

# ENERGY INNOVATION

Summer 2011



PENNSTATE



EARTH AND MINERAL SCIENCES  
**ENERGY INSTITUTE**  
COLLEGE OF EARTH AND MINERAL SCIENCES

*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.

**EMS Energy Institute**

The Pennsylvania State University  
C-211 Coal Utilization Laboratory  
University Park, PA 16802  
[www.energy.psu.edu](http://www.energy.psu.edu)

**Director**

Dr. Chunshan Song

**Associate Director**

Bruce Miller

**Writer/Editor**

Shea Winton

**Graphic Designer**

Elizabeth Wood

This publication is available in alternative media on request. The Pennsylvania State University is committed to the policy that all persons shall have equal access to programs, facilities, admission, and employment without regard to personal characteristics not related to ability, performance, or qualifications as determined by University policy or by state or federal authorities. It is the policy of the University to maintain an academic and work environment free of discrimination, including harassment. The Pennsylvania State University prohibits discrimination and harassment against any person because of age, ancestry, color, disability or handicap, national origin, race, religious creed, sex, sexual orientation, or veteran status. Discrimination or harassment against faculty, staff, or students will not be tolerated at The Pennsylvania State University. Direct all inquiries regarding the nondiscrimination policy to the Affirmative Action Director, The Pennsylvania State University, 328 Boucke Building, University Park, PA 16802-5901; Tel 814-865-4700/V, 814-863-1150/TTY.

U.Ed. EMS 11-69

# Table of Contents

## Features

Global Energy ..... 4 <i>Challenges in the 21st Century</i>
EMS Energy Institute Researchers Showcase Work in Washington ..... 7
Institute Expands into Renovated Lab Space ..... 12
Interdisciplinary Group to Study the Issues Surrounding Rare Earth Elements ..... 15
Lessons Outside the Classroom ..... 16 <i>Student learns more than science in the Energy Institute lab</i>
Penn State and Dalian Establish the International Joint Center for Energy Research ..... 18
Group Studies Technology to Increase Output of Oil Reservoirs ..... 20
Impact of Institute Publications on the Rise ..... 21
Visit Our New Interactive Partner Map Online ..... 28

## Departments

Letter from the Director..... 3
EMS Energy Institute Research Programs ..... 4
Research Brief from Around the Institute ..... 8
New Faculty Affiliates ..... 14
Honors and Awards..... 22
Summary of Projects and Funding..... 26

# Letter from the Director

The focus of this issue is Global Energy. As resource supplies continue to decline and climate change threatens our future, our researchers are collaborating with institutions worldwide to develop more efficient, affordable, and environmentally friendly technologies. In fact, Penn State recently established the Joint Center for Energy Research with Dalian University of Technology (DUT) in China. A workshop and official opening ceremony were held in April 2011. Penn State President Graham Spanier, Provost Rodney Erickson, Vice President for Research Hank Foley, and Vice Provost for Global Programs Michael Adewumi met with DUT President Jinping Ou and Vice President Guiling Ning. They recognized the importance of U.S.–China and global collaboration in clean energy research and development, and education. Tom Richard, director of Penn State Institutes of Energy and the Environment, and I visited DUT to meet with leaders and faculty members in May 2011.



Also in April 2011, the Electricity Markets Initiative, led by Andrew Kleit, professor of energy and environmental economics, held its first conference. Over 80 attendees heard presentations from government, industry, and university representatives. In November 2010, energy researchers from the Institute took part in Penn State Energy Day, a daylong series of presentations, at the National Press Club in Washington D.C. to highlight energy research at Penn State.

Another major ongoing initiative at Penn State is the Regional University Alliance, a five-university consortium organized to provide a range of research services to the U.S. Department of Energy National Energy Technology Laboratory. This initiative is coordinated by Tom Richard; Alan Scaroni, associate dean for Graduate Education and Research, College of Earth and Mineral Sciences; and myself.

The Institute continues to grow and I am pleased to announce two new faculty affiliates. Samuel A. Oyewole, assistant professor of environmental health and safety engineering, and Russell T. Johns, professor of petroleum and natural gas engineering have joined the Institute. Johns brings with him the Gas Flooding Joint Industry Project, an industrial consortium investigating a wide range of issues around gas flooding.

In the previous issue, I mentioned that the Institute, with support from the University, the John and Willie Leone Family Department of Energy and Mineral Engineering, and the College of Earth and Mineral Sciences, was in the process of acquiring and renovating a new building. The building, now finished, houses several faculty members and their students. It gives us much needed research space and the ability to expand and attract new faculty affiliates without sacrificing research space and equipment.

It's obvious our faculty and students are passionate about energy research from the many awards received each year. Over the past year, researchers were presented with awards related to research, teaching, service, and publications from Penn State as well as external organizations. In addition, EMS Energy Institute researchers were responsible for over 50 energy-related journal publications in 2010 and received 1,300 science citations.

Even in the face of ongoing economic challenges, and budget restrictions, I have witnessed the launch of many groundbreaking research projects and initiatives. The Institute recognizes and is grateful for the ongoing support from the University, and the funding from state and federal agencies and industries, which allow us to continue our mission. We are looking forward to continuing our collaborations and cooperations with researchers and industrial and government organizations within the U.S. and worldwide in order to further advance research and development towards solving global energy problems.

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

## EMS ENERGY INSTITUTE RESEARCH PROGRAMS

Descriptions of these programs and contact information for key researchers can be found at [www.energy.psu.edu](http://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

### Transportation Program

Program Director: André Boehman

# Global Energy

## *Challenges in the 21st Century*



**A** decade into the 21st century, we can look back on the previous century as a time of **explosive growth in worldwide population, technology, and energy consumption.** In the last 100 years, we've become increasingly dependent on the combustion of hydrocarbon fuels such as gasoline, diesel fuel and jet fuel with the rise of engine-powered transportation such as cars, trucks, airplanes, trains, and boats. Now almost everything we touch has been shipped or trucked from somewhere else. Electricity, generated mainly from fossil fuels such as coal and natural gas, has become a vital part of the developed world with electrical power plants, home appliances, computers, phones, and cooling and heating. Looking forward, energy consumption is expected to steadily increase, especially in developing countries where population and income continue to grow. World population has more than doubled since 1950 and is set to increase by 40 percent by 2050. History has shown that as people become richer they use more energy. Countries such as China and India are just starting their journey on the energy ladder.

The downside to increased demand for fossil fuels is the pollutants emitted during combustion, which can include nitrous oxide, sulfur dioxide, particulate matter, and greenhouse gases such as carbon dioxide. According to the U.S. Energy Information Administration (EIA) nearly 70 percent of electricity worldwide is generated from fossil fuels with 42 percent from coal. As a result, electricity production accounts for 40 percent of global energy-related CO<sub>2</sub> emissions. Transportation, a close second, accounts for one quarter of global energy use and energy-related CO<sub>2</sub> emissions.

Greenhouse gases, especially CO<sub>2</sub>, are a major global concern because of the significant and continuous rise in atmospheric CO<sub>2</sub> concentrations. There is heightened interest worldwide in reducing those emissions, largely the result of consuming carbon-based energy using combustion-based energy systems. In addition, accelerated growth in the consumption of carbon-based energy worldwide, depletion of carbon-based energy resources, and low efficiency in current energy systems are important issues.

While fossil fuels have proved to be a reliable and economical source of energy in the past, this century brings many new challenges and research opportunities related to finding new energy sources, using existing sources in a cleaner manner, and making existing sources more sustainable.

### **Safely supply clean fuels, electricity and water to meet the growing energy demand worldwide despite declining resources.**

By 2035, the International Energy Outlook 2010, published by EIA, projects that demand for electricity will be almost twice as high as current demand. It cites the rapid growth in population and income in developing countries, the increase in the number of electrical devices in homes and commercial buildings, and the growth in electrically driven industrial processes as reasons for this surge.

At the same time, global resources continue to decline. Fossil fuels, such as oil, gas, and coal take tens of millions of years to form but continue to be consumed at an unprecedented rate. Although coal is the most abundant fossil fuel on earth, at the present rate of consumption it is expected to last for about another 200 years. Oil and natural gas reserves may not even last that long although estimates of these resources are being re-evaluated due to the implementation of unconventional oil and gas technologies and the discovery of major gas fields such as the Marcellus and Utica shale deposits in the U.S.

Another issue with these resources is the ongoing political turmoil in some countries where large hydrocarbon reserves are located. War and other unrest can lead to problems such as increased prices or supply disruptions, which adds to the future uncertainty of these resources.

Partly because of these factors, a combination of energy sources is needed to meet the energy demands of a 21st century society. While the use of fossil fuels will continue, countries must develop means to use them more cleanly, and intensify the development of renewable fuels, including solar, hydrogen, biomass, and geothermal. It is President Obama's goal to produce 80 percent of America's electricity

from clean energy sources, as defined in the context of the Clean Energy Standard as renewables, nuclear, combined-cycle gas, and fossil energy with carbon capture and storage, by 2035. In addition, Congress has mandated the production of 36 billion gallons of biofuel by 2022, which is more than a three-fold increase from today's production.

### **Overcome the limits of wasteful fossil energy systems and increase energy efficiency by developing new systems.**

Industry accounts for more than one-third of all the energy used in the United States, according to DOE, with the majority coming from natural gas and petroleum. Industrial energy efficiency has improved significantly since the 1920s and CO<sub>2</sub> emissions have declined in many sectors. However, growing industrial production worldwide offsets these improvements.

In addition, despite efficiency improvements, current energy systems are extremely wasteful, meaning we consume more resources than needed and emit more pollutants into the environment per unit of useful energy output. As much as 65 percent of energy input used in electric power plants, is wasted. Only 35 percent of the initial energy becomes useful energy output or electricity. The overall system energy efficiencies for cars, trucks, trains, and airplanes are even lower with 65–80 percent of energy input wasted as conversion loss in mobile energy systems like passenger cars.

There is a real need to drastically increase energy efficiency by developing new, more efficient and cleaner energy systems, rather than incrementally improving existing systems. Recent advances in new power system designs such as integrated gasification-combined cycle (IGCC), gas turbine combined cycle (GTCC), hybrid cars, hydrogen energy, and fuel cell developments offer some promises and clues to future development.



Hydrogen energy has the potential to make the energy conversion systems more efficient through the use of fuel cells and can significantly reduce the greenhouse gas emissions as well as eliminate the pollutant emissions from mobile and stationary sources. Hydrogen production, storage, and utilization via fuel cell systems are important research subjects in the long term.

### **Reduce pollution and stabilize green house gas emissions from energy utilization.**

Over the next 25 years, fossil fuels are expected to continue to make up about 80 percent of total primary energy use. When we consider increasing environmental stresses, including increasing CO<sub>2</sub> emissions and industrial accidents such as the Deepwater Horizon oil spill in the Gulf of Mexico, it's clear we need to move toward sustainable energy sources and new technologies to reduce and stabilize greenhouse gas emissions.

**For the foreseeable future, fossil fuels will continue to be the dominant and the cost-effective energy resource. However, the use of more renewable resources must be emphasized even if it costs more in the near term.**

Nuclear energy has a potential for growth in terms of meeting the energy needs without greenhouse gas emissions and industry has been seeing a resurgence in nuclear energy. However, nuclear energy involves major challenges that have resulted in the not-in-my-back yard syndrome worldwide. This is largely related to the accidents of nuclear power plants at Three Mile Island in the U.S. on March 28, 1979, at Chernobyl in the Ukraine on April 26, 1986, and most recently at Fukushima Daichi in Japan on March 12, 2011.

Capture, sequestration and utilization of CO<sub>2</sub> from energy systems are key areas of interest because they have the potential to achieve major reductions in CO<sub>2</sub> emissions from fossil fuel use. However, there are many issues around energy economics, policy regulations, environmental protection, and global climate change. For example, the costs for carbon capture are high, plus there are still some unknowns with carbon storage. Many of these issues are being addressed through research and development activities by countries throughout the world.

### **Develop sustainable and safe energy including more renewable sources.**

There is a long-term need to make more active use of renewable sources of energy (e.g., solar energy, biomass, wind, geothermal, wave) and design better conversion systems without negative impacts on the environment. CO<sub>2</sub> conversion and utilization with renewable energy input for producing fuels and chemicals also have intrinsic merits for sustainable development. For the foreseeable future (the next two decades), fossil fuels will continue to be the dominant and the cost-effective energy resource. However, the use of more renewable resources must be emphasized even if it costs more in the near term. Government incentives are necessary to nurture the growth of renewable sources such as solar and biomass along with recycled energy sources such as organic wastes, which are important for sustainable energy development.

Biomass provides a path for renewable sources of carbon-based energy, chemicals, and materials. Solar energy conversion via photovoltaic cells is a path that has the most energy and environmental benefits and also the potential to grow, provided that more efficient conversion devices can be made affordable. It should be noted that renewable energy utilization systems can have some negative impacts to the human and ecological environments (effects of solar energy facilities on land use; biomass growth on land area; wind power on birds; hydropower on aqua life, etc.). Nonetheless, there are also great benefits. It is a major challenge because the use of so-called renewable energy sources encounters regional distribution and seasonable availability issues as well as low energy density issues.

### **Develop sustainable organic material involving carbon-based feedstocks.**

We still need carbon-based feedstock for manufacturing chemicals and organic materials, even if the energy problem is solved. The world today depends on carbon-based chemicals and organic materials which characterize the current civilizations and shape our life style in a wide range of applications, from clothes to shoes, from kitchen to bedroom, from homes to offices, from cosmetics to automobiles, from plastic beverage bottles to gasoline tanks, from commercial buildings to manufacturing plants, from heat-resistant polymers to aerospace materials, and from computers to mobile cell phones. As the resources of fossil fuels are being consumed rapidly, we should be concerned equally for the future supplies of the feedstock for carbon-based chemicals and organic materials. Utilization of CO<sub>2</sub> for chemicals and materials offers a long-term option.

Refs. C.S. Song, *Catalysis Today*, 2002(77)17-50; 2006 (115) 2-32.



## EMS Energy Institute Researchers Showcase Work in Washington

Energy researchers from the EMS Energy Institute took part in a day long series of presentations on November 19, 2010, at the National Press Club in Washington D.C. to highlight energy research at Penn State. The Penn State Energy Day was sponsored by the U.S. Energy Association, which represents public and private energy-related organizations, corporations and government agencies, and aims to increase understanding of domestic and international energy issues.

The event, which was open to Penn State alumni, and government and industry personnel, included presentations by University faculty as well as government and industry representatives. It provided an opportunity for Penn State to showcase the scope of its faculty's energy-related research.

EMS Energy Institute researchers contributed posters that covered a variety of research topics such as CO<sub>2</sub> capture and storage, biomass gasification, and oxy-coal combustion. Posters are listed below.

- **CO<sub>2</sub> Capture by Molecular Basket Sorbents** - Emanuela Peduzzi, Eric Fillerup, Jiahua Guo, Xiaoliang Ma, Chunshan Song, Xiaoxing Wang, Dongxiang Wang, and Zhonghua Zhang
- **Biomass Gasification for CO<sub>2</sub> Reduction Benefits** - Bruce Miller and Sharon Falcone Miller
- **Oxy-coal Combustion for CO<sub>2</sub> Capture** - Sarma Pisupati, S. Roshan Dhanesavar, Bruce Miller
- **CO<sub>2</sub> Storage in Unmineable Coal Seams** - Jonathan Mathews and Derek Elsworth
- **Coal Gasification for CO<sub>2</sub> Capture** - Sarma Pisupati, Yaw Yeboah, N. Soundarajan, N. Krishnamurthy, L. Gibson, and A. Tchapda
- **Geological Carbon Sequestration Research at Penn State** - Li Li, Seth Blumsack, William Burgos, Peter Heaney, Susan Brantley, R.J. Briggs, Derek Elsworth, Zuleima Karpyn, Turgay Ertekin, Serguei Lvov, and Antonio Nieto

In addition, two Energy Institute researchers presented their recent work as part of a panel discussion. André Boehman, professor of fuel science and materials science and engineering, participated in *Future of Transportation Fuels*. Seth Blumsack, assistant professor of energy policy and economics, presented *The New Age of U.S. Electricity* in the panel discussion *Electricity Delivery and Storage*. Their presentations can be viewed at [www.research.psu.edu/events/2010/penn-state-energy-day-documents](http://www.research.psu.edu/events/2010/penn-state-energy-day-documents).

Others in attendance from the Institute included Chunshan Song, director of the EMS Energy Institute, who coordinated the poster session and led a discussion on *Carbon Capture, Sequestration and Utilization*, and Emanuela Peduzzi, graduate student in the John and Willie Leone Family Department of Energy and Mineral 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.*

This issue highlights projects administered as part of the National Energy Technology Laboratory (NETL) Regional University Alliance. The alliance, which consists of a five-university consortium, was created by NETL, part of the U.S. Department of Energy (DOE), in 2009 to assist in conducting energy and environmental research programs to advance U.S. national, economic, and energy security.

The universities, Carnegie Mellon University, West Virginia University, the University of Pittsburgh, The Pennsylvania State University, and Virginia Tech, are providing a range of research and engineering services to NETL. These institutions have a long history of successful contributions to energy technologies and the energy industry, as well as participation in DOE's fossil energy research program.

The consortium of universities joined with URS Corp., a major industrial firm, to pursue the awards that follow. The URS-led team is providing personnel, facilities, equipment, materials, supplies, and services to support NETL. URS is also working with NETL's research staff to provide research and infrastructure support; health, safety, and quality control support; and logistical and technical coordination support.

This alliance combines NETL's expertise in fossil energy technologies with the universities' experience and capabilities. Shared laboratory facilities, computational capabilities, personnel, equipment, and other resources are a key part of the program.

Some of the current research teams include advanced gasification, CO<sub>2</sub> capture, CO<sub>2</sub> storage, fuel cells, and multi-scale and multiphase flow. For more information on the NETL University Research Alliance, visit [www.netl.doe.gov/rua/index.html](http://www.netl.doe.gov/rua/index.html).





# CARBON CAPTURE AND STORAGE RESEARCH

One of the major sources of CO<sub>2</sub> emissions is the combustion of fossil fuels. Fossil fuels provide over 80 percent of the world's energy and are expected to continue to dominate energy production throughout the century. The CO<sub>2</sub> capture and storage teams are working to develop low cost technologies in order to reduce greenhouse gas emissions from power plants. Carbon capture and storage (CCS) is one of the most promising approaches to reducing the world's greenhouse gas emissions, which is vital to the sustainability of fossil energies. However, existing capture technologies are not cost effective for many power plants, and other large-scale industrial sources of CO<sub>2</sub>. Other challenges include developing the best possible infrastructure for transporting the CO<sub>2</sub> and selecting underground reservoirs that will safely store the gas for centuries.

## Exploring new CO<sub>2</sub> capture technologies

The conventional flue gas for a coal-fired power plant contains about 10–15 percent CO<sub>2</sub> as well as moisture, inert nitrogen gas, and some impurities. Chunshan Song, Distinguished Professor of Fuel Science and the director of the EMS Energy Institute, is the principle investigator on two projects that focus on technologies for capturing and separating the CO<sub>2</sub> from those power plant emissions. The goal of one project, *A Novel Rapid-cycle Process for CO<sub>2</sub> Capture from Flue Gas of Coal-fired Power Plants*, is to develop a new rapid-cycle process for fast capture and separation of CO<sub>2</sub> from coal-fired power plant flue gas. This process can also be used to remove contaminants, including sulfur dioxide and nitrogen dioxide.

Based on the higher sorption capacity and much faster sorption/desorption rates of new molecular-basket sorbents, it is possible to design a novel capture process based on a rapid-cycle sorption-desorption bed. Penn State researchers have already built a proto-type model of a rapid-cycle sorber where sorption and desorption can take place quickly.

A second project, *Next Generation Solid Molecular Basket Sorbents with desired Nano-structure for CO<sub>2</sub> Capture from Flue Gas*, centers around a new generation of nano-structured molecular basket sorbents (MBS-NS). The new MBS-NS consist of specially designed polymer-core/silica-shell nanostructures, which increases the number of sorption sites for the CO<sub>2</sub> and, as a result, increases the CO<sub>2</sub> capacity to higher than 20 weight percent. This project's focus is on developing a molecular basket sorbent that will exploit those increased sorption sites as well as quicken the mass transfer for CO<sub>2</sub> sorption and desorption. For comparison, previous molecular basket sorbents were based on conventional mesoporous materials and had a CO<sub>2</sub> capacity up to 14 weight percent. A molecular basket sorbent with a higher CO<sub>2</sub> capacity will result in more energy-efficient and cost-effective greenhouse gas capture.

## CO<sub>2</sub> transport and pipeline considerations

Once the CO<sub>2</sub> has been removed from the flue gas, it needs to be transported by way of pipelines for storage. Serguei Lvov, professor in the John and Willie Leone Family Department of Energy and Mineral Engineering, is the principle investigator on a project to determine the optimal materials for transport pipelines and how to ensure the longest possible life for those materials. Mark Fedkin, research associate, EMS Energy Institute, is also working on the project, which is part of the Electrochemical Technology Program at the Institute. The project, *Electrochemical In-situ Monitoring of Metal Degradation in Carbon Sequestration Processes*, is assessing materials and conditions affecting CO<sub>2</sub> sequestration transport pipelines in order to limit corrosion and safety hazards. The researchers are examining the fluid composition to determine allowable impurity limits as well as the pipeline material to find the most sustainable choice.

Pure supercritical (or liquid phase) CO<sub>2</sub>, the primary fluid traveling through the pipelines, is non-corrosive, but impurities, and elevated temperature and pressures can cause fast degradation and failure in metal pipes. Based on previous studies, water will significantly affect the corrosive behavior of supercritical CO<sub>2</sub>; researchers expect the presence of sulfur compounds and oxygen to further increase corrosion rates. One goal of this project is to determine the maximum impurity content the pipelines can tolerate without damage.

Changing the pipeline material could also impact corrosion rates. The standard material for transport pipelines is carbon steel because of its low cost although several alternative metals and alloys have better corrosion resistance in other applications. For this project researchers will test these materials using conditions specific to CO<sub>2</sub> sequestration to determine an ideal combination of fluid composition and pipeline material. This research will aid in the design of carbon capture systems and contribute to the development of government regulation for CO<sub>2</sub>-capture technology, including pipeline design and composition, time of operation, and safety.

## Storage reservoir challenges

Lvov is also the principle investigator on a project related to carbon storage. For this project, *Modeling of CO<sub>2</sub>-Water-Rock Interactions*, researchers, including Fedkin, are developing an experimental modeling system to study phase equilibria in CO<sub>2</sub>-brine-mineral systems, which will result in equilibria diagrams and a better understanding of some of the challenges associated with geologic CO<sub>2</sub> storage or the injection of supercritical CO<sub>2</sub> into deep geologic formations.

According to the NETL website, there are eleven major types of geologic storage reservoir classes. Brine, or saline water, is present in many of these, as it exists in most sedimentary basins worldwide. Therefore, formations containing brine have very high storage potential.

In this project, researchers are developing an experimental system to conduct measurements to better understand interactions between CO<sub>2</sub> and water and the effect of pH on those interactions. The experimental system allows researchers to monitor brine pH so the brine composition can be closely matched to the typical conditions found in U.S. CO<sub>2</sub> sequestration reservoirs.

Safe and effective long-term storage for CO<sub>2</sub> is required for wide-scale use of carbon capture and sequestration. In addition to identifying best reservoir sites, permanent CO<sub>2</sub> storage relies on the presence of seals (often called caprocks), as wellbores and natural faults or fractures can be release pathways for the CO<sub>2</sub>. A multi-scale multiphase flow team is addressing these storage challenges by developing tools and techniques for predicting the behavior of underground storage sites for CO<sub>2</sub> over a variety of scales and timeframes.

Zuleima Karpyn, associate professor of petroleum and natural gas engineering, is the principle investigator on the project *Experimental Investigation of Conditions Affecting Wellbore Integrity due to Chemical Reaction using X-ray microCT Imaging*.

Once CO<sub>2</sub> is injected into a reservoir, chemical reactions can degrade casing, cement, and shale caprock leading to unintended CO<sub>2</sub> leakage. For this project, researchers are observing cement degradation using X-ray microCT imaging to characterize conditions affecting wellbore integrity and the potential consequences on long-term CO<sub>2</sub> storage. These observations coupled with geochemical reaction and transport models can help to identify the best conditions for preserving geologic and artificial seals exposed to CO<sub>2</sub>. This information will be useful in the design, implementation, and prediction of storage-site performance.

## FUEL CELL RESEARCH

An NETL fuel cell team is working to develop highly efficient and environmentally clean power generation from coal using Solid Oxide Fuel Cell (SOFC) technology. The projects focus on developing affordable, robust and active anode and cathode materials thereby improving the efficiency and lifetime of SOFC materials, which are used to convert chemical energy stored in fuel to electrical energy.

Along these lines, Lvov and Fedkin are working on a project, *Electrochemical Evaluation of Liquid Metal Anode (LMA) SOFC Performance*, to analyze various LMA systems in SOFCs operating under hydrogen and coal. Researchers are using electrochemical impedance spectroscopy (EIS) to explore and analyze the behavior of SOFC electrodes, reaction kinetics, and ionic conductivity in SOFC components during electrical power generation. EIS will also be used to monitor SOFC degradation and understand the degradation mechanism. The goal is to develop electrical circuit models of the LMA SOFC, which will be used to evaluate performance differences associated with operating current, fuel type, and anode composition.

In addition, researchers will evaluate the electrochemical operation and performance of coal-fueled LMA SOFCs in 24 hour and 100+ hour tests to determine how trace compounds in unprocessed fossil fuels influence the SOFC performance and lifespan. Researchers will again use EIS to determine the effects of the contaminated fuels on various SOFC components. Ultimately, researchers will be able to recommend the most promising anode constituent materials and operational conditions.

## ADVANCED GASIFICATION RESEARCH

The scope of the advanced gasification projects is to generate clean power and fuels using domestic resources thereby reduce CO<sub>2</sub> emissions. Derek Elsworth, professor in the Department of Energy and Mineral Engineering, has a project investigating the use of coal–biomass mixtures in gasification systems.

The use of a coal and biomass together has the potential to reduce net carbon emissions over pure coal firing because of the inclusion of a carbon-neutral supplementary fuel — biomass. However, to use coal – biomass mixtures in conventional coal-fired plants the granular mixture needs to be continuously-fed into the combustor in a form close to the traditional hard coal form, which requires that the mixture be preprocessed under compactive stress and/or temperature to improve its handling and gasification characteristics.

For continuously-fed compaction and gasification systems, the mechanical (fictional strength and rheology) and transport (permeability) properties of the biomass–coal mixture are key variables, but little is understood about the relationships between these characteristics. For this project, *The Mechanical and Transport Characteristics of Coal-Biomass Mixtures – Application to Dry-Feed Systems for AIGCC SOW*, researchers are evaluating the mechanical and gas transport characteristics of various coal–biomass mixtures under compactive stresses experienced in continuous feed systems currently under development. The goal is to gain an understanding of the high- and ultrahigh-friction regime for particle flow to allow for quick and cost effective development of dense phase particle feed solutions.

Sarma Pisupati, associate professor in the Department of Energy and Mineral Engineering, is leading a second project, *Gasification of Coal and Biomass Blends*, to derive pyrolysis kinetic parameters for nitrogen and sulfur species (NH<sub>3</sub> and H<sub>2</sub>S) and to study the effect of alkali content in biomass samples during pyrolysis and gasification.

Since inorganic species in biomass samples can vary significantly, researchers are exploring how various low alkali and high alkali biomass components influence gasification kinetics and product distribution during high temperature pyrolysis and char conversion. Researchers will conduct tests in a high pressure, high temperature entrained flow reactor (EFR) currently under construction at the EMS Energy Institute. The goal of this project is to derive fundamental gasification parameters to plug into the MFIX (Multiphase Flow with Interphase eXchanges) formulation.



Below: Top section of the EFR. Right: Construction on a structure to support the EFR at the EMS Energy Institute.





# Institute Expands into Renovated Lab Space





As the quest for clean, reliable, and affordable energy gains momentum, the EMS Energy Institute continues to grow. However in the last few years, space became a major hurdle as the Institute broadened the scope of its research and brought in more researchers. In order to accommodate our expanding number of faculty affiliates, staff, and students, the Institute, with strong support from the University, the College of Earth and Mineral Sciences, and the John and Willie Leone Family Department of Energy and Mineral Engineering, acquired and renovated a new energy building.

The EMS Energy Institute Building, which was officially handed over in early 2010 will house research faculty and students in several program areas, including petroleum & natural gas, industrial health and safety, and clean fuels and catalysis. The building contains six state-of-the-art labs in addition to office and conference space. It is located about three miles from the University Park Campus on Pine Hall Drive.

The following faculty are the initial occupants and will be utilizing the new lab space for their research.

- Yongsheng Chen, assistant professor, materials science and engineering
- Russell Johns, professor, petroleum and natural gas engineering
- Samuel Oyewole, assistant professor, environmental health and safety
- Paul Painter, professor, polymer science
- John Yillin Wang, assistant professor, petroleum and natural gas engineering

# Welcome

## New Faculty Affiliates

The EMS Energy Institute welcomes the following principal investigators and faculty associates who have joined the EMS Energy Institute for research support and collaborations in the last year. As our research team continues to grow, the EMS Energy Institute anticipates many new projects that will broaden the scope of our research and enhance our ability to provide training and outreach. Detailed profiles can be found at [www.energy.psu.edu](http://www.energy.psu.edu).



**Samuel A. Oyewole**

*Assistant Professor*

Environmental Health and Safety Engineering

Dr. Oyewole earned his Ph.D. in Industrial Engineering from The Pennsylvania State University in 2009 and joined Penn State as an instructor of industrial health and safety. Dr. Oyewole was appointed assistant professor of Environmental Health and Safety Engineering in July 2010. His research expertise includes global safety and health management, nuclear safety and risk management, human health risk/exposure assessment, ergonomics/human factors engineering, hazard and risk management, quantitative methods in safety intervention and resource allocation methods. Dr. Oyewole's current research includes global environmental health and safety management, pipeline safety and risk management, and environmental risk/exposure assessment of human health-related hazards in the Mississippi and Niger Delta regions. He is also evaluating various optimization methods for improving cost effectiveness and reducing incident rates in safety and health intervention resource allocation decision-making.



**Russell T. Johns**

*Professor*

Petroleum and Natural Gas Engineering

Dr. Johns' work focuses on enhanced oil recovery, unconventional gas recovery, geothermal energy, well testing, and the theory of gas injection processes. Before coming to Penn State, Dr. Johns served on the faculty at The University of Texas at Austin. In addition, he 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. His current research projects include experimental studies of surfactant flooding of live crude oil as well as the development of numerical simulation codes for Middle Eastern oil fields. In addition, Dr. Johns directs the Gas Flooding Joint Industry Project at the EMS Energy Institute, which conducts industry-led research on gas flooding for enhanced oil recovery.

# Interdisciplinary Group to Study Issues Surrounding Rare Earth Elements

Rare earth elements (rare earths or REE) are a collection of 17 elements vital for a wide range of sustainable energy technologies as well as military applications, cell phones and computers. Their uses in “green” technology range from hybrid/electric cars to efficient light bulbs to large wind turbines. While most rare earth elements are not necessarily rare, minable concentrations are less abundant than many other resources.

The supply of rare earths comes almost entirely from China. Currently, China accounts for 93 percent of the world rare earths production and more than 99 percent of some elements such as dysprosium and terbium. In addition, China holds 57 percent of the global reserves of rare earths according to the U.S. Geological Survey.

In the last several years, China has drastically reduced its export of rare earths in order to mitigate domestic issues such as smuggling, illegal mining and environmental damage as well as to meet the increasing Chinese demand for these elements. The current Chinese dominance in REE supply is an important factor to consider as the U.S. energy sector continues to move toward sustainability. The feasibility of any significant shift away from fossil fuels for the U.S. will rely heavily on the importation of rare earths from China.

A Penn State interdisciplinary research group on rare earth elements and sustainability has been formed to focus on the complex issues that surround these elements and their sustainability. The group, led by Andrew Kleit, professor of energy and environmental economics, combines Penn State expertise in mineral engineering, material science, economic and policy analysis, and international politics.

The goal of the Rare Earth Elements Research Group is to examine the issues surrounding these minerals, including the impact of China’s near monopoly on rare earth markets, the future of rare earth markets, and the impact of rare earths on the environment and the development of green technology. The research group applies a variety of approaches including economic and market data analysis, field and case studies with investigations into mining supply possibilities, and

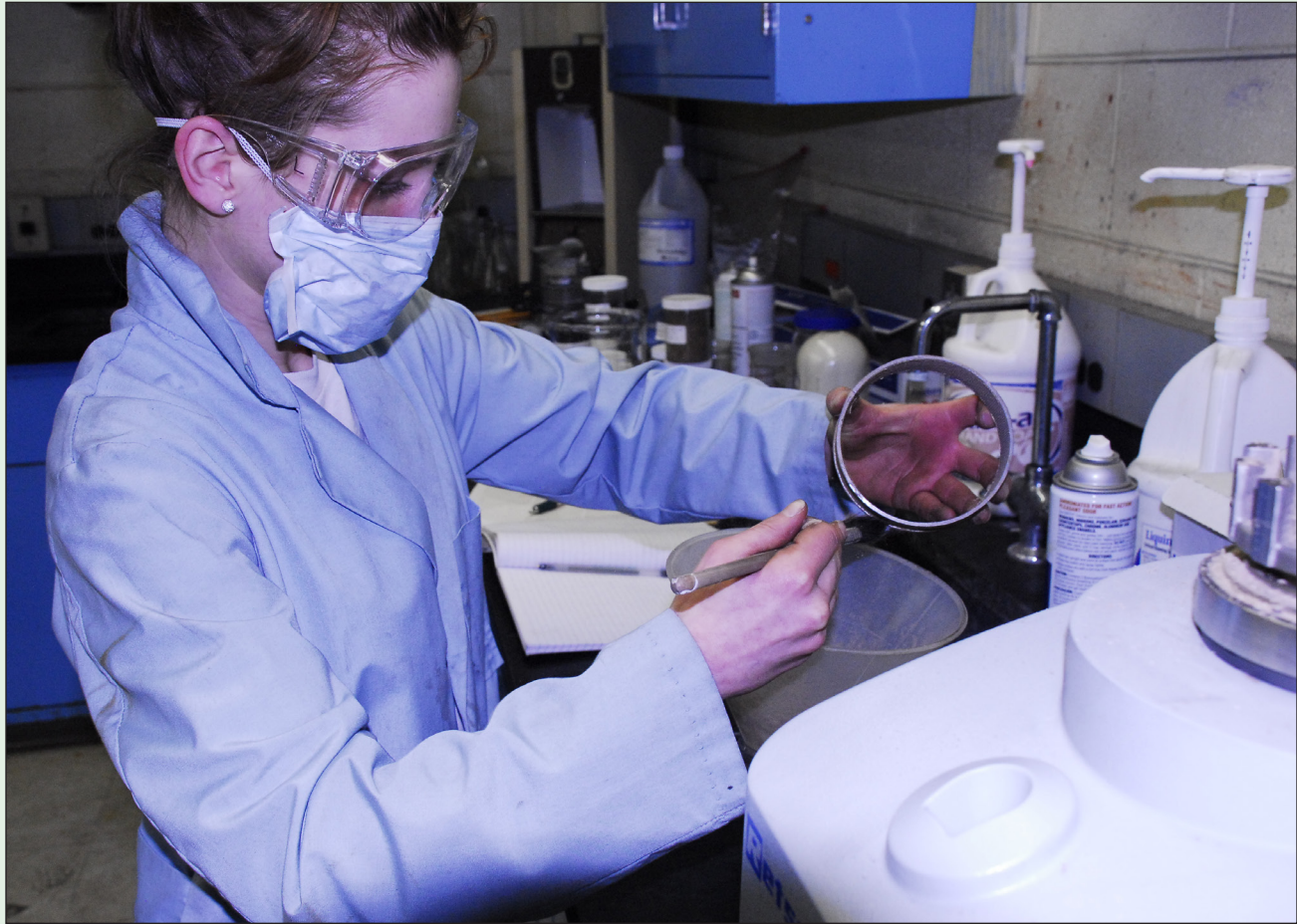
international political economy analysis. The results of the group’s research will be used, in part, to make policy recommendations relating to rare earths.

The group held meetings with experts and staffs in the U.S. Congress, Department of Energy, Department of Defense, U.S. Geological Science, and a number of international and industrial groups, during their two-day trip to Washington D.C. in March, 2011. In collaboration with two prominent Chinese Universities in metallurgy and mining, University of Science and Technology Beijing and Jiangxi University of Science and Technology, the group is organizing an International Workshop on Tehnology and Economics of Rare Earths and Metals in Beijing, China.

The research initiative is supported by a seed grant from The Penn State Institutes of Energy and the Environment (PSIEE). Other members of the research team are Seth Blumsack, assistant professor of energy policy and economics, R.J. Briggs, assistant professor of energy and environmental economics, Jeffrey Brownson, assistant professor of energy and mineral engineering, Zhen Lei, assistant professor of energy and environmental economics, and Antonio Nieto, associate professor of mining engineering, all in the the John and Willie Leone Family Department of Energy and Mineral Engineering.

For more information about the Rare Earth Elements Research Group, visit, [www.energy.psu.edu/oeo/ree](http://www.energy.psu.edu/oeo/ree).





## Lessons Outside the Classroom

### Student learns more than science in the Energy Institute lab

*On the last day of the semester Natalie Keener ('11 B.S. Energy Engineering) along with her teammates from a recent project stopped by the EMS Energy Institute to thank the research staff and pose for photos. (The project won an award detailed on page 24) The only woman in the group, Keener posed with her teammates, holding up the award they received for their accomplishments, her cheerful demeanor showing in her smile.*

While Keener's excitement about the prospect of starting a career was obvious, it was also apparent that she appreciated her experiences in the EMS Energy Institute as well as the faculty and staff who worked with her. In talking about her experiences, she made sure to mention specific people who were especially important to her accomplishments.

"I am very thankful for my experience at the Institute, and I look forward to giving back in the future," Keener said.

Some of those experiences have very little to do with energy. Keener found out that lab work offered learning opportunities beyond a science textbook. She noted that her research at the Institute gave her a better understanding about the importance of project planning, time management, communication and coordination, which she sees as an advantage for future leadership roles.



She acknowledged that the biggest takeaway from working on projects at the Institute was workplace communication and accountability. Although, true to the nature of lab work, she was given a lot of freedom when it came to work hours and deadlines, she made it a point to hold herself accountable for specific tasks. In addition, research projects are often collaborative and her work was no different. So good communication and coordination with team members, Institute staff, outside company contacts, and supervisors was imperative to getting her work done.

Much of Keener's time at the Institute was spent working on a Biomass Combustion Properties Database for the Electric Power Research Institute (EPRI) with her supervisor Bruce Miller, senior scientist and associate director of the EMS Energy Institute. Keener collected biomass information and analysis; classified the biomass as woody, herbaceous, or processed biomass; and added them to the database, which she helped develop.

This project coincided with a course she was taking, Biomass Energy Systems (ABE 497B), and offered a learning opportunity she might not have had otherwise.

"Although some of the data I was working on was a bit daunting in the beginning, the content of this course helped me understand more of the combustion properties," Keener said. "Because I was able to make it a learning experience, I enjoyed it very much."

In part because of this greater understanding, Keener opted to continue biomass research through the Spring 2011 semester. Under the supervision of Sharon Falcone Miller, research associate at the EMS Energy Institute, Keener performed biomass torrefaction and grinding studies as part of her senior research project course (EGEE 494A) and independent study (EGEE 496). She also trained a new hire to continue her work on the EPRI database when her schedule got too busy. In December 2010, the Institute recognized Keener for her service to the research, service, and educational missions of the Institute (page 25).

In addition to the biomass projects, Keener worked at the Institute on a group Capstone Design project for EGEE 464W, advised by André Boehman, professor of fuel science. Members of the team, which was awarded best project at the Lockheed Martin Design Awards, included Natalie Keener, Adam Kimmerle, Liam O'Sullivan, Timothy Tomko, and Shaun Valentine. The team designed and built a hydrocyclone enhanced with

a four-pole AC electromagnet pulsing in the direction of the hydrocyclone flow to improve the industry method of recovering magnetite once it has been used in a slurry mix to separate mineral matter from coal.

In addition to classes and research, Keener was also the president of The Society of Energy Engineers, which began in Fall 2009 to increase the awareness and involvement of energy engineers in professional activities. While president, she coordinated group activities for energy engineers to learn about existing energy technologies and discover new ones. Some of the events members participated in included the 2010 PA Renewable Energy Festival, 2011 Mid Atlantic Region Wind Energy Conference, and Braezeale Nuclear Reactor tours. In addition, industry professionals came to talk to the group.

*I am very thankful for my experience at the Institute, and I look forward to giving back in the future.*

"It was a great opportunity to connect energy engineers, find strengths among them, and use those strengths to gain more awareness and respect for the major," Keener said.

Currently Keener's focus is on finding a full-time position as an energy or environmental services consultant. She wants to practice her knowledge of energy technology while enabling the average person to be more efficient with what they have.

"I want to become a leader in energy efficiency awareness, teaching, and practice," Keener said when asked about her career goal.

She explained that while companies can hire a consultant to change systems, reduce energy input, and decrease costs, a lot of efficiency gain can be made every day through individual choices.

"I went into Energy Engineering for the prospect of increasing efficiency and reducing environmental impact, and this is the effect I would like to have in my career," Keener said.

# Penn State and Dalian Establish the International Joint Center for Energy Research

*On April 12, Penn State and Dalian University of Technology (DUT) in China celebrated the establishment of the Penn State – Dalian Joint Center for Energy Research (JCER). Ceremony attendees included Penn State President Graham Spanier, Penn State Vice President for Research Henry Foley, Penn State Vice Provost Michael Adewumi, State College Mayor Elizabeth Goreham, DUT President Jinping Ou, DUT Vice President Guiling Ning and many other faculty and staff members from both universities.*

The JCER aims to facilitate collaborative and multi-disciplinary research in energy sciences and technology. In addition, the center will serve as a hub for innovative research and global education and provide an institutional umbrella for interacting with industry, the U.S. and Chinese governments, and local communities in the area of clean energy.

“The Joint Center for Energy Research provides great opportunities to better address critical issues in contemporary science and technology development, and help connect Penn State faculty and students to their counterparts in China,” said Penn State President Graham Spanier.

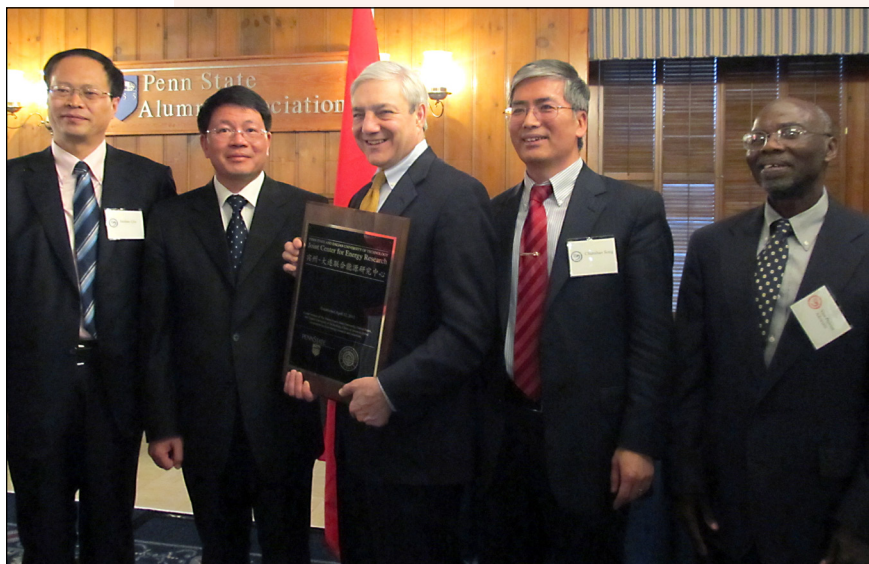
Chunshan Song, director of the EMS Energy Institute and Distinguished Professor of Fuel Science, and Jieshan Qiu, associate dean for DUT faculty of chemical and

environmental technology, will co-direct the Center. The EMS Energy Institute at Penn State will coordinate the JCER activities, including faculty and student exchanges and collaborations.

“The collaboration between faculty and students at Penn State and DUT will help to solve critical energy problems important for both U.S. and China,” said DUT President Ou.

The initial areas of collaboration include clean coal utilization, catalysis for chemicals and clean fuels, carbon dioxide (CO<sub>2</sub>) capture, CO<sub>2</sub> conversion to fuels, bio-energy, water treatment, fuel processing for bio-fuels, computational energy research, carbon materials, characterization of materials, and energy economics.

The ceremony, which was followed by a musical performance and banquet, also celebrated the opening of the Confucius Institute at Penn State. The Confucius Institute is a collaboration between Penn State and DUT to promote the study of Chinese language, culture, and research on China not only at Penn State, but also in local K-12 schools. The Confucius Institute is led by Eric Hayot, director of the Asian Studies Program in the College of Liberal Arts, and Xiaochun Niu, associate professor of the school of foreign languages and deputy director of the international office at DUT.



**“The collaboration between faculty and students at Penn State and DUT will help to solve critical energy problems important for both U.S. and China.”**  
– DUT President Ou

From left to right: JCER co-director from DUT Jieshan Qiu, DUT President Jinping Ou, Penn State President Graham Spanier, JCER co-director from Penn State Chunshan Song, and Penn State Vice Provost Michael Adewumi with the plaque commemorating the new Center.

While academic leaders from Penn State and DUT came together to kick off the official opening of the JCER, this event also served as the second Penn State – Dalian Joint Energy Workshop. Penn State and DUT have an ongoing relationship and many existing cooperative efforts between faculty members. The establishment of the JCER will allow the universities to formalize and expand on these collaborations and promote the exchange of faculty and students.

The second PSU–DUT Joint Energy Workshop, which was held at the EMS Energy Institute, provided an opportunity for faculty from both institutions to come together and talk about their expertise with the goal of finding areas of mutual interest for collaborations. Participants included faculty members in multiple colleges from both Universities.

DUT President Ou gave brief remarks encouraging the collaborative energy research and thanking Penn State faculty members for their participation, and Qiu gave a presentation on DUT's energy research areas. Next Song provided an introduction of the JCER and some general information about the EMS Energy Institute, and Tom Richard, director of the Penn State Institutes of Energy and the Environment (PSIEE), gave an overview of energy and environmental research areas at Penn State.

From Penn State, Andrew Zydney, department head of Chemical Engineering; Bruce Logan, director of the Hydrogen Energy Center; Yaw Yeboah (represented by Semih Eser), department head of the John and Willie Leone Family Department of Energy and Mineral Engineering, and John Yen, director of Strategic Initiatives, College of Information Science and Technology briefly introduced their units with respect to research and education. From DUT, Xinwen Guo, dean for DUT School of Chemical Engineering; Haoquan Hu, associate dean of the DUT School of Chemical Engineering; and He Guo, associate dean for DUT School of Software Engineering introduced their units and briefly mentioned some possible areas for future collaboration.

After the speakers, guests from DUT participated in a tour, led by Bruce Miller, associate director of the EMS Energy Institute, of the Institute laboratories. Workshop attendees then spent time discussing key issues and action items for the JCER.

The collaboration between Penn State and DUT began as the result of discussions in October 2008. In October 2009, a delegation from DUT visited Penn State and the EMS Energy Institute to discuss the establishment of a Joint Energy Research Center. During the visit, DUT and Penn State leaders signed a Memorandum of Understanding (MOU) agreeing to develop a Joint Energy Research Center. In October 2010, Penn State and DUT held their first joint energy workshop at DUT.

DUT is one of the top national universities in China with strengths in various engineering fields and business management, especially in the fields of Chemical Engineering (including Energy Chemical Engineering), Mechanics, Civil Engineering, Mechanical Engineering, Mathematics, Environmental Engineering, and Management, and has strong research in energy and environmental areas and chemical engineering. The university has over 40,000 students and over 3,000 faculty members.



Penn State President Graham Spanier and DUT President Jinping Ou sign the official documents establishing the JCER.



Xiaoliang Ma, senior research associate at the EMS Energy Institute, (right) discusses the equipment in an Institute lab with DUT visitors.

# Group Studies Technology to Increase Output of Oil Reservoirs

Increasing the volume of oil recovered from oil reservoirs could be an important step in growing the nation's oil supply and reducing our dependence on imported resources. Depending on the geographical characteristics of a reservoir, over 50 percent of the original oil can be left behind after initial production according to the U.S. Department of Energy's National Energy Technology Laboratory (NETL). Enhanced oil recovery (EOR) refers to methods that are used to increase the amount of oil recovered from petroleum reservoirs. Typically EOR is employed after primary and secondary methods are exhausted. However, to be viable the cost of the extraction must be kept relatively low.

In order to extract oil, a certain amount of pressure needs to be present. Primary recovery methods exploit the energy naturally present in a reservoir such as gas under pressure or natural water displacing oil downward. Secondary methods usually refer to the use of waterflooding or the injection of water into the reservoir.

Once the initial pressure of a reservoir has been depleted through primary and secondary recovery methods, EOR can be used to increase the yield of a reservoir. Gas flooding is the most commonly used EOR approach because gas, unlike water, is miscible, or has the

ability to mix with, oil. Gas flooding refers to the injection of gases into a reservoir to cause miscibility and the efficient extraction of previously trapped residual oil. While not the only viable gas, CO<sub>2</sub> is used most often in gas flooding because it's relatively inexpensive, and has efficient extraction of oil at relatively low reservoir pressures. Injection of CO<sub>2</sub> also has the advantage of sequestering a gas that is associated with climate change. According to NETL, CO<sub>2</sub> flooding currently produces about 190,000 barrels of oil per day.

As the director of the Gas Flooding Joint Industry Project, Russell Johns has assembled a research team to investigate a wide range of topics related to the issues around gas flooding. The group includes faculty from several universities including Penn State and the University of Texas. The majority of funding for the program comes from industry membership and, in order to ensure the research is highly relevant, the group encourages industry affiliates to provide topics and data for the research. Current member companies are British Petroleum, ExxonMobil, Maersk, Marathon, Occidental, OMV, and Shell.

Johns, professor of petroleum and natural gas engineering at Penn State, initiated this program in 2006 with the goal of generating innovative research in gas flooding and closely related areas as well as recruiting and training graduate students in petroleum engineering for careers in the oil industry. In addition to student recruitment and shared research outcomes, technology transfer is one of the major benefits for gas flooding

members. Members have access to an interactive website, annual workshops and meetings, and software toolkits. These toolkits provide members with practical software, which facilitates the dissemination of research results to oil companies as well as providing a platform to store graduate student knowledge.

The group's research falls into several key areas, including gas flooding processes such as CO<sub>2</sub> gas flooding and rich gas flooding, thermodynamics & phase behavior, geo-chemistry, petrophysical properties, and numerical simulation of gas floods.

Current research projects include:

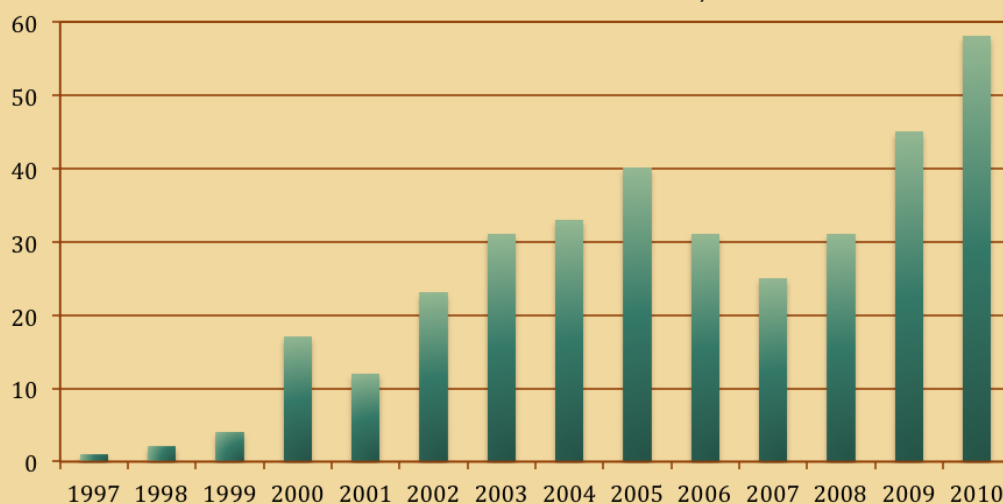
- Development of Miscibility for Various Oils and Injection Mixtures
- CO<sub>2</sub> Flooding in Carbonates
- Prediction of the Optimum WAG Performance
- Three-Phase Capillary/Capillary Equilibrium in Oil-Wet Media
- The Effect of Wettability on Three-Phase Relative Permeability During Gravity Drainage
- Foams and Emulsions Stabilized with Nanoparticles for Potential Conformance Control Applications
- Upscaling of Miscible Gas Floods
- Asphaltene modeling using the SAFT EOS
- Miscible Gas Flooding in Naturally Fractured Reservoirs
- Analytical Modeling of Three Phase Coning

For more information on the Gas Flooding Joint Industry Project, visit the website, [www.energy.psu.edu/gf](http://www.energy.psu.edu/gf).

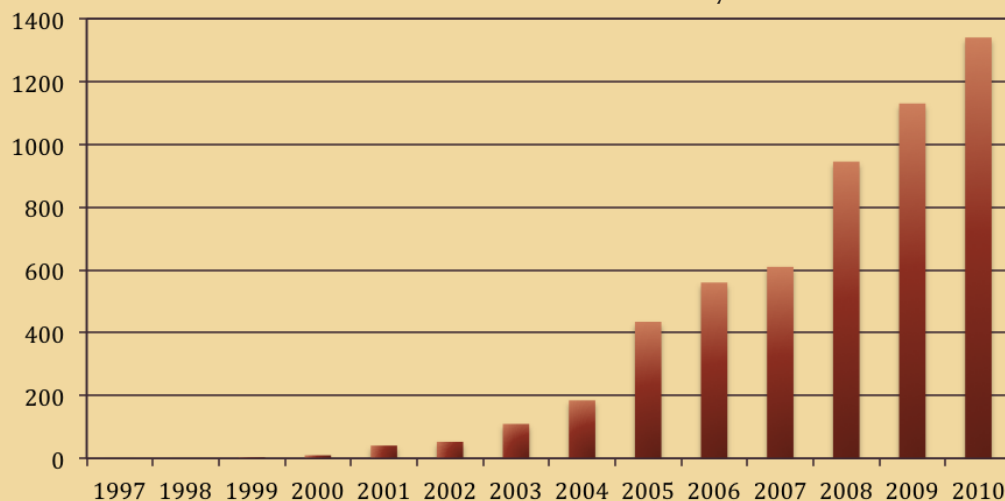
## Impact of Institute Publications on the Rise

The EMS Energy Institute faculty and researchers take a strong interest in presenting and publishing their work for the greater scientific community. Over the last thirteen years, there has been a significant jump in the number of publications resulting from Energy Institute research. Subsequently, the number of times these publications have been cited has steadily risen. The first publication that included the Energy Institute as an affiliation appeared in May 1997. In 2010, over 50 publications were affiliated with the Institute. Citations from these articles began to appear in 2000. Currently, Institute publications collectively receive over 1,300 citations a year. Since 1997, Energy Institute researchers have published over 350 articles that have been cited over 5,400 times. This drastic increase in publications corresponds with the continued rise in research taking place at the Institute as more faculty, researchers, and students come onboard. In addition, the high number of citations credited to Institute researchers' publications demonstrates the high impact of this research in the scientific community as a whole.\*

### Number of Journal Articles by Year



### Number of Citations in SCI+ by Year



\*Science Citation Index

\*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 2010. Only publications that had the Energy Institute listed in the affiliation section are included.



## Randy Vander Wal's Work Contributed to NASA Group Achievement Award

On August 19, the NASA Alternative Aviation Fuel Experiment (AAFEX) Team received a NASA Group Achievement Award. Randy Vander Wal, associate professor in energy and mineral engineering, and his team supported the AAFEX field campaign studying alternative fuels and recently presented some of this work at the Fall 2010 American Chemical Society National Meeting.

The work of Vander Wal's team, along with that of other teams, was recognized during the annual awards presentation at Langley "for outstanding achievement in establishing the impact of synthetic fuels on commercial aircraft engine and auxiliary power unit performance and pollutant emissions."

The NASA Group Achievement Award is given to individuals for an outstanding group accomplishment that contributes substantially to NASA's mission.



## Zuleima Karpyn Awarded Wood Fellowship

Zuleima Karpyn has been selected as the Quentin E. and Louise L. Wood University Endowed Fellow in Petroleum and Natural Gas Engineering. The purpose of the fellowship is to provide additional funding to an outstanding member of the petroleum and natural gas engineering faculty in order to further his or her contributions to teaching, research, and public service.

Karpyn, an assistant professor of petroleum and natural gas engineering, is a recipient of the 2005 Penn State Wilson Research Initiation Grant, 2008 Faculty Early Career Development (CAREER) Award granted by the National Science Foundation, and the 2010 Penn State Wilson Award for Excellence in Teaching. She is also Associate Editor for the Society of Petroleum Engineers Journal, and an active member of the Society of Core Analysts and the American Geophysical Union. Her teaching and research interests include reservoir characterization and multiphase transport phenomena in porous media, including applications in reservoir engineering, underground hydrology, and environmental remediation.

## Chunshan Song to Receive 2011 ACS Distinguished Researcher Award in Petroleum Chemistry

Chunshan Song, Distinguished Professor of Fuel Science in the John and Willie Leone Family Department of Energy and Mineral Engineering and director of the EMS Energy Institute in the College of Earth and Mineral Sciences has been selected to receive the 2011 Distinguished Researcher Award from the Petroleum Chemistry Division of the American Chemical Society (ACS). The award, which began in 2008, will recognize Song for his extensive original contributions to research in the petroleum chemistry field.

Song, who is also professor of chemical engineering (courtesy) and associate director of the Penn State Institutes of Energy and the Environment, is internationally known for his contributions to clean fuels, catalysis, and CO<sub>2</sub> capture and utilization research. A prolific author of many high-impact publications, Song has delivered 45 plenary or keynote lectures at international conferences and over 210 invited lectures worldwide. He has over 180 refereed journal articles (which received over 5000 citations), 6 refereed books, 11 special journal issues, 22 patents and patent applications, and over 280 conference papers.

The ACS Petroleum Chemistry Division will hold an Award Symposium in Honor of Chunshan Song at the Fall 2011 ACS National Meeting in Denver, CO with around 30 invited lectures by selected researchers worldwide.

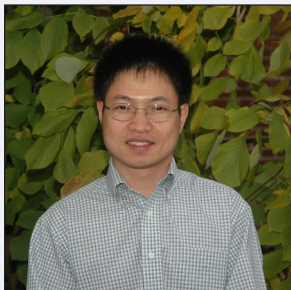
## André Boehman Honored with Colwell Merit Award



André Boehman, professor of fuel science and materials science and engineering, was selected to receive the 2009 Arch T. Colwell Merit Award in recognition of a technical paper he co-authored, “An Experimental Investigation of the Origin of Increased NO<sub>x</sub> Emissions when Fueling a Heavy-Duty Compression-Ignition Engine with Soy Biodiesel.” The paper was published in the October 2009 issue of SAE International Journal of Fuels and Lubricants.

This award was established by Arch T. Colwell to recognize authors of outstanding papers presented at SAE meetings. Papers are judged for their value as contributions to existing knowledge of mobility engineering, and primarily with respect to their value as an original contribution to the subject matter. Award winning papers are selected from the many papers which were published for SAE meetings during 2009.

The paper’s lead author was Charles J. Mueller, Sandia National Laboratories. Co-authors included André Boehman and Glen C. Martin, Sandia National Laboratories. Previously, the paper received the 2009 SAE John Johnson Award for Outstanding Research in Diesel Engines.



## Yongsheng Chen Receives DARPA Young Faculty Award

Yongsheng Chen, assistant professor of energy and mineral engineering and the Virginia S. and Philip L. Walker, Jr. Faculty Fellow, has received a 2010 Young Faculty Award from the Defense Advanced Research Projects Agency (DARPA). DARPA Young Faculty Awards are given to junior faculty conducting research in the areas of the physical sciences, engineering and mathematics.

## Two Faculty Members Elected to the 2010 Class of ACS Fellows

Two Institute faculty members, Harold Schobert and Chunshan Song, were elected to the 2010 class of Fellows of the American Chemical Society (ACS).

Schobert, professor of fuel science in the John and Willie Leone Family Department of Energy and Mineral Engineering and leading researcher in fuel chemistry in the EMS Energy Institute, came to Penn State in 1986 and served as the Fuel Science Program Chair from 1988 – 1996 and as the EMS Energy Institute Director from 1998 – 2006. He has made many important contributions to the advancement of fuel science and is internationally recognized as a leading researcher for his accomplishments in the areas of fuel chemistry, including molecular structures of coals, conversion of coals to synthetic fuels and to carbon materials, coal-based jet fuels, coal ash behavior, and CO<sub>2</sub> capture.

Song is a Distinguished Professor of Fuel Science and the director of the EMS Energy Institute. In addition, he is a professor of chemical engineering and associate director of the Penn State Institutes of Energy and the Environment. Song has been member of the University faculty since 1989 and is internationally recognized for his original and innovative contributions to clean fuels, catalysis and CO<sub>2</sub> capture and conversion research.

The ACS Fellows Program, created in 2008 to “recognize members for their contributions to the chemical sciences and outstanding service to ACS,” honored the inaugural class of 162 Fellows in 2009.



## Students Place First in the Lockheed Martin Design Awards

By Anna Morrison, the John and Willie Leone Family Department of Energy and Mineral Engineering



From left to right: Adam Kimmerle, Liam O'Sullivan, Timothy Tomko, Keith Miska, Natalie Keener, Shaun Valentine, and Ronald Wasco stand in front of the team's design.

Two teams of energy engineering students walked away with top prizes at the Penn State College of Engineering's spring 2011 Design Project Showcase, held April 28, 2011, at the Bryce Jordan Center. The teams won first place Lockheed Martin Design Awards in the best project and best poster categories. "This is a tremendous accomplishment for the department and college coming from a new engineering program," said Yaw Yeboah, head of the John and Willie Leone Family Department of Energy and Mineral Engineering.

The Design Project Showcase is an exhibit of engineering design projects created by students with the support of Penn State faculty members and industry sponsors. The projects allow students to display their solutions to problems posed by their industry sponsors. Both energy engineering teams entered the competition with their senior capstone design projects under the supervision of André Boehman, professor of fuel science and materials science and engineering.

Members of the team awarded best project included Natalie Keener, Adam Kimmerle, Liam O'Sullivan, Timothy Tomko, and Shaun Valentine. Sponsored by Daniel Yanchak of CONSOL

Energy, Inc., they were tasked with devising a way to improve the industry method of recovering magnetite once it has been used in a slurry mix to separate mineral matter from coal. The energy engineering team designed and built a hydrocyclone enhanced with a four-pole AC electromagnet pulsing in the direction of the hydrocyclone flow. Initial testing showed the electromagnetically-enhanced hydrocyclone achieving a recovery efficiency of 96 percent. Much of the work for this project was completed at the EMS Energy Institute and Institute research staff Keith Miska and Ronald Wasco assisted the team with carrying out their design.

Members of the team awarded best poster included Andrew Eldridge, Erik Horn, Arwen Kandt, Roman Keniuk, Douglas Middleton, and Kaitlin Myers. Sponsored by Jason Steiner of Boeing, their project centered on the development of a mechanical energy storage system.

In all, there were 92 senior capstone design projects on display at the Design Showcase, with nearly 430 students in ten academic departments participating.

## Song Receives Faculty Scholar Medal

Chunshan Song has been selected to receive a 2011 Faculty Scholar Medal for Outstanding Achievement. Established by the University in 1980, the award recognizes scholarly or creative excellence represented by a single contribution or a series of contributions around a coherent theme. The contribution may be original basic research in any area of science; may represent application of knowledge in the creation of a process or device useful to society; or may be in any area of the arts or humanities. A committee of faculty peers reviews nominations and selects candidates.

Song, Distinguished Professor of Fuel Science in the John and Willie Leone Family Department of Energy and Mineral Engineering, and the director of the EMS Energy Institute, was the engineering award recipient. He is regarded as an international leader in fuel science and catalysis. He is recognized for new approaches for removing sulfur by selective adsorption for ultra-clean liquid fuels, new approaches for designing sulfur and carbon resistant catalysts, shape-selective catalysis, novel molecular basket sorbents for CO<sub>2</sub> capture, and a new process known as tri-forming of natural gas, using CO<sub>2</sub> in flue gas as a method to produce industrially useful syngas. His contributions were described as "brilliant and prolific" by one of his external references.



## 2011 Wilson Banquet and Awards Presentation

The College of Earth and Mineral Sciences held its 2011 Wilson Banquet & Awards Presentation April 10 to recognize student achievement, faculty mentoring, faculty commitments to service, and excellence in research and teaching.

### Gladys Snyder Education Grants



**Jeffrey Brownson**, assistant professor, energy and mineral engineering, received the Gladys Snyder Education Grant for *Exploring Renewable Energy Technologies and the Materials that Make it Happen: A PSU ASM Materials Camp*.



**Sarma V. Pisupati**, associate professor, energy and mineral engineering, also received a Gladys Snyder Education Grant at the 2011 presentation.

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

**Zuleima T. Karpyn**, assistant professor, petroleum and natural gas engineering, received the George H. Deike, Jr. Research Grant for *Experimental Investigation of Carbon Dioxide Trapping Due to Capillary Retention in Saline Aquifers*.

### 2011 DEPARTMENT OF ENERGY AND MINERAL ENGINEERING STUDENT AWARDS

#### Outstanding Graduate Teaching Assistants

Ramprasad Chandrasekharan  
Sakthivale Roshan Dhaneswar

#### BP Exploration Graduate Scholarship

Sachin Rana

#### Charles B. Darrow Award

Yu Noda

#### Charles B. Manula Memorial Scholarship

Arwen R. Kandt

#### Frank and Lucy Rusinko Graduate Fellowship

Gregory K. Lilik  
Olaide M. Oyetayo

#### Robert and Leslie Griffin Award

Gregory K. Lilik

## Staff Member Receives Future Star Award

Shea Winton, writer/editor and public relations specialist for the EMS Energy Institute, received the Future Star Award at the 2010 College of Earth and Mineral Sciences Dean's Staff Appreciation Luncheon. This award honors a staff member who has been with the College fewer than two years, who demonstrates initiative and commitment to their unit, and has made a significant impact within their short employment.

## 2010 EMS Energy Institute Celebration of Accomplishments

Several faculty, staff and students received awards last year for their achievements and service to the Institute during the EMS Energy Institute 2010 Celebration of Accomplishments banquet held in December. Below is a list of the awards presented and their recipients.

### Research Achievement Award

**Jonathan Mathews**, *Assistant Professor*

For outstanding research accomplishments as reflected by high-impact research publications in refereed journals.

### Distinguished Service Award

**Stephen Kirby**, *Research Associate*

For sustained and distinguished service to research and service missions of the EMS Energy Institute.

### Administrative Staff Excellence Award

**Shea Winton**, *Writer/Editor*

For superior performance in supporting faculty, students and research staff for research, service and outreach at EMS Energy Institute.

### Dedicated Employee Award

**Mamoru Fuji**, *Research Support*

For dedicated and excellent job performance at EMS Energy Institute.

### Student Achievement Award

**Chao Xie**, *Graduate Student*

For superior performance in research by graduate or undergraduate students working at EMS Energy Institute, as evidenced by publication.

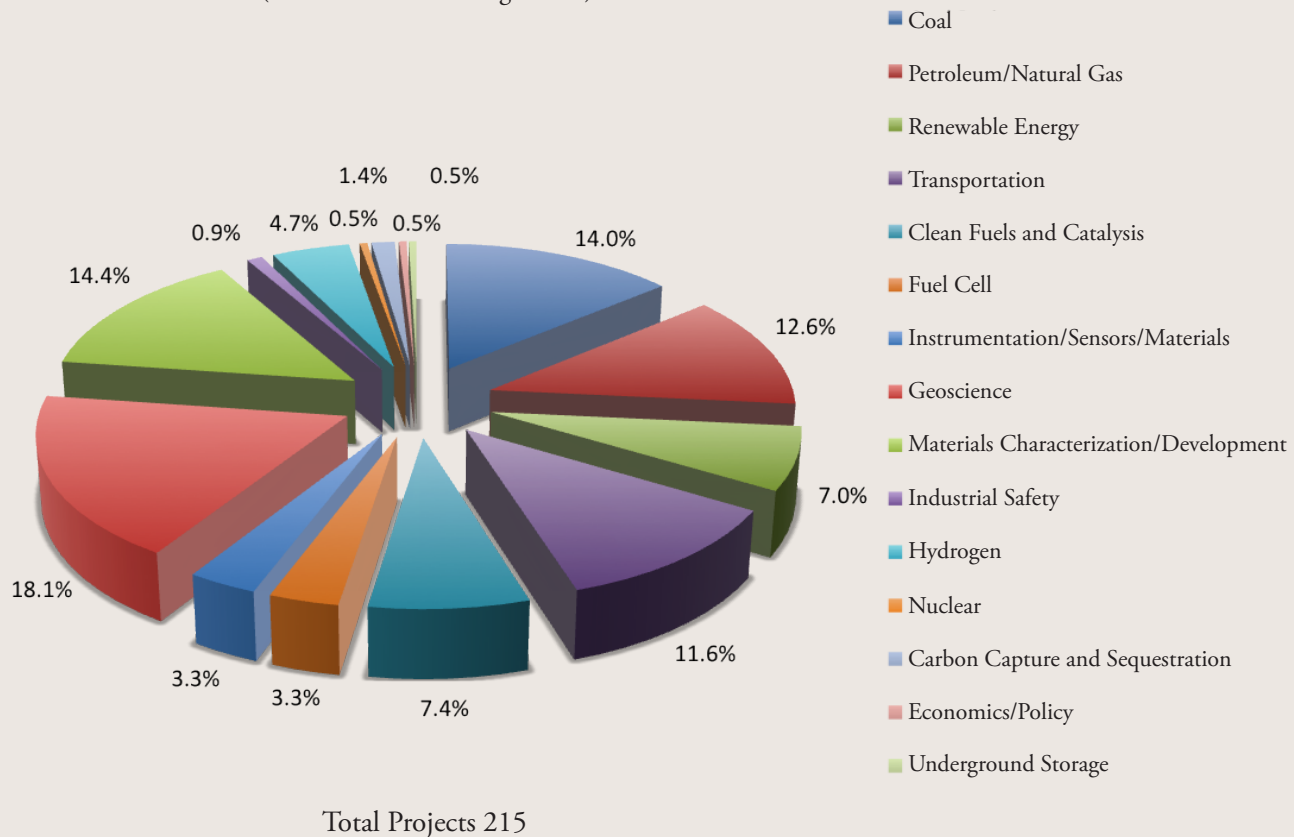
### Student Service Award

**Natalie Keener**, *Undergraduate Student*

For excellent service by graduate or undergraduate students to the research, service and educational missions of the EMS Energy Institute.

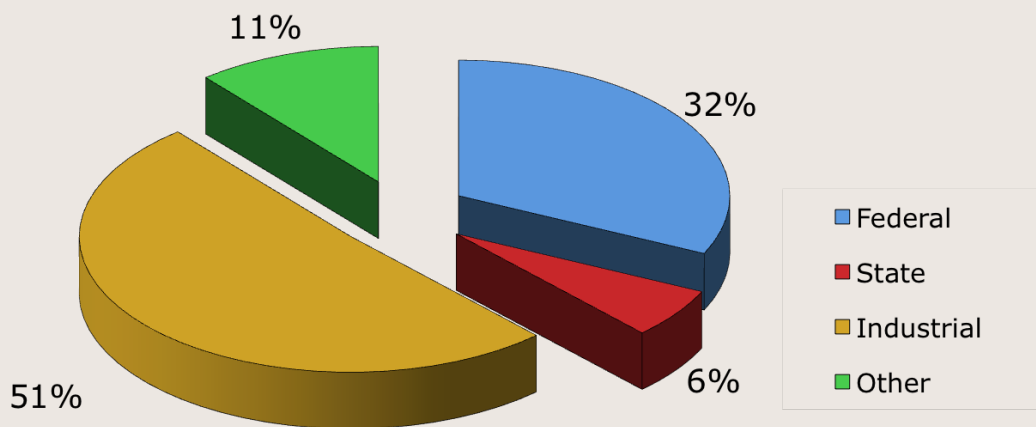
# Summary of Projects & Funding

EMS Energy Institute Projects by Program Area  
(Fiscal Year 2007 through 2010)



### EMS Energy Institute Awards by Source

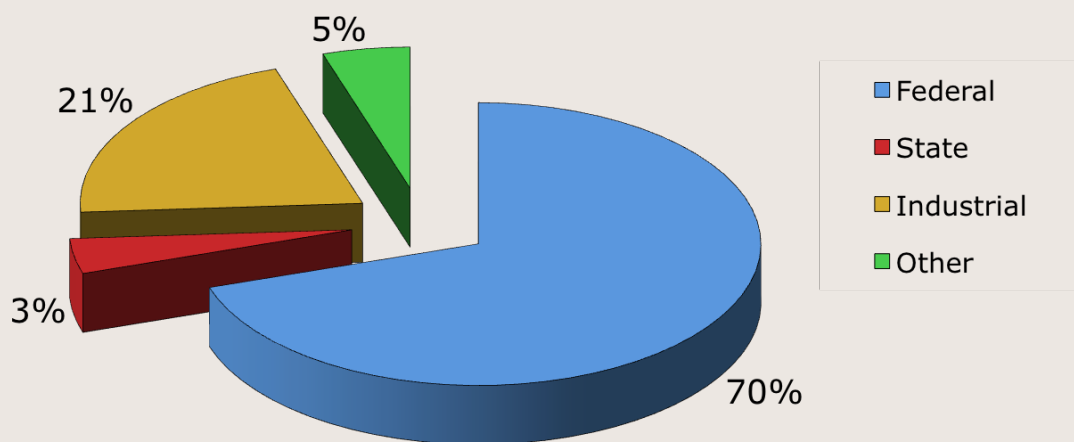
(Fiscal Year 2009 through 2010)



Total Awards 105

### EMS Energy Institute Funding by Source

(Fiscal Year 2009 through 2010)



Total Funding \$8.5 million

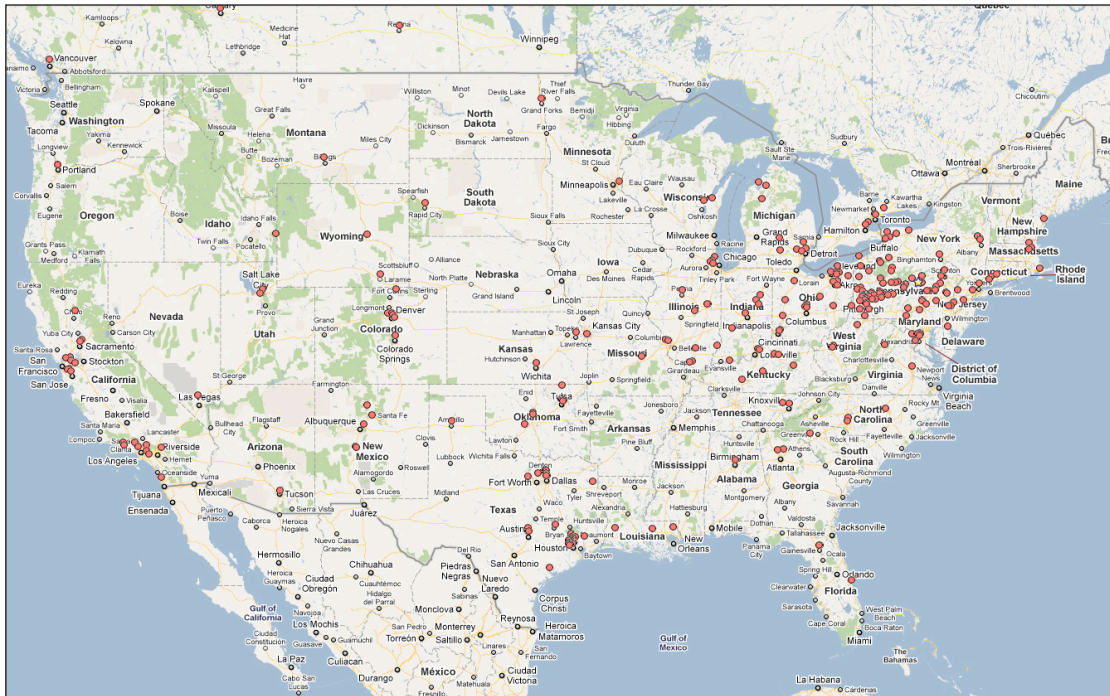
**Energy Innovation**

**EMS Energy Institute**

The Pennsylvania State University  
C-211 Coal Utilization Laboratory  
University Park, PA 16802, USA  
ei-questions@ems.psu.edu

## Visit Our New Interactive Partner Map Online

The EMS Energy Institute developed an interactive map that highlights our partnerships with government agencies, industry, and academia throughout the United States and 15 countries.



[www.energy.psu.edu/partnerMap.html](http://www.energy.psu.edu/partnerMap.html)