ENERGY INNOVATION

Summer 2023

PennState
College of Earth
and Mineral Sciences

Earth and Mineral Sciences
Energy Institute

Letter from the (interim) Director

Welcome to the summer 2023 edition of the EMS Energy Institute (EI) Newsletter. In the newsletter, we showcase faculty research in several topical areas with an emphasis on energy-related research contributions to human health, introduce new faculty, and highlight the honors received by our students, faculty, and staff.

This will be the last letter that I will be writing. Finally, after three years, EI will be getting a new director. Sanjay Srinivasan, formerly the head of the John and Willie Leone Family Department of Energy and Mineral Engineering at Penn State, has taken over the leadership of EI, effective July 1, 2023. Although Sanjay was not officially the director until July 1, we have been working on a six-month transition plan, so that Sanjay can "hit the ground running."

The research, education, and outreach efforts of the institute continue to focus on energy and energy-related environmental effects and involve researchers in the College of Earth and Mineral Sciences and the College of Engineering, along with collaborators worldwide. Current research projects cover the production and use of energy along with carbon dioxide capture, storage, and utilization, and the recovery of critical materials from various feedstock streams.

The faculty and staff of the institute have been very busy over the last year. In fiscal year 2021-22 (June 1, 2021, through June 30, 2022), the institute's staff assisted faculty in preparing 120 proposals, which resulted in fifty-seven projects being funded for a total of approximately $13.4 million in research funding. From July 1, 2022, through April 30, 2023, seventy-three proposals were prepared with forty-eight projects funded for a total of $7.2 million in research funding. Proposal preparation is handled primarily by two staff members, Kelly Rhoades and Heather Harpster. They were assisted by Stephanie Emigh, who handled our post-award activities, and Jennifer McKenrick, our administrative assistant, who joined EI in January 2023.

Faculty and staff received research support from Ronnie Wasco (safety officer, space and facilities coordinator, and researcher) and Brad Maben (research support technologist). Jennifer Matthews and Elizabeth Wood handled our communications and website management, respectively.

I want to take this opportunity to thank all institute faculty members, research staff, students, and visiting scholars whose ideas and hard work have advanced energy science and engineering research. I also want to thank all our staff members whose hard work supports our faculty-driven research efforts. I am extremely proud of our staff members. Sanjay is inheriting a very capable, efficient, and productive team.

Bruce G. Miller
Interim Director and Research Professor, EMS Energy Institute

Energy Innovation is an annual publication from the EMS Energy Institute in the College of Earth and Mineral Sciences. The EMS Energy Institute is a leading research and development organization focused on energy science and engineering.

Cover Image
Black coal dust with particles. Adobe Stock.

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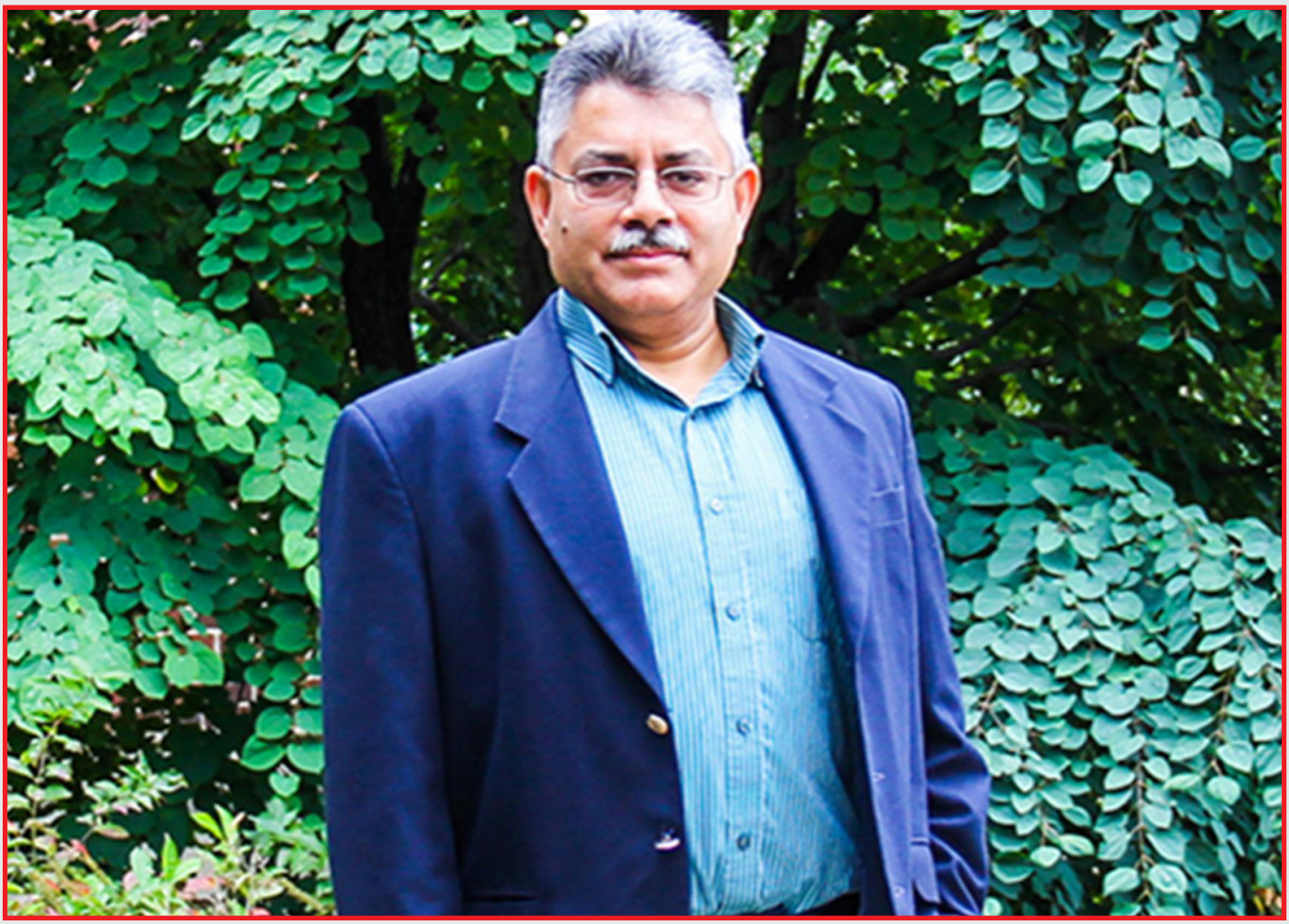
Sanjay Srinivasan named Earth and Mineral Sciences Energy Institute director

By Matthew Carroll



Sanjay Srinivasan, professor of petroleum and natural gas engineering, has been named director of the Penn State College of Earth and Mineral Sciences (EMS) Energy Institute (EI), effective July 1.

Srinivasan has served as head of the EMS John and Willie Leone Family Department of Energy and Mineral Engineering (EME) since 2017 and will step down from the position to become the EI director.

"The Energy Institute has a long history of excellent research, good infrastructure—some pilot scale facilities that other institutions can only dream about—a fairly big group of very talented faculty, researchers, and students who work on pertinent, important issues in the energy sphere and a good model and staff to support research and innovation," Srinivasan said. "It's a great place to be."

He replaces current EI interim director Bruce Miller, who has served in that role since June 2020 when Chunshan Song left the University after fourteen years leading the institute.

"We thank Bruce for leading EI through a time of transition and are fortunate to have Sanjay to step into the director role and continue the institute's important mission," said Lee Kump, John Leone Dean in the College of Earth and Mineral Sciences. "Sanjay has done an outstanding job in the Department of Energy and Mineral Engineering and leaves the department on good footing. We look forward to the energy leadership and research experience he brings to EI."

The institute is a leading research and development organization focused on energy science and engineering with work ranging from challenges related to fossils fuels to exploring new technologies for alternative energy. EI leads efforts to diversify the nation's energy sources, improve energy efficiency, and expand the use of indigenous resources while relying less on non-domestic energy sources.

"I think what drew me to this position in the first place is that it's a really exciting time to be working in the energy sphere," Srinivasan said. "There are important discussions happening about the optimum mix of energy sources—whether conventional or renewable—about climate change and the impact it will have on the resiliency of energy systems and about environmental justice how to roll out these new energy systems in a just and equitable way."

Srinivasan said he is also excited about outreach opportunities discussing technological, economic, and policy issues around climate change and the transition to new energy sources.

"For all that we think about energy and its important position in our social landscape, the average person may not be as familiar with the energy intensity of different things that they do in their day-to-day life," he said. "So there is an opportunity there to engage with people and talk with them about the scope of the challenge and what they can do to address some of these issues."

Srinivasan came to Penn State in 2015 to serve as the inaugural John and Willie Leone Family Chair in Energy and Mineral Engineering and in 2017 became department head.

"I've been very fortunate to lead this complex department," Srinivasan said. "We have policy economics decisions analysts who work together with petroleum and natural gas engineers and solar engineers and people in alternative energy biomass production and mining for resource extraction and then environmental systems people who look at the net impact of all these operations. I walk into this position at the Energy Institute with the background of how to manage these kinds of complex dynamics between education, research, and outreach."

Srinivasan's research interests are in spatial statistics, development of geostatistical techniques for data integration and modeling of complex geological systems, uncertainty quantification, and transfer of uncertainty to decision-making. He and his students develop techniques for monitoring the migration of the carbon dioxide plume during geologic sequestration, identifying sweet spots in unconventional plays by synthesizing information from multiple sources and at multiple scales, and investigating subsurface couplings that result in natural hazards such as sinkholes.

Before coming to Penn State, he was a professor in the Department of Petroleum and Geosystems Engineering at the University of Texas at Austin and has also served on the faculty in the Chemical and Petroleum Engineering Department at the University of Calgary.

Srinivasan received his bachelor of science degree in petroleum engineering from the Indian School of Mines, his master's degree in petroleum engineering from the University of Southern California and his doctorate in petroleum engineering from Stanford University.

Size Matters

Particle size is key factor in coal mining-related respiratory disease

By Jennifer Matthews

One of the major occupational health hazards for coal workers in the U.S. is coal mine dust-related respiratory diseases. New findings by Penn State researchers shed light on the causes of respiratory diseases related to coal mine dust.

> *"This project is the first of its kind to look at what is really contributing to the recent increasing trend of pneumoconiosis and silicosis in some regions in the United States, and the increasing trend of progressive lung fibrosis over the last decade," said Shimin Liu, associate professor of energy and mineral engineering in the John and Willie Leone Family Department of Energy and Mineral Engineering at Penn State.*

Inhalation of coal mine dust is known to cause several types of respiratory diseases, the most common being pneumoconiosis (CWP). The Mine Safety and Health Administration (MSHA) and other government entities have devoted substantial efforts to reduce the adverse effects of dust on miners' lung disease, but even with strict MSHA regulations, since 2000, the rates and severity of CWP have consistently increased, according to the NIH.

Reducing the permissible amount of exposure to respirable coal dust concentrations alone may not be effective because evidence suggests that excessive dust concentrations may not be the only root of CWP. Instead, its toxicity, composition, and size could be significant factors for the miners' lung diseases.

These studies showed nano-sized particles are more toxic than their larger counterparts due to their unique physicochemical properties and easier uptake by living organisms, but the underlying mechanism of miners' lung diseases due to nano-coal-dusts (NCDs) exposure is not yet well understood nor are the key factors resulting in CWP known.

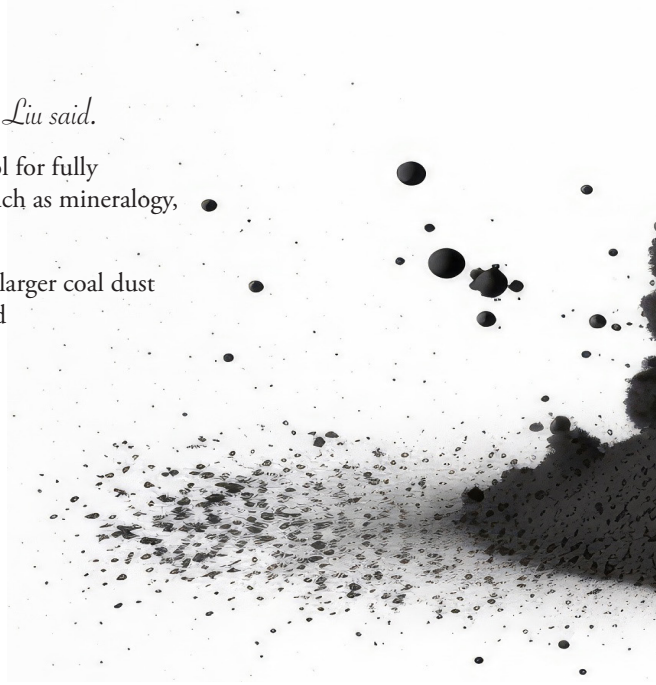
To close these knowledge gaps, researchers worked closely with partner mines to collect fresh coal dust at different working locations. They then characterized physical, compositional, and petrophysical properties of the coal dusts using techniques including scanning electron microscopy/energy dispersive spectroscopy (SEM-EDS), X-ray photoelectron spectroscopy (XPS) and X-ray diffraction (XRD). Finally, the samples were sent to Carnegie Mellon University where the coal dust particles were exposed to a novel lung cell device to monitor the biological effects.

The results were recently published in the *Journal of Hazardous Materials.*

> *"We wanted to know what the indications are that might be linked to the toxicity," Liu said.*

Through their work, the team successfully established a reliable, reproducible protocol for fully characterizing the potential of toxicity in the coal dust, which included parameters such as mineralogy, pore size distribution, and the geochemical perspective.

The results showed that several factors, including size, were important. Compared to larger coal dust particles (micron-scale), the nano-coal dust showed an increase in carbon content and aromaticity and a decrease in oxygen content along with the reduction of oxygen-containing functional groups. Pore volume and surface area had more than a five-time increase for the nano-coal dust. The reduction of oxygen content suggests a decrease in the ability of a water droplet to maintain contact with a solid surface, otherwise known as it's wettability. The increased pore volume and highly enhanced surface area in the coal nanoparticles along with weaker wettability suggest that nano-coal dusts have the potential to have significantly more toxicity when inhaled by coal miners.



"We found that nanoparticles have the same toxicity as silica," Liu said. "Many think progressive fibrosis is from silica, but really the coal nanoparticles also may contribute to the toxicity. This is the first study of its kind to understand nano-particulate toxicity."

Liu hopes that this discovery will influence U.S. regulation and advance industry implementation of personal protective equipment that better filters coal dust nanoparticles.

Moving forward, Liu says they will continue to explore NCDs and hopefully develop a national data survey for the nanoparticle contribution, which is still significantly unknown. Second, they want to lead research and instrumentation innovation.

"We know the different sizes matter, and the best practices from the mining industry are still valid, but we want to develop some wearable tools that can give the nanoparticle range of the dust exposure that is contributing to the long-term impact for the workers' health because, really, the miners are the ones who bear that health burden."

Sekhar Bhattacharyya, associate professor of mining engineering at Penn State; Rui Zhang, former post-doctoral researcher and Ph.D. student at Penn State; and Siyang Zheng, professor of biomedical engineering and electrical and computer engineering at Carnegie Mellon University, contributed to this work.

Research was supported by the National Institute of Occupational Safety and Health (NIOSH).

Black coal dust with particles. **Adobe Stock**.

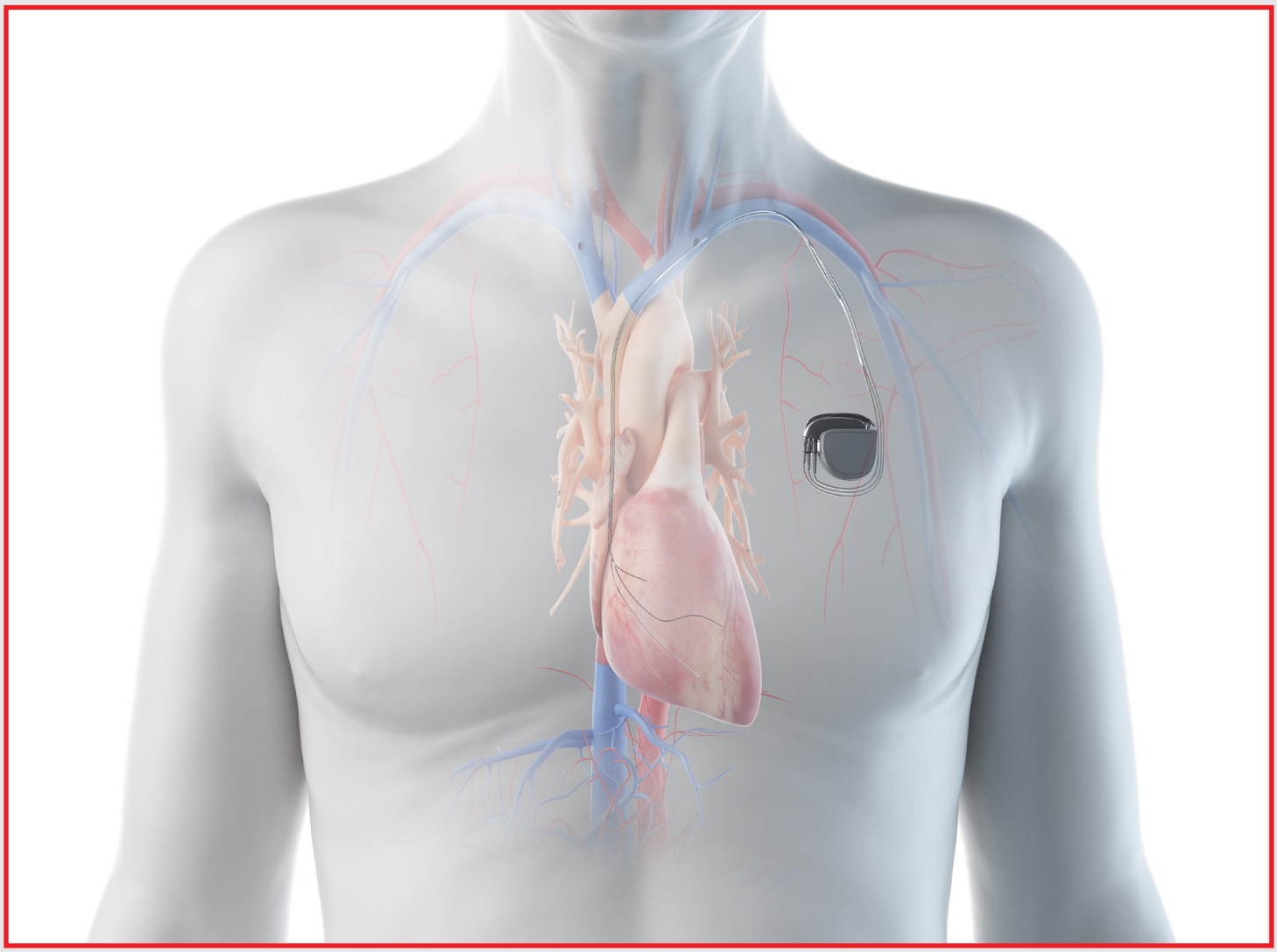
New wireless, rechargeable **BATTERY RESEARCH** aims to reduce surgical risks

By Jennifer Matthews

Researchers at Penn State are designing a new wireless rechargeable battery for biomedical electronics, such as cardiac pacemakers, that will allow them to be charged and managed without the need for invasive surgery.

"We want to optimize the battery and the materials design and couple that with wireless charging," said **Feifei Shi,** assistant professor of energy engineering in the John and Willie Leone Family Department of Energy and Mineral Engineering at Penn State. "Currently, we are limited to cable charging, and wireless charging is definitely the future."

Biomedical devices recreate physiological functions in the human body that relieve chronic pain and vastly improve quality of life, and the past few decades have seen tremendous growth in electronics and wireless technology that champion this cause. However, a remaining challenge for medical devices is the power supply. The bulk of most implantable electronic devices is driven by primary batteries that have a limited lifespan and must be charged using cables. With human longevity at an all-time high, scientists need a longer-lasting, more reliable alternative to the lithium iodine batteries currently being used.



3D rendered illustration of a man with a pacemaker. **Adobe stock.**

"Ten years ago, this was not the problem," Shi said. "But nowadays, battery replacements are much more frequent because people are living longer."

The first implanted cardiac pacemaker used a nickel-cadmium rechargeable battery. Zinc-mercury batteries were then developed, which lasted for more than two years. But nothing performed as well as the lithium iodine battery, invented in 1972. These batteries last for up to ten years and are the gold standard for many manufacturers of cardiac pacemakers. Problems arise, however, when people outlive their pacemaker batteries, sometimes by decades. Battery replacement surgeries, while relatively safe, do not come without risks, especially at an advanced age. These risks include infection, blood clots, damage to the blood vessels or nerves, collapsed lungs, and cardiac perforation.

To help solve this problem, Shi has received a grant from Johnson & Johnson for a three-year project to develop a rechargeable battery with the ability to be charged wirelessly. The result will be a first-of-its-kind remotely chargeable, high-capacity battery within the human body. This new, rechargeable battery system will eliminate the risk of infection and other complications associated with surgery and provide a more stable and durable power supply to allow more health diagnostic sensors to be integrated into implemented medical devices. If successful, Shi believes this project will save lives, minimize suffering, reduce costs, and trigger the next revolution in implementable medical devices.

The first step will be to adopt an existing non-commercial wireless charging method that is bio-safe and can penetrate muscle tissue, making charging within the body possible. To do this, they will run small-scale testing on some prototypes to find the optimal chemistry for this type of battery.

"Past research generally demonstrates wireless charging on a light bulb or a capacitor, they never demonstrate that they can charge a battery," Shi said. "There is a difference between igniting a light bulb, and a real usage and aging test."

The second task will be structural optimization. The device will need to be tiny, and the receptor will need to be integrated, which is a novel concept.

"I want to think of the battery as a whole and think about every component of it, this is not only about the battery's performance," Shi said. "We are starting from scratch, there is nothing like this that exists, so we have a lot of freedom. This is good because if we were working on existing technology, we don't have too much space to play. This gives us more opportunities to invent something new, something more useful for society."

The biggest challenges will be safety and battery life, Shi said. Ideally, she hopes to develop something that has a twenty- or thirty-year calendar life and is safe in the human body.

"If you have a car that catches fire, you can run away," Shi said. "But if you have something inside your body that is not accessible at all, it has to be reliable, so safety is the highest priority and the most complex."

Shi hopes that her background and experience in battery development along with cross-collaborative efforts with other researchers will allow her to make a battery that redefines biomedical battery technology.

"From both the battery aspect, and the wireless charging aspect, my ultimate goal is to customize a better battery that can accommodate wireless charging in the body," Shi said. "My research area is only one very narrow corner, and health and medical devices are multi-disciplinary research areas. We will need a lot of people working together to make this come true."

Thermally regenerative battery produces ample energy using low-grade waste heat

By Jennifer Matthews

Thermally regenerative ammonia batteries can produce electricity on demand from low-grade waste heat. A new process for creating these batteries improves their stability and affordability and may help address the country's growing grid-scale energy storage problem, according to a team led by Penn State researchers.

> *"We can use ammonia as an energy carrier to harness waste heat and recharge some battery chemistries," said Derek Hall, assistant professor of energy engineering. "But previous battery chemistries used metallic zinc or copper electrodes, which had major setbacks in terms of electrode stability. What we did was replace these deposition-based reactions with a novel copper complex chemistry to solve a lot of the major problems facing previous researchers."*

Low-grade waste heat is a significant source of unused energy in the U.S. and around the world, with sixty terawatt-hours of energy discarded into the environment each year by power plants and industry, according to recent studies. Technologies exist that can turn this low-grade waste heat into energy, including thermo-electrochemical cells (TECs), thermally regenerative electrochemical cycles (TRECs), and thermally regenerative ammonia batteries (TRABs); however, there remain limitations precluding wider use of these battery configurations.

Solid-state TECs are simpler to operate than electrochemical systems but exhibit exceptionally low power densities and lack the ability to store energy. TECs and TRECs have higher thermal efficiencies but still suffer from low power densities, limiting their viability. Of all these technologies, TRABs have the largest power densities and energy efficiencies that are competitive with the rest, but TRABs have relied on either cost-prohibitive precious metals like silver or used metal electrodes that degraded quickly, the scientists said.

Under a grant from the U.S. Department of Energy, Penn State researchers tested all-aqueous copper complexes in TRABs. In all-aqueous copper complexes, all the electroactive species—reactants and products—are contained in aqueous electrolytes. Previous thermally regenerative batteries required their electrodes to be built with electroactive materials. But all-aqueous copper reactions had never been used in a thermally regenerative ammonia battery before, so Hall said the first step was to see if this chemistry would work. Their results were recently published in the *Journal of Power Sources*.

> *"The sourcing and manufacturing of copper is a lot easier compared to other rare elements and critical minerals used in batteries," Hall said. "The all-aqueous feature of our battery allows us to decouple the energy and power capacity of this system, which is advantageous."*

TRABs operate similarly to other hybrid and conventional flow batteries, Hall explained. Battery electrolytes are contained in storage tanks, which are pumped into an electrochemical reactor to produce or store electricity. The size of the reactor directly correlates to the power capacity, and tank size correlates to energy capacity. Most TRABs are hybrid flow battery concepts, that is, they operate using redox reactions that deposit and deplete metals at the electrodes. Unlike other flow batteries, however, TRABs can recharge using low-grade waste heat through an ammonia separation process.

The researchers investigated the limitations of power and energy density and how they are impacted by the electrolyte composition and discharge currents through a series of single cell tests. By increasing the ammonia concentration, the power density of the battery increased, but the energy density decreased. Increasing discharge current densities increased the average power density during discharge without substantial losses in energy density. Increasing the copper concentration increased both energy density and energy efficiency but did not greatly impact the power density. Depending on the electrolyte composition, the battery produced power density up to thirty milliwatts per square centimeter and energy densities up to two watt-hours per liter. These results represent some of the highest performances ever achieved for a membrane-based low-grade waste heat to electricity system.

A new thermally regenerative ammonia battery design has improved stability and affordability and may help address the country's growing grid-scale energy storage problem. **Credit: Adobe Stock.**

"What this battery addresses is a technical gap in our energy utilization process," Hall said. "Only a fraction of the incoming heat we use for fossil fuels gets turned into useful energy. More than 50 percent is wasted in some cases, so being able to have something like this that can utilize that waste stream and create more power, provides additional value from these precious resources. It is good for the environment by making us more energy efficient."

The researchers' next steps are to further optimize their design and to consider how this technology can be implemented in the field from both system design and economic perspectives. They plan to explore how it would integrate into a thermal energy system, and how big of a physical footprint it would need to produce usable amounts of power and energy.

"The global energy transition is going to happen in myriad ways because decarbonization needs to occur in many different sectors," said Nicholas Cross, doctoral candidate in chemical engineering at Penn State and lead author on the project. "This technology could push forward that transition of how and where power and energy are produced by coupling new systems into already existing infrastructure."

Other researchers on this project include Christopher Gorski, associate professor of environmental engineering; Bruce Logan, Kappe Professor and Evan Pugh University Professor, Serguei Lvov, professor of energy and mineral engineering and materials science and engineering; and Matthew Rau, assistant professor of mechanical engineering.

The Lubrizol Corporation, a Berkshire Hathaway Company, advised Penn State on this research to ensure that project goals aligned with industry needs. The Lubrizol Corporation develops energy storage technologies for a wide range of industrial applications.

Welcome

New Faculty & Staff

The EMS Energy Institute welcomes the following new members who have joined the Institute since our last publication. Detailed profiles can be found at **energy.psu.edu**.

Nelson Dzade

Assistant Professor

Dzade is an assistant professor in the John and Willie Leone Family Department of Energy and Mineral Engineering. Prior to joining Penn State, he was the UK's Engineering and Physical Sciences Research Council (EPSRC) Innovation Research Fellow and independent group leader at the School of Chemistry at Cardiff University. Before that, he was a postdoctoral researcher in the Department of Earth Sciences at Utrecht University. He received his doctoral degree in computational materials science from the University College London. Dzade leads the materials and minerals theory group, which specializes in the development and application of advanced theoretical methods to unravel structure-property-performance relationships in solid-state materials. Often taking place in close collaboration with experiments, his current research emphasizes the development of ab initio methods and harnessing the predictive capacity of first-principles calculations to gain a detailed understanding of the fundamental science needed to rationally design and engineer novel functional materials with unparalleled performance in several renewable energy technologies such as photovoltaics, heterogeneous catalysis, high-capacity batteries, and mineral processing and separation.

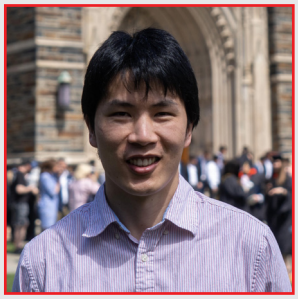
Agathe Eijsink

Postdoctoral Scholar

Eijsink has a bachelor of science degree in earth sciences and a master of science degree in earth structure and dynamics, both from Utrecht University in the Netherlands. She obtained her doctoral degree from MARUM – Center for Marine Sciences at the University of Bremen, Germany focusing on the spectrum of slow to fast earthquakes. She joined Penn State in June 2022 in Derek Elsworth's group and the rock mechanics lab, where she performs laboratory frictional sliding experiments to study the relationship between permeability and fault healing at conditions relevant for geothermal reservoirs.

Ashish Kumar
Assistant Professor

Kumar is an assistant professor in the John and Willie Leone Family Department of Energy and Mineral Engineering. He obtained his master of science degree and doctoral degree in mining engineering from the University of Kentucky. He holds a bachelor of technology degree in mining engineering from the Indian School of Mines. Prior to coming to Penn State, he worked in a large surface greenfield coal mine for three years and led several projects. He is a registered professional engineer in Kentucky. His research broadly focuses on the automation and control of mining systems, aerosol dynamics, and battery safety.



Kangan Li
Postdoctoral Scholar

Li joined Yashar Mehmani's group as a postdoctoral scholar. He received his doctoral degree in computational mechanics from Duke University. His past research focused on an embedded finite element technique called the shifted interface method for simulating problems with complex geometries. Examples include Darcy flow, fluid dynamics, and fracture mechanics. In 2014, he received his bachelor of science degree in mechanical engineering from Shanghai Jiao Tong University in China. His current research focuses on multiscale methods for fracture mechanics of porous materials. He maintains an interest in embedded finite element methods for solid and fluid mechanics.

Jennifer McKenrick
Administrative Assistant

McKenrick joined the Energy Institute in January 2023. Before beginning her current role, she worked in Transportation Services and then moved to HR Data and Onboarding. She holds a bachelor of science degree in business management.

Pengliang Yu
Postdoctoral Scholar

Yu is a postdoctoral scholar under Christopher Marone and Derek Elsworth. Prior to joining Penn state, he was a research assistant and graduate teaching assistant at the University of Auckland. He received his doctoral degree from the University of Auckland in engineering science. His research focuses on enhanced geothermal systems, induced seismicity, machine learning, numerical reservoir simulation, THM coupling, techno-economic analysis, uncertainty analysis, and experimental design.

End of Year Awards

2023

Wilson Banquet and Awards Presentation

The College of Earth and Mineral Sciences' annual celebration of accomplishments was hosted virtually on April 23, 2023. The following EI students, affiliates, and researchers were honored.

Gladys Snyder Junior Faculty Grant

The Gladys Snyder Junior Faculty Grants are given to young faculty for the development of new courses or the improvement of current offerings; for travel to professional meetings special course and seminars; to broaden the studies of junior faculty members; and/or to recognize significant contributions of faculty in their first five years in research efforts.

Ashish Ranjan Kumar, assistant professor in energy and mineral engineering

"Development of a Virtual Reality System for Classroom Teaching of Complex Mining Operations"

E. Willard and Ruby S. Miller Faculty Fellow

Luis Ayala, William A. Fustos Family Professor of Energy and Mineral Engineering

"Pore-scale investigation of multicomponent, multiphase flow of geofluids: A fugacity-based mesoscopic approach"

George H. Deike, Jr. Research Grant

The George H. Deike, Jr. Research Grant promotes innovative research of high scholarly merit. The award recipient receives $50,000 from the George H. Deike, Jr. Research Endowment Fund and a recognition memento.

Barbara Arnold, professor of practice in mining engineering

"Revalorization of mine tailings"

Wilson Award for Outstanding Service

Created in 1999, the Wilson Service Award honors exceptional achievement in service and expresses the gratitude and appreciation of the college.

Elizabeth Hajek, associate professor and associate head for diversity, equity, and inclusion, geosciences

Paul F. Robertson Award for EMS Research Breakthrough of the Year

The Paul F. Robertson Award for the EMS Breakthrough of the Year was created in 2012 with support from a generous gift by EMS alumnus Paul F. Robertson.

Mort Webster, professor of energy engineering

Spring 2022 EMSAGE Laureates

Ali Al Hassan, petroleum and natural gas engineering

Mufaddal Gheewala, energy engineering

Promotion and Tenure

Derek Hall, associate teaching professor of energy and mineral engineering

Arash Dahi Taleghani, professor of energy and mineral engineering

Xiaoxing Wang, research professor in the EMS Energy Institute

Tieyuan Zhu, associate professor of geosciences

Institutes of Energy and the Environment Seed Grants

2023

The following EME Energy Institute researchers were 2023 Institutes of Energy and the Environment (IEE) seed grant recipients:

Elizabeth Hajek, associate professor of geosciences for the project "CoRe at PSU: Growing Cold Regions Research Capabilities at Penn State University"

Nelson Yaw Dzade (left), assistant professor in the John and Willie Leone Family Department of Energy and Mineral Engineering; **Derek Hall** (right), assistant teaching professor in the John and Willie Leone Family Department of Energy and Mineral Engineering for the project "Rational Design of Bio-Inspired and Earth-Abundant Catalysts for Carbon Dioxide Reduction into Fuels and Fine Chemicals"

Yashar Mehmani (left), assistant professor in the John and Willie Leone Family Department of Energy and Mineral Engineering; **Anne Menefee** (right), assistant professor in the John and Willie Leone Family Department of Energy and Mineral Engineering for the project "Impact of CO_2 Mineralization on the Evolution of Storage-Rock Microstructure"

2022-23 Department of Energy and Mineral Engineering student awards

The 2022 and 2023 John and Willie Leone Family Department of Energy and Mineral Engineering awards banquets recognized students and faculty in the department. The banquet is held in conjunction with the G. Albert Shoemaker Lecture. EMS Energy Institute students who received awards are listed below.

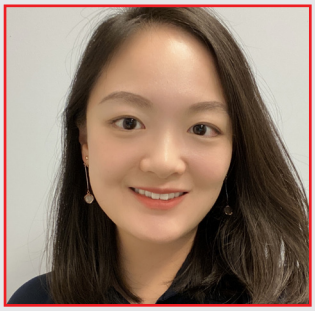
2022

Graduate Teaching Assistant of the Year

Shubhadeep Banik
Graduate student

Outstanding Graduate Teaching Assistants

Mpila M. Nkiawete
Graduate student



Jiayi Yu
Graduate student

Graduate Merit Award in Mining and Mineral Process Engineering

Akshay Pradip Gharpure,
Graduate student

2023

Outstanding Graduate Teaching Assistants

Mpila Makiesse Nkiawete
Graduate student

Elham Rahimi
Graduate student

Old Timers Club Award

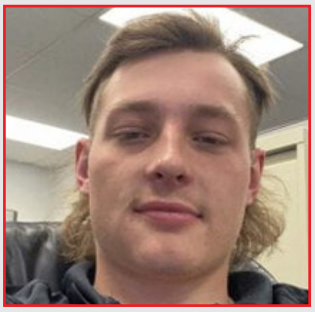
Evan Antonacci
Undergraduate student

Graduate Teaching Assistant of the Year

Hanif Yoga
Graduate student

EME Good Citizenship Award

Mufaddal Gheewala
Energy Engineering



Tristin Findlay
Petroleum and Natural Gas Engineering

Careers in Coal (CI-COAL) Award

Mark Hovingh
Graduate student

Mining PA

August 14-16

Join Penn State mining engineering faculty and students along with colleagues from the mining industry in Pennsylvania as they address challenges and opportunities in health and safety, environmental protection, critical minerals, and new technologies.

Mine and processing plant operators, equipment suppliers, government agencies, professional societies, and industry advocates will gather at the Penn Stater for a reception on August 14 followed by two days of dynamic speakers and opportunities to network. Participation from the Pennsylvania Department of Environmental Protection, the National Institute for Occupational Safety and Health, the U.S. Department of Energy's National Energy Technology Laboratory, the Society for Mining, Metallurgy, and Exploration (SME), Pittsburgh Section, the SME Penn Anthracite Section, the Pennsylvania Aggregates and Concrete Association, the Pennsylvania Coal Alliance, and others is expected.

Learn more: **https://www.energy.psu.edu/event/mining-pa**

Senator Casey visited Penn State, highlighting $2.1 million drainage research

U.S. Senator Robert Casey held a press conference on April 6 at Penn State's Coal Utilization Laboratory, led by Sarma V. Pisupati, director of the Center for Critical Minerals. The Coal Utilization Lab is part of the University's EMS Energy Institute and is focused on solving challenges related to fossil fuels and the exploration of new energy technologies. **Credit: Patrick Mansell/Penn State**

Elisa Alonso is a physical scientist at the U.S. Geological Survey. **Credit: Provided. All Rights Reserved.**

USGS scientist discussed **critical mineral commodities** at 2023 Shoemaker Lecture Energy of the Future seminar series

Elisa Alonso, a physical scientist at the U.S. Geological Survey (USGS), gave the 2023 G. Albert Shoemaker Lecture in Mineral Engineering at Penn State. Her talk, "Rare Earth Elements are Not the only Critical Mineral Commodities," was held on Friday, April 14, in the Hub-Robeson Center's Freeman Auditorium and online via Zoom.

Alonso's talk focused on the supply and demand analysis of the non-fuel critical mineral commodities identified by the director of USGS as essential to the United States' economy and defense, yet most of these commodities are mostly imported. Alonso discussed the need to broaden the focus beyond the rare earth elements, the seventeen metallic elements that are commonly used in the electronics and automotive industries, to include these additional mineral commodities and how further understanding is fundamental to assessments of their criticality.

Alonso joined USGS in 2020, and her work focuses on supply chain analysis and evaluating resource availability for critical materials such as rare earth elements. Prior to joining the USGS, Alonso was a strategic materials analyst supporting the Defense Logistics Agency Strategic Materials and Oak Ridge National Laboratory, where she collaborated with numerous government agencies to assess more than 200 specialty and commodity materials for potential shortfalls in national emergency planning scenarios.

Alonso graduated from McGill University with a bachelor's degree in metallurgical engineering and obtained a doctorate in materials science and engineering from the Massachusetts Institute of Technology.

Celebrating Women
in Energy and Water Research Lecture Series

The Celebrating Women in Energy and Water Research Lecture Series, established by the John and Willie Leone Family Department of Energy and Mineral Engineering to celebrate women conducting energy and water research, highlight their successes, engage women students, and provide an opportunity for faculty to establish and expand their professional network and mentoring relationships.

Recent lectures included:

- "Where Math Meets Social Justice," experiential seminar and Q&A with Dr. Erin Baker
- "Sustainable Power Planning Robust to Multiple Models: Meeting Mexico's 2050 Climate Goals," technical seminar with Dr. Erin Baker
- "A Passion for Science: Getting Lost and Finding Myself Again," experiential seminar and Q&A with Dr. Barbara Kutchko
- "A Sustainable and Prosperous Energy Future with the National Energy Technology Laboratory," technical seminar with Dr. Barbara Kutchko

The lecture series was established in 2021, with support from the Penn State Educational Equity Equal Opportunity Planning Committee. The series includes both experiential seminars aimed toward a broad, interdisciplinary audience and technical seminars dedicated to the speaker's research. Recordings of the seminars are available on EME's YouTube channel: **https://www.youtube.com/channel/UCpyCPzOOjBve6q41_w9aJkw**

Dr. Erin Baker, University of Massachusetts
Credit: University of Massachusetts

Dr. Barbara Kutchko, National Energy Technology Laboratory
Credit: Dr. Barbara Kutchko, LinkedIn

Honors & Awards

Professor awarded
DOE grant to study corrosion in
nuclear salt reactors

Credit: PIXABAY. All Rights Reserved.

FeiFei Shi, assistant professor in the John and Willie Leone Family Department of Energy and Mineral Engineering, received a $400,000 research and development award from the Nuclear Energy University Program in the U.S. Department of Energy to develop foundational research on the corrosive damage caused by molten salt in nuclear salt reactors.

https://www.psu.edu/news/earth-and-mineral-sciences/story/professor-awarded-doe-grant-study-corrosion-nuclear-salt-reactors/

EME graduate student
awarded fellowship grant

Elham Rahimi, a graduate student in the John and Willie Leone Family Department of Energy and Mineral Engineering, received the SME Ph.D. Fellowship grant from the Society for Mining, Metallurgy, and Exploration (SME). SME is a professional society whose more than 15,000 engineers, geologists, metallurgists, educators, students, and researchers serve the mining and minerals industry in more than 100 countries. The society seeks to advance the worldwide mining and underground construction community through information exchange and professional development.

https://www.psu.edu/news/earth-and-mineral-sciences/story/energy-and-mineral-engineering-graduate-student-awarded-fellowship/

Professor selected as **Society of Petroleum Engineers Distinguished Lecturer**

Arash Dahi Taleghani, professor of petroleum and natural gas engineering, will serve as a 2022-23 Society of Petroleum Engineers (SPE) Distinguished Lecturer. The SPE distinguished lecturer program seeks to provide outstanding speakers for the organization's section meetings and to recognize the professional contributions of the distinguished lecturers, according to the society.

https://www.psu.edu/news/earth-and-mineral-sciences/story/professor-selected-society-petroleum-engineers-distinguished/

Luis Ayala, professor of petroleum and natural gas engineering and holder of the William A. Fustos Family Professor in Energy and Mineral Engineering at Penn State, has been honored as a distinguished member by the Society of Petroleum Engineers. **Credit: Society of Petroleum Engineers. All Rights Reserved.**

Ayala named **distinguished member** by Society of Petroleum Engineers

Luis Ayala, professor of petroleum and natural gas engineering and holder of the William A. Fustos Family Professor in Energy and Mineral Engineering, has been honored as a distinguished member by the Society of Petroleum Engineers (SPE). SPE Distinguished Membership, limited to 1 percent of SPE professional membership, recognizes SPE members who achieve distinction deemed worthy of special recognition, who made significant contributions to the society, or who have attained eminence in the petroleum industry or the academic community. Ayala is one of six recipients selected for 2022.

https://www.psu.edu/news/earth-and-mineral-sciences/story/luis-ayala-named-distinguished-member-society-petroleum-engineers/

Ayala selected as **Administrative Fellow** for 2022-23

The Administrative Fellows Program offers Penn State faculty and staff the opportunity to work with senior University officers to gain knowledge and experiences pertaining to the challenges of leadership in the academic community. For the 2022-23 academic year, three Administrative Fellows were chosen including **Luis Ayala**, professor of petroleum and natural gas engineering; Meeghan Hollis, senior associate director for residence life; and Darcy Rameker, director of student activities.

https://www.psu.edu/news/administration/story/three-selected-administrative-fellows-2022-23/

Andreoli receives EMS award for **excellence in research**

Sara Andreoli, a postdoctoral researcher who recently completed her appointment with the Energy Institute at Penn State, received the esteemed 2022 EMS Postdoctoral Excellence in Research Award. The award, which includes a cash stipend and a memento, is designed to celebrate a postdoctoral scholar's outstanding achievements in research that have and will impact their field of study. Andreoli was honored at a college-wide awards ceremony on April 24, 2022.

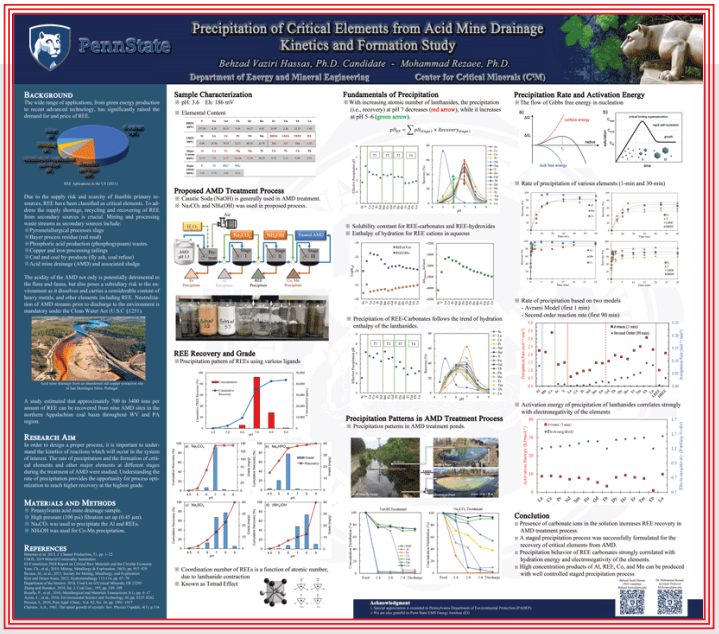
https://www.psu.edu/news/earth-and-mineral-sciences/story/sara-andreoli-receives-ems-award-excellence-research/

Petroleum and natural gas engineering professor receives Pioneer Award

Russell Johns, professor of petroleum and natural gas engineering, was selected to receive the 2022 Improved Oil Recovery (IOR) Pioneer Award from the International Society of Petroleum Engineers (SPE). The SPE IOR Pioneer Award is presented to select individuals who have made significant advancements over the years in improved oil recovery technology. The highly selective award is given every two years to three to five individuals and has been presented to ninety individuals since its inauguration in 1984. Johns was one of four recipients for the 2022 award. The awards were presented at the SPE Improved Oil Recovery Conference held virtually April 25-29, 2022.

https://www.psu.edu/news/earth-and-mineral-sciences/story/petroleum-and-natural-gas-engineering-professor-receives-pioneer/

EI students win first place awards at SME annual conference



Two Penn State students won awards during the MINEXCHANGE 2022 SME Annual Conference & Expo held February 27 through March 2, 2022, in Salt Lake City, Utah. MINEXCHANGE 2022 SME Annual Conference & Expo is the only conference dedicated to all disciplines of mining engineering. Featuring a wide variety of technical sessions and speakers combined with our expansive exhibit hall, MINEXCHANGE attracts thousands of mining professionals from around the world. The award winners included **Younes Shekarian** who won first place in the Environmental Division Poster Session for his poster titled "Precipitation of Co-Mn from Low Concentration Solutions using Various Ligands and a Chemical-Free Process, A Case Study of Acid Mine Drainage (AMD)" and **Behzad Vaziri Hassas** who won first place in the mineral and metallurgical procession division for his poster titled "Precipitation of Critical Elements from Acid Mine Drainage–Kinetics and Formation Study."

Penn State's **Center for Critical Minerals** to receive $2.1M for pilot program

Penn State's Center for Critical Minerals will receive $2.1 million in federal funding to design, build, and test a modular pilot-scale research and development unit intended to recover vital rare earth elements and other critical minerals from Pennsylvania streams and other environmental sources. These minerals are prevalent in essential components of everyday life, including batteries, cellphones, automobiles, appliances, and electronic devices. Critical minerals also play a central role in defense and homeland security applications, making them vital to national security and domestic economic growth.

https://www.psu.edu/news/earth-and-mineral-sciences/story/penn-states-center-critical-minerals-receive-21m-pilot-program/

Sarma Pisupati is director of the Center for Critical Minerals at Penn State. The center has received $2.1 million in federal funding to design, build and test a modular pilot-scale research and development unit intended to recover vital rare earth elements and other critical minerals from Pennsylvania streams and other environmental sources. **Credit: Patrick Mansell / Penn State. All Rights Reserved.**

A team of researchers is investigating how contaminants in power plant water cycles affect the integrity of steel pipes and tubing in power generation systems. **Credit: Adobe Stock. All Rights Reserved.**

Power plant pipe corrosion focus of industry research project

A team of researchers, led by Derek Hall, is investigating how contaminants in power plant water cycles affect the integrity of steel pipes and tubing in power generation systems. They are collaborating with the Institutes of Energy and the Environment's Center for Quantitative Imaging to expand their understanding of corrosion processes in extreme environments. The project's objective is to provide evidence of how different water contamination levels and types change the extent of damage observed from corrosion processes in a laboratory setting. The sponsor of the research is the Electric Power Research Institute, which looks to validate its boiler and turbine steam cycle chemistry guidelines.

https://www.psu.edu/news/research/story/power-plant-pipe-corrosion-focus-industry-research-project/

New process developed to **extract high purity** rare earth element oxides

Pennsylvania stream impacted by acid mine drainage. **Credit: Penn State. Creative Commons**

Critical minerals, including rare earth elements, are used to power devices like smartphones and computers and are essential to our nation's economy and national security. Penn State's Center for Critical Minerals has developed a new purification process that extracts mixed rare earth oxides from acid mine drainage (AMD) and associated sludges at purities of 88.5 percent. AMD and associated solids and precipitates resulting from AMD treatment are viable sources of multiple critical materials (CMs), including rare earth elements (REEs), aluminum, cobalt, and manganese. The U.S. Department of Energy has funded efforts to demonstrate both the technical feasibility and economic viability of extracting, separating, and recovering REEs and CMs from U.S. coal and coal by-product sources, with the goal of achieving mixed rare earth oxides from coal-based resources with minimum purities of 75 percent.

https://www.psu.edu/news/earth-and-mineral-sciences/story/new-process-developed-extract-high-purity-rare-earth-element/

A sealed gas well in Moshannon State Forest. **Credit: Pennsylvania Department of Environmental Protection. All Rights Reserved.**

Fossil fuel past, green future: **Abandoned wells** may offer **geothermal power**

Tapping into abandoned oil and gas wells in Pennsylvania—products of the state's long history of energy extraction—could provide a future source of affordable geothermal energy, according to Penn State scientists. Regulators estimate hundreds of thousands of oil and gas wells have been drilled in the state, many before modern regulations, and lost over time in fields, forests, and neighborhoods. Today, owners and operators are required to plug wells that have stopped production before abandoning them. This does not always happen, and wells that were not plugged, or that were not plugged properly or damaged, can leak the potent greenhouse gas methane into the atmosphere and groundwater. The federal government recently committed $4.7 billion to plug these wells across the U.S.

https://www.psu.edu/news/research/story/fossil-fuel-past-green-future-abandoned-wells-may-offer-geothermal-power/

A stack of mixed plastic waste. **Credit: Pixabay. All Rights Reserved.**

Scientists improve process for turning hard-to-recycle plastic waste into fuel

Turning plastic waste into useful products through chemical recycling is one strategy for addressing Earth's growing plastic pollution problem. A new study may improve the ability of one method, called pyrolysis, to process hard-to-recycle mixed plastics—like multilayer food packaging—and generate fuel as a byproduct. Pyrolysis involves heating plastic in an oxygen-free environment, causing the materials to break down and creating new liquid or gas fuels in the process. Current commercial applications, however, either operate below the necessary scale or can only handle certain types of plastics. **Hilal Ezgi Toraman**, assistant professor of energy engineering and chemical engineering, and her team conducted co-pyrolysis of two of the most common types of plastic, low-density polyethylene (LDPE) and polyethylene terephthalate (PET), along with different catalysts to study the interaction effects between the plastics. They found one catalyst, an HY zeolite, may be a good candidate for converting mixed LDPE and PET waste into valuable liquid fuels.

https://www.psu.edu/news/research/story/scientists-improve-process-turning-hard-recycle-plastic-waste-fuel/

Penn State, Aramco commemorate gift in kind, continued partnership

A recent gift of a Thermotron humidity chamber from energy company Aramco Americas will support numerous research projects in the College of Earth and Mineral Sciences. Aramco Americas, headquartered in Houston, Texas, operates research centers in Houston, Boston, and Detroit. Each year, Aramco's highly selective program sponsors more than 160 Saudi Arabian students to study science and engineering at Penn State. With nearly fifty women in the current cohort, the program also aims to increase gender diversity in male-dominated fields.

https://www.psu.edu/news/development-and-alumni-relations/story/penn-state-aramco-commemorate-gift-kind-continued/

Aramco colleagues (from left to right) Sanjay Srinivasan, Emily Quick, Tim Torre, Fahad Aljabry, Lee Kump, Wajih Malibari, Zuleima Karpyn, and William Shuey stand alongside Thermotron at its new home at University Park. **Credit: Penn State. All Rights Reserved.**

NSF CAREER award to improve understanding on how porous materials fail

Porous materials can be found everywhere from the concrete in our buildings to the bones in our bodies. In buildings, lightweight, high-strength porous materials help conserve energy, insulate acoustics, and bear higher loads. In armored vehicles and airplanes, they reduce fuel consumption. Porous rocks are used to mitigate climate change by serving as a medium for carbon dioxide storage and geothermal heat extraction. Despite the proliferation and broad applications of porous materials, very little is understood about how cracks form inside their microstructure and how they eventually fail. Yashar Mehmani, assistant professor in the John and Willie Leone Family Department of Energy and Mineral Engineering, received a $629,000 Faculty Early Career Development Program (CAREER) Award from the National Science Foundation (NSF) to pursue an integrated modeling, experimental, and educational plan to improve the basic understanding of failures in porous materials and develop a more accurate computational framework to predict them.

https://www.psu.edu/news/earth-and-mineral-sciences/story/nsf-career-award-improve-understanding-how-porous-materials-fail/

New model to help reframe the transition to low-carbon electric power

Governments and societies around the world face increasing urgency in responding to climate change by accelerating the transition to a low-carbon energy system but differing views remain on the combination of energy technologies that will best achieve this goal. Identifying technological pathways is complicated by wide uncertainties in economic and technological factors. Mort Webster and a team of Penn State researchers developed a model to help reframe the energy transition discussions. Their model demonstrates the value of flexible investment strategies and that many pathways are needed to meet the emissions reduction goals outlined in the Paris Agreement. Webster hopes their findings will reverse policy recommendations emerging from research literature calling to adopt narrow assumptions that favor, or limit, certain technologies while advancing highly specific portfolio recommendations. The reason is simple: the future is hard to predict.

https://www.psu.edu/news/earth-and-mineral-sciences/story/new-model-help-reframe-transition-low-carbon-electric-power/

The Nittany 1 solar array, one of three solar farms that make up the 70-megawatt solar array in Franklin County that will provide Penn State with 25 percent of its purchased electricity, across all campuses, over 25 years. **Credit: Lightsource bp. All Rights Reserved.**

Task force unveils recommendations for Penn State to eliminate carbon emissions

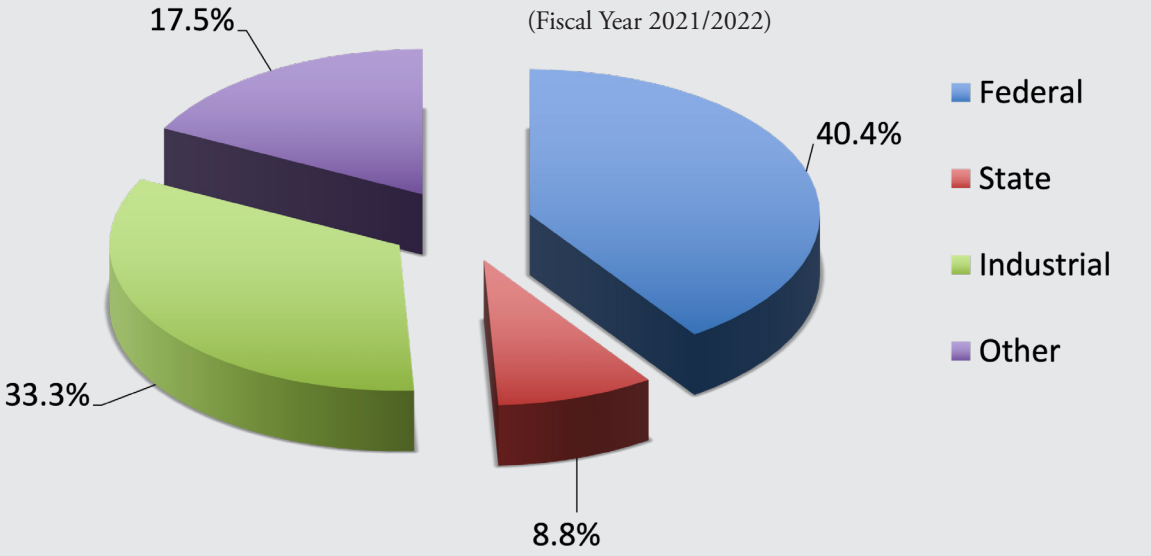
In the spring of 2021, at the request of then President Eric Barron, a team of more than twenty faculty members, staff members, and students began to formulate a plan to address climate change by significantly lowering the University's greenhouse gas emissions on all its campuses. Recently, the Carbon Emissions Reduction Task Force unveiled its recommendations for the University to achieve 100 percent emissions reduction by 2035. According to task force co-chair Robert Cooper, senior director of energy and sustainability in Penn State's Office of Physical Plant, the team's report comprises a comprehensive roadmap of goals, milestones, and actions that will position the University as a leader in climate-smart solutions. Specific recommendations for meeting these goals are numerous and include electrifying Penn State's fleet vehicles, expanding solar infrastructure through public-private partnerships, implementing metrics related to carbon emissions to increase purchasing efficiencies, decarbonizing building heating and cooling systems, and developing new net zero sources of energy and energy storage technologies.

https://www.psu.edu/news/story/task-force-unveils-recommendations-penn-state-eliminate-carbon-emissions/

Summary of projects & FUNDING

EMS Energy Institute Awards by Source

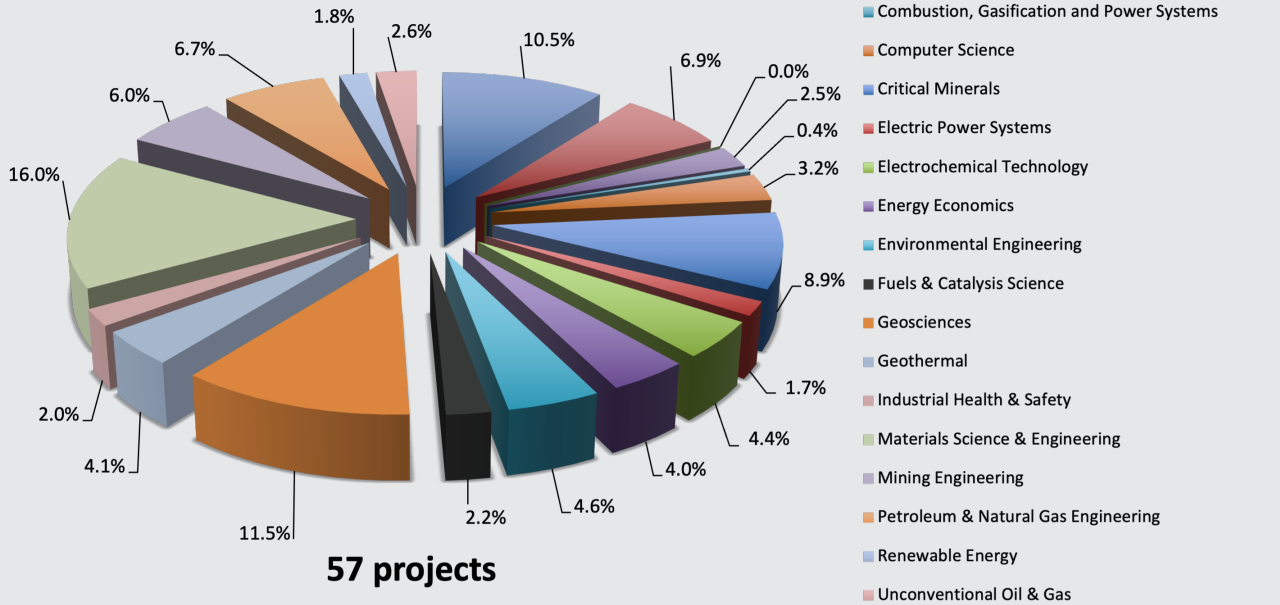
(Fiscal Year 2021/2022)



Total Awards 57

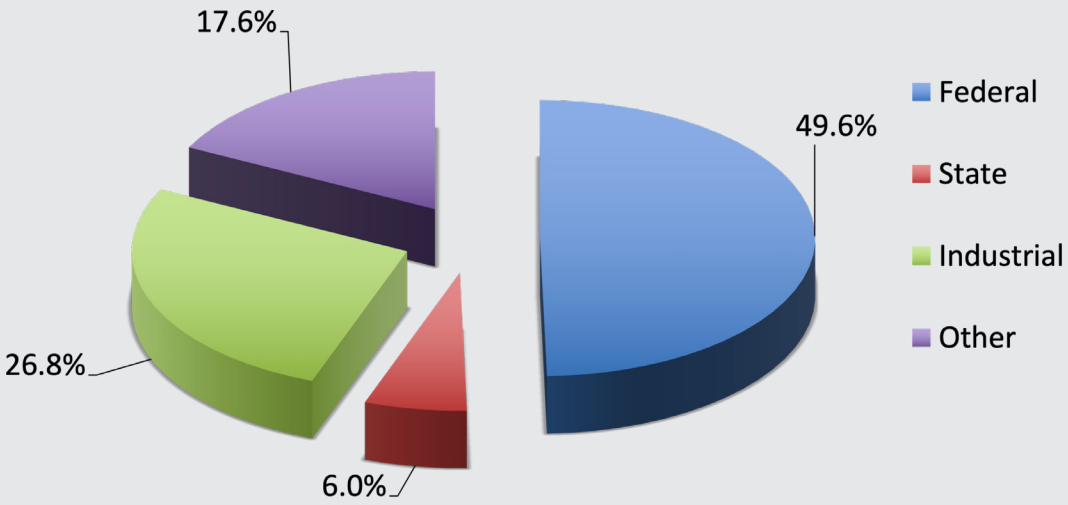
EMS Energy Institute Projects by Program Area

(Fiscal Year 2021/2022)



EMS Energy Institute Funding by Source

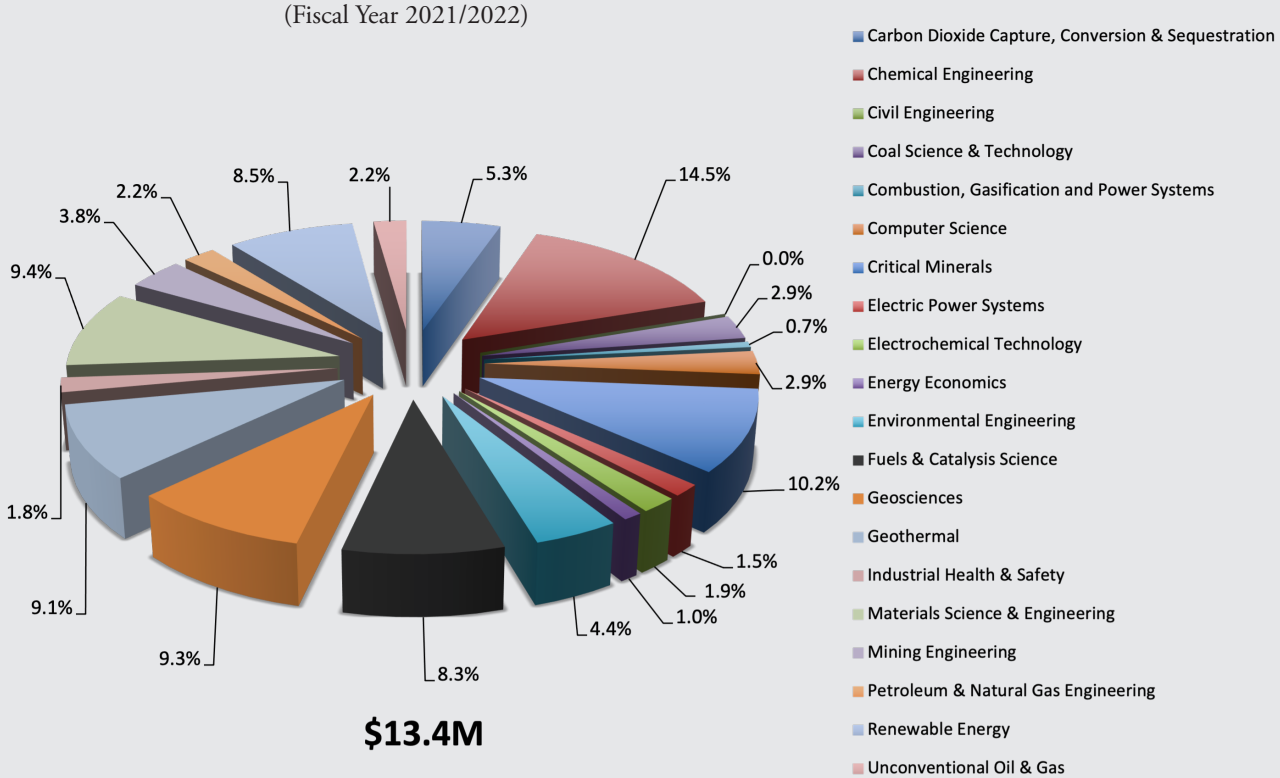
(Fiscal Year 2021/2022)



Total Funding $13.4 million

EMS Energy Institute Funding by Source

(Fiscal Year 2021/2022)



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