# Annual REPORT 2021

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 ANNUAL REPORT FISCAL YEAR 2021

September 2021

## WHO WE ARE

### SER LEADERSHIP

**Holly Krutka, Ph.D.** | Executive Director
**Scott Quillinan** | Senior Director, Research
**Kipp Coddington, Esq.** | Director, Center for Energy Regulation & Policy Analysis
**J. Fred McLaughlin, Ph.D.** | Interim Director, Center for Economic Geology Research
**Richard Horner** |Director, Center for Carbon Capture and Conversion
**Tim Considine, Ph.D.** | Director, Academic Programs
**Emma-Jane Alexander** | 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

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CEO, Enchant Energy

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Wyoming State Senator, Natrona County

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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)!

Looking back on FY21, my first full fiscal year, it was certainly a year of change, challenges and successes. Even for an industry accustomed to bust and boom cycles, the last year was unusually turbulent for the energy sector, including an international oil price war, a rapid drop in energy demand due to the pandemic and its economic impacts as well as a the implementation of federal energy policies targeting energy production – particularly on federal lands. These headwinds provided the backdrop for the sense of urgency and motivation that fueled the SER team to drive toward our mission: energy driven economic development for Wyoming.

In the last year SER had a renewed focus on our academic program – with an objective of training students for employment in the energy sector and related fields. SER conducted an independent strategic review of its academic program. The principal conclusions from that review were 1) the ERMD degree program can and should be revitalized through improved marketing and periodic reviews of the curriculum and 2) there are low- and no-cost collaborative academic offerings that can be pursued to increase the impact and number of students in SER's academic program. These recommendations are now being pursued, including the development of a new minor that is now open for enrollment.

In a year characterized by separation, SER's outreach efforts have been expanded through updating our website, improving our outreach materials both in appearance and content, growing SER's social media presence and launching a webinar series. These steps have allowed SER to connect with stakeholders in Wyoming and beyond in a particularly difficult time. Even after travel fully resumes, we believe the invigorated outreach program will continue to pay dividends and stand the test of time.

SER's research program remains strong and continued to grow over the fiscal year. After decades of work on carbon capture, use and storage (CCUS), SER experts are now sharing Wyoming subsurface data with commercial project developers. In many cases these commercial projects hinge on expanded support mechanisms that are currently being considered at the federal level and SER faculty and staff are grateful for the proactive nature of the Wyoming federal delegation.

SER's flagship research program is focused on carbon engineering – finding non-energy uses for Wyoming coal. That program is currently focused on high-volume materials, including soil amendments, construction materials and asphalt additives and replacements, as well as many other smaller-scale applications. This program has generated significant intellectual property and the processes and products are being demonstrated at progressively larger scales. In fact, SER is now in the planning and design stages for a continuous field demonstration to be built and operated near Gillette, WY.

The Wyoming CarbonSAFE project is a second flagship project, not just for SER, but also for UW and the state. Phase III of this project was launched on October 1, 2020. This project will pave the way for commercial project developers through developing new monitoring technologies, developing mechanisms to derisk $CO_2$ storage and demonstrating novel monitoring approaches. The project will also likely be the first in the state to obtain Class VI $CO_2$ storage permits. This project and others underway at SER and with our collaborators have moved Wyoming to the forefront of CCUS commercialization.

The SER research program also celebrated many other accomplishments over the fiscal year, including a growing program on rare earths and critical minerals marked by $3 million in awarded Department of Energy funding, hydrogen-production research, direct air capture, novel oil and gas production, reinvesting in the Wind Energy Research Center and much more. As the breadth and scope of our research program continues to grow, we commit to continue to focus on our mission to serve this great state that produces far more energy per capita than any other state in the union.

I offer my sincerest thanks for our supporters and collaborators. Without the support of the Wyoming legislature and the Joint Minerals Committee SER could not have the funds to carry out our work. Many thanks also to the Wyoming executive branch for providing leadership and guidance over the last year. As always, we are grateful for our passionate and engaged board, the Energy Resources Council, for providing us with guidance and oversight. To our collaborators at the Wyoming Energy Authority, Enhanced Oil Recovery Institute, Wyoming Business Council and subject matter experts at UW and beyond … we look forward to transition from one productive year to the next. Finally, to the energy industry of Wyoming, thank you for all you do to provide jobs, revenue and leadership in Wyoming. We are honored to serve you and this wonderful state.

Sincerely,

Holly Krutka

Holly Krutka, Ph.D.

Picture above:
(left) Dr. Holly Krutka presenting at the CarbonSAFE Public Outreach Meeting
(right) Graduate students conducting fieldwork under the direction of Prof. John Kaszuba

# GLOSSARY OF ACRONYMS

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

**A**
A&S - College of Arts & Sciences

**B**
BLM - Bureau of Land Management
BP - British Petroleum

**C**
CAQ - Center for Air Quality
CarbonSAFE - Carbon Storage Assurance Facility Enterprise
CBNGR - Center for Biogenic Natural Gas Research
CCCC - Center for Carbon Capture and Conversion
CCS - Carbon Capture and Storage
CCTI - Clean Coal Technologies Inc.
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
CERC-ACTC - U.S.-China Clean Energy Research Center Advanced Coal Technology Consortium
CORE-CM - Carbon Ore, Rare Earth and Critical Minerals

**D**
DFS - Dry Fork Station
DOE - Department of Energy

**E**
EERC - Energy and Environmental Research Center
EES Concentration - Energy and Environmental Systems
ELW Concentration - Energy, Land, and Water
EPC - Engineering, Procurement and Construction
ERC - Energy Resources Council
ERM - Energy Resource Management (minor)
ERMD - Energy Resource Management and Development

**F**
FY21 - Fiscal Year 2021

**H**
HB - House Bill
HERC - Hydrogen Energy Research Center

**M**
MOU - Memorandum of Understanding
MTR - Membrane Technology and Research
MVA - Monitoring, Verification, and Accounting

**N**
NCAR/Wyoming - National Center for Atmospheric Research
NEPA - National Environmental Protection Act
NETL - National Environmental Technology Laboratory
NREL - National Renewable Energy Laboratory
NSF – National Science Foundation

**P**
PCOR - Plains $CO_2$ Reduction
PI - Principal Investigator
PLM Concentration - Professional Land Management
PRB - Powder River Basin
PREC - Powell Research and Extension Center

**R**
RE Concentration - Renewable Energy
REE - Rare Earth Elements

**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
UW - University of Wyoming

**W**
WERC - Wind Energy Research Center
WRF - Weather Research and Forecasting
WyGISC - Wyoming Geographic Information Science Center

# EXECUTIVE SUMMARY

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, 2020, through June 30, 2021, in academics, research, newly emerging areas of focus, and engagement to keep UW and Wyoming at the forefront of the energy sector.

The fiscal year 2021 (FY21) was the first full year under the leadership of SER Executive Director, Dr. Holly Krutka. Under her guidance, SER has significantly grown and evolved in its critical areas of academics, outreach, and research, with a more targeted approach in achieving SER's core mission of energy-driven, economic development for the state of Wyoming.

Following a comprehensive strategic review, the academic program has flourished and is working towards a steady flow of increased enrollment numbers. SER launched a minor program to expand energy education opportunities campus-wide and cast a wider net for interdisciplinary learning at the nexus of energy, and hired new staff members to reinvigorate the program.

Outreach efforts underwent a similar revival and SER is working towards increased visibility, transparency, and collaborative opportunities.

SER has continued to be at the forefront of new and developing energy technologies in the state. Already deeply entrenched in conversations about alternative energy sources such as hydrogen and nuclear, SER has an eye on the energy transition, while maintaining its deep roots in the fossil fuel industries. Through the development of new products derived from Wyoming coal, or the storage of carbon dioxide underground, SER is committed to the ground-breaking research that will make large-scale commercialization possible on many fronts, and facilitating the partnerships between new and existing industries.

FY21 was a critical one for the Center for Carbon Capture and Conversion (CCCC) as many research projects moved into the field. The CCCC scaled up its coal solvent extraction pilot off the UW campus, completed two field-wide demonstrations of coal-derived soil amendments, and successfully developed high-quality and affordable building materials made entirely form Wyoming coal.

The Center for Economic Geology Research (CEGR) completed phase II of the Wyoming CarbonSAFE project, with a final report of its findings submitted to the Department of Energy (DOE) in an 800 page document. Phase III of the project began and is underway with field activities in the queue. In addition to the flagship CarbonSAFE project, CEGR was awarded DOE grants in two separate Wyoming basins to explore Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) opportunities.

Concurrent to all of SER's research endeavors has been the emphasis on energy law, policy, and economic analysis set forth by the Center for Energy Regulation & Policy Analysis (CERPA). Without the foresight and aid of CERPA to navigate the administrative roadmap of energy development, much of SER's research would stall. In it's first year, CERPA has provided critical assistance spanning multiple projects.

SER appreciates 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. SER's partnerships with UW faculty and industry representatives ensure the capability to be relevant and proactive, and are helping to keep energy a viable industry in Wyoming.

# ACADEMIC PROGRAM

## MISSION

The School of Energy Resources' academic mission is to develop innovative, interdisciplinary programs to meet the demands of the energy workforce and enhance societal literacy related to complex energy issues. Competitive success in the 21st century energy sector requires deep foundational knowledge and enabling skills to adapt to rapidly changing technologies and an escalating knowledge base. Competency-based learning that integrates problem-solving, critical analysis of uncertain and complex issues, and constant improvement in performance are overarching components of SER academic programs.

## STRATEGIC REVIEW

In FY21, the School of Energy Resources' academic program underwent a comprehensive strategic review. Led by Dr. David Whitman, UW Professor Emeritus, the review began on Sept. 1, 2020. Dr. Whitman was assisted in the project by a core steering committee that consisted of SER faculty, SER staff, and a representative from Academic Affairs. The review identified many strengths of the academic program, as well as areas of improvement. Following the recommendations outlined in the strategic review final report, the academic team at SER has implemented a plan to increase enrollment, retention of students, and bolster recruiting and marketing efforts.

## NEW HIRE

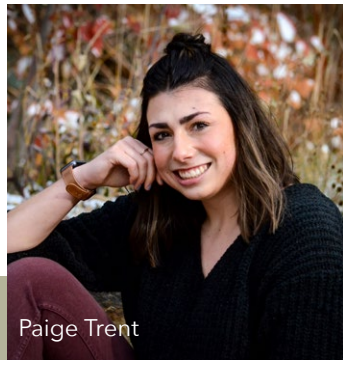
Kami Danaei was hired as the new Academic Advising Manager and began work on April 1, 2021. Kami is a Wyoming native and is originally from Kemmerer, Wyoming. As a first-generation college student, she attended a community college in Wyoming, Central Wyoming College. Kami then attended the University of Idaho for a bachelor's in communication, and lastly the University of Wyoming for both her master's in communication and her doctoral degree in education. Kami has been teaching/advising in higher education for 13 years. Kami has had roles at four Wyoming colleges in housing, admissions, and registrar offices as well.


Dr. Kami Danaei

## STUDENT AWARDS AND SCHOLARSHIPS

### Nominee, 2020 Rosemarie Martha Spitaleri and Tobin Memorial Outstanding Graduate Award

Paige Trent, BS Energy Resource Management and Development - Professional Land Management Concentration and BS Environment and Natural Resources.


Paige Trent

**Deans Honor Roll:** 7 | **President's Honor Roll**: 5
**Provosts List**: 1 | **First-Year Honor Roll**: 2

### Nielson Scholarship Awards

$6,030 shared between 3 students in Summer Nielson Scholarships

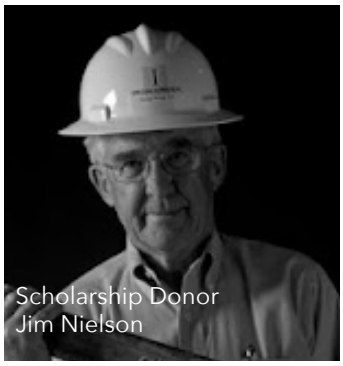
$9,000 shared between 3 students for Nielson Energy Scholarship for Women and Minorities

$2,000 shared between 2 students for Nielson Performance Award

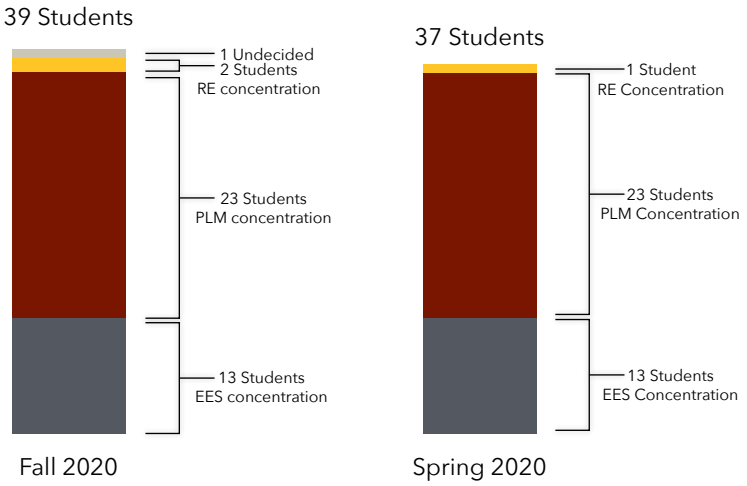
$2,400 shared between 2 students for Nielson Scholars Award

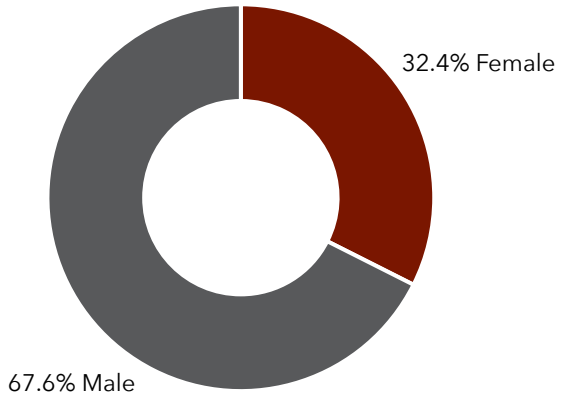
$5,400 shared between 2 students in Nielson General Scholarship

$12,250 shared between 39 students for Nielson Textbook Scholarship


Scholarship Donor Jim Nielson

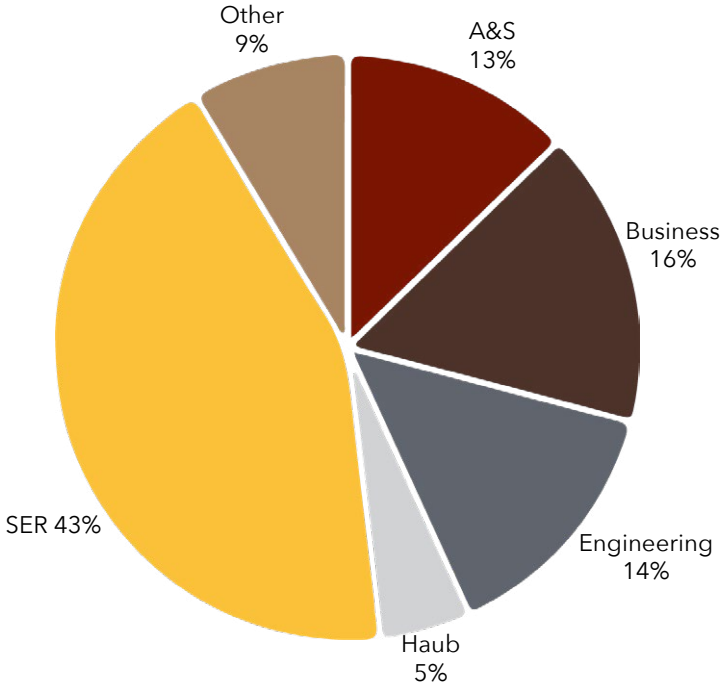
## ERMD STUDENT ENROLLMENT




## UW STUDENT ENROLLMENT IN SER COURSES

SER courses are interdisciplinary and energy education is provided outside of declared ERMD majors. Non-SER students accounted for 57% of enrollment in SER classes during FY21.




## GRADUATES

The School of Energy Resources graduated 11 total students from the ERMD degree in FY21. 2 students in December 2020, and 9 students in May 2021. Of the 11, 4 are continuing their education, 3 of which are attending law school in the fall.

## CONCENTRATION NAME CHANGE

**The Energy, Land, and Water (ELW)** concentration was renamed **Energy and Environmental Systems (EES)**. The name change is part of an effort to fully capture the essence of the coursework that students are undertaking in the concentration.

The quality of the degree will remain the same, as will the curriculum. It is expected that the name change will provide clarity in recruiting efforts to students, as well as for employers hiring SER graduates.

(left to right) Jordan Remley, Hugo Hernandez, Tori Strom, Alyson White Eagle-SoundingSides, SER Executive Director Holly Krutka, Paige Trent

## STUDENTS MAKING A DIFFERENCE

### Professional Land Management Students Work to Remove Non-Enforceable Covenants

Work initiated by Professor Koski and students in the Professional Land Management concentration to remove racists covenants in Wyoming went before the Wyoming Legislature as House Bill 0091.

PLM students worked to trace restrictive covenants, and then began door to door visits to ask homeowners to support removing the covenants. While restrictive covenants are no longer enforceable and violate the law, they remain on the books in many subdivisions. With their work halted by the pandemic, students under the guidance of Professor Koski introduced a bill to the Wyoming legislature. Legislative action would provide a means for removing the exclusionary language from the covenants permanently.

The legislature voted to approve the bill and it was codified into law beginning July 1, 2021.

## LAUNCH OF MINOR PROGRAM

The University of Wyoming's School of Energy Resources (SER) is now offering a new minor in energy resource management (ERM).

The new minor will allow a wider array of UW undergraduate students to gain access to specialized energy instruction to supplement and enhance their education. The minor will benefit students who are interested in business, economics, finance, engineering, science, law, real estate, lab sciences, land management, political science, sociology, agriculture, and environment and natural resources. By acquiring a foundational knowledge of diverse energy topics and interdisciplinary training, students will gain a competitive edge to expand career opportunities.

An additional strength of the program is that it is built entirely from existing courses throughout the university that have an emphasis on energy. There are no incremental costs associated with the program, and the added credential will help to boost enrollment and curricular overlap.

http://www.uwyo.edu/ser/academic-programs/minor-erm

# 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*** completed a study of federal oil and gas leasing policies in late December 2020. The report was released during an online press conference hosted by Governor Gordon of Wyoming. The study attracted considerable interest nationally and especially in the western states examined in the report including Wyoming, Montana, North Dakota, Colorado, Utah, New Mexico, California, and Alaska.

***Professor Po Chen*** has been working towards the commercialization of a full-3D, full-waveform seismic tomography software that he has developed at UW.

***Professor Maohong Fan*** led several National Science Foundation (NSF) and Department of Energy (DOE) projects in FY21. The projects included research in biomass and coal conversion, carbon dioxide ($CO_2$) capture and utilization and sequestration, and methane ($CH_4$) conversion. The projects are a collaborative effort with more than 10 universities, national labs and companies.

In a collaborative project with West Virginia University, ***Professor Tara Righetti*** of the College of Law and School of Energy Resources, and ***Associate Lecturer Kris Koski*** of the School of Energy Resources authored a study with the United States Energy Association (USEA). The study examined state's policies & regulations on permitting, infrastructure, incentives, royalty owners, eminent domain, and mineral-pore space as it relates to subsurface carbon storage and use.

***Professor Bruce Parkinson*** worked on an SER funded project to investigate the usefulness of covalent organic framework materials for hydrogen storage.

**106***
**Energy Publications**

**11***
**Students Supported on Faculty Projects**

**Numbers based only on SER faculty that reported. Additional energy publications were published and students funded in FY21 through our affiliates and Center's of Excellence. The number of students supported above reflects additional, non-SER funded projects brought in by SER faculty.*

# FACULTY MEMBERS

**Tim Considine**, Director, SER Academic Program and SER Professor of Economics and Finance

**Craig Douglas**, SER Professor of Mathematics

**Maohong Fan**, SER 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

**John Kaszuba**, SER Professor of Geology and Geophysics

**Tara Righetti**, SER Professor of Law

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

# MAJOR ACCOLADES

**Professor John Kazuba** was named the recipient of the John and Jane Wold Centennial Chair in Energy.

**Professor Dario Grana** was named the Wyoming Excellence Chair in Geology and Geophysics.

**Professor Tara Righetti** was the recipient of a Fulbright Scholarship and will spend a sabbatical year in Lille, France.

# SELECT FACULTY PUBLICATIONS

Jia, L., **Mallick, S**., and Wang, C., 2021, Data driven prestack waveform inversion using genetic algorithm-methodology and applications, Interpretation, acceptance pending final approval of Figures, Tables, and other publication documents.

**Kris Koski**, Jesse Richardson, **Tara Righetti**, & Sam Taylor, United States Energy Association, Study on State's Policies & Regulations per $CO_2$-EOR Storage Conventional, ROZ and EOR in Shale: Permitting, Infrastructure, Incentives, Royalty Owners, Eminent Domain, Mineral-Pore Space, and Storage Lease Issues (2020).

**D. Grana**, M. Liu+, and M. Ayani+, 2021, Prediction of $CO_2$ saturation spatial distribution using geostatistical inversion of time-lapse geophysical data, IEEE Transactions on Geoscience and Remote Sensing, 59 (5), 3846-3856.

Guobao Li, Qian Yang, Lenore Kubie, Joshua T. Stecher, Zbigniew Galazka, Reinhard Uecker and **Bruce A. Parkinson**, "Synthesis and Characterization of Multidentate Ligand Capped Water-soluble Monodisperse PbS Colloid Quantum Dots and Their Application for Highly Stable Sensitized Photocurrents", CHEMNANOMAT, 6(3), 461-469, (2020) doi.org/10.1002/cnma.201900679.

Liao, Wu-Yu & Lee, En-Jui & Mu, Dawei & **Chen, Po** & Rau, Ruey-Juin. (2021). ARRU Phase Picker: Attention Recurrent-Residual U-Net for Picking Seismic P - and S -Phase Arrivals. Seismological Research Letters. 92. 10.1785/0220200382.

**Tara Righetti**, Temple Stoellinger, Robert Godby, Kipp Coddington, Adapting to Coal Plant Closures: A Framework for Understanding Energy Transition Resistance (Forthcoming Environmental Law).

**Mallick, S**. and Chakraborty, D., 2021, Efficient estimation of the ocean water sound speeds via attribute-derived waveform inversion, Geophysical Journal International (under review).

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.

Ye, Runping & Liao, Lin & Ramirez Reina, Tomas & Liu, Jiaxu & Chevella, Dr. Durgaiah & Jin, Yonggang & **Fan, Maohong** & Liu, Jian. (2020). Engineering Ni/$SiO_2$ catalysts for enhanced $CO_2$ methanation. Fuel. 285. 10.1016/j.fuel.2020.119151.

**Tara Righetti**, Liberating Split Estates, 14 Int'l J. of the Commons 638 (2020).

R. Feng, **D. Grana**, N. Balling, and T.M. Hansen, 2021, Bayesian convolutional neural networks for seismic facies classification, IEEE Transactions on Geoscience and Remote Sensing, accepted for publication.

Mark T. Spitler, Miguel A. Modestino, Chengxiang X. Xiang, James R. Durrant, Sophia Haussener, Stephen Maldonado, **Bruce A. Parkinson**, David S. Ginley, Frances A. Houle, Thomas Hannappel, Nathan R. Neale, Daniel G. Nocera and Paul C. McIntyre, "Practical challenges in the development of photoelectro-chemical solar fuels production", Sustainable Energy Fuels, 2020, 4, 985. DOI: 10.1039/c9se00869a

**Considine, T**. "The Fiscal and Economic Impacts of Federal Onshore Oil and Gas Lease Moratorium and Drilling Ban Policies" (Dec. 14, 2020).

# 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 PROJECTS

### *Bayesian Learning Consortium*

The Bayesian Learning Consortium is an industry-sponsored consortium directed by Prof. Dario Grana. The consortium is currently funded by British Petroleum (BP). The consortium research focuses on seismic reservoir characterization methods for hydrocarbon reservoir and $CO_2$ sequestration. The research project aims to provide more accurate estimates of rock and fluid properties in the reservoir and quantify the uncertainty associated with them. Reservoir properties are predicted from seismic and well log data before and during oil production and $CO_2$ injection. In addition to Dr. Grana, the Bayesian Learning Consortium includes 1 Ph.D. student and 2 M.S. students.

### *Seed Funding Initiative*

At the mid-point in FY21 SER released a request for proposals for seed funding research to be completed by the end of the fiscal year. The ultimate goal of this seed funding was to support small projects and therefore enable the principal investigators to have sufficient information and tools to pursue external research grants, ultimately growing the foundation of work focused on Wyoming-energy-driven economic development. Projects were selected in the following topic areas:

- Carbon Capture, Use and Storage
- Rare Earth Elements Extraction and Exploration
- Energy Economic Development and Impact
- Wind
- Hydrogen Storage

Final reports were submitted by the project Principal Investigators (PI) in July. The overarching theme in all of the reports was that the funding was helpful to organize and generate new data and ideas for proposal submittal. Funding for the projects ended at the end of the fiscal year with no further commitments being made to these projects in FY22.

## CENTERS OF EXCELLENCE

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

**The Center for Energy Regulation & Policy Analysis**, Directed by Kipp Coddington

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

**The Shell 3D Visualization Center**, Managed by Emma Jane Alexander

## FACULTY-LED CENTERS OF EXCELLENCE

**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 Steve Carpenter

## HYDROGEN ENERGY RESEARCH CENTER

The School of Energy Resources has initiated new efforts to expand research and identify opportunities to diversify Wyoming's economy, including its energy sector. One such opportunity is hydrogen. Experts at SER believe that hydrogen, or $H_2$, is a natural fit for Wyoming energy production, as the state's natural resources and existing infrastructure are well-suited to launch a hydrogen economy. SER has begun fundraising efforts to support a Hydrogen Energy Research Center (HERC) which will focus on all forms of clean hydrogen.

## OCCIDENTAL FACULTY CHAIRS

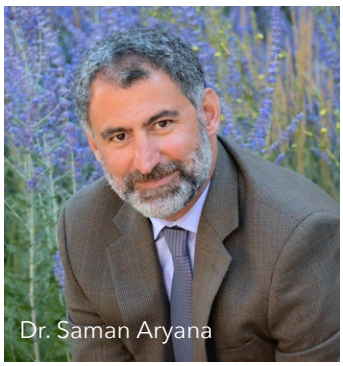
As a Wyoming producer and international leader on carbon management, SER is proud to collaborate with Occidental on a number of projects. Among these is administration of two distinguished faculty chair positions.

The ***Occidental Chair in Energy and Environmental Technologies*** was created to champion a distinguished UW faculty member whose research expertise lies in improving enhanced oil recovery techniques, as well as long-term carbon dioxide storage solutions.

**Dr. Saman Aryana** is the first Occidental Chair in Energy and Environmental Technologies.

A UW chemical engineering associate professor, Aryana's research has primarily focused on the fundamental physics of flow instabilities and the dynamics of subsurface displacement processes. Before joining UW's faculty, Aryana worked as a reservoir engineer for Occidental as part of a reservoir management team, and he served on a business development group for the company. He earned his B.S. and M.S. degrees in civil engineering from the University of Texas-Arlington, and his Ph.D. in energy resources engineering from Stanford University.

***The Occidental Chair of Energy and Environmental Policy*** will hold an appointment in the Helga Otto Haub School of Environment and Natural Resources (Haub School) with an affiliation to the School of Energy Resources. A search was initiated in FY21 and is ongoing to fill the position.


Dr. Saman Aryana


Haub School

## STUDENT AND FACULTY SUPPORT

SER research funded 182 faculty, research scientists, and students in FY21. The count includes state, foundation, and federal funding sources. The personnel reside in many of the University of Wyoming Colleges, including the Colleges of Agriculture and Natural Resources, Arts and Science, College of Business, College of Engineering and Applied Science, College of Law, Haub School of Environment and Natural Resources, School of Energy Resources.

# FACULTY-LED CENTERS OF EXCELLENCE

**CENTER OF EXCELLENCE FOR PRODUCED WATER MANAGEMENT (CEPWM)**: While maintaining its principal research focus on membrane development for water treatment technologies, CEPWM is working on novel approaches to electrolysis for hydrogen production. Recently two papers have been prepared and submitted to Environmental Engineering Science, that focus on magnetic field approaches to hydrogen production.

**CENTER FOR BIOGENIC NATURAL GAS RESEARCH (CBNGR)**: spent the year working with Cowboy Clean Fuels, LLC, which is a renewable natural gas company with the exclusive rights to commercialize technologies patented through the Center for Biogenic Natural Gas Research. The company was formed in 2020 to commercialize the University of Wyoming patent, Biomass-Enhanced Natural Gas from Coal (WO2012135847A1). Cowboy recently completed its Phase II field demonstration in Wyoming's Powder River Basin which established the economic viability of using the technology to transfer coalbed methane (CBM) into low carbon renewable natural gas using alternative microbial feedstock. For the foreseeable future, all research and development activities performed through the Center will focus exclusively on supporting commercial efforts.

**CENTER OF EXCELLENCE FOR AIR QUALITY (CAQ)**: recently completed modeling of 2017 ozone events in the Upper Green River Basin with the WRF-CHEM (Weather Research and Forecasting Model-Chemistry) model. The model was able to successfully simulate ozone episodes in the basin after modifications to snow albedo and ozone deposition schemes. This work represents a significant step forward in that CAQ scientists were able to successfully reproduce wintertime ozone formation during inversion events.

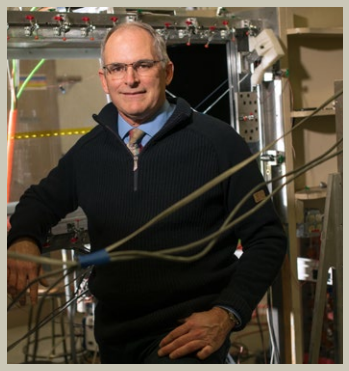
The CAQ in a cooperative agreement with -- and funded by -- the U.S. Bureau of Land Management (BLM) completed field work in a mobile air quality lab. The Wyoming Air Quality Assessment and Outreach Program performs air quality monitoring that is required by National Environmental Policy Act (NEPA) assessments to facilitate oil and gas development in Wyoming.

**WIND ENERGY RESEARCH CENTER (WERC)**: is a long standing Center of Excellence at the University of Wyoming. In FY21 SER worked to help reinvigorate the Center and bring it under the SER umbrella. Wind is currently the fastest-growing sector of the Wyoming energy economy. The goal of WERC upon incorporation into SER is to develop collaborative research programs to streamline wind energy development in Wyoming while also providing a trusted resource for information to state and local decision makers.

Based on previous wind plant modeling work, UW faculty and students are working with collaborators at the National Renewable Energy Laboratory (NREL) to model the wind resource across the 48 continental states, Alaska, Hawaii, and the ocean regions surrounding those states. The simulations are being carried out in the Weather Research and Forecasting (WRF) model covering the period from 2000-2020. This massive computational effort is using the NCAR/Wyoming supercomputer in addition to computational resources from DOE.


^ SER student **Isaac Boetcher** completed fieldwork with CAQ as part of a research internship.

Mechanical Engineering Professor **Jonathan Naughton** started WERC in 2008. v



# 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.*

## STAFFING

In FY21, SER reorganized its leadership positions. Scott Quillinan, CEGR's former Director became SER's Senior Director of Research. Dr. Fred McLaughlin stepped in near the end of the fiscal year as Interim Director. The organization chart was updated as well, with Drs. John Jiao and Erin Phillips serving as section leads for CEGR research scientists. CEGR staff continues to expand. In this fiscal year, CEGR hired Dr. Ying Yu under Phase III of the CarbonSAFE project and Selena Gerace (also partially under CERPA) under the PCOR project. At least two additional technical hires will made under the CarbonSAFE grant in the first quarter of the next fiscal year, and up to four hires could be made under new grants.

Scott Quillinan


J. Fred McLaughlin

## CARBON CAPTURE, STORAGE AND UTILIZATION

### *Wyoming CarbonSAFE Project*

The CarbonSAFE project is CEGR's flagship 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, which commenced October 1, 2020.

In Phase III, the project team will: (1) complete characterization of the $CO_2$ storage complex by rigorous commercial-scale surface and subsurface testing, data assessment, and modeling; (2) 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;

## WHO WE ARE

**J. Fred McLaughlin**, Interim Director

**Zunsheng 'John' Jiao** Senior Geologist/Project Manager

**Erin H.W. Phillips,** Senior Research Scientist/Geochemistry

**Yuri Ganshin,** Senior Research Scientist/ Geophysicist

**Heng Wang,** Senior Research Scientist/ Reservoir Engineer

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

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

**Matthew Johnson**, Research Scientist/ Geomodeling

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

**Selena Gerace**, Research Scientist/CO2 Reduction Policy

## UW CONTRIBUTORS

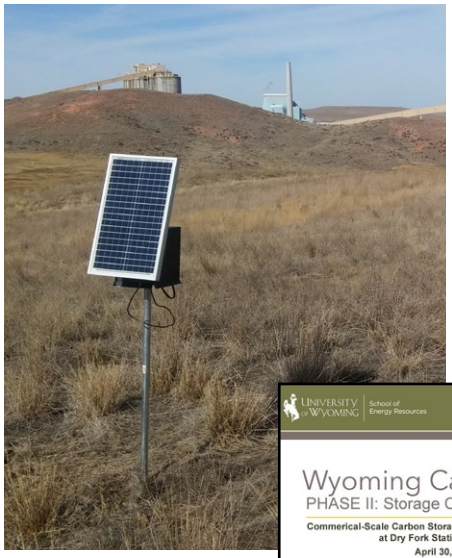
**Scott Quillinan**, Senior Director of Research

**Kipp Coddington,** Director, Center for Energy Regulation & Policy Analysis

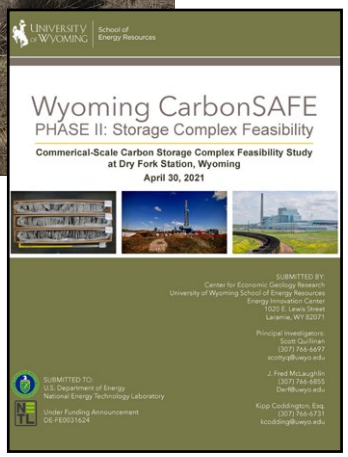
(3) integrate Membrane Technology Research's separately funded $CO_2$ capture FEED study at Dry Fork Station (DFS), and; (4) conduct NEPA analyses in support of eventual commercialization of the site.

Work to-date on Phase III includes deploying environmental monitoring systems for baseline site assessments, finalizing Class I permitting for both wells at the storage site, beginning the assessment of incorporating MTR's capture technology into storage infrastructure, and updating Phase II models, MVA and risk assessments with new data/interpretations.

With respect to the previous phase of the program, Phase II ended on January 31, 2021, with a final report delivered to the DOE in April of 2021. Under this phase, a stratigraphic test well was drilled to a depth of 9,873 feet below the land surface, providing 625 feet of geologic core from 9 geologic formations and fluid samples from 6 formations. A 3D seismic survey, centered around the test well, was collected in August 2020. In addition, the project team developed a commercialization approach to develop a storage hub around the primary site near DFS to include: a risk assessment and MVA strategy, land owner evaluation, relative storage capacity, economic assessments, and well requirements.



^ A fully deployed $CO_2$ sensor station




Wyoming CarbonSAFE Phase II Final Report >

### *U.S.-China Clean Energy Research Center Phase II (CERC II)*

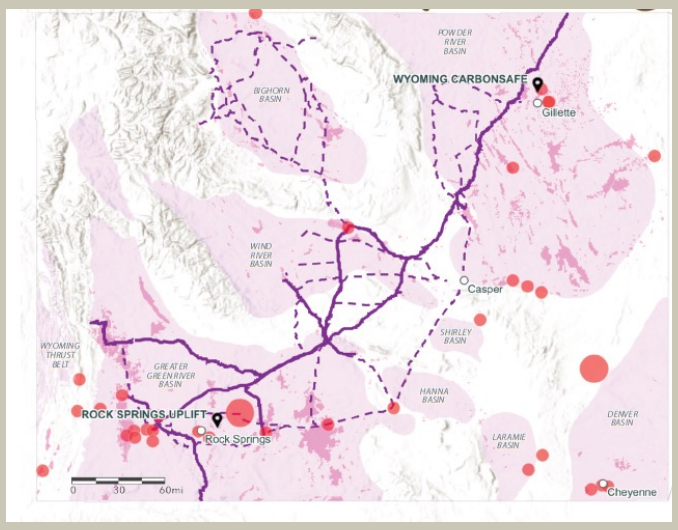
SER finalized its work with the Joint U.S.-China Clean Energy Research Center – Advanced Coal Technology Consortium (CERC-ACTC), a joint research effort between the United States and China. The U.S. membership consists of federal, private, and public sectors and is managed for the DOE by West Virginia University. The 5th and final year of Phase II of CERC closed on June 30, 2021.

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

CEGR is teamed with the Energy and Environmental Research Center, at the University of North Dakota in the PCOR Partnership, a Regional Carbon Sequestration Partnership.

The project began on May 1, 2020 and aims to develop a regional deployment of carbon capture and storage. The PCOR Partnership includes over 120 stakeholders from industry, regulatory, and academia.

The team is working on a Wyoming contribution to the revised PCOR Atlas, developing a template for Class VI permitting in Wyoming, and working with the EERC on a stacked storage summary for Wyoming.




^ A preliminary figure from the PCOR $CO_2$ Atlas showing Wyoming's $CO_2$ sources, infrastructure, and formations and basins capable of sequestration.

## 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. The 3 year project began in December of 2020.

### *NETL Cores of Opportunity*

SER is teamed with the National Energy Technology Laboratory to contribute samples and data to the Cores of Opportunity program, which will help to identify geologic controls on REE in sediments.

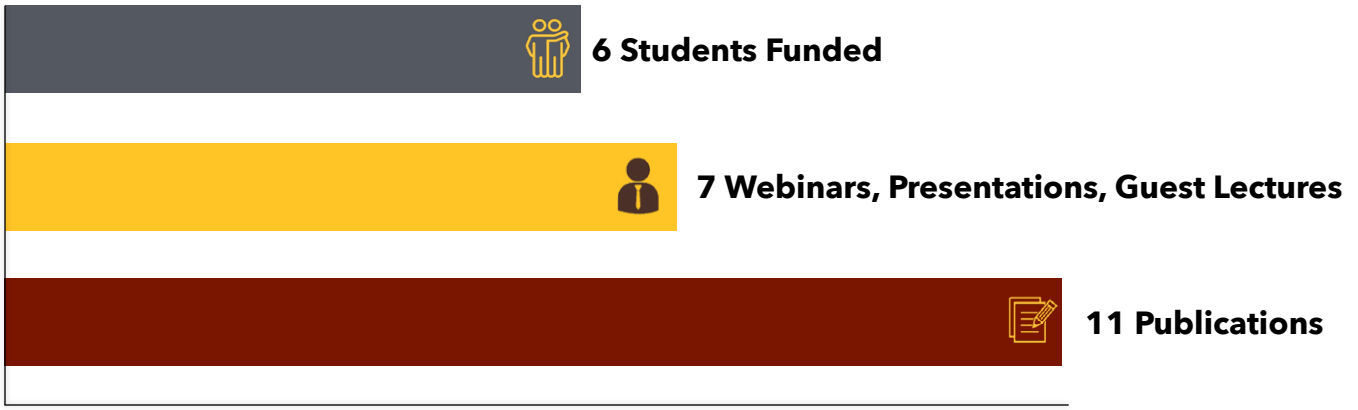
### *CORE-CM (carbon ore, rare earth and critical minerals)*

The Department of Energy (DOE) funded both of SER's proposals under the CORE-CM program initiative. The two proposals are CORE-CM Powder River Basin and CORE-CM Greater Green River and Wind River Basins led by Dr. Erin Phillips and Mr. Davin Bagdonas respectively.

The projects aim to develop technologies and collaborations to drive rare earth element and critical mineral production, extraction, and consumption industries, as well as carbon-based product research and development. Additionally, each project has assembled teams of more than 50 project partners, including entities and stakeholders representing industry; academia; state, county, and city government; economic development groups, and tribal leadership.

Both Phase I projects will last for two years, with anticipated start dates of September 1, 2021.

## OUTREACH AND ENGAGEMENT



# CENTERS OF EXCELLENCE

## CENTER FOR ENERGY REGULATION & POLICY ANALYSIS

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

## PROJECT UPDATES

### *Research Projects in FY21*

- Case Study of Regional Coal Plant Retirements Policies - ***Completed***.
- International, Federal and State Low-Carbon Policies Impacting Exports of Wyoming Energy - ***Commenced***.
- Techno-Economic Assessment of Retrofitting CCS/CCUS to Wyoming's Coal Fleet/HB 200 Analysis - ***Commenced.***
- Analysis of the Export of Low-Carbon Electricity from Dry Fork Station - ***Commenced.***
- An Assessment of How the Paris Agreement and a Possible Clean Electricity Standard Could Impact Wyoming - ***Commenced.***

### *Policymaker Support*

CERPA provided support to Wyoming policymakers – specifically in the form of drafting rulemaking comments, and providing expert subject matter input on various matters including the Wyoming Office of the Governor, the Wyoming Energy Authority and the Wyoming Business Council.

### *Industry Support*

CERPA provides guidances for industry partners in the state. During FY21, CERPA assisted the Petroleum Association of Wyoming.

### *Grant Support*

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

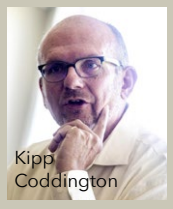
- Wyoming CarbonSAFE (all phases & continuing)
- Plains $CO_2$ Reduction Partnership (PCOR)
- Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) for U.S. Basins - Powder River Basin
- CORE-CM - Greater Green River and Wind River Basins.

## WHO WE ARE

**Kipp Coddington, Esq.**, Director

**Jada Garafalo, Esq.**, Assistant Research Scientist

**Selena Gerace**, Assistant Research Scientist


Kipp Coddington

## UW FACULTY CONTRIBUTORS

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

**Dr. Rob Godby**, Associate Dean, Haub School of Environment & Natural Resources; Associate Professor, 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.**, Assistant 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

### *Other Projects*

CERPA led an effort to obtain research funding from the U.S. Air Force (USAF) under the USAF's "Reimagining Energy" initiative; it advanced to the second round but failed to advance further.

CERPA participated in a still-pending proposal led by Professor and Oxy Chair Saman Aryana to the National Science Foundation on an Engineering Research Center related to future energy topics.

CERPA continues to provide ongoing administrative support to Professor Tim Considine related to work funded by the Charles Koch Foundation.


### *Select Publications*

Western, J., Freedman, K., **Gerace, S.** "Earning the Social License of Tomorrow in an Energy State", American Coal Council (June 17, 2021).

**Righetti, T.**, **Stoellinger, T.**, **Godby, R.**, **Coddington, K.** "Adapting to Coal-Plant Closures: A Framework for Understanding State Resistance to the Energy Transition" (CERPA working paper, 2021.

McLaughlin, F., Quillinan, S., **Coddington, K.** "Wyoming CarbonSAFE: Advancing Commercialization of Low-Carbon Energy Technologies in Fossil-Rich Wyoming", Proceedings of the 15th Greenhouse Gas Control Technologies Conference, March 15-18 (2021).

Western, J., **Gerace, S.** "Social License for Wyoming's Energy Future: What Do Residents Want?" (Nov. 2020).

**Righetti, T.**, Richardson, J., Koski, K., Taylor, S. "The Carbon Storage Future of Public Lands" (2020).

# 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 design and function of the technology used in these projects are created with the intention of conversion for large-scale, commercialization.*

**Clean Combustion & Carbon Capture** — A strong emphasis on coal beneficiation and sustainable energy use

**Strategic Objectives**

**Carbon Engineering Technology** — Develop and demonstrate new technology solutions to convert coal into non fuel and energy products.

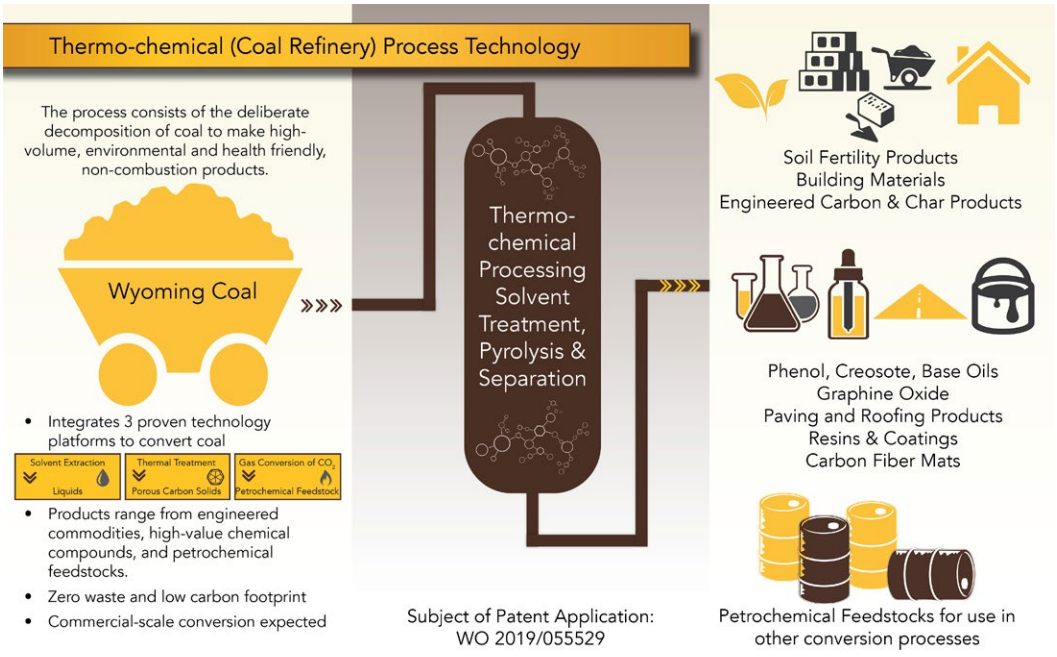
**Conduct Market Studies** — Assess the economic feasibility of products and technologies under development

## THERMO-CHEMICAL PROCESS TECHNOLOGY

The program is aggressively pursuing technology, scale-up, demonstration and commercialization objectives which support diversification of the Wyoming economy and creating new industry.

Three pilot plants have been commissioned and are in operation to deliberately decompose coal, which when integrated represent the UW proprietary (patent pending) processing solution to make products that do no harm to health and the environment.

The pilot plants, represent each of the process stages, which are **coal-pyrolysis**, **coal-solvent extraction** and **dry methane reforming**.



## COAL TO PRODUCTS FIELD DEMONSTRATION SHOWCASES

### *Coal Processing*

A collaboration and technology development agreement has been formalized with Atlas Carbon LLC, which manufactures activated carbon from coal in Wyoming. The intent is to engineer and demonstrate the pyrolysis and solvent extraction steps at their Gillette commercial manufacturing location, and investigate potential for integrating this technology with Atlas's own technology to make value added products.

An engineering feasibility study has started with Wood, an engineering, procurement and construction (EPC) contractor, who will frame and then detail engineering requirements for the showcase technology demonstration. This demonstration will be capable of processing between 1 and 5 tons of Wyoming coal per day.

### *Coal Derived Building & Construction Products*

The CCCC has developed and manufactured eco-friendly, high-performance building materials from coal. A design for a building that will demonstrate the performance of various coal derived construction products including char-bricks, dry wall boarding, plaster, structural members, roofing and waterproofing materials, has been completed and will begin construction in the fall.

### *Coal Based Asphalt Products*

A baseline formulation of coal-derived asphalt has been produced, using the extract intermediate that is yielded from solvent extraction of raw PRB coal. These formulations can be customized to suit the properties required for either whole paving or roofing applications. The current activities seek to optimize the techno-economics of producing a viable coal derived asphalt product(s).

### *Agricultural & Soil Fertility Products*

Researchers have continued monitoring field trials of coal derived soil amendments on sweet corn and silage crops that began in 2018-2019 with the UW Sustainable Agriculture Research and Extension Center (SAREC) in Lingle WY. The level of performance over the years has continued to improve, suggesting adding coal derived soil amendments have a long-term beneficial impact on soil fertility.

Based on the results, new field trials were started in FY21 at the UW Powell Research and Extension Center (PREC), which has a different soil type. In this case, evaluations are centered on sugar beet and silage crops.

## FUTURE OF COAL IN ENERGY & THERMAL APPLICATIONS

### *Coal Beneficiation*

Laboratory studies validated and confirmed the general performance attributes of Clean Coal Technologies Inc., (CCTI) proprietary PRISTINE® coal beneficiation technology, which claims to increase the energy content of Wyoming run-of-mine Powder River Basin (PRB) coal. An improved method to stabilize the coal-after drying has been proposed, and is subject to intellectual property protection. Process modifications have been recommended, to effect the 'new' coal stabilization solution, which is awaiting performance validation at the technology demonstration site location near Gillette, WY pending successful fundraising by CCTI.

### *Clean Combustion*

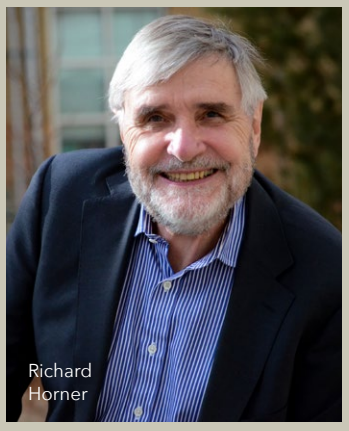
After unsuccessfully gaining a phase III award under the US. Department of Energy (DOE) large scale pilot plant program, to demonstrate flameless pressurized oxy-fuel combustion technology on Wyoming PRB coal, at a coal fired electricity generation location in Wyoming, the feasibility of hosting a commercially viable project in Wyoming has been validated. Discussions are currently underway with a Wyoming oil and gas operator to host a privately funded project, which will include combustion, carbon capture and below ground utilization.

### *Coal Market Study*

A study to evaluate and make recommendations to improve the Wyoming coal export supply chain to support sales in the Asia-Pacific region has started. The focus is to identify and recommend ways to reduce supply risk, improve availability and reduce cost. A number of already identified propositions are being validated and tested with market participants.

## WHO WE ARE

**Richard Horner**, Director


Richard Horner

## UW FACULTY & STUDENT RESEARCHERS

**10** UW Faculty

**23** Graduate Students

**5** Post Doctoral Researchers

**17** Staff & Part-Time Researchers

RESEARCH

# 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.*

## BUSINESS MODEL TRANSITION

A transition is underway in the 3D Viz Center to become a grant funded, self-sustaining facility. Even during a pandemic year, remote working, and various other challenges, the 3D Viz Center increased grant-funded totals by over 1000%.

## FY21 PROJECTS

**GRANT VALUE**
The total combined value of grant funding was $165,494

**CLIENTÈLE**
Diverse clients included: SER, UW Dept. of Anthropology, the UW Art Museum, Northern Wyoming Community College District, UW Life Sciences, UW Dept. Of Ecosystem Science and Management, UW Faye W. Whitney School of Nursing, and the Biodiversity Institute

**PROJECTS FUNDED**
11 projects were grant-funded during FY21

**AREAS OF RESEARCH**
Areas of investigation on projects include: linguistics, art, surface mine exploration, molecular bonding, health and wellness, business, wildlife, artificial intelligence, soil.

## MILESTONES

1. Successfully defined and began the transition to a grant funded facility (as of fall 2020)

2. Increased quantity and value of grant applications compared to previous year

3. Welcomed a new cohort of student interns on the Technology Associated Program (TAP)

4. Increased interactions with the UW Foundation and UW strategic planning UW Digital Pillar and the proposed school of computing

5. Established the new directors group & working group to provide insight and comment on both strategic and service provision.

6. Cultivated multiple stakeholder prospects

| FY21 Grant Funding Total: $165,494 | Previous Years Combined Total: $15,907 |
|---|---|

## WHO WE ARE

**Emma-Jane Alexander,** Manager

**Phil Black**, 3D Asset Developer

**Patrick O'Toole**, Scientific VR Lead Developer

**Kyle Summerfield**, Creative VR Lead Developer

## CONTRACTORS

**Jerry Evans**, Mechdyne

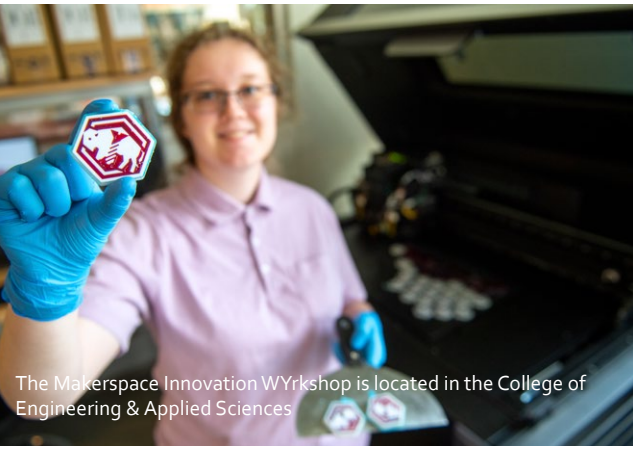
## SELECT PROJECTS IN PROGRESS

### *Riverbed Morphology*

The 3D Viz Center is facilitating a campus wide response to a potential multi-stakeholder project regarding riverbed morphology; the concept being that by performing routine data capture and being able to transition between the macro and micro scales (e.g., Google Earth or a grain of sand) the resulting tool could be utilized in teaching, research, engagement and entrepreneurial activity focused on the North Platte River (supporting tourism, water management, and economic development). Ms. Alexander is liaising with the UW Foundation, the College of Business, The Haub School, WYGISC, and the external project instigator.

### *Once Upon an Aquifer*

The proposal called Once Upon an Aquifer is in its final stages of development and is gaining interest and momentum from internal and external entities. The collaborative group of computer scientists, storytellers, and geologists are seeking endorsements from entities such as the City Council and the County Commission and will be seeking funding from the Wyoming Humanities Council, Wyoming Cultural Trust, and the Wyoming Community Foundation. Once Upon an Aquifer is an interdisciplinary arts-meets-science proposal which strives to innovate new methods of public, community and stakeholder engagement which utilize 360-degree data capture, immersive 3D visualization technology, and mobile application development. This highly digital proposal is brought to by a collaborative group whose mission it is to enlighten, educate, and inspire the Wyoming community about why aquifers are fundamental to their lives; Once Upon an Aquifer unites scientists and storytellers with technology to enable the telling of Albany County's very own "Water Story".



The Makerspace Innovation WYrkshop is located in the College of Engineering & Applied Sciences

Photo Pilot Hill Rainbow: Celebrating the Pilot Hill Project and Casper Aquifer Recharge Zone, Laramie High Mural Project, photo by Paul Taylor

### *Digital Badges*

The 3D Viz Center team are working on a variety of in-house short courses and Digital Badges (in collaboration with the UW Makerspace). The team are compiling a menu of course options and designing content to trial in delivery in the spring semester.

# OUTREACH AND ENGAGEMENT

Despite the difficulties and challenges imposed on regular outreach and engagement activities due to COVID-19 restrictions on travel and public gatherings, the School of Energy Resources remained steadfast in its mission to provide transparency on research activities, energy education, and engagement with Wyoming communities. By utilizing virtual platforms, SER continued to communicate with key stakeholders, industry partners, and members of the public.

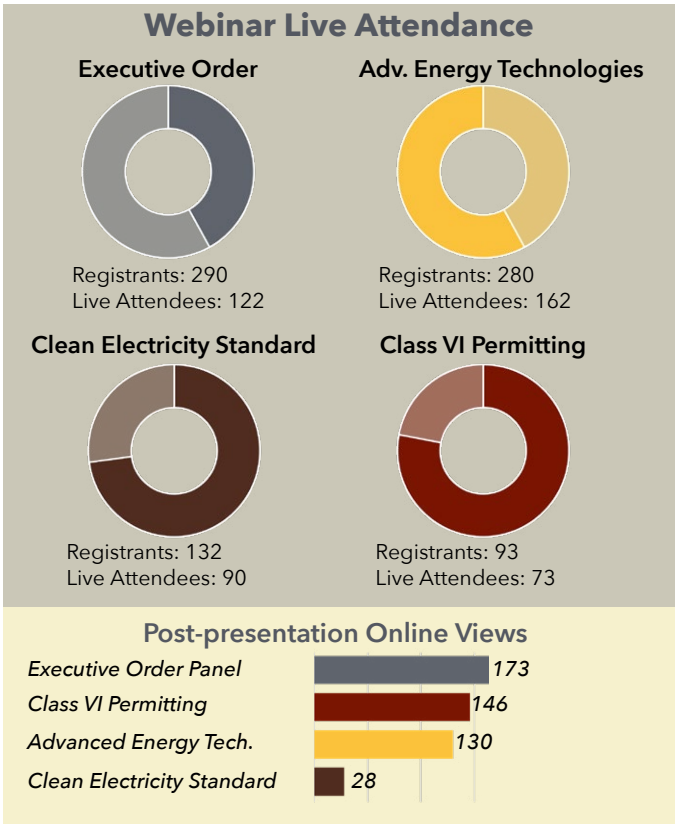
## STAFFING

SER hired an Outreach Director, Christine Reed in September of 2020. In her role, Christine has worked to fill gaps in communication both internally and externally, and has devoted her efforts to provide consistent and constant communication with SER constituents. Additionally she has provided support to individual research and academic units within SER.

## WEBINARS

Presented or supported webinars and online forums:

- UW Alumni Association Energy Town Hall
- Navigating Executive Orders & What They Mean for Wyoming | CERPA
- $CO_2$ Transport Infrastructure MOU Webinar: Pore Space and Legal Liability | CERPA
- Navigating Class VI Permits: What to Expect in Wyoming | SER/CEGR
- Advanced Energy Technologies: Legal and Environmental Considerations for Small Modular Reactors | CERPA
- Overview of A Possible New Federal Clean Electricity Standard: The View from Wyoming




## ELECTRONIC BLOG AND QUARTERLY NEWSLETTER

Outreach created a blog platform to highlight SER news about faculty, staff, research projects, and students. Fully integrated with SER's social media platforms, good news from SER is reaching more people than ever.

Additionally, outreach developed a quarterly newsletter that is distributed electronically in March, June, September, and December. Drawing from the news highlighted in the blog posts, the newsletter offers a compilation of SER's activities in an easy to read format.

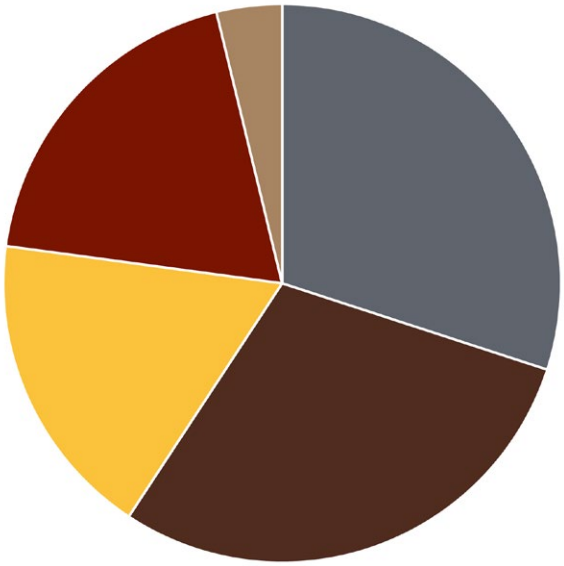
The most current issue of the newsletter is posted online for accessibility.

# FINANCIAL STATEMENT

## INCOME AND EXPENDITURES

Fiscal Year July 1, 2020 - June 30, 2021

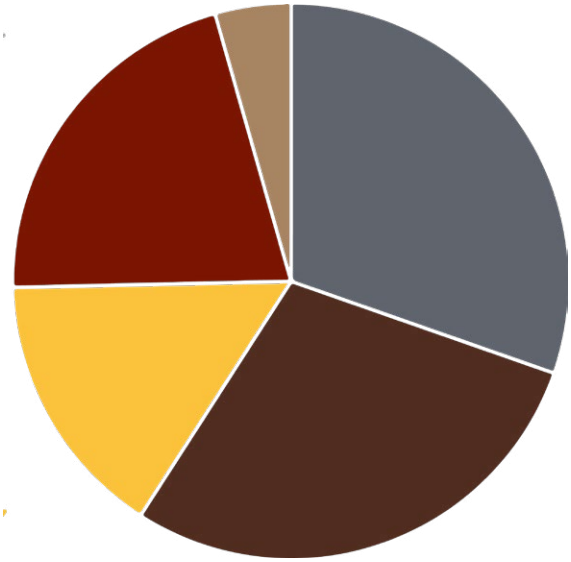
### ALLOCATIONS



- Administration 29% $2,610,875
- Operation and Communication 16% $1,413,293
- Emerging Technologies 21% $1,902,303
- Academics 30% $2,756,792
- CERPA 4% $400,000

**TOTAL ALLOCATION:**
**$9,083,263**

### EXPENSES



- Administration 29% $2,644,803
- Operation and Communication 18% $1,614,645
- Emerging Technologies 19% $1,723,470
- Academics 30% $2,711,556
- CERPA 4% $342,714

**ESTIMATED TOTAL EXPENDITURES:**
**$9,036,189**

## 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.

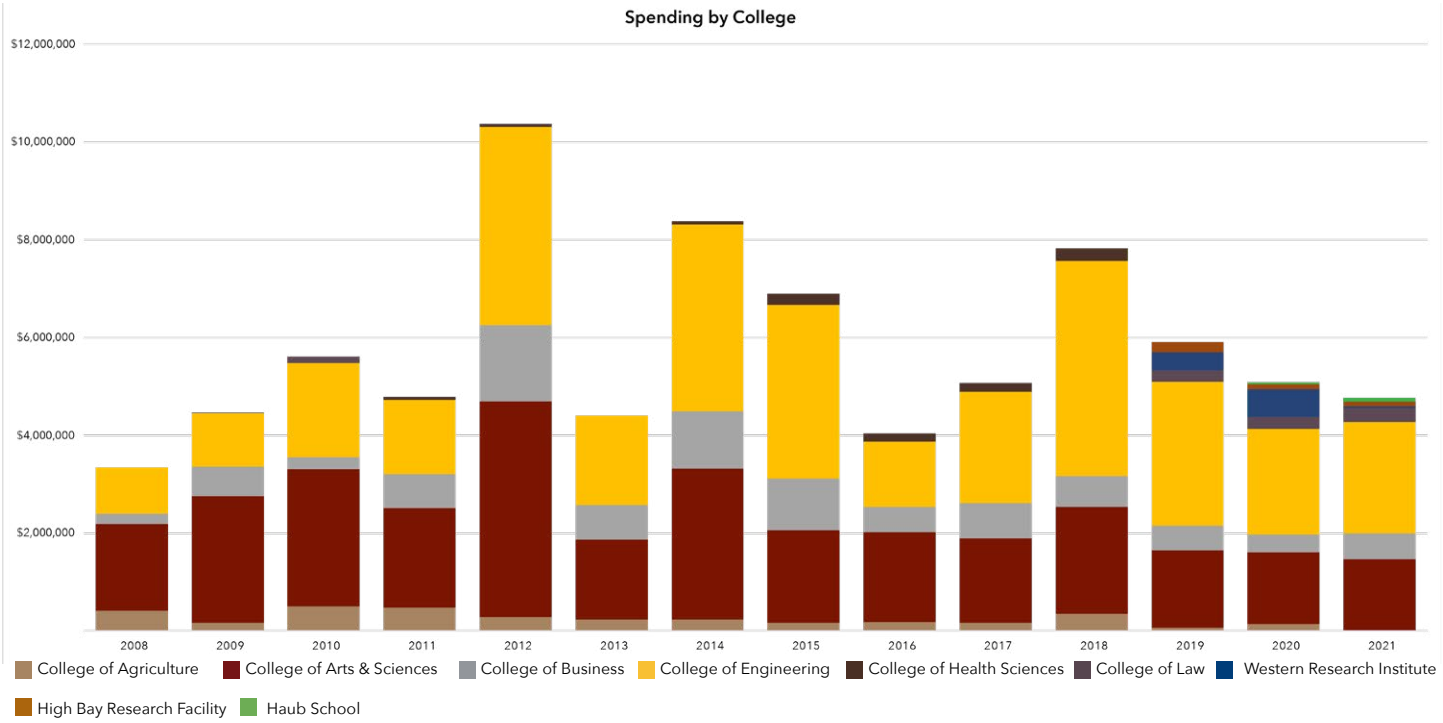
SER implemented its 10% Budget cut at the beginning of the biennium.

### FY21 FUNDS - JULY 2020

| | |
|---|---|
| Total Appropriation | $ 17,092,514 |
| Future of Coal (one time appr.) | $ 7,000,000* |
| Starting Total 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

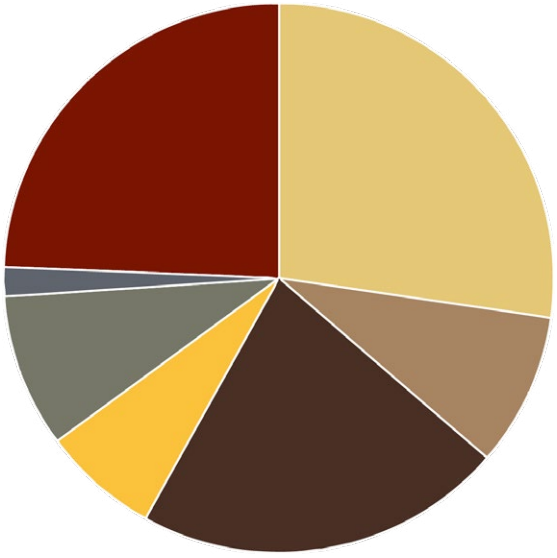


# EXCEPTION FUNDING

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

These funds cover the biennium (FY21 & FY22).

### ALLOCATION BY PROJECT



- Pilot Plant Testing 22% $2,644,803
- Construction Materials 7% $1,614,645
- Amount to be Allocated 24% $1,723,470
- Coal Beneficiation 2% $2,711,556
- Methane Reforming Catalyst 9% $342,714
- Paving and Roofing 27% $342,714
- Coal Based Soil Amendments 9% $342,714

### ALLOCATION BY YEAR AND EXPENSES

In FY21, $1,979,233 was spent of the $3,422,173 due to issues arising from the pandemic. The remainder is planned to be spent out in FY22.

| Biennium Exception Appropriation FY21 & FY 22 | | |
|---|---|---|
| Fiscal Year July 1, 2020 - June 30, 2021 | $3,422,173 | Total |
| Fiscal Year July 1, 2021 - June 30, 2022 | $3,577,827 | $7,000,000 |

| | FY21 SPENDING | FY21 BUDGET |
|---|---|---|
| Paving & Roofing | $ 557,356 | $ 783,220 |
| Methane Reforming Catalyst | $ 262,377 | $ 302,419 |
| Pilot Plant Testing | $ 696,133 | $ 757,518 |
| Construction Materials | $ 208,472 | $ 335,363 |
| Coal-based Soil Amendments | $ 254,894 | $ 298,562 |
| Coal Beneficiation | $ - | $ 58,316 |
| CE Field Study Pilot Demo | $ - | $ 886,775 |
| TOTAL | $ 1,979,233 | $ 3,422,173 |

## FOUNDATION ACCOUNTS

Fiscal Year July 1, 2020 - June 30, 2021

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

*To date, the School of Energy Resources has sixteen 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

### MAJOR LEVEL
*$25,000 and above*

Wold Foundation
Charles Koch Foundation

### LEADERSHIP LEVEL
*$2,000 - $5,000*

### STEAMBOAT LEVEL
*$1,000 - $1,999*

Bryan Shader
Harold York

### STANDARD LEVEL
*$1 - $999*

Robert and Alice Barnard
David Bentzin
Duke and Heidi Cooley
Ernest and Pamela Henderson
Morgan Horbatko
Robin and Roberta Hurless
Cynthia Ishkanian
Daniel and Gayle Killian
John and Nancy Koprowski
Kris Koski
Holly Krutka
Lynn Lockhart
Boyd and Teri Nelson
Scott Quillinan
Christine and Christopher Reed
Pamela Sajec
Joseph Tessaro
Trevor Turmelle
Emma Vannoy

## MAKE A GIFT

### CONTACT THE UW FOUNDATION

**John Small**,
Senior Associate Vice President for Development

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## CONCLUSION

**For more in-depth details on any project mentioned in the report, contact the School of Energy Resources or visit the website at www.uwyo.edu/ser**

SER remains steadfast in its commitment to support Wyoming's energy industry and its future by:

- Establishing and fostering relationships that enable us to rapidly assess and respond to the changing needs of Wyoming's energy stakeholders
- Preparing undergraduate and graduate students for technical and business careers in diverse energy sectors
- Providing technological advancements and diversification to Wyoming's energy industry
- Protecting current markets for Wyoming's fossil fuel energy industry


## HYDROGEN ENERGY RESEARCH CENTER

### SUPPORT OUR RESEARCH

The School of Energy Resources is actively fundraising to develop and support a research center devoted to hydrogen energy in Wyoming.

The Hydrogen Energy Research Center (HERC) at the University of Wyoming's (UW) School of Energy Resources (SER) will 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.

Hydrogen, or $H_2$, is a natural fit for Wyoming energy production, as the state's natural resources and existing infrastructure are well-suited to launch a hydrogen economy. The center will also look 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.

A gift to support HERC will help advance the mission of SER and position Wyoming to remain an energy leader in a low-carbon future. Initial Investment of Tier 1 funding will go toward the following research areas:

- Markets
- Production
- Storage, including sub-surface storage
- Transportation
- Consumption
- Socio-Economic Impacts

We would like to invite you to join these efforts. If you have any questions or would like to visit further about this proposal, please contact us: **john.small@uwyo.edu**

UNIVERSITY OF WYOMING

School of
Energy Resources