

UW School of Energy Resources

Holly Krutka, PhD
Executive Director

Prepared for the Joint Minerals, Business &
Economic Development Committee

August 27, 2020



THE WORLD NEEDS MORE COWBOYS.

Topics

- SER mission
- FY21-22 appropriations
- Research program
 - Select accomplishments
 - Competitive carbon management
 - Carbon engineering initiative
 - Critical minerals and rare earth elements
 - Center of Innovation for Flow through Porous Media



SER's Mission:

Energy-driven
economic
development for
Wyoming



*BUCKING
THE SYSTEM
SINCE 1886.*

FY2021-2022 Appropriations*

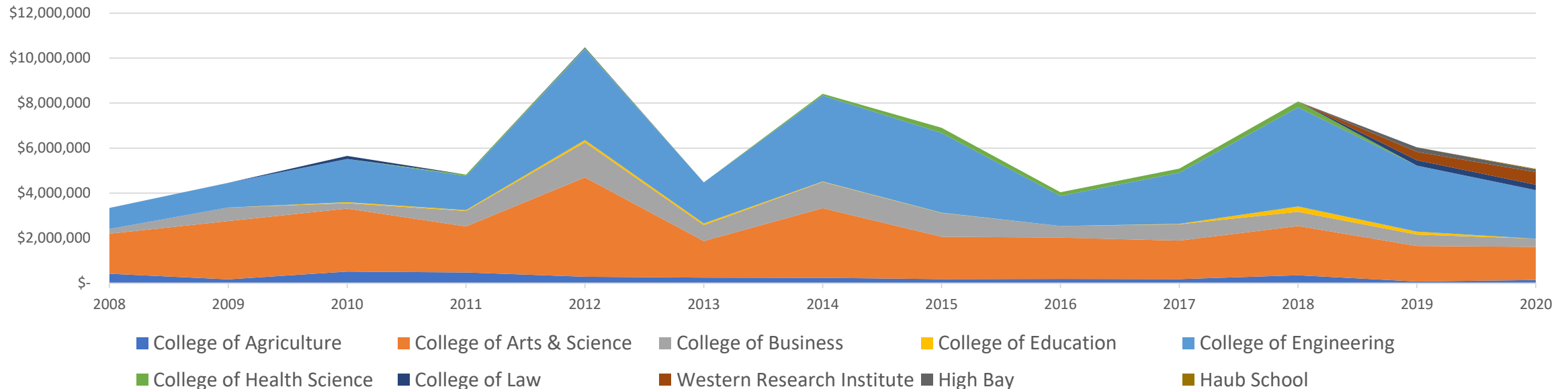
Funding Type	Total FY2021-2022 Appropriations	Description
Standard	\$18,885,027	Standard operating budget staff and faculty salaries and fringe, travel, building support, service to the state, legislative mandates, academics, research, outreach, etc.
Exception – One time (included in standard budget line in appropriations bill SF0001)	\$1,300,000	For an Academic Director hire, increased support for the Center for Energy Regulation and Policy Analysis and to reinvigorate Centers of Excellence
Exception – One time	\$7,000,000	Demonstration programs focused on coal-to-products – requires ERC approval
Exception – Matching	\$12,000,000	DOE project cost-share for pilot flameless pressurized oxy-combustion (FPO) power plant

*SER is funded separately from the UW block grant

SER Financial Outlays Across UW

- Historically, a significant portion of SER's budget is allocated to UW colleges
- From 2008, over \$76M of funds appropriated to SER have been spent by UW colleges for a wide variety of purposes, averaging approximately \$6 M/yr
- Commitments have included program support, GA's, start-up, salaries, matching funds, major equipment, and research funds

College Funding By Fiscal Year

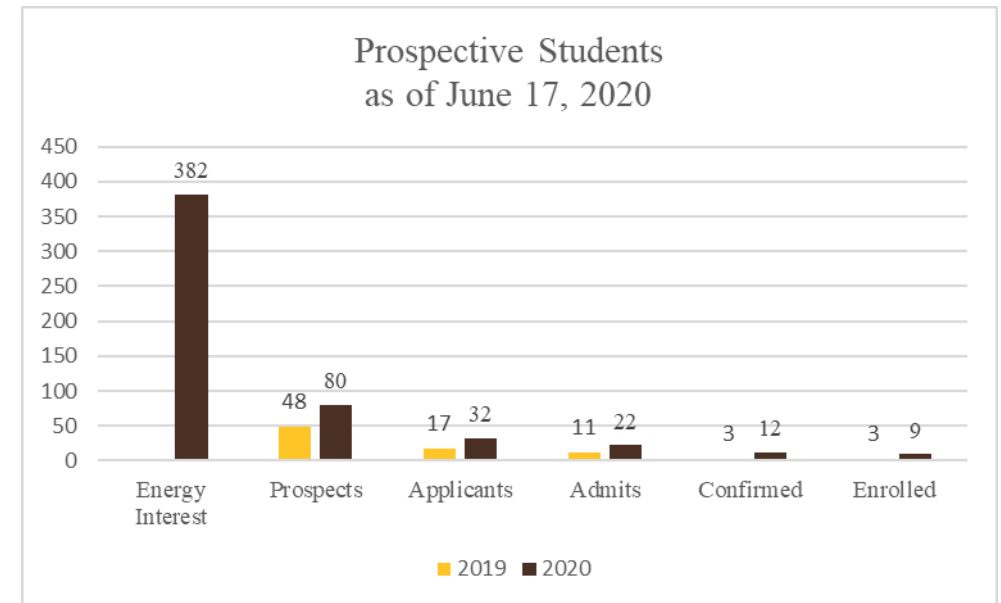


Academics

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SER Academics

- **Objective: Partner with UW colleges to be a “provider of choice” for energy-related undergraduate and graduate instruction**
- Energy Resource Management and Development Bachelor of Science highlights
 - 92% job and graduate school placement since the inception of the program in 2009
 - Enrollment is at ~40 students
- Recent changes
 - Appointed interim Academic Director
 - Launched a strategic review
- Potential
 - Consider a minor roll out
 - Expand the scope of land management to include utilities, renewables and regulation
 - Consider the possibility for interdisciplinary programs in energy data science and analytics



Research Program

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SER Research Benefits the University and State

- **Center for Economic Geology Research (CEGR) – Select Accomplishments over Last 5 Years***
 - Awarded **\$38** million in federal funding
 - SER supplied \$2.7 million in cost share, a **14:1** return for state funds
 - **\$4.3 million** in indirects to the university
 - Funded **26** graduate students in **8** departments
 - **\$11** million have been spent with Wyoming contractors
 - CEGR scientists have international reputations in the areas of carbon management, rare earth element resources and subsurface energy resources
- **Carbon Engineering – FY20 Select Accomplishments***
 - Coal beneficiation advancing with industry partnership
 - Advancing flameless pressurized oxy-combustion (FPO) power technology
 - Received \$250k DOE sub-grant for front end engineering and design (FEED) study – due Jan 2021
 - Potential to expand to \$60 million DOE project (\$12 million state matching appropriated) – Apr 2021
 - **8** patents filed on technologies focused on process to manufacture products from coal
 - Supported **11** faculty, **8** post-docs, **23** graduate assistants (8 with Tier 1), **8** undergraduate researchers, **2** senior design projects

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:

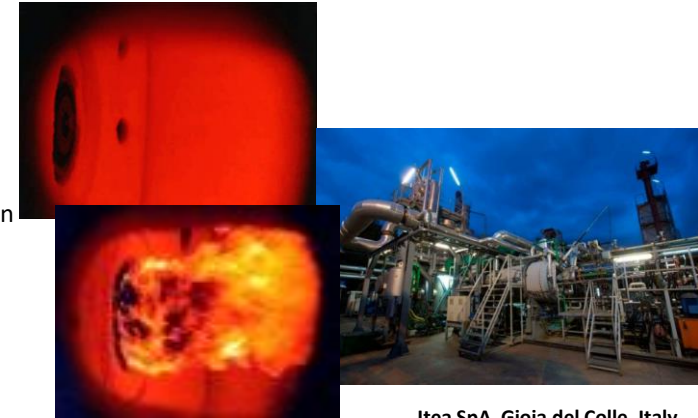
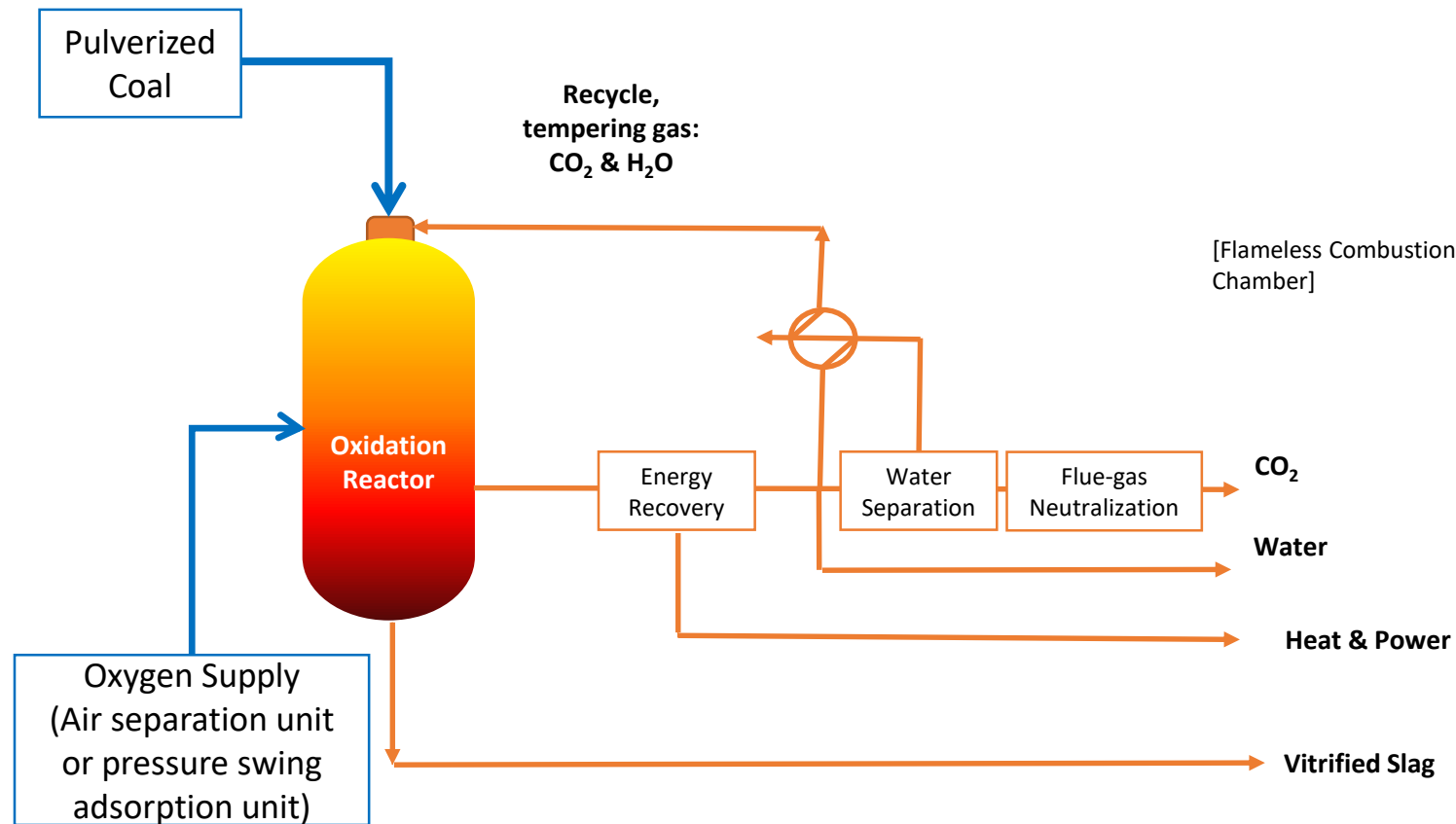
- Commercial-scale subsurface injection testing and monitoring
- Finalize geologic characterization
- Prepare and file Class VI permits
- Integrate this project with a separately funded CO₂ capture study
- Conduct the required NEPA analyses for commercialization of the site



Wyoming CarbonSAFE Team



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



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

FPO Project Update and Team

- **Phase II Update**

- Continuing FPO combustion model development which is 80% complete
- NEPA study for the selected site location due to start
- On track to deliver phase II FEED study by mid January 2021
- Decision on down select, and award of \$60 million to undertake detailed design, construction and demonstration expected near end April 2021

- **Phase III Critical Path**

- Application due January 2021
- Permit required to end Phase II and start Phase III at end of May 2021



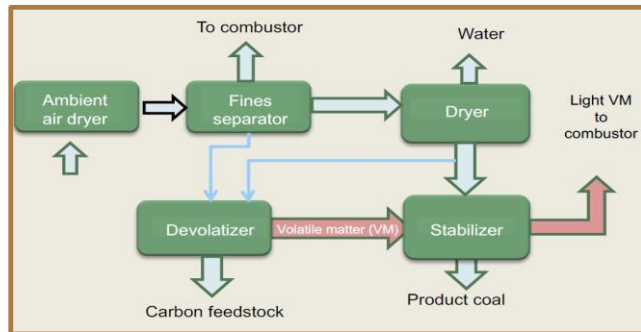
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Carbon Engineering Initiative

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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



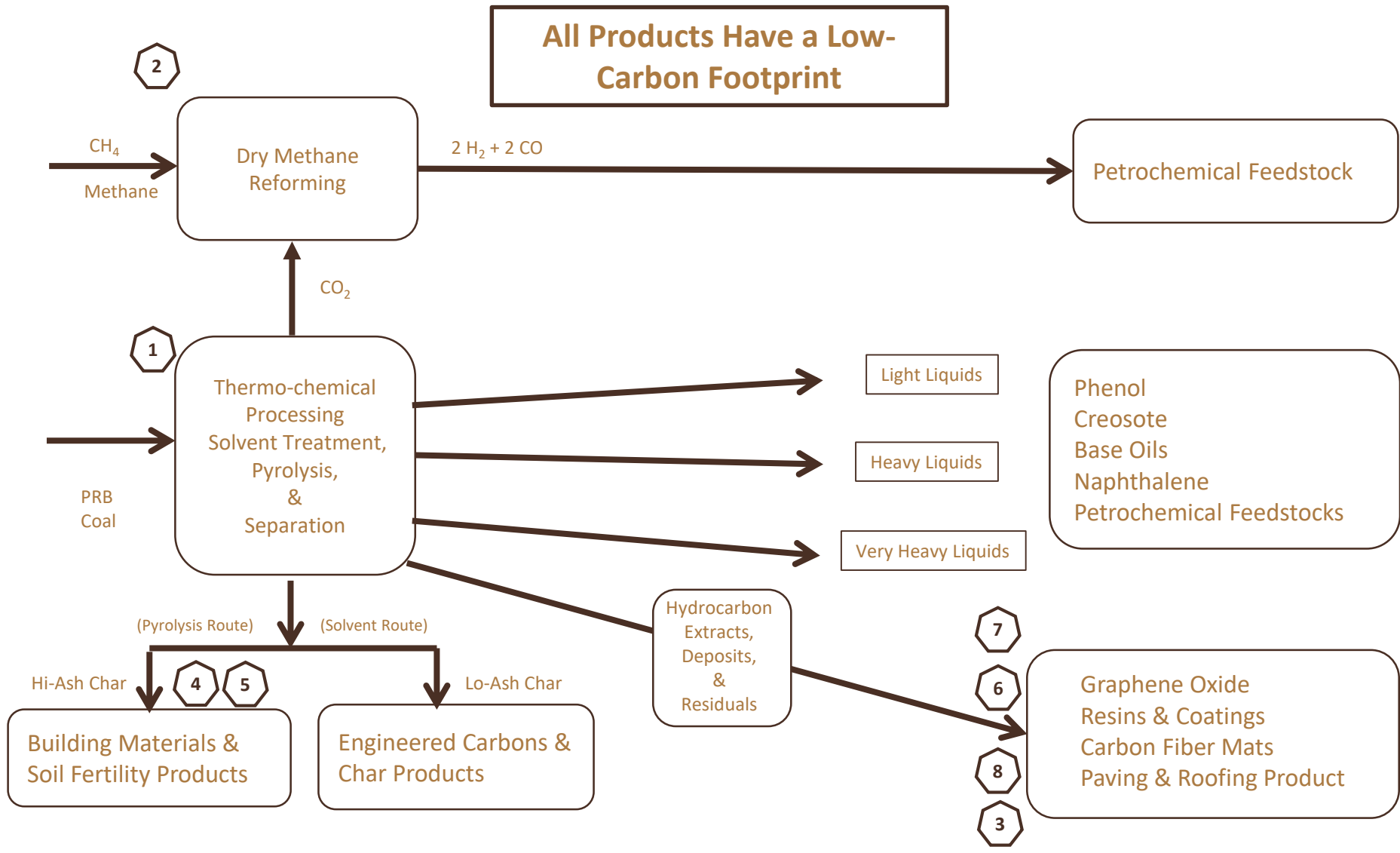
Rotating kiln onsite on 08/05/20

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

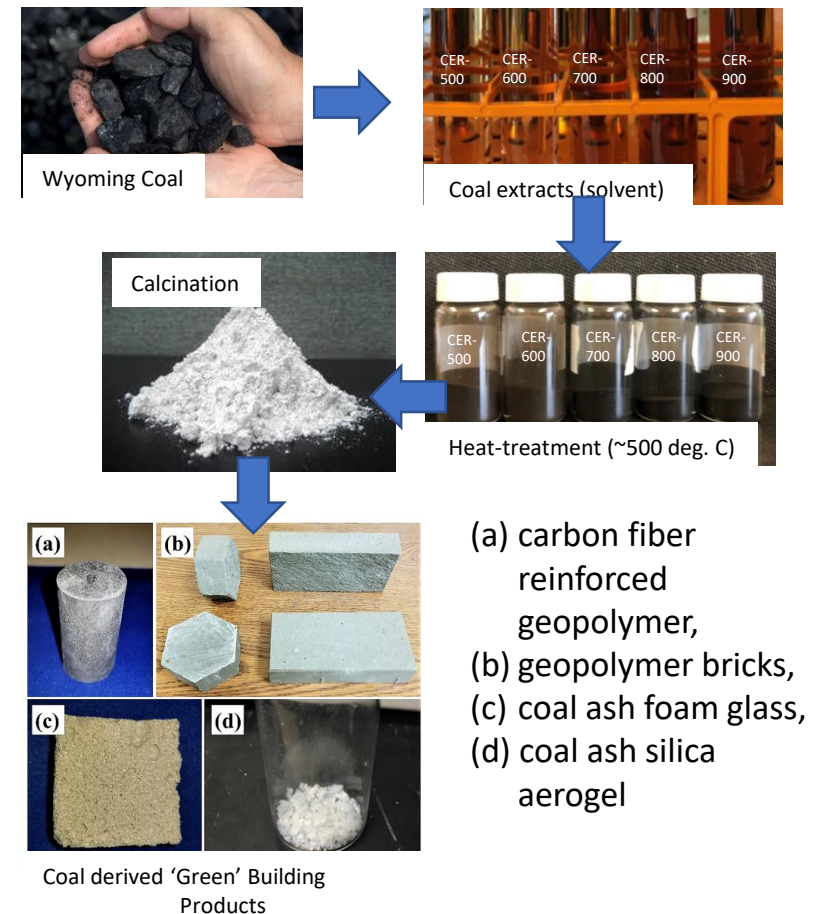


SER Research - Carbon Engineering: Background

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



SER Research - Carbon Engineering: Update

1. Three pilot plants (pyrolysis, solvent extraction and dry methane reforming) in commissioning and initial start up operational phase
2. Large-scale field demonstration of coal-derived soil amendment augmented with Wyoming-sourced nutrients, at three (3) WY sites - to start March 2021
3. Three formal agreements signed with (i) a leading roofing product manufacturer (ii) a paving product suppliers and (iii) WY-DOT to support scale up testing and road strip testing of coal derived asphalt products
4. Manufacture of coal-derived char bricks and plaster samples for demonstration building expected to be complete by end October 2020
5. Formal agreement to work with Denver-based technology company for scaling up electro spun mats for energy storage for emergency residential and commercial supply
6. Formal agreement signed with Atlas Carbon, Inc. to build the integrated thermo-chemical processing of coal demonstration at their WY industrial site, supported by EPC, Wood
7. Working with leading International Rubber Company for substituting coal derived fillers for carbon black

Critical Minerals and Rare Earth Elements

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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

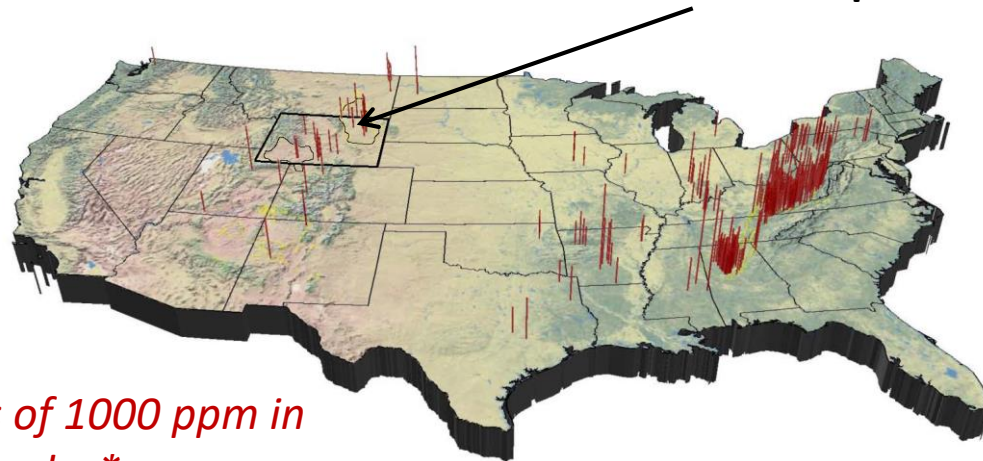


Rare Earth Elements in Coal

REEs in Coal:

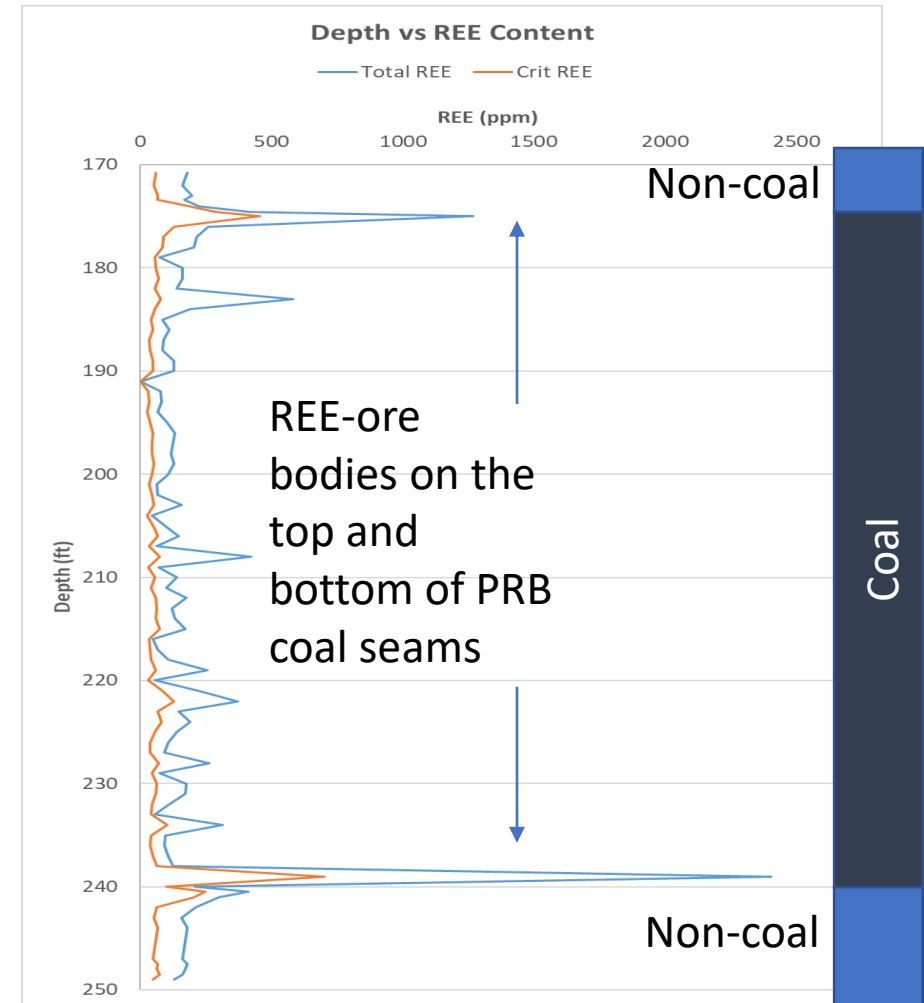
- 2,500 ppm total REE's
- Highest concentrations collect at the bottom and top of coal seams

**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



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

Center of Innovation for Flow through Porous Media

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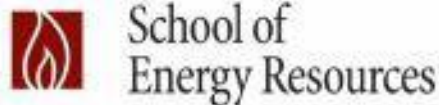
COIFPM: Background

- The Center of Innovation for Flow through Porous Media (COIFPM) is located at the High Bay Research Facility (HBRF) of the University of Wyoming (<https://coifpm.com>)
- The HBRF contains more than 90,000 square feet of high-bay and traditional laboratory space, and affiliated office and meeting areas. It is, to the best of our knowledge, the world's largest experimental research facility focused on flow through porous media problems.
- It is developed using more than \$100 million investment from the State of Wyoming and corporate sponsors.
- The Center provides imaging and flow capabilities at the atomic, nano, micro, and macro scales. Furthermore, it establishes an unparalleled capacity for scientists to conduct numerous studies in parallel.
- COIFPM is a world-class research entity with a distinguished track record in scholarly activity, technology development, commercialization, and fundraising. Technologies developed at this center of excellence have applications not only in oil and gas recovery problems but also in many other areas of science and engineering, thereby establishing a remarkable potential for future growth with appropriate investment and planning.



The High Bay Research Facility was inaugurated in August 2017

Partners/Contributors/Collaborators/Clients



Marian H. Rochelle

HALLIBURTON

Tom and Shelley Botts

These are some of the entities/institutions/individuals that have contributed to the establishment of HBRF, collaborated with COIFPM, and/or provided donations for different initiatives.

Current Research

The following list presents examples of technologies being developed under the research division of COIFPM in connection to exploitation of unconventional and conventional reservoirs:

Unconventional Reservoirs

- Foam-assisted hydrocarbon gas injection (FAGI) in unconventional reservoirs
- Confined Fluid Phase Behavior
- Advanced Well Stimulation Chemicals
- Multiphase Flow in Propped and Unpropped Fractures
- Proppant Wettability and Fracture Conductivity

Conventional Reservoirs

- Digital Rock Technology (DRT)
- Enhanced Oil Recovery (EOR): Investigations of efficacies of different EOR agents (e.g., surfactants, polymers, and engineered low salinity brine solutions), displacement physics, and recovery trends in non-water-wet sandstone and carbonate samples.
- Nanofluids: COIFPM scientists design/evaluate nanofluids (solutions of nanoparticles with/without surfactants) as EOR agents for different conventional reservoirs. For example, novel Wyoming coal-derived carbonaceous nanoparticles are being tested for enhanced oil recovery applications.



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