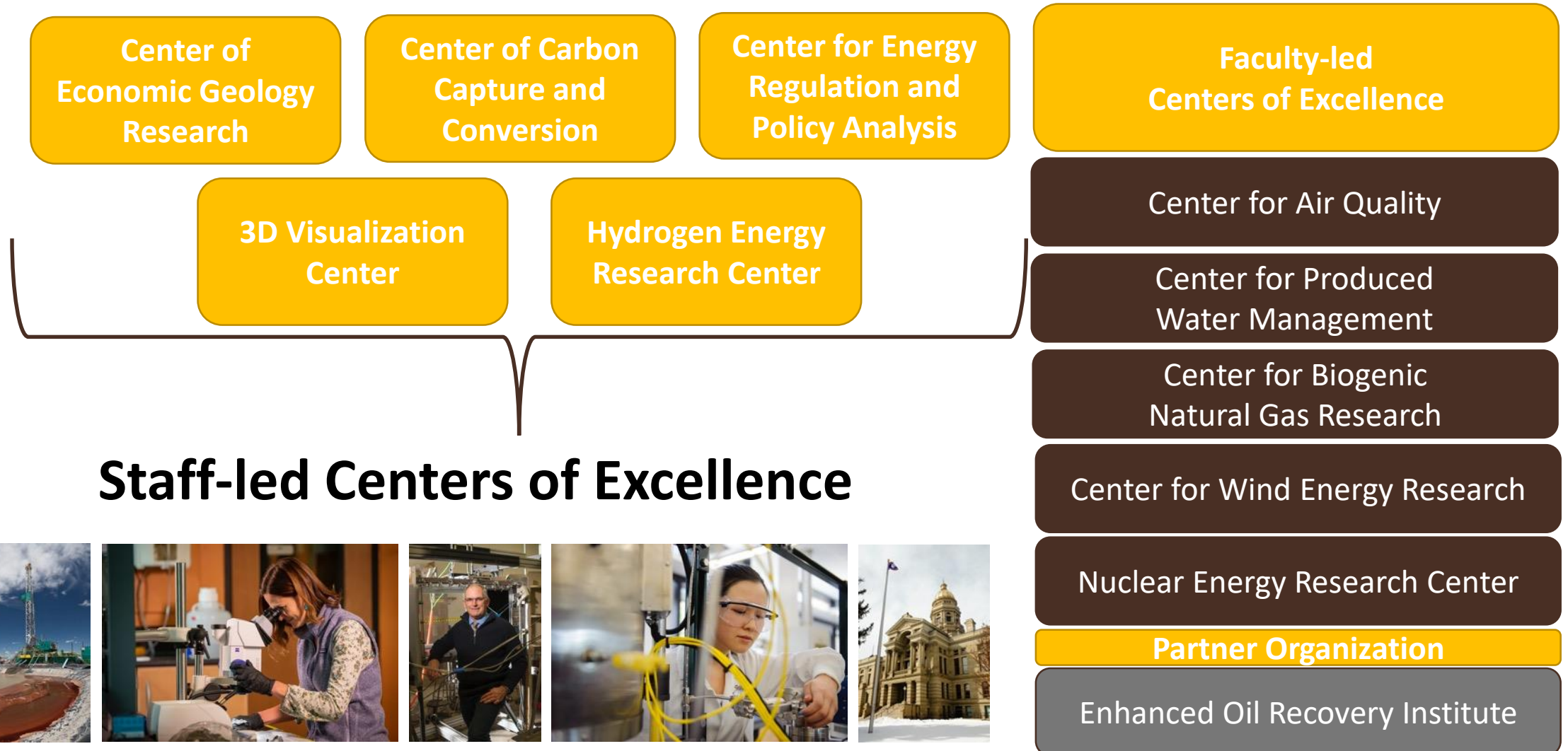
- **Academics**
 - Train students for careers in the Wyoming energy industries
- **Outreach**
 - Engage with stakeholders across state and beyond
 - Support elected and appointed officials
- **Research**
 - Develop technologies to advantage utilization of Wyoming natural resources
 - Focus on economic development
 - Conduct applied research focused on commercialization



SER Research Portfolio

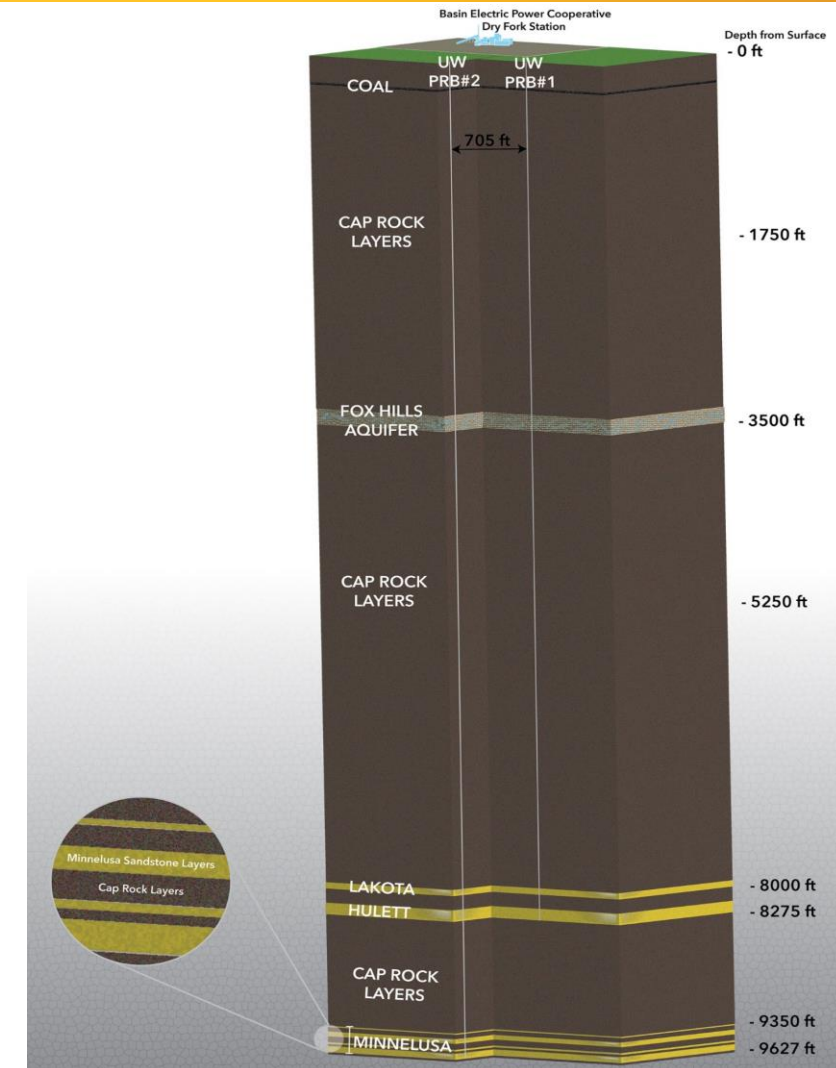
*THE WORLD NEEDS MORE
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SER Research Structure



CCUS Update

- Wyoming CarbonSAFE
 - Two test wells completed and sampled
 - Completed baseline monitoring assessments
 - 3D seismic survey
 - Storage hub property models and injection feasibility simulations
 - Regulatory assessments
 - Economic/business case assessments
 - Developing risk and MVA assessments
 - Completing permits to construct
- Building the commercial strategy
 - Supporting commercial developers on CCUS projects
 - Partnering with industry on IIJA funding requests
- Public engagement





Thermo-chemical (Coal Refinery) Process Technology

The process consists of the deliberate decomposition of coal to make high-volume, environmental and health friendly, non-combustion products.



Thermo-chemical
Processing
Solvent
Treatment,
Pyrolysis &
Separation

- Integrates 3 proven technology platforms to convert coal



- Products range from engineered commodities, high-value chemical compounds, and petrochemical feedstocks.
- Zero waste and low carbon footprint
- Commercial-scale conversion expected

Subject of Patent Application:
WO 2019/055529



Soil Fertility Products
Building Materials
Engineered Carbon & Char Products



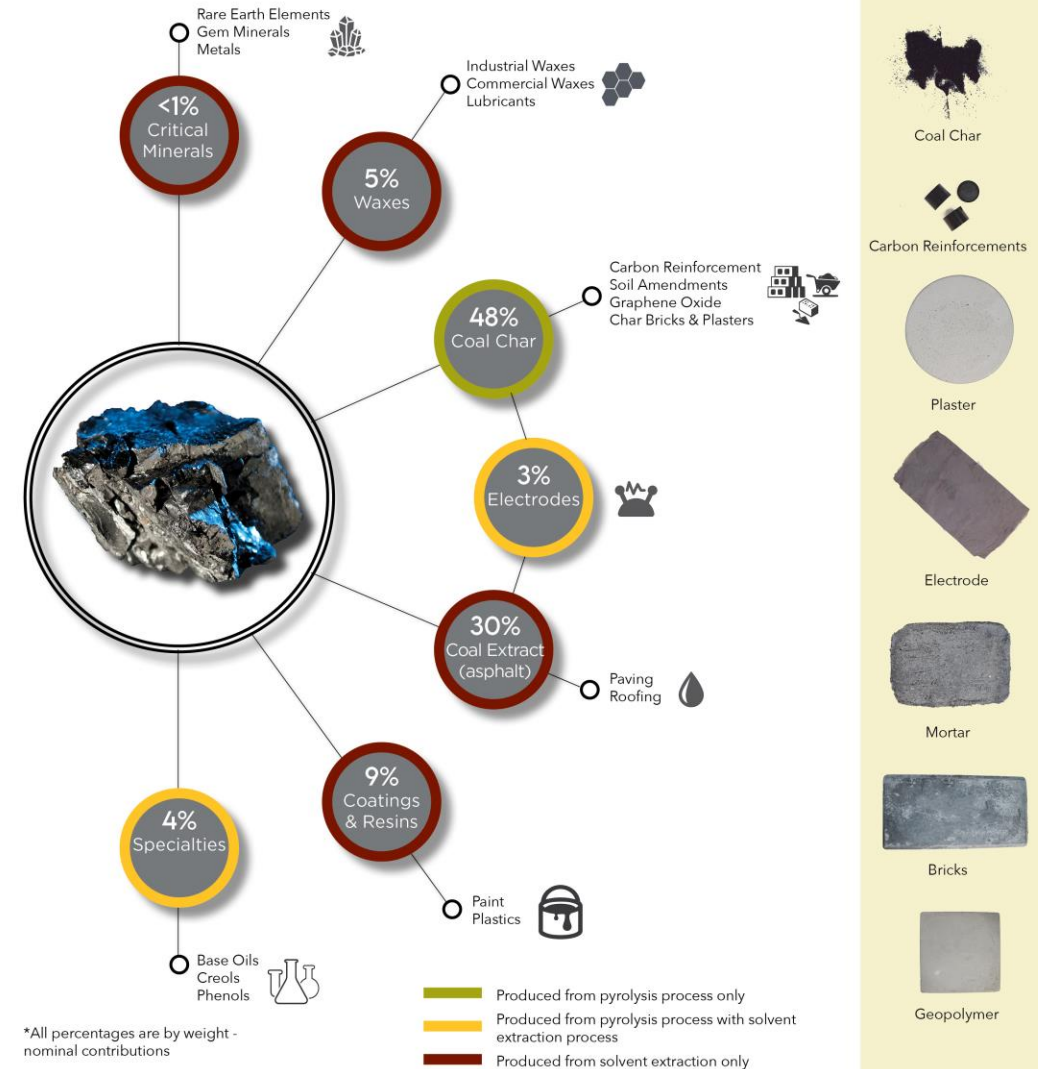
Phenol, Creosote, Base Oils
Graphine Oxide
Paving and Roofing Products
Resins & Coatings
Carbon Fiber Mats



Petrochemical Feedstocks for use in
other conversion processes

Coal to Products

*Using every
component in
Wyoming coal*



Coal-Related Research Update

- Coal refinery demonstration: Groundbreaking held and site work has begun
- Coal char brick: Demonstration house complete and data is being collected
- Soil amendments: Completed second round of greenhouse experiments using corn as a crop
- Asphalt: Continued development on coal derived asphalt binders and rejuvenators
- Increased research activity with regards to polymers and resins
- Coal transportation study nearly complete
- Increasing engagement with industry



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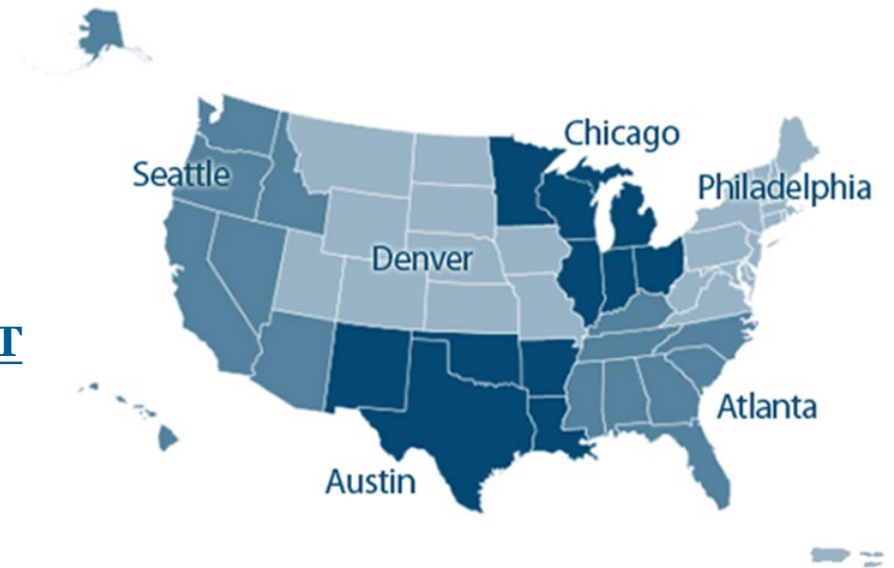


Cindy Edwards
Area Director / Denver Regional Office

EDA's Mission

To lead the federal economic development agenda by promoting innovation and competitiveness, preparing American regions for growth and success in the worldwide economy.

- Increase America's global ECONOMIC COMPETITIVENESS
- Support COMMUNITY-LED ECONOMIC DEVELOPMENT
- Help communities develop RESILIENT AND AGILE local economies
 - SIX REGIONAL OFFICES
 - DENVER— 10 STATE REGION



EDA's Investment Priorities



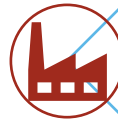
Equity



Recovery & Resilience



Workforce Development



Manufacturing



**Technology-Based Economic
Development**



**Environmentally-Sustainable
Development**



Exports & Foreign Direct Investment



Eligible Entities for EDA funding

- District Organization of an EDA-designated Economic Development District (EDD);
- Indian Tribe or a consortium of Indian Tribes;
- State, county, city, or other political subdivision of a State, including a special purpose unit of a State or local government engaged in economic or infrastructure development activities, or a consortium of political subdivisions;
- Institution of higher education
- Public or private non-profit organization or association acting in cooperation with officials of a political subdivision of a State

EDA does not provide funding to for-profit entities or individuals



EDA in Wyoming:

Since 2010, EDA has invested in **46 projects across Wyoming** totaling nearly **\$34 million**. These projects include:

Economic Development Assistance Program (EDAP) funding:

- Technical Assistance
- Partnership and Short-Term Planning
- Public Works
- Economic Adjustment Assistance
- Assistance to Coal Communities

Supplemental Appropriations:

- Disaster Relief
- COVID-19 Recovery Investment (CARES)
- ARPA Statewide Planning
- ARPA Statewide Travel and Tourism
- ARPA – Economic Adjustment, Tourism, Indigenous Communities



Wyoming Innovation Center



- 2019: EDA awarded \$1.46 million to Campbell County Economic Development Corporation to match \$1.46 million in state and local investment.
- Funding for new facility to serve as Advanced Carbon Products Innovation Center to advance coal-related technologies to move from lab to market.
- Project is estimated to create 40 jobs and catalyze \$15 million in private investment.

EDA Related investments supporting Ecosystem



- \$2.8 million for Northern Wyoming Community College District for capacity expansion, including equipment for training high-skill, high-demand careers using the latest technology.
- \$2.8 million for Campbell County for infrastructure and construction of Pronghorn Industrial Park to facilitate heavy industrial growth and diversify their extraction economy.
- \$579,000 for Gillette College Foundation to establish Office of Transformation to coordinate strategic planning and implementation of innovative economic development strategies to promote regional diversification and resiliency.
- \$500,000 for STEM equipment to supply workforce training equipment and initiatives at Gillette College.

EDAP - EDA Assistance to Coal Communities:



EDA awards funds on a competitive basis to coal communities through its Assistance to Coal Communities (ACC) initiative to assist impacted communities that support:

- Economic Diversification
- Job Creation
- Capital Investment
- Workforce Development
- Re-employment Opportunities

Competitive - rolling application process

Construction and non-construction projects

Generally \$500,000 - \$3 Million EDA investment

Requires matching funds – 20-50%



ARPA - Coal Communities Commitment

Ten percent of EDA's \$3B ARPA funding is invested in communities and regions that demonstrated how changes in the coal economy have resulted or are anticipated to result in job losses and layoffs in any coal-reliant commercial sector.

EDA's \$300 million ARPA *Coal Communities Commitment* - ensures support for coal communities as they recover from the pandemic and create new jobs and opportunities.

To demonstrate eligibility, applicants provided appropriate third party economic and demographic statistics that documented the extent to which contractions in the coal economy have negatively impacted the community or region.



Interagency Working Group on Coal (IWG)

- EDA participates in on-going IWG to discuss and coordinate activities in the State
- Promotes job-creating investments in communities impacted by coal mine and power plant closures and proactively investing in communities likely to be impacted declines in coal production and generation from coal-fired power plants.
- Provides a forum for communities and agencies to coordinate efforts and investments by federal agencies to support coal community transformation and diversification
- Partners include representatives from DOE, EPA, SBA, USDA, DOI, Wyoming state and local agencies and regional economic development representatives.



Resources

Visit our website for resources: www.eda.gov



Wyoming Contact:

Economic Development Representative

Aaron Pratt

406-599-9795

apratt@eda.gov



REE Recovery from Powder River Basin Coal Byproducts

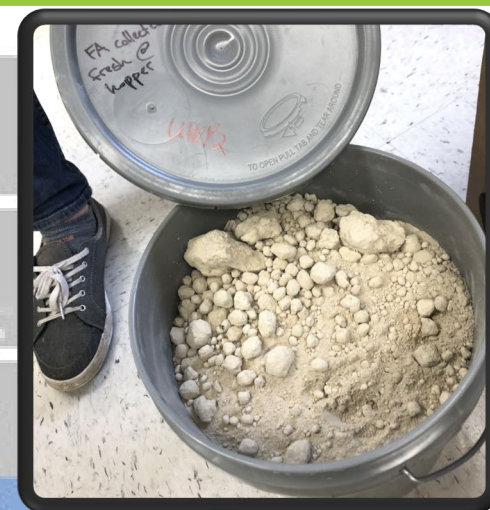
NARUC Webinar – R&D Spotlight: the Wyoming Innovation Center
& New Opportunities for Coal Resources

Dr. Christina Lopano October 12, 2022

Resources from Wastes

— Heavy Rare Earth Elements
— Critical Rare Earth Elements

21 Sc 44.955908 Scandium	22 Ti 47.88 Titanium	23 V 50.9415 Vanadium	24 Cr 51.9961 Chromium	25 Mn 54.9380 Manganese	26 Fe 55.845 Iron	27 Co 58.9332 Cobalt	28 Ni 58.6934 Nickel	29 Cu 63.546 Copper	30 Zn 65.38 Zinc	31 Ga 69.723 Gallium	32 Ge 72.63 Germanium	33 As 74.9216 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.80 Krypton
39 Y 88.90584 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.90638 Niobium	42 Mo 95.94 Molybdenum	43 Tc 98 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.8682 Silver	48 Cd 112.411 Cadmium	49 In 114.818 Indium	50 Sn 118.710 Tin	51 Sb 121.757 Antimony	52 Te 127.6 Tellurium	53 I 126.905 Iodine	54 Xe 131.29 Xenon
57 La 138.90547 Lanthanum	58 Ce 140.116 Cerium	59 Pr 140.90766 Praseodymium	60 Nd 144.242 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92535 Terbium	66 Dy 162.500 Dysprosium	67 Ho 164.93033 Holmium	68 Er 167.259 Erbium	69 Tm 168.93422 Thulium	70 Yb 173.054 Ytterbium	71 Lu 174.9668 Lutetium	72 Hf 178.49 Hafnium
104 Rf 101.07 Rutherfordium	105 Db 102.91 Dubnium	106 Sg 106.9051 Seaborgium	107 Bh 107.8682 Bohrium	108 Hs 108.90625 Hassium	109 Mt 108.90625 Meitnerium	110 Ds 112.411 Darmstadtium	111 Rg 112.411 Roentgenium	112 Cn 112.411 Copernicium	113 Nh 114.818 Nihonium	114 Fl 114.818 Flerovium	115 Mc 115.90476 Moscovium	116 Lv 116.92912 Livermorium	117 Uus 117.904 Ununseptium	118 Uuo 118.903 Ununoctium	119 Uuh 118.903 Ununhennium



Critical Minerals & Rare Earth Elements (REE)

Challenge: Foreign Dependence on Critical Minerals

- Import-dependent on >80% of U.S. rare earth element (REE) demand
- Import-dependent (>50% from foreign source) on >40 of 50* critical minerals
- Import-reliant (100% from foreign source) for at least 12 critical minerals

Legend:

- Light Rare Earth Elements
- Heavy Rare Earth Elements
- Critical Rare Earth Elements
- Critical Minerals

* Gd: IUPAC Light REE; USGS Heavy REE
 ** Included with rare earth elements Fluorspar: Ca & F
 *** Uranium: Fuel Material (USGS 202 Review)

Vital for the development
of green-energy
technologies



Valorization of FE Waste Streams

Carbon ore, coal byproducts, O&G drill cuttings, produced waters

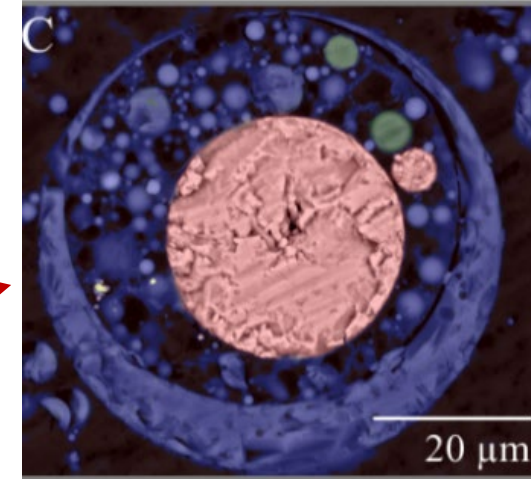
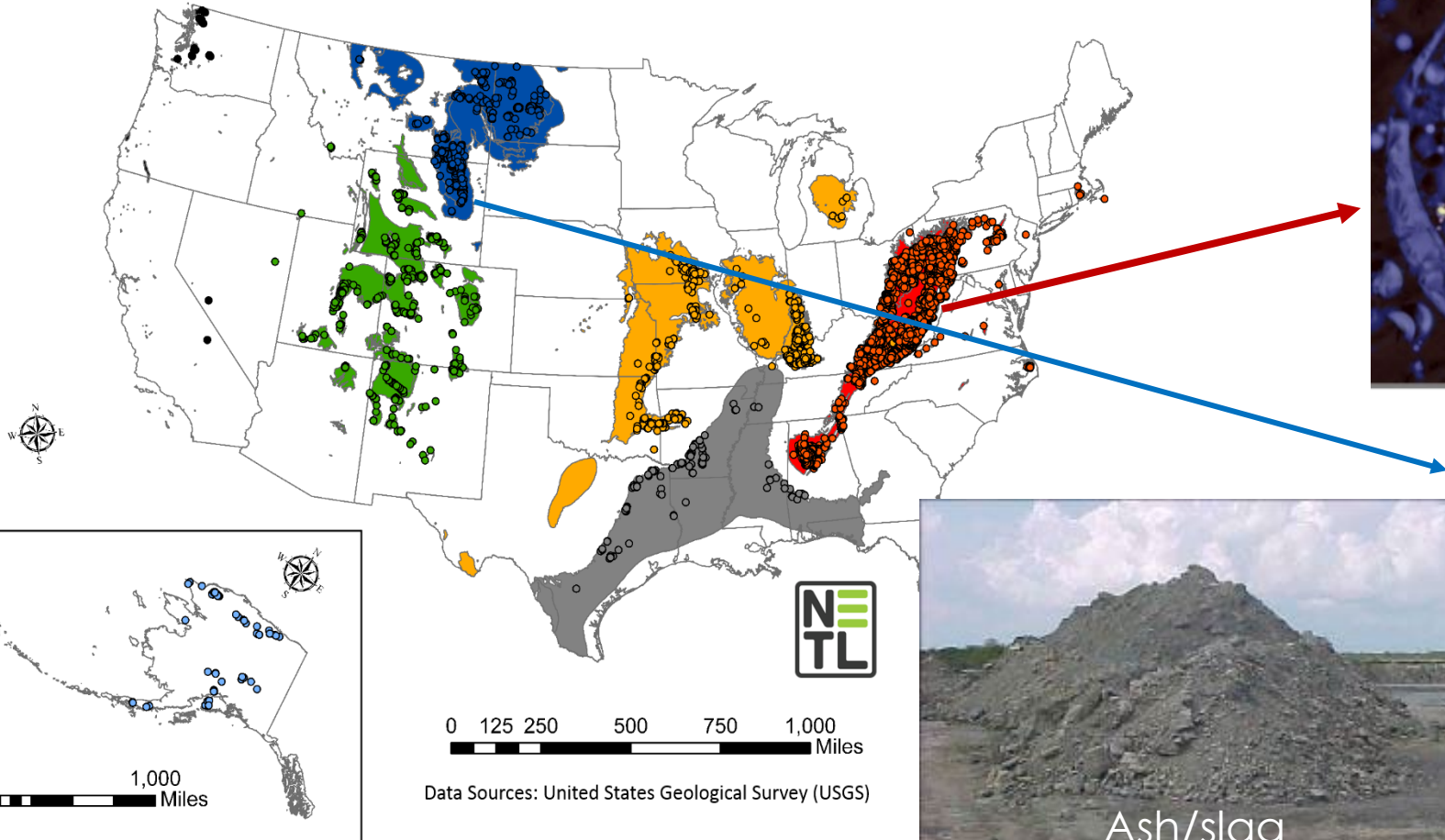


— COULD BE PROCESSED TO... —



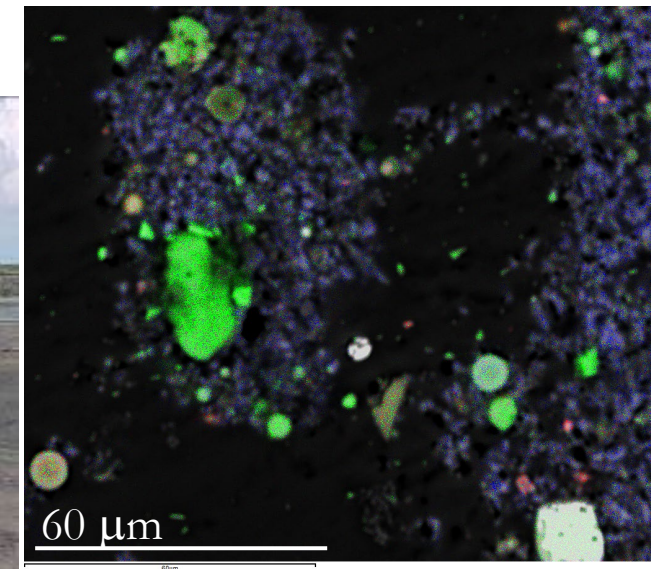
Coal Combustion Ash Wastes

~ up to 60% Ash is Disposed as Waste (millions of tons/yr)

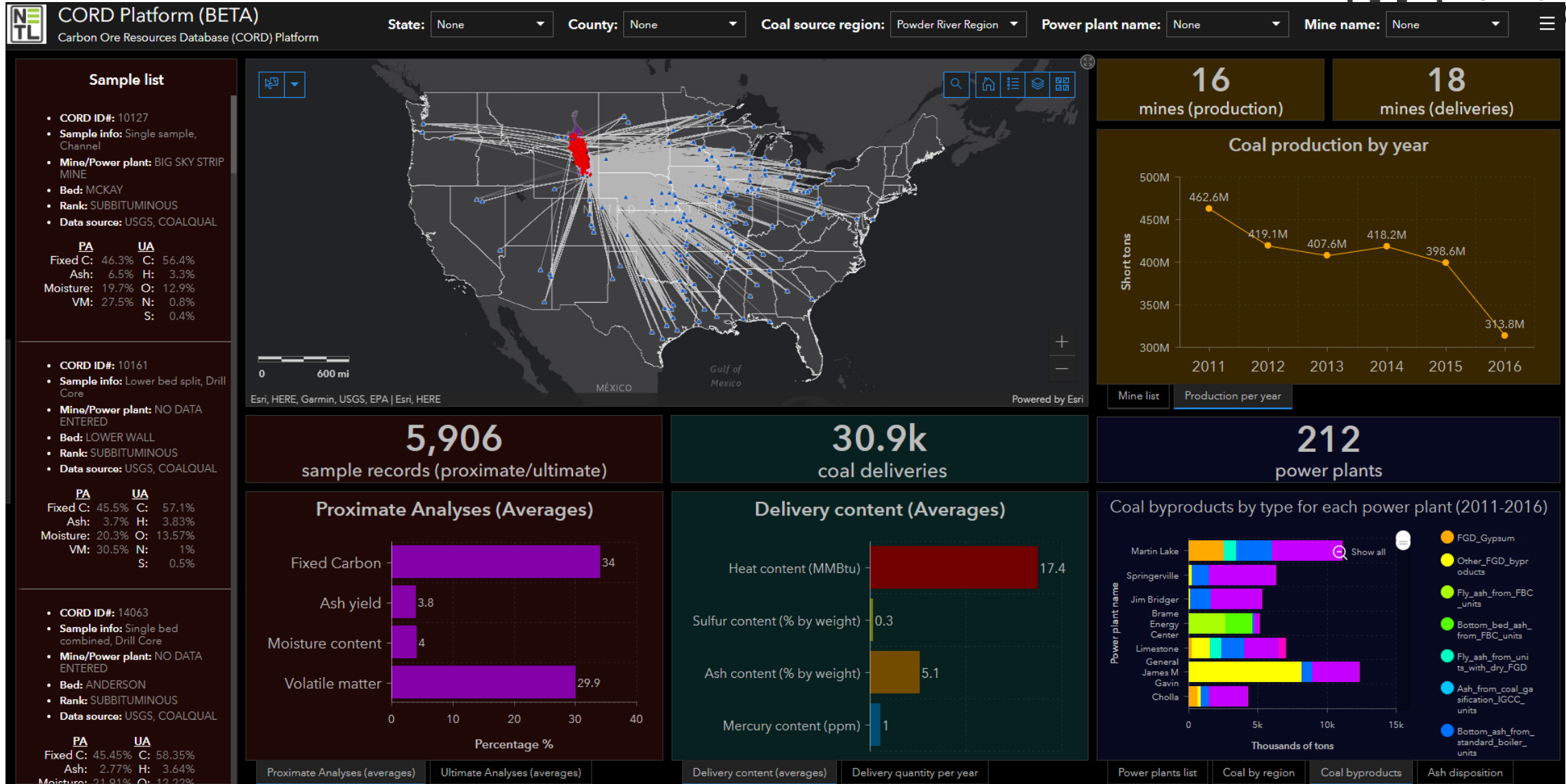


SEM BSE image of fly ash particles

amorphous Si-Al - purple
Fe-oxide - red
Ca-oxide - green
REE mineral - yellow



NETL Data Analytics: Understanding the Resources



Fundamentally Understanding the Resource

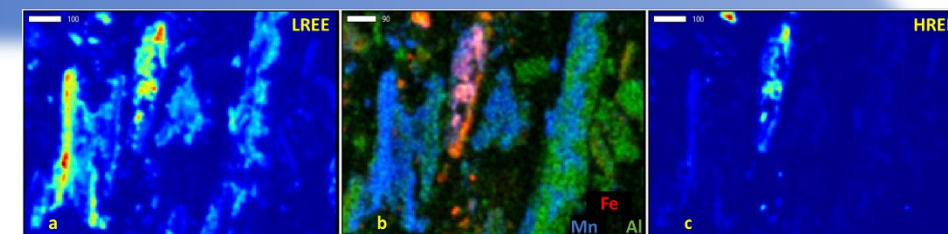
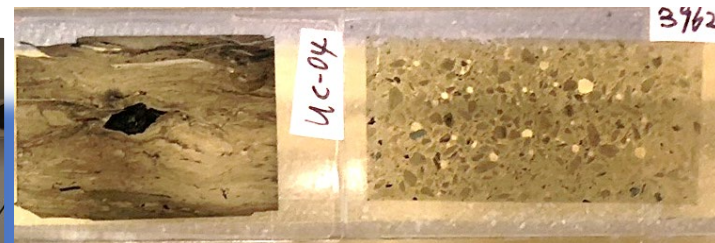
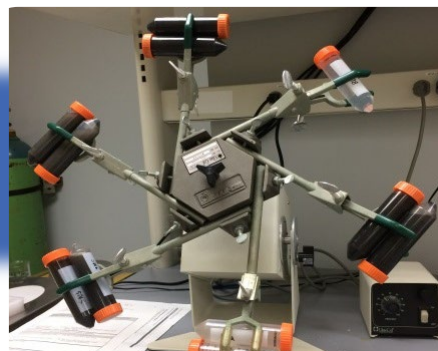
Ash & AMD Characterization to Recovery



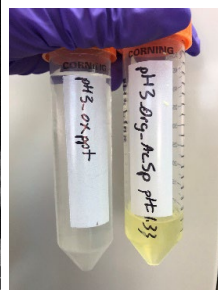
AMD solids



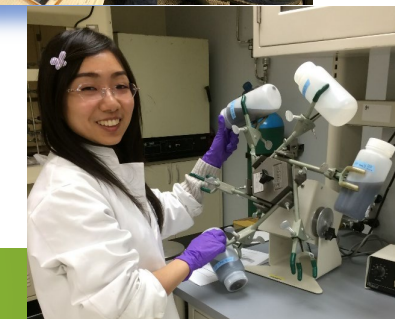
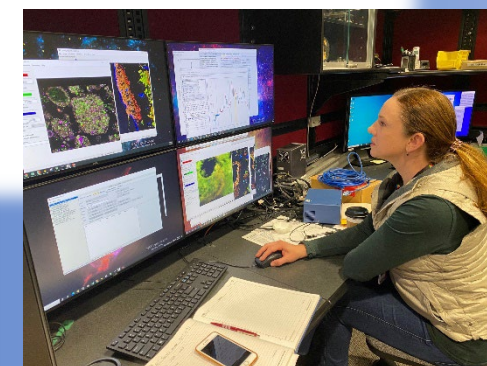
Fly ash



Utilize **characterization** of major REE-hosting solid fractions in different CCBs to **innovate targeted extractions** for efficient and economical REE recovery.



Stuckman, M.Y., Lopano, C.L. and Tarka, T. (2021)
U.S. Patent Pending, Serial No.: 63/053,925
<https://netl.doe.gov/node/10318>

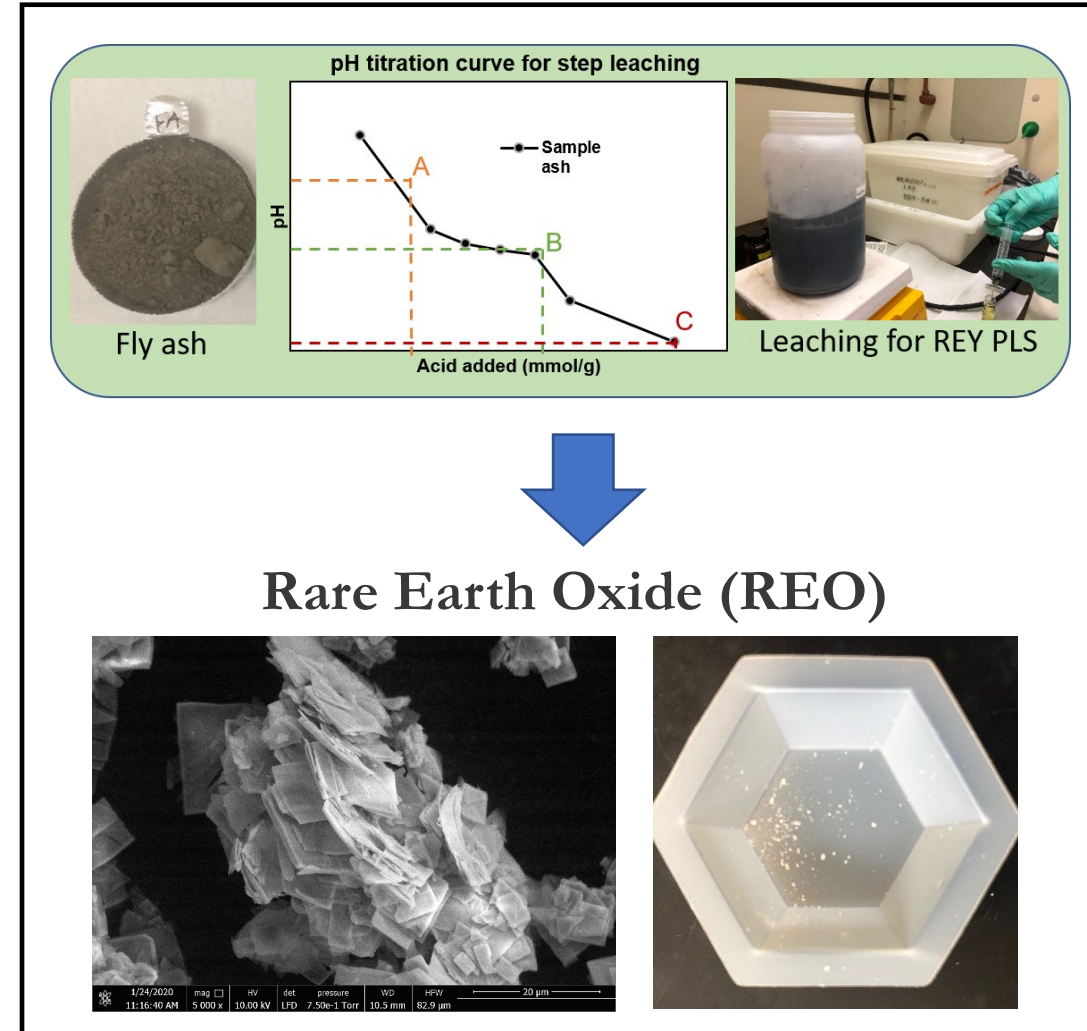


Recovery from Calcium-Rich Ash

Targeting Powder River Basin (PRB) Ashes to Reduce Extraction Steps & Conditions

Targeted Rare Earth Extraction (TREE)*

- ✓ Waste product that doesn't need to be mined
- ✓ No grinding and no pre-treatment required
- ✓ Step-leaching at ambient conditions
- ✓ No heating or elevated pressure required
- ✓ Mild acids (**90%** acid reduction compared to industrial use) and effective REE recovery (**80-100%** recovery rate)
- ✓ Reduced solvent consumption for subsequent REE purification and separation
- ✓ Wastes with mild pHs and minimal radioactive materials (Th and U)



Bridging the “Valley of Death”

US DOE Technology Commercialization Fund (TCF)

- Designed to increase the number of energy technologies developed at **DOE’s national labs** that graduate to commercial development and achieve commercial success.
- The fund also enhances DOE’s technology transitions system with an enterprising and competitive approach to **lab-industry partnerships**.
- Through the TCF, the applied program offices and national laboratories can pursue a strategic, forward-looking, competitive approach to commercializing technologies from lab-industry collaborations.
- 50% Cost share between DOE and partners

From Bench to Pilot: \$1.6 million TCF Project

NETL works with Wyoming partners committed to technology maturation:

- University of Wyoming School of Energy Resources
- Campbell County
- City of Gillette

State, Campbell County pursue rare earth opportunities

By Greg Johnson, Gillette News Record | Via Wyoming News Exchange Jul 5, 2020 [Comments](#) [OPEN ACCESS](#)

Rare Earth Elements Project Receives Federal Funding

NEWS DIRECTOR | Article Updated: June 23, 2020 | [COMMENTS OFF](#)

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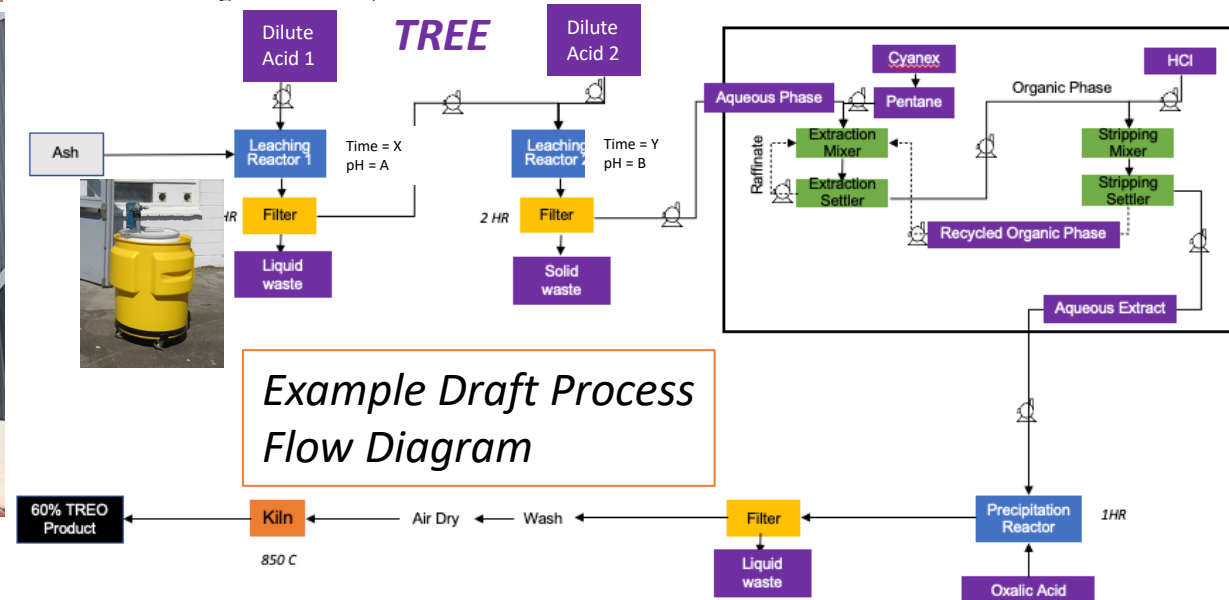
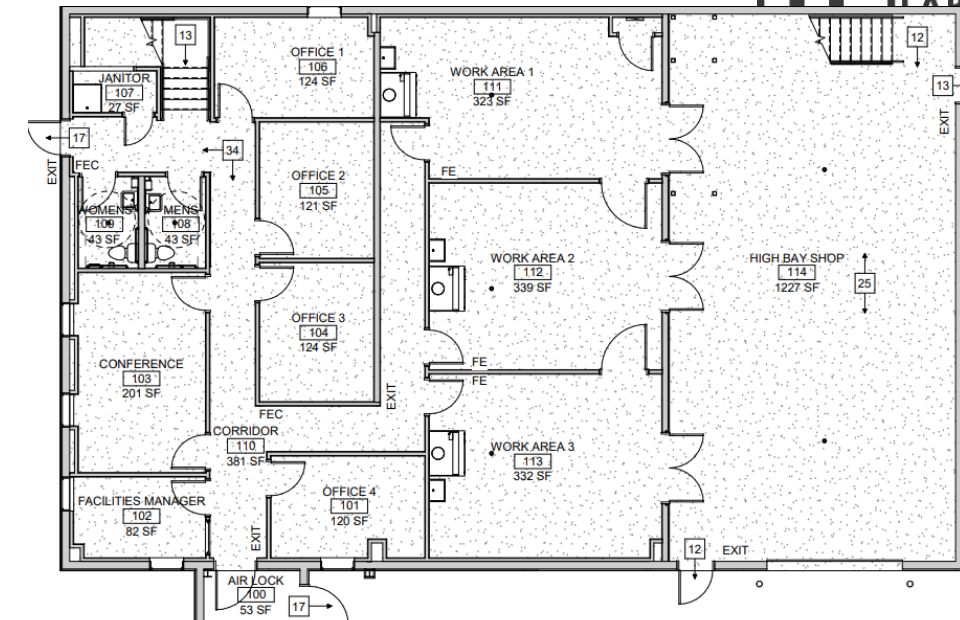


Wyoming Innovation Center



Ribbon cutting – June 14, 2022

[SER Participates in Wyoming Innovation Center Ribbon Cutting Ceremony and Meets with Key Stakeholders in Gillette \(uwyo.edu\)](#)



REE Recovery from PRB Coal Wastes: Pilot at WIC

TCF-20-21358

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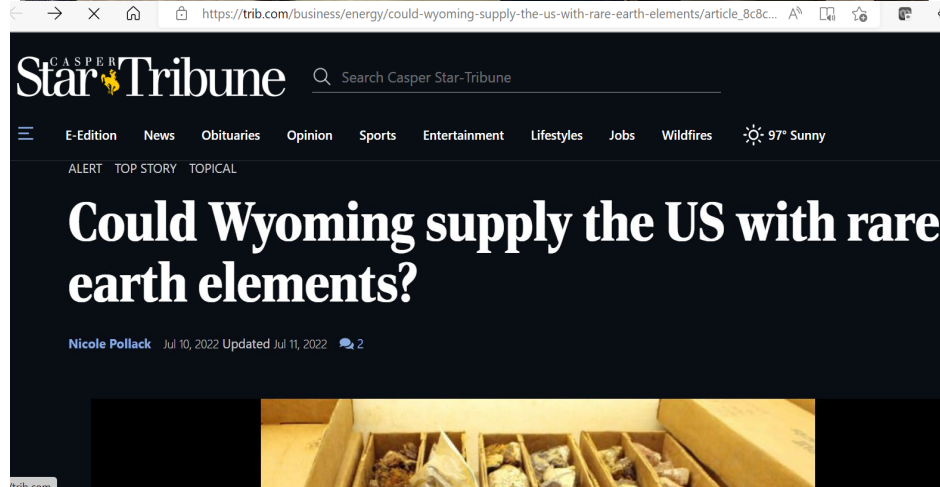
@NationalEnergyTechnologyLaboratory

CONTACT:

Christina Lopano & Tom Tarka

Christina.Lopano@netl.doe.gov

Thomas.Tarka@netl.doe.gov



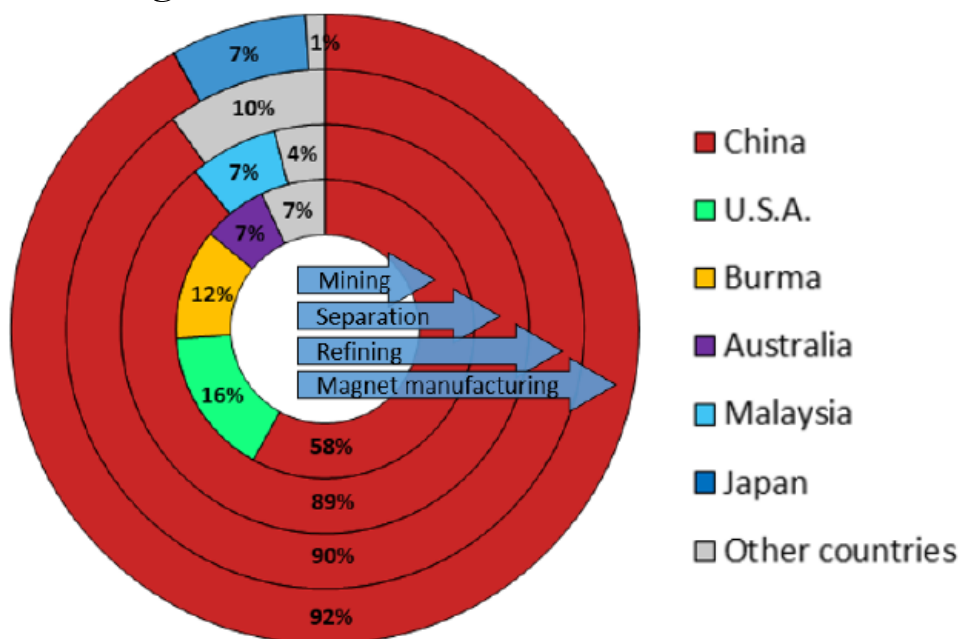


U.S. DEPARTMENT OF
ENERGY

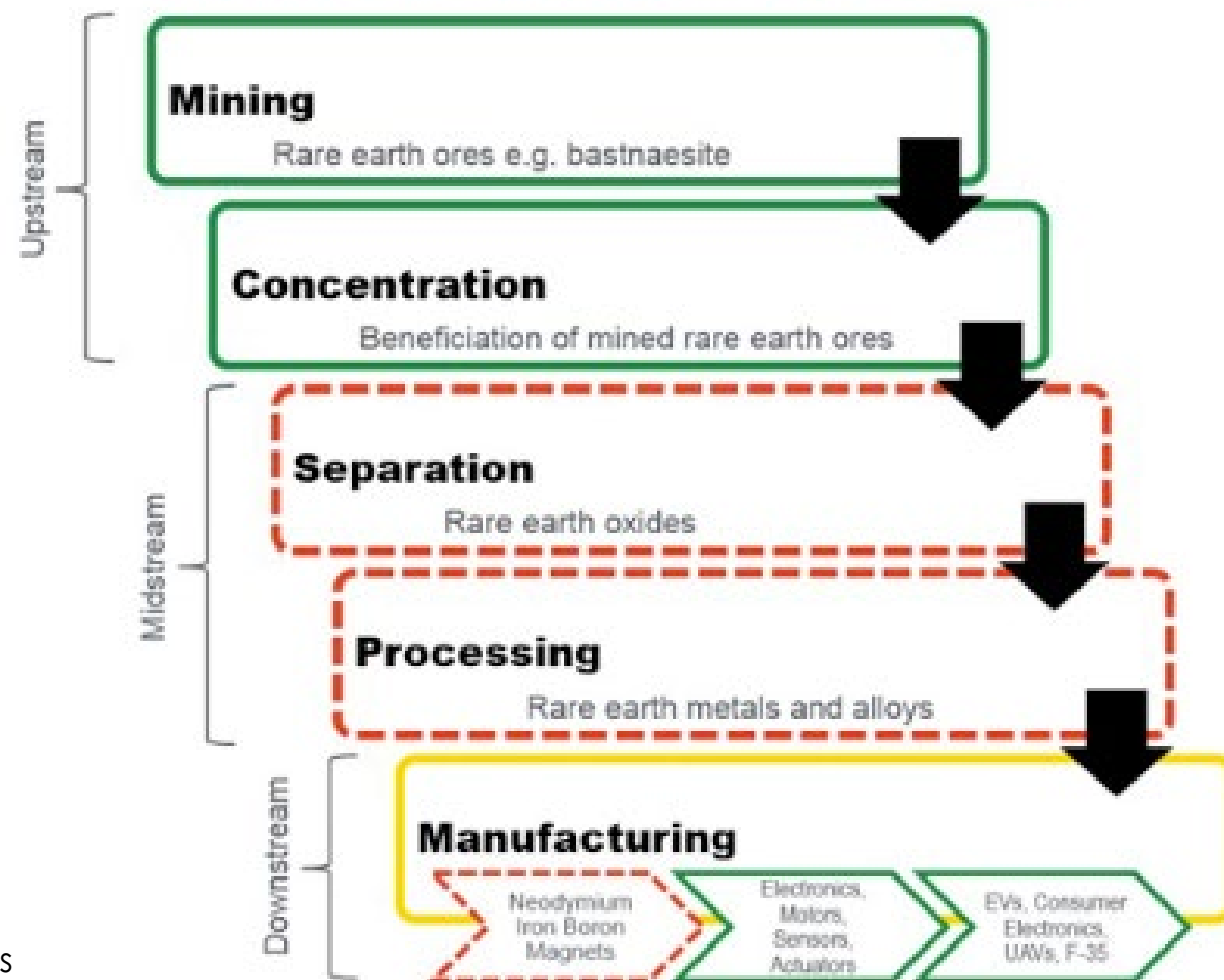
Understanding the REE Supply Chain

Challenge: Gaps in Domestic Supply Chain

- Up- and Mid-Stream capabilities concentrated in 1-3 countries
- Lack of midstream capabilities area a gap that limits growth of upstream supply & downstream manufacturing



Gaps in the domestic supply chain are shown in red.



Geographic concentration of supply chain stages for sintered NdFeB magnets

Commercialization Pathways: Pilot Projects

Producing High Purity MREO & CM (Co, Mn, Ni, etc.) from Coal-Based Sources



- Separating MREO concentrate from **lignite**
- August 2022 Pilot Facility Construction Complete
- October 2022 Pilot Facility start-up of Testing

2018	2019	2020	2021
5 – 10 g 5 – 15% purity	500 g 30 – 85% purity	Under Construction	



- Small-Scale Pilot plant cumulatively produced > 1 kg mixed rare earths on an oxide basis from **post combustion coal ash** by 2021. Ended March 2022.

2018	2019	2020	2021
0.004 kg ≥ 10% purity	.057 kg ≥ 14% purity	0.41 kg ≥ 67% purity	0.67 kg ≥ 91% purity



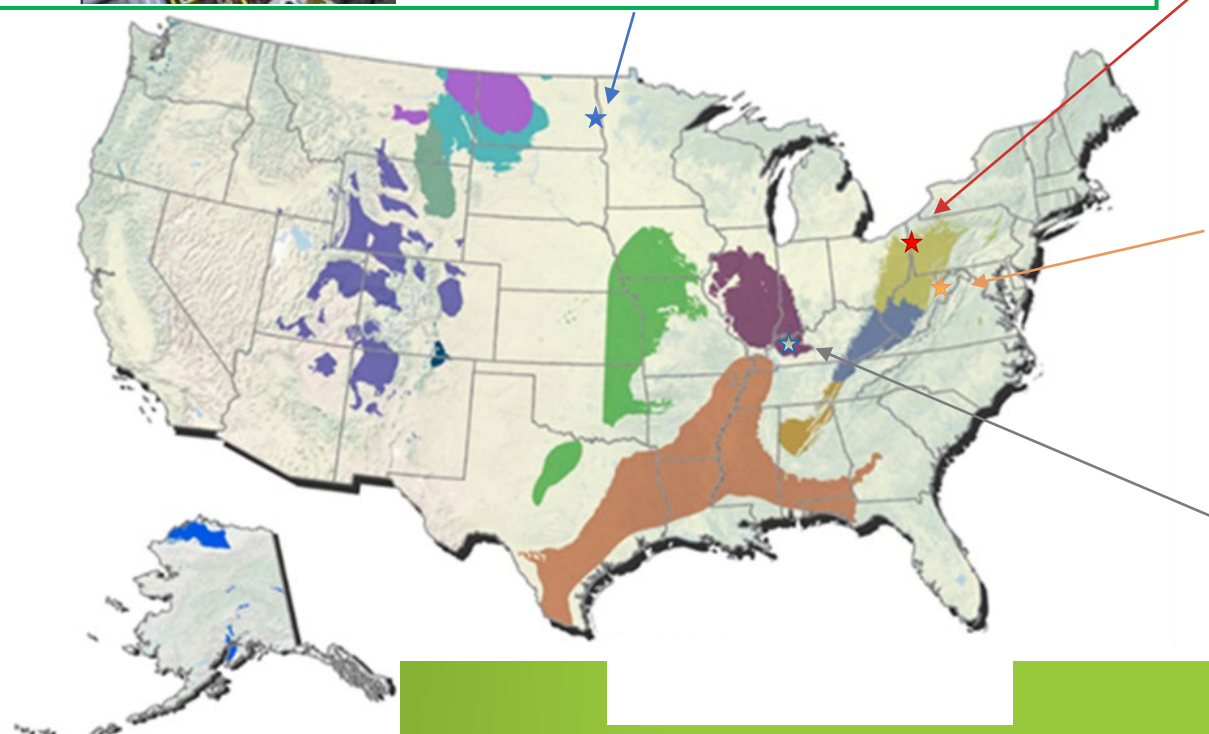
- Produced REE pre-concentrates from **AMD and sludge materials** with ~100% REE recovery, 45% is HREEs

2018	2019	2020	2021
44 g 95 – 99% purity		Field Pilot-Scale Under Construction to start up June 2022	



- Pilot plant operation started in Q4 FY21. Produced quantities MREOs in its *modular* pilot-scale facility from **coal refuse materials**

2018	2019	2020	2021	2022 (Q1)
0.6 kg 80% purity	1.5 kg > 90% purity	0.41 kg 98% purity	0.4 kg >50% purity & 4 kg 0.5%	0.72 kg >95% REE & 0.3 kg (8% Co, 30% Ni) & 0.27 kg (22% Mn)



Panelists

- **Cindy Edwards**, Economic Development Administration
- **Dr. Holly Krutka**, University of Wyoming School of Energy Resources
- **Dr. Christina Lopano**, Research and Innovation Center, National Energy Technology Laboratory



Upcoming

- NETL visit to Morgantown, WV & Pittsburgh, PA this december
- NARUC Annual Meeting & Education Conference in New Orleans, November 13-16, 2022
- Check www.naruc.org/cpi for information on upcoming activities



Thank you!

Visit www.naruc.org/cpi for additional resources

Contact Kiera Zitelman (kzitelman@naruc.org) and Kathryn Kline (kkline@naruc.org) with questions

