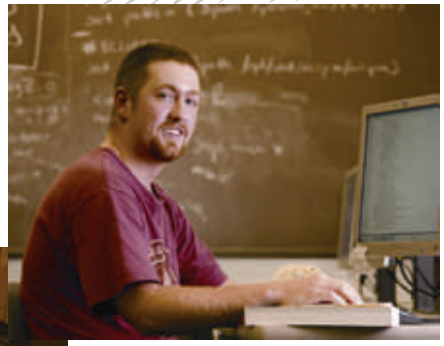
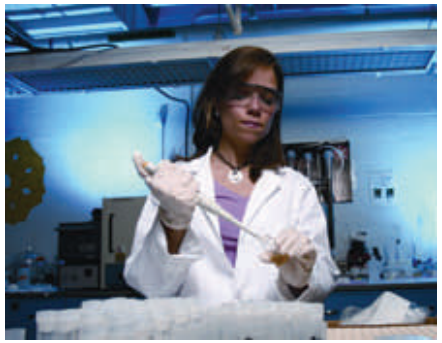
2008-09 ANNUAL REPORT

Notre Dame Energy Center Institute





HELPING TO BUILD A BETTER ENVIRONMENT WITH ENERGY RESEARCH, EDUCATION, AND POLICY DEVELOPMENT

MISSION

The Notre Dame Energy Center/Institute focuses on five key areas in developing new technologies to meet the global energy challenge: energy efficiency; safe nuclear waste storage; clean coal utilization; carbon dioxide separation, storage, sequestration, and use; and solar and other renewable resources. The institute is housed in the College of Engineering and is committed to playing key roles in energy education and literacy, the development of energy policy, and the exploration of the ethical implications associated with energy.

Contents

We are pleased to announce that we are going 100% *GREEN* and will no longer be providing printed copies of our annual report. A pdf version will be available on our web site and can be downloaded if you would like a printed copy. Please feel free to share our report with colleagues and friends and others who may be interested in energy education and research. If you have any questions, please feel free to contact Barbara Villarosa at villarosa.2@nd.edu. The report can be found at http://energycenter.nd.edu/

Letter from the Director

Dear Friends and Colleagues,

I am pleased to present to you the 2008-2009 Annual Report of the Notre Dame Energy Center, now known as the Notre Dame Energy Institute. I am thrilled to announce our reclassification from a “College Center” to a “College Institute,” which is an honor for us and truly a testament to the many loyal and dedicated faculty who serve and support our mission. Becoming an institute did not happen overnight nor did it result from any one single effort. Instead, our success has derived from the numerous research activities and educational programs that have been developed by many of you over the years. These programs have contributed greatly to the University’s goals of providing higher academic standards and becoming a premier research institution. As always, we thank you for your time and personal efforts to our continued growth. We will be changing to our new identity on all print and electronic materials in the near future, so your patience with us as we work through this process will be appreciated.

I am equally pleased to formally welcome to the University of Notre Dame Patrick M. Murphy, appointed in April 2009 as the first managing director of the Notre Dame Energy Center/Institute. Patrick has an outstanding list of credentials and a solid background of experience in proposal development and research operations. Prior to joining the University, Patrick directed efforts in the Homeland Security Advanced Research Projects Agency to provide more resilient electric power systems, including new grid architectures, back-up and distributed systems, demand management and alternative energy sources. There will be more about Patrick in the report. Please join me in welcoming Patrick to the University and to the Notre Dame Energy Center/Institute.

It is my privilege to report that we have had yet another successful and productive year. Thanks to all of you who have supported our efforts or have given your time so generously to increasing our research initiatives and providing outstanding education programs. I hope you will enjoy learning more about the Center/Institute and its many accomplishments over the last fiscal year.

Sincerely,

Joan F. Brennecke

Joan F. Brennecke
Director

Faculty Research

Energy related research conducted by faculty at the University of Notre Dame is a primary function of the Center/Institute's mission to develop new technologies to address the global energy challenge. Since its inception in 2005, the Center/Institute has highlighted energy related projects each year that have been funded by external sponsors. This year, the University received nearly $9.5 million in external funding in support of the following 28 energy related research projects. These projects are listed in alphabetical order by principal investigator. The chart on page 7 breaks down the total number of projects by department.

Overall, since the inception of the Notre Dame Energy Center/Institute, the University has received approximately $35 million from external sponsors to support energy related research at the University of Notre Dame. The graph on page 8 shows the total amount of external funding received by fiscal year and the total amount awarded for energy related projects.

Principal Investigator	Department	Project Title	Sponsor	Amount
Bohn, Paul W.	Chemical and Biomolecular Engineering	Molecular Aspects of Transport in Thin Films of Controlled Architecture	Department of Energy	$124,999
Brennecke, Joan F.	Chemical and Biomolecular Engineering	Ionic Liquids for CO_2 Capture from Advanced Post-Combustion or Advanced Pre-Combustion Gases	General Electric Foundation	$87,140
Brennecke, Joan F.	Chemical and Biomolecular Engineering	Notre Dame Geothermal Ionic Liquids Research: Ionic Liquids for Utilization of Geothermal Energy	Department of Energy	$984,000
Brown, Seth N.	Chemistry and Biochemistry	Probing the Articulation Between Electron Transfer and Bond Cleavage Using Early Metal Complexes of Redox-Active Phenoxides.	ACS Petroleum Research Fund	$100,000
Carmichael, Ian	Radiation Laboratory	Radiation Chemistry and Photochemistry in the Condensed Phase and at Interfaces	Department of Energy	$3,820,000
Carmichael, Ian Huang, Libai	Radiation Laboratory	Radiation Chemistry and Photochemistry in the Condensed Phase and at Interfaces	Department of Energy	$230,000

FACULTY RESEARCH *(CONTINUED)*

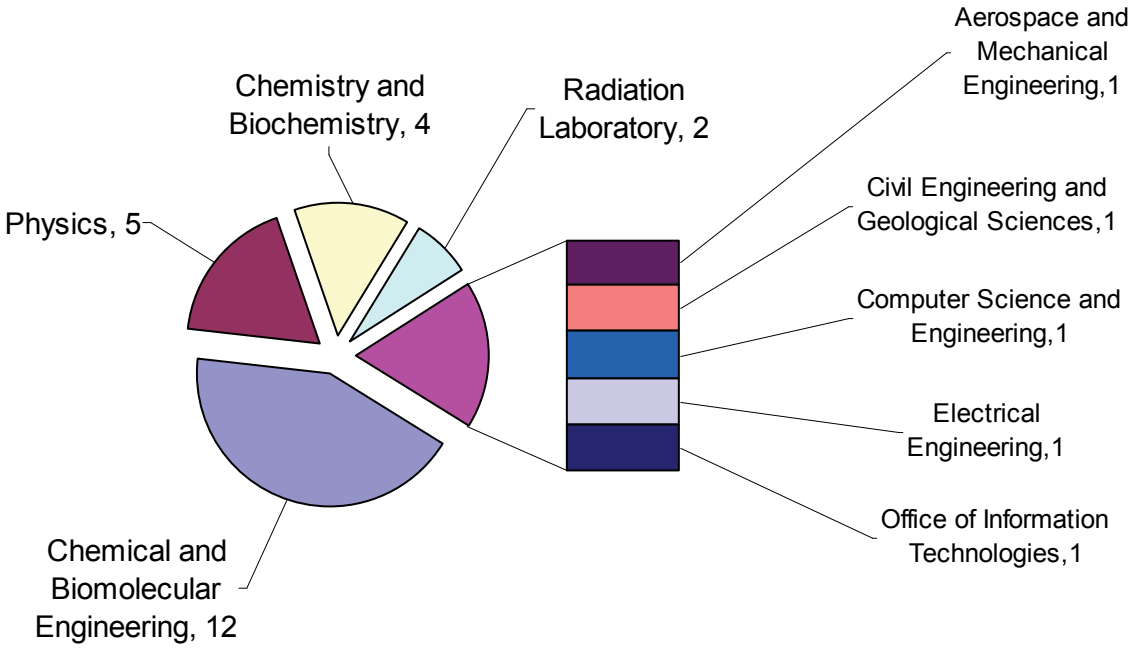
Principal Investigator	Department	Project Title	Sponsor	Amount
Corcelli, Steven A.	Chemistry and Biochemistry	Computational Studies of Hydrogen-Bond Dynamics in Methanol Probed by Ultrafast IR Spectroscopy	ACS Petroleum Research Fund	$50,000
Eskildsen, Morten R.	Physics	Vortices and the Interplay Between Superconductivity and Magnetism	National Science Foundation	$220,000
Fein, Jeremy B.	Civil Engineering and Geological Sciences	Phosphate Barriers for In Situ Immobilization of Uranium	Department of Energy	$120,800
Furdyna, Jacek K.	Physics	Monolithically Integrated Light Weight Multijunction Solar Cells with Ultrahigh Efficiency	Arizona State University	$98,000
Kamat, Prashant V.	Chemistry and Biochemistry	Transient Absorption and Emission Studies of Photoactive Materials	Honeywell International Inc.	$137,751
LoSecco, John M.	Physics	Research in CP Violation in the B Meson Sector	Department of Energy	$145,000
Maginn, Edward J.	Chemical and Biomolecular Engineering	Determination of Physical Properties of Ionic Liquids Using Molecular Simulations	Department of the Air Force	$115,000
Maginn, Edward J.	Chemical and Biomolecular Engineering	Ionic Liquids: Breakthrough Technology for Post-Combustion CO_2 Capture	Department of Energy	$1,011,949
McCready, Mark J.	Chemical and Biomolecular Engineering	Entrainment in two-phase gas-liquid flows	Chevron Research Company	$20,000
McGinn, Paul J.	Chemical and Biomolecular Engineering	Direct Methanol Fuel Cell Lifetime Improvement	NuVant Systems, Inc.	$150,000

FACULTY RESEARCH *(CONTINUED)*

Principal Investigator	Department	Project Title	Sponsor	Amount
Poellabauer, Christian	Computer Science & Engineering	CSR-EHCS (EHS), SM: Collaborative Research: Integrated Energy-Aware Resource Scheduling for Wireless Real-Time Systems	National Science Foundation	$221,156
Schneider, William F.	Chemical and Biomolecular Engineering	Towards Realistic Models of Heterogenous Catalysis: Simulations of Redox Catalysis from First Principles	Department of Energy	$140,000
Sevov, Slavi C.	Chemistry and Biochemistry	Nanorods of Silicon and Germanium with Well-Defined Shapes and Sizes	Department of Energy	$123,111
Tomar, Vikas	Aerospace and Mechanical Engineering	Microstructural Engineering of SiC-Si3N4 Nanocomposites Using a Combination of Classical Molecular Dynamics and Cohesive Finite Element Methods	National Science Foundation	$12,000
Wishon, Gordon D.	Office of Information Technologies	Northwest Indiana Computation Grid (NWIC-Grid)	Department of Energy	$1,000,000
Wolf, Eduardo E. Schneider, William Bernstein, Gary	Chemical and Biomolecular Engineering	Catalytic Nanodiode	National Science Foundation	$371,938
Xing, Huili	Electrical Engineering	THz power sources based on Negative Differential Resistance (NDR) in GaN	Department of Navy	$60,000
Zhu, Yingxi E.	Chemical and Biomolecular Engineering	Water-Immersed Polymer Interfaces and the Role of their Materials Properties on Biolubrication	Department of Energy	$150,000
			TOTAL	**$9,492,844**

FACULTY RESEARCH *(CONTINUED)*

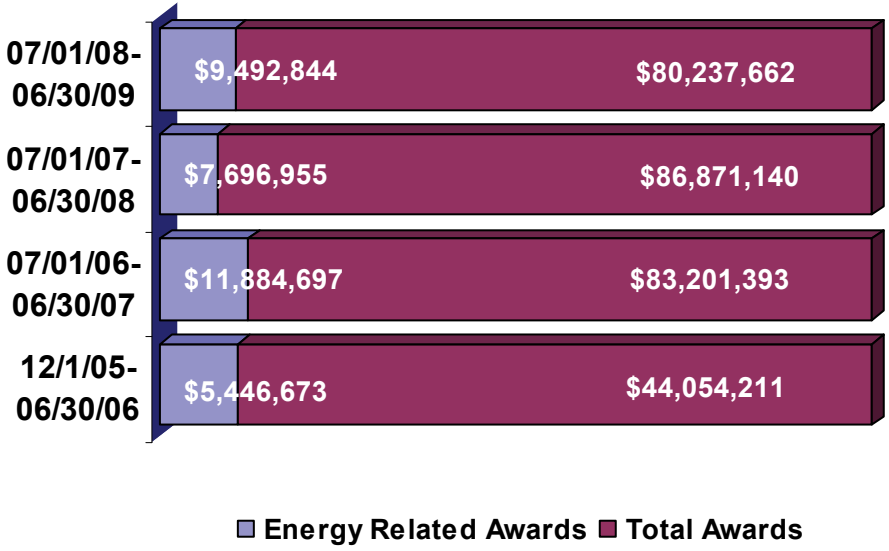
This chart breaks down the total number of energy related projects (28) by department for Fiscal Year 2008-2009.



FACULTY RESEARCH *(CONTINUED)*

This chart shows, by fiscal year, the total amount received by the University from external sponsors and the total amount awarded for energy related research, since the inception of the Notre Dame Energy Center/Institute.

Energy Related Research Awards vs. Total Awards Received Since the Inception of the Notre Dame Energy Center

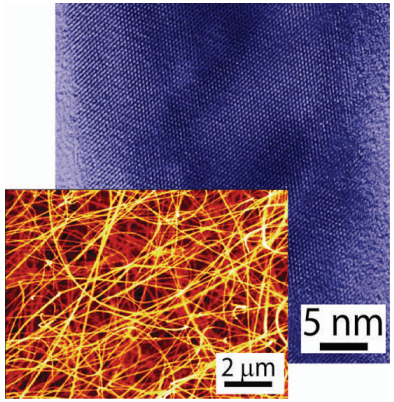


Chemistry and Biochemistry

Dr. Masaru (Ken) Kuno and Dr. Prashant Kamat
Yanghai Yu, Graduate Research Assistant

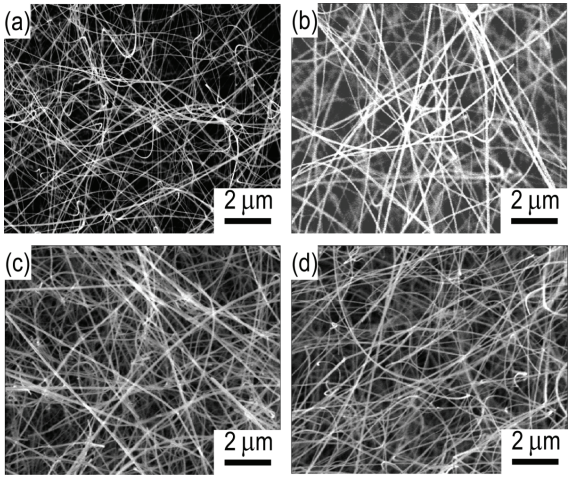
"CdSe nanowire photoelectrochemical solar cells enhanced with colloidal CdSe quantum dots"

ABSTRACT. Kuno and Kamat describe the fabrication and characterization of a CdSe nanowire (NW) photoelectrochemical solar cell. These proof-of-concept devices employ CdSe NWs to absorb incident light and also use them to transport photogenerated electrons to their respective electrodes. Early cells show maximum incident photon-to-current conversion efficiencies (IPCE) of ~18% at 500 nm with associated power conversion efficiencies, under simulated AM 1.5, 1 sun conditions, of ~0.004%. Interestingly, adding colloidal CdSe quantum dots (QDs) dramatically increases the observed maximum IPCE efficiency to 34%. Corresponding power conversion efficiencies double to ~0.01%. While the effect could, in principle, stem from the direct absorption of light and subsequent generation of carriers by QDs, the overall IPCE efficiency increase occurs across the *entire* visible spectrum, even at wavelengths where the dots do not absorb. As a consequence, we have investigated this phenomenon and have concluded that it originates from an interplay between NWs and QDs where the latter fill voids between interconnected NWs, enabling better carrier transport to electrodes. Residual polarization sensitivities of random NW assemblies are also suppressed. Thus introducing QDs to NW networks appears to address several limiting constraints of NW solar cells. The benefits seem to be general and may therefore aid the future design and implementation of other NW-based solar cells.



"Bismuth assisted CdSe and CdTe nanowire growth on plastics"

ABSTRACT. A modified chemical vapor deposition process has been used to synthesize long (>10 mm), 20-60 nm diameter CdSe and CdTe NWs at low temperatures on plastic. The approach applies synthetic strategies developed during the growth of solution-based semiconductor nanowires (NWs). Namely, a thin Bi film is employed to induce NW growth at temperatures as low as ~300 °C on polyimide. This polymer substrate is flexible, semi-transparent and possesses excellent chemical stability. Resulting wires have subsequently been characterized using various techniques, including scanning electron microscopy, transmission electron microscopy and energy-dispersive X-ray spectroscopy. NW formation appears to follow a vapor-liquid-solid (VLS) growth mechanism with Bi nanoparticles inducing directional crystallization. The length, width, and overall density of the wires can be modified by varying the growth temperature, Bi film thickness, as well as the introduced precursor metal:chalcogen stoichiometry. Additional studies have been conducted to deposit wires onto other substrates such as silicon, glass, indium-tin-oxide coated glass coverslips and Teflon™. This study highlights the ability to synthesize II-VI NWs at low temperatures onto a variety of materials including plastics and raises the possibility of eventually developing conformal NW solar cells.



RESEARCH HIGHLIGHTS

Chemistry and Biochemistry, and Physics

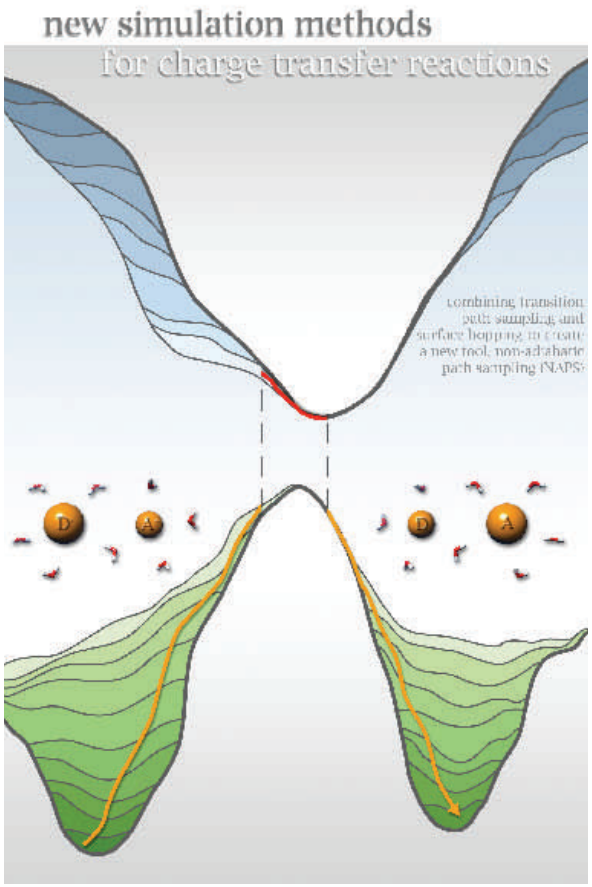
Dr. Steven Corcelli and Dr. Kathie Newman
Laura Kinnaman, Graduate Research Assistant

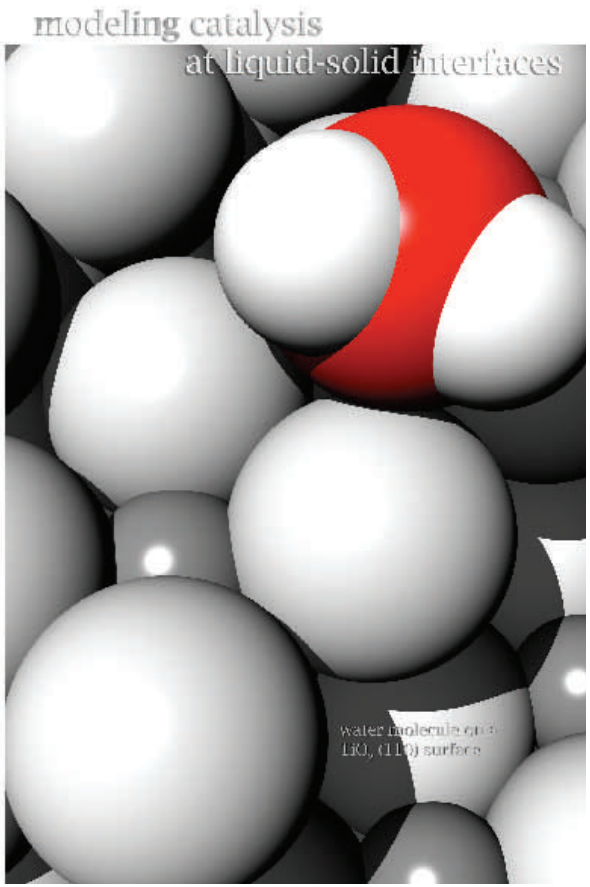
"Computer simulations of metal-oxide water interfaces"

SUMMARY: Metal oxides, such as TiO_2 and ZrO_2, are essential elements in most, if not all, chemical and photochemical energy conversion processes, including: environmental catalysis, solar energy cells, and photocatalysis. The dearth in our understanding of the factors that influenced the thermodynamics, kinetics, and mechanisms of chemical reactions at liquid-solid interfaces presents a fundamental impediment to the rational design of improved low-temperature catalysts. The long-term goal of this project is to develop, validate, and apply efficient computational models to predict the structure and reactivity of transition metal oxides in contact with water.

"Nonadiabatic transition path sampling (NAPS)"

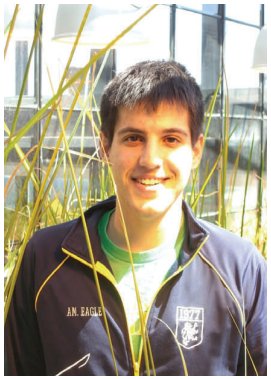
SUMMARY: Corcelli and others are developing a new theoretical and computational framework for the study of charge transfer reactions in the condensed-phase. This new method, nonadiabatic transition path sampling (NAPS), combines features of transition path sampling (TPS) and the molecular dynamics with quantum transitions (MDQT) surface-hopping algorithm. By combining TPS with MDQT, chemical reactions involving multiple electronic states that are dominated by rare but important events can be studied within the powerful TPS framework. By focusing specifically on reactive trajectories, TPS can infer detailed reaction mechanisms for processes whose timescales are outside of the range of direct simulation.





Biological Sciences

Dr. Jason McLaughlan
Chris Esber, Undergraduate Student



"Evaluating the role of evolutionary change in wetland carbon budgets"

Chris Esber, junior biological science major and 2008 Slatt Scholar, performed research under the direction of Professor Jason McLachlan on the project titled "Evaluating the role of evolutionary change in wetland carbon budgets."

Esber presented his research results at the Notre Dame College of Science JAM and will present at the 94th Annual Ecological Society of America Meeting in August 2009.

Below are highlights of Esber's research project and research results:

The impact of anthropogenic CO_2 production on climate and terrestrial primary production depends on the complex pools and fluxes of the global carbon budget. Plant primary production, growth and biomass allocation, processes at the root of the carbon cycle, are subject to evolution.

Recent studies show that changing environments (e.g., rising CO_2) might alter the way plants fix carbon and subsequently allocate it to above ground and below ground tissues. Yet, these studies do not examine the evolutionary potential of these traits in response to changing environments – a process which could alter our estimates of future production. Esber investigated the changing abilities of an ecologically important C3 coastal sedge, Schoenoplectus americanus, to store carbon over 100 years of rising CO_2 levels, sea levels, and competition with the C4 grass, Spartina patens.

-Esber found significant differences between modern populations of S. americanus for stem count, height and biomass.

-CO_2, salinity, and population had significant effects on aspects of S. americanus growth (stem number, stem height or biomass).

-Differences in growth between populations could alter ecosystem processes (such as marsh soil accretion and decomposition).

-Models that predict these ecosystem processes may need to take disparities in growth into account in order to make more accurate forecasts.

Economics

Dr. Richard Jensen
Colleen Kelly, Undergraduate Student

"Onshore wind power generation: America's energy savior or stepping stone to a less carbon intensive future"

Colleen Kelly, a senior economics major, conducted a project titled "Onshore wind power generation: America's energy savior or stepping stone to a less carbon intensive future" under the supervision of Dr. Richard Jensen, Professor and Chair of the Department of Economics and Econometrics. The study provided cost estimates of providing electricity generated by wind power for several wind tower heights and conducted sensitivity analyses of capacity, storage, capital, and transmission costs on these estimates. The primary finding is the levelized cost of electricity (in KwH) is inelastic to changes in these component costs.

Funding Opportunities

FACULTY RESEARCH—SEED FUND PROGRAM

Three projects pursuing novel concepts in clean energy were funded in Spring 2008 by the Notre Dame Energy Center's new Seed Fund program designed to support early-stage research related to energy production, delivery, and use. Two of the three projects have been completed and are summarized here.

Project: "Graded quantum dot-nanowire heteroassemblies for photovoltaics." Drs. Masaru Kuno and Prashant Kamat, Professors of Chemistry and Biochemistry.

During the period between July 2008 and July 2009, Notre Dame Energy Center funds were used to pay the salary of a joint Chemical Engineering graduate student, Yanghai Yu. Specifically, Yanghai was responsible for trying to implement solution-based semiconductor nanowires in 3rd generation solar cells. Various strategies were explored to achieve this. Kuno and Kamat ultimately focused on two projects that they felt would lead to immediate results that could be used to provide preliminary data for proposals to external funding agencies. These projects involved (a) learning to grow semiconductor nanowires at low temperatures on plastics and (b) introducing CdSe nanowires into photoelectrochemical cells to create proof-of-concept solar cells.

As a result of their work, many positive outcomes were achieved including several submissions to external funding agencies (pending) as well as the following publications and presentations:

Publications: (*denotes undergraduate)
"Bismuth assisted CdSe and CdTe nanowire growth on plastics", S. K. C. Lee*, Y. Yu, O. Perez*, S. Puscas*, T. H. Kosel, M. Kuno (submitted).

"CdSe nanowire photoelectrochemical solar cells enhanced with colloidal CdSe quantum dots" Y. Yu, P. V. Kamat, M. Kuno (to be submitted).

Presentations:
Bi-assisted Vapour-liquid-solid Synthesis of CdSe and CdTe Nanowires on Flexible Substrates. Simon K. C. Lee[1,2], Yanghai Yu[3] and Masaru Kuno[2]; [1]Nanotechnology Engineering, University of Waterloo, Waterloo, Ontario, Canada; [2]Chemistry and Biochemistry, University of Notre Dame, Notre Dame, Indiana; [3]Chemical and Biomolecular Engineering, University of Notre Dame, Notre Dame, Indiana. Materials Research Society, Spring Meeting, San Francisco, CA, April 2009.

Electrochemical Solar Cells Based on CdSe Nanowires and Quantum Dots. Yanghai Yu[1], Prashant V Kamat[3,2,1] and Masaru Kuno[2]; [1]Chemical and Biomolecular Engineering, University of Notre Dame, Notre Dame, Indiana; [2]Chemistry and Biochemistry, University of Notre Dame, Notre Dame, Indiana; [3]Radiation Laboratory, University of Notre Dame, Notre Dame, Indiana. Materials Research Society, Spring Meeting, San Francisco, CA, April 2009.

Drs. Kuno and Kamat plan to continue to have Yanghai Yu work on solar cells using nanowires in hopes that with additional data and publications they will secure external funding to further their research.

Project: "Towards simulating chemical and photochemical reactions for clean energy: Methodologies for the solid-aqueous interface." Steven Corcelli, Professor of Chemistry and Biochemistry; Kathie Newman, Professor of Physics; and Bill Schneider, Professor of Chemical and Biomolecular Engineering.

During the period between September 2008 and August 2009, Notre Dame Energy Center funds were used to hire a postdoctoral research associate, Dr. Hannah Fox, for a one-year appointment. The goal of the project was to develop, validate, and apply computationally efficient theoretical models to predict the structure and reactivity of metal oxides in contact with aqueous solutions. Working with Dr. Fox, Corcelli and others have demonstrated that the self-consistent-charge density functional tight binding (SCC-DFTB) methodology is nearly as accurate as state-of-the-art density functional theory (DFT) in calculating bulk and surface properties of titanium dioxide (TiO_2) at approximately 1/100th of the computational cost. These results are the subject of a manuscript that was submitted to the Journal of Chemical Theory and Computation.

FACULTY RESEARCH—SEED FUND PROGRAM
(continued)

In addition, Corcelli and others have submitted two proposals and have developed the following publication and presentation:

H. Fox, K.E. Newman, W.F. Schneider, and S.A. Corcelli, "Bulk and Surface Properties of Rutile TiO_2 from Self-Consistent-Charge Density Functional Tight Binding (SCC-DFTB)," Journal of Chemical Theory and Computation (in revision, 2009).

American Chemical Society National Meeting symposium The Physical Chemistry of Photon to Fuel Conversion, Washington, D.C., August 16-20, 2009; H. Fox, K.E. Newman, W.F. Schneider, and S.A. Corcelli, "Toward the Simulation of Thermal Catalysis at the Aqueous Titanium Dioxide (110) Interface."

As a result of this project, several other energy related initiatives have been generated:

- A graduate student co-advised by Corcelli and Newman, Laura Kinnaman, is utilizing SCC-DFTB to investigate the structure, dynamics, and spectroscopy of liquid water.
- A graduate student working with Schneider, Mandelle Danser, is using SCC-DFTB to investigate CO_2 capture in ionic liquids.
- By working closely with software engineers at the Center for Research Computing, Corcelli and others have integrated several key algorithms into DFTB+, a publically available computer program for performing SCC-DFTB simulations.

More recently, Corcelli and others have progressed toward studying reactivity at the aqueous TiO_2 (110) interface by investigating the dissociation of water at oxygen vacancy defects. The next step is to investigate how the presence of an aqueous solvent influences the reactivity of water at oxygen defects on the TiO_2 (110) surface.

Success Story

Ionic Liquids for CO_2 Removal from Post-Combustion Flue Gas

A Notre Dame research team, led by Professors Ed Maginn, Bill Schneider, and Joan Brennecke, has developed low melting point salts (ionic liquids) that can efficiently remove carbon dioxide from the flue gas of coal fired power plants. The ionic liquids react with the CO_2 to separate it from the flue gas and then release the CO_2 in concentrated form so that it can be stored in geological formations. A major breakthrough has been the ability to design new ionic liquids that are optimized for the strength of the reaction between the ionic liquid and the CO_2, based on theoretical quantum calculations – generating performance improvement completely from computational prediction. Another breakthrough has been discovering how to eliminate a problematic increase in the viscosity of the ionic liquid when it reacts with CO_2. Higher viscosity decreases mass transfer and requires greater pumping energy for the liquids, and hence, lowers the overall efficiency of the process. Process designs developed by industrial partners Air Products and Trimeric Corporation using these two breakthroughs indicate that the ionic liquid technology will require between 18% and 22% of the energy produced by the power plant to run the separation process. This is significantly less than the ~30% energy load that would be required for the only commercial technology that can be used for removal of CO_2 from flue gas currently. The Department of Energy is funding a laboratory scale demonstration of the technology, which is scheduled for installation in the Notre Dame Energy Center in the newly constructed Stinson-Remick Hall in 2010-2011. Thus, the Notre Dame team is making carbon capture and sequestration a reality.



Funding Opportunities

Undergraduate Student Research

The **Vincent P. Slatt Endowment for Undergraduate Research in Energy Systems and Processes** provides financial support to undergraduate students who are interested in conducting research in the field of energy systems and processes. Awards are made annually up to $5,000 per recipient depending on the needs of the research. Now, in its fourth year, the Slatt Scholars for 2009 is the largest group of honorees in the history of the center. Seven in total, they are:

Scott Deakins, Junior, Aerospace and Mechanical Engineering.
Advisor: Dr. Mihir Sen. Project: "Utilization of molecular dynamics to understand solid-state thermal energy devices." Award: $4,200.

Kyle Higdon, Sophomore, Aerospace and Mechanical Engineering.
Advisor: Dr. Robert Nelson. Project: "An experimental study to optimize active flow control actuators for wind turbine load control." Award: $3,308.

Meehan Lenzen, Sophomore, Civil Engineering and Geological Sciences.
Advisor: Dr. Peter Burns. Project: "Solubility of uranyl peroxide hydroxide spherical nanoclusters." Award: $2,027.

Thomas Noel, Sophomore, Chemical and Biomolecular Engineering.
Advisor: Dr. Joan Brennecke. Project: "Absorber/stripper for CO_2 separation from gas mixtures." Award: $4,975.

Kelsey Poinsatte-Jones, Sophomore, Environmental Science.
Advisor: Dr. Jessica Hellmann. Project: "Examining the role of temperature on the fitness of butterflies outside their distribution range." Award: $4,975.

Kevin Sallah, Sophomore, Chemical and Biomolecular Engineering.
Advisor: Dr. Paul McGinn. Project: "Characterization of solid electrolytes for li-ion batteries." Award: $4,820.

Kathleen Stanley, Sophomore, Chemical and Biomolecular Engineering.
Advisor: Dr. Joan Brennecke. Project: "Ionic Liquids Synthesis." Award: $4,980.

Slatt Awards in 2009 totaled more than $28,000.

Success Story

DOE Energy Frontiers Research Center (EFRC) on Materials Science of Actinides

The Department of Energy awarded the University of Notre Dame an $18.5 Million, 5- year research grant for an Energy Frontiers Research Center (EFRC) in the Materials Science of Actinides. This was the first solicitation for the new EFRC program. Over 260 proposals were submitted. Notre Dame was one of only 31 universities to receive awards. Peter C. Burns, Henry Massman Professor in the Department of Civil Engineering and Geological Sciences, will serve as director of the center and will lead its efforts to understand and control materials that contain actinides (radioactive heavy elements such as uranium and plutonium) to lay the scientific foundation for advanced nuclear energy systems using nanotechnology techniques that have only recently become available. These new techniques offer the promise of greater efficiency of nuclear fuels, safer waste products and less potential for energy products being used for weapons. Notre Dame leads the center which includes participants from the University of Michigan, University of California-Davis, George Washington University, Rensselaer Polytechnic Institute, Pacific Northwest National Laboratory, Savannah River National Laboratory and Sandia National Laboratory. This experienced team will develop advances in nuclear energy systems that will provide reliable, scalable alternatives to carbon intensive fossil fuels (coal, gas and oil) and intermittent renewable sources (solar and wind), with less risk and less nuclear waste than current nuclear options.

Success Story

Nanowire-Quantum Dot Photoelectrochemical Solar Cells

A Notre Dame research team, led by Professors Prashant Kamat and Masaru Kuno, has developed proof of concept devices using a combination of nanowires (NWs) and quantum dots, both nano-sized structures that have only recently become practical to fabricate in the lab using low cost solution chemistry, to increase the efficiency of thin film solar cells. These proof-of-concept devices employ Cadmium Selenide (CdSe) NWs to absorb incident light and also use them to transport photogenerated electrons to their respective electrodes. Typical quantum dot solar cells in use today have an efficiency of ~<1% and absorb solar energy at a limited light bandwidth spectrum. Early cells show incident photon to current conversion efficiencies of ~18%; adding colloidal CdSe quantum dots (QDs) dramatically increases the observed maximum efficiency to 34%. The overall efficiency increase occurs across the *entire* visible spectrum, even at wavelengths where the QDs do not absorb. Additional investigation has led the team to conclude that the increased efficiency originates from interplay between NWs and QDs, where the QDs fill voids between interconnected NWs, enabling better carrier transport to the electrodes of the solar cell. The benefits seem to be general and will therefore aid the future design and implementation of other NW-based solar cells, eventually leading to systems that could make solar power more economical and more cost competitive with traditional power sources.

Funding Opportunities

Undergraduate Student Research

In 2008, the Center/Institute was granted an annual gift from a University donor wishing to support **undergraduate research in solar energy**. The inaugural recipient of the annual award was Dr. Vikas Tomar, Professor of Aerospace and Mechanical Engineering. Dr. Tomar worked with three undergraduate students — Michael Brundage, Avery Scott, and Adam Woodruff — to study the interaction of CdSe quantum dots functionalized with proteins with plant cells. Their project titled "Quantum dot bioconjugation as a means of augmenting photosynthetic efficiency" focused on seeing what changes could be brought upon in the light sensitivity of plant cells by manipulating their interaction with quantum dots in different light exposures. According to Tomar, this project could lead to a broader study that would focus on harnessing multi-bandwidth solar energy from plant cells using quantum dot based manipulation. The undergraduate students presented the results of their research during the annual University of Notre Dame Undergraduate Research Symposium.

Funding Opportunities

Center/Institute Support

Each year, the Energy Center/Institute offers funding opportunities to support energy related programs and research at the University of Notre Dame. Either in whole or in part, the Center/Institute provides funds in support of various education and research activities that serve to improve energy awareness on campus and promote opportunities for students and faculty to conduct energy related research.

Events funded by the Center/Institute have been campus-wide, while others have been individual occurrences, such as students requesting assistance to attend energy related conferences and seminars. Whether benefiting the masses or helping but one student, the Center/Institute is committed to providing resources—both tangible and intangible—to the intellectual development of students and to the enhancement of energy related research at Notre Dame.

During Fiscal Year 2008-2009, the Center/Institute contributed more than $58,000 toward education programs and research projects related to energy.

Success Story

Indiana Advanced Electric Vehicle Training and Education Consortium (I-AEVtec)

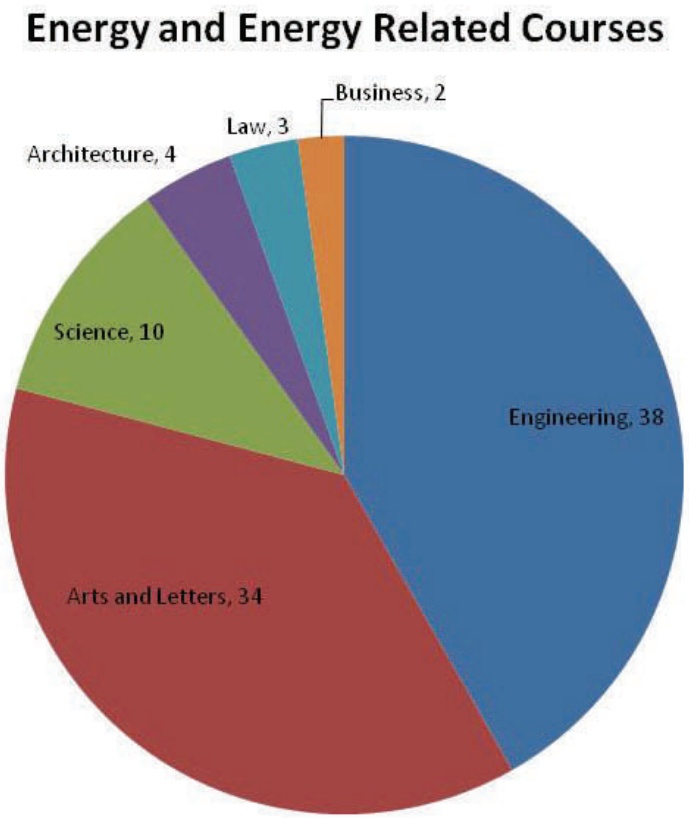
Notre Dame will participate in a consortium of the leading technical universities and colleges in Indiana to educate and train the workforce needed to design, manufacture, and maintain advanced electric vehicles and associated infrastructure. The Indiana Advanced Electric Vehicle Training and Education Consortium (I-AEVtec) will develop and offer Certificates and Associate degrees for vehicle technicians, BS and MS degree programs for design and manufacturing engineers in the electric vehicle industry, and a Certificate program in electric vehicle safety for emergency responders. Purdue University, the consortium lead, estimates that each year these programs will matriculate 300 degree/certificate students in electric vehicle technology, and provide an additional 2000 students with at least one course in supporting technologies. The $6.1 Million grant is shared by the University of Notre Dame, Purdue University, Indiana University-Purdue University Indianapolis, Ivy Tech Community College, Purdue University Calumet, and Indiana University Northwest. Dr. Paul McGinn, Professor of Chemical and Biomolecular Engineering, will lead Notre Dame's participation in this effort, which will include developing an Electric Vehicle Certificate to be offered as part of BS and MS engineering degree programs, and will provide special expertise in fuel cells and the manufacturing technology for fuel cells that will be shared with the other I-AEVtec partners.

Education Courses in Energy

The University of Notre Dame offers 14 unique energy focused courses in 4 Colleges: Engineering, Science, Arts & Letters, and Business.

(As shown graphically here) There are 91 total energy focused and energy related courses offered in 6 colleges by 46 faculty: Engineering, Science, Arts & Letters, Business, Architecture, and Law.

A list of the energy focused courses are provided below. This list is not all inclusive, yet it is a sampling of the energy focused and energy related courses at Notre Dame.



Energy Focuses Courses

- Ethics of Energy Conservation
- Energy and Society
- Energy and Environment: Current Policy Issues
- Future of Energy/Energy and Society
- Energy and Climate
- Energy Systems
- Alternative Energy Devices and Materials
- Directed Readings in Sustainable Energy
- Economic and Environmental Sustainability Biofuels
- Special Studies in Energy Systems
- Electrical Machinery and Power Systems
- Electric and Hybrid Vehicles
- Electrical Energy Extraction
- Energy-Constrained Devices and Circuits
- Energy Technology and Policy
- Energy Law

Energy Related Courses

- Deciding to be Green
- Environmental Politics
- Self, Society, and Environmental
- Is There an Environmental Crisis?
- Environmental Justice
- Energy Policy: Environment and Social Change
- Ecology, Ethics, and Economics
- Global Issues and the United Nations
- Environmental Law
- Environmental Chemistry
- Environmental Microbiology
- Environmental Biotechnology
- Environmental Justice
- Environmental Systems
- Globalization and Corporate Responsibility
- United Nations Global Impact

Education and Outreach

Conference Overview and Objectives

On July 7, 2008 the **Notre Dame Energy Center** and the **University of Notre Dame** brought together some of the most creative engineers and scientists and governmental leaders for a free, one-day conference focusing on the future of energy research, its effect on society, and the potential it bears for transformative economic change.

Known as "The Crossroads of America," Indiana is already a leader in clean coal technologies and biofuels and is poised to take strategic advantage of wind resources and highly dispersed third generation solar technologies. For these reasons, Indiana is fit to be at the center of discussions exploring how strategic investments in basic and applied energy research — whether in advanced storage concepts, non-traditional and renewable power generation research, or highly inventive methods to manage the state's carbon footprint — can transform the lives of consumers of energy. More important, the new businesses, work alliances, and strategic partnerships that will be required to realize and deliver these technologies hold the additional potential for fundamental and radical economic transformation across Indiana, the Great Lakes region and, indeed, the nation.

The conference explored: (1) how strategic investments in basic and applied energy research can connect to near-term bridging technologies and transformation of our energy industry in the longer term; (2) how the citizens in Indiana and across the country can position themselves to take best advantage of these new technologies as consumers; and (3) how these new technologies must connect to the creation of new businesses and enhanced economic opportunities.

Conference Highlights and Executive Summary

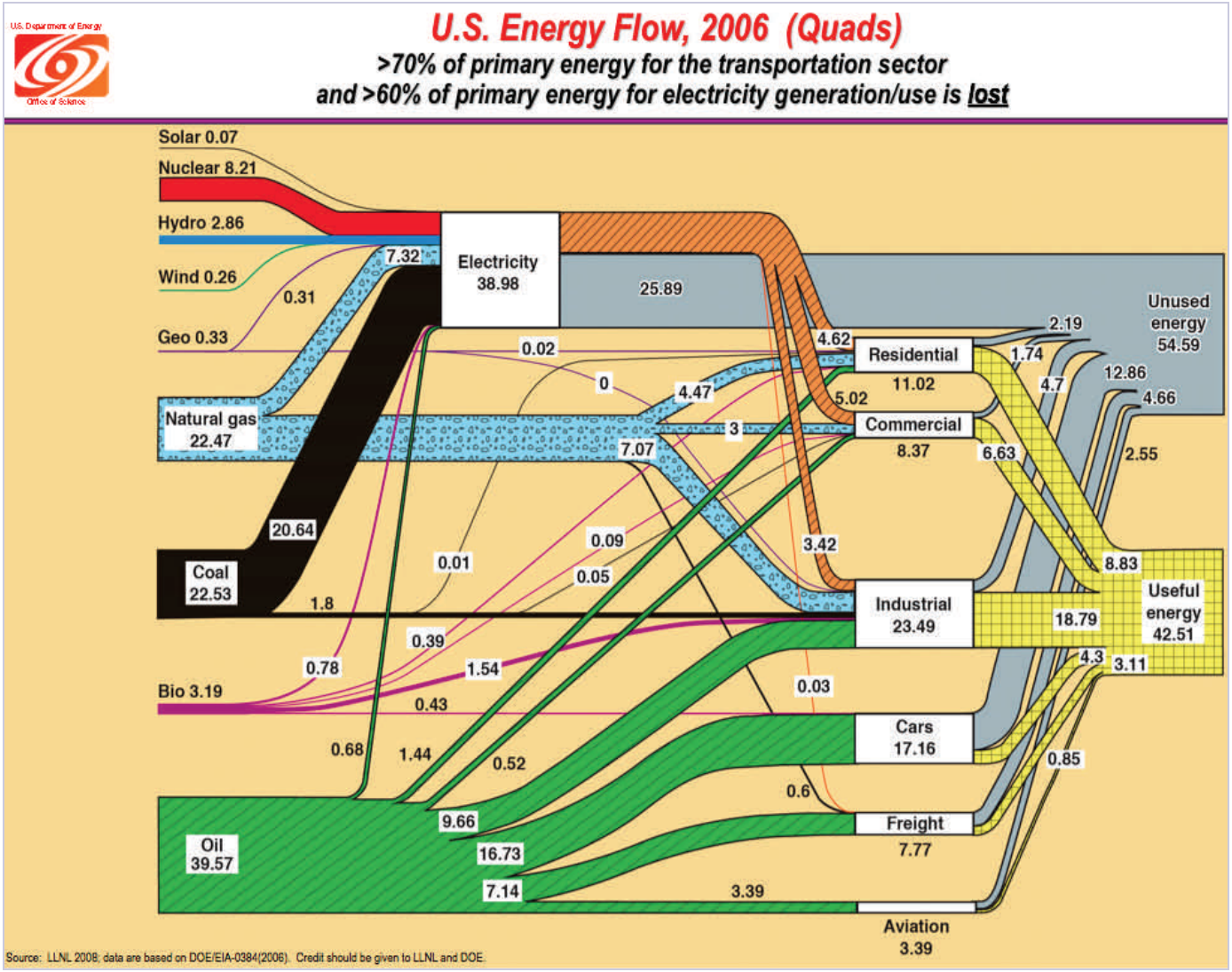
Presenters were keynote speaker Rep. Joe Donnelly, D-Ind.; Michelle V. Buchanan, associate laboratory director for physical sciences at Oak Ridge National Laboratory; Patricia M. Dehmer, deputy director of the Office of Science for the U.S. Department of Energy; Jay P. Gore, director of the Discovery Park Energy Center at Purdue University; Paul J. Mitchell, policy director for economic development, workforce and energy for the state of Indiana; Hratch G. Semerjian, president and executive director of the Council for Chemical Research; Vinod K. Sikka, director of product development at Ross Technology-Oak Ridge; and Joan F. Brennecke, Keating-Crawford professor of chemical and biomolecular engineering and director of the Notre Dame Energy Center.

Key conclusions and highlights of the conference are given here.

- In his keynote address, U.S. Representative Joseph Donnelly emphasized that the issues before us form an interconnected web - energy production from all sources, the need for improved capabilities in renewable sources and the research needed to realize them, and their role in developing economic opportunity for citizens of Indiana and America.
- The complexity of energy flow (*see page 19*) was emphasized, highlighted by the inefficiencies of current electric power generation technologies. A successful response to the energy dilemma must incorporate a comprehensive, across-the-board effort to improve production through renewable sources, enhance our current sources through technologies such as carbon capture and sequestration, and must accomplish all of these goals in an environmentally responsible manner.
- There are numerous opportunities for new materials to produce revolutionary shifts in technology in areas such as energy storage, hydrogen transport, and solar energy. These materials do not exist now, but the opportunities are apparent.

Conference Highlights and Executive Summary *(continued)*

- Carbon capture and sequestration will play an important role in a sustainable energy future. The exciting possibilities of new materials, such as ionic liquids, to capture CO_2 from coal fired plants was given as an example of a "breakthrough" technology with the potential to make the 57 Billion tons of coal in Indiana accessible to clean power generation.
- Basic research in the chemical sciences produces documented returns on that investment. Every $1 invested in basic research produces an average 17% annual return and stimulates economic activity resulting in $8 of tax returns. It is anticipated that similar returns are available for fundamental energy research.
- There are many examples of how fundamental research has made significant impact on commercial enterprises. For instance, in a detailed case study, replacing the standard steel rollers with components made with NiAl alloy technology in a moderate-scale plant resulted in 1.8 Trillion BTUs of energy saved, 10,000 tons of CO_2 production avoided and $8,000,000 in energy costs eliminated.
- The State of Indiana is vigorously supporting efforts in forward-looking generation strategies, including 20 recently constructed biofuels plants, a 750 MW wind farm, and 2 new integrated gasification combined cycle (IGCC) coal plants, highlighting the value of a distributed approach to power generation.



Adapted from the presentation of Dr. Patricia Dehmer, Deputy Director for Science Programs, U.S. Department of Energy

Learn more about the conference by visiting
http://www.nd.edu/~ndenergy/enepolicy2008/index.html

Education and Outreach

NOTRE DAME energy week

The Notre Dame Energy Center sponsored its second annual Energy Week, themed BE ENLIGHTENED. Running from September 17 through September 24, it was scheduled in conjunction with the annual Notre Dame Forum on Sustainable Energy.

Organized by members of the center's Student Advisory Board, each day of Energy Week featured energy education and awareness activities, including participation from major energy companies, a display of hybrid vehicles, carbon dioxide footprint calculators, information on renewable energy sources, tours of the Notre Dame power plant, and screenings of documentaries and energy-focused movies, such as Who Killed the Electric Car and An Inconvenient Truth.

Students also participated in a career luncheon featuring representatives from major energy companies, attended a "green" prayer service and participated in the second annual "Lights Out." This activity encouraged students, faculty and staff across campus to power down and turn lights off for three hours on September 24. Last year's one-hour Lights Out resulted in a 2.7 percent reduction in electricity as measured by the Notre Dame power plant, while the 2008 activity resulted in a 5.3 percent reduction.

In the dining halls during Energy Week, students were also able to select from locally grown and sustainable food items.

The Student Advisory Board ended Energy Week 2008 by urging all students to attend the 2008 Notre Dame Forum, which examined the challenges of a sustainable energy future.

The forum was held September 24 from 3 to 5 p.m. in the Joyce Center on Notre Dame's campus and explored how charting pathways to a sustainable energy future is emerging as one of the world's greatest challenges. It also examined underlying concerns, including technological, environmental, economic, political and geopolitical issues, as well as social justice and ethical considerations.

Forum panelists included Gov. Bill Ritter Jr. of Colorado, General Electric Co. chairman and chief executive officer Jeff Immelt, Sustainable South Bronx founder Majora Carter and Ernest Moniz, Cecil and Ida Green Distinguished Professor of Physics at the Massachusetts Institute of Technology. The discussion was moderated by Anne Thompson, chief environmental affairs correspondent for NBC News and a 1979 Notre Dame graduate.

For more information about the forum, visit http://enlighten.nd.edu/.

SUSTAINABLE ENERGY

A NOTRE DAME FORUM ENLIGHTEN. ENGAGE. EMPOWER.

Education and Outreach

SURGE: Symposium of Undergraduate Research on Green Energy

On October 1, 2008 GreeND and the Student Forum Committee for the 2008 Notre Dame Forum hosted the Symposium of Undergraduate Research on Green Energy (SURGE). Expanding on the Forum topic of Charting a Sustainable Energy Future, SURGE showcased the current energy-related research being done at Notre Dame, as well as provided an opportunity for those inspired by the Forum to explore starting points for their own research. All undergraduate students were encouraged to participate. Presentation topics were not limited to science and engineering, but covered all issues relating to energy and sustainability, from energy economics, policy, and ethics to conservation, sustainable development, and energy technology. Students were invited to present either a 15-minute oral presentation or a poster presentation on their research.

Sen. Richard Lugar Visit

On October 8, 2008 Senator Richard Lugar, R-Indiana, visited the campus of Notre Dame. He toured the Notre Dame Energy Center and spoke with students about their energy related research projects. He concluded his visit by giving a campus-wide presentation on "Energy Security and U.S. Foreign Policy." At the end of his talk, Sen. Lugar presented GreeND, a student organization focused on energy and environmental issues, the Energy Patriot Award. This award honors a student, professional, scholar or member of the business community who has demonstrated leadership and initiative in taking concrete action to improve America's energy security.

Graduate Research Symposium

On November 21, 2008 graduate students for the first time showcased their exemplary research work during a symposium that was open to the community. All colleges and divisions of research were represented with a special division dedicated to the topic of the Notre Dame Forum on Sustainable Energy.

What an Engineer Has Learned About Oil Trading

On December 1, 2008 Dr. Jeffrey C. Kantor, Professor of Chemical and Biomolecular Engineering, provided an overview of oil trading from an engineer's perspective and discussed, among other questions, with students:

(1) How does oil get from the well to the pump?
(2) Who needs oil traders?
(3) What does the market tell us**?**

Trash to Class: A Green Fashion Show

Students and members of the Notre Dame community learned about how to conserve resources and why more sustainable habits are important (and in vogue), while male and female models demonstrated eco-friendly outfits made from recycled fabrics during a fashion show on December 3, 2008. Selected items were on silent auction after the show, and proceeds from admissions went to benefit the Majora Carter Fund: Sustainable South Bronx.

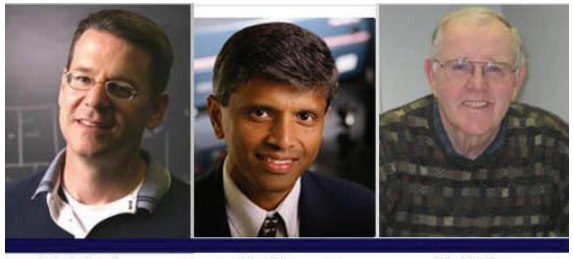
A Discussion By Dr. Amitava Dutt and Dr. Frank Incropera

Notre Dame graduate and undergraduate students were invited to a discussion on February 23, 2009 by Dr. Amitava Dutt, Professor of Economics, and Dr. Frank Incropera, Professor of Aerospace and Mechanical Engineering. Professors Dutt and Incropera discussed examples in which either environmental or economic considerations have won out in the past; outlined some of the current discussions taking place on these issues; and attempted to lay out how they should be balanced in the future.

Michiana Area Engineers Week Celebration

The Energy Challenge: Perspectives on clean coal utilization, CO_2 capture and sequestration, and renewal energy sources

A panel of senior faculty from the University of Notre Dame spoke at the annual Michiana Area Engineers Week Celebration on February 28, 2009. Dr. Prashant Kamat, Chemistry and Biochemistry; Dr. Ed Maginn, Chemical and Biomolecular Engineering; and Dr. Robert Nelson, Aerospace and Mechanical Engineering, discussed the challenges of developing abundant and inexpensive energy sources that are not harmful to the environment. There were more than 100 engineers from the Michiana community in attendance.

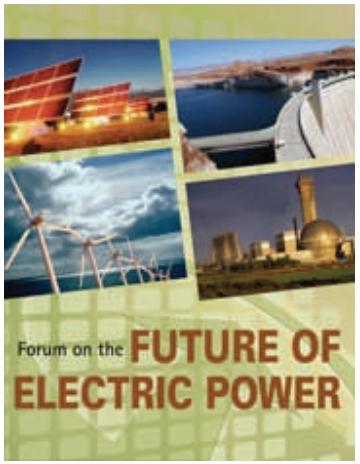


E. Maginn *P. Kamat* *R. Nelson*

Education and Outreach

The Forum on the Future of Electric Power

Sponsored by the Notre Dame Energy Center and the College of Engineering, a panel discussion was held on February 25, 2009 focusing on the future of electric power and energy. The forum was open to all Notre Dame faculty, students, and staff and to members of the Michiana and surrounding communities.



Moderated by Joan F. Brennecke, Keating-Crawford Professor of Chemical and Biomolecular Engineering and Director of the Notre Dame Energy Center, panelists were:

Anthony Earley Jr.: Chairman and Chief Executive Officer of DTE Energy, which includes Detroit Edison, an electric utility serving more than 2.2 million customers.

Patrick Eilers: Managing Director of Madison Dearborn Partners with responsibility for acquisition and management of energy and power systems.

William Hederman: Special Advisor to Congress. Previously: Executive Director of the Energy Resources Group, Morgan, Lewis and Bockius, LLP; Founding Director of the Office of Market Oversight and Investigations at the Federal Energy Regulatory Commission (FERC); and Vice President of Strategic Initiatives at Columbia Energy Group.

Michael O'Sullivan: Senior Vice President for Development at FPL Energy, a world leader in the production of clean energy, including wind and solar power.

A link to the live discussion is available to Notre Dame associates with a netid and password. Details can be found in the Events Archives at http://energycenter.nd.edu.

Distinguished Lecture—Spring 2009

On April 22, 2009 Thomas M. Cushing, Senior Vice President of Membership and Business Development of the Chicago Climate Exchange (CCX), discussed ***Market Incentives for Sustainability***. He explained

that the United States has the largest cap and trade program of any nation in the world, operated by the private sector through the Chicago Climate Exchange (CCX). CCX is the world's first exchange for greenhouse gas emission allowances, and its affiliates operate the largest emissions exchange in Europe and the first exchange for environmental products in China. Cushing also discussed the operation of CCX and the use of financial tools to provide incentives for the reduction of greenhouse gas emissions. Participants learned why US power companies (AEP, DTE), manufacturers (DuPont, Ford), universities (Michigan State, Oklahoma) and cities (Chicago, Oakland) are reducing emissions and trading carbon through CCX, and thought through the implications for the national cap and trade program under development in Washington, DC.

Before joining CCX, Mr. Cushing practiced as a civil trial attorney in Cook County, Illinois, from 1988 to 2006. In those years he recorded dozens of verdicts and appeals and distinguished himself in the legal community. He was invited to join the Chicago Society of Trial Lawyers, The American Board of Trial Advocates and Loyola University School of Law's Circle of Advocates. He also taught as an adjunct professor at the Loyola University School of Law, was an invited instructor at DePaul Law School and the National Institute of Trial Advocacy, and was an invited speaker for various bar groups. Mr. Cushing adjusted the focus of his advocacy toward the issue of global climate change when he joined the Chicago Climate Exchange in 2006. He is a Chicago native. Mr. Cushing has been a lifelong teacher, starting his professional career teaching sixth grade for two years. He earned his JD degree from Loyola University School of Law, and his BA (1983) from the University of Notre Dame.

Other Lectures and Energy Related Events

Nearly 200 administrators, students, faculty and staff gathered February 9, 2009 for the **Green Summit** to discuss ways to make the campus greener.

Students from the Notre Dame Energy Center **Student Advisory Board** and **GreeND** promoted EARTH HOUR on March 28, 2009. From 8:30—9:30 p.m. faculty, staff and students were encouraged to join the millions of people around the world in turning off lights for one hour to raise awareness and to take action against climate change.

D**r. Charles Westbrook** from the Lawrence Livermore National Laboratory discussed "The Role of Combustion in Future Energy Scenarios" during a lecture sponsored by The Center for Applied Mathematics on April 1, 2009.

On April 18, 2009 students from the University of Notre Dame participated in a **GE**-sponsored visit to the Grand Ridge Wind Farm and LaSalle Nuclear Power Plant in Illinois.

The Earth Day Rally on April 22 was the center of attention during Earth Week 2009. Sponsored by the **Students for Environmental Action**, other activities included the screening of Mountaintop Removal and a no waste vegetarian dinner.

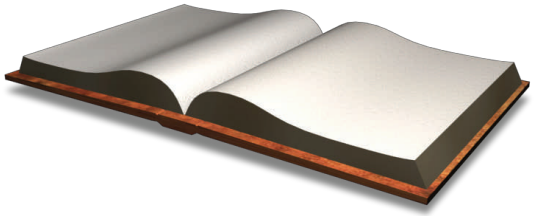
On April 22, 2009 the Electrical Engineering Department hosted a seminar by **Dr. Timothy Sands** from the School of Materials Engineering at Purdue University titled "Metal/Semiconductor Superlattices: Thermoelectric Metamaterials for Solid-State Energy Conversion."

On June 5 and 6, 2009 energy related presentations were once again offered during the annual Alumni Weekend. Notre Dame faculty discussed the following:

> "Solar Energy—Beyond the Hype" by **Dr. Prashant Kamat**, Professor of Chemistry and Biochemistry.
>
> "Climate Change Propaganda: Can We Find the Facts Amid the Myths and Distortions?" by **Dr. Mark McCready**, Department Chair and Professor of Chemical and Biomolecular Engineering.
>
> "Wind Energy Research at Notre Dame" by **Dr. Thomas Corke**, Professor of Aerospace and Mechanical Engineering.
>
> "Strategic Energy Resilience" by **Patrick Murphy**, Managing Director of the Notre Dame Energy Center.

Dr. Frank Incropera, The H. Clifford and Evelyn A. Brosey Chair in Engineering, served as the co-organizer for the University of Notre Dame Forum on *Sustainable Energy,* held September 24, 2008.

Dr. Incropera also organized the College of Engineering and Energy Center Forum on *The Future of Electric Power*, held February 25, 2009.



Education and Outreach

Center Director Tours Wind Farm

Dr. Joan Brennecke, Director of the Notre Dame Energy Center/Institute, is shown here waving atop a 90 meter (296 feet) wind turbine. Dr. Brennecke visited the wind farm on Maui, Hawaii, in March 2009, consisting of 20 wind turbines, each capable of 1.5 MW. Firstwind owns and operates the wind farm and currently supplies 80% of the electricity for Maui.

For more information about Firstwind, visit http://www.firstwind.com/.

Looking Ahead

Fall 2009 Notre Dame Energy Center Distinguished Lecture Series

September 17

"Spain: Bringing Renewable Energy to the U.S. and Beyond"

Enrique Alejo, Economic and Commercial Counselor of Spain for the Midwest Trade Commission of Spain in Chicago

October 5

"Grim Fair Tales: Myths that Enable Our Addiction to Coal"

Michael Hogan, Power Progamme Director, European Climate Foundation

October 15

"Carbon Capture and Sequestration: Progress, Challenges, and Opportunities"

Dan Connell, Research and Development Engineer, CONSOL Energy, Inc.

November 6

"Hydrothermal Energy Conversion and Recovery From Biomass and Geothermal Resources"

Jefferson W. Tester, Croll Professor of Sustainable Energy Systems, Cornell University

November 20

"World Energy Markets: A Changing Landscape"

Raymond Scheppach, Executive Director, National Governors Association

Guy Caruso, Senior Advisor, Energy and National Security Program, Center for Strategic and International Studies

Thomas Gresik, Professor of Economics and Econometrics, University of Notre Dame

Moderator: Patrick Murphy, Managing Director, Notre Dame Energy Center/Institute

December 3

"Future Automobile Fuels: Fill Up or Plus In?"

Michael J. Desmond, Distinguished Advisor, Conversion Technology, BP America, Inc.

NOTRE DAME energy week

The **3rd Annual Notre Dame Energy Week** will be held **September 13-19, 2009** on Notre Dame's campus. Sponsored by the Notre Dame Energy Center/Institute, GreeND, and the Office of Sustainability.

Organizational Overview

Administration

Strategic planning and business operations for the Notre Dame Energy Center/ Institute are provided by three individuals: Joan Brennecke, Patrick Murphy, and Barbara Villarosa. Patrick, being the newest member of the team, joined the University on April 6, 2009 as the first managing director of the Notre Dame Energy Center/Institute. Contact information is provided here along with a reprint of the news article announcing Patrick's appointment.

Dr. Joan F. Brennecke
Keating-Crawford Chair in Chemical and
Biomolecular Engineering
Director, Notre Dame Energy Center/Institute
(574) 631-5847
jfb@nd.edu

Mr. Patrick M. Murphy
Managing Director, Notre Dame Energy
Center/Institute
(574) 631-1425
pmurphy8@nd.edu

Mrs. Barbara A. Villarosa
Programs and Research Specialist,
Notre Dame Energy Center/Institute
(574) 631-4776
villarosa.2@nd.edu

(Reprint—News Release)

Patrick M. Murphy Joins the Notre Dame Energy Center

NOTRE DAME, Ind. — Patrick M. Murphy, most recently program manager in charge of electric power systems research for the Department of Homeland Security (DHS), has been named managing director of the Notre Dame Energy Center. His appointment begins April 6, 2009.

According to Center Director Joan F. Brennecke, the Keating-Crawford Professor of Chemical and Biomolecular Engineering, "With his experience in operations and research supporting energy technologies, Patrick Murphy is an exciting addition to our team." His main responsibilities will be to coordinate efforts in energy related research at Notre Dame, develop a University-wide vision and plan relating to energy research, organize and support competitive proposals from faculty within the energy center and serve as a liaison with government officials relative to energy policies and issues.

Murphy comes to Notre Dame with more than 17 years of experience as a research and development manager. Most recently, he directed efforts in the Homeland Security Advanced Research Projects Agency to provide more resilient electric power systems, including new grid architectures, back-up and distributed systems, demand management and alternative energy sources.

Prior to his work in the DHS, he was an associate at Booz Allen Hamilton, where for various government clients he was responsible for coordinating research efforts with national and federal laboratories, specifically regarding projects to prevent chemical, biological, radiological, nuclear and explosive threats; assessing risks and vulnerabilities; and determining potential impacts of possible attacks. He also served as the lead business developer for the company's modeling, simulation, war gaming and analysis team as it worked to identify and exploit systems engineering and modeling and simulation opportunities.

Before launching his civilian career, Murphy served in multiple positions as an army intelligence officer, responsible for intelligence databases on Bosnian factions, for the impact of threat capabilities and for information on the effects of weather and terrain on operations.

Murphy graduated from Notre Dame with a dual degree in electrical engineering and government in 1992. He earned a master's degree in international affairs from George Washington University in 2000, where he is currently pursuing a doctorate in operations research. Mr. Murphy will be accompanied to Notre Dame by his wife, Inês Vieira Murphy, Esquire, his daughter, Emily, and his son, Owen.

Industrial Advisory Board

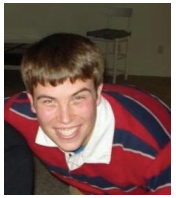
The Industrial Advisory Board provides guidance and counsel to the Director and Managing Director of the Notre Dame Energy Center/Institute in support of its mission. Members of the board are:

Thomas Degnan, Jr., ExxonMobil
Anthony Earley, DTE Energy
Patrick Eilers, Madison Dearborn Partners
Michael O'Sullivan, Florida Power and Light

Student Advisory Board

Each year, graduate and undergraduate students apply for membership to the Center/Institute's Student Advisory Board. Selected members serve a one-year term beginning in January and ending in December. Student Advisory Board members are involved in several activities throughout the year, including the annual Notre Dame Energy Week and other education programs and research initiatives. 2009 board members are listed here along with some interesting information about each of them.

Alexander Augugliaro



Senior, Chemical Engineering
Hometown: Haddonfield, NJ
Favorite Energy Source: Wind turbines because they are highly efficient in their production of energy, and wind can be found almost everywhere, especially in South Bend.
One Interesting Fact: I studied abroad in Australia last semester and traveled all over the country as well as to New Zealand and Fiji.

Michael Bergerson

Graduate, Law
Hometown: Michigan City, IN
Favorite Energy Source: Nuclear because it offers great potential to increase American-made energy and provokes intense environmental, social, and economic debate. If waste storage and safety issues can be resolved, nuclear energy could be part of a new national energy policy that all sides could support.
One Interesting Fact: I worked on energy issues for Indiana Congressman Pete Visclosky in Washington; played college golf for four years at DePauw University.

Thomas A. Catanach

Sophomore, Physics and Classical Languages
Hometown: originally from Allen, TX; now living in Trinity, AL
Favorite Energy Source: Nuclear because I believe that it can produce large amounts of clean energy, which is necessary to meet the world's growing need for energy and also protect the environment.
One Interesting Fact: I have not touched food since I was in 6th grade.

Jonathan Conway

Junior, Chemical Engineering
Hometown: Lancaster, PA
Favorite Energy Source: Geothermal because it is readily available and only requires a capital investment to tap into it.
One Interesting Fact: I drank water off the Mendenhall Glacier in Alaska.

Student Advisory Board *(continued)*

Lindsay Ficke

Graduate, Chemical Engineering
Hometown: Cincinnati, OH
Favorite Energy Source: Solar because of the sun's reliability and the vast potential of the developing technologies.
One Interesting Fact: I have been skydiving twice!

Jenna Heffernan

Sophomore, Business
Hometown: Boca Raton, FL
Favorite Energy Source: Solar because I'm from the Sunshine State!
One Interesting Fact: I know every single word to "We Didn't Start the Fire" by Billy Joel.

Sean Hoban

Graduate, Biology
Hometown: Louisville, KY
Favorite Energy Source: Solar for three reasons: (1) it is completely renewable and abundant; (2) as a plant biologist, I find it fascinating that we can harness the same energy source that plants have captured for hundreds of millions of years to make food with; and (3) it can be harvested on extremely small scales, even by individual people for their homes, so it should empower and encourage actions by individual people rather than needing the support of large groups and lots of money.
One Interesting Fact: I also work as a DJ at WVFI.

Colleen Kelly

Senior, Economics
Hometown: Western Springs, IL
Favorite Energy Source: Solar because it is estimated that the amount of solar energy that hits the Earth every day is enough to supply the world's energy needs for 25 years!
One Interesting Fact: I have never gone to a school without another person named Colleen Kelly.

Jennifer Kovacs

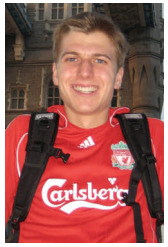
Junior, Chemical Engineering
Hometown: Houston, TX
Favorite Energy Source: Solar because if I were in a place where we could use solar energy, it would mean that it would be sunny most of the time.
One Interesting Fact: I have been to 12 countries and 38 states.

Meehan Lenzen

Junior, Environmental Geosciences
Hometown: Bloomington, IN
Favorite Energy Source: Cellulosic ethanol (not corn ethanol) because if scientists could just find a way to effectively mass-produce it, it could become a great stepping stone away from fossil fuels and towards renewables.
One Interesting Fact: I hate static electricity (and, therefore, fleece too) more than almost anything in the world.

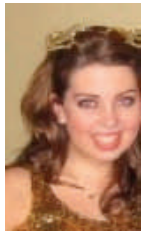
Student Advisory Board *(continued)*

Tim Malecek



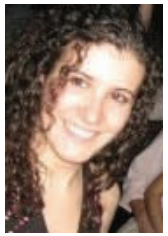
Senior, Mechanical Engineering
Hometown: St. Louis, MO
Favorite Energy Source: Wind because I believe it has the most potential for the future.
One Interesting Fact: I can unicycle.

Meghan Manning



Junior, Political Science
Hometown: New York City, NY
Favorite Energy Source: Solar because it's remarkably clean, virtually inexhaustible, and we have already developed the technology (especially for a solar-electric economy) to command true change with it very quickly. While the costs of solar panels are currently too expensive for many to use, I think that the amazing developments we have seen in recent years (i.e. with hybrid cars) shows that we can work to making solar energy a realistic alternative energy source for many consumers.
One Interesting Fact: I'm a dual citizen of the United States and Ireland.

Regina McCormack



Junior, Environmental Sciences
Hometown: Decatur, IL
Favorite Energy Source: Wind because it uses the Earth's resources efficiently and is feasible in many climates.
One Interesting Fact: I enjoy visiting art museums.

Laura Moore-Shay

Senior, Environmental Geosciences and Anthropology
Hometown: Granger, IN
Favorite Energy Source: Wind because it can be economical in a large area of the United States and has a smaller environmental impact than other forms of energy.
One Interesting Fact: I spent the last two summers in western Ireland doing archaeology research.

Krysta Pfeifer

Senior, Chemical Engineering
Hometown: Overland Park, KS
Favorite Energy Source: Solar because it is amazing how much the sun already provides and that it has the potential to do even more.
One Interesting Fact: I went bungee jumping in New Zealand.

Thomas Ronan

Senior, Chemical Engineering
Hometown: Sioux Falls, SD
Favorite Energy Source: Solar because all forms of energy are derived from solar energy in some fashion, so I see solar as the least invasive and most promising form of alternative energy.
One Interesting Fact: I was born on Christmas Eve.

Organizational Overview

Faculty are key to the success of the Notre Dame Energy Center/Institute, which is largely due to their unsolicited time and devotion to energy education and research. The number of faculty has grown each year since 2005, when the Center/Institute began. Now totaling 45, a list of the faculty are provided here with

J. Matthew Ashley
Theology
Energy efficiency

Stephen M. Batill
Aerospace and Mechanical Engineering
Energy efficiency

Paul W. Bohn
Chemical and Biomolecular Engineering
Solar and other renewables

Joan F. Brennecke
Chemical and Biomolecular Engineering
Energy efficiency; CO_2 separation, storage, sequestration, and use

Paul R. Brenner
Center for Research Computing
Energy efficiency

Seth N. Brown
Chemistry and Biochemistry
Energy efficiency

Peter C. Burns
Civil Engineering and Geological Sciences
Safe nuclear waste storage

Hsueh-Chia Chang
Chemical and Biomolecular Engineering
Energy efficiency

Patrick Fay
Electrical Engineering
Solar and other renewables

Jeremy B. Fein
Civil Engineering & Geological Sciences
Safe nuclear waste storage

Thomas A. Gresik
Economics
CO_2 separation, storage, sequestration, and use

Gregory Hartland
Chemistry and Biochemistry
Energy Efficiency

Jessica J. Hellmann
Biological Sciences
Safe nuclear waste storage; CO_2 separation, storage sequestration, and use

Kenneth Henderson
Chemistry and Biochemistry
Energy efficiency

Davide A. Hill
Chemical and Biomolecular Engineering
Energy efficiency

Frank P. Incropera
Aerospace and Mechanical Engineering
Energy efficiency; solar and other renewables

Boldizsar Janko
Physics
Energy efficiency

Debdeep Jena
Electrical Engineering
Solar and other renewables

Richard A. Jensen
Economics and Econometrics
Solar and other renewables

Prashant V. Kamat
Chemistry and Biochemistry
Energy efficiency; solar and other renewables

Jeffrey C. Kantor
Chemical and Biomolecular Engineering
CO_2 separation, storage, sequestration, and use; solar and other renewables

Masaru K. Kuno
Chemistry and Biochemistry
Solar and other renewables

Faculty *(continued)*

A. Graham Lappin
Chemistry and Biochemistry
Energy efficiency

Edward J. Maginn
Chemical and Biomolecular Engineering
Energy efficiency; safe nuclear waste storage; CO_2 separation, storage, sequestration, and use

Mark J. McCready
Chemical and Biomolecular Engineering
Energy efficiency

Paul J. McGinn
Chemical and Biomolecular Engineering
Energy efficiency

Gerald P. McKenny
Theology
Energy efficiency

Jason S. McLachlan
Biological Sciences
CO_2 separation, storage, sequestration, and use

Dan Meisel
Chemistry and Biochemistry
Safe nuclear waste storage; solar and other renewables

Albert E. Miller *Emeritus*
Chemical and Biomolecular Engineering
Energy efficiency

Alexander S. Mukasyan
Chemical and Biomolecular Engineering
Energy efficiency

Patrick E. Murphy
Marketing
CO_2 separation, storage, sequestration, and use; solar and other renewables

Robert Nerenberg
Civil Engineering and Geological Sciences
Energy efficiency

Samuel Paolucci
Aerospace and Mechanical Engineering
Energy efficiency

Christian Poellabauer
Computer Science and Engineering
Energy efficiency

Joseph Powers
Aerospace and Mechanical Engineering
Energy efficiency

John E. Renaud
Aerospace and Mechanical Engineering
Clean coal utilization

William F. Schneider
Chemical and Biomolecular Engineering
Energy efficiency; clean coal utilization

Mihir Sen
Aerospace and Mechanical Engineering
Energy efficiency

Anthony Serianni
Chemistry and Biochemistry
Energy efficiency

Slavi Sevov
Chemistry and Biochemistry
Energy efficiency

Mark A. Stadtherr
Chemical and Biomolecular Engineering
Energy efficiency

Vikas Tomar
Aerospace and Mechanical Engineering
Clean coal utilization

Eduardo Wolf
Chemical and Biomolecular Engineering
Energy efficiency

Huili (Grace) Xing
Electrical Engineering
Solar and other renewables

The Notre Dame Energy Center/Institute will be moving to its new location in the new Stinson-Remick Hall.

Housed within the College of Engineering in Fitzpatrick Hall since its inception in 2005, the Center/Institute's labs and offices will be moving in December 2009 to its new location on the first and third floors of Stinson-Remick Hall.

Notre Dame Energy Center/Institute
115 Stinson-Remick Hall
Notre Dame, Indiana 46556

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