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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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Cover photo: Image of proppant materials. Photo provided by John Hellmann.

Letter from the Director

As we move into the summer of 2013, I have been surveying refereed publications, reflecting on the variety of research taking place throughout the Institute and the far-reaching impacts of our faculty and students' work. I would like to take this opportunity to thank all the EMS Energy Institute faculty members, research staff, and students whose ideas and hard work have resulted in many journal publications and awards in the last year. I also want to thank our Institute support staff members, whose hard work often goes above and beyond the normal call of duty in support of these research efforts.

One measure of the EMS Energy Institute's impact on the greater scientific community is the increased number of high-quality refereed journal articles published by Institute faculty, staff, and students. In the last two years there have been over 65 journal publications per year affiliated with the Institute versus 25-30 journal publications five years ago. In addition, according to the Web of Science, Institute publications received over 2,000 science citations in 2012. These numbers demonstrate the visibility and importance of our research endeavors.

The EMS Energy Institute continues to enhance global collaboration. We are continuing our work with Dalian University of Technology in China as part of the PSU-DUT Joint Center for Energy Research (JCER). The next JCER Joint Energy Workshop will be held in China in Spring 2014. We are also hosting two major international conferences in 2013 with Institute faculty acting as conference chairs. In June, the Twelfth International Conference on Carbon Dioxide Utilization (ICCDU) will be held in the Washington D.C. area. In September, the International Conference on Coal Science and Technology (ICCS&T) will be held on the Penn State campus. Both conferences have had over 200 papers submitted and are expecting participants from over 20 countries. The Institute is very excited to be hosting two of the most important conferences in their respective fields.

This past year the Institute also established a seminar series. The series, which focuses on clean energy, especially in the area of fossil fuels, was extremely successful and we saw talks from external industrial professionals and government representatives as well as Penn State faculty. The talks were well attended and received excellent feedback. We are planning to continue the series on a biweekly basis throughout the academic year and are in the planning stages for the fall semester speakers.

On July 1, 2013, I will be starting a one-year sabbatical leave. Much of my time will be spent working at Dalian University of Technology in conjunction with the JCER. Dr. Zuleima Karpyn, associate professor in petroleum and natural gas, will be taking over the day-to-day director activities during that time. Dr. Karpyn has been associated with the Institute for many years. She leads our petroleum and natural gas program as well as co-directing our center for quantitative imaging lab. I am sure she will be an excellent and capable interim director.

In closing, I hope you will find the contents of this issue interesting. Please let us know if you have any suggestions or comments.

Dr. Chunshan Song
Director, EMS Energy Institute
Associate Director, PSIEE
Distinguished Professor of Fuel Science and Chemical 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.

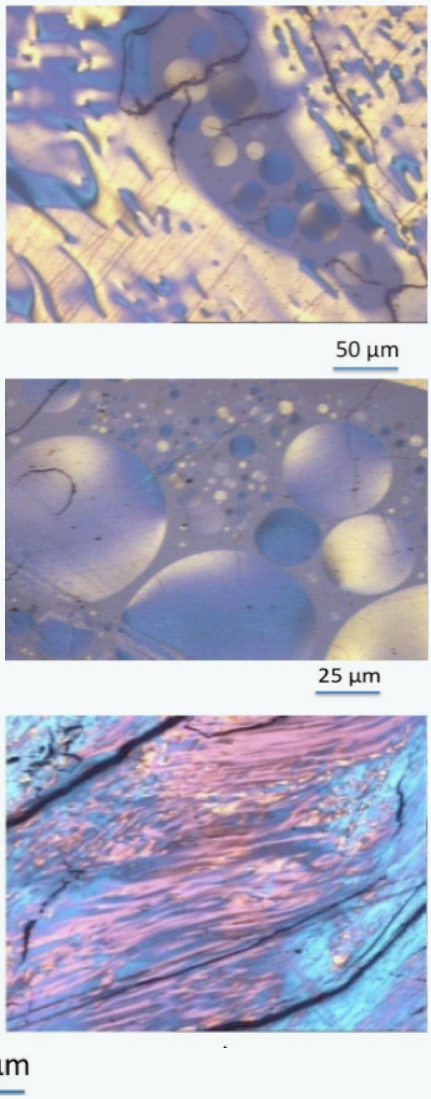
Using Polarized-light Microscopy to Assess Coke Quality for Manufacturing Carbon Anodes and Graphite Electrodes

-- Contributed by Semih Eser

Semih Eser, professor, energy and geo-environmental engineering, and co-workers Ronald T. Wincek, graduate student, and Gareth D. Mitchell, research associate, EMS Energy Institute, have been working on a project funded by Foster Wheeler USA Corporation that combines laboratory-scale and pilot-plant coking experiments using various feedstock materials. Coke samples produced from these experiments are embedded in epoxy resin and polished for examination under a polarized-light microscope.

Using a protocol developed by Eser, polished sections of the cokes are examined to generate optical texture data for assessment of the microstructural anisotropy of the coke samples. Structural anisotropy of the cokes results from the development of a liquid crystalline phase (carbonaceous mesophase) during coking, or carbonization. Two focus areas in this project include studying the role of feed components in mesophase development (formation of the coke texture) and seeking relationships between the coking conditions and the texture (microstructural anisotropy) of the resulting cokes. Microstructural anisotropy determines the properties of cokes that are critically important for manufacturing graphite electrodes from these cokes.

Eser traveled to Beijing in October 2012 to meet with officials of PetroChina Northeast Refining & Chemical Engineering Co., Ltd. for discussions on starting a research project at EMS Energy Institute on delayed coking of petroleum fractions. The project is likely to start in Summer 2013.



These polarized-light micrographs are examples of optical textures of semi-cokes obtained from laboratory experiments.

Coal Molecular Modeling—Light at the End of the Tunnel

-- Contributed by Jonathan Mathews

The ability to explore and predict behavior through atomistic simulations has altered scientific progression. Unfortunately, coal science has perhaps the greatest challenge in capturing the structural features, or to be more specific, the distribution of structural features that contributes to the apparent structural continuum.

Jonathan Mathews, associate professor, energy and mineral engineering, along with other Institute researchers have progressed the capturing and creation of coal and char structures using new approaches so that transformations and behavior can be explored. With the advances made by numerous EMS Energy Institute graduate students, colleagues, and other collaborators there is light at the end of the tunnel -- the use of atomistic structures in a meaningful manner. These advancements are centered on capturing the distributions of structural features.

With large-scale models or structures (>50,000 atoms) there is a change in the construction paradigm. Rather than using an inefficient and repetitive trial and error approach, Institute researchers use image analysis of high resolution transmission electron microscopy (HRTEM) lattice fringe micrographs to directly capture the aromatic structure of the coal samples. Using HRTEM imaging information, the structure is manipulated through scripting approaches to add heteroatoms that have the desired functionality. Model structures can then be used to determine theoretical analytical data, including pore size distribution, stacking, and orientation. The theoretical data can then be used to conform to actual experimental analytical values to aid in improving the model structure. This approach results in structures that are much larger and more accurate. In addition, construction of the structures takes hours or days, rather than months, leaving time to be invested in the scientific exploration of utilizing the structures rather than in the construction.

The figure below shows a montage of work demonstrating researcher's advances in structural representations, visualization, and utility. In collaboration with Adri van Duin, associate professor, mechanical engineering, and his group, reactive simulations are done on the model structures. To date, Institute researcher's have investigated pyrolysis of coal and combustion of char structures using high performance computing. They also explore the kinetics of liquefaction and dissolution with coal. Using these computational techniques, these researchers explore the optimization of experimental research and maximize the potential of that most wonderful black rock—coal!

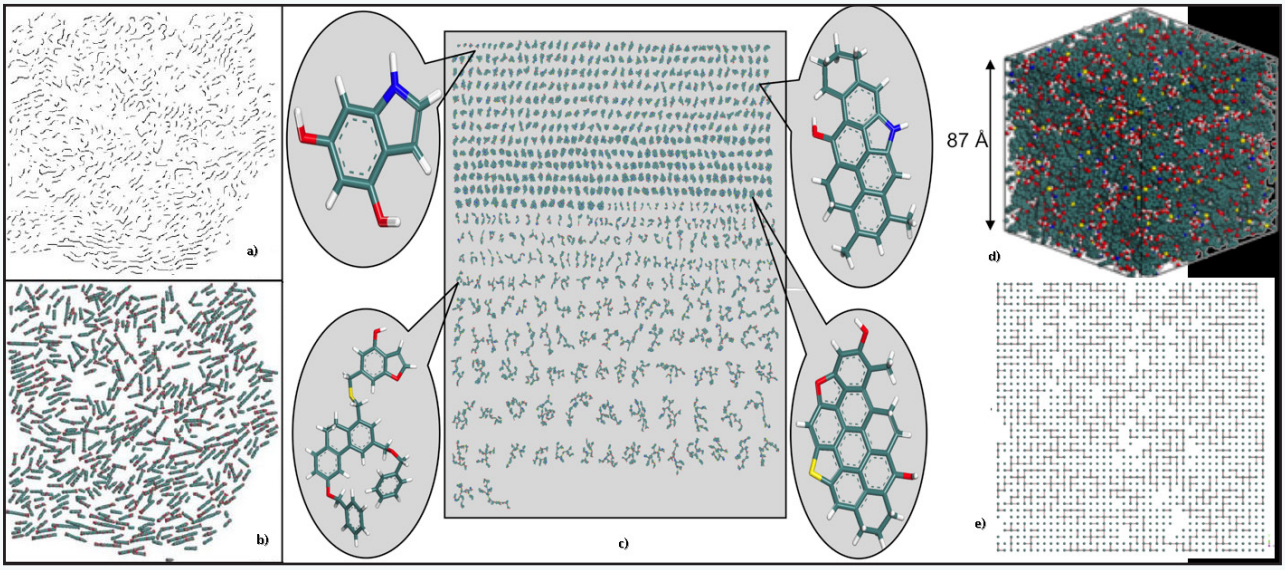
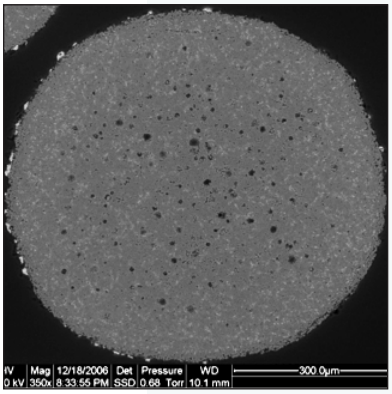
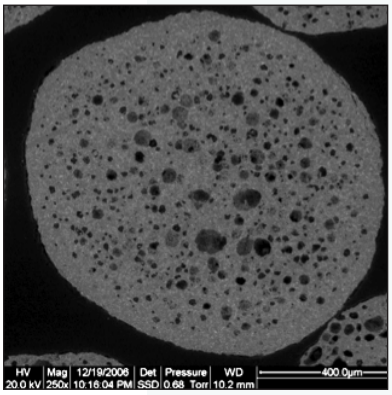


Figure 1. a) HRTEM lattice micrograph of coal, b) Slice model duplicating HRTEM observations (with added oxygen), c) Complexity of a structural distribution for a 50,000 atom representation (Illinois no. 6 bituminous coal), d) Lattice view of the same structure capturing the cross-linking with nodes being the hydroaromatic structure.

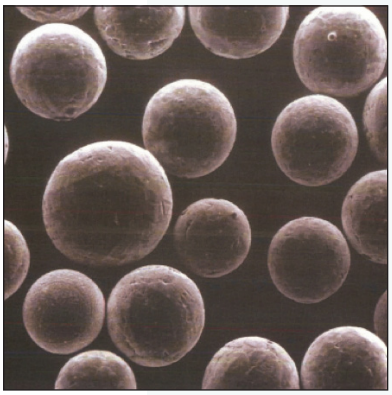
Development of High Performance Proppants for Stimulation of Oil and Gas Shales

-- Contributed by John Hellmann





Sintered bauxite proppant possessing a core-shell structure, effective specific gravity < 1 g/cc, and high strength (diametral compressive strengths in the range of 150-300 MPa). U.S. Patent #7,828,998



"Smart Proppants" that permit placement via magnetophoresis, re-stimulation of the proppant pack using alternating magnetic fields, and interrogation of the electromagnetic and/or acoustic response of the propped region.

The goal in hydrofracturing and stimulation of gas and oil wells is maintaining high permeability paths for resource recovery over the life of the well. This goal is commonly achieved with a slurry of surfactants, corrosives, and ceramic aggregates injected under pressure to induce and maintain fractures emanating from the well bore. The aggregates, or proppants, are pinned by closure stresses after the hydrofracturing pressure has been relieved, and "prop" the fracture open, thereby providing a permeable pathway for oil and gas to migrate to the well bore for subsequent extraction.

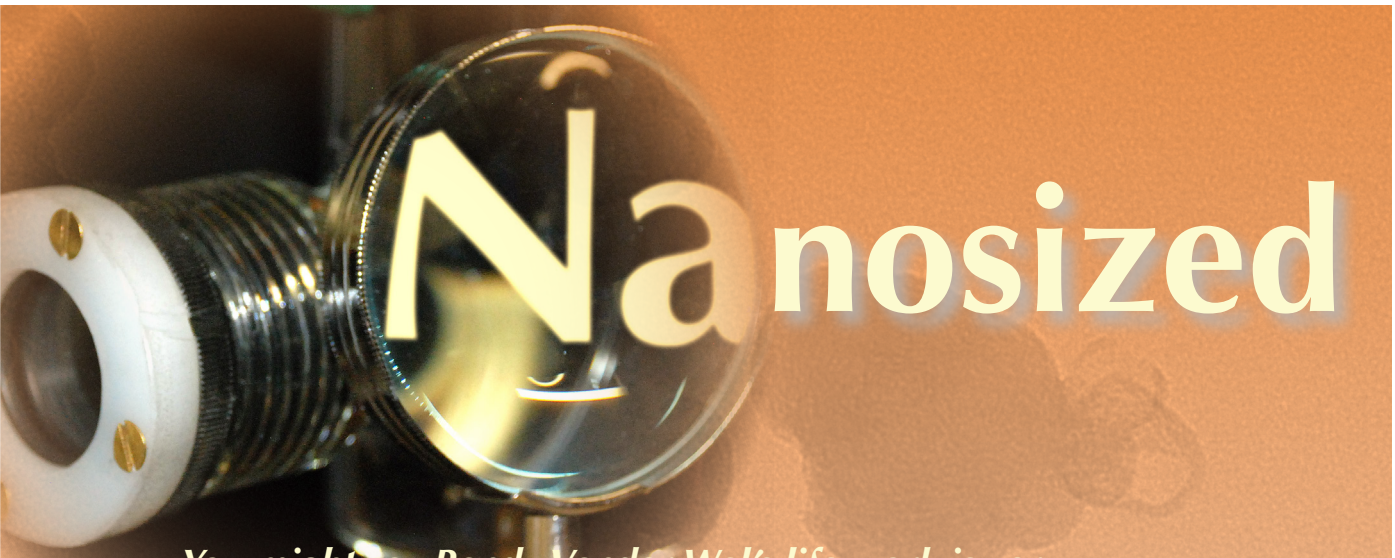
A wide range of materials have been employed as proppants over the years, including walnut hulls, Brady and Ottawa sands, glass, sintered bauxite and kaolin, and fused zircon. Current state-of-the-art proppants are predominantly derived from sintered high-grade bauxite. However, an increased demand for high-grade bauxite for aluminum metal production and use in industrial refractories has created a significant shortage and accompanying cost increase. The ability to manufacture high quality proppants from alternative raw materials, closer to the site of application, offers strategic benefit and substantial shipping cost savings potential.

Research at Penn State by Professors John Hellmann and Barry Scheetz, and their graduate students over the past ten years successfully addressed the development of high-strength proppants from a wide range of raw materials plentiful in regions in which oil and gas development is currently underway or emerging (e.g. Marcellus and Utica gas shales, the Bakken oil shales, and Eagle Ford gas and oil shales). In collaboration with a major manufacturer and worldwide supplier of proppants, Hellmann and his group developed high-strength, neutrally buoyant proppants from lower grade sintered bauxites. With the use of dopants to enhance sintering mechanisms, promote desirable microstructural evolution, and tailor surface reactivity, high performance proppants can be manufactured from these lower grade, more readily available bauxites and kaolins. In addition, they can be manufactured with a range of specific gravity that will enable their use with alternative stimulation fluids, such as supercritical carbon dioxide, allowing an entirely new stimulation technology in which environmentally sensitive additives commonly used in water-based stimulation fluids are no longer required.

Researchers have also employed industrial by-products for manufacturing high quality proppants that rival commercially available sintered bauxite-based materials in strength, hardness, specific gravity, and behavior in crush and permeability tests. These materials include chemically bonded pozzolonic materials (fly ash and slags); ion exchanged glass beads; and rhyolite, andesite and basalt-based glass-ceramics. Researchers are now extending this work to cuttings from the oil and gas well drilling process itself. Drill cuttings contain trace quantities of naturally occurring radioisotopes (referred to in the industry as Technology Enhanced Naturally Occurring Radioactive Materials – TENORMS). In addition, drill cuttings contain significant amounts of mineral oils left over from the drilling process. Therefore, the drill cuttings must be treated as residual waste and disposed of in engineered landfills. Removal of these materials from the waste stream and employing them as raw materials for proppant manufacturing offers a tremendous environmental benefit, while returning them to the geological strata from whence they came.

In related work, Hellmann and collaborators are developing "Smart Proppants", in which the electromagnetic properties are tailorable using metamaterial design principles. These characteristics are being engineered to permit precise placement of the proppants, stimulation of the proppant, and detection of proppant placement.

Funding for this work has come from the U.S. Department of Energy, Penn State's Stripper Well Consortium, several proppant manufacturers, and the energy industry. The results of this work are currently being licensed to a variety of proppant manufacturers and end users.



Nanosized

You might say Randy Vander Wal's life work is very, very, very, very tiny. The nanoscale materials he studies are beyond the reach of even the strongest magnifying glass. But the implications of his research are vast and they stretch across many disciplines.

When I sat down with Randy Vander Wal, professor, energy and mineral engineering and materials science and engineering, to talk about his research, there was one question I was dying to ask. *How do you use those lasers in your lab?*

"I grew up using multiple lasers for spectroscopy," Vander Wal said. "It was a very arduous task." As a postdoctoral scholar at Sandia National Laboratory, he continued working in laser spectroscopy, a technique in which lasers are used to excite a sample, allowing the researcher to analyze the range of electromagnetic radiation emitted or absorbed by the sample.

Later, he began using lasers as an engineering tool for material processing instead of spectroscopic diagnostics. With lasers, researchers can heat materials, anneal materials, and induce phase transitions (transitions between solid, liquid, or gaseous states of matter) at incredibly fast rates. Think about the time it takes an ice cube to melt. Instead of waiting hours, minutes, or seconds – depending on the external environment – lasers can alter the state of materials in 10s of nanoseconds. To the human eye it seems instantaneous.

Vander Wal considers himself to be a diverse chemist and somewhat of an opportunist. His research varies greatly and, depending on the sponsor, ranges from soot to nanomaterials to energy. However, the more he talks about his work, the easier it is to see how each of these areas is connected.

"I consider the periodic table as the playground and build from there," Vander Wal said. It was the intellectual challenge that drew him to the realm of nanomaterials. While early on, he had considered work in the fields of astrophysics or nuclear physics, instead he worked as an engineer at NASA for 18 years. Vander Wal received bachelor degrees in physics, chemistry, and math at Calvin College and completed his doctoral degree in chemical physics at the University of Wisconsin.

Prior to coming to Penn State, the focus of Vander Wal's work was on space and aeronautics research as he managed a contract research group at the NASA-Glenn Research Center in Cleveland, Ohio. The group worked on batteries, sensors, composites, laser diagnostics, and more. The space research, for example, focused on the needs for long-term human sustainability in space. *What is needed for a closed-loop system? What problems could arise on the surface of Mars or the moon and how could they use resources at hand for long-duration stays without resupply?* Work also included testing nanomaterials for applications such as lubrication in satellites and solar sails, which require dry lubricants that are radiation resistant, heat tolerant, and last for decades – essentially the lifetime of the device.

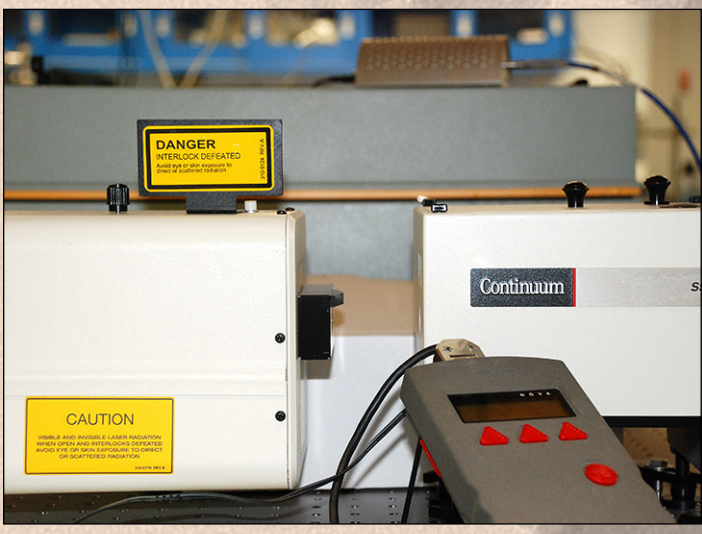
Vander Wal has been immersed in nanomaterial research for at least the last dozen years with research ranging from the synthesis of "nanocarbons" to metal oxide semiconductors. Strictly speaking,

nanomaterials are materials with two dimensions less than 100 nanometers (a nanometer is 100,000 times smaller than the diameter of a typical human hair). Nanomaterials can be engineered, but they also exist in nature and have been in existence, quite literally, since the dawn of time. Carbon black, a product of the incomplete combustion of heavy petroleum byproducts, has been around for nearly 100 years and used for core applications such as reinforcing rubber products and in more recent times, conductive plastics, toner, etc. While Vander Wal noted carbon black is not technically considered a nanomaterial, it's on that scale. Nanomaterials also have a long history in catalysis research, although the term dispersion was historically used to describe how finely divided the catalyst particles were.

Since nanomaterials are too small to be seen even with conventional microscopes, finding and characterizing these particles has only been possible in recent decades with the help of new tools. But, as if to make up for lost time, the number of applications for these materials has since proliferated. Just walking through your house, you could touch dozens of items that contain nanomaterials, linoleum floor tiling, cosmetics, car body parts, paints, and common medications. Many food products use nanoscale silica as a binder, and nanoparticles of titanium dioxide or zinc oxide are what makes sunscreens appear white. Additives in the form of nanoparticles enhance various properties of materials, making them stronger or tougher, or conductive as in antistatic packaging.

"I consider the periodic table as the playground and build from there."

In order to really understand how nanomaterials work, one has to look at surface area and related surface properties instead of focusing on a strict size classification. The fundamental principle that nanomaterials rely on is – the smaller the particle size, the higher the surface area. The classic example is to take one cubic centimeter of material and finely divide it into small cubes, each cube one nanometer in size. The result would be a billion trillion cubes with a combined surface area equivalent to that of a football field. A general hallmark of nanomaterials is that the surface area is vastly magnified from that of a solid material of the same mass.



Laser equipment in Dr. Vander Wal's research lab.

The idea of surface area is very important to understanding how nanomaterials fit into the energy field. Since coming to Penn State, Vander Wal's focus has been on the intersection between energy and nanomaterials.

"Why is there an intersection? How do they even fit together? Usually when people think about energy, they think about combustion, but nanomaterials are generally valuable, something you don't necessarily want to burn," Vander Wal said. He explains that most energy processes occur at an interface and, since nanomaterials have large amounts of interfacial surface area, nanomaterials can serve as interfacial modifiers. When those processes occur at multiple interfaces the result can be faster reaction times, better performance, and longer lifetimes.

One good example of how this concept can transfer into energy applications lies in batteries. Picture a battery as a brick of material. The transport of energy would be extremely slow through that solid material. But if you could subdivide that brick into billions of sheets or layers you could achieve a much faster reaction rate because the higher surface area enables faster charging or discharging of the battery. In addition to batteries, nanomaterials can enhance the performance of materials used in every energy process from harvesting and generation to storage and transfer. Just a few of these applications could include enhancing materials for the harsh environments in the oil and gas industry, fuels cells for vehicles, new catalysts for petrochemicals, and efficient solar cells sustainable energy.

Vander Wal's "environmental niche" lies in soot analysis with the goal of making combustion environmentally friendly, or better yet, health friendly.

"If you look at soot closely enough – the nanostructure – you can start to understand how it's formed," Vander Wal said. " And if you understand how it's formed, you might be able to design a process, or alter a process that results in less soot."

One of Vander Wal's graduate students, Chung-Hsuan Huang, has been looking at soot from jet aircraft using alternative fuels. While the government is very interested in fuels from alternative sources, other than petroleum, what those fuels produce in terms of particulate soot is essentially unknown and uncharacterized. Certainly these emissions have implications for the environment, but there is also a concern about human health. We don't know what are we breathing at the airport. If you smell "exhaust" (incomplete combustion gases), it's more than likely you are breathing some particulate and the smaller it is, the worse it is for your health.

Vander Wal has also proposed looking at the health and safety effects of exposure to nanomaterials in manufacturing. As applications for nanomaterials continue to increase, there is a concern about absorption through the skin or accumulation in the lungs for workers since the particles are so small. Beyond that, he continues to look for opportunities to collaborate on research.

Talking to Vander Wal, I can see how absorbed he is in his research. And he believe that as a professor, he can instill that passion and interest in his students as well. He emphasizes that to be successful and find fulfillment, researchers have to be creative and highly engaged, and approach their work with the mindset of "I like thinking about this."

Chung-Hsuan Huang, a graduate student, works in Dr. Vander Wal's lab at the EMS Energy Institute.

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**.

Heather Harpster
Administrative Support Assistant
EMS Energy Institute

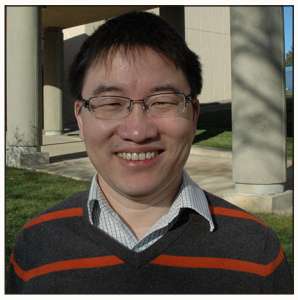
Heather Harpster assists with the preparation and submission of grant proposals, creates and maintains documents and files, and assists faculty with the submission of reports. She also helps generate, prepare, and maintain financial reports/spreadsheets, and acts as the Institute's key custodian. Prior to coming to the EMS Energy Institute, she was a Career Services Assistant at South Hills School of Business and Technology. In that position, she designed various materials and worked with students, graduates, and employers.

Stacey Horner
Administrative Support Assistant
EMS Energy Institute

Stacey Horner 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. Prior to joining the Institute, she worked as a medical assistant.

Yaming Li
Visiting Scholar
EMS Energy Institute

Yaming Li is a professor at the State Key Laboratory of Fine Chemicals, Dalian University of Technology, China. He is currently a visiting scholar at the EMS Energy Institute. Li's research focuses on designing and evaluation of transition metal catalyzed cross coupling reactions, C-H activation, and carbon dioxide transformation and utilization. Projects relate to the conversion of carbon dioxide into chemical feedstock using late transition metal catalysts, for example the development of Ni and Cu catalysts for the coupling of Allyl chlorides with carbon dioxide into acrylic acid; mechanistic studies into the catalyzed carboxylation; and Cu catalyzed C-C, C-N, C-O and C-S Ullmann-type Coupling Reactions.



Shimin Liu
Assistant Professor
Energy and Mineral Engineering

Shimin Liu joined Penn State as assistant professor in 2013 after completing his doctoral degree from Southern Illinois University. His expertise is in gas storage and transport mechanism in coalbed methane reservoirs and carbon sequestration in geological formations, especially in the areas of laboratory characterization of gas-coal interaction, analytical modeling of gas transportation under in situ conditions for carbonaceous rocks, volumetric behaviors of coal with gas adsorption/desorption, carbon dioxide sequestration in coal seams, and enhanced gas production. His research interests include: reservoir assessment of unconventional gas resources, reservoir stress changes with depletion, gas drainage from coal mines, and geological carbon sequestration.

EMS Energy Institute Welcomes Interim Director

Zuleima Karpyn, associate professor and Quentin E. and Louise L. Wood Faculty Fellow in Petroleum and Natural Gas Engineering will serve as the interim director of the EMS Energy Institute for one year while Director Chunshan Song is on sabbatical leave. Dean William Easterling, College of Earth and Mineral Sciences, announced that Karpyn's appointment will officially begin July 1, 2013. She has already been working closely with the Institute's leadership.

Karpyn has been active with the EMS Energy Institute for many years and is currently the petroleum and natural gas program director at the EMS Energy Institute. In addition, she is co-director for the Center for Quantitative X-ray Imaging (CQI), located in the Institute. Karpyn is an expert on multiphase flow and transport phenomena in porous media, as well as digital rock physics, including applications in reservoir engineering, unconventional resources characterization, underground hydrology, and environmental remediation. Her research group studies multiphase flow and transport phenomena in porous media to improve the representation and prediction of hydrocarbon recovery processes, underground pollutant migration, carbon sequestration, and the natural flow of ground water. She uses X-ray computed microtomography to characterize structural properties of porous media, rock fractures, mineralogy, and to monitor fluid-fluid and fluid-rock interactions in dynamic systems.

Karpyn holds a bachelor's degree in chemical engineering from Universidad Central de Venezuela, and master's and doctoral degress in petroleum and natural gas engineering from Penn State. In 2003 she became an instructor in the Department of Energy and Geo-Environmental Engineering at Penn State and in 2005 she became an assistant professor for the John and Willie Leone Family Department of Energy and Mineral Engineering (former Department of Energy and Geo-Environmental Engineering).

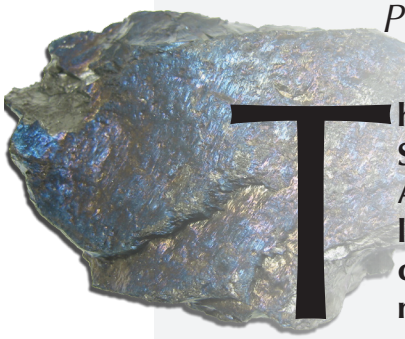
Karpyn has over 55 publications in refereed journals and non-refereed conference proceedings and has been the recipient of several awards both within and outside of Penn State. She received the 2005 Penn State Wilson Research Initiation Grant, the 2008 Faculty Early Career Development (CAREER) Award granted by the National Science Foundation, the 2008 Outstanding Service Award for the American Association of Petroleum Geologists – Eastern Section, and the 2010 Penn State Wilson Award for Excellence in Teaching.

Karpyn is an active member of the Society of Petroleum Engineers, the Society of Core Analysts, the American Chemical Society, and the American Geophysical Union. In addition, she has been involved with several technical conferences as program committee member, technical review committee member, and session chair. She is also associate editor for the Society of Petroleum Engineers Journal, and has served as a guest editor for the *International Journal of Oil, Gas and Coal Technology* for a special issue on Pore-Scale Flow and Transport Processes in Petroleum Reservoirs, 2010 to 2011. From 2004 to 2009, Karpyn served as the elected chair of the scholarship program for the Pittsburgh Petroleum Section of the Society of Petroleum Engineers, and from 2003 to 2009, she was the faculty advisor for the Penn State Student Chapter of the Society of Petroleum Engineers.

"Zuleima has been leading the petroleum and natural gas program and co-directing CQI at the EMS Energy Institute for several years. I am sure she will be an excellent and capable interim director," said Song.

Looking for Coal?

With the Acquisition of a New Coal Sample Bank, the Institute can Provide Researchers with Samples to Almost Any Specification.



The EMS Energy Institute recently acquired the Argonne Premium Coal Sample Bank, one of the most extensively used sample banks in the world. Argonne National Laboratory, where the coals were previously housed, is no longer active in coal research. However, the research significance of these coals made it essential to find a new location where the samples could be maintained properly and continue to be distributed.

Penn State has a long history of coal research dating back to the 1930s. In 1957, the College of Earth and Mineral Sciences officially established its coal research program. Ten years later, with funding from the U.S. Department of Energy, the College developed the Penn State Coal Sample Bank and Database. Today the EMS Energy Institute continues to be an active center for coal research with a significant percentage of our funding tied to coal programs. Funding from various federal and state government agencies has allowed the Institute to continue operating as well as gradually expand the collection. The Penn State sample bank holds 38 well-preserved Department of Energy coal samples and nearly 500 historical samples as well as analytical data on 1,270 samples. The coals in this collection represent a wide spectrum of the major coalfields of the United States and were selected in order to achieve a useful distribution of important coals by rank, geologic province, maceral composition, sulfur content and forms, ash yield, and composition.

The Argonne coals are a valuable complement to the Institute's existing sample bank. The Argonne sample bank contains eight coals, including lignite, subbituminous coal, high volatile, medium volatile, and low volatile bituminous coal, as well as a liptinite-rich, an inertinite-rich, and a coking coal. The samples in this collection are as chemically and physically identical as possible. They are well characterized and packaged to be stable over long periods of time.

The Argonne Premium Coal Sample Bank was conceived in 1981 at a coal sample bank workshop. Funding for the sample bank was later made available from the Division of Chemical Sciences of the Office of Basic Energy Sciences of the U. S. Department of Energy. From 1983 to 1985 Argonne National Laboratory designed and built a facility to house the samples. Since then, over 33,000 samples have been shipped to government, academic, and industrial researchers all over the world, according to Argonne National Laboratory.

The Argonne coals, mined from locations selected to represent significant differences among the available coal types in the United States, have been packaged in humid nitrogen environments as free of oxygen as possible and carefully characterized by a variety of techniques. About 80 percent of the samples are sealed in five-gallon carboys for storage and the remaining are sealed in glass ampules for distribution. Because of the premium quality and sample uniformity, these coals are ideal for researchers to generate comparable results with other labs and to determine if apparent difference in results between two laboratories is due to the samples or the experimental technique.

The Argonne coal collection is an important acquisition for the Institute because it serves a different purpose than the Penn State sample bank. Researchers can now look to the Institute to provide them with coal samples for any of their research needs. In addition, the Institute's faculty and staff can provide assistance in identifying samples that match specifications or best suit a researcher's needs. For more information on our sample banks, visit the outreach section of our website, **www.energy.psu.edu/energyoutreach**.

A shelf full of sealed glass ampules containing coal samples.

A New Seminar Series Brings Energy Research Experts to the Institute

The EMS Energy Institute has established a new seminar series, Energy Exchange, as part of the Institute's outreach mission. The seminars focus on highly relevant energy topics, especially in the area of fossil fuels. Energy topics discussed include new innovations in carbon dioxide utilization, clean coal, petroleum and natural gas, fuel cells, and more.

For Spring 2013, the theme was clean energy and experts from academia and industry gave talks on a wide variety of topics. The talks, which are open to anyone, provide an in-depth look at current research endeavors as well as an opportunity for networking and the exchange of ideas. When possible, we offer students the opportunity to meet with external speakers in a small group setting.

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.** Feedback and speaker suggestions are always welcome at **ei-communications@ems.psu.edu**.


Bruce Rising


John R. Hellmann


Zuleima Karpyn


James Freihaut

energyXchange
A seminar series on energy science & technology.

Spring 2013 Speakers

James Freihaut
Director, DOE Mid-Atlantic Clean Energy Application Center

Zuleima Karpyn
Associate Professor, Petroleum and Natural Gas Engineering

John R. Hellmann
Associate Dean, Graduate Education and Research, College of Earth and Mineral Sciences

Bruce Rising
Strategic Business Manager, Siemens Power Systems Sales

Hamid Sarv
Assistant Director, Babcock & Wilcox Research Center

Robert Romanosky
Deputy Director, DOE/NETL Office of Coal and Power R&D

Mark your calendar Fall 2013 Dates

September 4
September 18
October 9
October 23
November 6
November 20
December 4

Undergraduate Students find research offers a learning experience unlike anything else

Understanding the Benefits of Undergraduate Research

Undergraduate research opportunities can open doors for students as they take the next step in their journey. For students considering graduate school, a research experience can help make that decision by giving the student a taste of what's to come. Students who have never even considered graduate school might realize they have an affinity for research. Even students who don't plan to continue with a graduate education, can gain a huge edge in the job market from having a experience with research. As students begin to enter the job market, they are realizing that employers are looking for potential employees who have real-world experience and an understanding of the research process. Research gives students a greater understanding of the concepts and ideas they study as part of their coursework and working through an individual research project forces students to look for answers beyond their textbooks and navigate through issues, developing essential critical thinking skills.

Although the majority of the students working at the Institute are graduate students, we take every opportunity to support undergraduate research for interested students. We offer research experience for wage payroll students, students enrolled in the senior research-focused Energy and Geo-Environmental Engineering (EGEE) 494 or the industrial-oriented capstone energy design course (EGEE) 464 as well as for students completing independent coursework or honors thesis projects. The students that work at the Institute benefit from working along side faculty, research staff, and graduate students. They receive guidance and training, but are pushed to think for themselves through processes and outcomes.

Educating Students on Research Opportunities

As part of our outreach and recruitment efforts, the EMS Energy Institute participates each year in the Earth and Mineral Sciences Exposition (EMEX). Sharon Falcone Miller, director of the Office of Student Development at the Institute, coordinates the effort. She is usually joined by one or two students currently working on research projects at the Institute who are able to discuss their work and answer questions on their experience. Dr. Miller spends the day talking to attendees and providing an overview of the opportunities available through the Institute in one of our nine research focus areas with the goal of educating potential students on the benefits of having a research Institute available to them. Many students are unaware of the option to complete research as an undergraduate and how that experience can benefit them in the future.

EMEX is the College of Earth and Mineral Sciences annual open house. All high school students, current Penn State students, and transfer students who are considering an EMS major are invited to attend. Faculty, staff, students, and alumni answer questions and talk to attendees about EMS majors, curriculum requirements, career opportunities, student life, and special features of the College of Earth and Mineral Sciences. This year the event was held on March 16 and over 425 prospective students and their families participated.

For more information on student research or the opportunities available through the EMS Energy Institute, visit the Office of Student Development website, **www.energy.psu.edu/osd/index.html**, or contact Sharon Falcone Miller, **sfm1@psu.edu.**

"The opportunity to participate in undergraduate research at the EMS Energy Institute was a way for me to apply the knowledge I learned in my classes to real world problems. ***My research experience taught me more about designing and building experimental set-ups, data collection, and data analysis than any of my classes because instead of following a set of prescribed lab procedures, I was challenged to collaborate with my colleagues and solve open ended problems.*** *My mentors taught me a wide range of skills from how to approach research problems, to giving presentations to collaborators, to using Swagelok fittings. I was very fortunate to be able to publish a first author paper on my work, as well as present my project at two technical conferences. My work at the Institute motivated me to seek new research opportunities and to apply to graduate school."*

-- **Laura Bradley** ('11) is a PhD candiate at the University of Southern California.

"Participating in research projects as an undergraduate student helped me to develop many skills that are difficult to attain through regular classwork. *EMS Energy Institute research projects were an opportunity to work with a team of students to design, construct and operate experimental systems under the guidance of talented researchers."*

-- **Derek Hall** ('12) is a graduate student working at the EMS Energy Institute.

"Unlike the normal classroom atmosphere where a certain curriculum must be followed, the senior research project is chosen by each student to focus on their strengths in addition to interest in the field of engineering. [Offering] a choice [for students] to research a topic that the student has fully chosen on their own, creates a learning experience unlike others. ***The experience teaches long term self-reliance and time management which complement the skills required in the working field of today's industries."***

-- **Ken Meagher's** ('13) project examined the properties of the coal-derived jet fuel JP 900 as they relate to transportation and miliary diesel fuel needs. He plans to work in combustion analysis in the transportation industry.

"Participating in a research project as part of my undergraduate degree helped me connect with other students and professors who share similar interests. ***The challenges associated with working on a project helped further develop skills in solving complex problems."***

--**Eric LaRow** is an undergradaute student in the Penn State Schreyer Honors College. His research at the Institute focuses on characterizing and improving the performance of a CuCl electrolyzer as part of the CuCl hybrid thermochemical cycle.

"I was able to learn more about a topic that was directly relevant to my interests, and I had the freedom to take an in-depth look at something that I am passionate about. It wasn't always easy along the way, and there was a good deal of problem solving and troubleshooting I had to do to get things to work; sometimes a reaction would go wrong, or scheduling proved more difficult than I expected. In the end, I was able to work things out and accomplish what I set out to do. ***I learned how to adapt and shape my project into something meaningful, something that I'm proud of.*** *I have no doubt the experience will be valuable to me when I begin to work in the alternative energy field."*

-- **Karl Koerner** ('13) completed a project on the economic viability of converting waste fryer oil into biodiesel in the State College area. He plans to work in the alternative energy field and eventually pursue an advanced degree in order to teach.

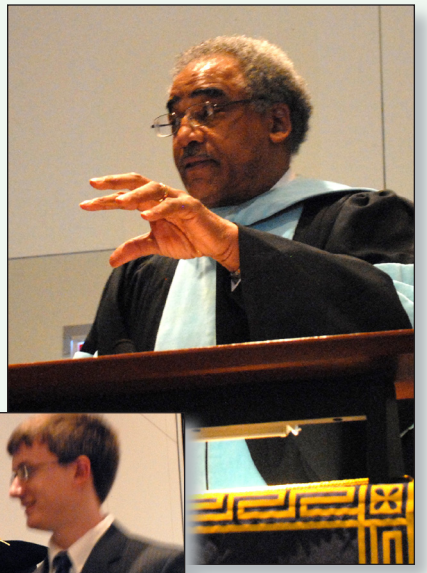
Institute Serves the Greater University Community by Housing Penn State Chapter of National Honor Society

For over 15 years, the EMS Energy Institute has housed the Penn State Chapter of the national honor society, Phi Kappa Phi. Phi Kappa Phi is an undergraduate honor society open to students in all majors across all Penn State campuses. It recognizes excellence across all academic branches. The chapter elects members from only the top 7.5 percent of the junior class and top 10 percent of the graduating class. Each year, staff at the EMS Energy Institute work to notify students and organize a banquet to recognize those students.

Sharon Falcone Miller, senior research associate at the Institute and associate professor in Energy and Mineral Engineering, is the current president, a position that she has held since 2006. Prior to Miller, Peter Luckie, Professor Emeritus in Energy and Mineral Engineering, served as chapter president for 10 years.

This year the chapter held its induction ceremony on March 24. The chapter initiated 313 new members, of which 80 were able to attend the ceremony. Students at the ceremony were addressed by guest speaker Edgar Farmer, Professor Emeritus of Higher Education, College of Education, Penn State.

Phi Kappa Phi is the oldest of all discipline honor societies at Penn State, established in 1900. In 1900, the presidents of the University of Maine, the Pennsylvania State College (now The Pennsylvania State University), and the University of Tennessee pledged their support, and the society thus became national, with three chapters. Currently there are over 300 chapters of Phi Kappa Phi. The society draws its name from the classical Greek words for the first three letters of its motto: philosophia krateito photon, "let the love of learning rule humanity."



In addition to the annual ceremony, the Penn State Chapter of Phi Kappa Phi also sponsors awards for undergraduate students. The Peter T. Luckie Award, started in 2008 to honor Peter Luckie, is presented to top juniors at the Undergraduate Research Exhibition. This year, Jordanna Lemba received the award for excellence in research in behavioral and social science, and Breecher Hartley Watson received the award for excellence in research in engineering and physical science. These students were joined by 170 entries from undergraduate students from all Penn State campuses.

In December, Phi Kappa Phi sponsored the Freshman Award as part of the College of Earth and Mineral Science's first undergraduate exhibition. Jared Fisher, Mohammed AlSaud, Mohammed Alnahas and Sven Alagic received the award for their Davis-Besse Nuclear Reactor Vessel Head.

For more information on the Penn State Chapter of Phi Kappa Phi, visit the website at **www.energy.psu.edu/pkp.**

Penn State's New Natural Gas Center to Keep Pennsylvania at Forefront of Industry

-- Parts from the College of Earth and Mineral Sciences news story

Penn State is bringing together one of the largest contingents of natural gas experts in the United States with the establishment the Institute for Natural Gas Research (INGaR). The institute is expected to provide much-needed study into this important form of energy at a time when the U.S. Energy Information Administration projects U.S. natural gas production will increase 44 percent by 2040.

INGaR members will work closely with industry, and state and federal government partners to conduct independent scientific research in the broad area of natural gas. Through the institute, researchers and students will develop interdisciplinary approaches to study the complex processes involved in natural gas exploration, production, transmission, storage, processing, combustion, infrastructure, and water transport, usage and impact.

Chunshan Song, director of the EMS Energy Institute, was part of the team responsible for writing the initial white paper that was used to establish the INGaR. A major goal of the new institute is to support the ongoing development of a natural gas-based economy that will allow the country to eventually consume a predominantly domestic supply of gas for many years to come.

INGaR is a collaborative effort between the Penn State colleges of Earth and Mineral Sciences and Engineering. Currently, more than 50 faculty members in various departments at Penn State have significant research interests and active research programs in natural gas and related areas. Over the next four years, 12 new faculty members will be hired to further strengthen key areas and produce the needed joint information and knowledge that will solve some of the complex challenges related to the exploration and use of natural gas.

The EMS Energy Institute plans to develop more collaboration in conjunction with this new institute. In addition, we plan to expand on current natural gas research at the EMS Energy Institute as well as bring in new research. Faculty affiliated with the EMS Energy Institute will perform research in such areas as fluid flow in porous media, gas-to-liquids conversion of fuels, and gas and liquids combustion systems.

While the prospects for shale gas production are promising, particularly in Pennsylvania, there remains considerable uncertainty regarding various aspects of this resource and its overall impact, including environmental concerns. Through INGaR, Penn State can lead the nation in world-class expertise in natural gas that can help Pennsylvania retain a strong competitive advantage in natural gas for decades to come.

INGaR has started meetings with potential industry affiliates during which the Institute is serving as a catalyst to connect the Penn State researchers with their counterparts from these industries and to establish research agendas. Several companies in Pennsylvania and elsewhere have pledged support for INGaR and the first collaborative research proposal focusing on joint research work with industry is expected to be submitted this summer.

"INGaR will have the depth and breadth of expertise to tackle comprehensive problems encountered in the exploration, drilling, transport and use of natural gas, including the environmental challenges of extraction," said William E. Easterling, dean of the College of Earth and Mineral Sciences.

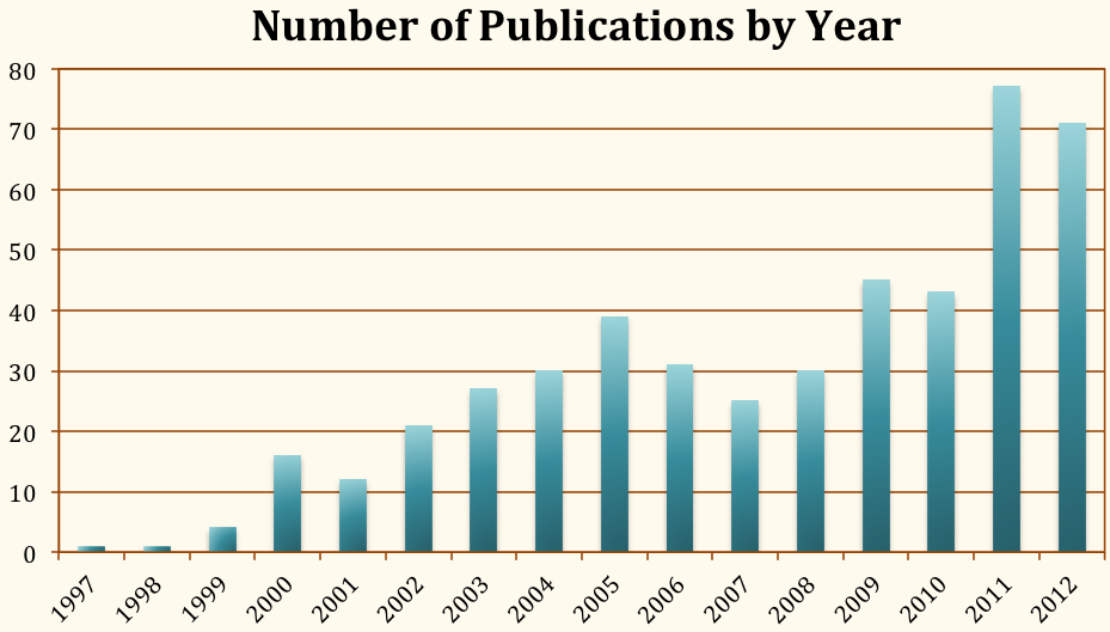
Turgay Ertekin, department head, John and Willie Leone Family Department of Energy and Mineral Engineering, and professor of petroleum and natural gas engineering, and Andrew Zydney, department head, Department of Chemical Engineering, and professor of chemical engineering, will co-direct INGaR during the search for a permanent director. INGaR will be overseen by an external advisory board consisting of academic, government, and industry experts who will help guide INGaR research toward topics that provide maximum benefit to companies, promote scientific excellence, and help educate the public on the facts of natural gas.

Publications Demonstrate Value of Research*

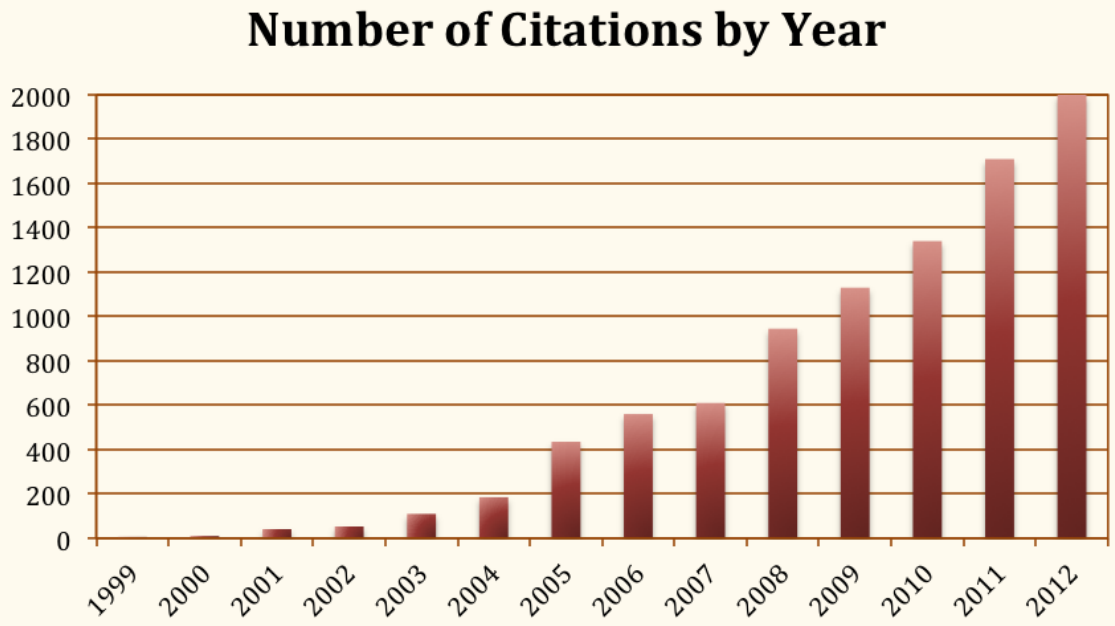
Faculty, students, and other researchers at the EMS Energy Institute undertake projects that are highly relevant to current world energy issues. Although the focus of the Institute's research has long been dominated by fossil energy, technical expertise over the last several years has broadened to include a wide range of topics, such as renewable and fossil energy, combustion, fuel processing, fuel cells, hydrogen energy, environmental issues, geoscience, and carbon dioxide management. The impact of this research goes far beyond the walls of Penn State and far beyond the boundaries of the United States. EMS Energy Institute faculty and students present their work throughout the world at international conferences and publish papers in some of the most respected journals in these fields.

The EMS Energy Institute was officially established in the College of Earth and Mineral Sciences at Penn State in late 1996 under Dean Eric Barron. It was largely based on the former Energy and Fuels Research Center, and in 1996 it consisted of the former combustion laboratory, the laboratory for hydrocarbon process chemistry, and the organic petrology laboratory. Alan Scaroni was the director of the Energy and Fuels Research Center, and therefore became the first director of the EMS Energy Institute. He served as director from 1996 to 1998 when he accepted a position as department head of Energy and Geo-Environmental Engineering. Harold Schobert then served as the director of the EMS Energy Institute from July 1998 to 2006. Scaroni returned as interim director for a brief period until Chunshan Song was appointed director in May 2007.

The first publication that included the EMS Energy Institute as an affiliation appeared in May 1997. By 2007, Institute researchers were publishing between 25 and 30 publications each year. Since then, that number has continued to climb. Currently, Institute researchers publish about 70 refereed journal articles a year. In addition, more of these papers appear in publications designated as high-impact factor journals and the number of articles based on collaborative research has grown.



Information for this article was obtained through ISI Web of Knowledge, Web of Science. The search terms were such that it included refereed publications by EMS Energy Institute faculty and researchers through 2012. Only publications that had the EMS Energy Institute listed in the affiliation section are included. Institute faculty have many other publications that do not fall under the refereed journal article designation. All publications can be found on our website* ***www.energy.psu.edu/publicationsAll.html**.*



Perhaps an even greater indicator of the extensive visibility and high quality of this research is the substantial increase in citations to Institute-affiliated publications. Citations from articles referencing the EMS Energy Institute began to appear in 2000. Today, EMS Energy Institute publications collectively receive over 2,000 citations a year in the Science Citation Index. Just five years ago, publications affiliated with the Institute were receiving about 650 citations a year.

Since 1997, EMS Energy Institute researchers have published over 494 journal articles that have been cited over 9,700 times. The high number of citations credited to Institute faculty and students demonstrates the importance of their work within the greater national and international scientific communities.

EMS Energy Institute Research Programs

Descriptions of these programs and contact information for key researchers can be found at **www.energy.psu.edu**.

Carbon Materials Program
Program Director: Semih Eser

Coal Science & Technology Program
Program Co-directors: Jonathan Mathews and Sarma Pisupati

Clean Fuels & Catalysis Program
Program Director: Chunshan Song

Energy Economics Program
Program Director: Andrew Kleit

Electrochemical Technologies Program
Program Director: Serguei Lvov

Nanomaterials Program
Program Co-directors: Randy Vander Wal and Angela Lueking

Petroleum & Natural Gas Program
Program Director: Zuleima Karpyn

Stationary Power Program
Program Director: Bruce G. Miller

Sustainable Energy Program
Program Director: Joel Morrison

Institute Hosts Two International Research Conferences this Year

International Conference on Carbon Dioxide Utilization

The Twelfth International Conference on Carbon Dioxide Utilization (ICCDU), will be held from June 23-27, 2013, in Alexandria, VA. Chunshan Song, director of the EMS Energy Institute and Distinguished Professor of Fuel Science, is the conference chair and is responsible for all of the conference details along with an organizing committee and a local arrangement committee.

ICCDU, which began in 1991 in Nagoya, Japan, provides a multi-disciplinary forum on recent innovations in fundamental and applied aspects of carbon dioxide utilization. In 2013, the focus will be on carbon dioxide conversion and utilization for chemicals, fuels, and materials for sustainable development. The goal of the conference is to facilitate the advances in carbon dioxide research and bring together the academic and industrial communities for the exchange of ideas, concepts, and innovations.

ICCDU XII will include about 220 presentations in three tracks: CO_2 Conversion, CO_2 Utilization, and CO_2 Capture and Separation. Over 25 countries are represented at the conference and organizations presenting include government agencies, industries, and universities. Invited speakers are listed below, with plenary speakers in bold. Visit our website for more information, including their presentation titles.

- **Michele Aresta, *University of Bari, Italy***
- Ronald R. Chance, *Algenol Biofuels, USA*
- Emily Barton Cole, *Liquid Light, Inc., USA*
- **Anthony Cugini, *National Energy Technology Laboratory, U.S. DOE***
- Yuichiro Himeda, *Nat. Institute of Advanced Industrial Science and Tech., Japan*
- Osamu Ishitani, *Tokyo Institute of Technology, Japan*
- Gabor Laurenczy, *École Polytechnique Fédérale de Lausanne, Switzerland*
- Xiao-Bing Lu, *Dalian University of Technology, China*
- **Sang-Eon Park, *Inha University, South Korea***
- Abdelhamid Sayari, *University of Ottawa, Canada*
- **Peter Styring, *The University of Sheffield, UK***
- Bala Subramaniam, *University of Kansas, USA*

If you are interested in attending ICCDU XII, there is still time to register. Visit our website, **www.energy.psu.edu/ICCDU,** for more information on the conference or to register online.

International Conference on Coal Science and Technology

Jonathan Mathews, associate professor of energy and mineral engineering, and program director for the Institute's coal science and technology program, is chairing the 2013 International Conference on Coal Science and Technology (ICCS&T). The conference will be held September 29 through October 3, 2013, at the Penn Stater Hotel and Conference Center near the Penn State University Park Campus.

ICCS&T is held every two years in locations across the globe, including Okinawa, Japan; Nottingham, England; Cape Town, South Africa; and Oviedo, Spain. The 2013 ICCS&T will be held on the beautiful Penn State campus in State College, Pennsylvania. This year marks the first time this conference will be held in Pennsylvania, which boasts a rich history in coal.

The 2013 conference will attract a diverse international audience and focus on all aspects of coal science, technology, and related areas of interest. There will be an emphasis on clean coal technologies, including combustion, oxy-combustion gasification, liquefaction, coal-to-liquids, biomass co-firing, co-gasification, CO_2 sequestration, carbon capture, coal structure, coke, coal tar, coalbed methane, coal chemistry, and ash chemistry.

ICCS&T 2013 will include over 300 oral and poster presentations from researchers representing more than 27 countries. Visit our website for more information on the technical program. In addition to our technical sessions, we have invited four keynote speaker, listed below.

- Jack C. Pashin, *Oklahoma State University, USA*
- Juan Tascón, *Instituto Nacional Del Carbón, Spain*
- Michael T. Klein, *University of Delaware, USA*
- Harold Schobert, *Pennsylvania State University, USA*

More information on the conference is available at **www.iccst.info**. If you are interested in attending the conference, you can register through our website. Early registration discounts area available through July 31, 2013.

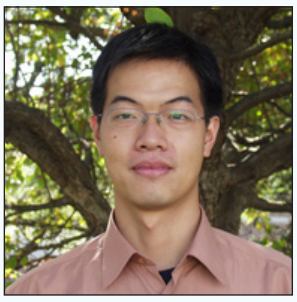
The EMS Energy Institute will play host to these two large International conferences this year. Both conferences are held biennially in various locations throughout the world. The Institute is excited to be the hosting organization as these conferences represent some of the most important events in their respective research areas.

Penn State's EcoCAR Team Wins Several Awards

Penn State's Advanced Vehicle Team won six awards at the EcoCAR 2 Year One Final Competition May 18 to 23, 2012, in Los Angeles.

Eduardo Barrientos, a graduate student working at the EMS Energy Institute, served as the graduate research assistant and team leader to the EcoCAR 2 Team.

The goal of the three-year contest is to reduce the environmental impact of a General Motors-donated Chevrolet Malibu by improving its fuel efficiency and reducing its emissions while retaining its performance and consumer appeal.



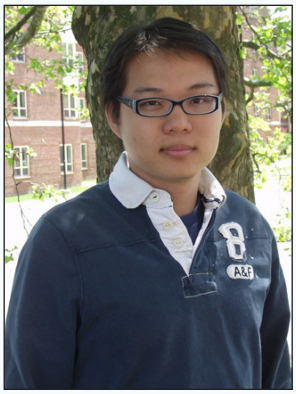
Faculty Receive Promotions

Randy Vander Wal received a promotion to professor and tenure. Vander Wal is co-director of the nanomaterials program at the Institute and his research focuses on applications for nanomaterials. Specific experience includes synthesizing a range of nanomaterials including carbon nanotubes, onions, capsules, metal oxide semiconductors, noble and transition metal catalysts, and nitrides. Synthesis methods have included CVD, plasma, and ablative methods with emphasis upon reacting flows for scalable production, for example, carbon nanotubes production.

Demian M. Saffer received a promotion to professor. Saffer's research falls between geohydrology, active tectonics, fault mechanics, and structural geology. His research group focuses on quantifying the relationships between fluid flow, mechanics and deformation, solute transport, and heat transport in a range of geologic settings. The work address fundamental problems in the geosciences, such as understanding the role of fluids in earthquakes, faulting, and heat transport, and quantifying the nature and timing of fluid flow, which ultimately affects processes ranging from fault healing between earthquakes to the sustenance of biological communities at the seafloor.

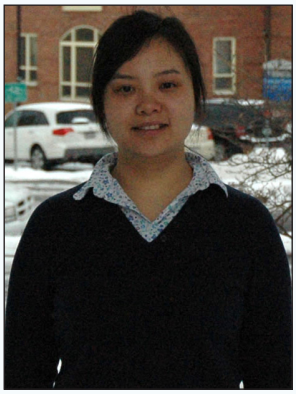
Xiaoxing Wang received a promotion to senior research associate at the EMS Energy Institute. Wang specializes in catalytic conversion of energy resources including petroleum, natural gas, and biomass, as well as the synthesis, characterization, and evaluation of materials such as microporous and mesoporous materials for energy related applications. His current research interests include catalysis and adsorption for fuel processing, desulfurization/purification of bio-gas, natural gas and other fuel gases, reforming of hydrocarbons and bio-fuels for hydrogen production, and carbon dioxide capture and utilization.

Jonathan Mathews received a promotion to associate professor and tenure. Mathews is co-director of the coal science and technology program at the Institute. His research focuses on many aspects of coal structure and its influence on coal behavior. This includes carbon dioxide sequestration in coal, molecular modeling of coal/char, coal to liquids research, and structural representation of complex behavior.



Chung-Hsuan Huang Wins Award for Work with NASA

Randy Vander Wal, professor of energy and mineral engineering and materials science and engineering, and Chung-Hsuan Huang, a doctoral student in energy and mineral engineering, were part of the NASA Alternative Aviation Fuel Experiment Team who recently received their second NASA Group Achievement Award for "outstanding achievement in establishing the impact of hydro-treated renewable jet fuels on commercial aircraft engine performance and pollutant emissions." Tasked with testing whether a biofuel made from chicken fat can be used as a viable jet fuel alternative, the team used a NASA DC-8 to conduct several studies with the biofuel, regular jet fuel, and a 50-50 blend of biofuel and jet fuel. The successful measurement of the biofuel's effects on aircraft performance and gaseous and particulate emissions will assist both the U.S. military and the commercial airline industry in its assessment of alternative fuels for aviation use.



Peilin Cao Receives First Place in Poster Session

Peilin Cao, a doctoral candidate working at the EMS Energy Institute, received first place for her poster submitted in the Energy and Engineering category at the 2013 CarbonEARTH Carbon Conference. Cao is part of Professor Zuleima Karpyn's flow in porus media research group. Cao's research focuses on wellbore integrity and degradation of well cement under carbon dioxide sequestration conditions.

The Carbon Conference, which was held on February 23, brings together the University's carbon research community and features talks by distinguished faculty on novel carbon research and an undergraduate/graduate/postdoctoral research poster competition.

Siddarth Sitamraju Receives Award to Attend Catalysis Conference

Siddarth Sitamraju, a graduate student working at the EMS Energy Institute, received the Kokes Awards, sponsored by the North American Catalysis Society and administered by the North American Meetings (NAM) organization. Sitamraju is a student in energy and mineral engineering with a fuel science option. He is part of Professor Chunshan Song's clean fuels and catalysis research group.

The objective of the Richard J. Kokes Travel Award program is to encourage the participation of students in the biennial North American Catalysis Society Meetings. Students who receive the award present a paper at the conference and contribute some time to the running of the conference. Traditionally, these awards have been presented to graduate students, but at the 22nd North American Meeting undergraduate students who met eligibility requirements were also considered.

Sijuola Odumabo Receives Award at Graduate Exhibition

Sijuola Odumabo, a graduate student in petroleum and natural gas engineering received 3rd place at the 2013 Graduate Exhibition for her poster. The poster, "Gas Flow Hindrance Fracturing Fluid Invasion in Low Permeability Sandstones," highlights work she is doing at the EMS Energy Institute. Odumabo's advisor is Zuleima Karpyn, associate professor, petroleum and natural gas engineering.

The Graduate Exhibition is open to all degree-seeking graduate students who are currently enrolled in graduate degree programs at Penn State and wish to present their scholarly work.

Chunshan Song's Journal Publications are among "Hottest Articles"

Chunshan Song, Distinguished Professor of Fuel Science has had two refereed journal publications listed in the top five most cited articles in *Catalysis Today*. The ranking is based on most cited articles among the over 5,500 published in the journal from 2002 to 2012.

Both articles have been cited over 500 times and, according to the Science Citation Index on Web of Science, both articles have remained as the "Top 25 Hottest Articles" for more than 10 years. The publications are titled "An overview of new approaches to deep desulfurization for ultra-clean gasoline, diesel fuel and jet fuel" and "Fuel processing for low-temperature and high-temperature fuel cells — Challenges, and opportunities for sustainable development in the 21st century." The articles were published in the journal *Catalysis Today*.

Connect with the EMS Energy Institute on LinkedIn

At the EMS Energy Institute, we work with students to provide them with opportunities for networking and collaborating with other researchers from industry, academia, and universities. The goal is to enhance our research collaborations and give students an edge when looking for jobs or furthering their education. In light of these goals, the EMS Energy Institute has created a 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 EMS Energy Institute community to engage in discussion and professional networking with professionals in energy-related fields.

Our hope is that this space will become a valuable discussion forum benefiting our students as well as others in the energy community. Faculty and students at Penn State and other universities as well as government officials and industry professionals that work in the area of energy are invited to join the group. To join our group on LinkedIn visit **www.linkedin.com/groups/EMS-Energy-Institute-4754804/about**. Or search for the EMS Energy Institute.

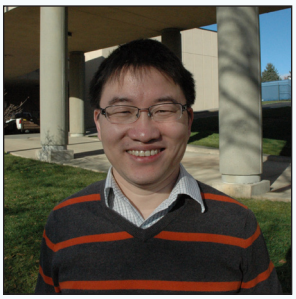
2013 Wilson Banquet and Awards Presentation

The College of Earth and Mineral Sciences held its 2013 Wilson Banquet and Awards Presentation on April 28 to recognize student achievement, faculty mentoring, faculty commitments to service, and excellence in research and teaching.

25-Year Service Award

Semih Eser, professor, John and Willie Leone Family Department of Energy and Mineral Engineering, and **Bruce Miller**, senior scientist, EMS Energy Institute were recognized for their commitment to service.

Wilson Research Initiation Grant



Shimin Liu, assistant professor, John and Willie Leone Family Department of Energy and Mineral Engineering, received the Wilson Research Initiation Grant for *Analysis of Production Induced Stress Changes and Its Implications for Seismicity During Gas Shale Production*.

EMSAGE Laureate

Kelleen Lanagan, undergraduate, Geosciences, was recognized for her involvement with Earth and Mineral Sciences Academy for Global Expereince (EMSAGE). EMSAGE helps students develop as communicators and collaborators and prepares them to be effective leaders in their discipline and responsible global citizens.

2013 Department of Energy and Mineral Engineering student awards

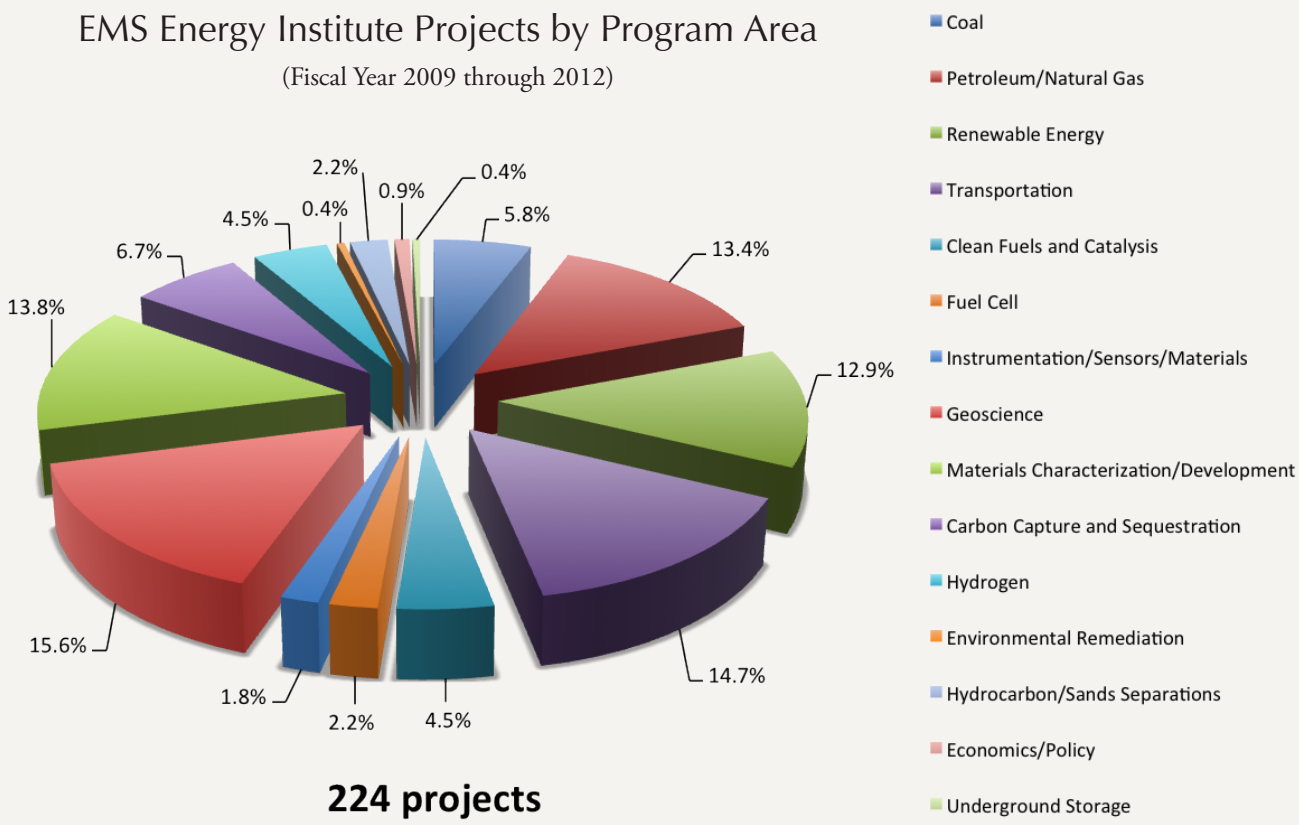
The John and Willie Leone Family Department of Energy and Mineral Engineering had its 2013 Awards Banquet on April 26. This banquet recognizes students and faculty in the department. The banquet is held in conjunction with the G. Albert Shoemaker Lecture. EMS Energy Institute Students who received awards are listed below.

Outstanding Graduate Teaching Assistant
Kyungsoo Kim, Ph.D. Student

C.C. Wright Award
Fidel Castro Marcano, Ph.D. Student

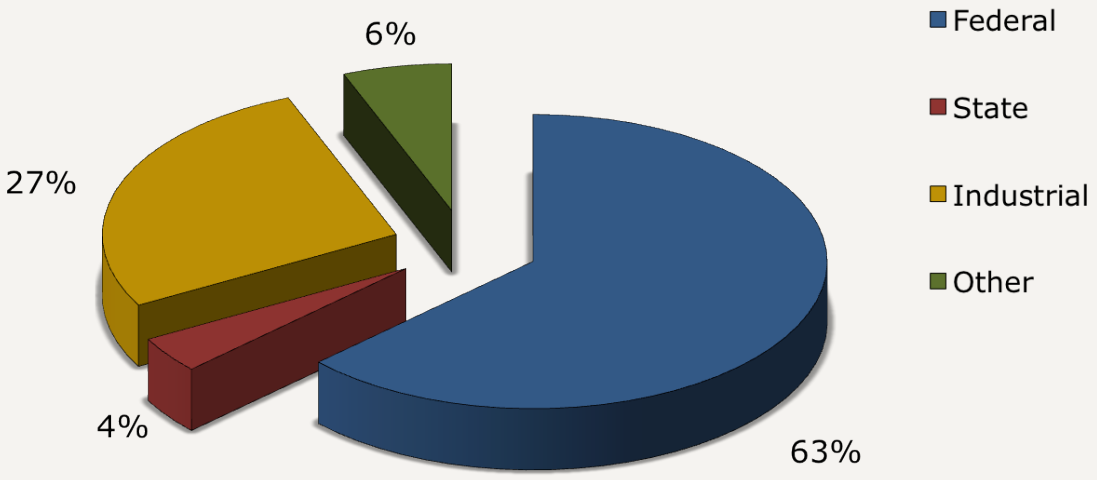
Fank and Lucy Rusinko Graduate Fellowship
Aime Hilaire Tchapda, Ph.D. Student

Summary of Projects & Funding



EMS Energy Institute Awards by Source

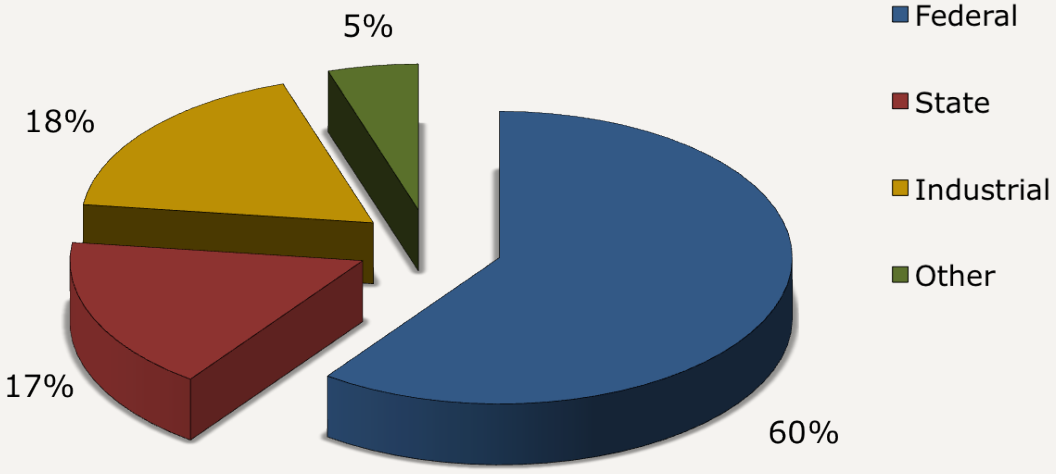
(Fiscal Year 2011 through 2012)



Total Awards 114

EMS Energy Institute Funding by Source

(Fiscal Year 2011 through 2012)



Total Funding $6.1 million

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