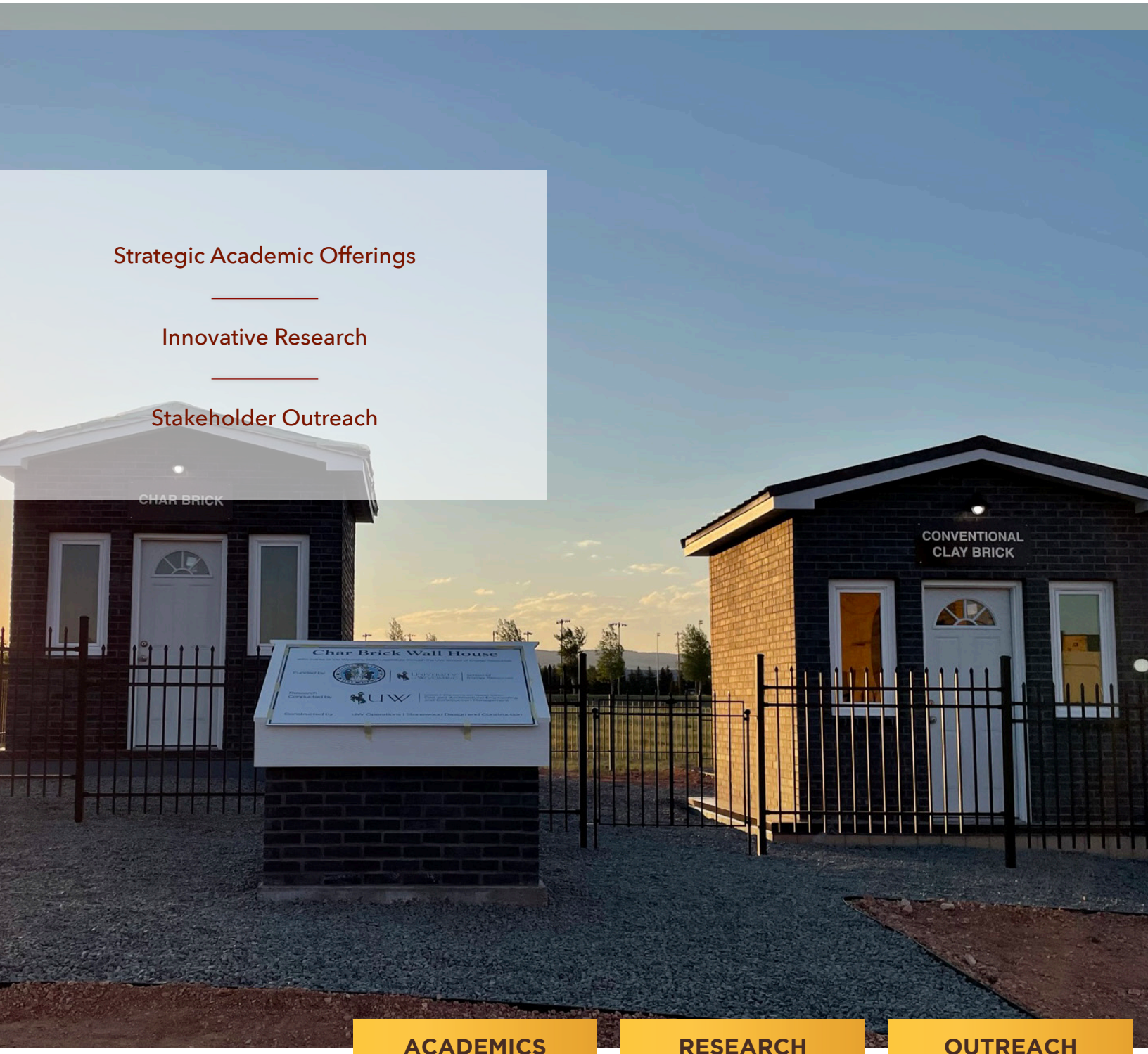
Annual REPORT 2022

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 2022

July 1, 2021 through June 30, 2022

WHO WE ARE

SER LEADERSHIP

Holly Krutka, Ph.D. | Executive Director
Scott Quillinan | Senior Director, Research
J. Fred McLaughlin, Ph.D. | Director, Center for Economic Geology Research
Richard Horner | Director, Center for Carbon Capture and Conversion
Eugene Holubnyak | Director, Hydrogen Energy Research Center
Kami Danaei, Ed.D. | Director, Academic Programs
Kyle Summerfield | Interim 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.

SER's operating structure and policies are established by the UW Board of Trustees.

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, (W.S. 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 Advisory for the State of Wyoming, and 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 Doegler
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

NEW BOARD MEMBERS

WELCOME TO THE BOARD

In FY22, the School of Energy Resources welcomed Representative Don Burkhart of the Wyoming Legislature and Chad Teply, the Senior Vice President of Project Execution for Williams as the newest board members to the Energy Resources Council.

A member of the Wyoming House of Representatives for District 15, Burkhart was first elected to the chamber in 2010 and assumed office in 2011. From 2017 to 2018 he served as the House Speaker Pro Tempore. Currently, he is an important member of the House Minerals, Business & Economic Development committee among others, and is the Chair of the Select Federal Natural Resource Management committee and the House Transportation, Highways & Military Affairs committee. Burkhart earned a B.S. in Physics from John Carroll University. Before assuming office, Burkhart worked as a safety engineer for BP America Production Compact and served on the Board of Directors of the Wyoming-Montana Safety Council.

Teply became Senior Vice President of Project Execution for Williams Cos. in May 2020. He is responsible for successfully delivering projects across the company's footprint through project management, construction, environmental, regulatory and permitting, facilities and land management functions. He previously served as Senior Vice President, Business Policy and Development for PacifiCorp, as well as the Vice President, Resource Development and Construction at PacifiCorp previously. Before joining PacifiCorp, Teply served as Director of Engineering for Northern Natural Gas and also held engineering and project management roles at other energy industry companies based in Iowa and Illinois. Early in his career, Teply was a project engineer assigned to the construction of Williams' Pine Needle LNG facility. He earned his B.A. in mechanical engineering from South Dakota State University.

GRATEFUL FOR SERVICE

The School of Energy Resources offers its sincerest gratitude to Representative Mike Greear and Tom Botts for their years of service on the ERC.

A member of Wyoming House of Representatives, Mike Greear has been a long-standing member of the ERC. He is the president and chief executive officer of Wyoming Sugar Company, a grower owned cooperative located in Worland, WY that manufactures food grade sugar from sugar beets.

Tom has served on the ERC Board since 2012. After earning Civil Engineering degree from the University of Wyoming in 1977, he joined Royal Dutch Shell as a production engineer in the upstream. He continued to move up the ladder in Royal Dutch Shell, holding positions as United Kingdon (UK) Gas Director, UK Oil Director, UK Managing Director and Executive Vice President for Shell's Global Manufacturing portfolio. Tom retired from Royal Dutch Shell at the end of 2012.

(left) Thomas Botts (right) Rep. Michael Greear

LETTER FROM THE EXECUTIVE DIRECTOR


Dr. Holly Krutka
Executive Director

Greetings from the School of Energy Resources (SER)!

The fiscal year 2022 (FY22) saw much growth in every pillar critical to SER.

Under new leadership in the Academic program, the Energy Resource Management and Development degree program has significantly increased enrollment. With the addition of a new Energy Resource Management minor, the footprint of SER has expanded throughout the university as students in other colleges have gained interest and added the minor. With the latest addition of a 3+3 Quickstart Accelerated degree program in partnership with the College of Law, SER looks forward to further growth and interest in the program while it continues to train the energy leaders of tomorrow.

Outreach has thrived with community engagement efforts, events, and educational programs on energy topics important for Wyoming, and the reputation and recognition of SER and its people is on the rise. With increased media attention, notoriety, and collaboration across the university and within the public and private sectors, SER continues to be an in-demand partner for innovative research.

SER has continued to be at the forefront of new and developing energy technologies in the state and the Research program is a testimony to those efforts. In order to address the changing landscape of energy sources, SER has added two new Center's of Excellence (COE) -- the faculty-led Nuclear Energy Research Center, and the Hydrogen Energy Research Center. Both COE's have hit the ground running in addressing a new energy mix and what it means for Wyoming.

The Center for Carbon Capture and Conversion (CCCC) achieved major developments in its quest to move carbon engineering technologies close to commercialization. Plans are in development to scale up multiple projects, and the Center built a demonstration showcase house on campus constructed from coal-derived char bricks.

The Center for Economic Geology Research (CEGR) conducted multiple activities on the Wyoming CarbonSAFE project to establish baseline monitoring in the area surrounding Basin Electric Power Cooperative's Dry Fork Station, including seismic and soil gas monitoring. Most importantly, the CEGR team drilled a second deep well to Class VI standards in order to further characterize the storage and cap rock formations in an effort to advanced commercial-scale carbon dioxide underground storage.

I am deeply appreciative of the continuing confidence of the Wyoming Legislature. In the face of tightening budgets, SER's commitment to providing funding support for energy education, targeted research, and engagement across multiple colleges at the University of Wyoming is more important and effective than ever. We are proud of all we have accomplished and are excited for what the future holds.

Sincerely,

Holly Krutka

Holly Krutka, Ph.D.

GLOSSARY OF ACRONYMS

#
3D Viz - Shell 3D Visualization Center

A
AAPL - American Association of Professional Landmen
A&S - College of Arts & Sciences
APS - Advanced Photon Source

C
C3 - Colorado Coordinated Campaign
CAQ - Center for Air Quality
CarbonSAFE - Carbon Storage Assurance Facility Enterprise
CBM - Coal Bed Methane
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
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

D
DFS - Dry Fork Station
DJ - Denver-Julesburg
DOE - Department of Energy

E
EES Concentration - Energy and Environmental Systems
EIC - Energy Innovation Center
EORI - Enhanced Oil Recovery Institute
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
FY22 - Fiscal Year 2022

G
GGRB-WRB - Greater Green River Basin and Wind River Basin
GPA - Grade Point Average

H
H_2ERC - Hydrogen Energy Research Center
HPC - High Performance Computing

I
I-WEST - Intermountain West Energy Sustainability & Transitions

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

N
NEPA - National Environmental Protection Act
NERC - Nuclear Energy Research Center
NETL - National Environmental Technology Laboratory
NEUP - Nuclear Energy University Program
NREL - National Renewable Energy Laboratory
NSF – National Science Foundation

P
PCOR - Plains CO_2 Reduction Partnership
PLM Concentration - Professional Land Management
PRB - Powder River Basin
PtG - Pilot-to-Gas

R
RANGE - Rocky Mountain Alliance for Next Generation Energy
REE - Rare Earth Elements
RNG - Renewable Natural Gas

S
SAREC - UW Sustainable Agriculture Research and Extension Center
SBIR - Small Business Innovation Research
SER - School of Energy Resources

T
TAP - Technology Associated Program

U
USAF - United States Air Force
USEA – United States Energy Association
UK - United Kingdom
UW - University of Wyoming

V
VOC - Volatile Organic Compounds

W
WERC - Wind Energy Research Center
WISHH - Western Inter State Hydrogen Hub
WRF - Weather Research and Forecasting
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, 2021, through June 30, 2022, in academics, research, newly emerging areas of focus, and engagement to keep UW and Wyoming at the forefront of the energy sector.

ACADEMIC PROGRAM

STAFFING

Academic Director

Kami Danaei was named the new academic director of the School of Energy Resources (SER) academic program at the University of Wyoming. She oversees the curriculum, course development and scheduling of the degree program. Danaei is also tasked with the management of accreditation reports and requirements; establishment of learning outcomes and assessment standards in accordance with accreditation standards; and leading professional development efforts.


Dr. Kami Danaei

College Relations Representative

Karolina Klatka was hired as the new College Relations Representative. In her role, Klatka works directly with SER's Academic Program to actively recruit new students to the Energy Resource Management and Development (ERMD) degree program as well as the Energy Resource Management (ERM) minor.


Karolina Klatka

The duo makes up the small but mighty team actively growing the academic program at the School of Energy Resources, and ensuring that energy leaders of tomorrow receive a quality education and are prepared to hit the ground running upon entry into the workforce.

REACCREDITATION

The Professional Land Management (PLM) Concentration is one of only ten programs accredited nationally by the American Association of Professional Landmen (AAPL).

AAPL
Powering The Profession

The PLM Concentration was due for a 5-year annual site visit in the spring of 2022 from the AAPL for accreditation renewal. The Academic program submitted a report with specific criteria to AAPL for evaluation in February in order to evaluate continued accreditation of the program. In April, SER hosted three members of the AAPL reaccreditation committee on campus for the site visit. This included meetings with SER academic leadership, SER faculty, the Student Chapter for Energy Resources, and meetings directly with PLM students. The program officially received notice of renewed accreditation status and remains one of the top PLM programs in the nation.

SCHOLARSHIPS

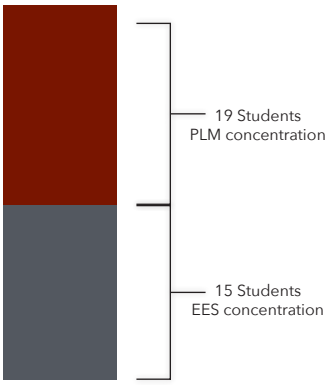
Total Amount Awarded FY22
$63,250

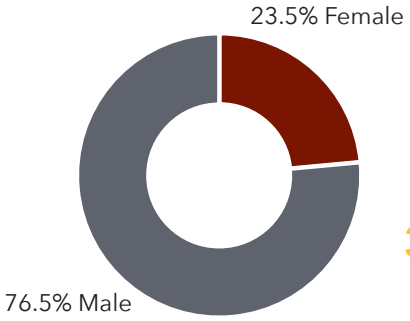
Scholarships	Number of Students	Total Dollars Awarded Fall 2021 & Spring 2022
James C. Nielson Transfer Student Scholarship	4	$7,000
Nielson Energy Scholarship for Women and Minorities	4	$12,000
Nielson Performance Scholarship	7	$6,500
Nielson Scholars	7	$7,200
York Future of Energy Scholarship	1	$3,600
Nielson Textbook Scholarship	32	$26,950

STUDENT ENROLLMENT BY THE NUMBERS

Energy Resource Management and Development Major

34 Total Students





14 ERMD Majors have Minors or Certificates in other Departments

6 Students are a dual majors (seeking 2 Bachelor degrees)

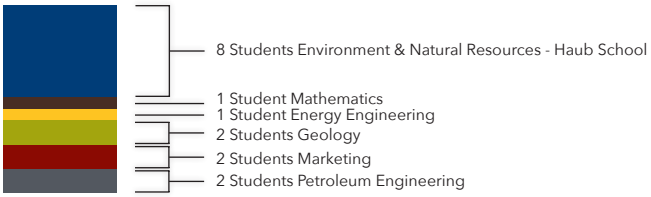
3.034 ERMD Majors average GPA

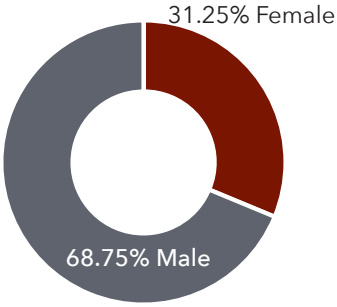
100% Employment within six months of graduation.

Fall 2021/Spring 2022

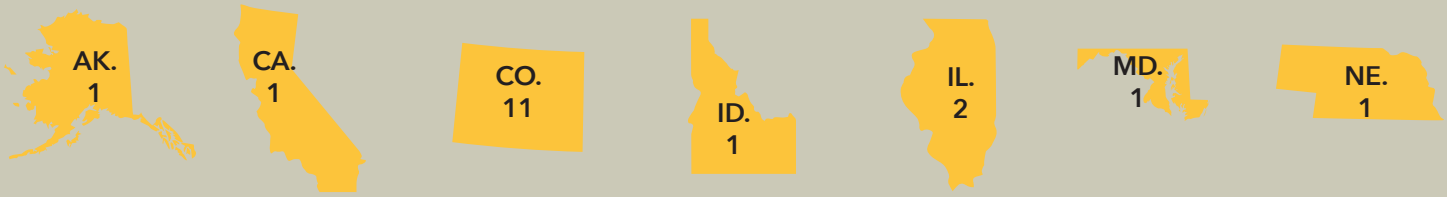
Energy Resource Management Minor

16 Total Students from various other departments





3.153
ERM Minors average GPA



STUDENTS ENROLLED IN ERMD MAJOR AND ERM MINOR BY STATE

GRADUATES

SER graduated **13** total students from the ERMD degree and ERM minor in FY22. **2** students in December 2021, including the first graduate with the new ERM minor. **6** students graduated with degrees in ERMD in spring 2022, **3** in each concentration, and **5** students graduated with the ERM minor.

Pictured top - spring ERMD grads: Isaac Boetthcher, Emily Lantiegne, Juliana Santarelli, Caleb Bowen, Caleb Durgin, Hunter Lee

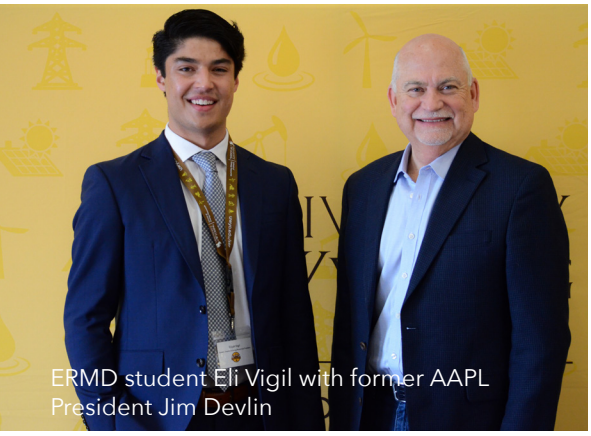
Pictured bottom - winter ERMD grad Jak Tanner and ERM minor grad Meredith Hoerman.

STUDENT INVOLVEMENT

Rocky Mountain Professional Landman Conference

In April, SER hosted the Rocky Mountain Professional Landman Conference in Laramie. The in-person forum brought together industry professionals and PLM alumni in the Rocky Mountain region to showcase the esteemed profession; discuss current topics and issues facing the industry; and explore career paths and opportunities for future graduates.

With over 90 people in attendance, the event was a big success and included a keynote address from then AAPL President, Jim Devlin.



ERMD student Eli Vigil with former AAPL President Jim Devlin

Students working on soil gas sensors for the Carbon XPRIZE

UW Student Team Wins XPRIZE and Musk Foundation Award in Carbon Removal Competition

A team of students from the University of Wyoming is a winner of the Carbon Removal Student Competition funded by XPRIZE and the Musk Foundation.

The UW team – Shane Heavin, of Rock Springs; Danielle Jones, of Gillette; Anna Savage, of Greybull; and Lander Stone, of Laramie – submitted a project proposal in the category of Measurement, Reporting and Verification Technologies to improve the design of existing carbon soil gas monitoring sensors created and produced by Earth Platform Systems (EPS).

The first generation of the carbon soil gas sensors were deployed near the project site for the Wyoming CarbonSAFE Project near Gillette.

LAUNCH OF 3+3 QUICKSTART ACCELERATED DEGREE PROGRAM

The University of Wyoming's School of Energy Resources launched an accelerated degree program in collaboration with the UW College of Law.

The Quickstart 3+3 program allows UW students to earn a bachelor's degree in energy resource management and development through SER and a law degree through the College of Law. Students can now gain the combined professional credentials in six years instead of the traditional seven.

Students will spend the first three years earning credit toward a bachelor's degree and the last three completing the law degree requirements. The credits earned after successfully completing the first-year law school curriculum will transfer back to the undergraduate program for awarding a bachelor's degree.

SER FACULTY

COLLABORATIVE SOLUTIONS

SER recruits and retains multidisciplinary faculty with expertise relevant to Wyoming's energy industry. Housed in 7 different departments across 5 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 Tim Considine testified at a hearing concerning KP Kaufman vs. the Colorado Oil and Gas Commission concerning penalties for environmental violations in September 2021.

Professor Maohong Fan made Clarivate Analytics' list as one of the world's most highly cited researchers. For the fourth year in a row, Fan was listed in the "cross-field" category that identifies researchers with substantial influence across several fields during the last decade.

Professor Bruce Parkinson led a team of UW researchers that were Phase 1 semifinalists of the U.S. Department of Energy's (DOE) American-Made Geothermal Lithium Extraction Prize, a $4 million competition designed to advance technologies and techniques to support direct lithium extraction from geothermal brines.

Professor Craig Douglas initiated a new research project with the Occidental Chair in Energy and Environmental Technologies, Professor Saman Aryana, to computationally study the physics of flow instabilities and the dynamics of subsurface displacement processes at the nanometer scale (4-60 nm).

Professor Tara Righetti is an author on a leading oil & gas law casebook. The 11th edition of "The Law of Oil and Gas: Cases and Materials," was published in December.

Professor Dario Grana organized a series of seminars on campus about Diversity and Inclusion in Geoscience.

Students supported on SER Faculty Projects

12*

**Numbers based only on SER faculty that reported. Additional students were funded in FY22 through SER affiliates and Center's of Excellence. The number of students supported here reflects additional, non-SER funded energy research projects brought in by SER faculty on separate grants and projects in their home departments.*

FACULTY MEMBERS

Tim Considine, SER Professor of Economics and Finance

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, 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

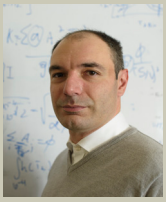
Tara Righetti, SER Professor of Law

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

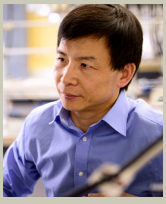
MAJOR ACCOLADES

Prof. Bruce Parkinson announced his retirement after 14 years on the SER faculty

Prof. Dario Grana Received the Outstanding Educator Award from the Society of Exploration Geophysicists



Prof. Maohong Fan was awarded the Carell Family Energy and Petroleum Professorship



SELECT FACULTY PUBLICATIONS

Ding, **Fan**, et al. "Core–Shell Covalently Linked Graphitic Carbon Nitride–Melamine–Resorcinol–Formaldehyde Microsphere Polymers for Efficient Photocatalytic CO2 Reduction to Methanol", Journal of the American Chemical Society, 2022, 144, 9576.

Toward Fully Autonomous Seismic Networks: Backprojecting Deep Learning-Based Phase Time Functions for Earthquake Monitoring on Continuous Recordings, W-Y Liao, E-J Lee, D. Mu and **Chen, P.** (2022), Seismological Research Letters, XX, 1-15, doi: 10.1785/0220210274.

Grana D., Parsekian A., Flinchum B., Smeltz N., Callahan R., Li A., Hayes J., Carr B., Singha K., Riebe C., Holbrook S., 2022, Geostatistical rock physics inversion for predicting the spatial distribution of porosity and saturation in the critical zone, Mathematical Geosciences, 1-51.

Considine, T.J. and **T.K. Righetti** (2022) "Oil and gas development on federal lands: Policy issues and research questions," A Research Agenda for Energy Politics, Edward Elgar Publishing Ltd.

Mesh-free simulation of two-phase fluid flow in porous media based on the shock-fitting method. Lee, E. J., Wang, W., **Chen, P**., Jiao, Z., Gong, Y., Mu, D., & Liao, W. Y. (2022). Journal of Petroleum Science and Engineering, Volume 215, Part B, August 2022, 110637. https://doi.org/10.1016/j.petrol.2022.110637

K.K. DuVivier and **Tara Righetti**, Changing Paradigms for a Low Carbon World, 46 Harv. Env. L. Rev. Online 59 (2022).

Jew, Adam & Druhan, Jennifer & Ihme, Matthias & Kovscek, Anthony & Battiato, Ilenia & **Kaszuba, John** & Bargar, John & Brown, Gordon. (2022). Chemical and Reactive Transport Processes Associated with Hydraulic Fracturing of Unconventional Oil/Gas Shales. Chemical Reviews. 122. 10.1021/acs.chemrev.1c00504.

Wang, Li & Bo, Zhao & Russell, Christopher & **Fan, Maohong** & Wang, Baojun & Ling, Lixia & Zhang, Riguang. (2021). Cu_2O-catalyzed C_2H_2 selective hydrogenation: Use of S for efficiently enhancing C_2H_4 selectivity and reducing the formation of green oil precursor. Chemical Engineering Science. 246. 116984. 10.1016/j.ces.2021.116984.

Jia, Lingxiao & Sen, Satyakee & **Mallick, Subhashis**. (2022). Improvement of generalization capability of two-dimensional salt segmentation via iterative semi-supervised learning. Interpretation. 1-43. 10.1190/int-2021-0089.1.

Manderson, E. and **T.J. Considine** (2022) "The effect of temperature on energy demand and the role of adaptation," revise and re-submit, Journal of Environmental and Resource Economists (considered the top journal in environmental and resource economics.

Fu, Zhuangen & Hill, Josh & **Parkinson, Bruce** & Hill, Caleb & Tian, Jifa. (2021). Layer and material-type dependent photoresponse in WSe2/WS2 vertical heterostructures. 2D Materials. 9. 10.1088/2053-1583/ac3c9c.

David E. Shropshire, Christi Bell, Todd Allen, Michael Craig, **Tara Righetti**, John Parsons, Kathleen Araújo, & Steven E. Aumeier, Emerging Energy Market Analysis Initiative, Methodological Framework. https://doi.org/10.2172/1838119 (Nov. 2021).

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, SER bridges the gap between academia and industry – and ensures deployment of technology and policy solutions.

NEW RESEARCH CENTERS OF EXCELLENCE

Nuclear Energy Research Center

The newly launched Nuclear Energy Research Center (NERC), is a faculty-led research center supported by the SER. It is focused on interdisciplinary nuclear-energy capacity building across the UW community by connecting UW faculty and staff that are already active in research fields critical to the success of nuclear energy, and developing collaborative relationships both external and internal to UW. UW Professors Tara Righetti and Caleb Hill were selected as co-directors to lead the center.

Hydrogen Energy Research Center

The Hydrogen Energy Research Center (H_2ERC) is an SER staff-led center. H_2ERC was created to lead applied research and collaborate with Wyoming stakeholders to support growth of a hydrogen industry focused on serving the state's existing energy customers and growing new markets.

SER hired Eugene Holubnyak in the spring of 2022 to direct H_2ERC. The Center will continue to grow under his leadership.

STUDENT RESEARCH COMPETITIONS

9H Research Foundation Student Competition

Sponsored by the 9H Research Foundation and SER, the energy competition challenged UW students to present a technoeconomic analysis of different routes for hydrogen production in Wyoming and was launched in collaboration with UW's SER.

Baker Hughes Decarbonization Prize Student Competition

Sponsored by SER, the Wyoming Energy Authority and Baker Hughes, the goal of the competition was to advance energy solutions through innovative applications for existing products and services, or to introduce new concepts that will drive decarbonization.

WHO WE ARE

Scott Quillinan, Senior Director of Research

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 Holly Krutka

The Center for Carbon Capture and Conversion, Directed by Richard Horner

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 Brandt

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

FACULTY-LED CENTERS OF EXCELLENCE

CENTER OF EXCELLENCE FOR AIR QUALITY (CAQ): The CAQ deployed its mobile lab in July and October to the Denver-Julesburg (DJ) Basin as part of the Colorado Coordinated Campaign (C3) campaign. This campaign is a coordinated effort between the University of Wyoming, Colorado State University, Carbon Mapper Inc., The Colorado Department of Public Health and Environment, and the majority of oil and gas producers in the DJ Basin. The goal of the project that the University of Wyoming is focused on is to reconcile estimates of methane leakage from airborne versus ground-based approaches to leak detection and quantification.

The CAQ performed data analysis and written manuscripts for publication from the FY21 deployment to the Permian Basin as part of the Environmental Defense Fund's PermianMap project. Similar to C3, the PermianMap project is focusing on quantifying methane emissions from the Permain basin via a number of different methods ranging from satellites to aircraft to ground-based efforts. The CAQ was also focused on quantifying Volatile Organic Compounds (VOC) emissions in the Permian Basin.

CAQ has been in development of a drone platform for estimating emissions

SER student Austin Moon presented a paper co-written with Robert Field at the Air Sensors International Conference

NUCLEAR ENERGY RESEARCH CENTER: NERC hit the ground running as the newest faculty-led Center of Excellence at SER and began capacity building efforts within UW. NERC granted proposal preparation grants to faculty submitting proposals to the Department of Energy and to NASA's EPSCoR program. One of these grants was funded by Nuclear Energy University Program (NEUP) for a total award of $800,000 and will support a study led by the Haub school on environmental justice aspects of nuclear energy in Wyoming. Additionally, NERC supported summer GA positions for 4 graduate students from mechanical engineering, chemistry, and the Haub School doing work related to Nuclear Energy.

Together with the Mechanical Engineering department, NERC supported a visit to campus by Dr. Benjamin Spencer, director of computational mechanics and materials at Idaho National Labs.

WIND ENERGY RESEARCH CENTER (WERC): In FY22, WERC supported the research of 3 graduate and doctoral students on wind energy research projects.

-- Ph.D. student Sarah Buckhold continued to run high performance computing (HPC) simulations of the Wind Resource across the United States. Together with researchers from the National Renewable Energy Laboratory (NREL), these HPC simulations will result in a new National Wind Resource data base.

-- Ph.D. student Narges Helmi commenced her research on dynamic stall impacts on wind turbine airfoil performance. She will begin to conduct wind tunnel tests as well as modal analysis approaches to analyze data prior to using AI to predict dynamic stall behavior.

-- M.S. student Will Schutz completed taking data in rotating wakes. This work seeks to better understand the behavior of wind turbine wakes that impact wind plant performance. He presented this work at the Torque conference in Delft, Netherlands in June 2022.

CENTER OF EXCELLENCE FOR PRODUCED WATER MANAGEMENT (CEPWM): During FY22 reporting year, CEPWM researchers were involved in several external research pursuits that were aimed at developing technologies for recovering lithium from produced waters and other brines.

-- One collaborative effort involved Dr. Brant, the Director of CEPWM, and Drs. Parkinson and Hoberg from the Department of Chemistry, focused on the development of a chloro-alkali process, using covalent organic framework-based membranes, advanced to Phase II of the HeroX Geothermal Lithium Extraction Prize competition.

-- In a separate effort Dr. Brant is working with Materials Modification Inc. to develop selective membranes for lithium recovery from mixed brines. This ongoing project was recently awarded an National Science Foundation (NSF) Small Business Innovation Research (SBIR) Phase 1 grant.

-- In a third project CEPWM researchers are working with SER researchers and Williams on a Wyoming Energy Authority sponsored project. The goal of this project is to evaluate the feasibility of producing hydrogen in Wyoming as an energy resource. CEPWM's role in this effort is to identify viable water resources, which are critical to producing hydrogen through electrolysis, and conduct treatability assessments of these waters for the purposes of producing the hydrogen.

CENTER FOR BIOGENIC NATURAL GAS RESEARCH (CBNGR): The CBNGR is currently providing research and development support for Cowboy Clean Fuels, LLC, a renewable natural gas (RNG) company with the exclusive rights to commercialize technologies patented through the Center for Biogenic Natural Gas Research and owned by the University of Wyoming. Cowboy has raised over $2M in private venture capital funding and recently acquired 139 coalbed methane (CBM) to support field efforts to commercialize the patented technology. The technology leverages existing economically depleted CBM and natural gas infrastructure in Wyoming's Powder River Basin (PRB) to enhance existing natural processes that created fossil biogenic methane and carbon dioxide from the slow metabolism of coal over geologic time while enabling those same processes to produce new low carbon RNG from highly bio-available feed stocks in real time.

The CBNGR recently filed its fourth (4) patent, U.S. Patent Application No. 17/695,521, Methods for Microbial Gas Production and Use as and Isotopic Tracer.

FY22 Publications Produced in Faculty-led Centers of Excellence

- Nuclear Energy Research Center (7)
- Center for Air Quality (3)
- Wind Energy Research Center (3)
- Center for Biogenic Natural Gas Research (9)

SER Students, Faculty, and Staff supported through Research in FY22

184

Approx. $36.9M

FY22 Federal Grant and State Funded Projects

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

US Gold Corp. Mine Project

CEGR research scientists are coordinating with U.S. Gold Corp. to develop mapping and sampling strategies; collect and document critical samples; and process samples for geochemical, geochronological and petrological analysis. U.S. Gold Corp. is examining the prospect of reopening the Copper King (CK) Gold mine -- a hard rock mine located near Curt Gowdy State Park in southeastern Wyoming.

Nadia Dworian, a University of Wyoming geology undergraduate student from Anchorage, Alaska, will work with U.S. Gold Corp. on the project.

Nuclear

CEGR is coordinating with the Geology and Geophysics Department to work on a geotechnical assessment for the Natrium reactor project location near Kemmerer. CEGR/Geology and Geophysics research staff will prepare and analyze core from the location to help advance building plans.

Hydrogen

Williams Southwest Wyoming Hydrogen Hub:

CEGR and other University of Wyoming collaborators are assisting Williams Companies Inc. with a feasibility study of deploying a green-hydrogen production and transport hub in southwest Wyoming. The CEGR project team began work on a hydrogen-focused groundwater resource assessment compiling regional water production data and associated geochemical analysis. The project team also visited the field to sample Williams-owned wells within the Wamsutter field.

TallGrass Energy Blue Bison ATR Plant:

CEGR is working to complete a Front End Engineering Design (FEED) study of developing blue hydrogen at existing gas facilities in Douglas, Wyoming by incorporating an autothermal steam reforming (ATR) plant. Both SER and the Enhanced Oil Recovery Institute (EORI) are project task leads and will collaborate to provide a site-specific CCUS feasibility assessment, develop economic models, and help with project management.

WHO WE ARE

J. Fred McLaughlin, Director

Zunsheng 'John' Jiao, Project Manager

Erin H.W. Phillips, Project Manager

Yuri Ganshin, Senior Research Scientist/ Geophysicist

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

Grant Copeland, Assistant Research Scientist/Geochemistry

UW CONTRIBUTORS

Scott Quillinan, SER Senior Director of Research

Kipp Coddington, SER Senior Advisor

CARBON CAPTURE, STORAGE AND UTILIZATION

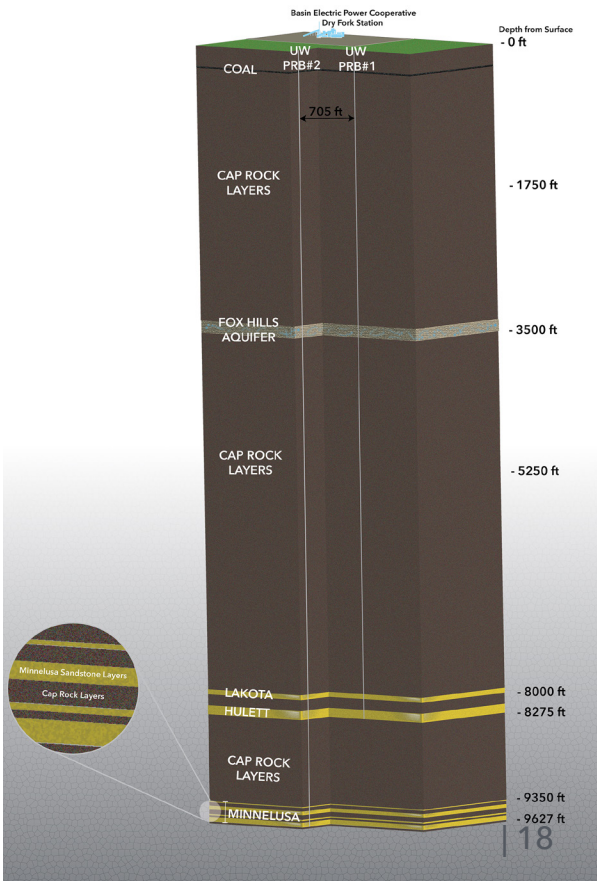
Wyoming CarbonSAFE Project

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. Wyoming CarbonSAFE was one of five national projects to move to Phase III.

In Phase III, the project team is working to complete characterization of the CO_2 storage complex by rigorous commercial-scale surface and subsurface testing, data assessment, and modeling; prepare and file Class VI permits for two wells located at the storage site with the Wyoming Department of Environmental Quality under the Underground Injection Control Program; integrate Membrane Technology Research's separately funded CO_2 capture FEED study at Dry Fork Station (DFS), and; conduct National Environmental Protection Act (NEPA) analyses in support of eventual commercialization of the site.

Phase III Milestones:

- ☑ **Public Outreach Day - August 3, 2021**
  SER, along with Basin Electric Power Cooperative, hosted a public outreach meeting at the Integrated Test Center at DFS in Gillette. The event allowed the public to learn about CCUS and the Wyoming CarbonSAFE Project planned field activities.
- ☑ **Deployment of Microseismic Sensors**
  Researchers at CEGR deployed a series of microseismic sensors as part of the baseline monitoring operations.
- ☑ **Drilled and Completed a Second Well - UW PRB#2**
  The research team drilled a second deep test well for site characterization. Adjacent to a first well that was completed in 2019, the new well allows researchers to gain valuable data and fully characterize the geologic layers of the subsurface site, including the target storage reservoirs and the cap rock seals.
- ☑ **Media Day - January 5, 2022**
  Media day allowed state leadership and members of the media to visit the actual drill site for UW PRB#2, see samples, meet the crew, and experience the project in real time.
- ☑ **Cross Well Tomography Conducted**
  Researchers on the project completed a cross well seismic tomography analysis as part of the detailed site characterizing for Phase III of the Wyoming CarbonSAFE project.



Plains CO_2 Reduction (PCOR) Partnership:

Members of CEGR, CERPA and SER attended the annual PCOR meeting. The project team continues to work on statewide reservoir storage assessments, lessons learned documents from Wyoming-led projects, CCUS-focused economic and jobs reports, and state-focused CCUS regulatory analysis such as the potential impact of releasing guidance on federal pore space attainment.

SELECT PUBLICATIONS

"Decarbonizing the Coal-Fired Power Sector in China via Carbon Capture, Geological Utilization, and Storage Technology," Ning Wei, **Zunsheng Jiao**, Kevin Ellett, Anthony Y. Ku, Shengnan Liu, Richard Middleton, and Xiaochun Li Environmental Science & Technology 2021 55 (19), 13164-13173, DOI: 10.1021/acs.est.1c01144

"Rare Earth Element Resource Evaluation of Coal Byproducts: A Case Study from the Powder River Basin, Wyoming," **D.A. Bagdonas**, A.J. Enriquez, **K.A. Coddington**, D.C. Finnoff, **J.F. McLaughlin**, M.D. Baziliane, **E.H. Phillips,** T.L. McLing, Renewable and Sustainable Energy Reviews Volume 158, April 2022, 112148.

"Predicting Rare Earth Element Potential in Produced and Geothermal Waters of the United States via Emergent Self-Organizing Maps." Engle, M.A.; **Nye, C.W.**; Neupane, G.; **Quillinan, S.A.**; **McLaughlin, J.F.**; McLing, T.; Martín-Fernández, J.A. Energies 2022, 15, 4555. https://doi.org/10.3390/en15134555

RARE EARTH ELEMENTS AND CRITICAL MINERALS

Rare Earth Element (REE) Pilot

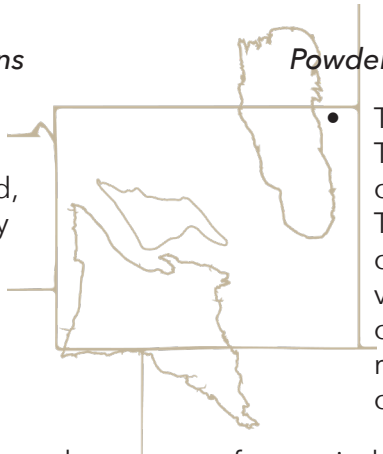
SER is teamed with the National Energy Technology Laboratory (NETL), the city of Gillette, and Campbell County on a $1.6M REE pilot project in Gillette, WY. The project will complete the REE characterization of PRB fly-ash and economically demonstrate PRB-specific NETL extraction technologies. With the completion of the Wyoming Innovation Center (WyIC), the project is poised to be the first tenant at the site.

CORE-CM (carbon ore, rare earth and critical minerals)

Officially launched in fall 2021, the two projects at SER that were awarded funding under the federal CORE-CM Initiative 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.

Greater Green River and Wind River Basins (GGRB-WRB):

- Several of the first project milestones were met and delivered, including developing a preliminary inventory of infrastructure, industries, and businesses in the GGRB-WRB, and a preliminary review of alternative uses for coal basin materials.



Powder River Basin (PRB):

- The project team organized a Technology Roundtable for all collaborators and stakeholders. The project team continued to compile all available resource and volume data, with an emphasis on PRB coal. Completion of the resource assessment will guide all other tasks.

Recognizing that collaboration will be key to the success of a new industry, the PRB and GGRB-WRB projects have worked together on several outreach endeavors including hosting joint webinars, conducting surveys and hosting industry partners interested in connecting on the project.

CENTERS OF EXCELLENCE

CENTER FOR ENERGY REGULATION AND POLICY ANALYSIS

The mission of the Center for Energy Regulation and Policy Analysis (CERPA) is to conduct results-driven, interdisciplinary energy policies analyses for the economic benefit of the state of Wyoming.

PROJECT UPDATES

Grant Support

CERPA provided support to multiple grants in the School of Energy Resources in collaboration with other Centers of Excellence.

- Wyoming CarbonSAFE (all phases & continuing)
- Plains CO_2 Reduction Partnership (PCOR)
- Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) for U.S. Basins - Powder River Basin
- CORE-CM - Greater Green River and Wind River Basins

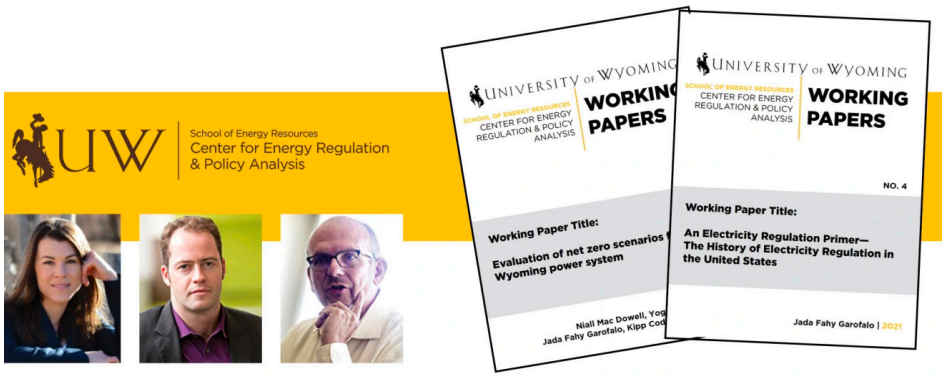
Publications and Resources

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 FY22, CERPA produced two working papers. The first paper released is an Electricity Regulation Primer authored by SER Research Scientist Jada Garofalo. The paper provides the history of electricity regulation in the U.S., which is meant to help states navigate the impending shift in generation, regardless of the regulatory scheme that operates where they sit.

The second working paper released entitled, "Evaluation of Net Zero Scenarios for the Wyoming Power System," presents a scenario-based technopolicy analysis of a range of pathways for Wyoming to transition to net zero.



WHO WE ARE

Holly Krutka
SER Executive Director

Jada Garafalo, Esq.,
Assistant Research Scientist

Selena Gerace,
Assistant Research Scientist

UW FACULTY CONTRIBUTORS

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Dr. Tim Considine, Professor of Economics and Finance, College of Business

Dr. Rob Godby, Associate Dean, Haub School of Environment & Natural Resources; Interim Dean, College of Business

Matt Henry, Haub School of Environment & Natural Resources; Scholar in Residence

Tara Righetti, Esq., Professor of Law, College of Law

Temple Stoellinger, Esq., Associate Professor, Haub School of Environment & Natural Resources

Haibo Zhai, Associate Professor of Civil and Architectural Engineering, College of Engineering and Applied Science

RESEARCH AFFILIATES

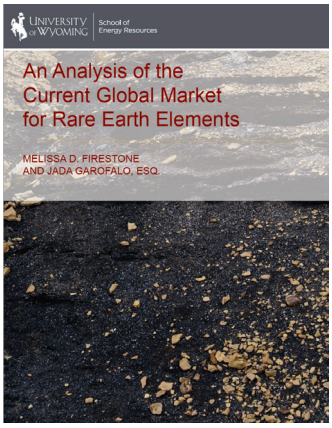
Niall Mac Dowell, Professor of Future Energy Systems, Imperial College London

Morgan Bazilian, Director, Payne Institute and Professor of Public Policy, Colorado School of Mines

Melissa FIrestone, Contract Energy Economist

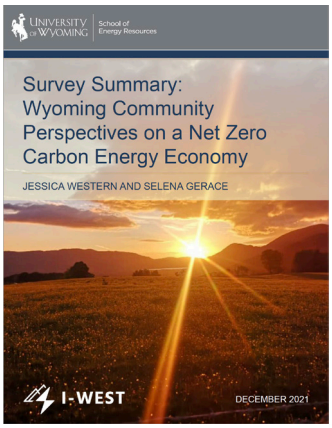
Resource Papers

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 the Current Global Market for Rare Earth Elements

In FY22, CERPA released a resource paper that provides an economic analysis of Rare Earth Elements (REE). The paper is the first in a two-part series focusing on the REE industry, and aims to provide a base understanding of REE, the REE production and extraction process, an overview of the global REE market, and a summary of US government interest, policies, and funding being directed to further the development of a REE supply chain in the US.



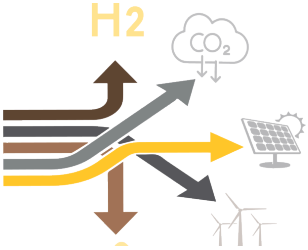
Survey Summary: Wyoming Community Perspectives on a Net Zero Carbon Energy Economy

A second resource paper was released to explore Wyoming residents' views on achieving a net-zero carbon energy economy. The survey, conducted on the request of the U.S. Department of Energy, specifically examines the needs, expectations and concerns of Wyoming citizens related to a carbon-neutral future, as well as the opportunities and technologies that stakeholders feel will be more effective in meeting that goal in Wyoming.

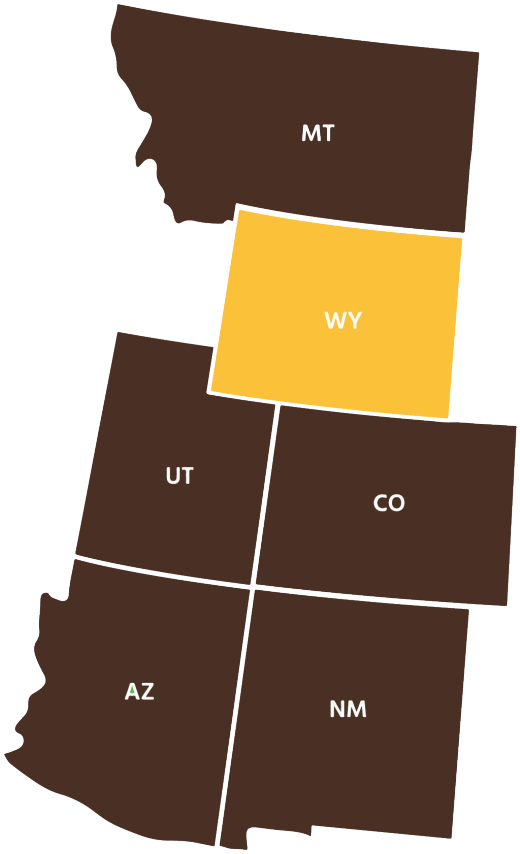
I-WEST

The Intermountain West Energy Sustainability & Transitions (I-WEST) initiative is developing a technology roadmap to transition the region to an economically sustainable, carbon neutral energy system. The roadmap will outline ways for the Intermountain West states to meet challenges, capitalize on opportunities, and build an equitable energy transition strategy.

Working with the I-WEST initiative, CERPA conducts interdisciplinary research to produce value-added surveys, publications, and discussions on energy-related policy, law, and regulatory issues in Wyoming.



Pathways to Net-Zero



As part of the I-WEST initiative, CERPA hosted two 'Pathways to Net Zero' workshops for local Wyoming communities to discuss goals, needs, and concerns in

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, commerical application.

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. The system consists of 3 integrated technologies: thermal coal solvent extraction, fast pyrolysis processing, and dry methane reforming.

During FY22, a feasibility study was completed engineering company Wood, and a lease negotiated with and Atlas Carbon LLC for siting a field demonstration which will commence in FY23 near Gillette, Wyoming.

Fast Pyrolysis Processing

The fast pyrolysis processing technology will be installed early in the field demonstration. The byproduct of the pyrolysis process yields coal char, which is used to manufacture useful products such as building materials and soil amendments. Construction for this phase of the project is anticipated to start in FY23 and will be completed in FY24.

Thermal Coal Solvent Extraction

After achieving success in both the lab and pilot plant, the solvent extraction technology is continuing to collect data and improve design for future a field demonstration.

Dry Methane Reforming

Researchers working on the dry methane reforming technology were invited to use the Advanced Photon Source (APS) – a high-energy X-ray light source facility – at the Argonne National Laboratory in Lemont, Ill. The results from the studies at the Argonne APS facility will be crucial for selecting the desirable catalyst synthesis formulation and catalyst manufacturing route.

WHO WE ARE

Richard Horner
Director

Trina Pfeiffer,
Senior Research Scientist

Stefan Holberg,
Associate Research Scientist

ChooiKim Lau,
Assistant Research Scientist

UW FACULTY CONTRIBUTORS

Dr. Kam Ng, Associate Professor of Civil and Architectural Engineering

Dr. David Bell, Professor Emeritus of Chemical Engineering

Dr. Peter Stahl, Professor Emeritus of Ecosystem Science and Management

Dr. Patrick Johnson, Department Head and Professor of Chemical Engineering

Dr. Erica Belmont, Associate Professor of Mechanical Engineering

Dr. Jing Zhou, Professor of Chemistry

Dr. Michael Stoellinger, Associate Professor of Mechanical Engineering

Dr. John Oakey, Professor of Chemical Engineering

Dr. Katie Dongmei Li-Oakey, Professor of Chemical Engineering

RESEARCH AFFILIATES

Jeramie Adams, Western Research Institute

Paul Behrens, Research Consultant

COAL TO PRODUCTS FIELD DEMONSTRATION SHOWCASES

Coal Derived Building & Construction Products

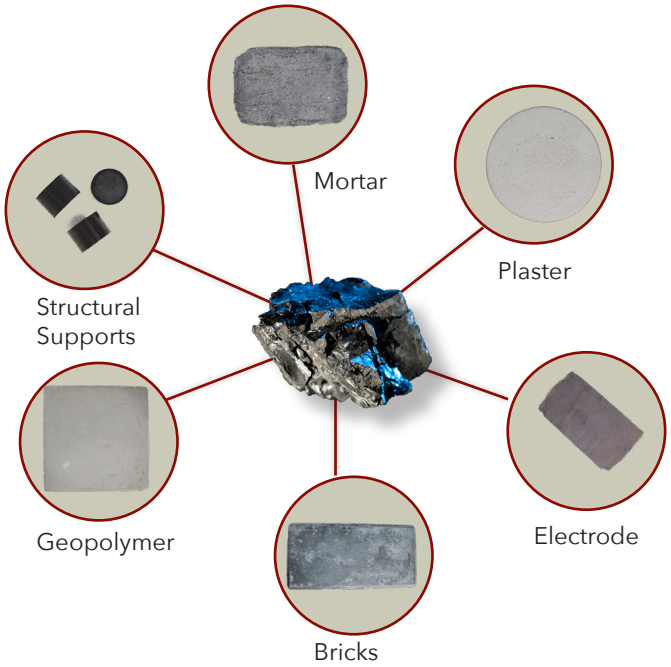
The CCCC achieved major milestones in the development and manufacturing of eco-friendly, high-performance building materials from coal. In FY22, the team manufactured 4,000 coal-derived char bricks and a demonstration house was constructed on the University of Wyoming campus in tandem with a house constructed from conventional clay bricks. The team will monitor the performance of both houses for comparison throughout FY23.

Char Bricks...

- Received a grade "A' fire resistance rating
- Are strong with a very high compressive strength
- Have excellent thermal properties
- Produced with little energy and have a low carbon footprint

In addition to char bricks, the CCCC research team developed coal-derived insulation foam, plaster, mortar, structural supports, flooring and roofing materials which will eventually be worked into the demonstration house for further analysis.

Research has also been conducted in the coal-derived polymers paints and coatings, and waxes.



The CCCC was awarded funding from the U.S. Department of Energy (DOE) as a subawardee in a collaborative grant proposal with Baker Hughes Energy Transition LLC to develop innovative solutions and uses for coal waste in additive manufacturing processes.

Baker Hughes

Agricultural & Soil Fertility Products

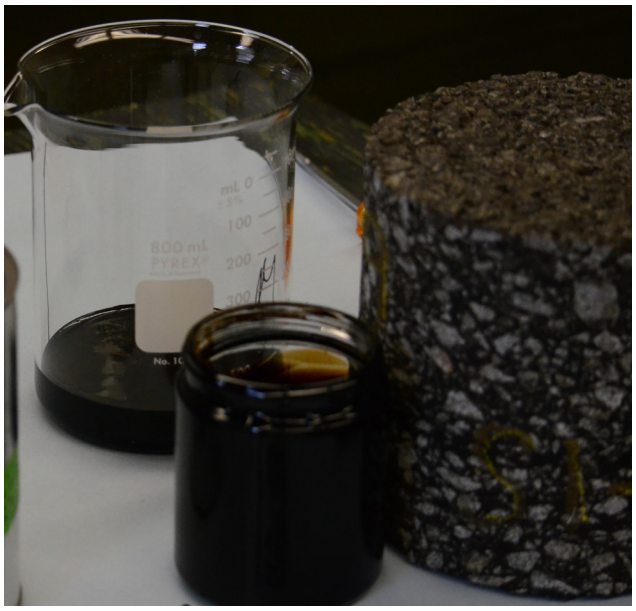
Further field tests and evaluations have been completed on coal derived soil amendment products, on both sugar beat and field corn, planted in a number of soil types representative of Wyoming agricultural environments.

Performance data showed that the coal derived soil amendments performed at least as well as more expensive biochar and comparable with conventional agricultural practices using manure. Plans have been developed for the FY23 field demonstration program of coal derived soil amendments and a formal collaboration with Western Sugar Cooperative has been formed to conduct full scale semi commercial demonstrations of the coal derived soil amendment products

Coal Based Asphalt Products

Industrial sized samples of coal derived asphalt products are being produced and will be provided to a number of asphalt industry companies for their evaluation. There is increasing interest in the products under development from the asphalt industry, not only because of concerns about future supply of petroleum derived asphalt materials constraints, but also because a recent change in policy from the Federal Environmental Protection Agency (EPA), restricting pollution emissions.

While the performance of the coal derived products developed to date still needs to be improved from a technical performance perspective to equal that of petroleum derived asphalt, coal derived material has the benefit of (i) assured reliable and available supply, (ii) can compete on price and (iii) offers full compliance with this recently introduced federal mandate.



FUTURE OF COAL IN TENERGY & THERMAL APPLICATIONS

Coal Export Study – Wyoming Coal to Asia

The outlook for imported coal sales into the Asia Pacific region has drastically changed, since receiving the original commissioned consultant report in December 2021. The scope for exporting Wyoming coal to Asia Pacific markets is being reevaluated in the context of recent changes in energy markets, together with product switching affecting energy supply and demand balances. The cost, use and introduction of containerized freight handling and shipping will be a main feature of the recently started study, as there are now thought to be attractive supply chain and economic benefits adopting this approach compared to unit train overland transport and sea cargo using Panamax vessels -- the current practice.

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_2ERC 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.

STAFFING

Eugene Holubnyak is the latest center of excellence director in the University of Wyoming School of Energy Resources (SER), taking the helm in the Hydrogen Energy Research Center.

Holubnyak is charged with managing SER's efforts to identify and quantify the relative competitive advantages of Wyoming in an emerging low-carbon hydrogen economy.

Originally from Lviv, Ukraine, Holubnyak is an expert in CCUS with more than 14 years of experience in applied geoscience and energy-related research.

H_2ERC is working to hire research and support staff in the center for FY23.

H_2ERC Director, Eugene Holubnyak

FUNDRAISING

Following the successful model of existing Centers of Excellence, H_2ERC will operate with two full-time staff members and utilize interdisciplinary collaborators within SER and across the UW campus. Within five-years of it's launch, H_2ERC will grow into a self-sustaining entity through external research grants and will conduct research to keep Wyoming positioned as a major energy exporter. Kickstarting the funds needed to launch the center, SER received two generous gifts for H_2ERC in FY22.

Williams Cos. made a $500,000 commitment to help fund H_2ERC. The gift will be spread over five years to support the new center dedicated to applied hydrogen research, collaboration with Wyoming stakeholders and the growth of a hydrogen industry in Wyoming.

Members of Williams and SER

SER received a generous donation from The Anschutz Corporation to help launch H_2ERC. The donation was the first substantial private financial investment made in support of the center, which will focus on clean hydrogen produced by diverse energy sources. The gift is intended to kick-start the center and advance research into key technical aspects of the hydrogen production, delivery and deployment sector, which stands to complement and enhance Wyoming's already robust energy sector, helping to diversify its economy.

PROJECTS

Initial Engineering of the CO_2 Capture Unit of Blue Bison ATR Plant

Led by Tallgrass MLP, this DOE-funded project, named Blue Bison, is an 18-month project that began on October 1, 2021. The $1.9M project is studying developing blue hydrogen around existing gas facilities in Douglas, Wyoming. H_2ERC and EORI are leading tasks and will provide a site-specific CCUS feasibility assessment (H_2ERC), develop economic models (EORI), and help with project management (both entities). In this term, the H_2ERC/EORI project team assessed data needs for the techno-economic analysis and determined the feasibility of CCUS at the study site.

Williams Southwest Wyoming Hydrogen Hub

H_2ERC and other University of Wyoming collaborators are assisting Williams Companies Inc. with a feasibility study of deploying a green-hydrogen production and transport hub in southwest Wyoming. This project duration is 18 months, with a total project budget of ~$1.2M. H_2ERC and the SER Center for Produced Water Management will study southwest Wyoming water sources and treatments suitable for green hydrogen production.

Feedstock Evaluation for CI estimate via Biomethanation

Jonah Energy is evaluating projects that can reduce the company's carbon emissions. First, they focus on reducing natural gas leaks within their system. They are also interested in renewable natural gas (RNG), particularly the biomethanation process. Jonah is seeking SER's assistance to evaluate a potential pilot power-to-gas (PtG) project paired with a new solar array they plan to build in southwest Wyoming. The solar-generated electricity would off-set the electricity cost of the compressor's operation and could reduce the carbon intensity of a PtG demonstration project at the site. Gas utilities have market demand and interest in off taking the RNG from the PtG project.

Net-Zero Project

The U.S. Department of Energy's (DOE) Office of Fossil Energy and Carbon Management announced up to $644,000 for SER to assess the economic impacts of fossil energy production in Wyoming and evaluate opportunities and research needs to deploy clean hydrogen technologies. The study also will include direct outreach and engagement with local tribal nations and other traditionally marginalized groups to ensure that the study's findings represent a diverse set of perspectives.

THE WESTERN INTER-STATES HYDROGEN HUB

The Western Inter-States Hydrogen Hub (WISHH) will be the national model for clean hydrogen production, transport, and use across a large geographic region – and will be a key driver in building the national hydrogen network. WISHH was created by a Memorandum of Understanding between the governors of Colorado, New Mexico, Utah, and Wyoming – four states that produce over 10% of the nation's energy. H_2ERC and SER are an integral part of this initiative and the Rocky Mountain Alliance for Next Generation Energy that is managing the MOU.

RANGE
ROCKY MOUNTAIN ALLIANCE *for* NEXT GENERATION ENERGY

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.

STAFFING

FY22 saw a transition in leadership for the 3D Visualization Center. After a decade of service, Emma Jane Alexander stepped down as manager in March of 2022. Kyle Summerfield took over as the interim manager, while continuing to provide his creative services as the Center's lead developer.

WHO WE ARE

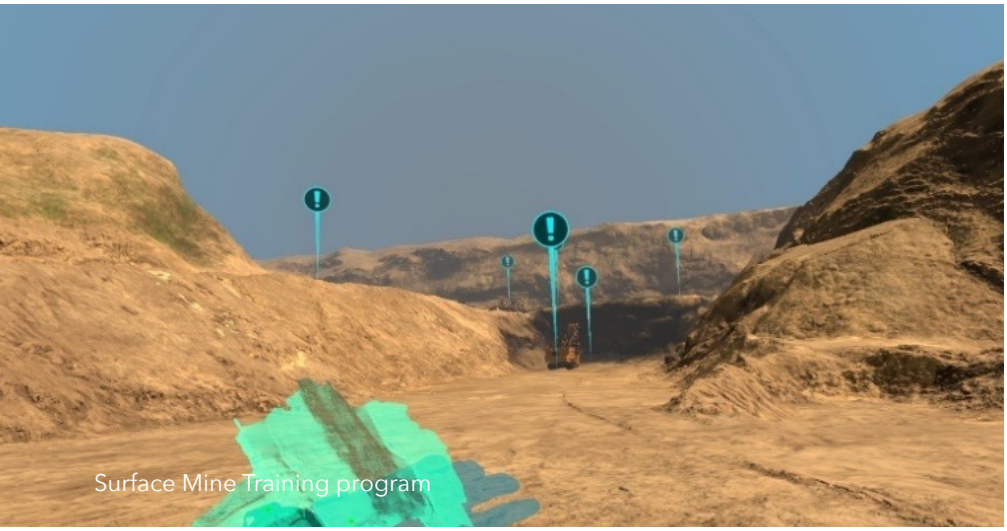
Kyle Summerfield,
Interim Manager and Lead Developer

Phil Black,
3D Asset Developer

Patrick O'Toole,
Scientific VR Lead Developer

CONTRACTORS

Jerry Evans, Mechdyne



Surface Mine Training program

Students at Gillette College experiencing Surface Mine Training

PROJECTS

Surface Mine Training Program

The 3D Viz Center devolped an interactive surface mine training program for Gillette College and in collaboration with the Mine Safety and Health Administration (MSHA). A release version of the New Miner VR Training program was completed and delivered. All capture and development efforts were completed in-house at the Visualization Center, and minor support development is ongoing. By the end of FY22, over 3000 students had already experienced the program as a part of their New Miner training course. Reception has been extremely positive, and discussions are underway for future projects with Gillette College.

SELECT PROJECTS IN PROGRESS

Buffalo Roads and Related Language Elicitation Work

The 3D Viz Center completed several applications designed to assist in language revitalization for the Arapaho tribe. Using data captured by ground-based LiDAR and 360 photography, applications have been deployed to VR, mobile, desktop, and browser platforms. Each application centers around locations important to the Arapaho people.

Bumble of Bees

The 3D Viz Center implemented and delivered an educational game about Bumblebee morphology and adaptability in collaboration with the UW department of Zoology and Physiology, the Biodiversity Institute, and the University of Alabama. The work is the second pollinator-related project undertaken with this group and was used in 13 high school science classes in Rock Springs.

Molecular Processes in Augmented Reality

Developed by the 3D Viz Center in collaboration with UW professors in the departments of Zoology and Physiology, Molecular Biology, and the School of Teacher Education, the project aims to explore the impact of group-based Augmented Reality simulations on learning outcomes.

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 FY22

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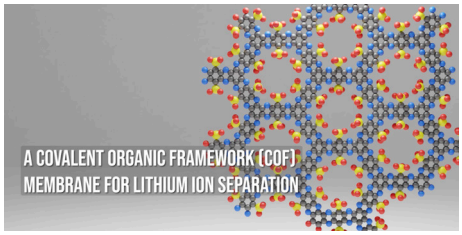
SER RESEARCH UNIT SUPPORT

Lithium Animation

The 3D Viz Center developed an animation of membrane technology for lithium extraction as part of a submission video for the Geothermal Lithium Extraction Prize submitted by SER faculty members. The team was ultimately selected as a winner for the grant.



Hydrogen Energy Research Center (H_2ERC) Animation

To aid in the fundraising and awareness of the developing initiative in the Hydrgen Energy Research Center, an animation video was completed. The 3D Viz Center worked with SER as the client and created a piece of quality animation to reflect the science, strategy, and fund-raising goals of the initiative.

360-degree Energy Innovation Tour

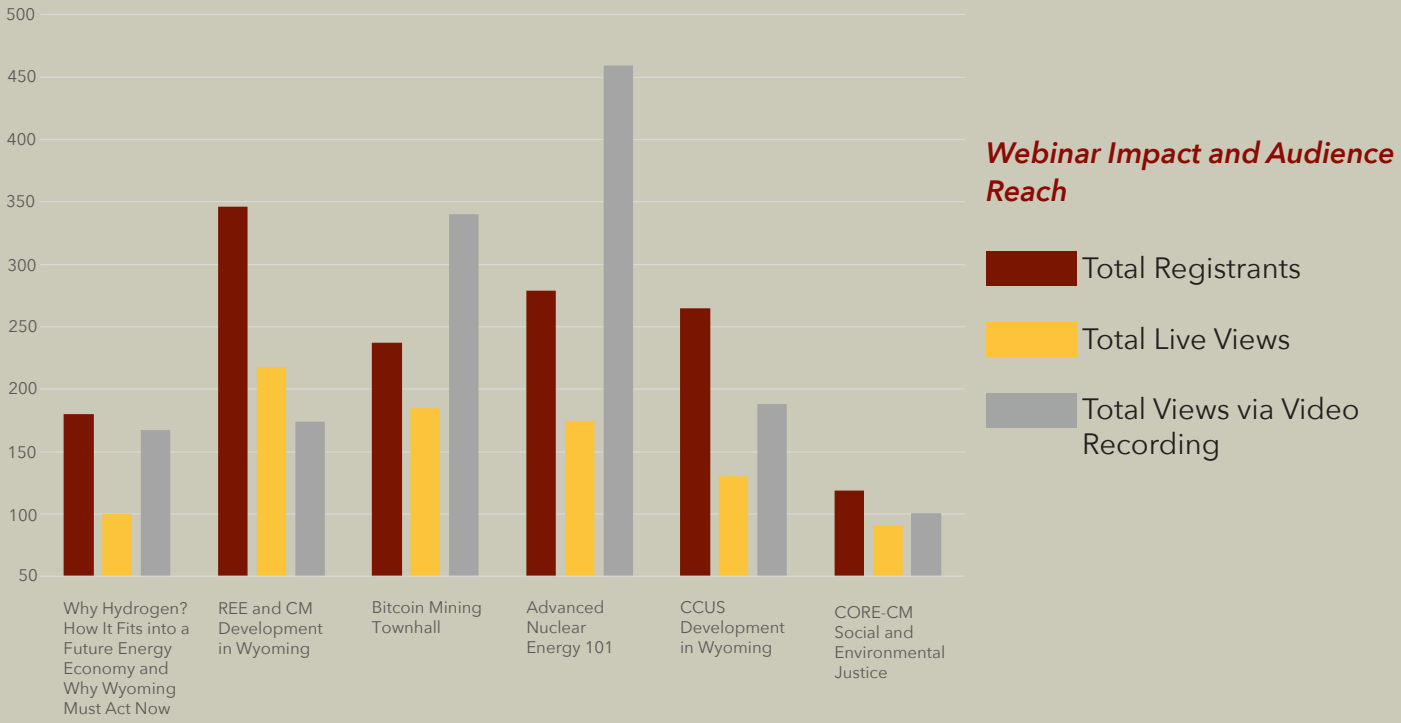
The 3D Viz Center has been working to create a browser-based tour of the Energy Innovation Center (EIC). Initial photography has been completed, along with many individual interviews to facilitate individual staff and faculty introductions. This project is slated for completion by the end of the summer 2022, and will be used as a recruiting tool for the Energy Resource Management and Development undergraduate degree program.

OUTREACH AND ENGAGEMENT

WEBINARS

Presented or supported webinars and online forums:

- Why Hydrogen? How It Fits into a Future Energy Economy and Why Wyoming Must Act Now | SER
- REE and CM Development in Wyoming Webinar | CERPA
- Bitcoin Mining Townhall Webinar | SER/Center for Blockchain and Digital Innovation
- Advanced Nuclear Energy 101 Webinar | SER/NERC
- CCUS Development in Wyoming Webinar | CEGR
- CORE-CM Social and Environmental Justice Webinar | CERPA/CEGR



LIVE EVENTS AND CONFERENCES

Distinguished Speaker Series

Outreach resumed in-person events in fall 2022 and hosted a series of distinguished speakers in both an in-person and online format. In FY22, the series featured six speakers in the fall, and five speakers in the spring.

Energy Day

Outreach was a main sponsor of the UW Athletics Energy Day festivities with Cowboy Football. Outreach hosted a booth for the pre-game tailgate to highlight the school and distribute information on the programs - particularly the academic program - to the public.

Sponsored Events and Exhibition Booths

Outreach continues to boost the presence and visibility of SER through sponsorship and exhibition opportunities. FY22 events included:

- University of Wyoming Celebrate Energy Day Football Game
- Petroleum Association of Wyoming Annual Forum
- Basin Electric Power Cooperative Annual Meeting in Bismarck, ND
- Governors Business Forum
- American Association of Professional Geologists' Annual CCUS Conference in Houston
- Wyoming Energy Authorities "Next Frontier Energy Summit"

SER RESEARCH UNIT SUPPORT - SELECT PROJECTS

Academics

Outreach provided graphic design and content assistance for a complete redesign of the academic program recruiting booklet. Outreach also provided logistical support for the Rocky Mountain Professional Landman Conference.

Center for Economic Geology Research

Outreach organized both the Public Outreach Day and the Media Day for the Wyoming CarbonSAFE Project in order to showcase Phase III activities, and in particular the drilling of UW PRB#2.

Outreach also provided support for all CEGR webinars and the Technology Roundtable conducted for the CORE-CM project.

Center for Energy Regulation and Policy Analysis

Outreach provided graphic design support to format the papers produced within the Center as well as provided support for all webinars conducted with policy and energy regulation.

Center for Carbon Capture and Conversion

Outreach provided the design and assistance in creating a timeline wall for the milestones of the coal-to-products research projects. The vinyl timeline can be extended and added to as programs achieve success, and is on display in the carbon engineering project room on the third floor of the EIC.

Outreach also produced multiple videos on the coal processing technology and products created in the Center to help the general public understand the mission and the new role that coal can play in a net-zero future.

CONTINUING ENGAGEMENT ACTIVITIES

- Internal Newsletter and External Quarterly Newsletter
- Electronic News Blog and Collaborative Press Releases
- Photos and Videos
- Social Media

News Stories and Press Releases on SER

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WHO WE ARE

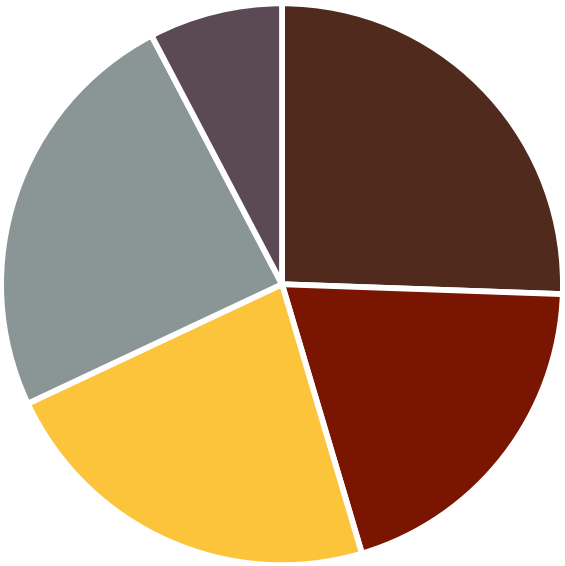
Christine Reed
Director of Outreach and Energy Resources Council Secretary

FINANCIAL STATEMENT

INCOME AND EXPENDITURES

Fiscal Year July 1, 2021 - June 30, 2022

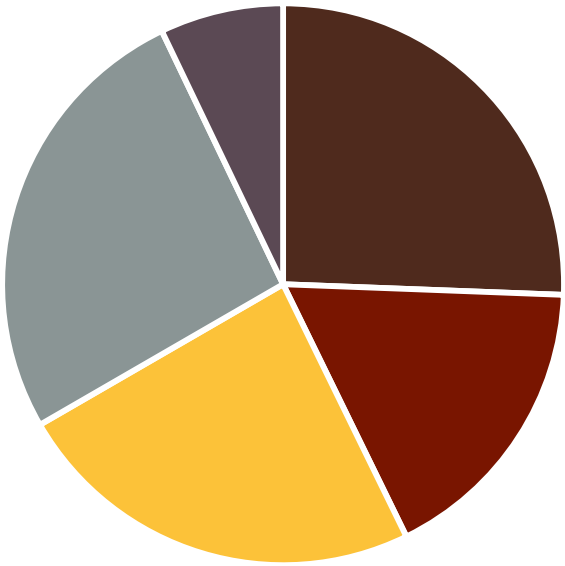
ALLOCATIONS



- Academics 26% $2,321,707
- Research 23% $2,053,275
- Administration and Outreach 20% $1,802,854
- CCCC 24% $2,206,799
- CERPA 8% $698,627

TOTAL ALLOCATION:
$9,083,262

EXPENSES



- Academics 26% $2,265,593
- Research 24% $2,114,392
- Administration and Outreach 17% $1,518,845
- CCCC 26% $2,321,469
- CERPA 7% $629,007

ESTIMATED TOTAL EXPENDITURES:
$8,849,306

BUDGET ALLOCATION AND REDUCTION

Like other state-funded entities, SER has taken a 10% reduction to its state appropriated budget. While some cash flow reductions have been realized due to reduced travel, this is only a temporary solution and SER is evaluating all options to ensure that these permanent cuts will be carried out as strategically as possible.

SER implemented its 10% Budget cut at the beginning of the biennium.

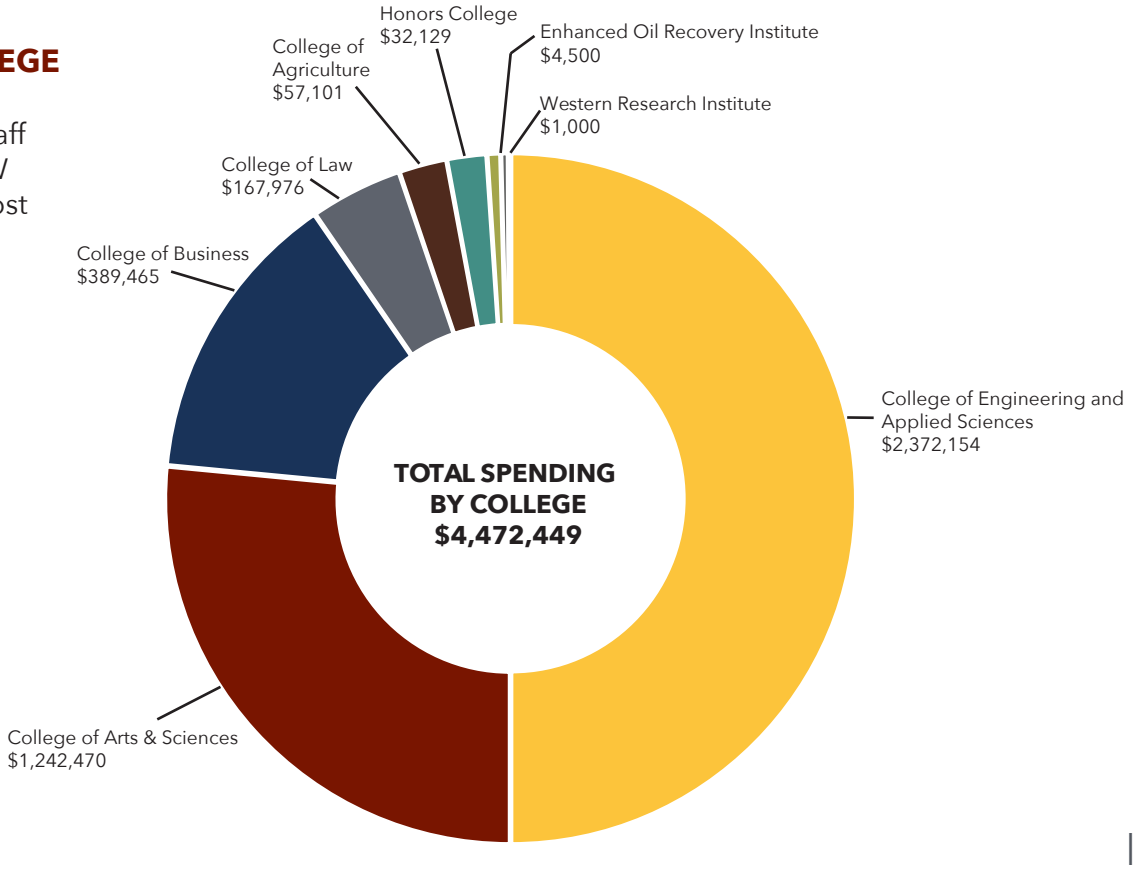
FY22 FUNDS - JULY 2022

Total Appropriation	$ 17,092,514
Future of Coal (one time appr.)	$ 7,000,000*
Annual Budget Before Cut	$ 10,092,514
10% Cut	$ 1,009,251
Amount Available for Allocation	$ 9,083,263

**$7,000,000 one-time appropriation funding is to be spent over FY21 & FY22 and does not revert. Greater detail of the appropriation is provided later in the report.*

SPENDING BY COLLEGE

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

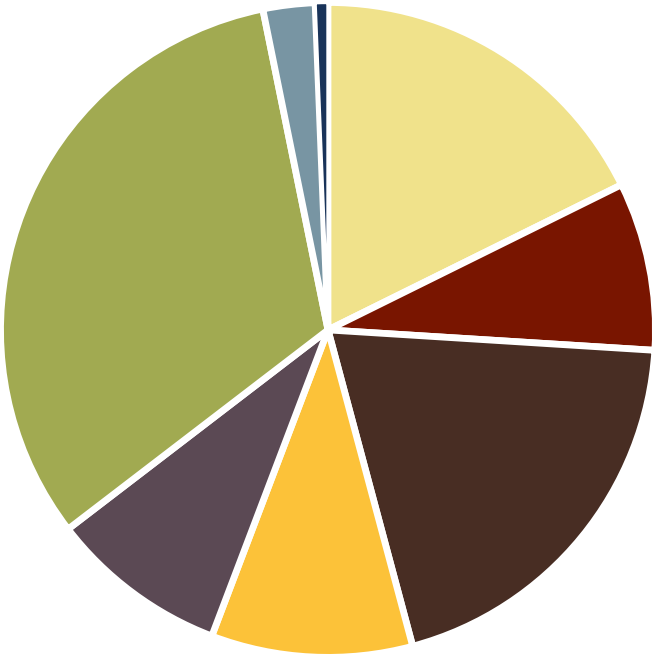


EXCEPTION FUNDING

$7M EXCEPTION FUNDING FOR CENTER FOR CARBON CAPTURE AND CONVERSION 'FKA' CARBON ENGINEERING

These funds cover the biennium (FY21 & FY22).

ALLOCATION BY PROJECT



- Paving and Roofing 18% $1,135,900
- Methane Reforming Catalyst 8% $533,331
- Pilot Plant Testing 20% $1,274,193
- Construction Materials 10% $586,254
- Coal-based Soil Amendments 9% $342,714
- Coal Refinery - Construction 32% $2,068,806
- Coal Refinery - Design 3% $164,581
- Coal Additives 1% $40,377

ALLOCATION BY YEAR AND EXPENSES

	BIENNIUM SPENDING	
Paving & Roofing	$	1,135,900
Methane Reforming Catalyst	$	533,331
Pilot Plant Testing	$	1,274,193
Construction Materials	$	638,274
Coal-based Soil Amendments	$	566,254
Coal Refinery - Construction	$	2,068,806
Coal Refinery - Design	$	164,581
Coal Additives	$	40,377
TOTAL BIENNIUM SPENDING (FY21-FY22)	$	6,421,717
To be spent in FY23	$	578,283
TOTAL $7M One-time Appropriation	$	7,000,000

FOUNDATION ACCOUNTS

Fiscal Year July 1, 2021 - June 30, 2022

Anderson, G. W. Landman Fellowship

Arch Clean Coal Technology Fund

Center for Excellence in Produced Water Management Research Center

Directors Discretionary Funds for the School of Energy Resources

ExxonMobil K-12 Energy Education & Workforce Development Initiative

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

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 Policy

School of Energy Resources Support Fund Students and Faculty

SER - Professional Land Management Program

SER - Reservoir Characterization Collaboratory

Wold, John & Jane Chair Energy

York Future of Energy Scholarship

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.

OUR GENEROUS DONORS

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$25,000 and above

The Anschutz Corporation
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Robert and Alice Barnard
Holly Krutka
Harold and Aeri E. York

STEAMBOAT LEVEL
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Duke and Heidi Cooley
Melinda Frazier
Lynn Lockhart

STANDARD LEVEL
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Kipp Coddington
Saeed and Kami Danaei
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School of
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