

Driving Coal Innovation in Wyoming

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UNIVERSITY
OF WYOMING

School of
Energy Resources

THE WORLD NEEDS MORE COWBOYS.

Topics

- **Wyoming background**
- **Research areas**
 - Competitive carbon management
 - Critical minerals and rare earths
 - Regulatory and policy analysis



SER's Mission:

Energy-driven economic
development for
Wyoming



*BUCKING
THE SYSTEM
SINCE 1886.*

Wyoming Background

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Wyoming Background



- Mineral industry maintains a strong social license to operate
- Largest coal producer in the country
- Largest coal mines in the world by volume and the related infrastructure
- Extremely low mining costs
- PRB coal offers lower upstream methane emissions
- Class VI well primacy
- Supportive state and local governments
- Proactive communities that are demonstration-ready
 - Wyoming Integrated Test Center
 - Wyoming Innovation Center facility
 - Upton shovel-ready industrial park

Competitive Carbon Management

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Wyoming CarbonSAFE Project

*Wyoming CarbonSAFE is focused on investigating the **feasibility** of practical, secure, **permanent, geologic storage** of carbon dioxide (**CO₂**) emissions from coal-based electricity generation facilities near Dry Fork Station Gillette, Wyoming....*

- Led by SER's Center for Economic Geology Research, CEGR
- Over \$33.1M project (spent and committed)
 - \$26.2M federal and \$6.9M cost share
 - Phase 1 = \$1.8M
 - Phase 2 = \$12.2M
 - **Phase 3 = \$19.5M (in award negotiations)**
- Phase III will begin on October 1, 2020

Research activities for Phase III:

- Commercial-scale subsurface injection testing and monitoring
- Finalize geologic characterization
- Prepare and file Class VI permits
- Integrate this project with a separately funded CO₂ capture study
- Conduct the required NEPA analyses for commercialization of the site



Project Participants

Academic partners:

- University of Wyoming
- Advanced Resources International
- Energy and Environmental Research Center
- Los Alamos National Laboratory

Carbon Capture:

- Membrane Technology and Research, Inc. (MTR)
- Wyoming Integrated Test Center

Industrial Partners:

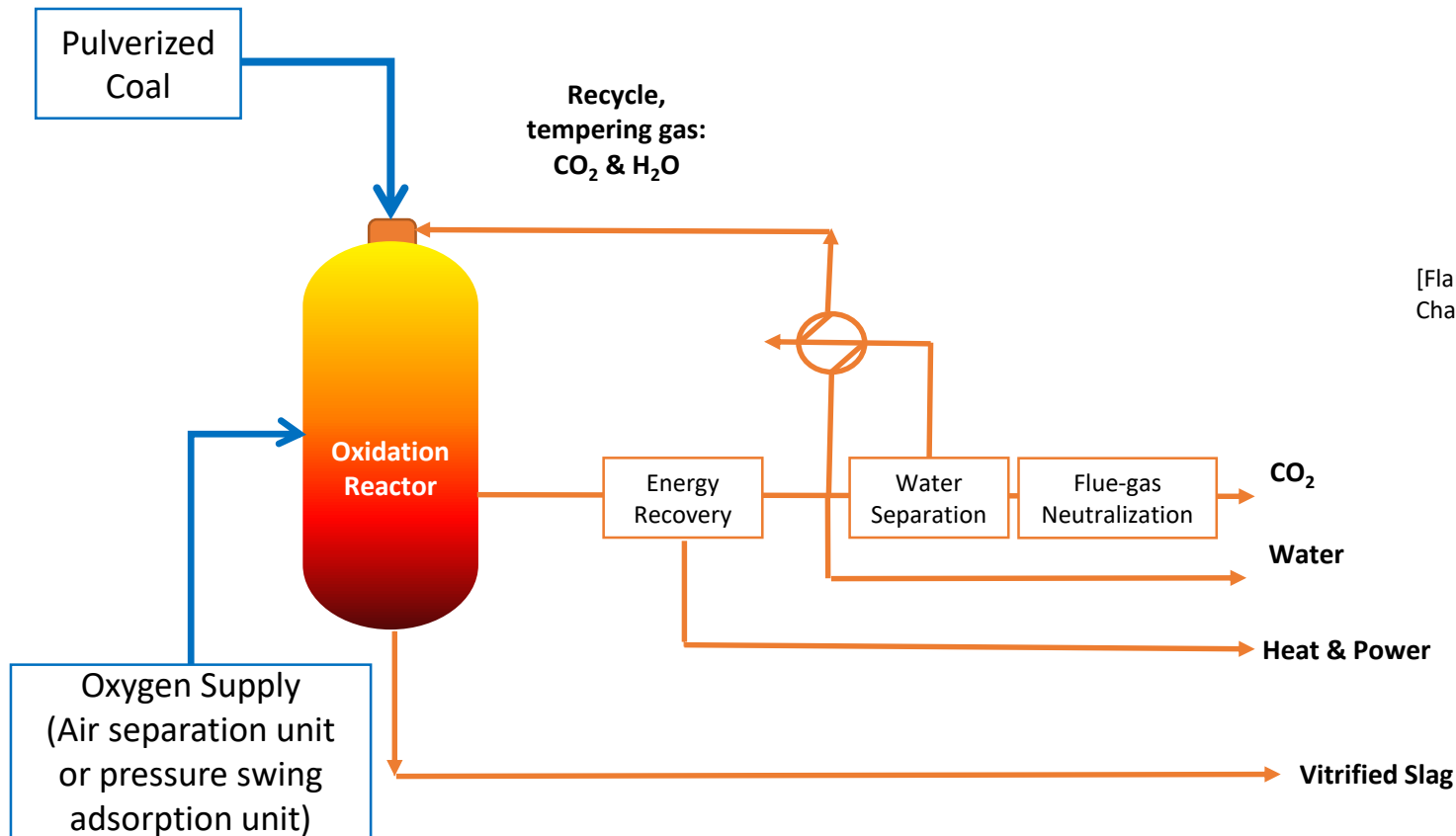
- Schlumberger Carbon Services
- Denbury Resources
- Oxy Low Carbon Ventures
- Carbon GeoCycle

Permitting, Environmental and Regulatory Experts:

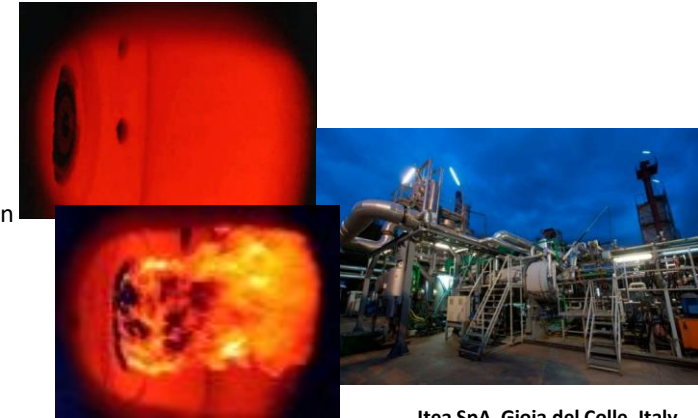
- Long Reimer Winegar, LLP
- Trihydro Corporation



A Novel Approach to Fossil Fuel Consumption: Flameless Pressurized Oxy-combustion



[Flameless Combustion Chamber]



Itea SpA, Gioia del Colle, Italy demonstration facility (5MWth)

Session 25: FPO-focused presentation, Richard Horner

CERC ACTC Project – CO₂ Utilization and Storage

The University of Wyoming leads Theme 3:
CO₂ utilization and storage



清洁煤技术(包括碳捕集和封存)联盟
Advanced Coal Technology Consortium

Theme 3. CO₂ Utilization and Storage CO₂利用与封存

Coordinators : Institute of Rock and Soil Mechanics, CAS (Li Xiaochun)
University of Wyoming (Jiao Zunsheng)

牵头单位: 中科院武汉岩土力学研究所 (李小春)
怀俄明州立大学(焦尊生)



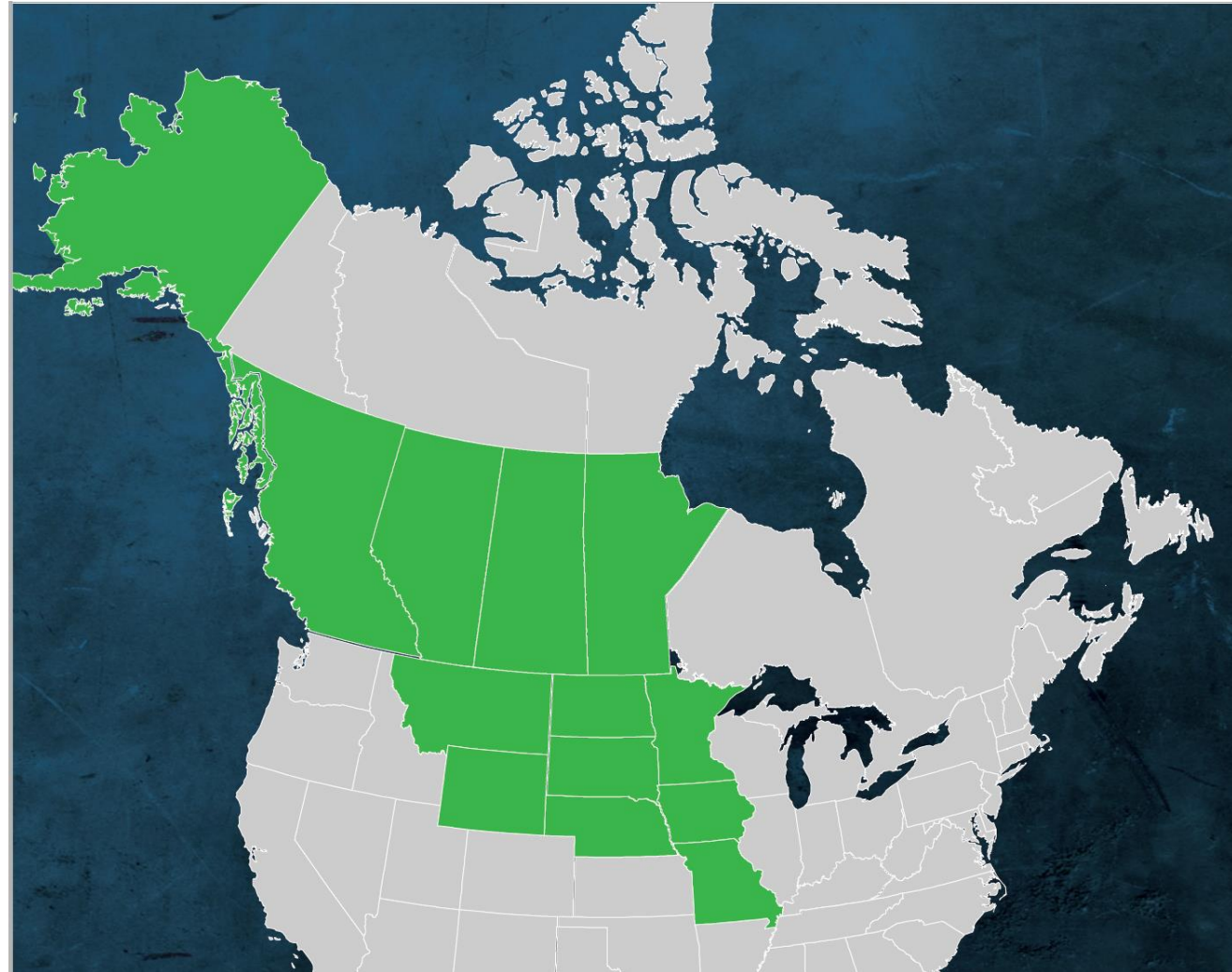
**Session 9: Zunsheng Jiao
will provide further details**

Joint Study to Develop a Commercial-Scale Integrated CCUS
Demonstration Project in the Ordos Basin and Wyoming Basin



New Partnership: Wyoming Has Joined PCOR

- Facilitate and support the identification, development and operation of CCUS projects
- Identify and address key non-technical challenges for regional CCUS deployment, including transportation and infrastructure, policy and regulation, business case development, and public awareness.
- Decrease the risk profile of CCUS projects through improved assessment methodologies and mitigation strategies
- Accelerate CCUS technology development in the region through collaboration with industry, DOE and the national labs
- Support the wider US DOE program for CCUS deployment, including international engagement and knowledge sharing



Carbon Engineering Initiative

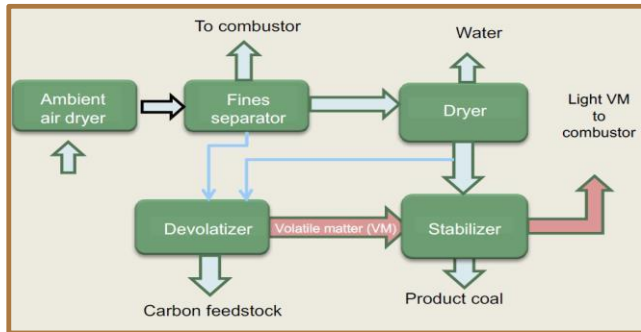
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PRB Beneficiation Technology

- Technology pilot plant operated in batch mode for 2 years at AES Power Plant, AL
- Engineering performance improvement ongoing with addition of counter current rotary kiln
- Integration and commissioning at Fort Union site, near Gillette WY to operate 24/7 on PRB coal
- Rotating kiln delivered and ready for commissioning
- Reassembly and commissioning expected to take 4 months
- Performance test campaign expected to start March 2021 and complete July 2021



Rotating kiln onsite on 08/05/20

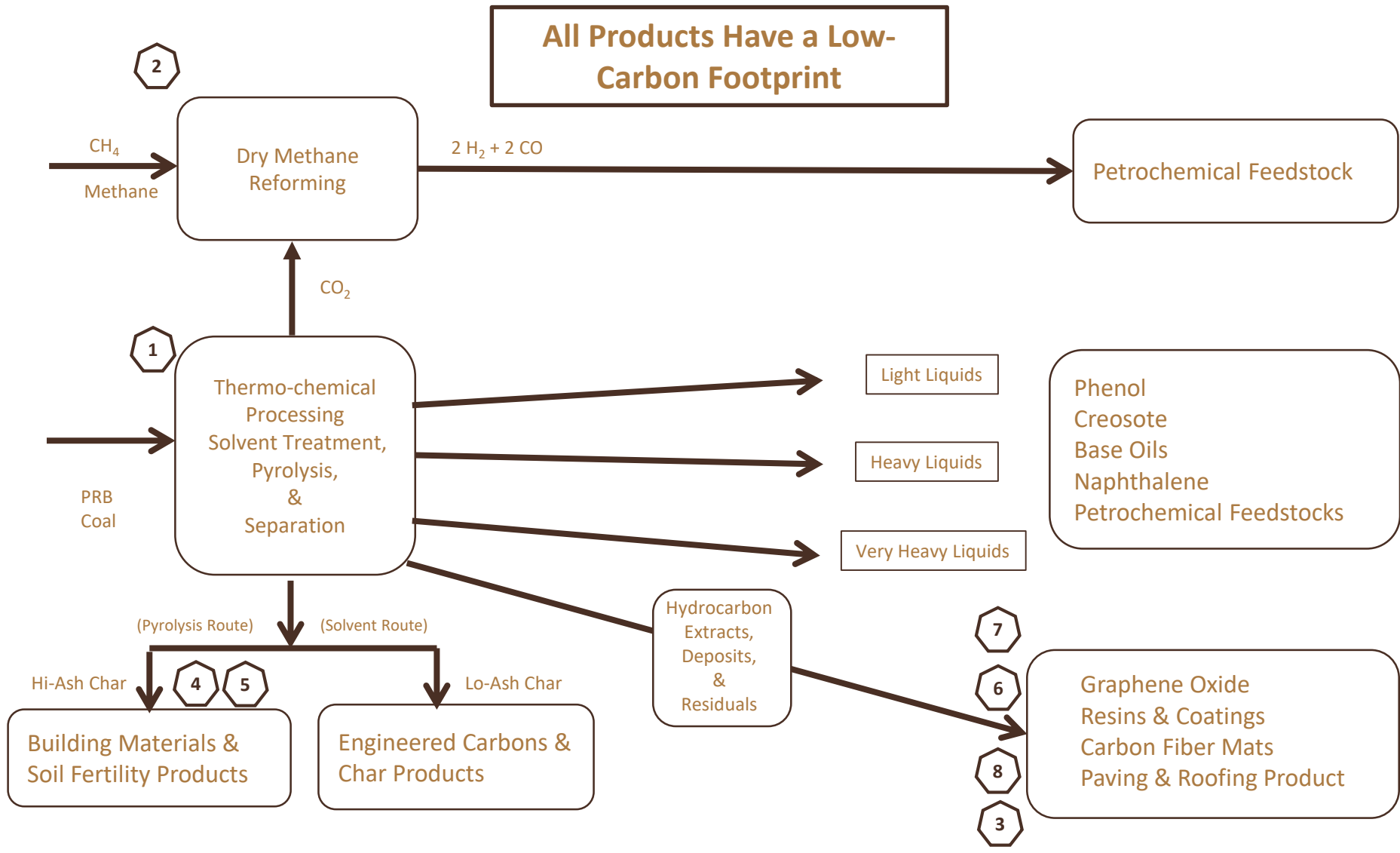


Powder River Basin Coal



| Sample | Proximate Analysis (%) | | | | Ultimate Analysis (%) | | | | | | |
|--------------|------------------------|-----------------|--------------|-----|-----------------------|------|-------|------|------|------|----------------|
| | Moisture | Volatile Matter | Fixed Carbon | Ash | C | H | O | N | S | Ash | HHV (BTU/lb) |
| PRB (RoM) | 27.42 | 31.65 | 36.43 | 4.5 | 50.23 | 3.41 | 13.55 | 0.65 | 0.22 | 4.5 | 8,800 |
| Beneficiated | 4.92 | 42.31 | 46.97 | 5.8 | 69.52 | 4.71 | 13.55 | 0.89 | 0.3 | 6.13 | 10,370* |

Primary technology platform, when tuned, can produce different intermediate feedstocks for conversion into engineered products

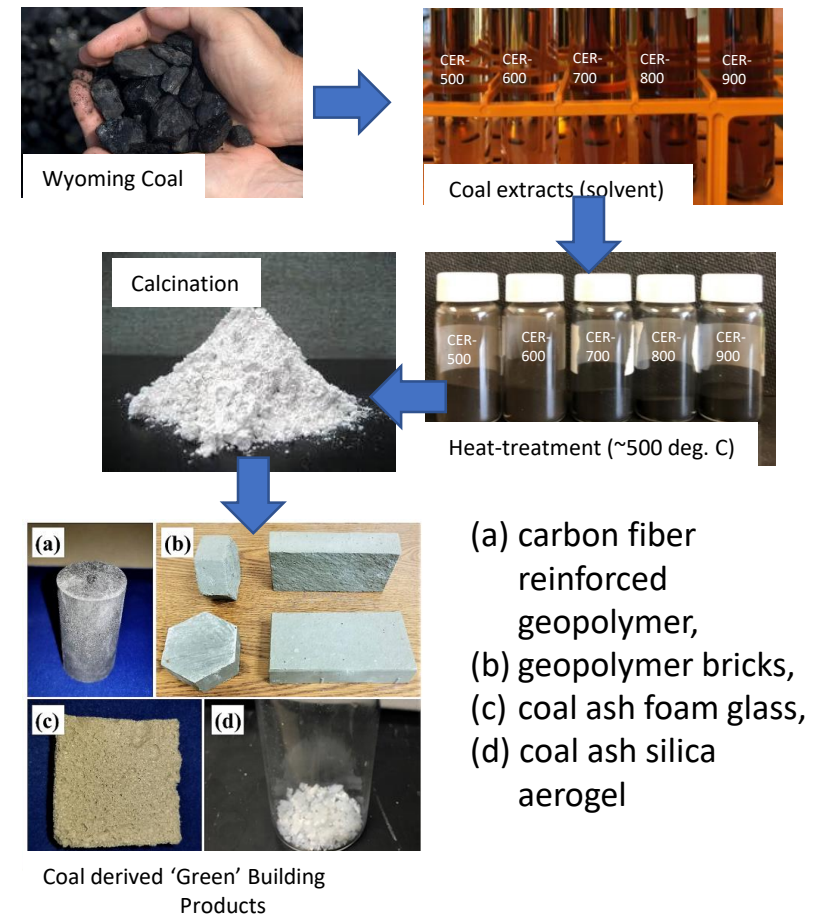


SER Research-Carbon Engineering

Coal-based Carbon Engineering Products:

- 1) Soil amendments:** Nitrogen enriched coal char. Aim to demonstrate at a sugar beet growth site near Wheatland
- 2) Asphalt and paving additives:** Proven in the laboratory and will be benched marked against oil-based materials this year
- 3) High temperature composites:** High-temp resins that exhibit superior temperature resistance to oil-derived products on the market
- 4) Nano-products:** Graphene oxides
- 5) Building products:** Coal based bricks with superior thermo-properties to conventional materials
- 6) Carbon fiber development:** For use in electric utilities and energy storage
- 7) Petrochemicals:** Dry methane reforming with CO_2 produced from coal pyrolysis ($\text{CO}_2 + \text{CH}_4 = \text{CO} + \text{H}$)
- 8) High-value chemicals:** Flash pyrolysis and solvent extraction to make intermediate products needed for the fibers, resin, polymers and asphalt materials

Example of green building materials from WY coal



Critical Minerals and Other Growth Areas

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Wyoming Rare Earth Element Resources

1. Coal and Coal Byproducts

- Preliminary results have identified concentrations up to 2,500 ppm
- REEs collect in ore bodies with coal seams

2. Bear Lodge Complex

- Contains nearly 30 million tons of REEs (Rare Earth Element Resources, INC; NI 43-101-compliant)
- Often referred to as the largest unmined REE deposit in North America

3. Oil and Gas Produced Water

- SER recently conducted a national survey of REE concentration in produced water
- Most produced waters contain REE in the parts per trillion level. Some geologic basins of Wyoming are enriched in Europium

4. Phosphoria Formation

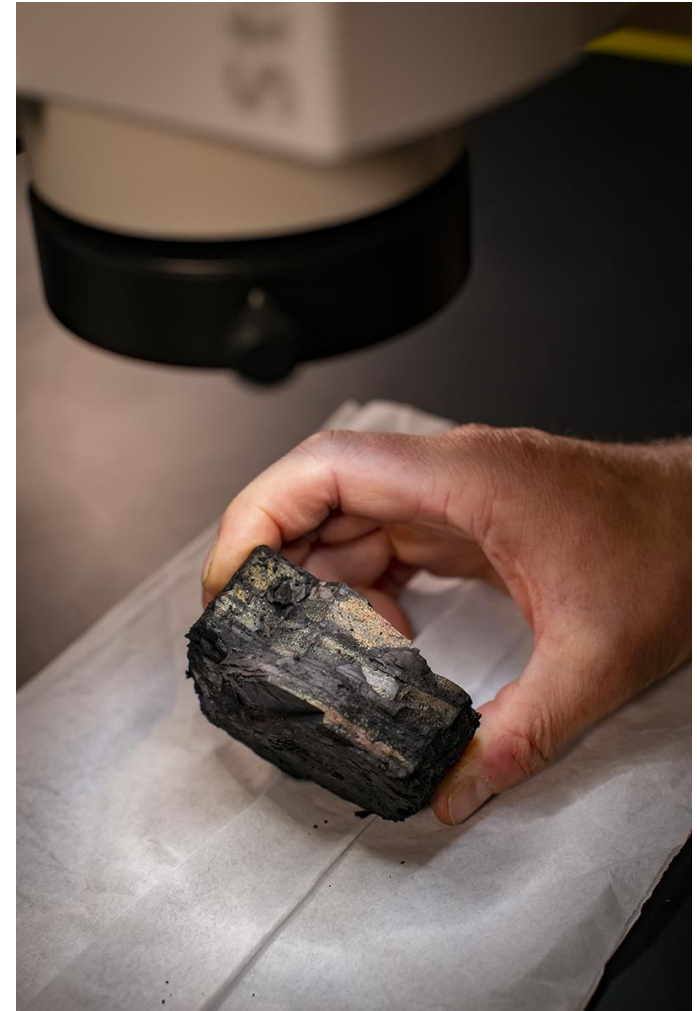
- Literature suggests that sedimentary phosphate deposits are major sources of REEs (up to 18,000 ppm Σ REE), and nearly 100% of REEs can be liberated with weak acids
- SER hopes to conduct a study next year to investigate the resource



Powder River Basin coal core for REE experiments

REE Current Work and Opportunities

- **Current**
 - \$1.62 million collaboration with NETL, SER, Campbell County, the city of Gillette and Energy Capital Economic Development on REE pilot on coal ash
- **Future opportunities**
 - Coring program to determine extent of coal-based ore bodies
 - In-situ mining techniques of CM and REEs from coal and other sediments
 - Development of remote sensing prospecting tools
 - Drone sensing of REEs and CMs
 - Machine learning techniques using pathfinders elements
 - Phosphate REE characterization and weak acid extraction

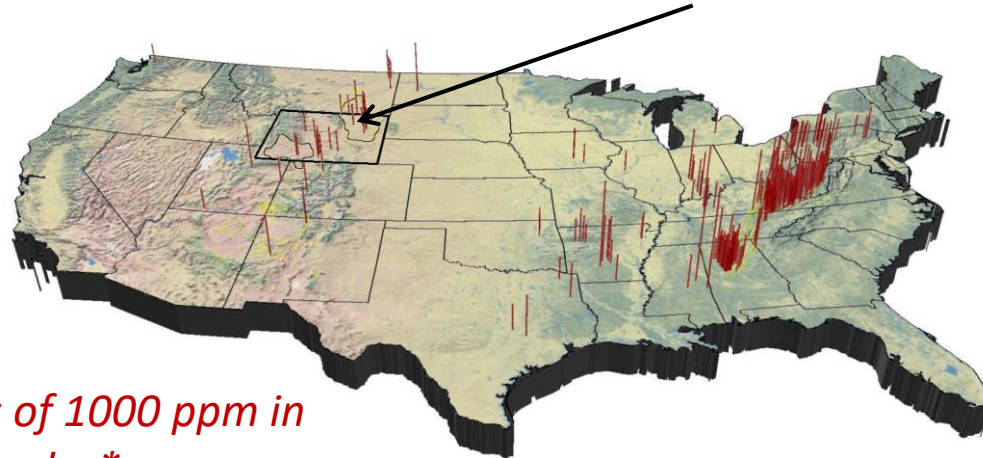


Rare Earth Elements in Coal

REEs in Coal:

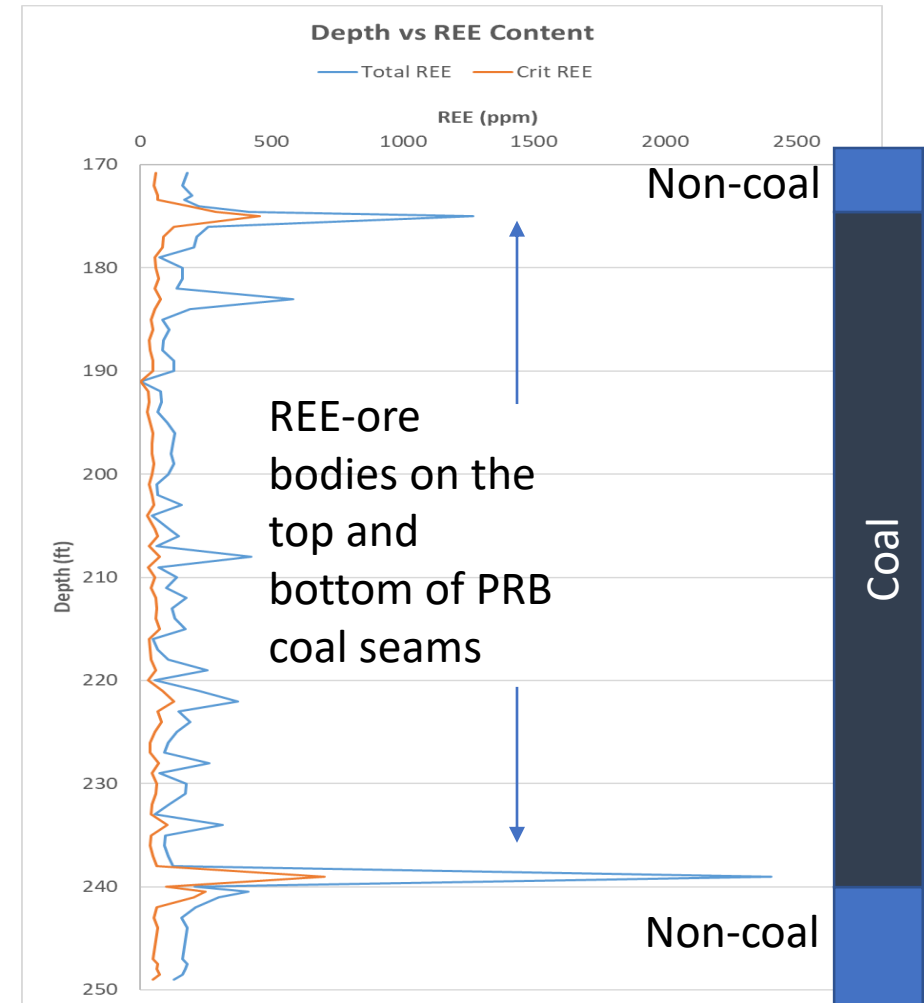
- 2,500 ppm total REE's
- Highest concentrations collect at the bottom and top of coal seams

**Powder River Basin =
40% of U.S. thermal coal
consumption**



*REEs in excess of 1000 ppm in
some coal samples**

*Ekman 2012, Bagdonas et al. 2016, 2019 and current NETL projects, °USGS COALQUAL Database



For more information on REEs in coal contact D. Bagdonas (abags@uwyo.edu)

SER Policy Research, Analysis & Solutions

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Center for Energy Regulation and Policy Analysis (CERPA)

- Relatively new SER initiative
- Director: Kipp Coddington
- Deputy Director: Rob Godby
- Based on interdisciplinary collaboration: Law, Economics & Finance, etc.
- Commercializing energy technologies generally requires law, regulation and policy solutions
- Select CERPA topics of focus:
 - Model commercial contracts for low-carbon energy projects (CCUS, special purpose vehicles for tax incentives, storage contracts, other)
 - Wyoming HB200 analysis (Wyoming's new low-carbon electricity standard)
 - Regulatory assessments of natural resource approaches (e.g., recovering REE's from federal lands)
 - Energy transition assessments
 - Near real-time policy support of local elected and appointed officials

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