Summer 2019

Connection

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PennState
College of Earth
and Mineral Sciences

John and Willie Leone Family
Department of Energy and Mineral Engineering

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Connection

The Connection newsletter is published twice a year, one print, and one online, for alumni, students, faculty, and friends of the John and Willie Leone Family Department of Energy and Mineral Engineering

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Dear Friends,

Another spring graduation—a very graceful ceremony that celebrated the accomplishments of our students—just wrapped up, marking the tireless progression of time. Several EME students were recognized for their accomplishments during the graduation ceremony, including Mr. Muhamad S. Hakimi as the engineering honor marshal, Mr. Dillon Mattis as the EME student marshal, and Ms. Katherine Campayo, as the GEMS Diamond Award winner. They join the more than 400 other graduates from EME, all well trained, all eager to make their mark as they start their careers.

Our students are our pride, whether they are working with ClearWater Conservancy to clean up the local riparian buffer, or organizing the Eastern Regional Mine Rescue competition here on campus, or cleaning up all the awards at the Society of Petroleum Engineers Pittsburgh section poster competition. They will join the ranks of our alumni, who have established themselves as innovators and trendsetters in energy and mineral-related industries and research organizations.

Much of what our students accomplish is due to the strong foundation instilled in them by our group of dedicated faculty members. Our faculty are fully engaged in providing the latest and best experience for our students in over fifty courses maintained in the department's inventory. They interact with students in classrooms, online chat rooms, and discussion boards, and during educational field trips and out-of-classroom immersive educational experiences—virtually every format that has been devised for enhancing the student educational experience. The online degree programs offered by our department faculty—the undergraduate Energy and Sustainability Policy (ESP) program as well as the graduate Renewable Energy and Sustainable Systems (RESS) program—are also thriving. It was indeed a proud occasion to witness our ESP and RESS program graduates walk through the graduation ceremony and receive their diplomas, a recognition of the incredible amount of effort expended by them, despite their busy professional careers, to pursue their dream of higher education.

Our faculty are also world-renowned for their research contributions and have received many honors: Derek Elsworth, Penn State Distinguished Professor; Chunshan Song, George A. Olah Award from the American Chemical Society; Sarma Pisupati, American Chemical Society Fellow; Russell Johns, Society of Petroleum Engineers Distinguished Lecturer; and Mort Webster, John T. Ryan Jr. Faculty Fellow.

Our faculty have also been extremely successful in attracting support for their research efforts, whether it be Chiara Lo Prete studying power networks with funding from the Sloan Foundation; Amin Mehrabian investigating the redistribution of subsurface stress due to oil and gas production through the American Chemical Society Petroleum Research Fund; Pisupati and Mark Klima working to produce high-purity rare earth elements from Pennsylvania coal mining waste with support from the Department of Energy; Zuleima Karpyn studying

scale breaks in sedimentary deposits; or Zhen Lei and Sekhar Bhattacharyya studying the opioid crisis in the Appalachian mining regions with funding from the EMS Postdoctoral Award Program. It is an honor to be the head of a department consisting of such a team of talented researchers and teachers.

Much of what the department is and what it aspires to be is contingent on the efforts of the staff who keep the machinery running and provide the needed adjustments as circumstances evolve. We are indeed fortunate to have a team of dedicated staff who are fully committed to getting things accomplished effectively and efficiently, including events and activities such as: the awards luncheon and the G. Albert Shoemaker Lecture, mainly organized by Rachel Conaway and Michelle Stem; undergraduate recruitment information sessions put together by Judi Hite; and undergraduate advising nights hosted by Alisha Simon and Amy Johnson. Graduate admissions coordination by Sue Hyde is critical for maintaining a healthy department environment and assisting faculty and students with their academic pursuits. Thanks to the efforts of Ashley Nottingham, our department website has a new look. Laboratory managers, Thomas Motel and James Miller, together with our college IT support, Robert Byers and Kevin Tate, were largely instrumental in converting some of our existing Hosler space into a state-of-the-art capstone design facility. Our department's financial engine proceeds smoothly thanks to the effort of Missy Stine. We ask much of them, and what they deliver is always much more than what we ask.

We each, and the department collectively, are living in a world where change is the norm, and changes in perceptions regarding energy production and utilization and the communication of those changes through various outlets is becoming increasingly prolific and vigorous. In this environment, I feel it is healthy to stake out the department's viewpoint regarding these discussions.

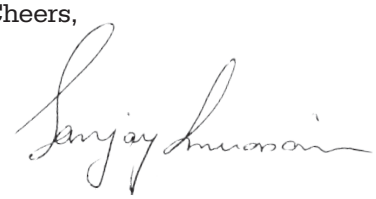
As many of you know, this department has a rich legacy of educational programs and research that has impacted many facets of energy and mineral resource production and utilization. Whether it be fossil energy production or utilization; the design and implementation of renewable energy production, utilization and storage or assessing the risk associated with the production of such energy resources; or providing economic and policy guidelines for energy and mineral production that are rooted in sound technical details, our faculty and students have led the way as thought leaders and innovators. It will be the department's priority to maintain this preeminent stature in all aspects of energy and mineral production and utilization. We will produce the next generation of graduates specializing in fossil and renewable energy production who are well trained to mitigate the environmental impact of such production and utilization; who will help develop technologies for enhancing the efficiency of recovery processes; and who will communicate to the communities around the world the importance of maintaining a balanced outlook on energy production and utilization. On a recent visit to the department, the president of the Society of Petroleum Engineering, Sami Alnuaim, shared his perspectives on how much of the perception-related issues surrounding the energy production industry stems from the inability of industry professionals to communicate clearly the technological advancements and the efforts being undertaken to emphasize sustainability in all aspects of energy production and utilization. It will be a priority of the department to address and rectify this shortcoming.

A pragmatic definition of sustainability remains elusive; however, in the context of this department, efficient production of energy while minimizing environmental impact in a manner to preserve the quality of human life in all parts of the globe would be a very worthy ideal. Correspondingly, it will also be a priority of the department to embed sustainability as a core aspect of all our curriculum.

I would like to conclude by saying that the continuous advancement of the department and the programs affiliated with the department to produce engineers and scientists who remain relevant regardless of the emerging energy landscape is an essential truth that we collectively will have to contend with. Evolving our curriculum while retaining the rich traditions of our programs, maintaining the structure prescribed by our accreditation process, and yet exposing our students to the latest in fields such as data analytics, risk analysis, decision-making and health and safety will take quite a lot of thinking on all our parts. I look forward to engaging with you on such important discussions and to filling you in on several other exciting developments during your next visit to the department and the campus.

Until then, enjoy the long, lazy, hazy days of summer with family and friends,

Cheers,



Did you know EME has a new website? Visit us at: eme.psu.edu

MINE RESCUE TEAM CONTEST

Program support funding makes mine rescue team a reality

The department is extremely fortunate to receive generous contributions to the many endowment and annual gift funds used to support its programs and activities. The Mount Nittany Mine Rescue Team is one example of how departmental support leads to opportunities for students.

Penn State's student mine rescue team trains students to respond to underground mining emergencies such as explosions, roof falls, and flooding. The team competes against other collegiate mine rescue teams across the United States to see who can rescue disaster victims most efficiently. The skills that the students learn are important in their field, and the connections that they make by engaging in the competitions can help them forge their careers.

While the importance and relevance of having a student mine rescue team is well acknowledged, the funding of the equipment and travel would still be a tremendous hurdle for the program and the department if it weren't for the generosity of our alumni and friends. Within the department, the "Carl A. Peterson Program Fund in Mining Engineering" and the "Mine Rescue Program Support Fund" together provide funding for uniforms and travel expenses each year. Those funds, along with direct support from the Society of Mining, Metallurgy and Exploration (SME), made it possible for Penn State to host the SME Eastern Collegiate Mine Rescue Contest for the first time on March 30.

To learn more about the importance of mine rescue contests for students, view the "Mining engineering students learn valuable skills through mine rescue contest" article on the next page.

Mining engineering students learn valuable skills through mine rescue contest

On March 30, Penn State hosted the SME (Society for Mining, Metallurgy and Exploration) Eastern Collegiate Mine Rescue Contest. Teams from Virginia Polytechnic Institute and State University, West Virginia University, the University of Kentucky, and Penn State competed throughout the morning in mock mine hazard scenarios.

The first competition kicked off with Penn State's Mount Nittany Mine Rescue Team gathering together to figure out their mine scenario. Tail captain Vanilo Antonio relayed to map man Mark Lawrence who told the team what the conditions were in the simulated mine scenario. Various mock situations were set up along the path of the mine, including a caved in roof and chemical hazards. The team had to work together to get past each scenario safely, including checking for oxygen levels, and ensuring all their equipment was in tow.

Kiazoa Joao, mining engineering student, waits for help

Students Joelson Alves and Edgar Liberato communicate to their team members from the fresh air base

"As the captain, I had the obligation to lead my team through a systematic exploration of the simulated mine. Knowing that my team relied on me to properly and successfully complete the course made me rethink more than once how I gave my orders. The challenges of being captain mostly come from being able to make quick decisions on what to do next and properly communicate to the rest of the team, as well as getting your team to trust you," said Kevin Toe, a senior mining engineering student.

In addition to the mock hazards throughout the mine scenario, the team was also tasked with locating a missing person. They needed to find out how to get to the person safely and rescue them from the mine.

"It was my first time with this experience, and it felt like a we were in a real-life situation. The team had to figure out whether there were people alive in the mine. Once they found out there was a live person trapped in the mine, they had to find a way to ventilate the mine and take me out of there alive," said Kiazoa Joao, a senior mining engineering student.

Although Penn State's team did not place, they still had a great opportunity to learn and test many new skills. Sekhar Bhattacharyya, associate professor of mining engineering and adviser for the Mount Nittany Mine Rescue Team, hopes the students learned skills related to leadership, attention to

The Mount Nittany Mine Rescue Team works it way through the mock mine hazards at the SME Eastern Collegiate Mine Rescue Contest

detail, time management, effective communication, and appreciation for the value of life. He also hopes they experience pride for being part of the great culture of mining engineering.

"Penn State is home to a high-quality mining engineering program, which was established in 1890. Currently, we are ranked fifth in the world in the 2018 QS World University Rankings. While research and academics are two very strong components of the program, deep-rooted industrial collaboration and training have always been of prime importance. I felt fortunate to be instrumental in hosting the SME Eastern Collegiate Mine Rescue Contest. My thanks go to all who supported organizing this event, especially the staff and Sanjay Srinivasan, department head, and Lee Kump, John Leone Dean in the College of Earth and Mineral Sciences," said Bhattacharyya.

Edward Zeglen Jr., the Mount Nittany Mine Rescue Team coach, originally started the team at Penn State and has been instrumental in training and preparing the students for mine rescues.

"I felt that the entire Mining Engineering program at Penn State did an outstanding job of putting on the contest. The trainers, mentors, and I were all very pleased with the event and spectators. We look forward to the future of the collegiate mine rescue contest and hope to host the event again at Penn State two years from now," said Zeglen.

Shimin Liu, associate professor of energy and mineral engineering, watches the competition with his son

Sarma Pisupati elected a 2018 American Chemical Society Fellow

Sarma Pisupati, professor of energy and mineral engineering, with Allison A. Campbell, immediate past president of the American Chemical Society (ACS), was inducted as an ACS Fellow at the society's 2018 national fall meeting. *Image: ACS/Peter Cutts Photography*

Sarma Pisupati, professor of energy and mineral engineering, was elected a 2018 Fellow by the American Chemical Society (ACS). Pisupati was one of fifty-one scientists selected as part of the 2018 class of ACS Fellows. He was honored during the society's fall national meeting held August 2018 in Boston.

The ACS Fellows Program recognizes and honors members of the American Chemical Society for their outstanding achievements in and contributions to the science and the profession and for their equally exemplary service to the ACS Society. Only 1,059 of the society's more than 157,000 members from academia, industry, government labs, and small business have been distinguished with this honor.

"This is a great honor to be appreciated by professional colleagues and elected a Fellow for my work in helping to solve industrial problems through fundamental research and training the future workforce. I am very grateful for this recognition," Pisupati said.

The ACS recognized Pisupati for "contributions impacting the availability and operation of gasifiers and fluidized bed combustors through excellence in fundamental and applied clean energy research, and outstanding energy engineering education."

His contributions to the ACS community were also cited. He served in several leadership roles in the ACS Division of Fuel Chemistry and Division of Petroleum Chemistry, initiated a trust fund for student travel, revitalized technical programming, and established an outreach web portal.

Pisupati co-directs the EMS Energy Institute's Coal Science and Technology Program. He earned his bachelor's and master's degrees in chemical engineering from Osmania University and the Indian Institute of Technology, respectively, and a doctorate in fuel science from Penn State.

Founded in 1876 and chartered by Congress, ACS identifies itself as the world's largest scientific society with more than 150,000 members. Its vision is to improve people's lives through the transforming power of chemistry.

Song receives George A. Olah Award in Hydrocarbon or Petroleum Chemistry

Chunshan Song, distinguished professor of fuel science and director of the College of Earth and Mineral Sciences' (EMS) Energy Institute, received the George A. Olah Award in Hydrocarbon or Petroleum Chemistry from the American Chemical Society.

This national award is presented to recognize, encourage, and stimulate outstanding research achievements in hydrocarbon or petroleum chemistry. Song received the award for "groundbreaking contributions to adsorptive desulfurization of hydrocarbon fuels, adsorptive carbon dioxide separation, and catalytic carbon dioxide conversion to fuels and chemicals."

"Song is an exceptional researcher, innovator, teacher, mentor, and leader in hydrocarbon and petroleum chemistry. Specifically, Song has addressed several difficult and complex problems in hydrocarbon and petroleum chemistry. These include outstanding contributions to adsorptive and catalytic desulfurization of hydrocarbon fuels, adsorptive carbon dioxide

separation, catalytic carbon dioxide conversion to fuels and chemicals, catalysis in fuel processing for fuel cells, thermal stability of jet fuels, and novel catalytic routes for petrochemicals, and advanced-engineering plastics," said Anne M. Gaffney, Idaho National Laboratory.

Song is the founding co-director for the international Joint Center for Energy Research (JCER), a partnership between Penn State and Dalian University of Technology formed in 2011. He also serves as the founding director of the University Coalition for Fossil Energy Research, a six-year, twenty million dollar project funded in 2016 by the Department of Energy's National Energy Technology Laboratory.

Bonnie A. Charpentier, ACS President (left) and John Adams, Chair of the Board of Directors, American Chemical Society (right), present the 2019 George A Olah Award to Chunshan Song during the ACS National Award Ceremony in Orlando, FL, on April 2.
Image: ACS

Song, also a professor of chemical engineering and associate director of Penn State's Institutes of Energy and the Environment, is a world leader in clean fuels and catalysis.

Song specializes in catalytic conversion and utilization of energy resources, such as coal, petroleum, natural gas, biomass, and carbon dioxide as a carbon source. His current research interests include catalysis in fuel processing for ultra-clean fuels and fuel cells; adsorptive carbon dioxide capture and separation, catalytic carbon dioxide conversion and utilization; reforming of hydrocarbon and alcohol fuels for syngas and hydrogen production; shape-selective catalysis for synthesis of organic chemicals; catalysis and reaction chemistry for energy conversion; and synthesis and applications of nano-porous catalytic and adsorbent materials.

For making clean liquid fuels, Song and his research team have developed sulfur-selective adsorbents for removing sulfur from liquid fuels at ambient temperature and pressure, which enabled liquid fuel utilization in fuel cells and changed the way of thinking in the field. Many prototype fuel processing systems have been fabricated by their industrial partners and applied for liquid fuel-based polymer electrolyte and solid oxide fuel cells. Song and his team have developed novel solid molecular basket sorbents (MBS) with high capacity for selective carbon dioxide capture and separation from gas mixtures such as flue gas from coal-fired power plants. The MBS has been successfully scaled up for carbon dioxide separation from laboratory experiments to a pilot plant for demonstration in collaboration with their industrial partner with support from the U.S. Department of Energy.

Song and his Penn State team, along with collaborators at JCER, have developed a series of novel catalysts for selective carbon dioxide conversion to chemicals and fuels. They have not only developed new bimetallic catalysts with high selectivity for carbon dioxide conversion to lower olefins, liquid hydrocarbons, and methanol, but also delineated the elemental reaction pathways on the surfaces of the new bimetallic catalysts.

Song has authored or co-authored 360 refereed journal papers, and thirty book chapters, edited eleven books, and eleven special issues of research journals, delivered sixty plenary or keynote lectures at national and international conferences, and given more than 290 invited lectures worldwide. He is also an inventor for eight patents.

Song is a Fellow of the American Chemical Society and has received many awards including Penn State's Faculty Scholar Medal. To view additional information about Song and his many awards visit: https://www.eme.psu.edu/directory/chunshan-song.

The George A. Olah Award in Hydrocarbon or Petroleum Chemistry was established in 1948 as the American Chemical Society Award in Petroleum Chemistry. It was renamed in 1997 after the Nobel laureate George A. Olah. Since 1997, the award under the current title has been supported through a fund initially created by donations from the Morris S. Smith Foundation and the Dow Chemical Company.

New research clusters

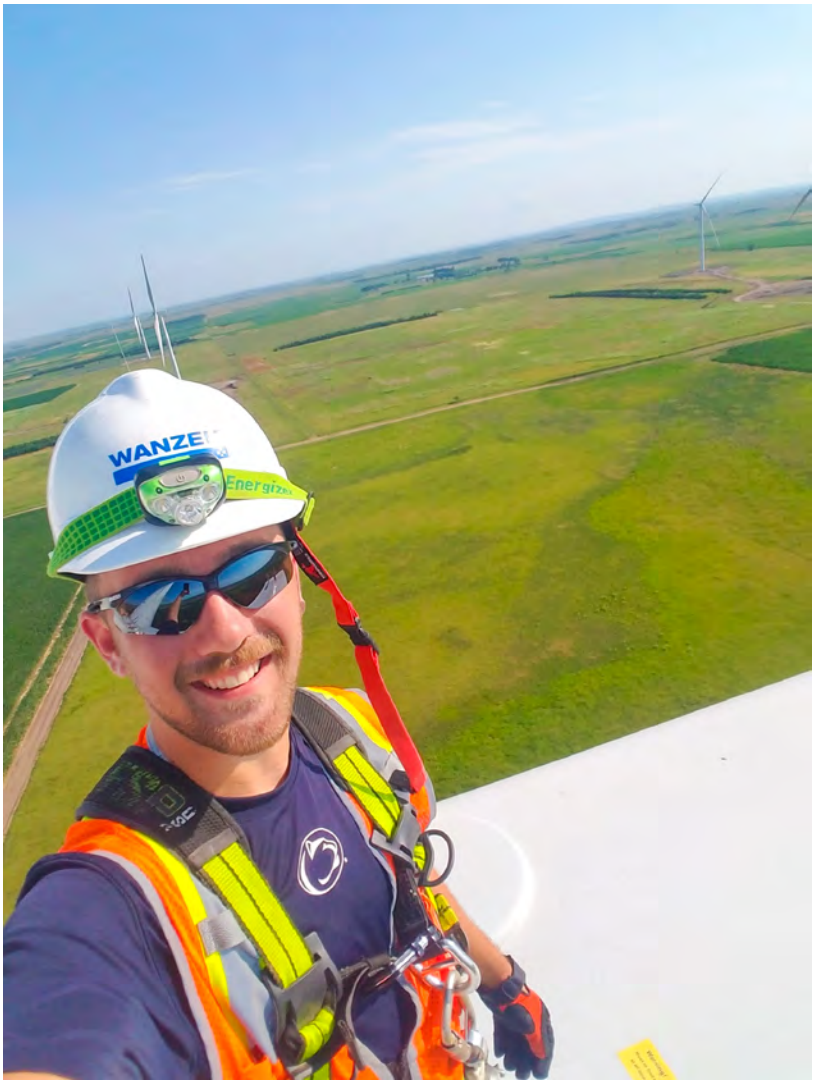
The John and Willie Leone Family Department of Energy and Mineral Engineering (EME) assembles experts from a wide variety of disciplines and all areas of energy in a single department. These interactions facilitate cutting-edge approaches to some of the greatest challenges in energy and resource management in the twenty-first century. Collectively, the department's research programs are focused on harnessing research to have an impact on industrial practice, public policy, and a more efficient and sustainable future.

Our research falls under four different research clusters within EME:

1. **Renewable energy technologies and power systems**
2. **Fossil fuel and georesource exploration, extraction, and utilizations**
3. **Advanced technology, and materials for energy and environmental applications**
4. **Energy and natural resource data, economics, and policy.**

Each of these research clusters brings a unique importance and prospective to energy within the department. To learn more, view the connecting stories on the following pages.

Research Cluster: Renewable Energy Technologies and Power Systems



Energy Business and Finance graduate Mathew Kaneski '19 working on a wind turbine.

This cluster includes science and engineering research into renewable energy technologies, including solar photovoltaics (PV), wind energy, biomass, energy storage, and hydrogen as well as engineering and economics research applied to the electric power system. Much of the research on these topics is interdisciplinary and integrates economics, operations research, and engineering to address the challenges in planning and operating the powers system of the next century. Many technologies and resources will need to be coordinated in order to efficiently and sustainably deliver energy.

Some of the research projects led by EME faculty include: the development of a low-cost technology for measuring the solar irradiance of potential PV sites, engineering of electrochemical systems for hydrogen generation, electricity market design, resiliency in natural gas and electricity networks, the value of flexibility in power systems, long-term transmission investment planning under uncertainty, an exploration of possible paths of evolution for the combined power and natural gas systems in the Mid-Atlantic of the United States, and a U.S. Department of Energy-funded project on modernizing the power grid.

Sloan Foundation grant looks at energy market structure for wind integration

Image: Pixabay

Chiara Lo Prete, assistant professor of energy economics, was awarded a $250,000 grant for early career researchers from the Alfred P. Sloan Foundation to examine the effectiveness of energy market structures in aggregating private information on wind production forecasts to better coordinate commitment and production decisions in electric systems.

Restructured wholesale electricity markets in the United States have a two-settlement design with coordinated day-ahead and real-time auctions. The day-ahead market provides commitment and dispatch instructions to power generation units with lengthy startup and slow response times, while the real-time market is mainly intended to correct for energy imbalances due, for example, to relatively small errors in forecasting electricity demand.

Increasing shares of intermittent renewables, like wind, into the energy mix, pose a challenge to this two-settlement structure because the real-time availability of renewable energy sources cannot be accurately predicted day ahead. The later the grid operators become aware of the need to modify day-ahead market schedules, the higher the costs associated with large forecast errors will be, due to greater inflexibility in power system operations closer to real time. In US electricity markets, changes in schedule and commitment between the day-ahead and real-time market are centrally made by the grid operator based on its forecasts.

Lo Prete's project investigates whether efficiency in power system operations may be improved by adding intraday markets that incent consumers and producers to individually adjust their day-ahead schedules as soon as updated forecasts of system conditions become available.

"Several European countries already run intraday markets that clear between the day-ahead and real-time markets. However, it would be dangerous to assume that lessons from Europe will necessarily translate to the United States given the important structural differences between the two electricity market designs," said Lo Prete. "Our results will provide insights into the most efficient path forward to better integrate and manage wind production uncertainty in wholesale electricity markets. While several approaches have been proposed to this end, our focus is on a potential market modification that may result in economic efficiency gains at much lower computational burden than other proposed solutions. Ongoing collaboration with PJM and ISO New England will enable dissemination of research findings to help inform stakeholder discussions about improvements in the design of energy markets in the United States."

Other Penn State faculty working on the project are Uday V. Shanbhag, the Gary and Sheila Bello Chair and professor in the Harold and Inge Marcus Department of Industrial

and Manufacturing Engineering, and Anthony Kwasnica, professor of risk management in the Smeal College of Business.

The team is integrating techniques from stochastic optimization and experimental economics. First, the researchers are developing unit commitment and dispatch models to simulate hourly operations decisions in an electric network under the two market designs. Simulation results will provide a benchmark for efficient market outcomes that would be observed if commitment and dispatch decisions were centrally made based on information available to individual market participants.

Second, the research team will design laboratory experiments to measure and compare performance characteristics of the two market designs. Predictions from the optimization models will be compared to outcomes from the experimental electricity markets to provide insights into real world market design. The experiments will be conducted in the Laboratory for Economic Management and Auction (LEMA), directed by Kwasnica.

"The laboratory is an ideal environment to evaluate market institutions under conditions that we can control, providing an opportunity to gather evidence on the relative strengths and weaknesses of a market institution and develop modifications at a relatively low cost before implementation in the field," said Lo Prete.

Founded in 1934 by industrialist Alfred P. Sloan Jr., the foundation is a not-for-profit grant-making institution that supports high quality, impartial scientific research; fosters a robust, diverse scientific workforce; strengthens public understanding and engagement with science; and promotes the health of the institutions of scientific endeavor.

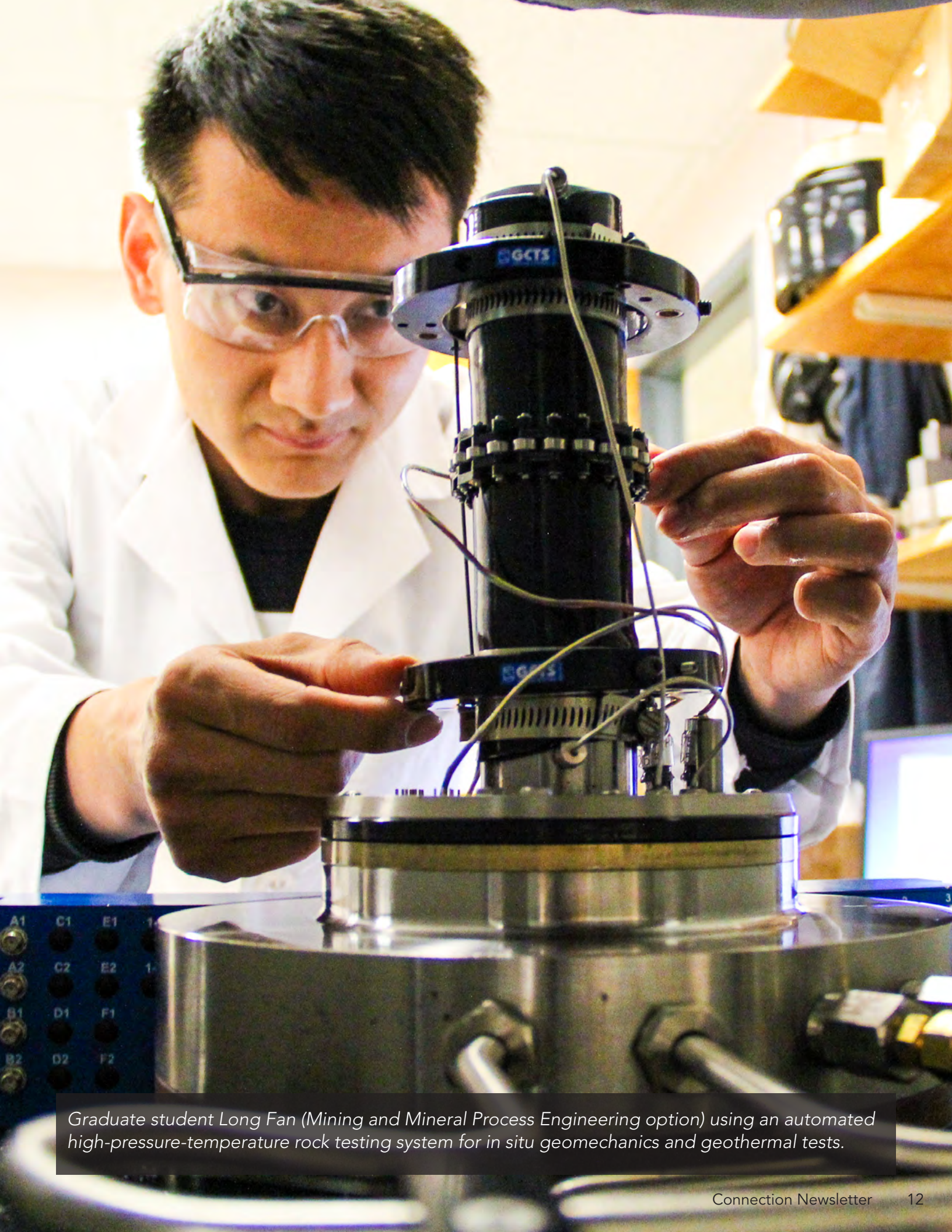
Research Cluster: Advanced Technology and Materials for Energy and Environmental Applications

In our fast-paced growing society and changing environment, there are two ways of responding to energy- and environmental-related challenges, reactively or proactively. The faculty and research of EME strive to design the future and are committed to pushing the existing boundaries of knowledge towards sustainable engineering and science practices through the advancement of technologies and materials.

This cluster aims to educate future decision makers in the industry and shift paradigms in engineering in the twenty-first century. It emphasizes the development of technologies that will shape the contemporary energy applications, environmental stewardship, and materials, which will improve their performance for a sustainable future. Some examples of research in this pursuit include:

- **Advanced power generation methods, including oxy-fuel combustion and coal and biomass co-gasification**
  Interests focus on designing entrained flow gasification processes at high temperatures and pressures under corrosive environments. Some of the research includes identifying an optimum condition of solid loading, particle-size distribution, as well as the type of additive and dosage of additive for a given carbonaceous solid-water slurry.
- **Extraction and separation of critical materials from conventional and unconventional sources**
  Research focuses on the development of reliable methods to characterize deposits of critical materials, advanced technologies for separation including bio-geochemical methods and solid-state separation technologies.
- **Reinforced polymer composite for hydrogen storage**
  Approach focuses on synthesizing carbon nanotubes directly on the metal foil to form a distributed interface when incorporated into the polymer matrix, bridging the dissimilar materials. This will result in strong interfacial bonding that is fundamental to composite reinforcement and consequently safe and efficient hydrogen storage.
- **Understanding carbon formation and deposition mechanisms to control structure, properties, and kinetics of desirable and undesirable coke formation and the production of carbon materials**
  Specific interests are in carbon materials from petroleum, coal, and carbon composite materials; graphitic carbon through carbonaceous mesophase formation; and preparation of activated carbons from biomass.

In tandem with these activities, materials research is essential to revitalize the energy sector and increase the efficacy of many environmental systems. EME researchers combine materials research with the above technologies to advance multivariable processes, such as unconventional oil and gas extraction, mining operations, or treatment of wastes produced from these activities. Examples of materials research spans from synthesizing thin films for photovoltaic devices to developing materials for hydrogen storage to innovating adsorbents for selective recovery of critical materials.



Graduate student Long Fan (Mining and Mineral Process Engineering option) using an automated high-pressure-temperature rock testing system for in situ geomechanics and geothermal tests.

Graduate student Lu Lee assists students from ENVSE 412 who are performing a field study at Penn State's Living Filter

Developing an engineering design simulator for risk-related decision making

Jeremy Gernand was recently awarded a Gladys Snyder Education Grant from the College of Earth and Mineral Sciences to develop a computer-based simulator to give undergraduate engineering students experience with the risk-related implications of system design decisions.

In the National Society of Professional Engineer's Code of Ethics, it says "Engineers shall hold paramount the safety, health, and welfare of the public." Consequences of failed engineered systems could be safety or health impacts on users or workers in addition to harm to the environment and the people who live in those areas.

"This proposal hypothesizes that engineers, like aircraft pilots or nuclear power plant operators, need the experience of a lifelike simulator to develop their intuition about risk and the efficacy of their decisions to mitigate risk. No such simulator currently exists to help train engineering students to calibrate their expectations and gain an intuitive grasp on the meaning of risk in engineered systems. In a professional setting, an engineer's estimate of risk is believed to be based on experiential learning following the end of formal education. This is problematic as it requires harm or near misses to occur to provide this feedback," said Gernand, assistant professor of environmental health and safety engineering.

Gernand said that this research seeks to develop a simulator that will be used as an educational tool to both measure and reduce engineering students' biases when estimating risk and help them to develop their decision-making skills to help mitigate risks.

This virtual experience will help students experience the consequences of their own decision making. These practice scenarios or games will also help students to enhance their empathic comprehension on the technological risks that may affect workers, users, the public, and the environment.

Currently an undergraduate research assistant is working to develop code for the simulator and will be recruiting test subjects.

"My role is to collect data through a game that simulates a real-life decision-making process and analyze this data based on my hypothesis about the factors that affect risk-related decision making," said Uzoezi Emmanuella Isaac-Onwah, who is majoring in petroleum and natural gas engineering.

The development and implementation of this simulator has the potential to transform the way the Engineering Risk Analysis course is taught. Not only will it cover the theory and application of risk analysis techniques, but also give students the experience with the practice of these techniques in actual engineering decision making.

> "I hope that by the end of this project, my research can be implemented and provide useful information for engineering students."
>
> ~Uzoezi Emmanuella Isaac-Onwah

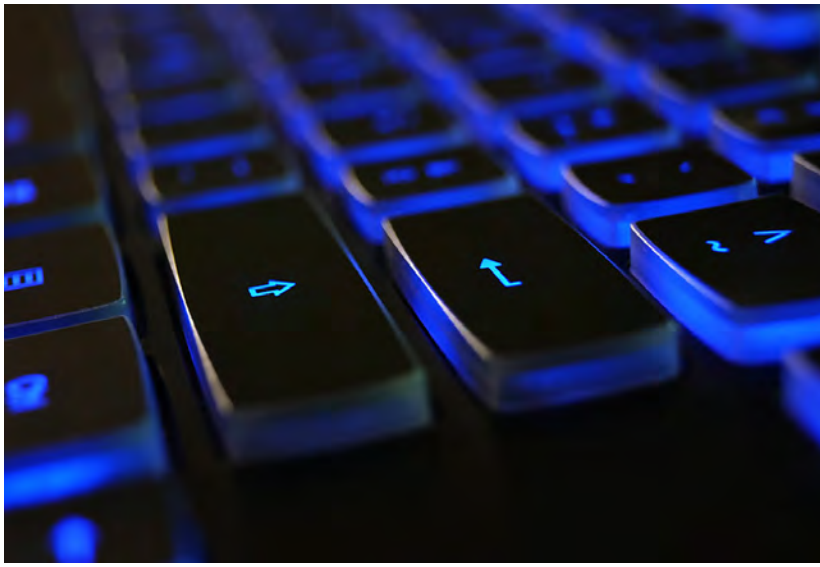


Image: Pexels

Research Cluster - Energy and Natural Resource Data, Economics, and Policy

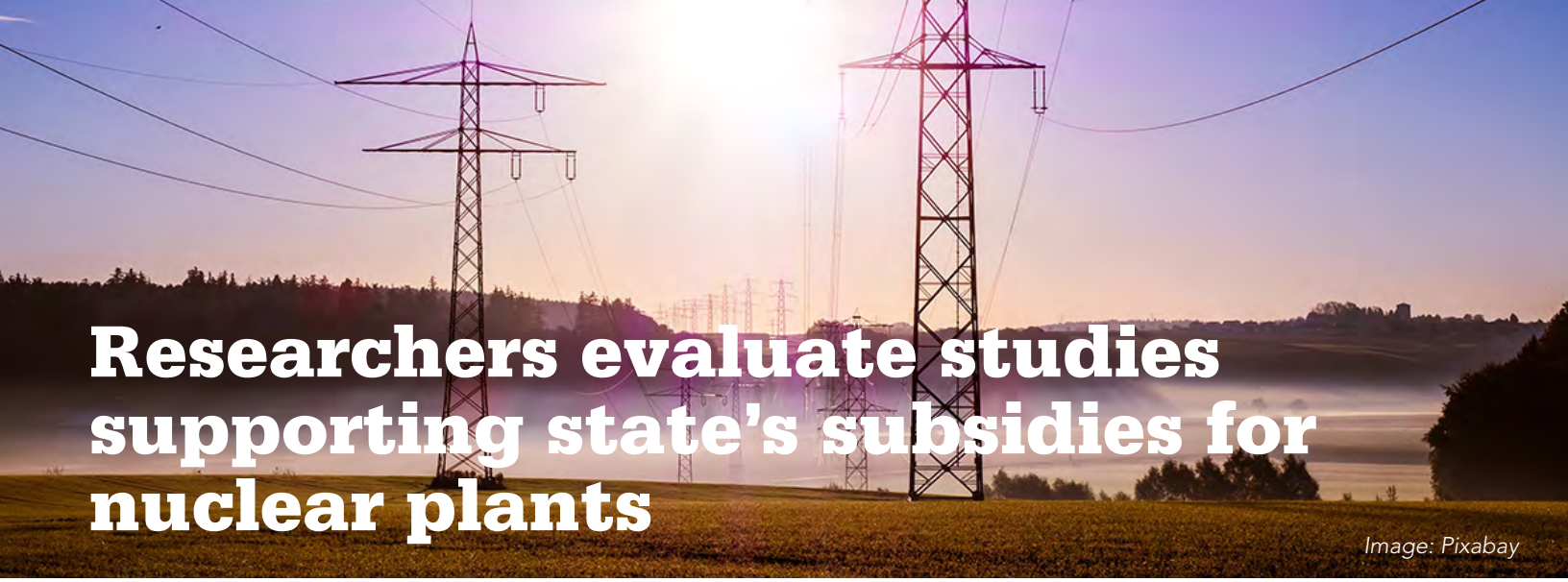
Researchers in EME are harnessing the availability of large amounts of data on energy and environmental systems to perform some of the world's cutting-edge research on energy resources.

Our faculty use techniques from machine learning, artificial intelligence, optimization, and statistics to study natural gas production, large-scale infrastructure systems, energy consumption behaviors, and energy markets in ways that are relevant to public decision makers and industry. In research, data analytics allow for powerful hypothesis testing and model validation on highly complex systems. Insights into processes and phenomena can be interrogated over large regions, as opposed to a handful of specific sites. The research skills of our faculty also translate into the classroom, where students get experience using real-world "big data" in simulation-oriented classroom environments.

Specific research topics in this area include:

- **Development of web applications for data science applications in the unconventional natural gas sector**
- **Data-driven modeling approaches to analyze the benefits and costs of environmental regulations**
- **Smart electric grids and the transition to more efficient and lower impact energy, electric power, and transportation systems**
- **Resilience analysis for complex interdependent energy infrastructures**
- **Data analytics and statistics for seismic fracture identification and restimulation decisions**
- **Combining decline curve analysis and geostatistics to forecast gas production in unconventional formations**
- **Geospatial analysis of large-scale renewable energy portfolios**
- **Design and operation of electricity markets**
- **Mobility data for energy system planning and to evaluate air quality impacts of urban transportation**
- **Air quality in energy production environments**
- **Economics of industrial carbon capture and geologic sequestration**

Joel Landry, assistant professor of environmental and energy economics, presents "Making Sense of Uncoordinated Efforts to Address Climate Change" at the EME Research Showcase in 2018



Researchers evaluate studies supporting state's subsidies for nuclear plants

Image: Pixabay

An intensive public debate is occurring in states with competitive electricity markets about the future of their existing nuclear generation plants. A team of Penn State researchers examined the set of studies that has been used in legislative discussions to provide evidence in support of subsidy programs.

With the fall of natural gas prices since 2014, electricity prices have correspondingly decreased and some nuclear plant operators in the Northeast and Mid-Atlantic are no longer profitable, with some announcing retirements ahead of their originally scheduled decommissioning. Several states, including Illinois, New Jersey, and New York, have created programs to subsidize their nuclear plants, and other states, including Pennsylvania, have considered similar programs.

"Recently, several states have enacted programs to provide subsidy payments to nuclear electricity plants that are financially distressed due to low electricity prices," said Mort Webster, professor of energy engineering.

"Other states, including Pennsylvania, are considering similar subsidy programs. Some of these legislative decisions have considered as evidence a set of studies that appears to argue or imply that subsidizing nuclear plants will result in lower carbon dioxide emissions, lower costs to consumers, and a more reliable and resilient power grid."

To inform the public debate in the Northeastern and Mid-Atlantic states about subsidies for financially distressed nuclear plants, the team of researchers analyzed previously released reports and offered a critical assessment from the perspective of economic theory and engineering fundamentals.

In their report, "Analysis of State Policy Interactions with Electricity Markets in the Context of Uneconomic Existing Resources: A Critical Assessment of the Literature," the researchers drew on economic theory to question the assumptions and findings in other studies.

Their findings caution lawmakers that the benefits of a subsidy could be much less and the costs could be much higher than the other analyses suggested.

"We found that the existing literature on this topic is flawed and should not be the basis for important public policy decisions," Webster said. "Subsidies are often a less efficient way to reduce emissions, and they shift the risk of poor investment choices made by utilities to consumers."

The findings from the study have already started to inform policy decisions. The report has been cited in testimony before the Pennsylvania Nuclear Caucus and in a filing by PJM Interconnection before the Federal Energy Regulatory Commission related to the wholesale power markets run by PJM.

"I do hope that it gets policymakers to ask more questions and demand better information and analysis before they make decisions that impact electricity costs for all of us, for years to come," said Seth Blumsack, professor of energy policy and economics and international affairs.

"As someone who is deeply concerned about reducing the impact of electric power supplies on our air, water, and climate, I naturally want to see more investments made that will reduce those impacts without affecting the reliability of the power grid. But there are more and less expensive ways to achieve this goal. Policymakers should not accept solutions just because they are easy to implement without being confident that those solutions are also as low-cost as possible. Even if the most economically efficient solution isn't politically feasible, I think policymakers should be given some sense of which solutions are going to be more or less costly," said Blumsack.

Other collaborators include Chiara Lo Prete, assistant professor of energy economics, and Uday Shanbhag, the Gary and Sheila Bello Chair and Professor of Industrial Engineering.

Funding for the report came from PJM Interconnection LLC, which is the regional transmission organization responsible for the power transmission grid in all or parts of thirteen states and Washington, DC. Pennsylvania lies nearly entirely within PJM's operational footprint.

Research Cluster - Fossil fuel and georesource exploration, extraction, and utilization

The responsible development of georesources is a key thrust area for research in the department. Research in this area spans from characterization of petrophysical and dynamic transport properties of tight sands, shales, and deep saline aquifers for carbon sequestration, to understanding the physics of earthquakes, including induced seismicity, and energy geomechanics including unconventional hydrocarbon reservoirs and geothermal energy, to understanding interfacial interactions of highly concentrated carbonaceous solid-water slurries that may be encountered during processes such as gasification.

Research topics and facilities in this cluster area include:

- **Experimental and numerical investigation of drill bit/rock interaction**
- **Integrated hydraulic fracturing design in the presence of natural fractures**
- **Novel expandable LCM materials and wellbore strengthening**
- **Assessment of well integrity after hydraulic fracturing, underground blowout, etc.**
- **Development of advanced phase behavior EOS based on curvature analysis of fluid interfaces**
- **Advanced models for phase behavior, fluid displacement, and component transport for design of enhanced oil recovery processes**
- **Center for Quantitative Imaging - world-class academic CT imaging facility that provides access to large-scale x-ray CT instrumentation for non-destructive, 3-D sample characterization**
- **Reactive shale mechanics and problems associated with lost circulation**
- **Seismic inversion and application for monitoring CO2 plume during sequestration**
- **Optimization and feedback control of hydrocarbon recovery processes**
- **Center for Geomechanics, Geofluids and Geohazards (G3 Center)—an interdisciplinary center focused on rock and fluid physics**
- **Mine ventilation and health risk due to dust particulates and other forms of atmospheric pollution**

Researcher to study Earth's subsurface stress during oil and gas production

Penn State researcher Amin Mehrabian was recently awarded a $110,000 grant from the American Chemical Society's Petroleum Research Fund to study subsurface stress in hydrocarbon reservoirs.

"Oil or gas extraction from the Earth's crust alters the mechanical equilibrium of the subsurface rock. Poromechanics theory enables us to identify the evolving states of rock stress when producing fluids from it," said Mehrabian, assistant professor of petroleum and natural gas engineering.

This large-scale operation can be compared to water in a sponge.

"When a wet sponge is squeezed, fluid will drain out. Conversely, the sponge will tend to shrink in size if you withdraw enough water from it. My research seeks to find out how rock deforms when producing hydrocarbon from the underground energy resources. Nearly all phases of an oil or gas field development project will require accurate knowledge of the subsurface stress. It is, therefore, necessary to improve our understanding of the intimate entanglement between the rock solid and its pore fluid behaviors," said Mehrabian.

This fundamental research, said Mehrabian, could potentially help us better plan the wells, drill less costly wells, produce more efficiently from the wells, and maintain the overall well integrity during the production life of the wells.

"This grant will certainly help me advance my research at Penn State. The research outcomes may be used to solve applied problems of interest in various phases of a hydrocarbon field development project from drilling and completions to production and workover operations," said Mehrabian.

Research funded by this grant will begin in September.

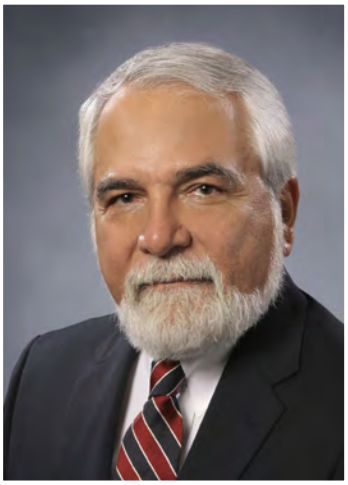
Distinguished Achievement Awards

The department hosted its annual awards banquet on Monday, April 15, to recognize some of our most outstanding alumni and friends.

Jack Trackemas
Branch Chief, Ground Control Branch
Pittsburgh Mining Research Division, NIOSH

Robert Stefanko Distinguished Achievement Award in Mineral Engineering

Jack Trackemas is currently branch chief of the Ground Control Branch at the Pittsburgh Mining Research Division at the National Institute for Occupational Safety and Health (NIOSH). He began his career in the mining industry in 1981, working for Emerald Mines Corporation as an engineer trainee. Over the next thirty years his career continued with the mines that ultimately became part of Alpha Natural Resources. During this time, he served in many roles, from coal miner to general mine manager to corporate director of engineering. Trackemas has designed both surface and underground mines, and managed some of the largest mines in the United States. He quickly became known for his steady leadership in the industry and especially for the engineering innovation that he brought to bear on production, safety, and environmental problems. He led the design and installation of the widest longwall face in the world, overcoming several engineering barriers, and introduced the practice of cable bolting for supplemental support in underground coal mines. Trackemas has been working since 2012 at NIOSH, where he provides leadership and technical expertise in several important research areas including ground control, ventilation, and emergency response.



Turgay Ertekin
Professor Emeritus, Petroleum and Natural Gas Engineering, Penn State

C. Drew Stahl Distinguished Achievement Award in Petroleum and Natural Gas Engineering

For more than four decades, Turgay Ertekin devoted his career to education and the future of petroleum and natural gas engineering. He is now professor emeritus of petroleum and natural gas engineering at Penn State. Until his retirement in 2017, he served as the George E. Trimble Chair and head of the John and Willie Leone Family Department of Energy and Mineral Engineering. He served as the chair of the Petroleum and Natural Gas Engineering program for thirty years. Ertekin has had extensive experience with the development and application of fluid flow models in porous media. He has been involved in the mathematical modeling of flow problems using hard and soft computing techniques for fifty years. His current research deals with the flow of gases in tight formations, coal seam degasification processes, well test analyses for composite reservoirs, enhanced oil recovery techniques, and artificial neural network applications in petroleum and natural gas engineering. Ertekin has developed several multiphase, compositional, multidimensional isothermal and non-isothermal numerical flow models that simulate the performance and applicability of some thermal and non-thermal recovery techniques in the petroleum reservoirs. The multi-mechanistic flow formulations in tight formations that he conceptualized and developed with his students is widely accepted and implemented in most of the contemporary reservoir simulators.

Distinguished Achievement Award in Fuel Science & Energy Engineering

Angelos Kokkinos is the associate deputy assistant secretary for Clean Coal and Carbon Management in the U.S. Department of Energy's Office of Fossil Energy. Kokkinos is responsible for managing and planning of coal research, and development. He has more than forty years of experience in fossil fuels, energy generation, and air pollution control equipment design and operation. Prior to joining the U.S. Department of Energy, he was chief technology officer for Babcock Power, Inc., a major supplier of steam generation and environmental control equipment for utility and industrial applications. He is the holder of six U.S patents and received a B.S. in chemical engineering from the University of Massachusetts Lowell and M.S. in fuel science from Penn State.

Angelos Kokkinos
Associate Deputy Assistant Secretary for Clean Coal and Carbon Management
U.S. Department of Energy's Office of Fossil Energy

Aaron Pontzer
Mining Permit Compliance Specialist
Pennsylvania Department of Environmental Protection

Distinguished Achievement Award in Environment Systems Engineering

Aaron Pontzer graduated with a B.S. in environmental systems engineering in 1995. At that time, it was called geo-environmental engineering. He graduated from the Penn State environmental pollution control program with his M.S. in 1997. Pontzer is a licensed professional engineer and has worked in the environmental engineering field in central Pennsylvania for the last twenty years. He worked for engineering consulting companies early in his career and for the last six years he's been working for the Pennsylvania Department of Environmental Protection. Pontzer currently works in the Pennsylvania Department of Environmental Protection's Moshannon District Mining Office in Philipsburg, Pennsylvania. He is responsible for the assessment, operation, maintenance, and construction of passive and chemical mine drainage treatment facilities, the reclamation of abandoned mine sites, and watershed restoration.

Richard L. Gordon Distinguished Achievement Award in Mineral Economics & Energy Business and Finance

Wesley C. Pickard started his professional career at Bethlehem Steel Corporation as an economic and market research analyst. In 1972 he joined Synergy, Inc., a provider of strategic planning analysis and technology solutions for defense operations and logistics. Major clients of Synergy included the U.S. Department of Energy, Bureau of Mines, Air Force, Navy, Environmental Protection Agency, Assistant Secretary of the Interior, and various other Department of Defense offices and agencies. Pickard served many roles at Synergy including chief financial officer, as well as president, vice chair, senior vice president, and chief operating officer throughout his thirty-three-year tenure. He helped grow the company from five employees to more than 200, with revenues of approximately $25 million when the company was sold to IFC Consulting in 2005. Pickard holds a B.S. in mining engineering from University of Pittsburgh, an M.S. in mineral economics from Penn State, and an MBA from the University of Chicago, where he also completed coursework and exams for a Ph.D. in economics.

Wesley Pickard
Former Chief Financial Officer, President, Vice Chair, Senior Vice President, and Chief Operating Officer, Synergy

Penn State alumna applied petroleum and natural gas degree to expansive career

When she approached college, Carol Bailey felt like her future could go anywhere. She was creative, yet also had a mind of an engineer, an interest further piqued by the professions of her father and sister.

She considered petroleum and natural gas engineering because it fit her technical interests. When she found out her grandmother—a "maverick of the family"—worked on a cable tool drilling rig, that made the decision even easier.

When she graduated in 1981 from Penn State with a degree in petroleum and natural gas engineering, she discovered that she could still go anywhere.

So she did just that.

Bailey started out working for Halliburton, working on then record-setting deep wells in Wyoming's overthrust belt. She moved on to managing massive natural gas storage fields for the Southern Gas Company in California. She worked for Enron, witnessing the rise and fall of the energy giant, where a job managing project risk helped her manage her own personal risks.

"I would not change a thing for those experiences," Bailey said. "It really gave me a huge opportunity to look at the world through a completely different lens."

One project especially gave her a better perspective on the nuances and politics of global decisions in the energy world. She was working to help improve the availability of energy in a developing country when she hit a snag: leaders there told her they feared the proposal for a new power plant because they felt having energy could further education and information, perhaps shaking their solid footing in power.

"It woke me up to the power of power," Bailey said. "Having access to energy is life changing. For us, power outages are a real inconvenience, but when you go to developing countries and see that there is no grid, and there's no intent to change anything for common people, it's unsettling. This is the world, and the lifelong path I chose—based on my career, which began at Penn State—was to change that."

Bailey said she was dismayed about the lack of change until learning that a colleague found success in another developing country by taking a different tack. He bought a few sewing machines for the wives of several country leaders he was working with. Those machines led to small businesses, which led to more employees. It also led to progress on the development of a new power plant.

"It all came down to this harebrained thought," Bailey said. "You want to change the world by providing more access to energy, and it came down to a sewing machine. It's not hard to change the world. You just have to have the vision and make the effort."

As Bailey progressed through her undergraduate education at Penn State, it took just that—vision and effort. She admits that she wasn't the greatest student, but she had the drive and creativity to prove she could succeed in the energy business.

And it was especially tough for women in the engineering field. Bailey relied on her skills, education, and trailblazers like her grandmother to keep going. Bailey, who now works as a research portfolio manager for the Electric Power Research Institute, tells those entering the field what helped her at the time:

"There are people who have gone through this already, and you're not the only one who has faced challenges. Others have paved the way. There are people out there who will support you," she said. "You won't and shouldn't face these challenges alone."

EME Welcomes New Faculty & Staff

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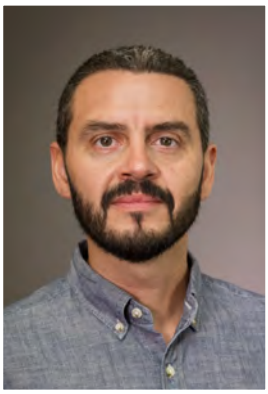
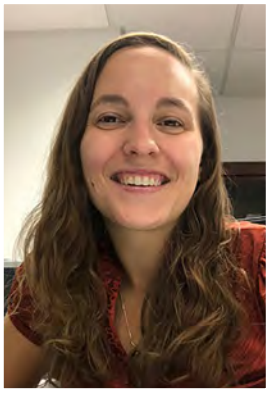
Graduate Program Coordinator

Amy Johnson
Academic Adviser



Thanasis Karamalidis,
Asst. Prof. of Environmental Systems Engineering

James Miller
Research Technologist/ Laboratory Coordinator



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