# Annual REPORT 2023

Strategic Academic Offerings

Innovative Research

Stakeholder Outreach

**ACADEMICS** **RESEARCH** **OUTREACH**

University of Wyoming | School of Energy Resources

*Prepared for the Wyoming Legislature*

*Joint Minerals, Business, and Economic Development Committee*
*Joint Appropriations Committee*
*Joint Education Committee*

# THE UNIVERSITY OF WYOMING SCHOOL OF ENERGY RESOURCES (SER) ANNUAL REPORT FISCAL YEAR 2023

July 1, 2022 through June 30, 2023

## WHO WE ARE

### SER LEADERSHIP

**Holly Krutka, Ph.D.** | Executive Director
**Scott Quillinan** | Senior Director, Research
**John Litynski** | Senior Advisor
**J. Fred McLaughlin, Ph.D.** | Director, Center for Economic Geology Research
**Trina Igelsrud Pfeiffer** | Director, Center for Carbon Capture and Conversion
**Eugene Holubnyak** | Director, Hydrogen Energy Research Center
**Kara Fornstrom** | Director, Center for Energy Regulation and Policy Analysis
**Kami Danaei, Ed.D.** | Director, Academic Programs
**Kyle Summerfield** | Program Manager, Shell 3D Visualization Center
**Rachel Ferrell** | Director, Business Operations
**Christine Reed** | Director, Outreach

## OUR MISSION

Energy-driven economic development for the state of Wyoming.

## CONTACT US

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# ENERGY RESOURCES COUNCIL

The University of Wyoming Energy Resources Council (ERC) was established by Wyoming statute 21-17-117(e) to guide SER in setting priorities for energy-related academics, research, and outreach. The ERC, consisting of leaders from industry, the legislature and UW, provides direction for responsive, internationally recognized, interdisciplinary energy-related programs that are integral constituents of the university's identity.

Required by provision (c)(iv) of WY Stat § 21-17-117 and in accordance with WY Stat § 9-2-1010 through 9-2-1014., SER submits its budget directly to the ERC for review and approval before final submission to the governor.

The ERC contributes a unique business perspective on the diverse research and workforce demands of both Wyoming's private and public energy sectors, and is responsible for producing a valuable return on the state's investment in UW's energy programs.

In addition to the advisory role of the ERC, the Wyoming Legislature, (WY Stat § 21-17-121), directed the Advanced Conversion Technologies Task Force, consisting of the voting members of the ERC, to award and oversee funds to proposals for clean coal and advanced conversion technologies after submitting recommendations to the Wyoming Legislature Joint Minerals, Business and Economic Development Interim Committee.

The ERC currently consists of thirteen members. Seven members represent diverse sectors of Wyoming's energy industries and are appointed to three-year terms by the governor with confirmation by the Senate. Additional members include one member from the Wyoming Senate (appointed by the President of the Senate), one from the House of Representatives (appointed by the Speaker of the House), and four ex-officio members: the President of the University of Wyoming, the Director of the Haub School of Environment and Natural Resources, the Chief Energy Advisor for the State of Wyoming, and an informal seat is occupied by a member of the UW Board of Trustees.

## BOARD MEMBERS

**Cindy Crane**, *Chairwoman*
CEO, Enchant Energy

**Jim Anderson**, *Vice Chairman*
Wyoming State Senator, Natrona County

**Carl Bauer**
President, C.O. Bauer Consulting, Inc.

**Donald Burkhart, Jr.**
Wyoming House of Representatives, Carbon County

**Mark Doelger**
President and co-owner, Barlow & Haun, Inc.

**David Emery**
Retired Chairman and CEO, Black Hills Corporation

**Vello A. Kuuskraa**
President, Advanced Resources International, Inc.

**Charlene Russell**
Vice President of Commercial Development for North America, Baker Hughes

**Chad Teply**
Senior Vice President of Project Execution for Williams Cos.

## EX-OFFICIO MEMBERS

**Edward Seidel**
President, University of Wyoming

**Dave True**
Trustee, University of Wyoming

**Randall Luthi**
Chief Energy Advisor, State of Wyoming

**John Koprowski**
Dean, UW Haub School & Ruckelshaus Institute

# LETTER FROM THE EXECUTIVE DIRECTOR


Dr. Holly Krutka
Executive Director

Greetings from the School of Energy Resources (SER)!

We have reached the end of another exciting fiscal year at SER and appreciate the opportunity to report on our many activities and achievements, none of which would be possible without the support from elected and appointed officials in Wyoming, the Energy Resources Council, industry partners and of course our incredible faculty, staff and students. As I read this annual report, I was both humbled and proud of what the team has achieved as they remained focused on our mission to support energy-driven economic development for Wyoming.

Our academic program continues to make great strides in expanding the energy-focused curriculum available to University of Wyoming students, including providing opportunities for students in other disciplines to gain valuable exposure to the energy sector. Recognizing industry needs and focused on a determination to provide our graduates with a significant edge when entering the workforce, the UW Board of Trustees approved two new certificate programs open to both traditional and non-traditional students. The certificates in Carbon Capture, Utilization and Storage (CCUS) and Land Administration officially went live this fall 2023 semester.

On the research front, SER experienced an unprecedented year of funding opportunities as a result of the Infrastructure Investment and Jobs Act and support from the state of Wyoming. With a sense of urgency, SER rose to the occasion and submitted proposals totaling over $90 million. Of those submitted, many have already been selected to negotiate awards including a Phase III CarbonSAFE cooperative agreement to stand up the Sweetwater Carbon Storage Hub in Wyoming – the largest single competitive award in the University of Wyoming's history.

Wyoming's executive and legislative branches also increased their investment in our research program, including the expansion of the Mowry Project, a state-funded initiative to bring together experts across UW to help support industry to unlock Wyoming's largest unconventional reservoir. Through seed-funding opportunities, SER has mobilized an interdisciplinary research team to seek answers in unlocking the wealth of the tight geologic formation.

Our Centers of Excellence have all achieved major accolades throughout the year as they work to broaden the scope of their work and become self-sufficient in funding. For example, the Nuclear Energy Research Center made significant progress in building capacity on campus and in the region while generating new funds to support opportunities in nuclear energy at UW.

Additionally, the official integration of the Integrated Test Center, after the execution of an MOU between the Wyoming Energy Authority, Governor's Office and SER, is complete. SER is now responsible for overseeing all operations at the facility at a very exciting time when two large projects are under construction.

SER's outreach program has taken the lead on showcasing the advancements of ongoing initiatives and upholding our commitment to public engagement and education on energy topics, while concurrently making valuable new connections with future partners.

Finally, through concerted fundraising efforts in collaboration with the UW Foundation, SER has successfully secured philanthropic funding from the private sector. SER has been the recipient of substantial philanthropic gifts from PureWest, Arch, and Peabody and more to support the researchers driving innovative technologies development.

While SER and our partners continuously look to develop novel technologies that will lead to breakthroughs, we are also closely focused and committed to ensuring our large-scale field work is successfully executed. We anticipate significant growth in FY24 to help meet the needs of ever-expanding portfolio. I am proud of our accomplishments, confident in our strategy and inspired by our extraordinary team. I look forward to the coming fiscal year, and as always, am grateful for the enduring support and confidence we receive from Wyoming and its best-in-class energy community.

Sincerely,

Holly Krutka

Holly Krutka, PhD

# GLOSSARY OF ACRONYMS

**#**
3D Viz - Shell 3D Visualization Center

**A**
AAPL - American Association of Professional Landmen
A&S - College of Arts & Sciences
ARPA-E - Advanced Research Projects Agency–Energy
ATR - Advanced Technology Resources

**C**
CAQ - Center for Air Quality
CarbonSAFE - Carbon Storage Assurance Facility Enterprise
CBEA - Center for Business and Economic Analysis
CBNGR - Center for Biogenic Natural Gas Research
CCCC - Center for Carbon Capture and Conversion
CCUS - Carbon Capture, Utilization and Storage
CEGR - Center for Economic Geology Research
CEPS - College of Engineering and Physical Sciences
CEPWM - Center of Excellence for Produced Water Management
CERPA - Center for Energy Regulation & Policy Analysis
CM - Critical Minerals
$CO_2$ - Carbon Dioxide
COE - Centers of Excellence
CORE-CM - Carbon Ore, Rare Earth and Critical Minerals
CSU - Colorado State University

**D**
DAC - Direct Air Capture
DFS - Dry Fork Station
DJ - Denver-Julesburg
DOE - Department of Energy

**E**
EES Concentration - Energy and Environmental Systems
EIC - Energy Innovation Center
EGU - Electric Generation Units
EORI - Enhanced Oil Recovery Institute
EMF - Energy Matching Funds
EPA - Environmental Protection Agency
ERC - Energy Resources Council
ERM - Energy Resource Management (minor)
ERMD - Energy Resource Management and Development

**F**
FEED - Front End Engineering Design
FY23 - Fiscal Year 2023

**G**
GGRB-WRB - Greater Green River Basin and Wind River Basin

**H**
$H_2$ERC - Hydrogen Energy Research Center
HERO - Hermiston, Oregon

**I**
INL - Idaho National Laboratory
ITC - Integrated Test Center

**K**
KHI - Kawasaki Heavy Industries

**L**
LANL - Los Alamos National Laboratory

**M**
MOU - Memorandum of Understanding
MTR - Membrane Technology and Research
MSHA - Mine Safety and Health Administration
MTR - Membrane Technology Research
MW - Mega Watt

**N**
NEPA - National Environmental Protection Act
NERC - Nuclear Energy Research Center
NETL - National Environmental Technology Laboratory
NRC – Nuclear Regulatory Commission
NREL - National Renewable Energy Laboratory
NSF – National Science Foundation

**P**
PCOR - Plains $CO_2$ Reduction Partnership
PLM Concentration - Professional Land Management
PNNL - Pacific Northwest National Laboratory
PRB - Powder River Basin
PREC - Partnerships for Research and Education in Chemistry
PtG - Pilot-to-Gas

**R**
REE - Rare Earth Elements
RENEW - Research Explorations for Nuclear Energy in Wyoming
RFP - Request for Proposals
RNG - Renewable Natural Gas

**S**
SAREC - UW Sustainable Agriculture Research and Extension Center
SER - School of Energy Resources

**T**
TAP - Technology Associated Program

**U**
USAF - United States Air Force
USEA - United States Energy Association
USGS - United States Geological Survey
UW - University of Wyoming

**V**
VR - Virtual Reality

**W**
WERC - Wind Energy Research Center
WICHE - Western Interstate Commission for Higher Education
WIP - Wyoming Innovation Partnership
WRF - Weather Research and Forecasting
WRI - Western Research Institute
WyIC - Wyoming Innovation Center

# ABOUT THE SCHOOL OF ENERGY RESOURCES

The University of Wyoming (UW) School of Energy Resources (SER) was created in 2006 to enhance the University's energy-related education, research, and engagement. SER directs and funds cutting-edge energy research and technology development, which integrates with the formulation and conduct of academic programs at UW and bridges academics and industry through targeted engagement efforts. The partnerships formed between academics and industry ensure programs are relevant, current, and deliver impact and high value to stakeholders and the state.

Since its inception, SER has maintained flexibility in its focus and structure to meet the changing needs of Wyoming's energy industries and the state's economy—which is now more critical than ever.

This report highlights SER's significant achievements from July 1, 2022, through June 30, 2023, in academics, research, newly emerging areas of focus, and engagement to keep UW and Wyoming at the forefront of the energy sector.

# ACADEMIC PROGRAM

## UNDERGRADUATE CERTIFICATE PROGRAMS

In FY23 the UW Board of Trustees approved two certificate programs in the School of Energy Resources that officially launch in fall of 2023.

### *Carbon Capture, Utilization and Storage*

The certificate includes a comprehensive cross-section of disciplines covering the technology, economics and policy of CCUS, and it is designed for a broad, multidisciplinary audience with an interest in energy, sustainability and climate change mitigation.

Students are able to study the current engineering problems that are applicable to CCUS, as well as gain a familiarity and a working knowledge of geological concepts, models of the subsurface, engineering of fluids and flow, policy and regulations related to $CO_2$ emissions, pore-volume use, injection, monitoring and safety.

### *Land Administration*

Through the new land administration certificate program, students will become knowledgeable leaders in the complex role energy, natural resources and agriculture play in land administration. The certificate complements the existing degree program in energy resources management, enhances any other degree offered at UW, and can help bolster credentials and knowledge of working professionals.

The curriculum offers both a philosophical and functional view that is applicable to a wide range of careers, with courses from SER, the College of Agriculture, Life Sciences and Natural Resources, and the Haub School of Environment and Natural Resources.

Raymonda Burgman Gallegos

## ARTICULATION SUMMIT

SER hosted the Wyoming Articulation Summit – an annual statewide gathering of higher education administrators, faculty, staff and other professionals to discuss transfer articulation efforts, impacts and plans.

Raymonda Burgman Gallegos, vice president of programs and services for the Western Interstate Commission for Higher Education (WICHE), gave the keynote address.

## WHO WE ARE

**Kami Danaei**, Academic Director

**Kris Koski**, Director, Professional Land Management Program

**Karolina Klatka,** College Relations Representative

**Helen Qin,** Office Associate, Sr.

## MAJOR ACCOLADES

**Kris Koski** was recognized as a "Top Prof" by the Mortar Board Chapter at the University of Wyoming.

**Kami Danaei** was the recipient of a Mortar Board "Tip of the Hat Award" for outstanding service to students.

### NOMINEE, 2023 ROSEMARIE MARTHA SPITALERI AND TOBIN MEMORIAL OUTSTANDING GRADUATE AWARD

**Molly Murnane**, *BS Energy Resource Management and Development; Energy and Environmental Systems Concentration*

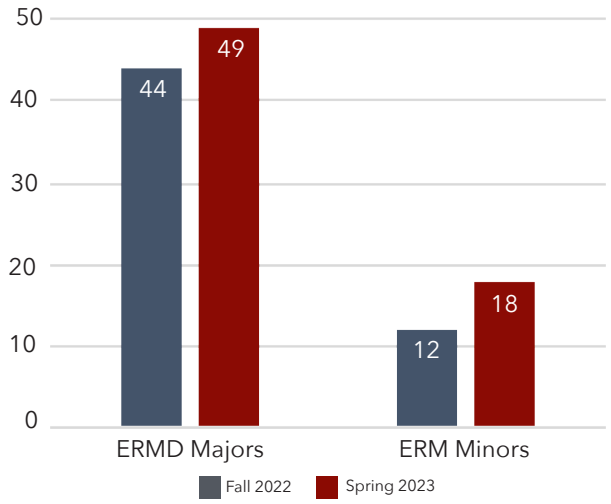
### FINALIST, 2023 AMERICAN ASSOCIATION OF PROFESSIONAL LANDMEN (AAPL) OUTSTANDING GRADUATE AWARD

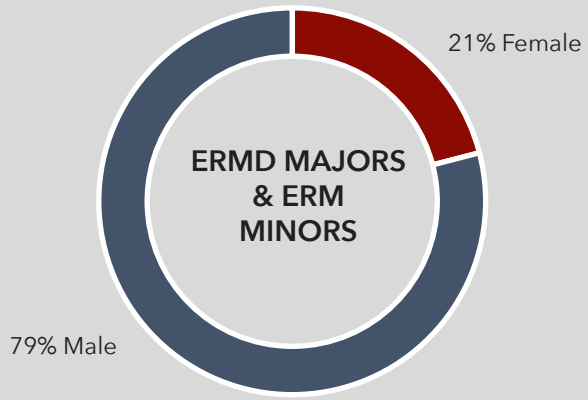
**Kieran McMullen**, *BS Energy Resource Management and Development; Professional Land Management Concentration*

**100%** Employment within six months of graduation, or placement in a graduate or professional program.

## BY THE NUMBERS

### *Energy Resource Management and Development Major and Energy Resource Management Minor Enrollment*




## GRADUATES

SER graduated **12** total students from the ERMD degree and ERM minor in FY23. **1** student graduated in December 2022 in the EES concentration, while **9** students graduated with degrees in ERMD in spring 2022; **6** in the PLM concentration and **3** in the EES concentration. **2** students graduated with the ERM minor.


SER Executive Director Holly Krutka leads the spring 2023 graduates Dayton Reese, Elijah Vigil, Montgomery Hughes, Kieran McMullen, Michael Fenton, Molly Murnane, Shane Heavin, and Christopher Welch.

### *Energy Resource Management Minor by Department*

| MAJOR | COLLEGE | STUDENTS ENROLLED |
|---|---|---|
| *Business Economics* | *Business* | *1* |
| *Entrepreneurship* | *Business* | *1* |
| *Management* | *Business* | *1* |
| *Marketing* | *Business* | *1* |
| *Environmental Systems Science* | *Haub School of Environment and Natural Resources* | *2* |
| *Astronomy* | *Engineering and Physical Sciences* | *1* |
| *Geology* | *Engineering and Physical Sciences* | *5* |
| *Mechanical Engineering* | *Engineering and Physical Sciences* | *2* |
| *Construction Management* | *Engineering and Physical Sciences* | *1* |
| *Petroleum Engineering* | *Engineering and Physical Sciences* | *3* |

**NIELSON TEXTBOOK SCHOLARSHIPS**

Total Amount Awarded FY23 to 40 Students

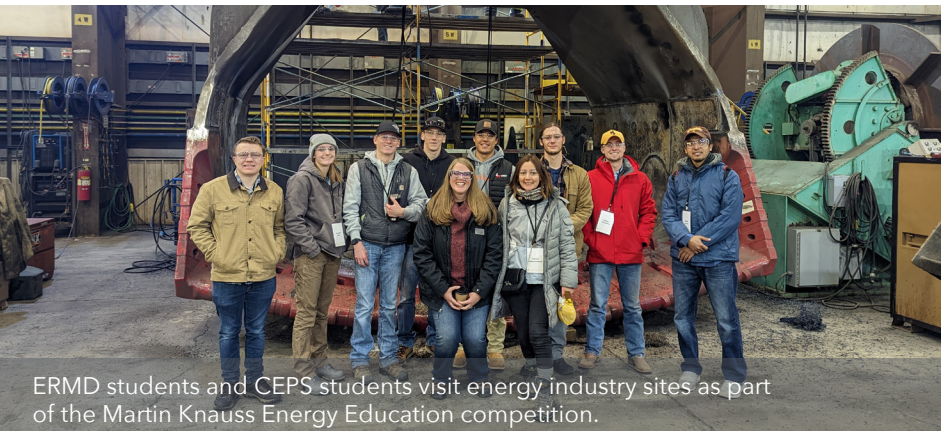
**$38,000**

## MARTIN KNAUSS EXPERIENTIAL OPPORTUNITIES

### *Martin Knauss Experiential Energy Education Competition*

During the fall, students in the University of Wyoming's School of Energy Resources (SER) and the College of Engineering and Physical Sciences (CEPS) received scholarship awards as part of the Martin Knauss Experiential Energy Education competition.

Sponsored by 1980 petroleum engineering alumnus Martin Knauss, the competition was administered jointly by SER and CEPS to help students "discover how Wyoming's natural resources can be leveraged to produce energy, in all forms, for the betterment of Wyoming and the world."



ERMD students and CEPS students visit energy industry sites as part of the Martin Knauss Energy Education competition.

Staff Engineer and UW alumnus Jack de Ryk of Trihydro, meets with Junior Geology student Colby Van Baal

### *Knauss Employment Shadowing Externship Program*

During the end of the spring semester, students in SER and CEPS participated in an employment shadowing externship program to gain insights into a professional environment.

Further supported by a gift from Knauss, six students from both the undergraduate and graduate levels spent between four and eight hours during the month of April shadowing employees at the Laramie offices of energy and environmental companies Trihydro Corporation and Millipore Sigma.

The experience allowed students the opportunity to observe real world practices, ask questions, and engage in discussions on various issues with members of the industry.

## AT THE INTERSECTION OF EDUCATION, RESEARCH AND OUTREACH

### *UW Student Works to Advance Hydrogen Feasibility With SER and Williams*

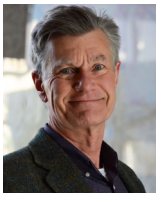
A feasibility study led by energy infrastructure company Williams – in conjunction with SER – advanced with the help of ERMD undergraduate student Jacob Schneider. As part of the study, Schneider created a modeling story map to help Williams identify the best site for the possible location of a hydrogen electrolysis plant. Working as a research assistant in SER's Center for Economic Geology Research, Schneider performed a geospatial analysis to identify areas containing all of the necessary infrastructure and resources near Wamsutter and Opal ideally suited for a plant.

*"It has been rewarding to know that I am working on a topic that is going to make a tangible impact in the immediate future. It also has been really valuable to learn from the other people who work here and on the project." ~Jacob Schneider*

# SER FACULTY

## COLLABORATIVE SOLUTIONS

*SER recruits and retains multidisciplinary faculty with expertise relevant to Wyoming's energy industry. Housed in 6 different departments across 4 UW Colleges and Schools, professors in the School of Energy Resources are internationally recognized energy experts who are actively involved in both energy research and teaching. Committed to achieving top learning outcomes, SER faculty develop students' curiosity and capacity for complex problem solving.*



***Professor John Kaszuba*** was named a 2023 recipient of the UW Foundation Stewardship Award. The Award recognizes commitment to providing high-quality stewardship through meaningful and personalized interactions with donors, students, and faculty.

***Professor Tara Righetti*** was named the Occidental Chair in Energy and Environmental Policies. She was also selected to serve on the White House Council on Environmental Quality task force for Carbon Dioxide Capture, Utilization, and Sequestration on Federal Lands and Outer Continental Shelf Permitting.

***Professor Soheil Saraji*** co-wrote a book examining blockchain technology and its applications in the energy industry.

***Professor Kam Ng*** was named a recipient of one of the inaugural Provost Term Professorships at the University of Wyoming. Nominees were exemplary faculty whose scholarship, creative activity, research or community-engaged contributions are on a very positive trajectory.

***Professor Haibo Zhai*** published a study on brackish or salty groundwater that has the potential to replace fresh water for cooling coal- and natural gas-fired power plants in the journal *Nature Water*.

***Professor Dario Grana*** was the recipient of the Thomas Jefferson Research Award from the French-American Cultural Exchange (FACE) Foundation, and his work in the Bayesian Learning Consortium led to new modeling methods that were published in *Geophysics and Mathematical Geosciences*.

***Professor Maohong Fan*** was awarded three U.S. patents in the last year.

## FACULTY MEMBERS

**Tim Considine**, SER Professor of Economics

**Craig Douglas**, SER Professor of Mathematics

**Maohong Fan**, SER and Carell Family Energy and Petroleum Professor of Chemical and Petroleum Engineering

**Subhashis Mallick**, SER Professor of Geology and Geophysics

**Bruce Parkinson**, *Emeritus* SER Professor of Chemistry

**Po Chen**, SER Professor of Geology and Geophysics

**Dario Grana**, SER Professor of Geology and Geophysics and Wyoming Excellence Chair

**John Kaszuba**, John and Jane Wold Centennial Chair in Energy, SER Professor of Geology and Geophysics

**Tara Righetti**, Occidental Chair of Energy and Environmental Policies and SER Professor of Law

**Kristopher Koski**, Director, Professional Land Management Program and Associate Lecturer

## ADJUNCT FACULTY MEMBERS

**Erica Belmont**, Associate Professor of Mechanical Engineering

**Ben Cook**, Senior Assistant Dean and Professor of Economics

**Jonathan Naughton**, Professor of Mechanical Engineering

**Soheil Saraji**, Associate Professor of Energy and Petroleum Engineering

**Temple Stoellinger**, Professor of Environment and Natural Resources and Wyoming Excellence Chair

**Haibo Zhai**, Roy & Caryl Cline Distinguished Chair in Engineering and Professor of Civil and Architectural Engineering

**Kam Ng**, Associate Professor of Civil and Architectural Engineering

**Mary Lou Dunzik-Gougar**, Associate Professor of Nuclear Engineering, Idaho State University

# SELECT FACULTY PUBLICATIONS

**D. Grana**, L. de Figueiredo, and K. Mosegaard, 2023, Markov chain Monte Carlo for seismic facies classification, *Geophysics*.

Qomi M., Q. Miller, S. Zare, H.T. Schaef, **J. Kaszuba**, and K.M. Rosso. 2022. Molecular-Scale Mechanisms of $CO_2$ Mineralization in Nanoscale Interfacial Water Films. Nature Reviews Chemistry 6, no. 9:598-613. PNNL-SA-169144. doi:10.1038/s41570-022-00418-1.

Lee, E. J., Wang, W., **Chen, P**., Jiao, Z., Gong, Y., Mu, D., & Liao, W. Y. (2022). Mesh-free simulation of two-phase fluid flow in porous media based on the shock-fitting method. Journal of Petroleum Science and Engineering, 215, 110637.

**Tara Righetti** and Denis Voinot, edito, Vers une économie circulaire du carbon, REVUE JURIDIQUE DE L'ÉCONOMIE CIRCULAIRE (2022).

**TJ Considine**, **TK Righetti**. Oil and gas development of US onshore federal lands: policy issues and research questions. A Research Agenda for Energy Politics, 261.

Chengda Li, Yueli Wen, Bin Wang, **Maohong Fan**, Wenlong Liu, Zheng Cui, Wei Huang. Enhancement of catalytic activity of PAI-NaX catalyst for side-chain alkylation of toluene with methanol: Effects of dehydrogenation component Cu, *Fuel*, Volume 354,2023,129271, ISSN 0016-2361, https://doi.org/10.1016/j.fuel.2023.129271.

M. Liu, Divakar Vashisth, **D. Grana**, and T. Mukerji, 2023, Joint inversion of geophysical data for geologic carbon sequestration monitoring: a differentiable physics-informed deep learning model, *Journal of Geophysical Research: Solid Earth*.

Liao, W. Y., Lee, E. J., Chen, D. Y., **Chen, P**., Mu, D., & Wu, Y. M. (2022). RED-PAN: Real-Time Earthquake Detection and Phase-Picking With Multitask Attention Network. *IEEE Transactions on Geoscience and Remote Sensing*, 60, 1-11.

H Yu, S Kharel, C Lau, **K Ng**, Development of high-strength and durable coal char-based building bricks, *Journal of Building Engineering* 74, 106908.

T. Ji, **H. Zhai**, C. Wang, C.M. Marin, W.C. Wilfong, Q. Wang, Y. Duan, R. Xia, F. Jiao, Y. Soong, F. Shi, M. Gray, Energy-efficient and water-saving sorbent regeneration at near room temperature for direct air capture, Materials Today Sustainability, Volume 21, 2023, 100321, ISSN 2589-2347, https://doi.org/10.1016/j.mtsust.2023.100321.

Q. Hu+, K. Innanen, and **D. Grana**, 2023, Feasibility of seismic time-lapse monitoring of $CO_2$ with rock physics parameterized full waveform inversion, *Geophysical International Journal*.

T. Ji, **H. Zhai**, C. Wang, J. Culp, C.M. Marin, H.P. Paudel, W.C. Wilfong, Y. Duan, R. Xia, F. Jiao, B. Kail, Q. Wang, Y. Soong, F. Shi, M. Gray, Microwave-accelerated regeneration of a non-aqueous slurry for energy-efficient carbon sequestration, *Materials Today Sustainability*, Volume 19, 2022, 100168, ISSN 2589-2347, https://doi.org/10.1016/j.mtsust.2022.100168.

R. Miele+, L. Azevedo, **D. Grana**, L. Varella, and B. Barreto, 2023, Iterative geostatistical seismic inversion with rock physics constraints for permeability prediction, Geophysics.

# RESEARCH SUMMARY

*SER's research programs focus on maximizing energy production, minimizing environmental footprint, and leading technology innovation, always to benefit the state. Through its Centers of Excellence (COE), SER bridges the gap between academia and industry – and ensures deployment of technology and policy solutions.*

### *What is a Center of Excellence?*

COEs are mechanisms to bring together faculty and graduate students from multiple disciplines to develop important energy research programs. With SER funding, the COEs are expected to capture external funds and attain financial independence within a few years. COEs evolve with time; new groups may form to work on emerging challenges, while some centers may disband as their programs are completed.

**In FY23, the research team completed and submitted project proposals for funding opportunities totalling in excess of $90 million.**

## NEW RESEARCH AND PROPOSALS

### *The Mowry Project*

The SER research team launched a new initiative to investigate Wyoming's Mowry Shale Formation. The Mowry Shale is the largest hydrocarbon source for the Lower Cretaceous petroleum system in the Powder River Basin (PRB). In 2009 the USGS estimated that 116–307 million barrels of undiscovered oil and gas reserves lie in the Mowry Petroleum System in the PRB. However, the Mowry Petroleum System has only rarely been a direct focus of unconventional oil and gas exploration and production.

SER initiated two rounds of seed funding opportunities internal to UW with the aim of improving production and increasing reserves.

Mowry Shale core samples

## WHO WE ARE

**Scott Quillinan**, Senior Director of Research

**John Litynski,** SER Senior Advisor

**Tiffany Bishop,** Project Specialist

**David Lucke,** Project Specialist

## CENTERS OF EXCELLENCE

**The Center for Economic Geology Research**, Directed by J. Fred McLaughlin

**The Center for Energy Regulation & Policy Analysis**, Directed by Kara Fornstrom

**The Center for Carbon Capture and Conversion**, Directed by Trina Igelsrud Pfeiffer

**The Shell 3D Visualization Center**, Managed by Kyle Summerfield

**The Hydrogen Energy Research Center**, Directed by Eugene Holubnyak

## FACULTY-LED CENTERS OF EXCELLENCE

**The Nuclear Energy Research Center**, Directed by Tara Righetti and Caleb Hill

**The Center for Produced Water Management**, Directed by Jonathan Brant

**The Center for Air Quality**, Directed by Shane Murphy

**The Wind Energy Research Center**, Directed by Jonathan Naughton

**The Center for Biogenic Natural Gas Research**, Directed by Michael Urynowicz

## PARTNER RESEARCH ORGANIZATIONS

**Enhanced Oil Recovery Institute**, Directed by Lon Whitman

## WYOMING INTEGRATED TEST CENTER

Management of the Wyoming Integrated Test Center (ITC) was added to the research portfolio of the of the School of Energy Resources. Formerly under the purview of the Wyoming Energy Authority, the ITC is a carbon capture and utilization test center located at Basin Electric Power Cooperative's Dry Fork Station near Gillette. Opening its doors in 2018, the center provides space for researchers to test carbon capture, utilization and storage technologies using actual coal-based flue gas.

In addition to raising the profile of Wyoming as a leader in carbon capture, utilization and storage technologies and research, testing conducted at the facility will help support jobs and both local and state economies – and, in the long term, will help electricity generation remain reliable and affordable through the implementation of promising technologies tested at the site, paired with Wyoming's abundant natural resources. The work at the ITC complements SER's mission to advance energy-driven economic development for the state.


### *Tenant Groundbreaking Ceremony*

Current ITC tenants Kawasaki Heavy Industries (KHI) and its partner, Japan Carbon Frontier Organization (JCOAL), and California-based Membrane Technology and Research (MTR) broke ground on their respective projects in a ceremony at the facility in May.

KHI and JCOAL are working to advance their solid sorbent capture technology, while MTR will begin its membrane carbon capture technology project as part of the U.S. Department of Energy's large-scale pilot carbon capture program. Notably, MTR is collaborating with Wyoming stakeholders on several projects, including a large-scale front-end engineering design study and the Wyoming CarbonSAFE project led by SER, focused on commercial-scale $CO_2$ storage.

ITC WYOMING INTEGRATED TEST CENTER

# FACULTY-LED CENTERS OF EXCELLENCE

## NUCLEAR ENERGY RESEARCH CENTER (NERC)

*NERC is focused on interdisciplinary nuclear-energy capacity building across the UW community, and cultivating new resources in nuclear research.*

### *RENEW Conference*

NERC hosted the Research Explorations for Nuclear Energy in Wyoming (RENEW) Academic workshop. Led by NERC co-Directors Tara Righetti and Caleb Hill, the event brought together experts in advanced nuclear energy topics from federal agencies, national labs and higher education institutions with the aim of facilitating discussions on emerging research needs, partnership opportunities, challenges and best practices in nuclear research, and resources available to researchers.

### *Faculty Advancement Grant*

The U.S. Nuclear Regulatory Commission's (NRC) Office of Nuclear Regulatory Research announced the University of Wyoming as a recipient for a Faculty Development Advancement Award as part of the NRC's University Nuclear Leadership Program. The $600,000 award is intended to support new faculty in the nuclear-related fields of nuclear engineering, health physics and radiochemistry, and it advances the NRC's goal of focusing on university-led projects that complement current and future research needs. SER will augment the funding with an additional $100,000.

### *Nuclear Chemistry Core Facility*

UW was selected to receive a $300,000 award from the U.S. Department of Energy (DOE) to support the establishment of a nuclear chemistry core facility on campus. Once established, the lab will facilitate nuclear-focused educational opportunities for UW students.

### *Request for Proposals on Nuclear-related Research Projects*

SER released a request for proposals to UW faculty, researchers, and staff for a funding opportunity on nuclear-related research projects as part of an initiative to grow nuclear research capacity among the campus community.

Three research proposals were chosen to receive seed funding under the RFP that could be used to bolster either laboratory-based nuclear research or submissions to support research, or personnel focused on producing papers, data or other output to support a nuclear industry built in Wyoming.

Dr. Kathryn Huff, assistant secretary for the Office of Nuclear Energy in the U.S. Department of Energy gave the RENEW keynote address.

Nuclear seed -funding recipients from left to right: Charlie Zhang, Caleb Hill and Brad Carr.

## NERC PUBLICATIONS

- Aumeier, Steven E., Shropshire, David E., Araújo, Kathleen, Koerner, Cassie, Bell, Christi, Fauske, Gretchen, Johnson, Richelle, Parsons, John, Gerace, Selena, Holubynak, Eugene, & Righetti, Tara. *Microreactor Applications in U.S. Markets: Evaluation of State-Level Legal, Regulatory, Economic and Technology Implications.* United States. https://doi.org/10.2172/1964093
- NERC released five white papers on nuclear-related topics relevant to Wyoming. They can be downloaded from the NERC webpage.

**CENTER OF EXCELLENCE FOR AIR QUALITY (CAQ)**:

*The CAQ is involved in research concerning emissions from oil and gas exploration and production activities, and methane monitoring and mapping technology.*

### *New Project: Methane Emission Measurements in Wyoming and Colorado Basins*

The CAQ will help conduct research to accurately depict methane emissions from oil and gas supply chains in Wyoming and Colorado basins. The U.S. Department of Energy's Office of Fossil Energy and Carbon Management selected the Colorado State University (CSU) Energy Institute's Methane Emissions Program to lead the project.

With intentions to advance innovative methane measurement, monitoring and mitigation technologies, the collaborative team of CSU, UW and Penn State University aims to demonstrate that high-frequency sampling can be used to create inventory emissions estimates that accurately represent emissions in a basin.

While the project will focus on the Denver-Julesburg Basin in Colorado, an important component will be to demonstrate that the methods developed in one basin can be replicated in other basins with equal success. UW's CAQ project team plans to lead a secondary study under the scope of the project in Wyoming's Upper Green River Basin to demonstrate the relevance and applicability of the approach. The CAQ has long-standing relationships with Wyoming natural gas producers in the Basin.

The School of Energy Resources is providing the cost share to help enable the expanded scope.

**WIND ENERGY RESEARCH CENTER (WERC)**:

*WERC is a collaboration with the College of Engineering and Applied Science dedicated to improving wind energy technology and its applications in Wyoming.*

### *New Project: Supercomputer Wind Modeling*

A collaboration between University of Wyoming researchers and a wind energy company has provided new insights into the use of high-performance computing to predict wind resources.

A team led by Michael Stoellinger, an associate professor in UW's Department of Mechanical and Energy Systems Engineering and co-director of the Wind Energy Research Center, compared sophisticated computer simulations of wind flow with data recorded at the Power Company of Wyoming's Sierra Madre wind farm site near Rawlins. The research was selected as a featured article in the Journal of Renewable and Sustainable Energy.

### *New Project: WIND Toolkit*

Ph.D. student Sarah Buckhold started to use the new WIND Toolkit Long-Term Ensemble Dataset (WIND TKE-LED) database that she has helped create with previous funding from SER, the National Renewable Energy Laboratory (NREL), and the NCAR-Wyoming Supercomputing Center (NWSC).

- Sarah proposed a study for using stranded wind energy for hydrogen production to the SER Hydrogen Center, and the proposal was selected for an award.

- Sarah used the WIND TKE-LED database to support the initial wind resource assessment for a potential wind project on coal mines in Wyoming owned by the Prairie Eagle Companies.

WERC Produced 6 publications during FY23

## CENTER OF EXCELLENCE FOR PRODUCED WATER MANAGEMENT (CEPWM):

*CEPWM provides innovative science and engineering research for application in energy industries that are economical and sustainable.*

-- CEPWM researchers competed in the Geothermal Lithium Extraction Prize for developing new technologies for the recovery of lithium from brines. This effort focused on developing covalent organic framework (COF) based membranes for deployment in an electrochemical separation process. The COF membranes were designed to be selective for lithium over sodium, where the latter is the most prevalent cation in brine solutions. The Wyoming team made it to the second round of the competition.

-- CEPWM researchers continued working on the development of a new magnetic system that can improve water permeance across membranes used in desalination applications. This outcome ultimately reduces the energy that is required for desalination and is viewed as an avenue for making desalination more practical for small communities, like those in Wyoming. A new start-up company, Wyoming Water Innovations, LLC was spun out of this work to commercialize this new technology.

-- CEPWM researchers continue a National Science Foundation supported project focused on the development of COF membranes for desalination applications.

## CENTER FOR BIOGENIC NATURAL GAS RESEARCH (CBNGR):

*CBNG develops and commercializes technologies to enhance the production of renewable, clean-burning natural gas using indigenous microorganisms.*

Cowboy Clean Fuels, a premier energy technology company formed to produce carbon-negative, renewable natural gas ("RNG") from readily available waste agricultural byproducts announced the closing of a $7.5 million Series A financing led by Machan Investments, LLC and advised by Syren Capital, LLC. The capital will be used to clear regulatory pathway objectives, provide initial engineering design and prepare for the Company's initial commercial-scale project launch in the Powder River Basin of Wyoming.

The Company's proprietary technology was developed by Cowboy Clean Fuels Co-Founder and Chief Technology Officer, Dr. Michael Urynowicz, Ph.D, at, and exclusively licensed from, the University of Wyoming's Center for Biogenic Natural Gas Research.

## CEPWM PUBLICATIONS

- Seyyedi, M., Wu, T., and Brant, J.A., Ion Dehydration Using Magnetic Fields and Impacts on Permeability Across RO Membranes, *Journal of Membrane Science*, Vol. 668, 2023, 1-10.
- Heinz, S., Heinz, J., and Brant, J.A., Mass Transport in Membrane Systems: Flow Regime Identification by Fourier Analysis, *Fluids*, Vol. 7(12), 2022, 369.
- Butler, E. and Brant, J.A., Emulsion Separation and Fouling of Electrospun Polyacrylonitrile Membranes for Produced Water Applications, *Separation and Purification Technology*, Vol. 306, 2023, 1-14.

# CENTERS OF EXCELLENCE

## CENTER FOR ECONOMIC GEOLOGY RESEARCH

*The mission of the Center for Economic Geology Research (CEGR) is to investigate solutions to the challenges in Wyoming's fossil fuel and mineral industries. CEGR research projects explore opportunities to use Wyoming's distinctive geology and resources in order to develop those opportunities, diversify Wyoming's economy, and to maintain competitiveness in a low-carbon fossil energy future.*


## NEW PROJECTS

### *HERO Basalt CarbonSAFE: Phase II*

Researchers in CEGR will lead the HERO Basalt CarbonSAFE (Hermiston Oregon Carbon Storage Assurance Facility Enterprise) project in partnership with Oxy Low Carbon Ventures (Oxy), Pacific Northwest National Laboratory (PNNL) and Calpine to accelerate the scale-up and deployment of commercial $CO_2$ storage in basaltic rocks at a storage complex near Hermiston, Ore.

The project was selected to receive $10.5 million from the U.S. Department of Energy for a research and development project advancing the wide-scale deployment of carbon management technologies to reduce carbon dioxide ($CO_2$) pollution.

The Pacific Northwest is a key market for Wyoming-sourced natural gas. The Northwest Pipeline that connects Wyoming natural gas resources to Washington and Oregon has over 14 million dekatherms of capacity. However, using that gas in a way that is consistent with regulatory requirements in Washington and Oregon will likely mean capturing and storing $CO_2$ emissions from gas plants such as Hermiston.

### *Sweetwater Carbon Storage Hub: CarbonSAFE Phase III*

The U.S. Department of Energy has selected UW's School of Energy Resources to receive a $40.5 million award over three years to support the development of a new and expanded large-scale, commercial carbon storage project in the Greater Green River Basin.

The project will develop the Sweetwater Carbon Storage Hub in collaboration with Frontier Carbon Solutions, LLC. This is the largest single competitive award in UW history.

In addition to the federal funding from DOE, the project will receive $10.1 million in cost sharing, bringing the total project to $50.6 million. The Wyoming Energy Authority has recommended the project to the Governor to receive funds from the Energy Matching Funds (EMF) to cover most of the cost share.

## WHO WE ARE

**J. Fred McLaughlin**, Director

**Zunsheng 'John' Jiao,** Project Manager

**Erin H.W. Phillips,** Project Manager

**Davin Bagdonas,** Research Scientist/Coal and Rare Earth Elements

**Charles Nye**, Associate Research Scientist/ Aqueous Geochemistry

**Bob Gregory**, Associate Research Scientist/ Geochemistry

**Matthew Johnson**, Research Scientist/ Geomodeling

**Ying Yu**, Research Scientist/Reservoir Engineering

**Selena Gerace**, Associate Research Scientist/Community Engagement and Policy

**Madeleine Lewis**, Assistant Research Scientist/Law and Policy

**Grant Copeland**, Assistant Research Scientist/Geochemistry

**Lily Jackson**, Assistant Research Scientist/ Regional Geology

**Tao Bai**, Assistant Research Scientist/ Geostatistical Modeling and Machine Learning

## CARBON CAPTURE, STORAGE AND UTILIZATION

### *Wyoming CarbonSAFE Project: Phase III*

The Wyoming CarbonSAFE project is CEGR's flagship carbon capture, utilization and storage (CCUS) project, working to advance a commercial-scale $CO_2$ storage complex near the Dry Fork Power Station north of Gillette, Wyoming.

Currently nearing the end of Phase III, the Wyoming CarbonSAFE team worked to complete an "extended" Phase III package, and submitted an expanded scope of work and budget to DOE project management. This will result in project readiness relative to Phase IV entry requirements.

### FY23 Technical Accomplishments

- ☑ Crosswell seismic testing conducted between the two completed wells to acquire microseismic signatures associated with injection activities.
- ☑ Field injection well test data was processed and analyzed.
- ☑ Completed applications for a total of 10 Class VI permits to anticipate the storage needs of $CO_2$ captured from Dry Fork Station at commercial-scale.


Completed well head of UW PRB#2, one of two wells drilled to Class VI standards as part of the Wyoming CarbonSAFE project.

## SELECT CEGR PUBLICATIONS


- Montross SN, Bagdonas D, Paronish T, Bean A, Gordon A, Creason CG, Thomas B, Phillips E, Britton J, Quillian S, et al. On a Unified Core Characterization Methodology to Support the Systematic Assessment of Rare Earth Elements and Critical Minerals Bearing Unconventional Carbon Ores and Sedimentary Strata. *Minerals*. 2022; 12(9):1159. https://doi.org/10.3390/min12091159
- Ying Yu, Sumaiya Farzana, Charles Nye, Davin Bagdonas, Prashant R. Waghmare, Zunsheng Jiao, Jonathan Fred McLaughlin, Wettability variation and its impact on CO2 storage capacity at the Wyoming CarbonSAFE storage hub: An experimental approach, Fuel, Volume 344, 2023,128111,ISSN 0016-2361,https://doi.org/10.1016/j.fuel.2023.128111.
- Kou, Zuhao. "Impacts of Carbonated Brine-Rock Reactions on Multiphase Flow Properties in Upper Minnelusa Sandstone: Implication for $CO_2$ Storage." Paper presented at the SPE Annual Technical Conference and Exhibition, Houston, Texas, USA, October 2022. doi: https://doi.org/10.2118/212389-STU

## RARE EARTH ELEMENTS AND CRITICAL MINERALS

### *CORE-CM (Carbon Ore, Rare Earth and Critical Minerals)*

The DOE-awarded projects are part of a national strategy to finding alternative domestic sources of rare earth elements and critical minerals, as well as to focus on expanding and transforming the use of coal and coal-based resources to produce coal-based products using carbon ore.

The SER-led projects in the Greater Green River and Wind River Basin (GGRB-WRB) and the Powder River Basin (PRB) have continued to build expansive networks of stakeholders in order to assess the feasibility of a new rare earth and critical mineral industry in Wyoming.

Teams for both projects have compiled all available resources and infrastructure data pertaining to building out a CORE-CM industry, as well as conducted resource assessments. Each project held an annual forum in fall 2022 to provide updates and encourage participation from regional stakeholders in industry, academia, and local government agencies.

***CORE-CM GGRB-WRB***
The project was selected for additional funding and a 6-month timeline extension from DOE.
*Anticipated project completion date:* **2/28/24**

***CORE-CM PRB***
The project was selected for additional funding and a 12-month timeline extension from DOE.
*Anticipated project completion date:* **8/31/24**

### *A Machine Learning Screening Tool for Rare Earth Elements and Critical Minerals at the Mine Scale*

SER is partnered with Los Alamos National Laboratory and the WyoDak Mine on a DOE-funded Technology Commercialization Fund project that will advance understanding of critical mineral occurrence and distribution at the mine scale.

The project complements the efforts of the CORE-CM projects to assess and model critical minerals at the basinal scale.

## COLLABORATIVE SUPPORT

### *Hydrogen Storage Projects*

CEGR completed feasibility assessments and modeling of the $CO_2$ storage potential for the proposed Blue Bison ATR Plant operated by Tallgrass.

CEGR supported the Williams Southwest Wyoming Hydrogen Hub project by providing an analysis of produced water source for potential use in the project.

### *Mineral Enrichment Processes within the Silver Crown Mining District*

CEGR worked with the UW Department of Geology and Geophysics to determine the petrogenesis of US Gold Corp's mining venture west of Cheyenne. A graduate student collected and processed samples to determine the history of the copper and silver deposits.

### *Mowry Shale Geologic Database*

CEGR began development of a database for the Mowry Shale in the PRB, mapping the Mowry structure and stratigraphy across the basin. The tool will characterize the properties of the geologic formation.

### *Natrium Geotechnical Assessment*

Colleagues from CEGR and the Department of Geology and Geophysics completed an initial report of the geologic character of the site proposed for the future nuclear plant in Wyoming. The data will be used to develop and identify the safest building materials and construction strategies for the plant foundation and infrastructure.

# CENTERS OF EXCELLENCE

## CENTER FOR ENERGY REGULATION AND POLICY ANALYSIS

*The primary function of Center for Energy Regulation and Policy Analysis (CERPA) is to produce meaningful, high-quality, impartial analysis to inform policymakers, stakeholders and the public about issues critical to the economic development of Wyoming's energy resources.*

## STAFFING

In FY23, CERPA expanded its research team, including new leadership to expand develop the vision and strategy of the center. Kara Brighton Fornstrom, a prominent natural resources attorney and regulatory policy expert, joined the center as the new director.

Fornstrom leads a team of research scientists and attorneys to monitor and evaluate existing legislative and regulatory issues relating to energy development issues in the State, and to serve as a resource for decision-makers at the local, state, regional and national levels.

CERPA also welcomed Madeleine Lewis to the research team. A Wyoming licensed energy and natural resources attorney in Wyoming, Lewis conducts legal policy research and public outreach in support of SER's mission.

## WHO WE ARE

**Kara Fornstrom, Esq.,**
Director

**Madeleine Lewis, Esq.,**
Assistant Research Scientist

**Selena Gerace,**
Assistant Research Scientist

### *Plains $CO_2$ Reduction (PCOR) Partnership:*

SER continues to partner with the Energy & Environmental Research Center at the University of North Dakota on various research projects to accelerate the commercial deployment of CCUS as part of a regional partnership.

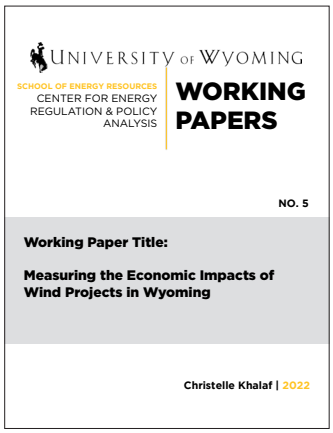
The region includes ten states (Alaska, Iowa, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, Wisconsin, and Wyoming) and four Canadian provinces (Alberta, British Columbia, Manitoba, and Saskatchewan).

## *Publications and Resources*

### Working Papers

Intended as a platform to solicit academic feedback prior to publication, the working paper series features articles, book chapters, and reviews in various stages of completion in the area of energy regulation and policy. Papers in the series have not yet undergone the peer review process.

In FY23, CERPA and the Center for Business and Economic Analysis (CBEA) released a working paper measuring the economic impacts of future wind energy deployment scenarios in Wyoming, including potential income from federal revenue-sharing if such a provision were adapted for renewables. In addition, the working paper investigates the permitting process of wind projects and notes the significantly increased project timeline when siting on federal land.

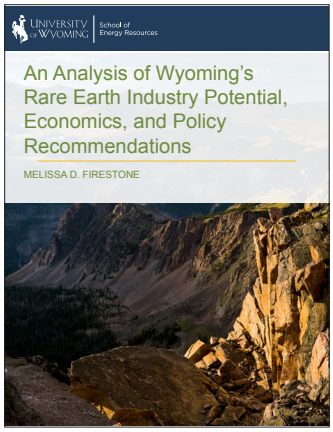



### Resource Papers

CERPA published papers are resources meant to inform lawmakers, the public and industry in Wyoming on potential policy issues, pitfalls, or relevant topics of interest related to energy production and mineral development. Resource papers may be targeted studies or a comprehensive analysis of surveys conducted in the State as they relate to energy issues.

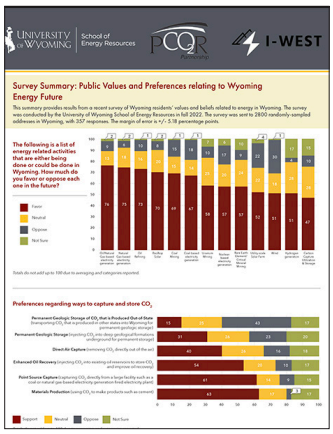
#### *An Analysis of Wyoming's Rare Earth Industry Potential, Economics, and Policy Recommendations*

CERPA published a second resource paper analyzing the economic viability of a Rare Earth Element (REE) and Critical Mineral (CM) industry in Wyoming. The paper is the second in a two-part series authored by energy economist Melissa Firestone, working under contract with CERPA. The first paper aimed to provide a base understanding of REE, the REE production and extraction process, and an overview of the global REE market.




#### *Survey Summary: Public Values and Preferences Relating to Wyoming's Energy Future*

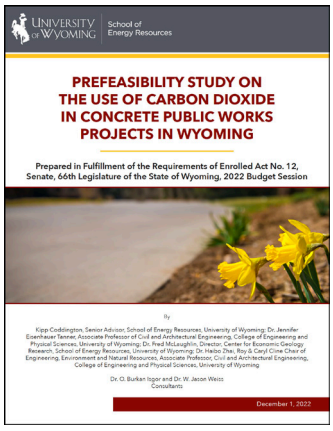
An updated survey from CERPA explores Wyoming residents' perspectives of energy development, including "social license" – the level at which Cowboy State residents support or oppose different forms and amounts of energy development. The study provides a summary of Wyoming residents' values and beliefs related to energy in Wyoming, including new and emerging energy technologies.




#### *Prefeasibility Study on the Use of Carbon Dioxide in Concrete Public Works Projects in Wyoming*

*Prepared in Fulfillment of the Requirements of Enrolled Act No. 12, Senate, 66th Legislature of the State of Wyoming, 2022 Budget Session.*

This prefeasibility study examines the potential use of carbon dioxide ($CO_2$) in concrete for public works projects in Wyoming, focusing on coal-fired electric generating units (EGU) as the $CO_2$ source(s).



# CENTERS OF EXCELLENCE

## CENTER FOR CARBON CAPTURE AND CONVERSION

*The mission of the Center for Carbon Capture and Conversion (CCCC) is to develop new high-volume uses for coal and to explore new opportunities in an evolving carbon market. CCCC delves into the potential marketable properties of higher-value coal products from Wyoming coal. The technologies and products developed in CCCC are focused on large-scale, commercial application.*

## STAFFING

Long-time CCCC Director Richard Horner retired in April 2023. Trina Igelsrud-Pfeiffer took the helm of the Center as the new director.

## THERMO-CHEMICAL PROCESS TECHNOLOGY

The CCCC has continued to advance its thermo-chemical process technology to efficiently decompose Powder River Basin coal which yields high-value liquids and solids that are then used to create environmentally friendly, non-energy products.

Both processes are at a critical juncture in which scale-up is necessary in order to produce enough feedstock material for downstream manufacturing research.

### *Fast Pyrolysis Processing*

The byproduct of the pyrolysis process yields coal char, which is used to manufacture useful products such as building materials and soil amendments.

### *Thermal Coal Solvent Extraction*

The byproduct of the solvent extraction process yields a liquid feedstock, which is used to manufacture useful products such as coal-based asphalt binder.

## WYOMING INNOVATION CENTER

The CCCC executed a lease at the Wyoming Innovation Center (WyIC) to advance technologies that consume Wyoming natural resources, including coal processing technology, in the large research complex.

## WHO WE ARE

**Trina Igelsrud-Pfeiffer**,
Director

**Stefan Holberg**,
Associate Research Scientist

**ChooiKim Lau**,
Assistant Research Scientist

## UW FACULTY PRINCIPAL INVESTIGATORS

**Kam Ng**, Associate Professor of Civil and Architectural Engineering

**Peter Stahl**, Professor Emeritus of Ecosystem Science and Management

**Patrick Johnson**, Department Head and Professor of Chemical Engineering

**Erica Belmont**, Associate Professor of Mechanical Engineering

**Jing Zhou**, Professor of Chemistry

**Michael Stoellinger**, Associate Professor of Mechanical Engineering

**John Oakey**, Professor of Chemical Engineering

**Jonathan Brant**, Professor of Civil and Architectural Engineering

## RESEARCH AFFILIATES

**Jeramie Adams**, Western Research Institute

**Marie Dudgeon**, Research Consultant

**Paul Behrens**, Research Consultant

## COAL TO PRODUCTS FIELD DEMONSTRATION SHOWCASES

### *Coal Derived Building & Construction Products*

The CCCC collected performance data of its coal-derived bricks on the demonstration house through four seasons. Preliminary data has been encouraging in comparison to the clay brick demonstration house. The coal-derived bricks show improved energy efficiency, noise reduction, and promising weathering properties.

Meanwhile, continued innovation yielded a higher char content "generation 2" brick with improved manufacturing. In FY24, the first generation bricks will be removed from the demonstration house and replaced by second generation bricks for a year of seasonal testing to collect performance data.

Other building materials such as coal char insulation foam and carbon structural units are being evaluated for scale up and economic viability.

### *Agricultural & Soil Fertility Products*

Researchers in the CCCC completed a second harvest of crops testing coal-derived soil amendments. In October 2022, a sugar beet crop was harvested at the Powell Research and Extension Center (PREC) in Powell, Wyo., followed by a harvest of corn at the at James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in November. The field studies are being conducted to test the novel coal-char soil amendment product against industry-used biochar, and are being led by Resham Thapa, from Pyuthan, Nepal, a Ph.D. candidate in the UW College of Agriculture and Natural Resources.

In partnership with Peabody, the CCCC is working on a reclamation project utilizing the coal derived soil amendment at the North Antelope Rochelle Mine near Gillette, Wyoming.

### *Coal-Based Asphalt Products*

Led by scientists at Western Research Institute (WRI), a baseline formulation of coal-derived asphalt (COphalt) has been produced using the extract intermediate that is yielded from solvent extraction of raw Powder River Basin coal. COphalt is a green alternative to petroleum-based asphalt and can be customized to suit the properties required for either whole paving or roofing applications.

## SELECT CCCC PUBLICATIONS


- Hossain, M.T., Lau, C., Yu, H. et al. Development of coal-derived carbon-based structural unit as a potential new building material. *Journal of Material Sciences*, 58, 757–772 (2023). https://doi.org/10.1007/s10853-022-08129-0

# CENTERS OF EXCELLENCE

## HYDROGEN ENERGY RESEARCH CENTER

*The mission of the Hydrogen Energy Research Center is to identify and quantify the relative competitive advantages of Wyoming in an emerging low-carbon hydrogen economy. $H_2$ERC focus on all forms of clean hydrogen with: low-cost coal via gasification, massive natural gas resources via methane reforming, and relatively high-capacity wind energy via electrolysis, as well as potential for solar, nuclear, and more.*

## WHO WE ARE

**Eugene Holubnyak**,
Director

**Dayana Zhappassova**,
Research Scientist, Energy Economics

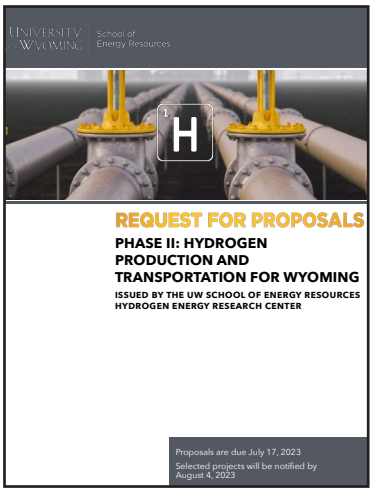
## STAFFING

$H_2$ERC is working to expand its research staff. In FY23, energy economist Dayana Zhappassova joined the research team. Originally from Karaganda, Kazakhstan, Zhappassova earned her Bachelor's degree in Finance and her Master's in Economics from the University of Wyoming. Before joining SER, she previously worked in the Peter M. & Paula Green Johnson Student Success Center at the College of Business.

## BUILDING CAPACITY AT THE UNIVERSITY OF WYOMING

### *Phase I - Hydrogen: Make, Move, Use or Store Project RFP*

In July 2022, $H_2$ERC issued a call for proposals from current UW faculty members on hydrogen energy. Topics of interest for the proposals included all levels of the supply chain, such as hydrogen production, use, transportation, and storage. Seven research proposals were chosen to receive seed funding under the opportunity and received funding for a full calendar year.




### *Phase II - Hydrogen Production and Transportation Research for Wyoming RFP*

In June 2023, $H_2$ERC issued a follow-up call for proposals from current UW faculty members on hydrogen energy with the aim of honing in research areas not covered in the initial request. Phase II proposals were requested in three areas of interest: hydrogen transportation, electrolysis hydrogen production systems, or hydrogen production from Wyoming's coal resources.

### *Hydrogen Energy Seminar Series*

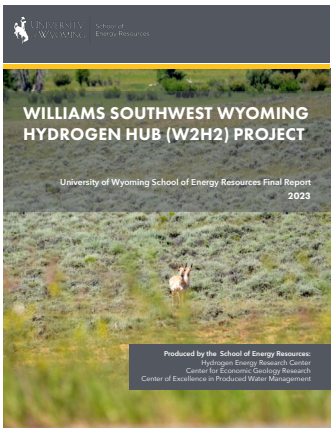
In collaboration with Cardiff University in Wales, United Kingdom, the monthly webinar series was launched to focus on emerging topics in hydrogen energy.

The series is planned for a full calendar year and will feature projects at each institution alternating months to showcase ongoing research. The partnership is intended to cultivate academic and cultural interchange, highlight research capabilities, and identify complementary expertise across the universities that will facilitate future collaborations on joint projects.

## PROJECT DEVELOPMENTS

### *Industry Research Projects*

$H_2$ERC supports multiple ongoing research projects, including blue and green hydrogen projects with Tallgrass MLP and Williams. Both projects are in the final stages, and technical reports are being prepared.




### *A Mid-Century Net-Zero Scenario for the State of Wyoming and its Economic Impacts*

In April, three technical milestone reports were submitted to DOE, and the project team reported the results at the DOE's project technical review meeting in Pittsburgh, Penn. Eugene Holubnyak, a PI for this project, has received several follow-up invitations to collaborate with national and international entities and was invited to present at the 47th International Technical Conference on Clean Energy.

### *White Papers*

$H_2$ERC organized the submission of four white papers exploring the geologic hydrogen production in Wyoming. These proposals will become a base for the future call for proposals for the Advanced Research Projects Agency-Energy (ARPA-E) Hydrogen program and the National Science Foundation Research Center.

# CENTERS OF EXCELLENCE

## SHELL 3D VISUALIZATION CENTER

*The mission of the Shell 3D Visualization (3D Viz) Center is to foster new knowledge and insight, support interdisciplinary research, and drive integration between research computing, data science, visualization, human interaction, and data-capture technologies by leveraging state and national opportunities.*

## WHO WE ARE

**Kyle Summerfield**,
Program Manager and Lead Developer

**Phil Black**,
3D Asset Developer

## CONTRACTORS

**Jerry Evans**, Mechdyne

## SELECT PROJECTS IN PROGRESS

### *Wyoming Innovation Partnership*

Kyle Summerfield, the program manager of the 3D Visualization Center, has been leading virtual reality (VR) and augmented reality (AR) integration into the state's community colleges as part of the Wyoming Innovation Partnership (WIP). Created at the request of Governor Mark Gordon, WIP is a collaboration to align education and workforce development and support innovation, entrepreneurship, and research to help drive Wyoming's economy.

Tasked with managing $2.5 million to enhance and expand Wyoming higher education institutions' capacities, Summerfield worked to integrate VR into courses, advanced the development and creation of VR applications, and coordinated the deployment of VR resources in a manner that maximizes return on investment.

The most substantial effort toward this program has been the preparation and delivery of a 3-day introduction to Virtual and Augmented Reality, data capture methods (360° photography, photogrammetry, and structured light scanning), and development environments. 35 participants from across the state's community colleges attended the training, and reception was overwhelmingly positive.

### *The Four Hills of Life and Related Language Elicitation Work*

The Four Hills of Life application (formerly called "Buffalo Roads") has seen considerable progress in FY23. The application is designed to designed to assist in language revitalization for the Northern Arapaho tribe. Three of the four modules are now completed, and several features have been added. Developments made for this project are intended to be portable and contained, allowing them to be used to create future applications with similar requirements.

## SER RESEARCH UNIT SUPPORT

### *Wyoming CarbonSAFE Project*

In support of the Wyoming CarbonSAFE project, the 3D Viz Center developed a 3D subsurface model which has been integrated into a 360° photo at the demonstration wells near the Dry Fork Station power plant. The model is an accurate representation of the subsurface into which captured carbon dioxide will be injected and stored, providing a useful informational outreach application.

### *CORE-CM (GGRB-WRB and PRB) Application*

Work was conducted on an outreach and stakeholder engagement application for these projects. Built primarily on web development tools, this application will allow for easy updates, visualizations, notification pushes, and resource centralization for both CORE-CM locations. The application is being built to work natively with the ArcGIS models already in production to produce attractive and informative informational tools relevant to the latest developments on each project. It also integrates the Pioneer Program (a workforce development and training portal produced earlier this year in collaboration with the Makerspace), a blog section with notifications, and various approaches to visualizing relevant data in a flexible, platform agnostic manner.

### *CORE-CM Makerspace Badge*

The PRB CORE-CM team, in collaboration with the Visualization Center, produced preliminary content for a Makerspace Badge on the basics of critical minerals. This outreach content is a way to connect potential employees with employers through digital credentials and will continue to be built out as the CORE-CM project progresses.

The Technology Associate Program (TAP) in the 3D Visualiztion Center is an internship program designed to train interns in virtual reality, animation, and augmentation software and techniques.

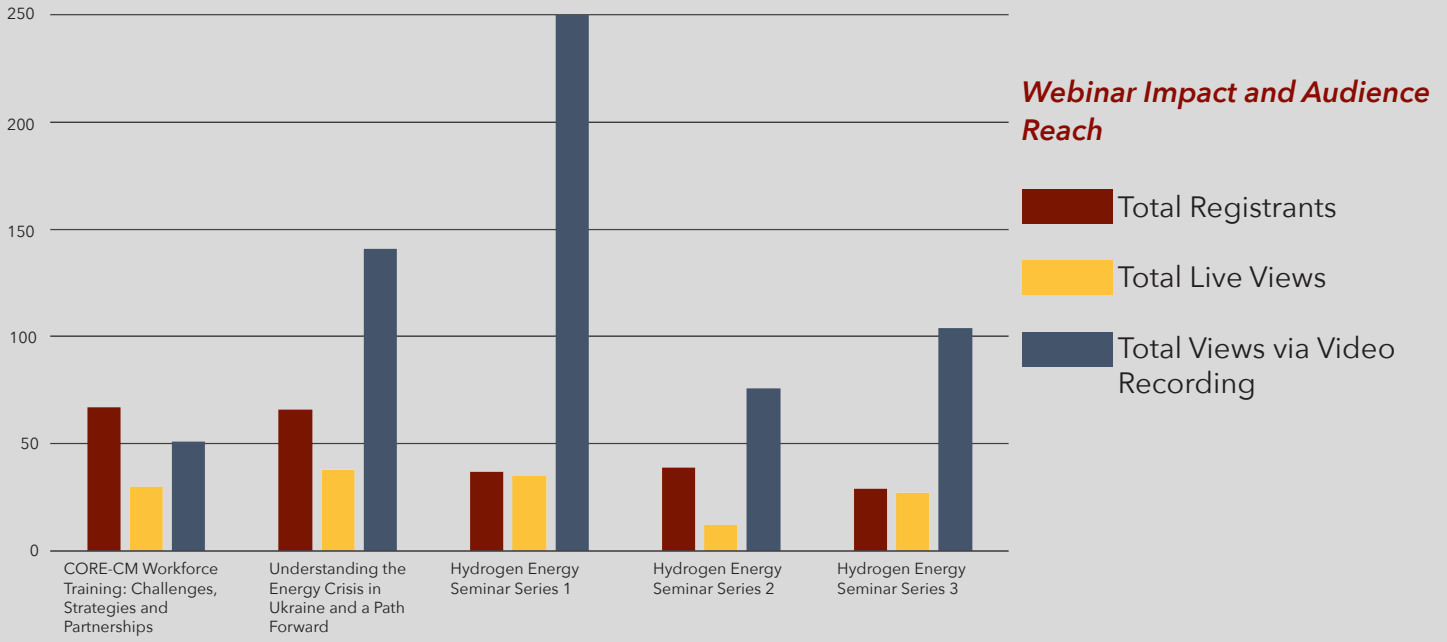
**Student Interns Trained in the TAP Program in FY23**

**6**

# OUTREACH AND ENGAGEMENT

*Outreach supports research and stand-alone efforts to engage with local, regional, national, and international stakeholders and community members on efforts within the School of Energy Resources to advance energy-driven economic development for the state of Wyoming.*

## WEBINARS




## LIVE EVENTS AND CONFERENCES

### *Wyoming's Energy Future Symposium*

The School of Energy Resources and the Wold Foundation hosted a joint symposium focused on the state's energy future. Examining different topics from an industry perspective as well as an academic perspective, the in-person forum featured leading experts across the spectrum of energy development and various state stakeholders to collaborate and learn about what comes next for energy in Wyoming.

Panels composed of industry leaders, academic experts and state administrators explored coal, oil and gas, rare earth elements and nuclear energy development in Wyoming while tackling issues related to current policy, economic and social challenges. Gov. Mark Gordon gave the keynote address.

WYOMING'S ENERGY FUTURE
Sponsored by the UW School of Energy Resources and the Wold Foundation

### *Distinguished Speaker Series*

SER Outreach brings energy leaders to campus to share cutting edge research, the latest industry trends, and expertise on new energy technologies through the Distinguished Speaker Series program. During FY23, the Distinguished Speaker Series featured 11 different speakers on varying energy topics.

### *National Lab Day*

SER featured prominently during UW's National Lab Day in conjunction with the Department of Energy. SER actively partners with national laboratories across the country to advance multiple research projects, boasting successful collaborations with the Idaho National Laboratory (INL), the Pacific Northwest National Laboratory (PNNL), the National Energy Technology Laboratory (NETL), Los Alamos National Laboratory (LANL) and the National Renewable Energy Laboratory (NREL) among others. As part of the day's activities, Researchers in the School of Energy Resources led multiple breakout sessions featured on the agenda covering areas of expertise and active projects.

## EXTERNAL VISIBILITY

Holly Krutka, the Executive Director of the School of Energy Resources testified before the U.S. Senate Committee on Energy & Natural Resources. The purpose of the hearing was to examine federal regulatory authorities governing the development of interstate hydrogen pipelines, storage, import, and export facilities.

In her testimony, Dr. Krutka provided an overview of the ongoing projects related to a hydrogen economy currently at play in Wyoming, as well as the activities of SER's Hydrogen Energy Research Center.

The committee is chaired by West Virginia Senator Joe Manchin, and the ranking member of the committee is Wyoming's Senator John Barrasso, who has served on the committee since 2007.


## CONTINUING ENGAGEMENT ACTIVITIES

- Internal Newsletter and External Quarterly Newsletter
- Electronic News Blog and Collaborative Press Releases

**News Stories and Press Releases on SER in FY23**

**83**

## WHO WE ARE

**Christine Reed**
Director of Outreach and Energy Resources Council Secretary

**Helen Qin**
Office Associate, Sr.

# FINANCIAL STATEMENT

*The financial team at SER manages the standard appropriation from the Wyoming legislature, and administers the multi-million dollar research program funded by the state, the private sector and federal cooperative agreements (aka grants).*

## WHO WE ARE

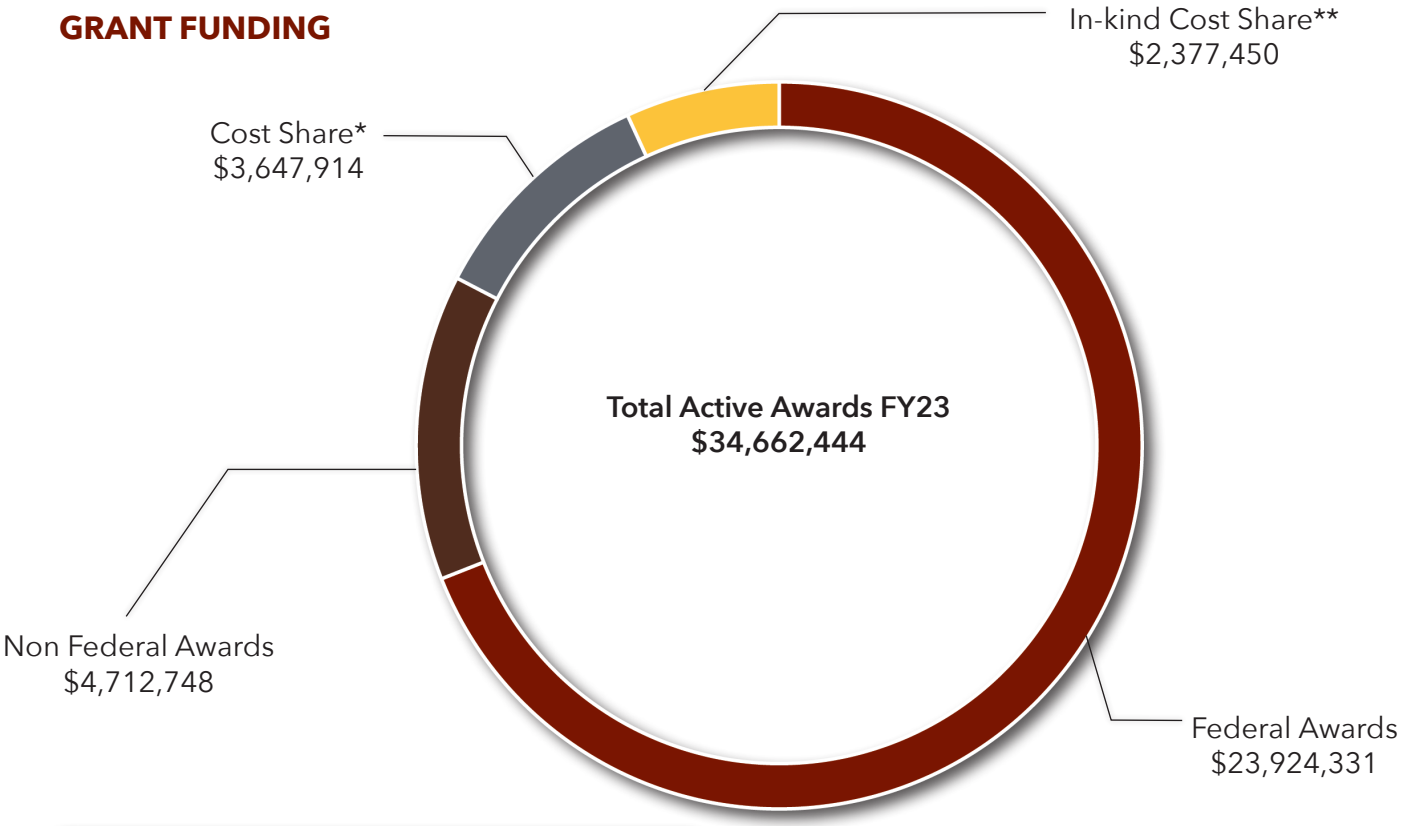
**Rachel Ferrell**,
Director of Business Operations

**Carrie Ver Burg**,
Assistant Director, Business Operations

**Cindy Ishkanian**,
Grants Manager

**Frankie Vogt**,
Business Manager

## GRANT FUNDING




**$34,662,444**

| | |
|---|---|
| **Awards Funded** | **39** |
| **UW Departments Funded** | **9** |
| **Principal Investigators Supported** | **22** |
| Internal SER P.I.s | 12 |
| External UW Dept. P.I.s | 10 |

**Cost Share - the resource contributions to a sponsored project beyond the amount funded by the sponsor. Could be from SER, industry partner, legislative support or from a state agency.*

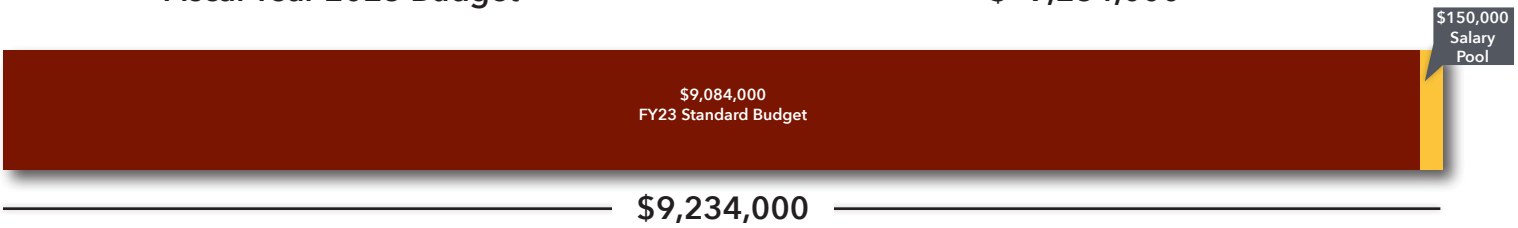
***In-kind Cost Share - contributions representing the fair market value of non-cash contributions allocated to the sponsored project such as employee labor, use of existing equipment or real property.*

# FINANCIAL STATEMENT

## STANDARD BUDGET ALLOCATION

Fiscal Year July 1, 2022 - June 30, 2023

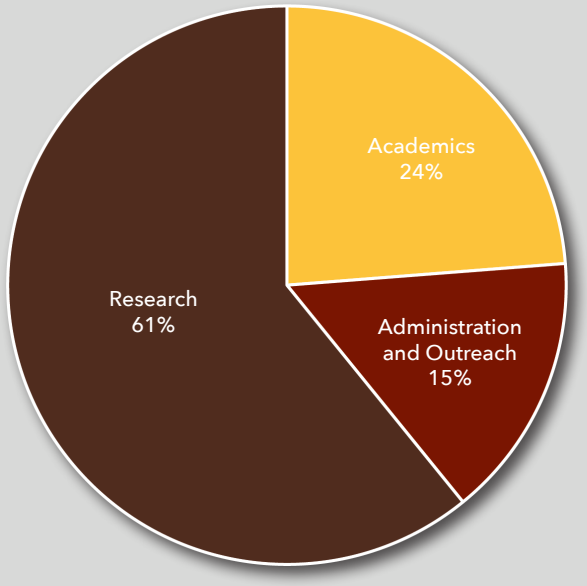
| | |
|---|---|
| FY23 Standard Appropriation | $ 9,084,000 |
| Raise Pool | $ 150,000 |
| Fiscal Year 2023 Budget | $ 9,234,000 |



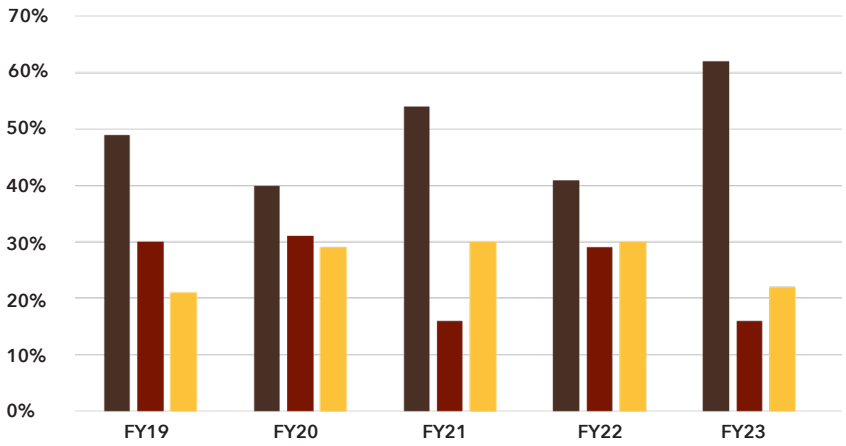

## EXPENSES

- Academics $2,194,144
- Research $5,619,352
- Administration and Outreach $1,420,504

**TOTAL EXPENDITURES:**
**$9,234,000**

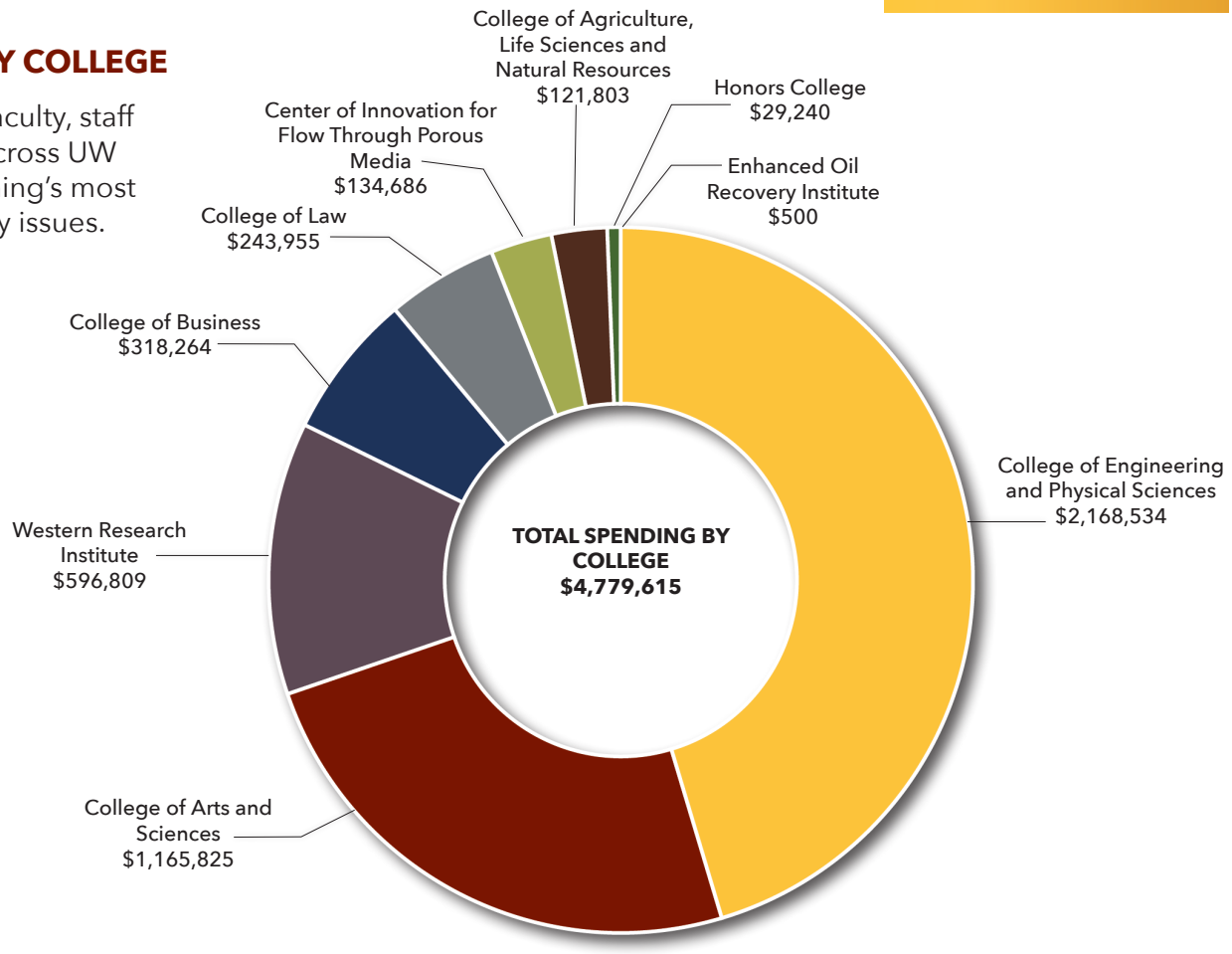



## School of Energy Resources Standard Budget Allocations FY19 - FY23



## SPENDING BY COLLEGE

SER supports faculty, staff and students across UW to tackle Wyoming's most pressing energy issues.



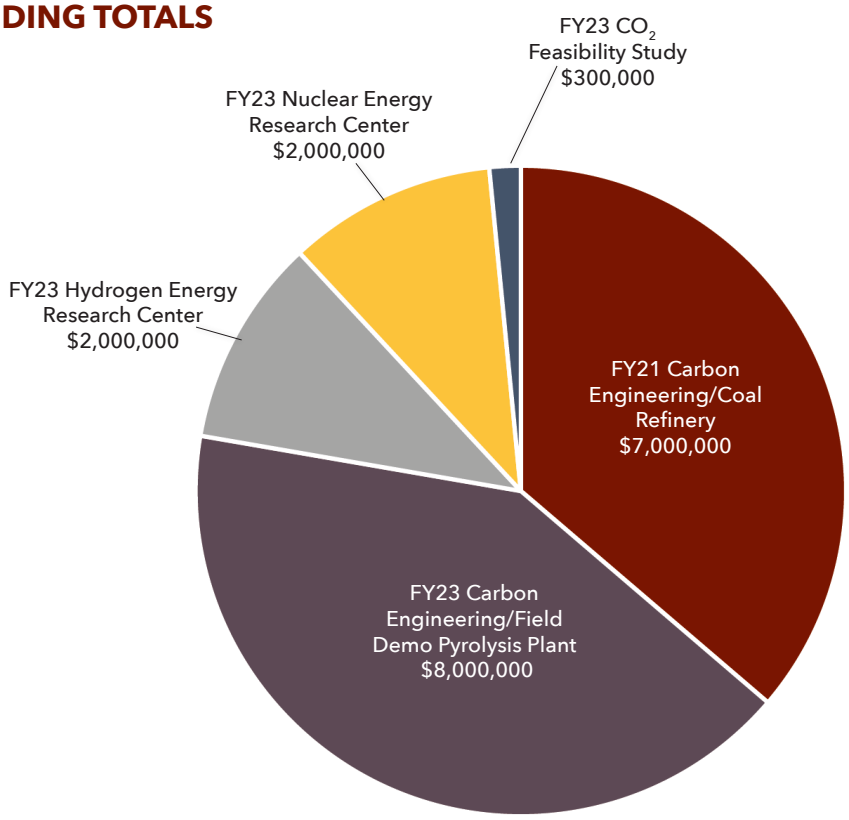

## PERSONNEL SUPPORTED BY SER FUNDING

### 259 People

**Faculty and Staff** ..... **90**
**Student Support** ..... **169**
Graduate Assistants (92)
Hourly, Non-Benefitted (77)

# EXCEPTION FUNDING

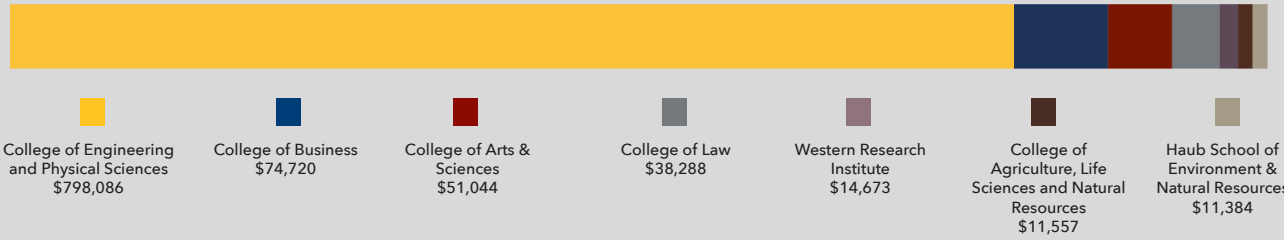
## EXCEPTION FUNDING TOTALS




## ALLOCATION BY YEAR AND EXPENSES

| | FY23 SPENDING | PRIOR TO FY23 SPENDING | EXCEPTION FUNDING TOTALS |
|---|---|---|---|
| FY21 Carbon Engineering/Coal Refinery | $ 286,101 | $ 6,421,717 | $ 7,000,000 |
| FY23 Carbon Engineering/Field Demo Pyrolysis Plant | $ 416,098 | $ - | $ 8,000,000 |
| FY23 Hydrogen Center of Excellence | $ 543,096 | $ - | $ 2,000,000 |
| FY23 Nuclear Energy Collaboration | $ 245,588 | $ - | $ 2,000,000 |
| FY23 $CO_2$ Feasibility Study | $ 300,000 | $ - | $ 300,000 |
| **Total** | **$ 1,790,883** | **$ 6,421,717** | **$ 19,300,000** |

## EXCEPTION FUNDING SPENDING BY COLLEGE



## FOUNDATION ACCOUNTS

Fiscal Year July 1, 2022 - June 30, 2023

Arch Resources Technology and Sustainability Fund

Directors Discretionary Funds for the School of Energy Resources

Energy Vault SER Student Competition

ExxonMobil K-12 Energy Education & Workforce Development Initiative

Jonah Energy LLC Fund for the Center of Excellence in Air Quality

Hydrogen Energy Research Center

Martin Knauss Energy Student Enrichment Fund

Charles Koch Foundation UW Energy Policy Fund

Marathon Interdisciplinary Fossil Fuel Research Lab

James E. Nielson Excellence Fund for the School of Energy Resources

Occidental Chair in Energy and Environmental Technologies

Occidental Chair of Energy and Environmental Policies

Peabody Education, Innovation and Technology Fund

PureWest Energy Natural Gas Research Fund

School of Energy Building Fund

School of Energy Resources Support Fund Students and Faculty

SER - Professional Land Management Program

SER - Reservoir Characterization Collaboratory

J.E. Warren Chair for Energy & Environment

John & Jane Wold Chair Energy

York Future of Energy Exception Scholarship

**Total FY23 Foundation Spending $1,017,211**

## DONOR SPOTLIGHT

### Tribute to Jim Nielson

**James "Jim" Nielson**, a longtime supporter of the School of Energy Resources and the University, passed away on November 17, at the age of 91. A University of Wyoming graduate and a veteran, Nielson worked in Husky Oil, his family's energy company, and went on to start a number of successful energy-related businesses during his career. He was committed to education as a way to transfer knowledge to the public. He spent his time and energy conserving Wyoming's natural resources and promoting the sustainability of its environment.

He was honored by UW as a Distinguished Alumni in 2016. In 2006, Nielson created a $5 million endowment for the director of the UW School of Energy Resources and the Nielson Energy Scholarships, which are designed to support highly talented students planning a career in the energy sector.

Considered a pillar of his community, Nielson had a deep love for Wyoming and dedicated his life to serving the state and its people. His legacy will live on through the School of Energy Resources, as well as other important causes that he championed throughout his lifetime.

## OUR GENEROUS DONORS

Carbon Solutions, LLC
Rocky Mountain Power Foundation
AAPL Educational Foundation, Inc.
Wyoming Association of Professional Landmen
Energy Vault, Inc.
Wold Foundation
ConocoPhillips
Petroleum Association of Wyoming
Baker Hughes, Inc.
PureWest Energy
Peabody Energy
Occidental Petroleum Corporation Foundation
Arch Resources
Trevor S. Turmelle
Heidi M. Larson
Holly Krutka
Scott Quillinan
Mark Williamson
Andrew Klos
Robert N. Barnard
Wood, PLC
Thomas A. Galles Trust
Kenneth Burns
Andrew Allen Charitable Trust
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Mark A. Northam
John L. Koprowski
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Temple and Michael Stoellinger
Crowley Fleck Attorneys, PLLP
Holland & Hart, LLP
Davis Graham & Stubbs LLP
Ramaco Resources
Rare Element Resources, Inc.
Upton Chamber of Commerce
Landman Scholarship Trust
Talen Energy
Gene A. Aydinian
Western Fuels

## MAKE A GIFT

**CONTACT THE UW FOUNDATION**
**Angela Ver Ploeg**,
Director of Corporate Engagement
307-766-1939 | angela.verploeg@uwyo.edu

*The School of Energy Resources has accounts housed in the UW Foundation for the support of energy development, faculty research, and student success. Anyone wishing to make a financial contribution to SER may do so to any of the accounts listed above, or contact a UW Foundation representative about making a major gift and establishing a new account.*

UNIVERSITY OF WYOMING

School of
Energy Resources