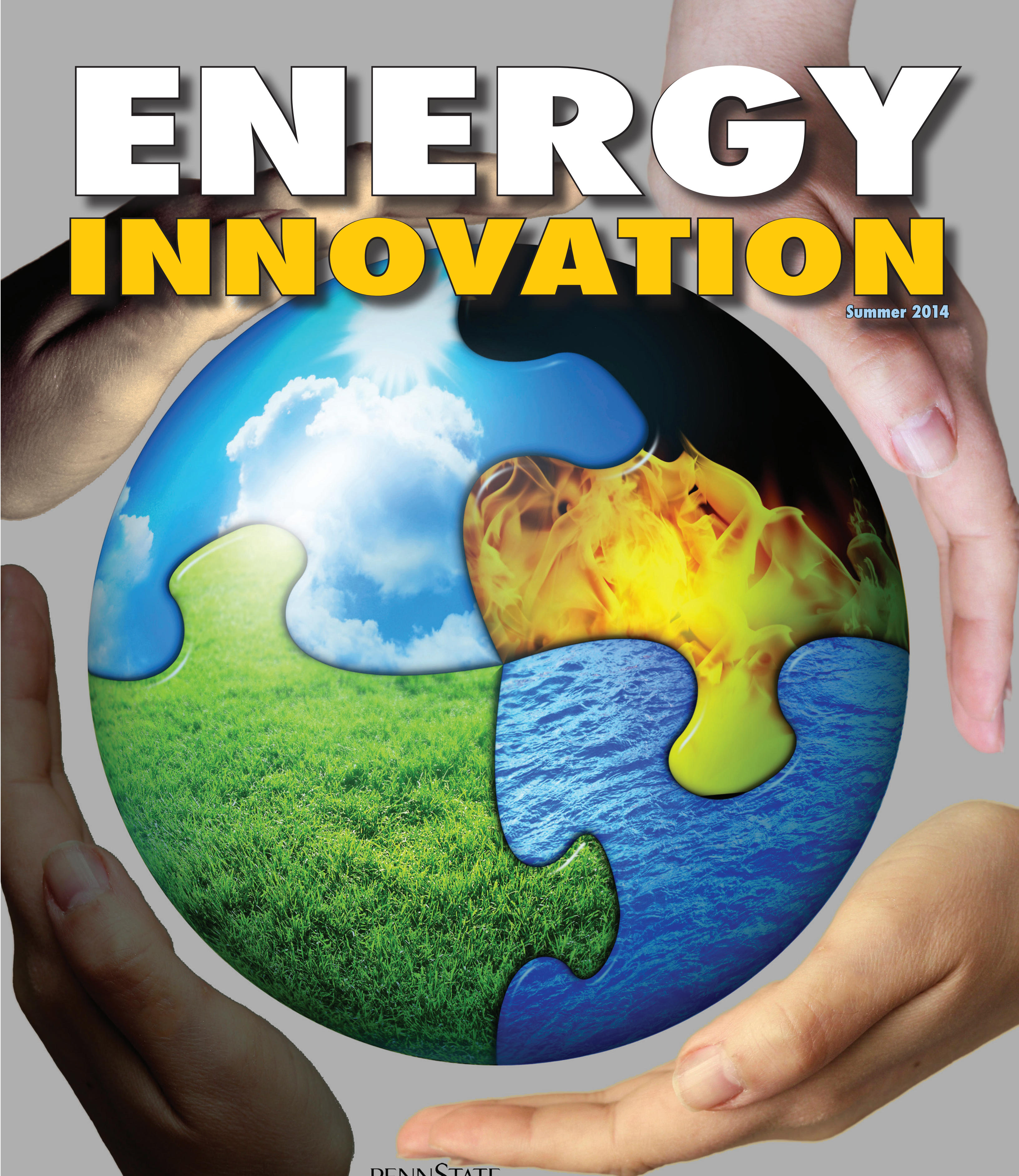
# ENERGY INNOVATION

Summer 2014



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*One of Penn State Institutes of Energy and the Environment*

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

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U.Ed. EMS 14-53

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# Letter from the Interim Director

I am pleased to invite you to explore this issue of Energy Innovation. While serving as interim director of the EMS Energy Institute, I have had the opportunity to witness first-hand the relentless work of our faculty, staff, and students; the value they create; and the collective impact they enable for all. My philosophy this year has been one that promotes access to facilities, resources, and information as a way to build bridges and empower our affiliates to execute their best research ideas. It has been a pleasure and valuable experience to serve the EMS Energy Institute in this role, and I thank you for your welcome and support.

The 2013-2014 academic year has been a time to reflect on our past, our future, and the strategies needed to fulfill our vision as the EMS Energy Institute crafted its 2014-2019 strategic plan within the overall Penn State strategic planning process. The goals and strategies put forth in this strategic plan follow the central theme of "energy resource development and the associated challenges of water and carbon management." Along with this thematic emphasis, the EMS Energy Institute seeks to expand research capabilities through shared instrumentation, promote synergistic activities and research collaboration, create professional development opportunities for graduate students, and grow Penn State's global presence in energy science and technology.

We are already well on our way to realizing some of the goals laid out in our strategic plan. Over the last year, the Institute has worked to implement a proposal process to fund collaborative research center initiatives, promote our facilities to a greater community and provide formal training on our instrumentation, and host a variety of speakers through the Energy Exchange Seminar Series.

As always, our faculty members continue to inspire research excellence. The research brief section of this newsletter will give you an idea of some of the diverse topics our faculty and students are exploring. I am also pleased to announce two new faculty affiliates: Mort Webster, who joined Penn State in February and is an associate professor of energy and mineral engineering, and Jeffrey Brownson, who was recently promoted to associate professor of energy and mineral engineering. Angel Johnson is also joining our superb support staff.

On July 1, 2014, we will welcome back EMS Energy Institute Director Chunshan Song after a one-year sabbatical leave working with Dalian University of Technology in China as part of the PSU-DUT Joint Center for Energy Research. We will work together to ensure a smooth transition into our renewed Institute strategy "To be the leading research hub for energy science and technology development."

Zuleima Karpyn
Interim Director, EMS Energy Institute
Associate Professor, Petroleum and Natural Gas Engineering

# Research Briefs from Around the Institute

*From exploring alternative energy sources to developing new technologies for the production, generation, and utilization of energy, the EMS Energy Institute is involved in almost every aspect of energy research. This section highlights the diversity of some of our ongoing projects.*

## Reservoir Flow Behavior in Coalbed Methane

*-- Information Contributed by Shimin Liu*

Coalbed methane (CBM) has become an important part of the world's natural gas resource portfolio. Coal deposits act as self-sourced natural gas reservoirs where the three crucial elements of a petroleum system – source rock, reservoir, and trap – are located together in a single geological unit. Methane is generated during the process of coal formation, either through a biogenic or thermogenic process. The methane is then adsorbed on to the internal surface of the coal matrix or compressed in the void space within the coal.

The energy industry classifies coal as an "unconventional gas reservoir" and has worked continuously on developing methods to economically produce gas from these formations. Because flow behavior through a coalbed methane reservoir is a complex process, a comprehensive understanding of flow dynamics through coal is essential to accurately model and predict gas production.

Gas storage capacity depends on the in situ pressure and adsorbed gas content in the coal and is usually quantified by the Langmuir sorption isotherm, which is established using crushed coal samples in the laboratory. For gas transport to take place in a coal seams the gas is first desorbed or released from the internal coal surface, then the gas is disffused through the coal matrix bounded by the cleat, and finally, the gas flows through the naturally occurring fracture network, known as the cleat system.

Pressure depletion is the standard practice for coalbed methane production. As the name suggests, this process involves depressurizing the coal by pumping water out of the coal seam since most coalbed methane reservoirs are initially saturated. When the pressure in the coal seam falls below a specific level, the methane is released and moved towards the cleat system. In the cleat system, there are three stages for flow in coalbed methane reservoirs: 1) single-phase water flow during dewatering; 2) non-saturated single-phase water flow; and 3) gas and water two phase flow – gas flow starts with further reduction in reservoir pressure and gas relative permeability increases with depletion. The changes in gas/water saturation in cleats result in fluid mobility changes in the cleat system, leading to a unique feature observed during coalbed methane production, a negative gas decline rate. The gas production rate initially increases to a peak production rate as the seam dewaters and the relative permeability to gas increases. After the peak rate is reached, it is followed by a normal decline in production rate as reservoir pressure decreases with continued production.

Shimin Liu, assistant professor of energy and mineral engineering, and his graduate students have established an experimental system to characterize the sorption behavior and estimate the sorption capacity of coal seams, estimate the pressure-dependent diffusivity of the coal, and measure and estimate the apparent permeability of coal with continuous depletion. Currently, Liu is working on a project to characterize the flow behavior of Pennsylvania coals. The results will be used to analyze coalbed methane production and carbon dioxide sequestration potentials in Pennsylvania coal seams, as well as to plan gas drainage systems for safe underground coal mining.

## Project Looks at Predicting Fluid Volume and Composition from Shale Reservoirs

*-- Information Contributed by John Yilin Wang*

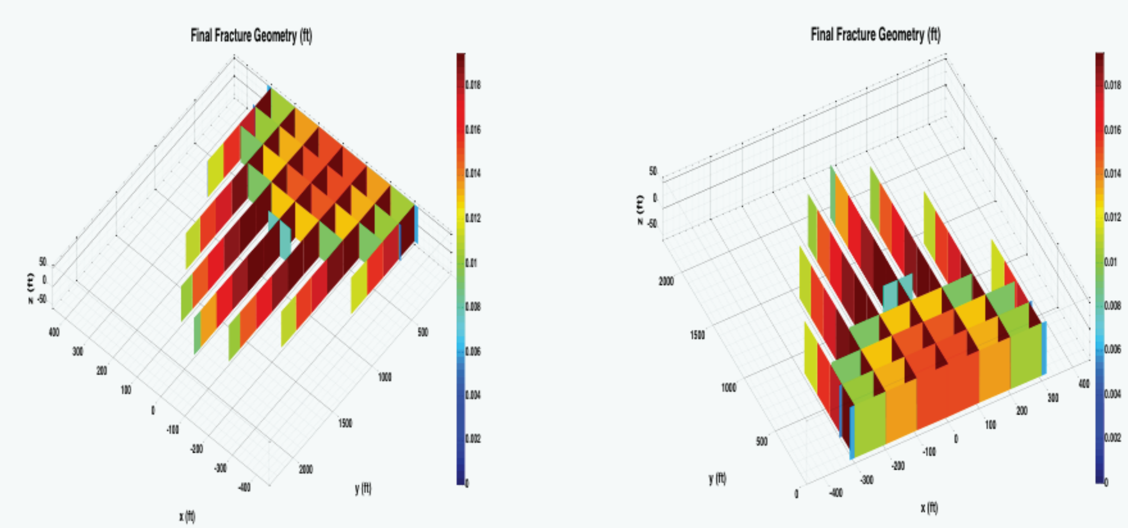
Shale gas production is promising in the U.S. and especially in Pennsylvania; however, many of the extraction technologies are relatively new and there is still a lot of uncertainty regarding the environmental impacts and other risks of developing this resource.

John Yilin Wang, assistant professor of petroleum and natural gas engineering, is working with four doctoral students on an integrated approach to make accurate, long-term predictions of fluid volume and composition produced from reservoirs. The work, being done in conjunction with the Department of Energy's National Energy and Technology Laboratory, will be used to assess the environmental impacts and risks in developing shale gas resources, especially in Marcellus shale formations.

Although samples of flowback fluids taken over a few months provide valuable information for understanding short-term effects, flowback volume and composition is affected by geology, well completion, stimulation treatments, field operations, and other physical mechanisms governing the fluids flow in the reservoirs. For this project, researchers are using integrated methods to understand and rank pertinent factors, including reservoir geology, stimulation, and fluid properties, affecting the volume and composition of produced fluids, such as gas, oil, and water. The goal is to provide a scientific understanding and assessment tools to ensure these key domestic oil and gas resources can be produced safely and in an environmentally sustainable way.

First, researchers use a statistical approach that involves data acquisition and analysis of hundreds of actual Marcellus shale gas wells. Next, researchers use numerical experiments to understand, quantify, and rank the factors affecting hydraulic fracture network propagation, proppant transport and long-term fracture conductivity, and volume and composition of flowback and produced fluids. Using these data, researchers will build a reduced-order model for quick and easy predictions of produced fluids in Marcellus plays.

This research will inform best practice procedures for improved efficiency and increased reserves in unconventional shale gas reservoirs, such as optimized drilling, well completion, stimulation, production operations, and produced water management. In addition, economic, environmental, and risk assessment of shale gas development will help policy makers during the rapid development of shale gas resources.




An example of hydraulic fracture network and width at the end of a stimulation treatment from Wang's hydraulic fracturing model. Image contributed by John Yilin Wang.

## Community Powered Solar Energy Installation

*-- Information Contributed by Jeffrey Brownson*

One of the major challenges that Central Pennsylvania faces in regards to solar electric is the perception that the region does not have enough sun to support solar as a major energy source. However, our local solar resource data shows that there is abundant sunshine in our region for successful photovoltaic systems. An ongoing project, "Community Solar on State: A Living Laboratory Framework for Outreach, Education, and Research" is taking on the challenge of changing that perception. Jeffrey Brownson, associate professor of energy and mineral engineering and materials science and engineering, along with Susan Stewart, assistant professor of aerospace engineering and architectural engineering, and Rob Cooper, director of energy and engineering for the Office of Physical Plant, are leading the solar project, which combines research with education and outreach to bridge the University, the surrounding community, and alumni.

The project's goal is to implement and document the integrative design process for a "solar garden" at the Penn State campus and to use the collected information to create an outreach and educational platform that will enable the greater community to move beyond a pilot photovoltaic project and enable additional solar projects as they evolve in the future.

The visibility of a large photovoltaic array at the University will serve as an important signal of a progressive approach to energy and sustainability on campus. In addition, the project is aligned with Penn State's strategic plan for emissions and would contribute to the continued efforts to reduce our collective greenhouse gas (GHG) impact.

Although the pursuit of a solar energy installation on the Penn State University Park campus has been ongoing for several years, efforts have been decentralized and largely undocumented for the broad base of alumni and the State College area community. This project will consolidate these efforts and provide guidance on how each component can come together to see a community solar project through to fruition. Researchers plan to leverage the Penn State community, State College area residents, and Penn State alumni living in Pennsylvania to support a central photovoltaic installation, separate from their own homes, by purchasing energy through a central energy firm that will manage the installation of the photovoltaic array on the Penn State University Park campus. The Community Solar on State project would be first university and community driven project in Pennsylvania, and perhaps the nation.

Beyond establishing a photovoltaic installation on campus, the goal of this project is to document the design and installation process in order to create online videos, materials, and educational modules as an open resource for future solar project development as well as for K-12 and college learning opportunities. In addition, the photovoltaic installation will serve as a living laboratory and provide hands on experience for student researchers. Currently, researchers are planning an integrative design workshop event to occur at the end of August as the next step in the process.

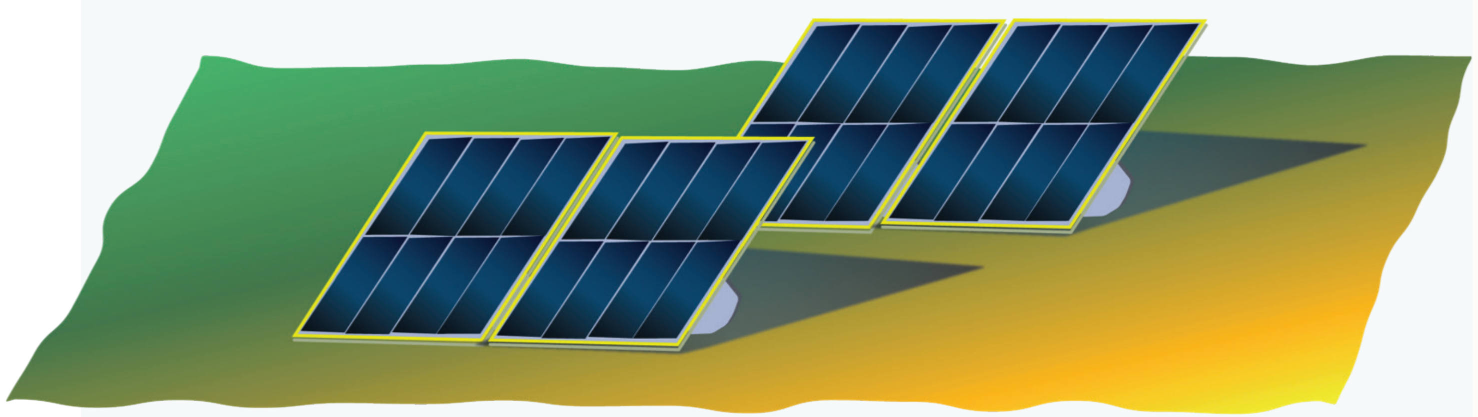


Image contributed by Jeffrey Brownson





# Institute Looks to Increase Industrial Engagement with Multi-Investigator Centers

**The World's energy challenges will not be solved by a single researcher or even a single research institution.** The sharing of ideas, information, and resources is key to successfully advancing energy sciences and exploring new energy technologies. The EMS Energy Institute has always had a multi-disciplinary focus and was founded to support and connect energy researchers from within the College and around the University. In keeping with that mission, the EMS Energy Institute is excited to announce a new funding opportunity specifically designed to strengthen innovative, multi-investigator research and expand industrial engagement.

The EMS Energy Institute is already organized to enable researchers from various energy-related disciplines to work closely and share ideas. The Institute was established through the consolidation of various labs and centers within the College of Earth and Mineral Sciences, but has since expanded to include faculty collaborations from the College of Engineering, the College of Agriculture, and other campus departments and institutes. Institute leadership facilitates these collaborations between Penn State faculty members as well as connects faculty and students with external researchers and stakeholders.

This year marks the first time the Institute has made funds available to our faculty for the purpose of expanding these connections. The goal of the new award is to encourage future collaborations and external funding opportunities by establishing new initiatives, which, if successful, will transition to self-supported research centers, consortia, or industry membership programs led by Institute-affiliated faculty. The Institute will award funds based on eligible proposals. The funds can then be renewed up to two additional times, contingent on the availability of funds and favorable annual reviews.

Industry-driven research is central to the EMS Energy Institute's research endeavors and the institute faculty and staff have extensive experience in administering research centers. Around 19 percent of our funding comes directly from industry. In addition, Institute-affiliated faculty members have managed many research centers and industry-driven consortia with funds from government awards or industry memberships. The centers' focuses have ranged from carbon products and electricity markets to stripper wells, gas storage, unconventional resources, and gas flooding. Along the same lines, the Institute administers a Joint Center for Energy Research in collaboration with Dalian University in China. By working closely with industry, researchers can ensure their work is relevant to current challenges and students have the opportunity to make connections that lead to internships and jobs. These activities have brought together faculty, students, and current industry professionals from around the Globe.

Our hope is to support new research centers that will attract external funding, advance our expertise, provide opportunities for students, and sustain research long after the three-year funding period ends. The Institute will award the first funds in July 2014. Researchers will be able to apply during the call for proposals each year and the Institute may fund multiple awards depending on the availability of funds.

For the funding period of July 2014 - June 2015 the Institute is funding two initiatives: the Center for Corrosion and Electrochemistry in Extreme Environments, directed by Sergei N. Lvov, professor of energy and mineral engineering; and the Center for Sustainable Electric Power Systems, co-directed by Mort Webster, associate professor of energy and mineral engineering, and Uday V. Shanbhag, associate professor of industrial and manufacturing engineering.

# Partnerships for Practical Research

*Industrial driven research consortia are beneficial for everyone involved, especially student researchers*

The EMS Energy Institute is primarily a research institution and our responsibility to students is to provide them with practical research training to augment their coursework. While many of the graduate students at Penn State hope to find positions in academia, many more hope to find employment in industry. One way that the Institute is able to offer real-world research experience is through industrial partnerships and consortia. These research hubs provide a framework for energy companies to fund research, receive progress updates, and contribute to decisions on research direction. In addition, these consortia offer networking opportunities for students and industry representatives that can lead to future internship or career connections.

Two of the industry-driven consortia administered by the Institute are the Gas Flooding Joint Industry Project (JIP) and the Unconventional Natural Resources Consortium (UNRC). The Gas Flooding JIP, managed by Russell Johns, professor of petroleum and natural gas engineering, focuses on issues surrounding gas flooding, or the injection of gasses into reservoirs to increase production. UNRC, managed by Luis Ayala, associate professor of petroleum and natural gas engineering and associate department head for graduate education, focuses on the reservoir engineering areas of unconventional natural gas exploration and production technology with an emphasis on shale gas, tight gas, and shale oil formations.

These groups have about nine industrial members between them. Companies include Shell, Chevron, BP, OMV Exploration and Production, and Kuwait Oil Company, among others. These consortia projects support research for more than 15 graduate students. As part of the group, students are required to present their work to industry representatives at annual workshops. The industrial members are able to provide feedback and suggestions directly to the students.

"Company representatives give us their advice and their advice leads us to do research on the topics that are beneficial in the oil industry and of practical use," said Bahareh Nojabaei, a doctoral candidate in petroleum engineering currently participating in the Gas Flooding JIP and the UNRC.

Interactions with company representatives are not limited to once a year. Students receive e-mail inquiries for updates throughout the year. The students can also contact consortia members for advice or information on field data. By becoming affiliated with a research consortium, students learn, first hand, about current issues affecting industry and how they might adjust their work to address those issues. These students also provide real results and software toolkits to industrial members for immediate use in the industry.

"I hope we can have more oil companies involved in such [joint industry] groups at Penn State," said Nojabaei. "Such joint industry projects help both universities and companies to offer solutions for practical problems."

Students, faculty, and industry members at a UNRC workshop.

*Two students, Bahareh Nojabaei and Saeid Khorsandi Kouhanestani, doctorate candidates in petroleum engineering, are working on projects for the UNRC and Gas Flooding JIP consortia. They shared a little bit about their positive experiences.*

## Tell me about your doctorate research.

**Saeid Kouhanestani:** I am developing analytical solutions for gas flooding problems that can be used to optimize recovery efficiency of gas flooding processes. The results can be used to improve performance of current simulation and flash calculation methods.

**Bahareh Nojabaei:** I am researching the effect of capillary pressure on phase behavior of reservoir fluid and production from tight rocks. I am also looking at the effect of capillary pressure on minimum miscibility pressure for gas flooding of shales. We are developing an extended black oil model to simulate production and gas injection for tight reservoirs.


Industry members receive a tour during a Gas Flooding JIP meeting

## How did you come to be a part of the Gas Flooding/UNRC research group(s)?

**SK:** I have a bachelor's degree in petroleum engineering from Petroleum University of Technology at Ahwaz-Iran and master's degree in reservoir engineering from Sharif University of Technology at Tehran-Iran. I was working on phase behavior for my master's project. Dr. Russell Johns is well known for his work in enhanced oil recovery and I found Dr. Johns research very interesting. The cutting edge research in gas flooding is scientific and applicable.

**BN:** My background is in mechanical engineering and thermal fluid sciences. I did my bachelor and master's degrees in Iran. I moved to the U.S. to accompany my husband to complete his doctorate at Penn State. I was looking for a doctorate position at Penn State that was relevant to mechanical engineering, but more practical. I found the Energy and Mineral Engineering Department to be very practical and decided to do my doctoral degree in petroleum engineering. My advisor, Dr. Johns, and other faculty members formed these research groups, funded by major oil companies and doing research on practical topics. I was interested to be involved in both gas flooding and UNRC research groups.

## How has being affiliated with the Gas Flooding/UNRC consortia enhanced your research experience at Penn State?

**BN:** We communicate with the companies through these research groups. We learn the major practical issues and problems facing the oil and gas industry so we can get ideas to do research on such topics to solve these issues.

## How has working with the Gas Flooding JIP given you a feel for real industry issues?

**SK:** The annual presentations give us the chance to represent our work for technical experts. They critique our work, which helps us find the correct direction for future research. Gas Flooding JIP research targets real problems in industry and the results of our research have direct application in industry. However, our research is not only focused on solving specific problems in industry, we also develop new ideas and tools to improve current processes of industry.

## What are your career goals and how is your experience with Gas Flooding/UNRC helping you to meet those goals?

**SK:** I would like to join an oil company. My long-term career goal is to continue the research in the field of phase behavior and enhanced oil recovery. With the Gas Flooding JIP, I have the chance to communicate with industry representatives, which could help me find a position with an oil company. Also the research in Gas Flooding JIP is similar to the research in R&D departments of oil companies.

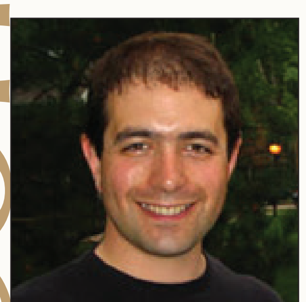
**BN:** I will be looking for a faculty position in petroleum engineering in near future. If I will be an assistant professor in petroleum engineering, I need to work with oil companies and I should be involved in such joint industry projects.

Bahareh Nojabaei presents at a UNRC meeting

PEOPLE

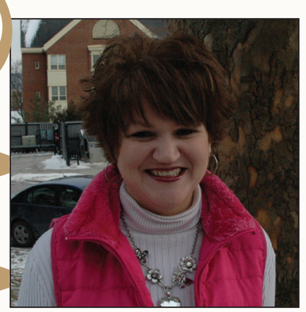
# Welcome New Faculty & Staff

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



**Jeffrey R. S. Brownson**
*Associate Professor*
Energy and Mineral Engineering

Jeffrey Brownson joined the faculty of the John and Willie Leone Family Department of Energy and Mineral Engineering (EME) in the summer of 2007. He began a joint appointment in the EMS Energy Institute in 2014. Brownson offers a unique background as a materials scientist for solar energy conversion systems, having completed his degrees in geoscience, materials science, and environmental chemistry. His research focuses on photovoltaic materials and systems design and deals with synthesis and characterization of inorganic photovoltaic materials, sustainable materials design for energy conversion; system-integrative photovoltaics (SIPV); and system scale transient energy simulations for buildings and for network (electrical grid) deployment of solar technologies.



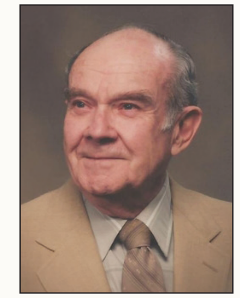
**Angelita Johnson**
*Administrative Support Assistant*
EMS Energy Institute

Angelita (Angel) Johnson is the assistant to the director of the EMS Energy Institute. She schedules meetings, meeting rooms, conference calls, and catering. She also handles travel arrangements and reimbursements for the director as well as other faculty and students. In addition, she processes research supply and equipment orders, makes fleet vehicle reservations, distributes visitor parking permits, and orders office supplies. She is in charge of all gas cylinder ordering.

**Mort Webster**
*Associate Professor*
Energy and Mineral Engineering

Mort Webster specializes in risk analysis, uncertainty analysis, and decision-making under uncertainty. Current research projects include stochastic dynamic modeling of the electric power system focusing on the integration of intermittent renewable generation, modeling technological change as a stochastic process and implications for near-term R&D portfolios, and flexible air quality strategies under uncertainty using integrated economic/energy/chemistry regional models. Prior to joining Penn State, Webster was assistant and associate professor of engineering systems at the Massachusetts Institute of Technology and assistant professor of public policy at the University of North Carolina at Chapel Hill. He received a doctoral degree in engineering systems and a master's degree in technology and policy from MIT, and a bachelor's degree in computer science and engineering from the University of Pennsylvania.

# Remembering the Life & Work of Influential Coal Researcher



Influential coal researcher and Professor Emeritus William Spackman (1919-2014) died on March 13, 2014 in Wilmington, North Carolina. Spackman was well known for his work in the characterization of peat and coal deposits, and coal utilization. He spent his entire career at Penn State and was instrumental in the development of the coal research section of the College of Earth and Mineral Sciences in 1957. Under Spackman's direction, the coal research section became an internationally acclaimed research facility and Penn State is still one of the few academic centers where there are formal education opportunities in coal. The coal research section was the precursor to the EMS Energy Institute, which was formed from 1993 through 1997 when several labs and centers were consolidated under the direction of Dean John Dutton.

Spackman also worked to start the Penn State Coal Sample Bank in 1967 to supply the research community with a variety of coal samples organized by rank and composition. The sample bank, which is housed at the EMS Energy Institute, is among the largest sample bank in the World with over 1,000 samples of coal and accompanying analytical data. Recently, the EMS Energy Institute expanded this collection even further with the addition of the Argonne Premium Coal Sample Bank.

Spackman received an associate of arts degree in 1940 from North Park College in Chicago. Then in 1942, he graduated with a bachelor's degree in botany from the University of Illinois. During World War II he served at the Philadelphia Naval Shipyard applying biological research to marine wood preservation. In 1949 he earned his doctorate in biology with a major in paleobotany from Harvard University.

Best known for his work in petrography, Spackman's research efforts ranged from defining the petrographic characteristics of coking coals, to understanding the association of uranium minerals with lignites, to exploring the historical development of peat deposits within the Okefenokee Swamp and the Everglades. In addition to the above accomplishments, Spackman helped to establish the Catalog of Fossil Spores and Pollen. He served as chair of the Paleobotanical Section of the Botanical Society of America; chair of the Coal Geology Division of the Geological Society of America; and member of the International Commission of Coal Petrology, serving from 1964 to 1975 as president of its Nomenclature Committee. In 1980 he became the founding editor of the first research journal devoted to coal geology, the *International Journal of Coal Geology.*

*Written with information from: Rich, F.J., et al., Obituary for Dr. William Spackman (1919–2014), Int. J. Coal Geol. (2014), http://dx.doi.org/10.1016/j.coal.2014.04.002*

## Connect with the EMS Energy Institute

***Join our LinkedIn group.*** The group is open to anyone working or studying in the field of energy research and provides a forum for members of the Institute community to engage in discussion and networking with professionals in energy-related fields. **www.linkedin.com/groups/EMS-Energy-Institute-4754804/about**.

***Sign-up for our listserv.*** Subscribe to our listserv to receive our annual newsletter by e-mail. You will also receive our e-newsletter three times a year.

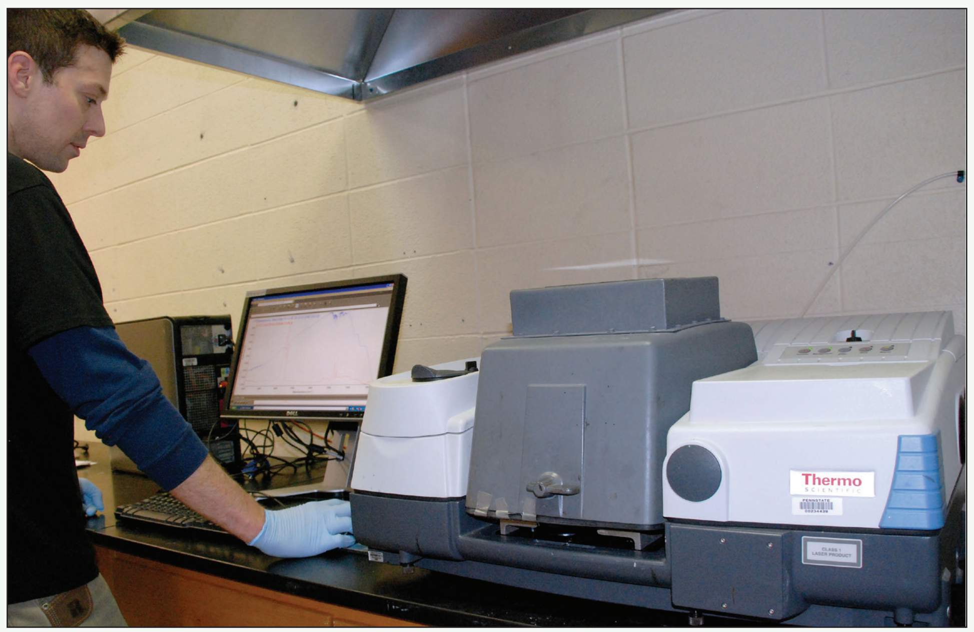
***Visit our website.*** Check our website regularly for events, such as our clean energy seminar series, analyzer training workshops, and calls for papers for major conference in the energy field. We also have information on all of our faculty and their research activities, facility descriptions and schematics, and more.

***Subscribe to our RSS feed.*** Stay up to date on news from the EMS Energy Institute, including student and faculty awards, events, and activities by subscribing to our RSS feed.

OUTREACH

# Energy Institute Facilities Open to the Greater University Community

The EMS Energy Institute's laboratories house a variety of analytical and computational facilities, laboratory reactors, imaging equipment, and several pilot- and laboratory-scale stationary combustion, gasification, coking, and hydrocarbon recovery from sands systems. These facilities are specially designed for each of our research areas; however, many of our analyzers and instrumentation are useful in other research areas and are available for use by any faculty, staff, or student in the University community. In order to make researchers aware of our instrumentation and its capabilities, the Institute is holding free workshops. We can also offer individual training or tours at any time. To view all of our facilities, please visit **www.energy.psu.edu/facilities.html**.




## Infrared spectroscopy facilities

Commercial infrared spectrometers became key pieces of equipment in polymer synthesis laboratories after the Second World War and infrared spectroscopy continues to be a useful technique for certain analytical tasks. Paul Painter, professor emeritus of polymer science, directs the FTIR (Fourier Transform Infrared) spectroscopy facilities now housed at the EMS Energy Institute. These facilities, which were moved to the Institute in 2014, greatly enhance our analytical capabilities.

Infrared spectroscopy is a technique that provides a sort of "fingerprint" of molecules. Infrared light is absorbed at particular frequencies (usually reported as wavenumbers, $cm^{-1}$) according to the types of chemical groups present. Researchers can measure how much light has been absorbed at each frequency by comparing intensities to light from the source that hasn't passed through the sample to identify the microstructure of a molecule.

Although FTIR spectroscopy is used routinely in polymer science, it has applications in other fields, including energy. Currently, researchers are using the Institute's FTIR facilities to support a project to extract hydrocarbons from sand and other materials using ionic liquids. Infrared spectroscopy allows the researchers to analyze the materials' structures before and after cleaning with ionic liquids.

If you are interested in learning more about our FTIR facilities for your research, please visit the Analytical Research Group web page at **www.energy.psu.edu/sp/facilities/arg.html**.

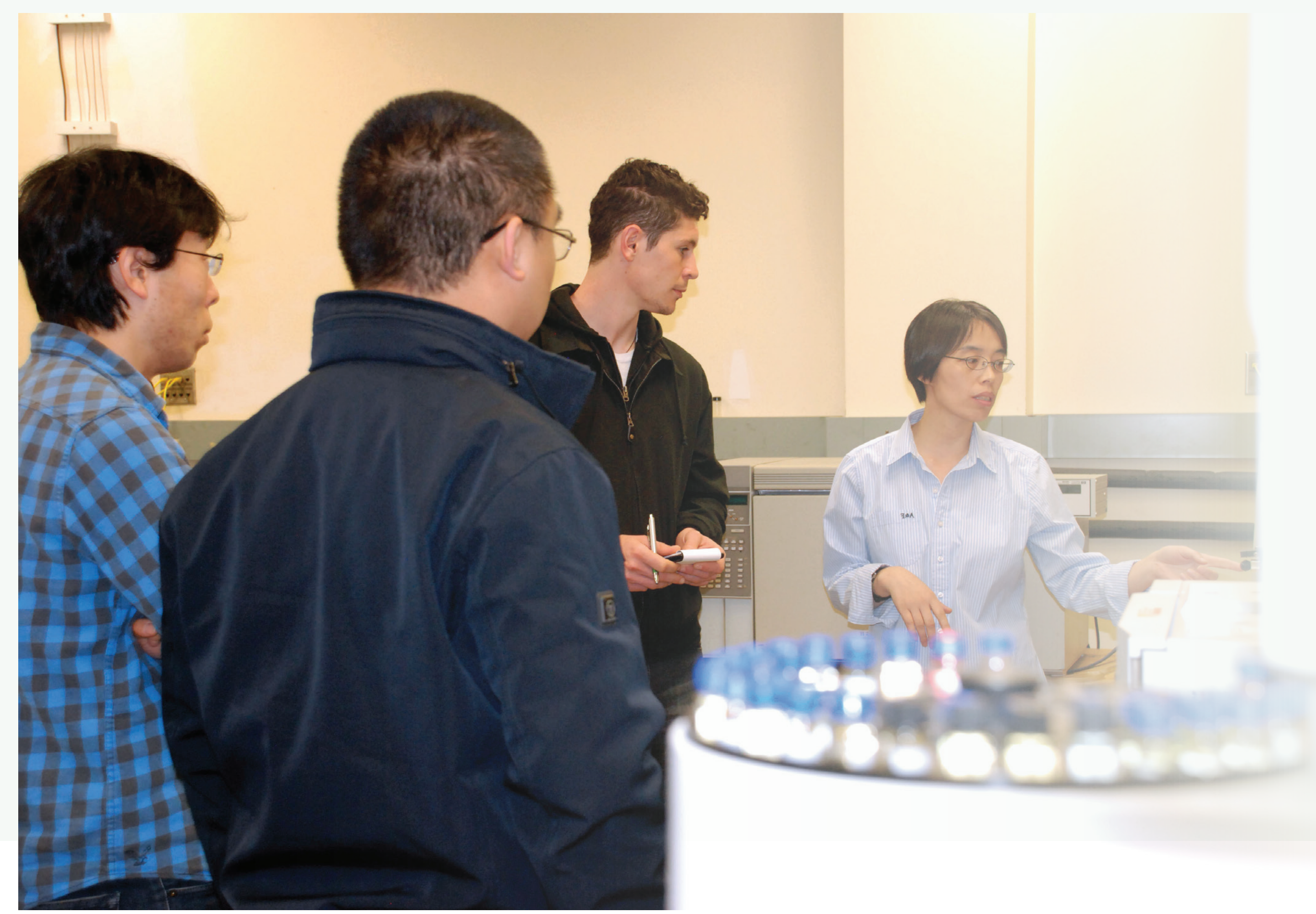
## Chromatography and spectroscopy analyzers

Chromatography is a separation technique widely used in analytical chemistry that enables the detection, identification, and quantification of individual species in a complex mixture. It is the most versatile and widely used technique for the separation and analysis of thermally stable and volatile organic and inorganic compounds. Small quantities of material can be separated and identified qualitatively and quantitatively. In the last 60 years, the applications of chromatography have grown extensively with the invention of sensitive detectors and highly specialized electronics and microprocessors.

The EMS Energy Institute has a diverse selection of gas chromatography techniques at its disposal. The Analytical Research Group at the EMS Energy Institute oversees the maintenance, scheduling, and use of this suite of chromatography and spectroscopy equipment. The majority of these technologies are focused on the detection and speciation of complex hydrocarbon mixtures. For example, analyzers can identify specific sulfur and nitrogen compounds in diesel fuels, analyze liquid fuels obtained from coal and biomass conversion processes, or measure the concentration of specific compounds in the emissions from flue gas.

In April and May 2014, the EMS Energy Institute held the first open workshops to highlight this instrumentation and its uses. The workshops provided an overview of chromatographic technique and applications as well as information on how chromatography can be a powerful detection tool when used with other techniques, such as mass spectroscopy or high performance liquid chromatography. The workshops also included a tour of the analyzer laboratory. The workshops were well attended by researchers from a variety of departments, including Geosciences, Mechanical and Nuclear Engineering, Chemistry, Biology, Agricultural and Biological Engineering, Animal Science, Plant Science, and Energy and Mineral Engineering.

To learn more about our analytical facilities or for a list of our available instrumentation, visit the Analytical Research Group web page at **www.energy.psu.edu/sp/facilities/arg.html**. The EMS Energy Institute will continue to host open workshops at the beginning of each semester. In addition, researchers may request analyses or schedule free customized training at any time by contacting Dongxiang Wang, **dxw43@psu.edu**.



## X-ray CT imaging for research

X-ray CT is a method for mapping X-ray absorption to provide non-destructive 3D images of the interior structure of objects. In its simplest form, a computer combines images of an object taken from many directions. The result is a 2D grid of numbers representing X-ray absorption of individual area or volume elements inside the sample. These slices can be stacked together to obtain 3D images. Because X-ray absorption depends on density and atomic number, the data can be interpreted in terms of density, porosity, fluid saturation, or component ratios.

The Center for Quantitative Imaging (CQI), which is located in the Institute, maintains an industrial X-ray CT scanner and a variety of associated equipment, including high-precision pumps, X-ray transparent core holders, high-precision quartz pressure transducers, and specially designed pressure vessels. This facility provides non-destructive imaging services to advance scientific knowledge and improve industrial manufacturing processes.

X-ray imaging has applications in many areas, including biological and anthropological studies; geological research, such petroleum and natural gas studies and carbon sequestration studies; and materials research.

Recently, CQI held a two-day short course on X-ray CT imaging of geo-materials with Dr. Phil Halleck, associate professor emeritus of energy and mineral engineering. The purpose of the course was to acquaint graduate students and researchers with basic principles of X-ray CT imaging and its application in the structural and compositional characterization of rocks, soils, and other similar porous materials. The course was captured on video as well for later viewing by researchers interested in using X-ray CT imaging in their work. For more information on the capabilities of CQI, please visit **www.cqi.psu.edu/facilities.html**.

## CQI expanding capabilities with new scanner

The Center for Quantitative X-ray Imaging is expanding its core instrumentation to offer world-class X-ray imaging capabilities to Penn State researchers interested in 3D and 4D images and analysis. The EMS Energy Institute in conjunction with the Penn State Institutes of Energy and the Environment, the College of Earth and Mineral Sciences, and the Earth and Environmental Systems Institute is leading the acquisition of a GE v|tome|x L 300 industrial X-ray computed tomography scanner for multi-scale, time-dependent characterization of natural and synthetic materials.

This industrial X-ray CT scanner has resolution capabilities down to the range of less than one μm and a large digital flat panel detection system capable of greater feature detectability and high image quality. The proposed system will be able to produce high quality volumetric images in the μm-resolution range with less distortion and more clarity than currently available in the CQI. The GE digital flat panel detector will allow larger pixel grids and therefore smaller voxel sizes on large samples (up to 500 mm wide x 600 mm high). The wider pixel grid allows volumes to be reconstructed with voxel dimensions up to 1/4000th maximum sample diameter.

The system, which will be housed at the EMS Energy Institute, represents significant improvements over current imaging capabilities and will enable a broad range of research projects, with particular emphasis on unconventional oil and gas resource development. The new scanner is anticipated to be available to the Penn State research community in Fall 2015. Look for updates in the next issue of *Energy Innovation.*

# Energy Exchange Seminar Series Connects Students and Faculty with Leaders in the Field

In 2013 the EMS Energy Institute began a seminar series to host talks on clean energy technology and policy, especially in the areas of fossil fuels and biomass. Energy Exchange, as the series is called, is part of the Institute's outreach mission. Each lecture focuses on a highly relevant energy topic and the speakers are from Penn State as well as leading energy companies, government agencies, and other universities.

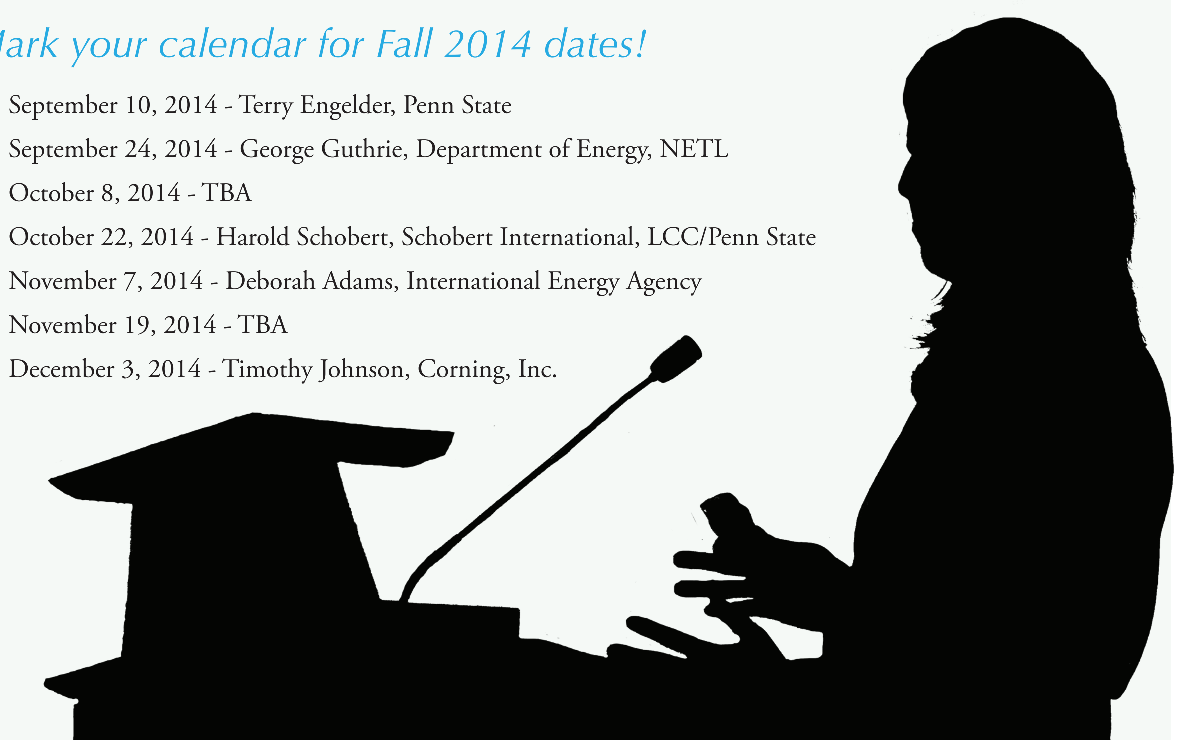
Each semester we host between six and eight speakers attracting faculty, research staff, graduate students, and undergraduate students from various University departments. This series provides an opportunity to bring research partners and potential research partners to campus to meet our faculty and students and tour our facilities. In addition, the series benefits Penn State students by giving them a space to talk with leaders in energy research about their background, their current work, the job market, and more. We host student lunches with the external speakers to encourage a more in-depth discussion in an informal atmosphere.

In the first three semesters the Institute has hosted the series, speakers have included individuals from Praxair, DuPont, Siemens Energy, the U.S. Department of Energy, and the Department of Conservation and Natural Resources, among others. Topics have touched on a variety of resources, including coal, oil, natural gas, and biomass fuels, and have covered topics from combustion and gas turbines to carbon dioxide emissions and energy policy. The series has been very successful and has attracted a varied audience of Penn State researchers and community members.

The Energy Exchange seminars are co-sponsored by the Penn State Institutes of Energy and the Environment. For more information on future dates and speakers, visit the Energy Exchange section of our website, **www.energy.psu.edu/energyoutreach/energyXchange.** We are actively looking for speakers for the next two semesters. If you are interested in giving a lecture or have a contact suggestion, pease e-mail **ei-questions@ems.psu.edu**.

*Mark your calendar for Fall 2014 dates!*

- September 10, 2014 - Terry Engelder, Penn State
- September 24, 2014 - George Guthrie, Department of Energy, NETL
- October 8, 2014 - TBA
- October 22, 2014 - Harold Schobert, Schobert International, LCC/Penn State
- November 7, 2014 - Deborah Adams, International Energy Agency
- November 19, 2014 - TBA
- December 3, 2014 - Timothy Johnson, Corning, Inc.



# Institute Plans for Next 5 Years

*With strategic plan that focuses on building bridges*

Late October 2013, a small group of EMS Energy Institute representatives gathered at the Penn Stater Conference Center to initiate a discussion on the direction in which the Institute should be heading. We updated our mission and vision statement to reflect our focus on energy technology research, student research training, and technical services. We narrowed down our ambitions into five obtainable goals. And we laid out a plan to meet those objectives in the next five years. Of course this was not all accomplished in one afternoon meeting.

The result of these workshop sessions is a strategic plan that will guide the Institute's decisions until 2019 with priorities that align closely with the goals of the College of Earth and Mineral Sciences and Penn State. The goals laid out in our plan respond to emerging research opportunities and societal needs that promote continued expansion of the Institute's research portfolio. However, there is also an overarching theme running through each of these objectives. For the Institute to thrive as a research entity, we must expand our connections by building on ties with other University units, industry, government, and global entities. This theme can be seen throughout the goals below, but also on the other pages of this newsletter as we have already put many practices into place with the intent of connecting our expertise, our facilities, and our people with others.

## Advance research to tackle contemporary challenges in energy resource development

Research is exciting because it is always evolving. New technologies or economic changes can make new energy sources viable and cost effective. At the EMS Energy Institute we will align our research accordingly by focusing on challenges with sustainable energy resource development related to water use and quality and carbon emissions. In response to a global shift to unconventional resources we plan to further our research in the area of unconventional oil and natural gas extraction, especially in harsh environments. At the same time, the Institute will perpetuate Penn State's position as a global leader in coal-related research by continue to cultivate core faculty strengths in coal and fossil fuel research.

In addition, the EMS Energy Institute administration plans to expand our faculty base in key research areas through joint tenure-track faculty appointments with other departments in the College of Earth and Mineral Sciences and through collaboration with the Institute for Natural Gas Research at Penn State.






## Expand capabilities through shared instrumentation

Most of our research relies heavily on specialized instrumentation, pilot- and lab-scale equipment, and unique software. Much of this equipment can last for decades and its uses cross research areas. But to remain innovative in emerging areas of energy technology, such as natural gas and sustainable energy, we must upgrade our infrastructure. The Institute plans to upgrade existing equipment and acquire new instrumentation to increase research productivity and provide new capabilities. Our goal is not to purchase equipment in a vacuum, but to focus on providing capabilities that are not available anywhere else on campus and to build a network to share instrumentation with researchers across the University.

## Cultivate synergies that promote research innovation

The main strength of the EMS Energy Institute is its ability to bring people together through projects, centers, and other initiatives. Along those lines, the Institute works to bring in speakers to promote the exchange of ideas with industry, government, and academia. However, we want to build on that strength by organizing more of these opportunities such as small group idea-sharing sessions, trainings, open houses, and workshops, all of which will help cultivate the connections that the Institute has worked to establish. Knowing the key to managing these synergies is strong communication, the Institute will build a robust web presence, expand listservs, and explore new communication technologies. We plan to continue to strengthen our communication and collaborations with other Penn State units, government, and industry.

## Enhance student educational experience

In alignment with the Institute's overall goals, the fostering and enhancement of future researchers' skills is of paramount importance. The proposed plan to enhance students' educational experiences is two-fold. First, we want to prepare current graduate students for a career as future researchers by giving them the tools necessary to perform high-impact scientific research. Second, we plan to mentor and develop undergraduate researchers through the creation of an NSF Research Experience for Undergraduates, where Penn State and external undergraduate students can interact with faculty, and each other, and prepare them for a future in graduate school.

## Grow global engagement

Industry-driven research has been at the core of the EMS Energy Institute research profile for nearly three decades. The Institute's research facilities, its number and mix of faculty, and its supporting technical staff provide the necessary flexibility to conduct industry-sponsored research. Maintaining this strong working relationship with the clean energy industries can provide students with employment and internships opportunities, provide faculty with research funding and access to commercial-scale facilities/field sites, and provide faculty with insight on key research needs for a particular company or energy sector. During the next five years, the Institute will strengthen and expand its collaboration with clean energy industries, in part by providing funding to faculty members to form cooperative research centers. In addition to continuing strong industry ties, we will look to internationalize more of our research collaborations in the future years.



# 2014 Mid-Atlantic Biomass Heat & Power Conference Supports Biomass Energy in the Mid-Atlantic Region

The 2014 Mid-Atlantic Biomass Heat & Power Conference was held on April 23-24 in Gettysburg, PA with the goal of expanding the biomass industry and helping to develop a consistent, unified vision for how biomass can be used to meet heat and power needs. Over 145 attendees from industry, government, school districts, hospitals, farms, national labs, and other energy-related organizations made the event a success.

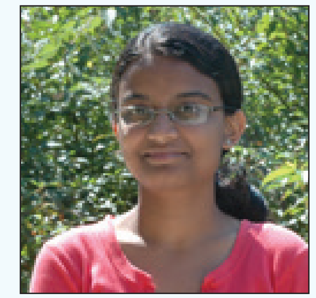
The Pennsylvania Biomass Energy Association (PBEA), the group responsible for organizing the conference, is a non-profit, industry-driven organization working to advance the use of Pennsylvania's sustainable biomass feedstocks for clean heat and combined heat and power applications in residential, small business, commercial, institutional, agricultural, and industrial sectors. Biomass feedstocks include plant and animal matter, such as trees, switchgrass, corn, willow, algae, food waste, and animal fats. Energy can be derived from these sources directly, with combustion, or indirectly, through conversion to biofuel. PBEA worked with state leaders from the Mid-Atlantic region to organize a conference that would provide attendees with a better understanding of how this swiftly growing renewable energy source can be used in an economically and environmentally responsible manner.

Conference talks focused on energy policy, environmental concerns, successful projects, system design, LEED building applications, and feedstock availability. The event also included tours of four locations that are currently using biomass energy. The tours included Slate Ridge Farm, who has a small-scale digester to recover energy from manure; Blue Ridge Landfill, which supplies 15 percent of the Borough of Chambersburg municipal utility's energy needs with methane; Caledonia State Park, where biomass heating systems are in use; and Twin Springs Fruit Farm, who replaced a coal greenhouse system with a biomass boiler.

The conference was hosted by the West Penn Power Sustainable Energy Fund and sponsored in part by the EMS Energy Institute. For more information on PBEA or the Mid-Atlantic Biomass Heat & Power Conference, visit PBEA's website at **supportpabiomass.org**. The website lists membership benefits, current member organizations, and upcoming events.



# Honors & Awards



## Aditi Khadilkar places third at graduate exhibition

Aditi Khadilkar, doctoral student in energy and mineral engineering, was awarded third place in the engineering category of the 2014 Penn State Graduate Exhibition for her poster titled, *Modeling agglomerate growth in fluidized bed combustion and gasification systems*.

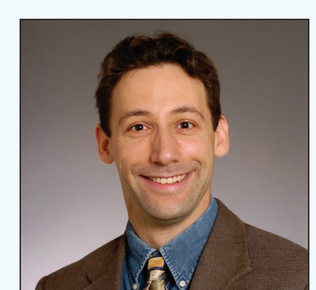
The annual graduate exhibition challenges students to effectively communicate their research to a general audience by presenting their work in clear, comprehensible terms to people outside their fields. The event includes poster competitions in six different fields, including arts and humanities, engineering, health and life sciences, physical sciences and mathematics, social and behavioral sciences, and visual arts. Each year, graduate students throughout the University are invited to participate.

## Lueking recognized for service to adult learners

Angela Lueking, associate professor of energy and mineral engineering and chemical engineering, received a 2014 Annual Recognition Award from the Penn State Commission for Adult Learners. This award recognizes commendable service provided to adult learners enrolled at Penn State.

## Brownson receives promotion

Jeffrey R. S. Brownson received a promotion to associate professor. Brownson teaches in the John and Willie Leone Family Department of Energy and Mineral Engineering. He offers a unique background as a materials scientist for solar energy conversion systems, having completed his degrees in geoscience, materials science, and environmental chemistry. His work focuses on synthesis and characterization of inorganic photovoltaic materials, considering sustainable materials design for energy conversion; system-Integrative Photovoltaics (SIPV); and system scale transient energy simulations for buildings and for network (electrical grid) deployment of solar technologies.



## Blumsack receives promotion and tenure

Seth A. Blumsack received a promotion to associate professor and tenure. Blumsack teaches in the John and Willie Leone Family Department of Energy and Mineral Engineering and is the co-director of the energy and environmental economics and policy initiative at Penn State. His work focuses on policy-relevant engineering, environmental and economic research for the energy, electric power and transportation industries. He also performs research in the area of complex engineered infrastructure networks.

## Johns receives SPE grant for student recruitment efforts

Russell Johns, Beghini Professor of Petroleum and Natural Gas Engineering, received the 2013 Society of Petroleum Engineers (SPE) Faculty Grant for PhD Pipeline. The award is designed to recognize petroleum engineering faculty who have developed innovative techniques to recruit doctoral students.

Johns is in the John and Willie Leone Family Department of Energy and Mineral Engineering, where he holds the Victor and Anna Mae Beghini Faculty Fellowship. Prior to his current position, he served on the faculty at The University of Texas at Austin from 1995 to 2010. He also has nine years of industrial experience as a petrophysical engineer with Shell Oil and as a consulting engineer for Colenco Power Consulting in Baden, Switzerland. He served as Executive Editor for SPE Reservoir Evaluation and Engineering Journal from 2002-2004, and in 2009 he was awarded the SPE Distinguished Member Award. Johns also directs the Gas Flooding Joint Industry Project at Penn State.

## Eser receives Fulbright grant for 2014-2015 academic year

Semih Eser, professor of energy and mineral engineering, has received a Fulbright grant to teach and conduct research at the Izmir Institute of Technology in Izmir, Turkey. His grant is for the 2014-2015 academic year.

Eser's research interests include the reactivity and microscopic characterization of cokes and carbons, coke/carbon formation and deposition mechanisms, inhibition of undesired carbon deposition, and molecular analysis and processing of petroleum feedstocks. Eser also coordinates the carbon research program at the EMS Energy Institute.

Eser received his bachelor's and master's degrees in chemical engineering from the Middle East Technical University in Ankara, Turkey, and his doctorate in fuel science from Penn State University. From 1987 to 1988, he worked as a research associate in the Department of Chemical Engineering at Auburn University. He returned to Penn State in 1988 and was appointed as an assistant professor of fuel science in 1989. He served the Department of Energy and Geo-Environmental Engineering as associate head (2001-2006) and acting head (2004).

The Fulbright Scholarship Program sponsors U.S. and foreign participants for exchanges in all areas, including the sciences, business, academe, public service, government, and the arts and continues to increase mutual understanding between the people of the United States and the people of other countries. The Fulbright Program was established in 1946 under legislation introduced by then-Senator J. William Fulbright. The program awards approximately 8,000 grants annually, including 1,200 grants to U.S. scholars.



Honors and Awards

## 2014 Wilson Banquet and Awards Presentation

The College of Earth and Mineral Sciences held its 2014 Wilson Banquet and Awards Presentation on April 27 to recognize student achievement, faculty mentoring, faculty commitments to service, and excellence in research and teaching.

### George H. Deike, Jr. Research Grant

**Luis Ayala**, associate professor and associate department head for graduate education, John and Willie Leone Family Department of Energy and Mineral Engineering, received the George H. Deike, Jr. Research Grant for *An Integrated Experimental and Analytical Approach to Production Performance Analysis of Liquid Rich Shale Reservoirs.*

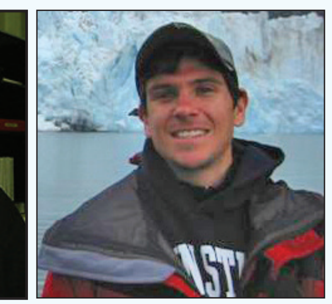
### Wilson Award for Excellence in Teaching

**Jeffrey R. S. Brownson**, associate professor, John and Willie Leone Family Department of Energy and Mineral Engineering, received the Wilson Award for Excellence in Teaching.

### E. Willard and Ruby S. Miller Faculty Fellow

**Randy Vander Wal**, professor, John and Willie Leone Family Department of Energy and Mineral Engineering, received the E. Willard and Ruby S. Miller Faculty Fellow award.

### Paul F. Robertson Award for the Breakthrough of the Year



**Chris Marone**, professor of geosciences and associate head of graduate programs and research, Department of Geosciences, and **Demian Saffer**, professor of geosciences, received the Paul F. Robertson Award for Breakthrough of the Year.

## 2014 Department of Energy and Mineral Engineering student awards

The John and Willie Leone Family Department of Energy and Mineral Engineering had its 2014 Awards Banquet on April 25. 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 Assistant**
Amrita Mukherjee, Ph.D. Student
Ronald T. Wincek, Ph.D. Student

**PNGE Merit Award**
Saeid Khorsandi Kouhanestani, Ph.D. Student
Victor A. Torrealba, B.S. Student

**Frank and Lucy Rusinko Graduate Fellowship**
Joseph P. Abrahamson, Ph.D. Student

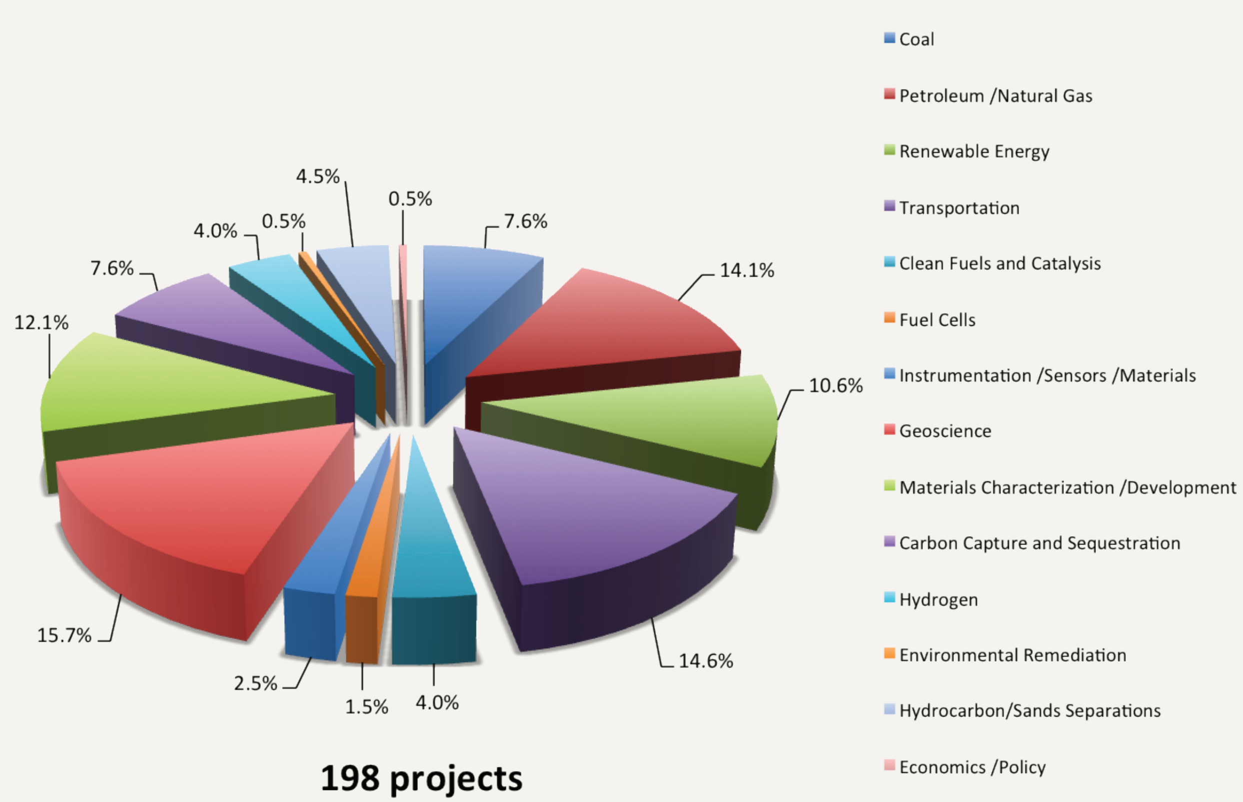
**Robert and Leslie Griffin Award**
Joseph P. Abrahamson, Ph.D. Student

**Charles B. Darrow Award**
Chethan K. Gaddam, Ph.D. Student
Aditi B. Khadilkar, Ph.D. Student
Wenjia Wang, Ph.D. Student

# Summary of Projects & Funding

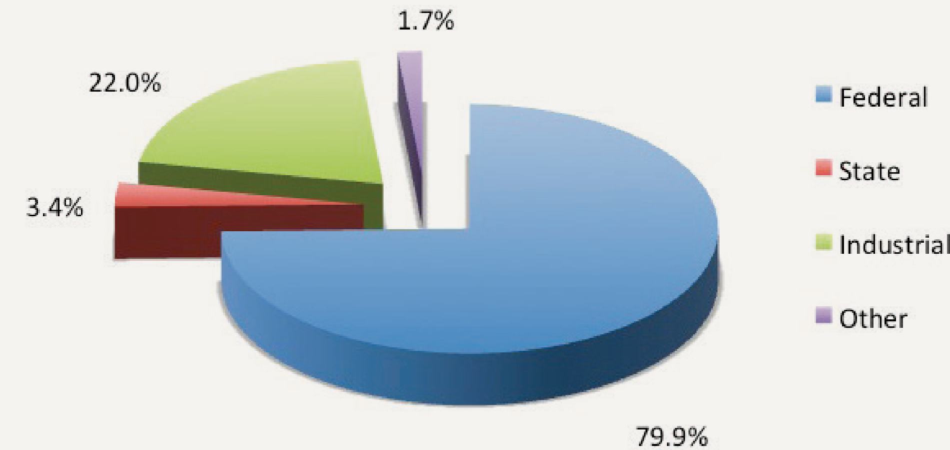
## EMS Energy Institute Projects by Program Area

(Fiscal Year 2010 through 2013)




## EMS Energy Institute Awards by Source

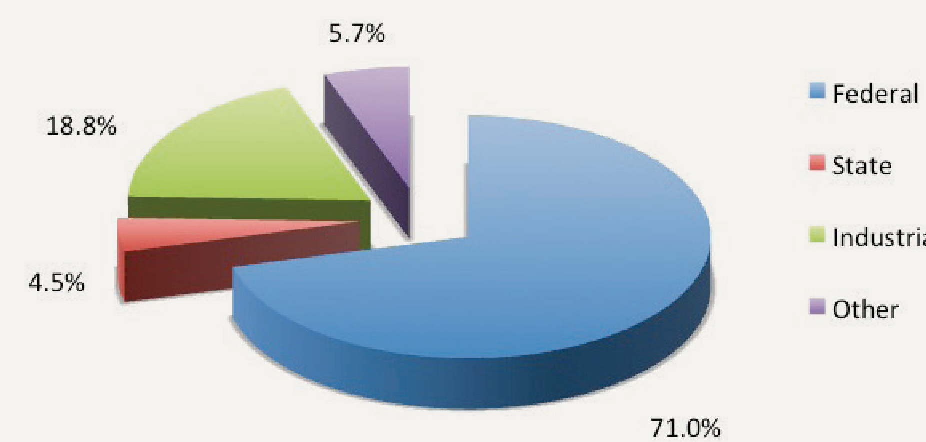
(Fiscal Year 2012 through 2013)




Total Awards 59

## EMS Energy Institute Funding by Source

(Fiscal Year 2012 through 2013)




Total Funding $4.2 million

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For more news as well as information on our research, facilities, and outreach programs, visit the EMS Energy Institute online.

**www.energy.psu.edu**