

ENERGY INNOVATION

Spring 2021



PennState
College of Earth
and Mineral Sciences

Earth and Mineral Sciences
Energy Institute

Letter from the (interim) Director



Welcome to the spring 2021 edition of the EMS Energy Institute (EI) newsletter. This edition showcases faculty research in several topical areas, introduces new faculty, and highlights the honors received by our students, faculty, and staff.

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. In 2019 and 2020, 224 proposals were prepared by the institute resulting in seventy-two newly funded external research projects, supported by nearly \$18 million in funding.

As you know, this last year saw many changes and was extremely trying. We received notice on a Friday afternoon in mid-March that all laboratories had to be closed down within days following a specific protocol and checklist. IT personnel worked quickly so that the faculty and staff could work remotely. Faculty pivoted from in-person learning to remote learning over spring break week. March flew by like a whirlwind. Many levels of pandemic-related planning were performed over the next several months for safe return to research, safe return back to work, and many more action items. The staff performed wonderfully during this era of the unknown. Limited back to research started in May/June, and all faculty research was on-going by summer. The staff and faculty continue to work remotely if they are able in order to limit personnel on campus until everyone can be fully immunized for COVID-19.

While all of this was occurring, Chunshan Song, director of EI since 2007 retired June 30, 2020 and accepted a deanship at the Chinese University of Hong Kong. We all wish him well in his new position. A national search is underway for a new director with a start date goal of July 1, 2021. We also saw the departure of Grace Choi, financial assistant, who moved to another position within the college.

I want to take this opportunity to thank all EI faculty members, research staff, students, and visiting scholars whose ideas and hard work have advanced energy science and engineering research, especially in these difficult times. I also want to thank our staff members whose hard work supports our faculty-driven research efforts. The staff has done a phenomenal job working during this unprecedented time. They have dealt not only with an entirely new mode of work, but have done so while the University forged ahead with some major enterprise changes. I am so proud of how the staff has handled the pandemic and has continued to work efficiently, accurately, and productively. I want to specifically acknowledge Ronnie Wasco for his herculean safety and facilities efforts, starting with closing down forty labs (half over a single weekend, half with faculty and student help over the next several days) followed by endless planning and safety issues along with getting the labs operational. I want to acknowledge Ron Nargi for making sure that the staff could work remotely within a week's time. And I want to acknowledge Kelly Rhoades for her leadership of the administrative staff to ensure continued EI proposal and research support.

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



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Cover Image

iStock, Rare earth minerals

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Song steps down

as director of the
EMS Energy Institute

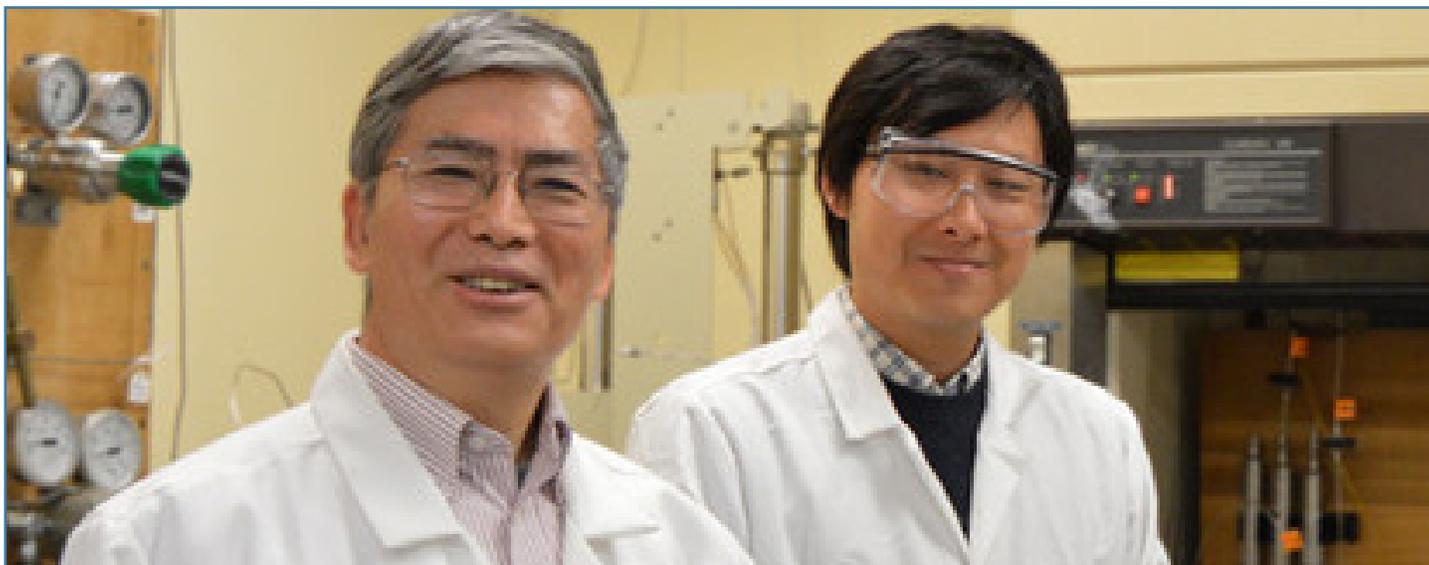
By Jennifer Matthews

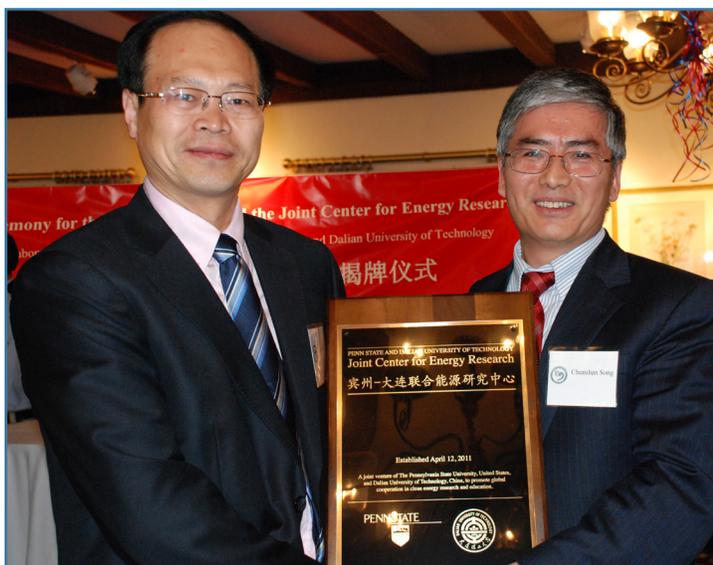
Chunshan Song stepped down as director of the Penn State College of Earth and Mineral Sciences (EMS) Energy Institute (EI) and left Penn State on June 30.

“Chunshan has accomplished a great deal during his 14 years as director of the EMS Energy Institute and more than 50 years at Penn State,” said Lee Kump, John Leone Dean in the College of Earth and Mineral Sciences. “During his tenure, he grew the institute to an \$8 million per year enterprise through research coalitions and partnerships with industry, government, and other universities. His diligent work has resulted in tremendous progress and has advanced the energy-focused research portfolio of the University, Commonwealth, and the nation.”

Along with his role as the director of EI, Song was a distinguished professor of fuel science and a professor of chemical engineering. He was also the founding director of the Penn State-Dalian Joint Center for Energy Research (JCER) and the founding director of the University Coalition for Fossil Energy Research (UCFER), funded by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL).

During his time at Penn State, Song worked tirelessly to advance energy research and education at the University. He served on a seven-member energy task force at the University that resulted in the creation of twenty-four new faculty positions in strategic energy research areas; led the technical efforts to develop the Chevron-Penn State Technology Alliance; served as associate director of the Institutes of Energy and the Environment (IEE); played a leadership role in developing the new Initiative for Clean Carbon Energy; led technical efforts to develop the ConocoPhillips-Penn State National Energy Prize program; led development for the Penn State partnership with the DOE NETL Regional University Alliance; and significantly increased the national and international visibility and reputation of EI through strategic leadership.





Left photo: Jieshan Qiu, associate dean for DUT and Chunshan Song



Right photo: 2019 George A. Olah Award recipient Chunshan Song (center) is presented his award by John Adams, Chair of the Board of Directors, American Chemical Society (right), and Bonnie A. Charpentier, ACS President (left) at ACS National Award Ceremony during ACS National Meeting in Orlando, Florida, on April 2, 2019. IMAGE: ACS

Under his leadership, refereed journal publications from EI researchers per year increased five times and worldwide science citations to the journal publications of EI researchers per year increased eight times during 2007-19, based on the Web of Science.

Song's major awards and honors include the George A. Olah Award, Henry H. Storch Award, American Chemical Society Fellow, Fulbright Distinguished Scholar Award, Herman Pines Award, Honorary Professor of Tianjin University, and Distinguished Professor and Faculty Scholar Medal at Penn State.

Song served as an elected chair of the American Chemical Society's Fuel Chemistry Division and Petroleum Chemistry Division; chair of the International Conference on Carbon Dioxide Utilization; co-chair of the North American Catalysis Society Biennial Meeting; and an advisory board member for research centers funded by both governmental agencies and industrial corporations, such as the DOE Energy Frontier Research Center, the National Science Foundation Engineering Research Center, the State Key Laboratory on Physical Chemistry of Solid Surfaces, the Collaborative Innovation Center of Chemistry for Energy and Materials, and the Saudi Aramco Research and Development Center. He also serves as editor-in-chief for *Advances in Catalysis*, and as an advisory board member for multiple prestigious journals in the areas of catalysis, energy and fuels, carbon dioxide utilization, chemistry, and chemical engineering.

Since joining Penn State in 1989, he taught twelve different courses at undergraduate and graduate levels, advised twenty-two Ph.D. students and fifteen M.S. students, co-advised eighteen Ph.D. students and fifteen M.S. students, supervised thirty postdoctoral scholars and thirty visiting scholars from sixteen countries, and advised thirty-one undergraduate students for their research in catalysis, energy, and fuels.

A widely recognized leading scholar in catalysis and chemistry of

energy and fuels research, Song authored or co-authored more than 370 refereed journal papers and thirty book chapters; edited thirteen books and twelve special issues of research journals; delivered sixty plenary or keynote lectures at conferences worldwide and given more than 290 invited lectures. He also holds eight patents.

Prior to joining Penn State, Song worked at Osaka Gas Company Research Center in Japan. He also held visiting professorships at international universities such as Imperial College London, Tsinghua University, Dalian University of Technology (DUT), Tianjin University, Dalian Institute of Chemical Physics in the Chinese Academy of Sciences, and the University of Paris VI (now Sorbonne University).

Song received his Ph.D. and M.S. in applied chemistry from Osaka University in Japan and his B.S. in chemical engineering from Dalian University of Technology in China.

Effective in July 2020, Song became the Dean of the Faculty of Science at the Chinese University of Hong Kong (CUHK), one of the top universities in the world, according to Times Higher Education's 2020 World University Rankings. CUHK is well-known for its achievements in scientific research and discovery. The Faculty of Science at CUHK presently has more than 250 faculty members and 3,000 students.

"It has been an honor and privilege to serve as the director of the EMS Energy Institute for the last fourteen years and also as a Penn State faculty member for more than three decades," Song said. "I have really enjoyed working with faculty, staff, students, and visiting scholars as well as the leaders at the department, institute, college and University levels at the University Park campus."

Song wanted to personally thank all the current and former EI

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New sulfur dioxide conversion method may transform current industrial techniques

By Jennifer Matthews

A single-step, plasma-enhanced catalytic process to convert sulfur dioxide to pure sulfur from tail gas streams may provide a promising, more environmentally-friendly alternative to current multistage thermal, catalytic, and absorptive processes, according to scientists at Penn State.

“Sulfur dioxide can cause significant environmental problems like acid rain, and it can cause sea acidification,” said Xiaoxing Wang, associate research professor at the Penn State EMS Energy Institute. “Sulfur dioxide can also contribute to fine particulate matter in the air we breathe, which can be more severe than the sulfur dioxide itself.”

Exposure to particulate matter was estimated to cause 4.2 million premature deaths and more than 100 million disability-adjusted life years—which measures years lost due to illness, disability, or death—according to *The Lancet* Global Burden of Diseases Study, published in 2015.

According to Wang, current desulfurization methods can successfully remove sulfur dioxide from tail gas streams but not without significant drawbacks.

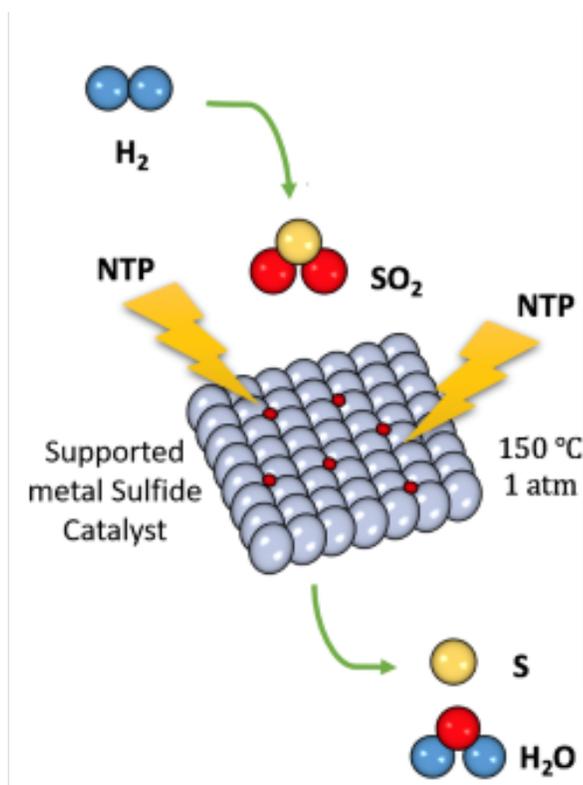
Flue gas desulfurization (FGD) technologies, for example, are the most used methods to capture sulfur dioxide, but these processes create a large amount of solid waste in the form of metal sulfate that requires disposal. Furthermore, these processes produce wastewater that requires additional treatment, making the overall method costly and environmentally unfriendly.

Alternatively, sulfur dioxide can be reduced to solid elemental sulfur through catalysis—a chemical reaction brought on by a catalyst and usually a reducing agent such as hydrogen, methane, or carbon monoxide—and then used as a raw material for such things as fertilizer. However, high temperatures are normally needed in the traditional catalytic process to attain high conversion levels. This is not ideal because it uses a great deal of energy and there is a loss of catalyst activity, according to the scientists.

Due to these flaws, Wang and his colleagues tested a novel technology, a one-step, low-temperature plasma-assisted catalytic process that eliminates the need for high temperatures and creates far less waste than FGD technologies.



Left - Photo of the produced sulfur. Right - Photo of the plasma discharge.



Schematic illustration of the plasma catalytic sulfur dioxide reduction with hydrogen or methane to sulfur at low temperature.

To test this process, the team loaded an iron sulfide catalyst into a packed bed reactor. Then they introduced the hydrogen and the sulfur dioxide gas mixtures, which passed through the catalyst bed at roughly 300 degrees Fahrenheit. They then turned on the nonthermal plasma (NTP) and the reactions immediately began to occur.

Once the process completed, they analyzed the samples to see how much sulfur dioxide was in the gas and how much hydrogen was consumed. They also collected and analyzed the solid sulfur, which accumulates at the bottom of the reactor. They published their results in *ACS Catalysis* and in the *Journal of Catalysis*.

“The temperature we used, 150 degrees Celcius (about 300 degrees Farenheit), is higher than the sulfur melt point to avoid sulfur deposition over the catalyst,” Wang said. “Through this process, the catalyst shows very excellent stability. When run for several hours, we do not see any deactivation. The activity and the selectivity stay the same.”

The researchers also found that this process dramatically promoted sulfur dioxide reduction at low temperatures, enhancing conversion by 148 to 200 percent and 87 to 120 percent using hydrogen and methane, respectively.

Sean Knecht, assistant teaching professor in the School of Engineering Design, Technology and Professional Programs, said that NTP works because highly energetic electrons interact with gas molecules to produce reactive species—radicals, ions, and excited molecules—enabling various chemical reactions at low temperature.

“The result is that the electrons are able to initiate what would appear to be thermodynamically-unfavorable chemical reactions through dissociation and excitation of reactants at much lower temperatures than thermal catalysis,” Knecht said. “If these reactions can be undertaken at much lower temperatures than are typical for thermal catalysis, as we have shown, then the power input to future systems is significantly reduced, which is a big deal.”

Wang added that using plasma allows them to achieve optimal performance using just 10 watts of electricity. Another advantage is that renewable energy, such as wind or solar, can be easily applied to this process to supply power to the plasma.

The researchers now want to better understand exactly how the plasma contributes to the catalysis process and seek to develop an even more effective catalyst.

“A current challenge that we are working to address is further isolating the effects of the plasma versus effects of the catalyst and the synergistic aspects,” Knecht said. “We are looking at some surface spectroscopy options presently and at some point, combining with computational modeling. Bringing these together can provide a more holistic understanding of the physics and chemistry at play.”

If the process is commercializable, it has the potential to largely replace the current FDG technologies.

“It’s highly beneficial to energy and the environment,” Wang said. “Our process saves energy, reduces waste, and saves water. This is very transformational.”

Other Penn State researchers on this project were Sven G. Bilén, head of the School of Engineering Design, and Technology, and Professional Programs and professor of engineering design, electrical engineering, and aerospace engineering; and Jennifer L. Gray, staff scientist at the Materials Research Institute. Also contributing to this research were: Mohammad S. AlQahtani, Penn State graduate student; Chunshan Song, distinguished professor emeritus at Penn State and dean of faculty of science, and Wei Lun professor of Chemistry at the Chinese University of Hong Kong;

A U.S. Department of Agriculture Sun Grant and a Penn State EMS Energy Institute seed grant provided funding for this research.

New acid mine drainage treatment turns waste into valuable critical minerals

By Matthew Carroll

A new way to treat acid mine drainage (AMD) could help transform the environmental pollution problem into an important domestic source of the critical rare earth elements needed to produce technology ranging from smart phones to fighter jets, according to Penn State scientists.

“Acid mine drainage has been a significant environmental concern for many decades,” said Mohammad Rezaee, assistant professor of mining engineering in the College of Earth and Mineral Sciences at Penn State. “This research shows we can modify existing treatment processes in a way that not only addresses environmental concerns, but at the same time recovers valuable elements and actually decreases the cost of treatment.”

A team of Penn State scientists developed a two-stage treatment process that enabled them to recover higher concentrations of rare earth elements using smaller amounts of chemicals than previously possible, the scientists said.



Acid mine drainage pollution in a stream in Cambria County, Pennsylvania

IMAGE: Rachel A. Brennan, Penn State

“This technique represents an efficient, low-cost, and environmentally friendly method to extract these valuable minerals that are used in a wide variety of consumer and industrial products,” said Sarma Pisupati, professor of energy and mineral engineering and director of the Center for Critical Minerals at Penn State.

Rare earth elements are a group of seventeen minerals widely used in advanced technologies and designated by the U.S. as critical to the country’s economic and national security. The U.S. currently imports nearly 100 percent of these materials, with China producing about 85 percent of the world supply.

AMD from coal mining operations in Appalachia represents a promising domestic source of rare earth elements because it often contains high concentrations of the minerals, and because it is already being collected and treated due to environmental concerns, the scientists said.

“We are currently incurring costs just to treat the water, and in many cases, we are not even collecting all these minerals,” Pisupati said.

“Now we are able to turn what had been considered a waste product into a valuable resource.”

AMD occurs when pyrite rock—iron sulfide—unearthed by mining activity interacts with water and air and then oxidizes, creating sulfuric acid. The acid then breaks down surrounding rocks, causing toxic metals to dissolve into the water, the scientists said.

Traditional treatment methods involve collecting the AMD in retention ponds and adding chemicals to neutralize the pH—an indicator of how acidic or basic a substance is. This causes the dissolved metals to precipitate, or form into solids, and settle out of the water. Up to 70 percent of rare earth elements can be extracted as a sludge using this process, and the rest are released along with the treated water, according to researchers.

The scientists found they could extract a higher concentration of rare earth elements and other critical minerals by adding carbon dioxide to the AMD and then bringing it to a neutral pH of 7, the target for environmental remediation, in two separate steps.

Using this method, 90 percent of aluminum was recovered at a pH of 5 and 85 percent of rare earth elements were recovered by pH 7, the scientists reported in *Chemical Engineering Journal*.

Adding carbon dioxide to AMD produces chemical reactions that result in the formation of solid minerals called carbonates, the scientists said. The rare earth elements bond with the extra carbonates and precipitate out of the water at lower pH values.

The process, called carbon dioxide mineralization, is an emerging technology being used to remove excess carbon dioxide from the atmosphere. This study represents the first time it has been used to recover large concentrations of rare earth elements from AMD, the scientists said.

Recovering the same concentration of rare earth elements from AMD using traditional treatment methods would require adding additional chemicals to increase the pH beyond 7. The scientists said by lowering recovery costs, the new treatment method could make the domestic rare-earth-element market more competitive.

“With a simple modification of existing treatment processes, industry could use less chemicals and get more value out of AMD waste,” Rezaee said. “This is the beauty of this research.”

Behzad Vaziri Hassas, a doctoral candidate at Penn State, also participated in this research.

The College of Earth and Mineral Sciences’ Energy Institute funded this research.



Nanoengineered cement shows promise for sealing leaky gas wells

By Matthew Carroll

Pictured is a natural gas well in Pennsylvania. When wells become damaged or degraded, methane can potentially escape into the environment. Penn State researchers developed a new nanomaterial cement mixture to address this issue.

Leaking natural gas wells are considered a potential source of methane emissions, and a new nanomaterial cement mixture could provide an effective, affordable solution for sealing these wells, according to a team of Penn State scientists.

“We have invented a very flexible cement that is more resistant to cracking,” said Arash Dahi Taleghani, associate professor of petroleum engineering at Penn State. “That’s important because there are millions of orphaned and abandoned wells around the world, and cracks in the casings can allow methane to escape into the environment.”

When natural gas wells are drilled, cement is used to secure the pipe, or casing, to the surrounding rock, creating a seal that prevents methane from migrating into the shallow subsurface,

IMAGE: Pennsylvania Department of Environmental Protection

where it could enter waterways, or the atmosphere, where it is a potent greenhouse gas, the scientists said.

Wells can extend miles underground and over time changing temperatures and pressures can degrade the cement, causing cracks to form. The scientists said repairs involve injecting cement in very narrow areas between the casing and rock, requiring special cement.

“In construction, you may just mix cement and pour it, but to seal these wells you are cementing an area that has the thickness of less than a millimeter, or that of a piece of tape,” Dahi Taleghani said. “Being able to better pump cement through these very narrow spaces that methane molecules can escape from is the beauty of this work.”

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Penn State's Center for Critical Minerals launches new website

By Jennifer Matthews

PennState
College of Earth and Mineral Sciences

Center for Critical Minerals (C²M)

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Welcome to the Center for Critical Minerals

The Center for Critical Minerals (C²M) combines Penn State's expertise across several colleges in partnership with industrial partners to develop the fundamental science and technology needed to harness domestic mineral sources. The center builds on Penn State's established interdisciplinary capabilities to make the University the premier technical and research support partner for companies developing commercial critical materials projects.

The Center for Critical Minerals (C²M) works to mitigate risk posed to the United States' dependency on raw and semi-finished materials for advanced manufacturing. In 2017, the U.S. produced an estimated \$75.2 billion of nonfuel materials. Those base materials were used in energy, medical, and defense applications along with consumer electronics. However, in production of those goods, the U.S. was completely dependent on imports of twenty-one out of the fifty nonfuel commodities. That dependency poses a national security and economic risk if the U.S. does not develop methods and technologies to create its own supply of critical materials.

Extracting rare earth elements from coal

eNews

- [Penn State, Colorado School of Mines will support US need for critical minerals](#) - November 9, 2020
- [Energy Fuels & Team from Penn State University Selected by U.S. Department of Energy to Develop Design for the Production of Rare Earth Elements from Coal-Based Resources](#) - September 21, 2020
- [Materia-USA Awarded U.S. Department of Energy Contract for Recovery of Rare Earths & Critical Minerals](#) - September 21, 2020

Just Out

- [Cobalt Production in Pennsylvania: Context and Opportunities](#) - November 2, 2020
- [Precipitation of rare earth elements from acid mine drainage by CO₂ mineralization process](#) - July 8, 2020

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The Center for Critical Minerals (C²M) launched its new website in 2020 to highlight the growing body of research its faculty are doing in the area of critical minerals and to provide technical support to industries in critical mineral project development.

The mission of C²M, established in 2019, is to mitigate the risk that is posed to U.S. national security due to foreign dependence on raw and semi-finished materials for U.S. advanced manufacturing. They do this by developing the science required to establish additional rare earth and critical minerals production capacity in the U.S. and by providing support to industrial partners to commercialize the science and technology for sources of revenue and economic development within the U.S.

“In 2017, the estimated value of total nonfuel mineral production in the United States was \$75.2 billion,” said Sarma Pisupati, professor of energy and mineral engineering and chemical engineering and director of C²M. “The U.S. was 100 percent import dependent for twenty-one of the fifty non-fuel mineral commodities.”

These commodities are used in a variety of fields including energy applications such as gas turbines and wind and power systems, defense applications, electronics, and the medical industry.

“Unless action is taken, the U.S. could face an annual shortfall of up to \$3.2 billion worth of critical materials,” Pisupati said. “Penn State already has existing capabilities—faculty and facilities—in the areas of geology, geosciences, mining engineering, mineral processing, hydrometallurgy, pyro metallurgy, materials science, fluidization, multiphase reaction kinetics, plant design, and simulation to address this need. Penn State has also already developed a Power and Mineral Industrial Stakeholders Group, which consists of representatives from the entire supply chain of critical minerals.”

Research must be taken to the marketplace and industry knows how to do this the best, Pisupati said. With a unique set of interdisciplinary capabilities, he believes Penn State can become the “go-to” university in critical minerals research and technical support to companies to develop commercial projects for critical materials. Industry working with Penn State in interdisciplinary fields will help them recruit top talent to revitalize domestic mineral industry.

Industrial leaders wishing to collaborate with C²M can find out more information on the website. In addition, student engagement opportunities throughout the research process are also available.

“This research and support for commercialization will aid in indigenous critical materials production that can attract and promote high technology manufacturing within the U.S. for defense, automobile, power, and medical industries,” Pisupati said. “This creates engaged scholarship opportunities for students, trains well-equipped workforce, and broadens employment opportunities for graduates.”

For more information, visit: <https://www.c2m.psu.edu/>

Internet fiber optics

could provide valuable insight into geological phenomena

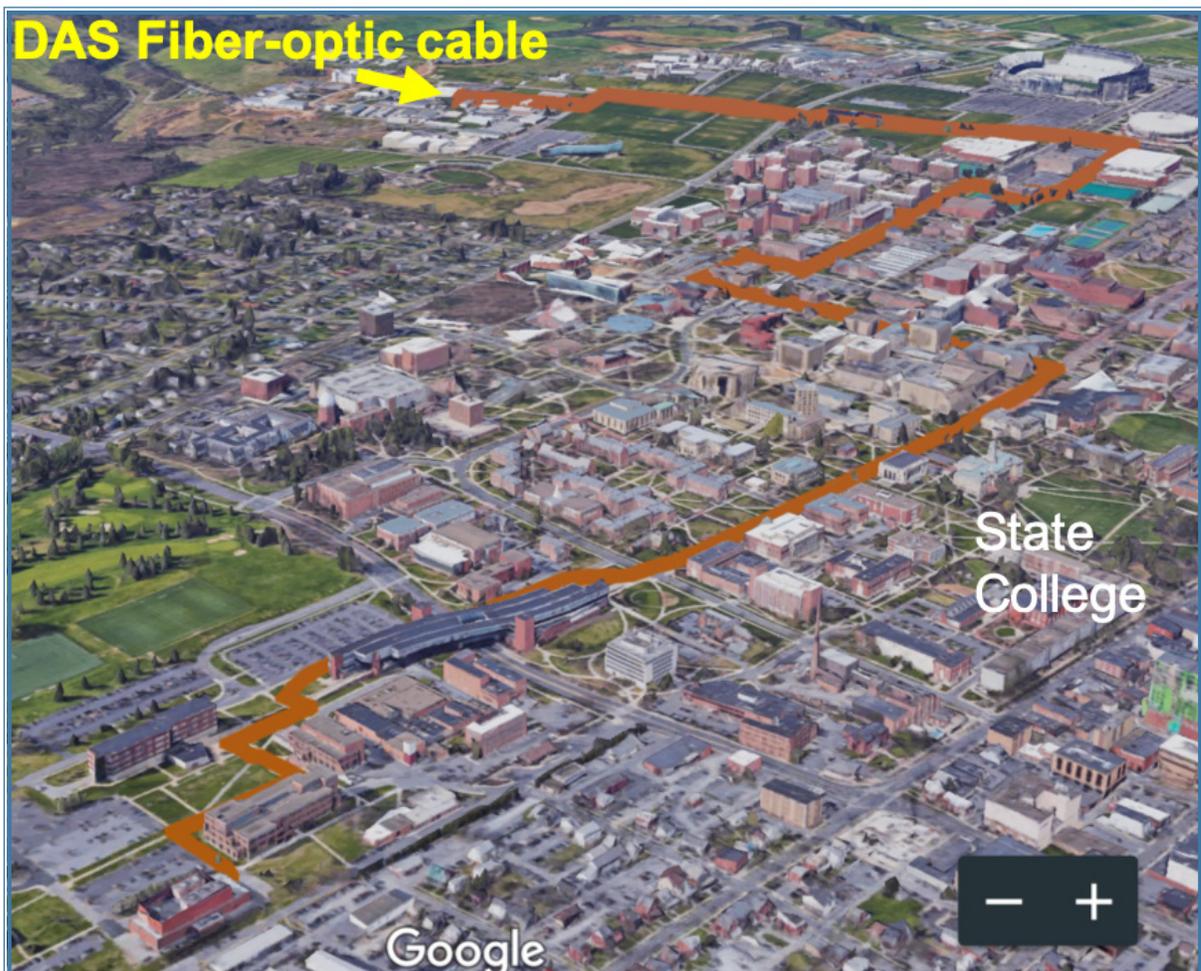
By Jennifer Matthews

Fiber-optic cables run underneath nearly all city grids across the United States and provide internet and cable TV to millions, but what if those systems could also provide valuable information related to hazardous events such as earthquakes and flooding? A team of researchers at Penn State have found they can do just that.

The scientists are using fiber-optic distributed acoustic sensing (DAS) technology to turn existing telecommunication infrastructure that is already installed underground into a valuable resource for monitoring ground vibrations.

“We discovered the fibers could pick up a wide variety of signal vibrations, from thunderstorms to human walking steps to music concerts,” said Tiejuan Zhu, assistant professor of geophysics at Penn State and principal investigator on the project. “We can even distinguish the specific song at a concert by the patterns of the high and low tones. That’s a great demonstration of the sensitivity of these sensors.”

Traditional seismic monitoring devices, called geophones, are difficult to deploy in urban areas. Obtaining permission and space to install sensors, protecting sensors against theft and vandalism, and the high costs to maintain them makes it prohibitive to gain reliable long-term data, the scientists said.



Bird's-eye view of the fiber-optic cables used for the FORESEE project in which scientists used pre-existing cables to monitor geological events

DAS technology allows scientists to plug into unused fiber, called dark fiber, greatly reducing the cost and setup time that hinders traditional seismic monitoring devices. A laser interrogator unit simply needs to be plugged into one end of a stretch of fiber to begin collecting data, the scientists said.

“Several experiments in California have been carried out by teams using existing telecommunication infrastructure,” Zhu said. “But deploying this technology on the East Coast is important because we have very special geology here.”

The soil and shallow bedrock in the Allegheny Mountains region create complex near-surface geophysical properties. The underlying bedrock can slowly dissolve due to circulating groundwater, which can form sinkholes and caverns. Especially in urban areas, sinkhole collapse and settling issues can threaten human safety and property. In addition, strong seasonal variations in temperature and precipitation create a very different environment to that of California.

Zhu and his research team created the Penn State Fiber-Optic for Environmental SENSing (FORESEE) project, the first deployment of the DAS technology in the eastern U.S. The goal of this project was to address the long-standing challenge of real-time monitoring of environmental and subsurface physical, chemical, and biological changes in urban areas. FORESEE also aims to develop the DAS fiber sensing arrays to turn the Penn State University Park campus and surrounding areas into a living lab for the collection of high-resolution data on environmental, energy, and infrastructure systems. The researchers report their results in *Solid Earth*.

The team gained access to dark fiber-optic cables beneath the campus and converted the cable to 2,300 seismic sensors using DAS. They then continuously recorded ground vibration data

along the three-mile stretch starting in April 2019. The experiment generated many tens of terabytes of data, which was stored in a network-attached storage server. The server was then connected to an internet network, providing the scientists with remote data access in real time. The density of the DAS recordings provided extraordinary resolution that enabled insight into their cause and allowed the researchers to distinguish between various signals, the scientists said.

The preliminary results suggest DAS has the capability to sense broadband vibrations and discriminate between the seismic signatures of different earthquakes and anthropogenic sources from events such as mining blasts, vehicles, music concerts, and walking steps.

But DAS does not come without limitations. Traditional geophones have three components, two horizontal sensors and one vertical sensor, allowing them to capture vibrations in all directions. DAS technology, however, is only able to sense vibrations horizontally as there is no need for vertical sensors in fiber-optic cables meant for internet and cable. Therefore, the data is not as comprehensive as data from traditional geophones.

“We know this is a limitation,” Zhu said. “Hopefully in the next five years, this can be overcome by new fiber-optic technology.”

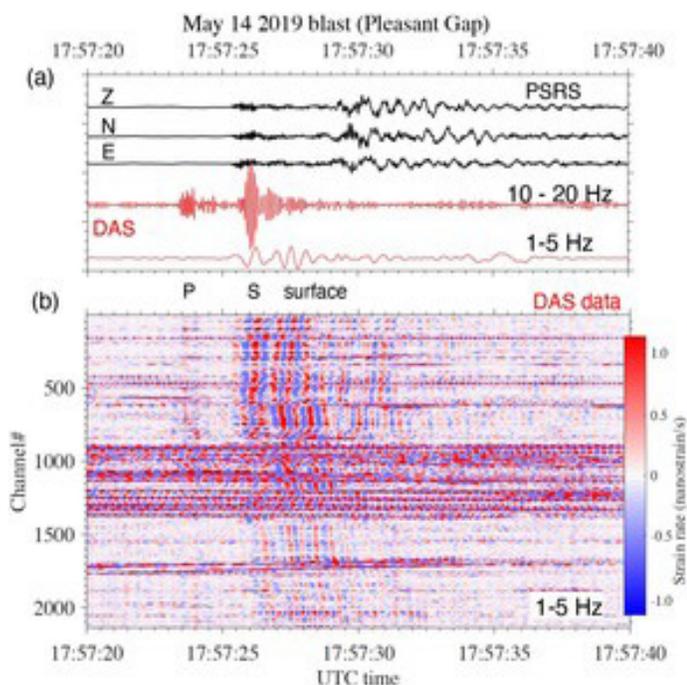
In addition to its geological uses, DAS can yield insights into varying patterns of human activities relevant to public health and urban planning. Traffic monitoring and redirection that does not require private cell phone data, gunshot detection, industrial noise pollution monitoring, and subsurface water utility monitoring may all be improved through the use of DAS technology, the scientists said. The value of DAS has also been recognized in inaccessible and harsh environments, enabling offshore ocean observations and the ability to monitor permafrost stability in the Arctic.

Now that the researchers know what the technology can do, Zhu said their next step is using DAS to monitor smaller events long-term, like the underground movements that lead to sinkholes and flooding. They also want to look at the events that occur where the atmosphere meets the earth since there is currently no way to monitor how a thunderstorm’s energy impacts the solid earth’s near surface.

“DAS arrays utilizing existing telecommunication fibers can play an increasing role in the development of resilient, sustainable cities,” Zhu said.

Other contributing researchers included Junzhu Shen, doctoral student, and Sam Hone, graduate student, both in geosciences at Penn State; and Eileen R. Martin, assistant professor of computational mathematics at Virginia Tech.

The U.S. Department of Energy partially supported this work.



Recording example from a local mining blast in May

Through teaching, leadership and research, Hellmann planted his legacy

Longtime ceramics expert retires after decades of service to materials science department, College of EMS

By David Kubarek

For as long as he can remember, John Hellmann was interested in science. He excelled in chemistry, physics, and other fields, but he was most drawn to fields that could be applied to solving real-world problems.

That's when he discovered engineering, a discipline that he learned at an early age was "the informed application of science."

That connection led Hellmann to a career spent finding discoveries that bettered our lives. He did that early on while working for Sandia National Laboratories in Albuquerque, New Mexico, and at Penn State—where he drove both research and teaching. In thirty-five years as a professor of materials science and engineering, he also mentored undergraduate and graduate students. The senior associate dean retired Feb. 1.

Hellmann's career will end where it began. At age sixteen, the New Jerseyan toured a few East Coast universities known for materials science before an interaction with a faculty member in the College of Earth and Mineral Sciences (EMS) solidified his decision to attend Penn State.

With his mom in tow (Hellmann lacked a driver's license), he was searching for the materials science department when he ran into C. Drew Stahl, a faculty member in petroleum and natural gas engineering, at the time. Stahl hand delivered Hellmann to the department, and after a lengthy talk with Guy Rindone, then chair of the ceramic science program, he knew before he left University Park where his undergraduate experience would begin.

From there, Hellmann earned his bachelor's degree in ceramic science with an eye on entering the field. He entertained ideas of earning a master's degree but a faculty member talked him into pursuing a doctorate after he did well on candidacy exams.

"I thought I bombed them, to be honest," Hellmann said. "But then I talked with my adviser, Vladimir Stubican, and he said 'you're not getting a master's. You're getting a Ph.D.'"

While earning his doctorate at Penn State, Hellmann researched doped zirconia systems for solid state electrolytes, orthopedic implants, and cubic zirconia gemstones.

The application of science

After graduating with his doctorate, his work earned him a spot in the ceramics development division at Sandia National Lab, which was then run by AT&T. There, he worked with a surging group of young scientists on Cold War era ceramics projects such as body and vehicle armor and nuclear and solar applications.

Hellmann said it was a place where pie-in-the-sky ideas came to life. Scientists were encouraged to dream big. But the informed application of that science was always the end goal.

"I worked in an environment that was science driven, but the application of that science was most important," Hellmann said.

"That's what drew me to the field of materials science. You're not just making new materials. You're designing them with their ultimate function in mind."

Returning to Penn State

About five years into his time at the lab, Hellmann got a call from his mentor Dick Tressler, who later headed the Department of Materials Science and Engineering. Tressler wanted Hellmann's help in starting the Center for Advanced Materials, which would soon become a large research center that focused on the design of, and with, ceramics in high-temperature systems. In 1986, Hellmann hauled his family across the country for a fixed-term faculty position for a chance to build this new center.

The center pulled in funding from industry and various federal agencies. Two major areas of research included the development of radiant ceramic tubes for industrial heating—a technology that replaced superalloys and is commonplace today—and components for the engine of the Rockwell X-30, NASA's National Aero-Space Plane.

"We were able to make a big impact right away," Hellmann said.

"We grew the center to something on the order of just over \$5 million a year from 1986 until about 1994."

Shift to undergraduate education

In the mid-90s, Hellmann shifted his focus to undergraduate education administration as the college followed a national trend and combined each of its four materials science disciplines to one major: materials science and engineering.

He worked to ensure that the shift didn't mean the department would lose its specialized identity in each of the four options—ceramics, polymers, metals, and electronic and photonic devices—while he oversaw undergraduate programs in the ceramics option.

In 2001, he became the associate head for undergraduate programs while maintaining an active research wing of a dozen graduate students and a few postdoctoral scholars.

In that time, he was instrumental in securing or renewing Accreditation Board for Engineering and Technology (ABET) accreditation for the department's engineering programs. Undergraduate enrollment—driven in part by advances in the energy sector—doubled under his tenure.

In 2007, Hellmann elevated to the role of associate dean of education—assisting students collegewide—until 2012.

Shift to graduate education

In 2012, Hellmann shifted to associate dean of graduate education and research for EMS, a position he held until July 2020. He said he was reluctant to take on the role with the bulk of his career in undergraduate education, but then Dean William Easterling convinced him to consider it.

Hellmann set out with three goals in mind: increasing the number of National Science Foundation Fellows (EMS had six of Penn State's eighteen fellows in 2020 and seven of twenty-four in 2019), improving diversity within the graduate ranks, and encouraging the commercial application of research. Hellmann himself saw his Penn State research reach commercial success. His work on proppants—which are used in oil and gas extraction—led to the commercial business venture Nittany Extraction Technologies LLC, which successfully demonstrated the scale-up of laboratory experiments to manufacturing large quantities for application in the oil and gas industry.

Concerning diversity, Hellmann credits the college's creation of the associate dean for educational equity position for improving diversity within the undergraduate and graduate ranks. He also helped create an EMS sustainability program that awards funds for faculty looking to commercialize their research.

“Those were three of the planks of my moonshot plan, while at the same time keeping the college's research enterprise vigorous and healthy,” Hellmann said. “Because we have great faculty who write great proposals and great staff to make those proposals successful, we're able to maintain an average research enterprise of about \$65 million a year. And it's growing now because we've recently added faculty who are also very, very vigorous proposal writers and researchers.”

The reward of teaching

Hellmann sees the application of his work materialize most significantly in the teaching of his students. At Penn State, he's taught undergraduate and graduate classes and has advised more than 100 students with their research and theses.

He's seen students go from young, bright minds to experts at national labs or companies such as Corning, Boeing and Texas Instruments. In that time, he's passed along what he knows but also the skills and the drive it takes to not just understand the properties of materials, but also to understand the performance of the material in its intended application.

continued on page 35



In retirement, ceramics expert John Hellmann said he'll dedicate more time to restoration and recreation in several of his vintage Jeeps such as this 1948 CJ2A Willys Jeep. IMAGE: COLLEEN SWETLAND

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.



Xuejian Liu

Postdoctoral Scholar

Liu earned his Ph.D. in exploration geophysics from the Institute of Geology and Geophysics and his B.S. in exploration geophysics from Ocean University of China. Prior to joining Penn State, Liu was a postdoctoral researcher at Los Alamos National Laboratory and the Institute of Geology and Geophysics. He also interned at Saudi Aramco and Statoil. He is currently a postdoctoral scholar in the Department of Geosciences.



Yashar Mehmani

Assistant Professor

Mehmani is an assistant professor in the John and Willie Leone Family Department of Energy and Mineral Engineering (EME) at Penn State. He is also a co-funded faculty in the Institutes of Energy and the Environment (IEE). His research interests are broadly related to porous media flow and mechanics with a special focus on computing and scale translation. He is particularly interested in how microscale physics affect macroscopic observations and how predictive tools based on such knowledge can be built. Applications that motivate his research relate to sustainability aspects of subsurface energy production, groundwater contamination, and renewables. He has a B.S. from the Sharif University of Technology, Iran, and a Ph.D. from the University of Texas at Austin.



Jacques Rivière

Assistant Professor

Rivière is an assistant professor in the Department of Engineering Science and Mechanics (ESM) and the Department of Acoustics at Penn State. His research interests include ultrasonics, geophysics, nonlinear acoustics, vibrations, nondestructive testing of materials, structural health monitoring, material characterization and damage assessment, and friction. He earned a Ph.D. from the University of Pierre and Marie Curie in Paris, France, and an M.S. in acoustics from the University of Le Mans, France.

New Faculty Spotlight

Barbara Arnold



Can you tell me about your area of expertise?

I'm a coal preparation engineer with a focus on flowsheet design (including the application of mathematical models) and fine coal processing—gravity, froth flotation, and dewatering. That is the expertise that I'll bring to the beneficiation/concentration piece of the work being done in Penn State's Center for Critical Minerals.

How does your work impact society?

Coal preparation for thermal coal can be used to reduce sulfur in coal and, therefore, sulfur emissions. Ensuring that the proper quality of coal is used in power plants increases their efficiency and decreases carbon dioxide emissions. The new focus on critical minerals will impact the availability of domestically produced renewable energy technologies. And I'd like to make an impact on the reduction of materials going into tailings disposal sites and, perhaps, putting those materials to beneficial use.

What various positions did you hold in industry, and what did you do in these positions?

My first industrial experience came as a summer student with U.S. Steel research. That's where I learned how to do coal froth flotation tests and fine coal washability analysis. The Electric Power Research Institute sponsored my Ph.D. research, and I went to work at their Coal Cleaning Test Facility before I finished my dissertation. I managed projects in our 20-tph test facility that looked at coal quality impacts on power plant efficiency and conducted research on coal handling, blending, and trace element removal. I also helped to develop a coal cleaning simulator using the Aspen platform. I was there for ten years and then started PrepTech, Inc. in 1997. My business partner, John Munjack, and I started out doing engineering projects for coal companies and engineering contractors, mostly looking at flowsheets for new coal preparation plants as well as retrofits. In 1999, we were approached by Multotec Process Equipment from South Africa to become their U.S. representative. We sold their cyclones and spirals and also picked up a few other product lines along the way. I also continued doing consulting, mostly developing flowsheets, though also doing some plant audits and the odd bid specification package.

Can you describe one or two standout projects you're most proud of?

One of my earliest projects was for my master's degree—the effect of clay on coal froth flotation. That work is referenced widely and has applications in other areas of mineral processing and dewatering of solids. Then there are the projects for which I've developed a flowsheet that went on to become an operating plant. Getting the flowsheet to balance; ensuring that equipment sizing is correct. Those aspects are always satisfying. I had one director of coal preparation tell me that my numbers were always good! That was a proud moment.

Have you had any involvement in the field outside of your career?

I wrote papers and volunteered with the Coal Preparation Society of America (CPSA) and the Society for Mining, Metallurgy and Exploration, Inc. (SME). I serve as the CPSA Board Secretary and as the representative to the International Organizing Committee for the International Coal Preparation Congress. I have also had the opportunity to help organize several conferences, and I served as the SME Foundation President in the early 2010s and as the 2018 SME President. Those are all roles in which I have had the opportunity to meet mining professionals nationally and internationally.

What brought you back as a professor of practice at Penn State?

I was asked! And the timing worked out well as Multotec decided to do their North American sales through their Canadian office. But, additionally, I have always had an interest in academia. I can share my experiences in the classroom and can also do research in some very interesting areas related to coal and mineral processing.

Why are you so passionate about your work?

I've generally been able to do something different every day! It's interesting! There have been some days when I started my morning interacting with South Africa or Spain and ended the day interacting with Australia, China, or India. And now, with the emphasis on critical minerals for batteries and renewable energy, someone has to figure out how to keep up with the demand with domestic sources. More mining and more mineral processing. It's cool stuff!

Are there any other additional achievements you'd like to mention?

My recent selection as an honorary member of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) was certainly a capstone to my career as an SME volunteer! Receiving the Frank F. Aplan Award given by SME/AIME and the Percy Nicholl's Award given by SME's Coal & Energy Division and ASME's Power Division have been highlights as well as becoming a Penn State Alumni Fellow. And I'm honored to present the Arthur Le Page Lecture to the Australian Coal Processing Society (virtually) in March 2021.

What do you like to do outside of work for fun?

I sing at church—both in the choir and as a cantor. I volunteer with my "local" Penn State Alumni Society at the New Kensington Campus. I knit, crochet, etc. And there are a few TV shows that I never miss: The Curse of Oak Island, The Walking Dead, and, when it was on, Game of Thrones (go Arya!). And I have been known to be an avid reader—just need a bit more time to get back to fiction—I've been reading too many technical books to prep for classes!

125th Anniversary

Celebrating
125
YEARS

1896 - 2021

The Penn State's College of Earth and Mineral Sciences has a rich history dating back more than a century, from the original focus on mining engineering, to today's interdisciplinary focus on earth, energy, and materials sciences and engineering. The college was formed in 1896, and we are embarking on a yearlong celebration in 2021 of our upcoming 125th anniversary. The college will be hosting numerous celebratory events to commemorate this milestone.

Upcoming Events

- **June 25: Village Lecture Series: Conversations with Colleagues** Speaker: Bill Brune Talk: "Lightning Induced Chemistry in Atmospheric Science"
- **June: GEMS 125th Anniversary Educational Series** Speaker: Clive Randall, director of the Materials Research Institute. Talk: "Commercialization of Cold Sintering of Ceramics"
- **July 28: Pioneers in Remote and Online Education** Speaker: Jane Suttelin and Maria Wherley Talk: "How Technology and Learning Science Can Change Your Teaching"
- **August: GEMS 125th Anniversary Educational Series** Speaker: James Kasting, Evan Pugh University Professor of Geosciences (tentative) Talk: "The Search for Life on Planets Around Other Stars"
- **Ryan Family Student Center Welcome Home** Event will be held in conjunction with Homecoming annual parade watching gathering
- **October 29-30: "Carbon: From Fuels to Materials" - 125th Anniversary Symposium** A series of invited lectures, primarily by Penn State alumni, that illustrates the history, the progress and the synergism of fuels/materials connections with a view toward an even brighter future.
- **October: Ryan Family Student Center Showcase** Ribbon-cutting ceremony and open house for newly renovated center, will showcase expanded services, etc.
- **October: Materials Research Institute Showcase** Facilities will be open for guided tours.
- **October: John and Willie Leone Family Department of Energy and Mineral Engineering's 125th Anniversary Celebration** Events will include a graduate student research showcase, facility tours, presentation of Hosler renovation plans, activities with student societies, and reception with the dean
- **October: Joel N. Myers Weather Center** Friday reception and Saturday breakfast/brunch
- **October: Computational and Data Science in Earth Science 125th Anniversary Innovations in Education and Research Symposia** Sponsored by the Institute for Computational and Data Sciences
- **October 29-30: Celebration Weekend** Recognition of 125th Fellows, poster sessions, tours of facilities, etc.
- **October 30: Earth and Environmental Systems Institute Showcase and Reception** Open house showing the renovated second floor and sharing of plans for third floor JEWEL renovation

Previous Events

- **May 19: Panel - "Getting to Negative: strategies, ethics, and co-benefits of carbon capture and sequestration"** Panel was part of IEE's Energy Days.
- **April 20: GEMS 125th Anniversary Educational Series (virtual webinar)** Speaker: Tim White, research professor and director of the EMS Sustainability Council
- **April 15: 125th EMS Anniversary Steidle Café** Speakers: Amit Das, State-of-the-Art; Long-Qing Chen, MatSE; George Kotsoni, doctoral candidate.
- **April 14-15: "Reflections and Future Perspectives of Polymer Science in EMS" (virtual event)** Series of lectures by both Penn State and non-Penn State faculty and keynote and plenary speakers, Geoffrey Coates and Thomas Epps III
- **April 14: Department of Meteorology and Atmospheric Science's Hussey Lecture (virtual event)** Speaker: Harry Campbell, Chesapeake Bay Foundation
- **April 14-15: Celebration of Undergraduate Engagement (virtual event)** Student presentations, workshops, and guest speakers highlighted undergraduate research and engagement experiences.
- **April 11: Center for Energy Law and Policy and EME Joint Webinar** Panel Discussion: "Planning for the Unplanned: Designing Resilience in Energy Systems"
- **April 9: 2021 G. Albert Shoemaker Lecture in Mineral Engineering** Speaker: Sustainability Officer - Freeport-McMoRan Americas Talk: "Meeting Escalating Stakeholder Expectations of the Mining Sector"
- **March 26-27: EMEX - 125th Anniversary Century of Excellence Activity (virtual event)** Earth and Mineral Sciences EXposition (EMEX) is the college's annual student-run open house
- **March 25: Center for Energy Law and Policy and EME Joint Webinar** Panel Discussion: "Who Decides on Resilience for Energy Systems?"
- **March 25: Village Lecture Series: Conversations with Colleagues** Speaker: Erica Smithwick Talk: "Role of Wildlife on Ecosystem Function"
- **March 18: 125th EMS Anniversary Steidle Café** Speakers: Doug Wolfe, ARL; Trevor Clark, Materials Characterization Lab; Conghang Qu, doctoral candidate.
- **March 8: Center for Energy Law and Policy and EME Joint Webinar** Panel Discussion: "What Messed With Texas, and Could it Happen Here?"

Seminar examines initiative's effects on energy costs, power grid



Pennsylvania is set to join the Regional Greenhouse Gas Initiative (RGGI), a multi-state compact to reduce greenhouse gas emissions from the electric power grid. The Commonwealth hosts one of the largest and most diverse power generation fleets in the country, and its decision to join RGGI will affect electricity provision across many states in the region. Joel Landry, assistant professor of environmental and energy economics in the John and Willie Leone Family Department of Energy and Mineral Engineering, discussed the effects of joining RGGI on energy costs and the power grid on October 2, 2020.

Landry's talk covered topics such as how RGGI works, the impact of the RGGI carbon price on power grid operations, and its effectiveness at reducing greenhouse gas emissions and other pollutants from power plants.

Landry's talk is part of the Regional Greenhouse Gas Initiative seminar series hosted by Penn State's Center for Energy Law and Policy. The center is a University-wide initiative that supports independent and interdisciplinary research, education, and stakeholder engagement on complex energy issues. It provides thought leadership on energy issues where emerging science and technology are intertwined with legal, economic, and social

institutions. For more information on the Center for Energy Law and Policy, contact Seth Blumsack, center director, at sab51@psu.edu.

EESI EarthTalks panel to focus on energy education in post-pandemic world

The current coronavirus pandemic caused (dramatic) volatility in the price of oil to drop and education to happen remotely. How should institutions like the College of Earth and Mineral Sciences, which offers degree programs in petroleum and natural gas engineering as well as renewable energy and climate, adapt? Susan Brantley, director of the Earth and Environmental System Institute, and Lee Kump, John Leone Dean in the College of Earth and Mineral Sciences, led a panel discussion on the future of energy education.

Panelists included Jennifer Baka, assistant professor of geography; Seth Blumsack, professor of energy policy and economics and international affairs; Mike Loudin, former head of geoscience workforce development at ExxonMobil; Kevin Smith, CEO for the Americas, Lightsource BP; and Sanjay Srinivasan, head, John and Willie Leone Family Department of Energy and Mineral Engineering.

The panel was held on May 18, 2020. The talk was free and open to the public.

The energy panel was part of the spring 2020 EESI EarthTalks series, "Societal Problems, EESI Science towards Solutions." The series featured scientists from Penn State's Earth and Environmental Systems Institute (EESI) and explored the human impacts on the global environment and how to apply this knowledge to decision-making.



Energy forum engages Penn State community

A series of energy forums is being held to discuss how Penn State can continue to strengthen its position as an energy leader. The first forum took place on December 11. The virtual event was titled “Energy University: Concept and Current Activities.” Penn State faculty, staff, and students were invited to participate.

The forum featured an Energy University overview from Penn State President Eric Barron. He discussed the status of Energy University and introduced areas that the University will focus on for growth and investment.

“Universities have an obligation to the people and the communities they serve to create a better tomorrow,” Barron said. “In the case of energy, we need solutions that will provide sources that are clean, abundant, safe, and affordable. At Penn State, we take this challenge very seriously, from the solar energy that will provide more than 25 percent of Penn State’s purchased electricity over the next twenty-five years, to the education and support that the University provides through Penn State Extension and beyond. The demand for energy is only increasing, and it’s imperative that universities lead the way through education, research, and implementation to show that it is not just reasonable, it is achievable.”

The following focal areas had short presentations:

- “Energy Transitions” was delivered by Seth Blumsack, director of the Center for Energy Law and Policy, who was introduced by Hari Osofsky, dean of Penn State Law and the School of International Affairs.
- “Developing Solutions” was delivered by Bruce Logan, director of the Consortium for Integrated Energy Systems, who was introduced by Lee Kump, dean of the College of Earth and Mineral Sciences.
- “Strengthening Communities” was delivered by Esther Obonyo, director of the Global Building Network, who was introduced by Marie Hardin, dean of the Donald P. Bellisario College of Communications.
- “Advancing Literacy and Leadership” was delivered by Rachel Brennan, director of the Drawdown Scholars Program, who was introduced by Justin Schwartz, dean of the College of Engineering.

Lora Weiss, senior vice president for Research, moderated a panel that focused on big ideas for Energy University. The panel discussion explored the opportunities and impacts that Penn State can have in energy.

“For Penn State to bolster its impact as an energy leader, we must use the resources, talent, and creativity within our research enterprise,” Weiss said. “The University’s extensive knowledge in all aspects related to energy is found within our world-renowned energy researchers and facilities that house some of the most advanced research equipment in the world; we have a responsibility to explore and advance research directions that can be translated into real-world improvements.”

Finally, Tom Richard, director of the Institutes of Energy and the Environment, moderated an open discussion where attendees could share their feedback and input on Energy University.

“Energy is central to nearly every aspect of our lives, from housing and transportation to food, manufacturing, education, and health,” Richard said. “The full depth and breadth of disciplines from across Penn State are critical in this era of rapid energy transitions. I look forward to this dialogue about how we can work together to achieve our Energy University ambition.”



IMAGE: PIXABAY

Seminar examines **Regional Greenhouse Gas Initiative** amid state energy policy

The Regional Greenhouse Gas Initiative (RGGI), aimed at reducing greenhouse gas emissions from the electric power sector, will change Pennsylvania's energy landscape, but it will not be the only major element of the Commonwealth's energy policy. Daniel Mallinson, assistant professor of public policy and administration at Penn State Harrisburg, and graduate student Andrew Bell discussed how RGGI might interact with Pennsylvania's Alternative Energy Portfolio Standard and Act 129 on December 4, 2020.

The talk also covered topics such as reinvesting revenues generated by RGGI and ideas for leveraging these revenues to encourage equitable energy innovation for the post-COVID-19 economic recovery in Pennsylvania.

The seminar, which was free and open to the public, was held through Zoom.

Mallinson's talk is part of the Regional Greenhouse Gas Initiative seminar series hosted by Penn State's Center for Energy Law and Policy. The center is a University-wide initiative that supports independent and interdisciplinary research, education and stakeholder engagement on complex energy issues. It provides thought leadership on energy issues where emerging science and technology are intertwined with legal, economic, and social institutions. For more information on the Center for Energy Law and Policy, please contact Seth Blumsack, center director, at sab51@psu.edu.

Honors & AWARDS



Mining engineering professor selected as **honorary member of AIME**

Barbara Arnold, professor of practice in mining engineering, has been awarded honorary membership in American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME). AIME honorary membership is one of the highest honors that the institute can bestow on an individual. Honorary membership is awarded in appreciation of outstanding service to the institute or in recognition of distinguished scientific or engineering achievement in the fields embracing the activities of AIME and its member societies.

IMAGE: Courtesy Barbara Arnold

2020 Millennium Café Pitch Competition winner

The 2020 Millennium Café Pitch Competition was held virtually on June 2, 2020. Sponsored by PPG Industries, the Millennium Café Pitch Competition is an opportunity for graduate students to pitch research in two minutes or less using no more than four supporting slides. **Sandra Ike** won first place for her presentation titled "Creating Graphitic Carbons from Biopolymers."





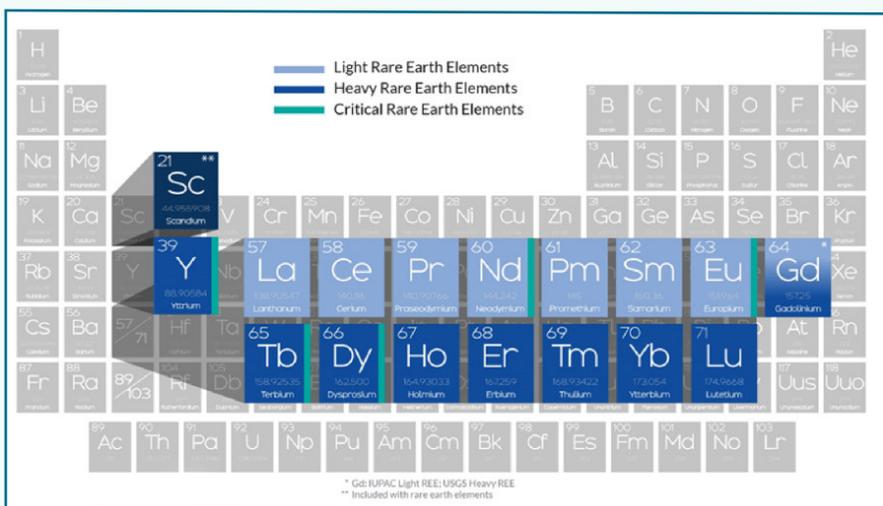
El faculty member joins the Institutes of Energy and the Environment

Hilal Ezgi Toraman, an assistant professor in the College of Earth and Mineral Sciences with a joint appointment in the College of Engineering, has become a cofunded faculty member in the Institutes of Energy and the Environment (IEE). Toraman’s research interests include chemical reaction engineering with a focus on developing new processes, materials, and technologies for efficient and sustainable use of shale gas, biogas, biomass, and plastic waste. Her research is in line with the Stewarding Our Planet’s Resources thematic area of Penn State’s strategic plan. Toraman was also recently named the Virginia S. and Philip L. Walker Jr. Faculty Fellow in Materials Science and Engineering and Fuel Science Program at Penn State.

Penn State, Colorado School of Mines will support U.S. need for critical minerals

Penn State has entered a memorandum of understanding (MOU) with the Colorado School of Mines to establish a collaboration designed to be responsive in supporting the United States’ need for critical minerals. Through the MOU, the two universities will partner on research to support U.S. producers and consumers of critical mineral commodities and help advance the country’s manufacturing sector while developing a well-trained workforce to meet the demands on U.S.-sourced critical minerals.

“Both schools are committed to developing new innovations to enable a complete U.S. capability for critical minerals, from basic science to supply chain through to production,” said Lora Weiss, Penn State’s senior vice president for research. “Together we span from Appalachia to the Rockies and collectively we have the technical base and established relationships with stakeholders to realize the full potential value of our natural resources. Our combined team is well positioned to be extremely responsive to the country’s critical minerals needs.”



Periodic table showing the seventeen rare earth elements that are part of the group of critical minerals significant to domestic and national security, energy and daily consumer products. IMAGE: U.S. DEPARTMENT OF ENERGY



Rezaee named outstanding young engineer

Mohammad Rezaee, assistant professor of mining engineering in the John and Willie Leone Family Department of Energy and Mineral Engineering, has been awarded the Outstanding Young Engineer Award from the Society for Mining,

Metallurgy, & Exploration's (SME) Mineral and Metallurgical Processing Division. The Outstanding Young Engineer award was created in 1984 and recognizes a young individual, age thirty-six or younger, with a significant contribution within the mineral processing and extractive metallurgy discipline. Rezaee, who holds the Thomas V. and Jean C. Falkie Mining Engineering Faculty Fellowship in the College of Earth and Mineral Sciences, was selected for "his significant contributions in the development of methodologies and applications of mineral processing unit operations and circuits to enhance the sustainability of mining operations." He received the award at the SME 2020 annual Conference & Expo held in Phoenix, Feb. 23-26, 2020.

IMAGE: Courtesy Mohammad Rezaee

Energy, chemical engineering professor receives fellowship

Hilal Ezgi Toraman, assistant professor of energy engineering and chemical engineering, has been named the Virginia S. and Philip L. Walker Jr. Faculty Fellow in Materials Science and Engineering and Fuel Science Program. The fellowship was awarded to Toraman for her contributions to teaching, research, and service in the John and Willie Leone Family Department of Energy and Mineral Engineering.



"I want to convey my sincere thanks to Virginia and Phillip Walker for supporting me as a researcher in the field of fuel science," Toraman said. "The Virginia S. and Philip L. Walker Jr. Faculty Fellowship is not only a source of funding to further my contribution in teaching, research, and public service but also a great source of motivation."

IMAGE: Jamie Oberdick



Interdisciplinary team wins Department of Energy Optimization Challenge

A team of Penn State researchers is part of the first round of winners for the Department of Energy's (DOE) Grid Optimization Competition. Presented by the DOE's Advanced Research Projects Agency-Energy, the selective competition presents challenges for the development of optimization algorithms for a crucial set of operational problems faced by the United States' power grid. The team, led by **Uday V. Shanbhag**, the Gary and Sheila Bello Chair and professor in the Harold and Inge Marcus Department of Industrial and Manufacturing Engineering in the College of Engineering, received \$100,000 to advance their methods and share their technology with industry partners. Future competitions, beginning with challenge two, will build on the models used in challenge one, but may include complicating factors such as solving larger network models, optimizing power flows over both transmission and distribution systems, contending with uncertainty and discreteness, leveraging power flow control devices, and increasing model detail. Challenge two will likely continue its focus on optimal power flow and disburse fewer, but larger, awards.

IMAGE:© ISTOCK IMAGES / METAMORWORKS

Penn State seed grant leads to NSF funding to study stress wave mitigation

Seismic waves make the Earth quake, shaking the developments on the planet's surface. But what if there were a way to stop those seismic waves from reaching buildings, bridges, or entire towns? What if the energy from the waves could potentially be redirected or even harnessed, just by building a structure on the ground? **Parisa Shokouhi**, associate professor of engineering science and mechanics and acoustics at Penn State, is interested in the possibility of controlling this type of stress wave. Known as surface waves, they move along the border between two differing media; a common example is an ocean wave moving along the boundary between water and air. Shokouhi's interest motivated her to pursue a Penn State Multidisciplinary Seed Grant in 2017, which served as the first step toward an external grant. Now, with a \$641,162 National Science Foundation grant, Shokouhi is exploring the possibilities of surface wave control using an array of resonating elements collectively called a metasurface that could redirect waves in the material it is attached to.



An array of resonators glued on an aluminum plate. IMAGE- Chris Hakoda

College of Engineering awards five Multidisciplinary Research Seed Grants

The Penn State College of Engineering awarded 2020 Multidisciplinary Research Seed Grants to five faculty research teams across the College of Engineering, the College of Medicine, and the College of Earth and Mineral Sciences. The Multidisciplinary Research Seed Grants support research projects that will increase the competitiveness of faculty in attracting high-impact multidisciplinary and center-level research funding from the state and federal government, industry, or foundations. These seed grants will support the awardees' projects for one year. **Parisa Shokouhi**, associate professor of engineering science and mechanics, and **Daniel Kifer**, associate professor of computer science, were awarded a grant for "A wave physics-informed deep learning framework for acoustic data." They will develop a framework to integrate complex wave physics into machine learning prediction models that use acoustic sensory data, such as systems used for geophysical surveys, non-destructive evaluations, and medical diagnostics.



Deborah Kelly, far right, reviews lab results with students (left to right) Madison Evans, Michael Casanata, and G.M. Jonaid. Photo taken September 2019.

IMAGE: JAMIE OBERDICK

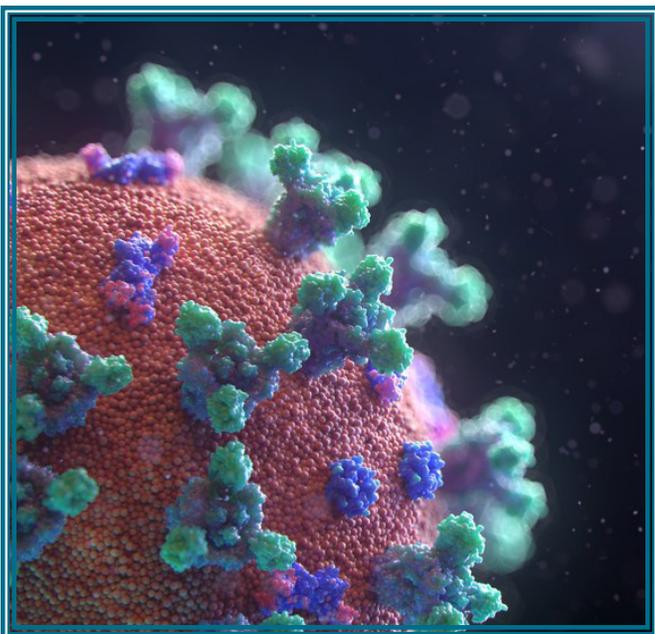
Jump-starting COVID-19 ravaged lungs with newly modified therapeutics

Deborah Kelly, Lloyd & Dottie Foehr Huck Chair in Molecular Biophysics and professor of biomedical engineering, and [James Adair](#), professor of materials science and engineering, biomedical engineering, and pharmacology, are partnering with researchers from the College of Medicine to re-engineer a cancer drug for COVID-19 patients. The team is researching potential viral applications of a protein therapeutic known to be effective at decreasing lung inflammation in cancer patients. The research is one of the projects funded by the Huck Institutes of the Life Sciences coronavirus seed grant initiative.

IST seed grants support tech projects related to COVID-19

The College of Information Sciences and Technology recently announced six projects that will receive funding from the college's seed grant program. Each project will take different approaches to tackle various challenges and needs related to the novel coronavirus pandemic. The college's seed grant program is designed to jump-start critical research projects that explore innovative ideas that have a short-term impact, as well as those that will position researchers to support, advance, and develop long-term solutions to local and global issues. EI's [Sharon Huang](#), associate professor, received funding for her project titled "AI Methods and Tools in Response to the COVID-19 Open Research Dataset." This project aims to rapidly develop artificial intelligence methods and tools in response to the COVID-19 Open Research Dataset, using natural language processing, text mining, image mining, and other AI techniques to generate new insights related to COVID-19 for policy makers and medical experts.

IMAGE: FUSION MEDICAL ANIMATION, UNSPLASH



Penn State and University of Auckland announce 2020 joint collaboration projects

In late 2019, Penn State and the University of Auckland launched the Joint Collaboration Development Program, a jointly financed seed-fund program with the aim to foster collaborative research and educational projects. The Office of Global Programs has announced that eight projects have been funded and commenced in June 2020. Grant recipients will have the opportunity to help shape the direction and future investment in the university collaboration at the level of an institutional partnership and contribute to the universities' vision and strategic goals. Among those awarded was [Meng Wang](#), for her project titled "Re-Engineering Anaerobic Treatment Processes for Novel Functionalities."



Seth Blumsack is a part of a multi-university team that is studying the decision-making process that governs how people in the U.S. receive electricity.

IMAGE: Adobe Stock

Shedding light on the rules that govern the U.S. power grid

A Penn State researcher is a part of a multi-university team that received a \$513,000 grant to study the decision-making process that governs how people in the U.S. receive electricity. [Seth Blumsack](#), professor in the College of Earth and Mineral Sciences and director of the Center for Energy Law and Policy, is co-leading an interdisciplinary team investigating how the rules for the power grid are made and how they affect the real world.

"Electricity is the platform for our economy and is tightly connected to people's well-being," said Blumsack, a cofunded faculty member in the Institutes of Energy and the Environment, who has been studying the electric power industry for more than twenty years. "These rules that govern the grid are critical elements for changing the way we produce electricity."

According to Blumsack, the rules have important implications for the grid and society, such as grid reliability, cost to customers, environmental impact, and technology.

Lo Prete receives NSF CAREER award

to investigate capacity adequacy options

Chiara Lo Prete, associate professor of energy economics, received a Faculty Early Career Development Program (CAREER) award from the National Science Foundation to investigate electricity market structures to provide efficient incentives for generation capacity investment under increasing renewable penetration. Organized wholesale electricity markets in the United States converged to a common market design framework that has been successful at promoting efficient and reliable operations of electric power systems since the 1990s. However, the growth of intermittent renewables poses challenges that were unknown, or less material, in the early design efforts. Lo Prete's group will examine market design challenges associated with increasing renewable penetration using an approach that combines optimization and experimental economic methods.

IMAGE: PIXABAY



CDC grant to focus on effects of nano-coal dust on lung disease in coal miners

Penn State researchers in the John and Willie Leone Family Department of Energy and Mineral Engineering received a \$400,000 grant from the Centers for Disease Control and Prevention's National Institute for Occupational Safety and Health to research coal dust in underground mines and its effect on lung disease in miners.

Inhaling coal mine dust is a major occupational hazard for coal miners and is known to cause several types of respiratory diseases, with coal worker's pneumoconiosis (CWP), often called black lung, the most common. The increase in CWP in certain areas of the country points to the need for further research into the cause of this increase. This research will characterize physical, compositional, and petrophysical properties of coal dusts and investigate the biological effects of nano-coal dust on lung cell and tissue using a lung-on-a-chip device.



Nathan Gendru, graduate student in mining and mineral process engineering who is advised by Shimin Liu, reviews the characterization of coal dust under a high-resolution microscope. IMAGE: PENN STATE

Institute for Computational and Data Sciences awards computational and data sciences seed grants

Understanding polarized political opinions, predicting Arctic Sea ice levels, and accelerating quantum computing with machine learning—these are just a few focuses of the dozens of new Penn State research projects that have been funded by Institute for Computational and Data Sciences seed grants, in conjunction with supplemental funding from the colleges of Arts and Architecture, Earth and Mineral Sciences; Information Sciences and Technology; Education; and Engineering. Of the fifty-one proposals received, thirty-two projects were funded. Among those, **Arash Dahi Taleghani**, associate professor of petroleum and natural gas engineering, received funding for his proposal titled “Artificial Intelligence Method for Fast and Reliable Interpretation of DFIT and Flowback Data.” **Sharon Huang**, associate professor of information sciences and technology, also received funding for her proposal titled “Towards Dynamic Patient-centric Personal Health Libraries.” **Tieyuan Zhu**, assistant professor of geosciences, received funding for his proposal titled “Machine Learning of Massive Real-time Environmental Monitoring Data from Penn State Fiber-optic Array for Mitigating Urban Geohazards.”

IMAGE: Penn State Institute for Computational and Data Sciences



Penn State faculty teams awarded seed grants for AI research

Multi-Disciplinary Research Grants were recently awarded to eight research groups from across Penn State’s colleges and campuses conducting research related to artificial intelligence (AI) and machine learning (ML). In collaboration with numerous research institutes and colleges, these grants are funded in concert with the 2020 industryXchange, an annual University-wide event hosted by the College of Engineering. These one-year seed grants will support research on application-specific development in AI and ML in the areas of cybersecurity, energy, health care, manufacturing, and transportation. Among them were Jinchao Xu, Verne M. Willaman Professor of Science, and **John Yilin Wang**, associate professor of petroleum and natural gas engineering, for their project titled “Advanced and Fast Simulation Technologies for Modeling Shale Gas Wells.”

2021 End of Year Awards

Wilson Banquet and Awards Presentation

The College of Earth and Mineral Sciences' annual celebration of accomplishments was hosted virtually on April 11, 2021. The following EI students, affiliates, and researchers were honored.

E. Willard and Ruby S. Miller Faculty Fellowship

The E. Willard and Ruby S. Miller Faculty Fellowship was created to support faculty of exceptional creativity who propose highly innovative approaches to major contemporary challenges in the earth, energy, and material sciences.



Hamid Emami-Meybodi, assistant professor of energy and mineral engineering, was selected for his proposal "Transport Behavior of Condensed Fluids in Ultratight Porous Media: Evidence for Mechanisms Other Than Advection"

Charles Hosler Diversity, Equity and Inclusion Faculty Award

This award honors faculty who have demonstrated exemplary leadership that manifests the ideals of diversity, equity, and inclusion into practical action in the College of Earth and Mineral Sciences.



Luis Ayala, professor of petroleum and natural gas engineering

Tenure



Chiara Lo Prete, associate professor of energy and mineral engineering

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.



Mohammad Rezaee, associate professor of mining engineering, was selected for his proposal "Unlocking Unconventional Lithium Resources through Development of Efficient, Low-cost, and Environmentally Benign Extraction Processes and Production of Lithium Battery Products"

Faculty Mentoring Award

This award was created to honor faculty members in the college for their outstanding work in mentoring students or junior faculty members. The recipient is honored with a recognition memento and a monetary award.



Luis Ayala, professor of petroleum and natural gas engineering



Feifei Shi, assistant professor of energy engineering, was selected for her proposal "Unlocking Unconventional Lithium Resources through Development of Efficient, Low-cost, and Environmentally Benign Extraction Processes and Production of Lithium Battery Products"

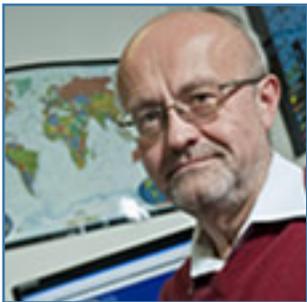
End of Year Awards

2020

Wilson Banquet and Awards Presentation

The College of Earth and Mineral Sciences' annual celebration of accomplishments was hosted virtually on April 26, 2020. The following EI students, affiliates, and researchers were honored.

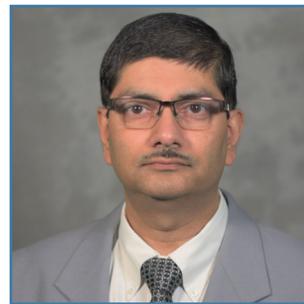
25-Year Service Award



Serguei Lvov, professor of energy and mineral engineering

Gladys Snyder Junior Faculty Grants

The Gladys Snyder Junior Faculty Grants are awarded to junior faculty for the development of new courses or the improvement of current offerings; for travel to professional meetings; to broaden the studies of junior faculty members; or to recognize significant contributions in research efforts.



Sekhar Bhattacharyya, associate teaching professor, was selected for his proposal "Transforming Teaching Focus from Fossil Fuel to Mineral Resources used in Enduring Products and in Renewable Energy Sector"

Fall 2019 EMSAGE Laureates

The College of Earth and Mineral Sciences Academy for Global Experience (EMSAGE) is the college's signature undergraduate recognition program. Select students are recognized with the distinctive designation of EMSAGE Laureate.



Ian Wasserman, energy engineering



Feifei Shi, assistant professor of energy engineering, was selected for her proposal "Novel Monolithic Single Atom Catalyst for Renewable Fuels"

Wilson Research Initiation Grant

The Wilson Research Initiation Grant was established to provide an extra spark to the research career of a junior faculty member.



Amin Mehrabian, assistant professor of petroleum and natural gas engineering, was selected for his proposal "Rate-Dependent Solutions for the Productivity and Injectivity Index of Deformable Subsurface Rock"

E. Willard and Ruby S. Miller Faculty Fellowship

The E. Willard and Ruby S. Miller Faculty Fellowship was created to support faculty of exceptional creativity who propose highly innovative approaches to major contemporary challenges in the earth, energy, and material sciences.



Tieyuan Zhu, assistant professor of geosciences, was selected for his proposal "Excitation of Seismic Waves by the Atmosphere: Using Thunderquakes by Lightning Stroke for Solid Earth Tomography"

Wilson Award for Outstanding Service



Seth Blumsack, professor of energy business and finance



William Groves, associate professor of industrial health and safety

2020 Department of Energy and Mineral Engineering student awards

The John and Willie Leone Family Department of Energy and Mineral Engineering had its 2020 Awards Banquet on April 20. This banquet recognizes 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.

Outstanding Graduate Teaching Assistants



Ziyang Li,
Ph.D. student



Sheng Zhi,
Ph.D. student



Yiming Zhang,
Ph.D. student

EME-PNGE Graduate Merit Award



Fengyuan Zhang,
Ph.D. student

EME Graduate Merit Award



Ziyang Li,
Ph.D. student

MNGE Undergraduate Merit Award



Harmonie Ngamuyeka,
undergraduate senior student

2020 Institutes of Energy and the Environment Seed Grants

The following EMS Energy Institute researchers were 2019–20 Institutes of Energy and the Environment (IEE) seed grant recipients:

Energy and Environmental Resilience



“Bioinspired Self-Healing Cement for Sealing Well Leakage: Towards Sustainable Shale Gas Supply”—**Dahi Taleghani Arash**, College of Earth and Mineral Sciences

Water

“Granulation of Algal-Bacterial Consortia for enhanced CO₂ capture and Resource Recovery”—**Meng Wang**, College of Earth and Mineral Sciences



Future Energy Supply



“Coupled Large-scale Energy Conversion and Storage by Biphasic Redox Flow Battery and Photo-ionic Cells”—**Feifei Shi**, College of Earth and Mineral Sciences

Through teaching, leadership and research, Hellmann planted his legacy cont.

“It’s amazing to me how many of my former students have told me how some experience that we had was transformational for them, and that they really appreciated it,” Hellmann said. “And that’s really heartwarming. That’s the reward of teaching.”

Retirement

In retirement, Hellmann will still be creating. He’s picked up a few hobbies over the years and plans to dedicate a bit more time to them.

He’s been restoring several vintage Jeeps, including a 1948-CJ-2A, 1950 M-38, and a 1952 Willys M38A1. He’s done complete restorations on all but the 1952 Willys, which he plans to “leave patina” because it’s in such great shape considering its age.

His research, teaching, and leadership, he said, often took precedence over his home. So he plans to put a fresh coat of paint on those twenty-seven-year-old walls, build an enclosed three-season porch, and landscape the yard. He also plans to visit his grandkids as often as he can, offering them rides in his Jeeps.

He’s been harvesting tree nuts from some of his favorite spots, stratifying the seeds over the winter so that they germinate, and then transplanting them into small containers before planting the seedlings on a rural property he purchased a couple decades ago. He estimates he’s already planted about 1,000 chestnuts, persimmon, hickory, and oak tree on the site.

Hellmann hopes to see the seeds he planted at Penn State continue to grow, too.

“The greatest satisfaction of my career has come from my service commitment,” Hellmann said. “I’ve enjoyed enabling our students, staff, and faculty to succeed in their own endeavors, through my teaching, mentoring, and collaboration. I enjoyed seeing, and indeed sometimes jointly experiencing, the epiphanies that students experience in the classroom as well as when I’m collaborating with a colleague. I’ve enjoyed mentoring and advising my students in their research; watching them grow and mature. It’s frequently transformative, and it’s why I chose academia for my career.”

Nanoengineered cement shows promise for sealing leaky gas wells cont.

Adding almost 2-D graphite created a cement mixture that better filled these narrow spaces and that was also stronger and more resilient, the scientists found. They recently reported their findings in the *International Journal of Greenhouse Gas Control*. Maryam Tabatabaei, a postdoctoral scholar in the John and Willie Leone Family Department of Energy and Mineral Engineering, also contributed to this research.

The scientists developed a multi-step process to uniformly distribute sheets of the nanomaterial into a cement slurry. By treating the graphite first with chemicals, the scientists were able to change its surface properties so the material would dissolve in water instead of repelling it.

“If we just pour this material in the water and mix it, these small particles have a tendency to stick together and form a conglomerate,” Dahi Taleghani said. “If they are not dispersing evenly then the graphite is not as strong inside the cement.”

The cement mixture can be used in active unconventional wells like those found in the Marcellus Shale gas play, or to seal orphaned and abandoned gas wells, the scientists said. It also shows promise for use in carbon dioxide capture and storage technology.

Graphite is more affordable than other nanomaterials previously used to bolster cement performance. In addition, very little of the material is needed to strengthen the cement, the scientists said.

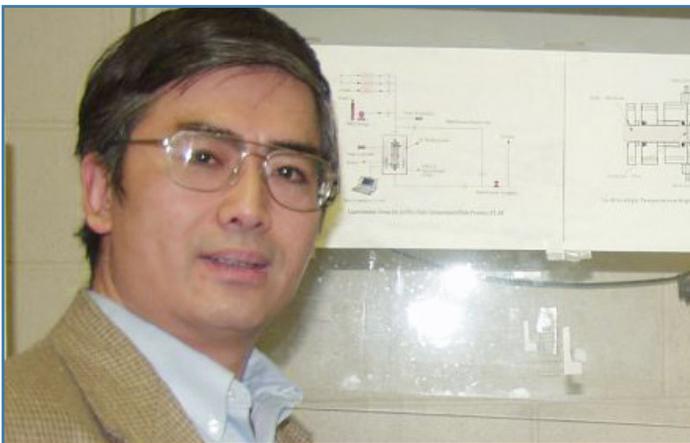
“Considering the low cost of the amount of graphite nanoplatelets required for this test, this technology may provide an economic solution for industry to address possible cementing problems in the field,” Dahi Taleghani said.

Song steps down as director of the EMS Energy Institute cont.

faculty members, particularly Harold Schobert and Alan Scaroni, former directors of EI; Yaw Yeboah and Sanjay Srinivasan, former and current heads of the John and Willie Leone Family Department of Energy and Mineral Engineering, respectively; current and former EI office staff, especially Bruce Miller and Kelly Rhoades; leadership in EMS, particularly Deans Bill Easterling and Lee Kump; Associate Deans Alan Scaroni and John Hellmann and the EMS staff, including Sue Lavan, Jennifer Lear, Rosie Long, John Barlett, and Patty Craig; IEE Director Tom Richard; Vice Presidents for Research Neil Sharkey and Hank Foley, and Senior Vice President for Research Eva Pell; Vice Provost Michael Adewumi; College of Engineering Deans David Wormley and Justin Schwartz, and Associate Dean Anthony Atchley; Department of Chemical Engineering chairs Andrew Zydny and Phillip Savage; Institute of Natural Gas Research director Monty Alger; Earth and Environmental Systems Institute director Sue Brantley; Hydrogen

Energy Center director Bruce Logan; and numerous participating faculty members at Penn State.

“Of course, I will always cherish the memories of working with all of my current and former students, research associates, postdoctoral scholars, visiting scholars, and collaborators inside and outside Penn State,” Song reflected. “Penn State is a truly inspiring place with wonderful people. Both our daughter and our son grew up in State College and graduated from Penn State. Penn State and State College will always hold a special place in our hearts. Building on the leadership skills I have developed through advancing energy research and forging partnerships, in addition to teaching and advising at Penn State, I am looking forward to taking on new challenges in advancing science education, research, and service as Dean of the Faculty of Science at CUHK.”



Chunshan Song 2002



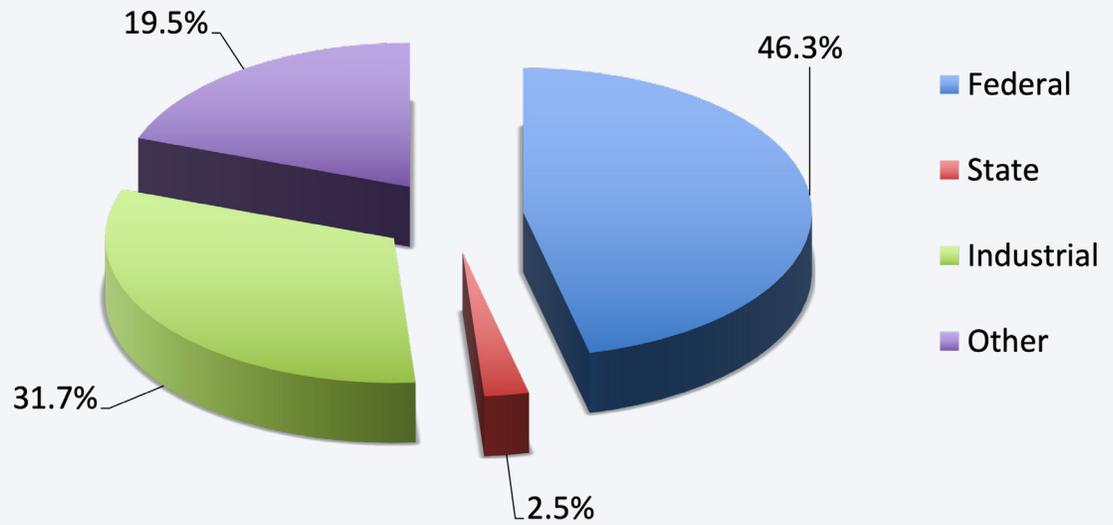
Chunshan Song presenting University Coalition for Fossil Energy Research at NETL's 2017 Crosscutting Research meeting.

IMAGE: Curtiosity of NETL

Summary of projects & FUNDING

EMS Energy Institute Awards by Source

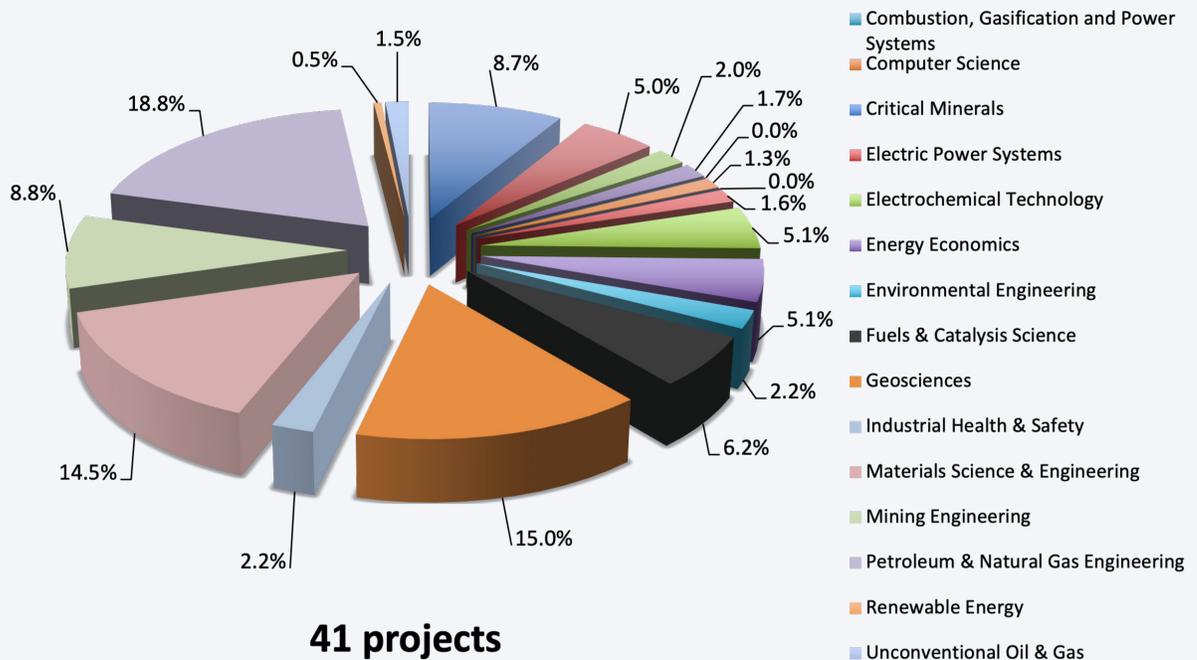
(Fiscal Year 2019/2020)



Total Awards 41

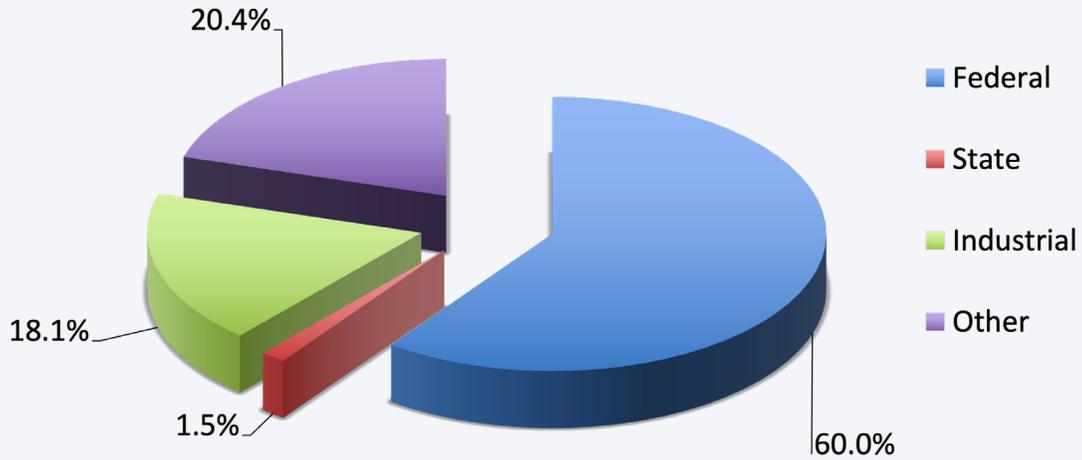
EMS Energy Institute Projects by Program Area

(Fiscal Year 2019/2020)



EMS Energy Institute Funding by Source

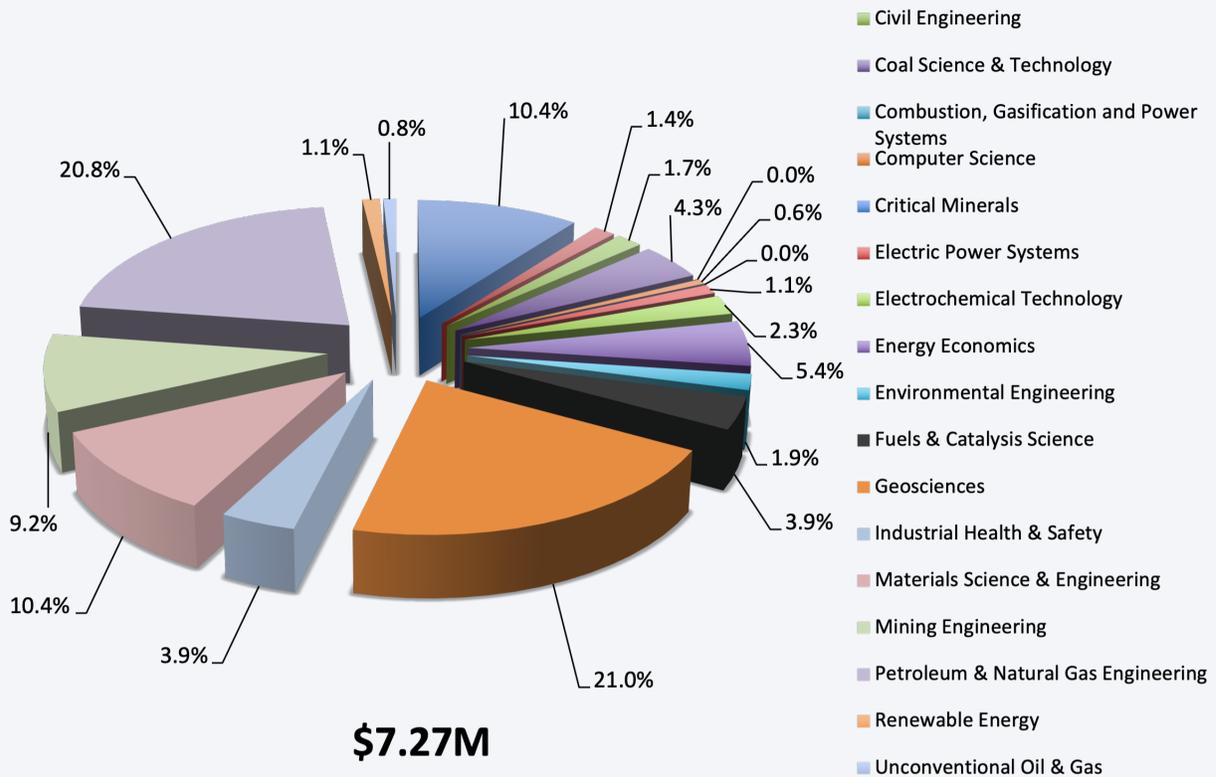
(Fiscal Year 2019/2020)



Total Funding \$7.27 million

EMS Energy Institute Funding by Program Area

(Fiscal Year 2019/2020)



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