ND Energy

The kiloJoule

Center for Sustainable Energy at Notre Dame

ND ENERGY IS A UNIVERSITY RESEARCH CENTER WHOSE RESEARCHERS MAKE NEW DISCOVERIES, SCIENTIFIC ADVANCEMENTS, AND TECHNOLOGICAL BREAKTHROUGHS THAT EMPOWER STUDENTS AND FACULTY TO INNOVATE, EDUCATE, AND INFLUENCE THE WORLD TOWARD A MORE SUSTAINABLE ENERGY FUTURE

UNIVERSITY OF NOTRE DAME | RESEARCH

2017 Annual Report

energy.nd.edu

Welcome

Dear Friends and Colleagues,

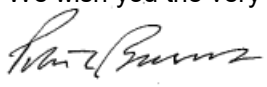
This report marks the end of my third full year as director of ND Energy. Having been appointed the director in July 2014, it has been a pleasure and a delightful challenge to lead and direct such a well established and productive University-wide research center with 80 affiliated faculty and nearly 300 associated researchers. The center is fortunate to have so many dedicated individuals working to support its mission and to enrich the lives of so many graduate and undergraduate students. It is through their dedication and scholarly advancements that we are able to highlight in this report the 2017 achievements in energy-related research and education at Notre Dame.

There are several reasons to celebrate our faculty and associated researchers this year, including the two new centers that were selected to receive substantial funding from the National Science Foundation and the National Nuclear Security Administration. These centers will work to advance new technologies in the use of shale gas and to deepen the understanding of actinide and nuclear chemistry. In addition, several junior faculty received early-career awards and other national recognitions for their outstanding research capabilities. These individuals were celebrated during ND Energy's inaugural research symposium that was held in early spring 2018 and is highlighted in this year's report.

You will also read about our new international research direction and the initiatives currently underway to enable individuals in low to middle income countries to produce and maintain their own electricity. You will meet the newest members of our affiliated faculty, staff, and student scholars, including the 2017 Class of the Energy Studies minor. In addition, you will get a glimpse of the many programs and services we provide for our faculty and associated researchers in an effort to empower them to innovate, educate, and influence the world toward a more sustainable energy future.

On behalf of the entire ND Energy team, thank you for your continual support and interest in reading about our CY2017 activities.

We wish you the very best throughout 2018,



Peter C. Burns
Director, Center for Sustainable Energy at Notre Dame (ND Energy)
The Henry Massman Professor of Civil and Environmental Engineering and Earth Sciences

SUSTAINABLE DEVELOPMENT GOALS

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all

Energy is central to nearly every major challenge and opportunity the world faces today. Be it for jobs, security, climate change, food production or increasing incomes, access to energy for all is essential.

Sustainable energy is opportunity – it transforms lives, economies and the planet.

Learn more: https://www.un.org/sustainabledevelopment/energy/

STAY CONNECTED … FIND US ON:

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energy.nd.edu

You can also sign up to receive **The *milli*Joule**—a weekly reminder of events and activities in the coming week; **The Joule**—a biannual newsletter, highlighting major accomplishments from the previous 6 months; and now **The kiloJoule**—an annual report, highlighting major accomplishments from the previous calendar year.

This report is published annually by ND Energy. Questions and comments may be directed to Ms. Barbara Villarosa, managing editor, at bvillaro@nd.edu or to Dr. Ginger Sigmon, managing director, at gsigmon@nd.edu.

Contents

The *kilo*Joule highlights major activities and accomplishments in energy-related research and education at Notre Dame. This annual report covers the work of faculty, researchers, educators, students, and administrators affiliated with ND Energy throughout CY2017. The key areas listed below represent the foundation of ND Energy's mission and vision to create a more sustainable energy future for all.

Mission

The Center for Sustainable Energy at Notre Dame (ND Energy) is a University Research Center whose mission is to foster and grow energy-related research toward sustainable and affordable energy solutions, to support energy-related education and outreach throughout the Notre Dame and surrounding communities, and to influence the national and global discussions of the most pressing energy policy issues and questions of our time. ND Energy plays a pivotal role in developing new and improved energy technologies and systems and focuses on developing engineers, scientists, entrepreneurs, and social scientists to be leaders in their disciplines and literate in the systems of energy production and use.

Global Vision

Aligned with Notre Dame's Catholic mission and Pope Francis's Encyclical Laudato si' (Praise be to you—On Care For Our Common Home), ND Energy has embarked upon an expanded vision that spans well beyond the traditional setting of a university laboratory where scientific discoveries are made. Instead, amidst the natural environment and habitats of people living thousands of miles away, research is being done to generate reliable and affordable electricity in countries where there are low to middle income communities. This new research enables greater emphasis on the sociological and humanistic aspects of sustainable energy and uses entrepreneurial approaches to developing "low tech" solutions for reliable energy.

Nepal

Peter Burns visiting with Nepalese families

Uganda

Goals

ND Energy strives to create a highly visible organization that promotes and provides resources for all energy-related, academic activities at Notre Dame. By collaborating with faculty, researchers, and students in all colleges and schools, ND Energy supports the development of new ideas, research initiatives, and other relevant programs. By interfacing with global leaders in academia, industry, and government, ND Energy ensures that topics of major importance in energy policy and ethics are at the forefront of major discussions.

The information in this report demonstrates the goals of ND Energy and highlights the various programs and services that enable advancements in energy-related research and education at Notre Dame.

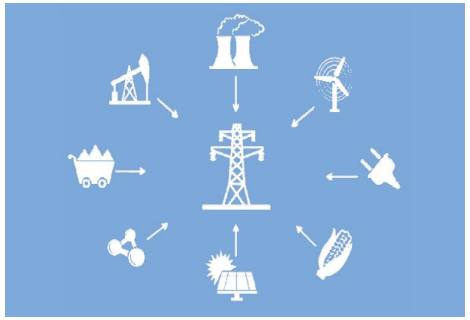
- Serve as a focal point for all University-wide energy research and education activities
- Improve inter-college participation
- Enhance research collaborations
- Increase educational opportunities at the undergraduate and graduate levels
- Create opportunities to promote informed choices for socially responsible and ethical energy production and use internationally, nationally, locally and individually
- Influence the national and global views on energy policy, ethics, and international relations
- Ensure long-term financial viability of these activities at Notre Dame

Research

Advancing research capabilities in energy and ensuring exceptional progress through world-class research facilities and programs are major cornerstones of ND Energy.

ND Energy supports faculty in all colleges and schools who have interests in cutting-edge scientific and engineering research aimed at addressing challenges in energy production, generation, and use; improving America's energy future; and enabling countries, where electricity is unreliable, to have access to affordable and reliable energy sources. Technological advancements and scientific discoveries are central to the work of our affiliated faculty and their associated researchers. These research efforts are organized into six research themes, each having a distinctive foci that supports the ND Energy mission and enables our researchers to address the most critical energy challenges facing the world today.

RESEARCH THEMES



Energy Conversion and Efficiency
energy catalysis, *conversion of fuels*, and *energy efficient separations*

Smart Distribution and Storage
smart grid technology and *battery storage*

Sustainable Bio/Fossil Fuels
biofuels design and *carbon sequestration*

Sustainable and Secure Nuclear
nuclear materials, *nuclear forensics*, and *nuclear structures*

Transformative Solar
photovoltaics and *energy conversion efficiencies*

Transformative Wind
ultra-tall towers and *site locations*

INTERNATIONAL RESEARCH

A new research area for ND Energy aims to create sustainable energy solutions for communities in Low to Middle Income Countries (LMICs) by using a unique approach to address the challenges of unavailable electricity.

The **Energy and Sustainable Development + Design laboratory**, directed by Abigail Mechtenberg, ND Energy's International Sustainable Development Researcher, provides a place for undergraduate and graduate students to study, engage, and prepare for key research projects in LMICs.

Currently, these areas include Uganda, Nigeria, Rwanda, and Nepal, where students are implementing E3—Education, Engineering design, and Entrepreneurship. E3 essentially teaches local technicians and engineers how to prototype, design, build, install, maintain, and create a business venture for renewable energy devices, using local materials and resident technical expertise.

COLLABORATORS

The success of E3 depends on the participation and commitment of local partners and collaborators who support project initiatives and share research discoveries through co-publications. Current collaborations include the following institutions:

Makerere University
Technology 4 Tomorrow
Uganda Martyrs University
Uganda Small Scale Industries Association
Mountains of the Moon University
Mulago Hospital

E3
Education
Engineering design
Entrepreneurship

DEVICES

The devices currently being implemented fall into three categories and provide enough power to produce electricity needed for the project area.

Mechanical to Electrical – cattle-go-round generator, merry-go-round generator, bicycle generator, hand-crank generator, hydroelectric generator, wind turbines.

Thermal to Electrical – concentrating solar power generator, thermal electric cookstove/ solar, waste incinerator generator.

Chemical to Thermal to Electrical – retrofitted petrol generator (biogas) using anaerobic digester: methane; retrofitted petrol generator (biogas) using urine electrolysis: hydrogen; bio-diesel generator using Ugandan algae: oil.

Energy and Sustainable Development + Design

RESEARCH CENTERS

On September 12, 2017 the National Science Foundation (NSF) announced four new Engineering Research Centers (ERCs), each focusing on a key research challenge in health and energy sustainability with an overall investment of nearly $80M.

The NSF **Center for Innovative and Strategic Transformation of Alkane Resources (CISTAR)**, led by Purdue University in partnership with the University of New Mexico, Northwestern University, University of Notre Dame, and University of Texas at Austin, will develop technologies for responsible conversion of light hydrocarbons from shale gas into fuels and chemicals using a network of portable, modular processing plants. CISTAR could enable lower carbon emissions and improved energy efficiency, and provide a viable bridge to a sustainable energy future.

Co-principal investigators at the University of Notre Dame will focus on several aspects of the project, including catalyst synthesis, catalyst characterization, catalyst performance measurements, membrane synthesis, membrane characterization and performance measurements, theory-driven molecular scale modeling, and process and economic evaluations. Investigators at Notre Dame are professors in the Department of Chemical and Biomolecular Engineering and include Thomas Degnan, Alexander Dowling, Ruilan Guo, Jason Hicks, William Schneider, and Eduardo Wolf. To follow the research progress and associated activities of the center, visit **https://cistar.us/**.

On October 1, 2017 the Department of Energy's National Nuclear Security Administration (NNSA) awarded two research grants totaling $27.5M.

The University of Notre Dame will lead the **NNSA Actinide Center of Excellence (ACE)** to conduct research in actinide and nuclear chemistry. Directed by Peter C. Burns, Henry Massman Professor of Civil & Environmental Engineering & Earth Sciences (CEEES), the center will focus its research on three specific themes: (1) the properties and structure of nanoscale radioactive materials; (2) the thermochemistry, or heat energy, associated with these materials; and (3) how nanoscale nuclear materials react in various chemical environments. Funding for the center will be provided by NNSA's Stewardship Sciences Academic Alliance program, which is tasked with prioritizing research that is important for Stockpile Stewardship — the certification that the nation's nuclear weapons are secure and operational.

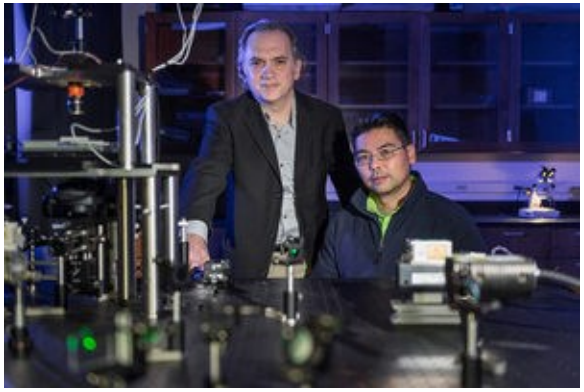
Other senior investigators at Notre Dame are professors Amy Hixon, Civil & Environmental Engineering & Earth Sciences, and Jay LaVerne, Physics and Radiation Laboratory. Team investigators include researchers from Washington State University, University of Minnesota, Oregon State University, and Northwestern University. For more information about the center, visit **http://actinidecenter.com/**.

RESEARCHERS IN THE NEWS

SOLVED: DECADES-OLD MYSTERY IN THEORETICAL CONDENSED MATTER PHYSICS

March 01, 2017 (published by College of Engineering)

Notre Dame researchers in the theoretical condensed matter physics group of Professor Boldizsár Jankó and collaborators have solved a decades-old mystery of fluorescence intermittency – blinking – that indicates classical physics behavior in a quantum mechanical system. The breakthrough explains the relatively long-lasting flashes in an experimental video by Chemistry and Biochemistry Professor Masaru Kuno of the reduction of graphene oxide. Using a random-sample Monte Carlo simulation, graduate student Anthony Ruth demonstrated that the emissions result from a chemical reaction, meaning that the video may also be the first direct movie of a chemical reaction in process. The ability to understand and control or prevent the blinking has implications in fields from flat-screen TVs to medical imaging and treatments. A paper on the discovery, “Fluorescence Intermittency Originates from Reclustering in Two Dimensional Organic Semiconductors,” was published in *Nature Communications*. Authors, in addition to Jankó, Kuno, and Ruth, are Michitoshi Hayashi of National Taiwan University, Peter Zapol of Argonne National Laboratory, Jixin Si of Notre Dame Physics, Matthew P. McDonald of the Max Planck Institute for the Science of Light, and Yurii V. Morozov of Notre Dame Chemistry and Biochemistry.



Boldizsár Jankó and Masaru Kuno

PERDIGÃO: CAPTURING THE COMPLEXITIES OF MOUNTAIN WINDS

June 02, 2017 (published by Office of Media Relations)

A team of close to 50 scientists, students and technical staff brought an unprecedented assembly of equipment to Vale do Cobrão, a valley in eastern Portugal. Researchers at the valley are collecting data on multiple aspects of wind flow patterns shaped by meteorological forcing on intricate terrain through carefully planned field observations. Field work on this project, called Perdigão in recognition of a town close to the valley, began May 1 with intense data gathering of measurements including velocity, turbulence, temperature, moisture and radiation. Harindra Fernando, Wayne and Diana Murdy Endowed Professor in the Department of Civil & Environmental Engineering & Earth Sciences and the Department of Aerospace and Mechanical Engineering, is the principal investigator on the study for the U.S. group. When completed, scientists will have a reference data set of incomparable spatial resolution. The research will aid wind resource assessment in Europe and elsewhere in the world and optimization of wind-turbine siting, as scientists will make use of an existing full-scale turbine at the Perdigão site to study the interactions of turbine wakes with varying wind flows and topography.

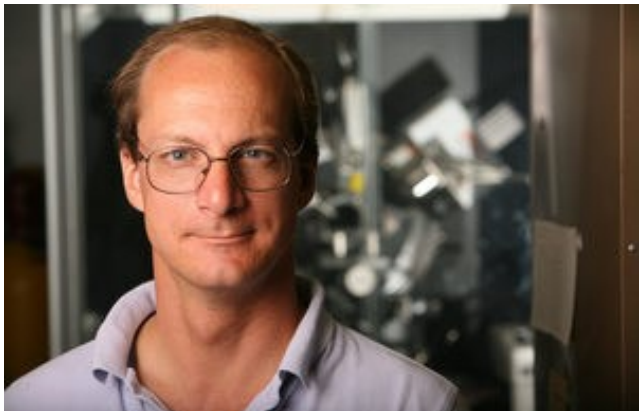
Perdigão Field Experiment

RESEARCHERS IN THE NEWS

RESEARCHERS WORK TO IMPROVE NUCLEAR WASTE RECYCLING

June 19, 2017 (published by Notre Dame Research)

The United States' current nuclear power process only uses about one percent of the total energy available from the fuel, resulting in radioactive waste that leaves a significant negative impact on the environment. Several other countries – such as France, Great Britain, and Russia – recycle nuclear fuel by reprocessing the used fuel to make even more energy. At the University of Notre Dame, researchers within ND Energy are thinking creatively about problems surrounding nuclear materials and are searching for solutions to reduce waste, decrease the cost of nuclear energy production, and increase efficiency and safety of the entire process. Led by Peter C. Burns, Henry J. Massman Professor of Civil & Environmental Engineering & Earth Sciences, researchers at Notre Dame have synthesized hundreds of compounds new to science over the past 20 years. His team has even developed a method that causes uranium – a naturally occurring element – to form clusters of uranium nano-molecules that could potentially be turned back into useable fuel.



Peter C. Burns

RESEARCHERS DISCOVER NEW CHEMICAL PROCESS THAT COULD REDUCE NITROGEN OXIDES FROM DIESEL EXHAUST

August 18, 2017 (published by Office of Media Relations)

Chemical engineers at the University of Notre Dame have discovered a catalytic process that could help curb emissions of nitrogen oxides (NOx) from diesel-powered vehicles, a priority air pollutant that is a key ingredient in smog. The study, published in the journal *Science*, is the culmination of a decade of collaborative research by the University of Notre Dame, Purdue University, and Cummins Inc., funded by the National Science Foundation and the Department of Energy. Co-authors of the study include William F. Schneider, H. Clifford and Evelyn A. Brosey Professor of Engineering, Christopher Paolucci, Sichi Li and Hui Li at the University of Notre Dame; Rajamani Gounder, Ishant Khurana, Atish A. Parekh, Arthur J. Shih, John R. Di Iorio, Johnatan D. Albarracin-Caballero, Jeffrey T. Miller, W. Nicholas Delgass and Fabio H. Ribeiro at Purdue University; and Aleksey Yezerets with Cummins Inc., which designs and manufactures diesel and alternative-fuel engines.

William F. Schneider

RESEARCH AWARDS AND RECOGNITIONS

Tengfei Luo, the Dorini Family Collegiate Chair in Energy Studies and associate professor in the Department of Aerospace and Mechanical Engineering, has been named to the **2016 Class of DuPont Young Professors**, one of only eight young faculty to receive the honor this year. (January 18, 2017)

Tengfei Luo

Paul W. Bohn, the Arthur J. Schmitt Professor in the Department of Chemical and Biomolecular Engineering, has been named the recipient of the **2017 American Chemical Society (ACS) Analytical Division Electrochemistry Award** for his contributions to the field of electrochemical analysis. (February 27, 2017)

Paul Bohn

Sylwia Ptasinska

Sylwia Ptasinska, associate professor in the Department of Physics, has joined the **editorial board of Plasma**, an open access journal published quarterly online by MDPI (Multidisciplinary Digital Publishing Institute). (April 3, 2017)

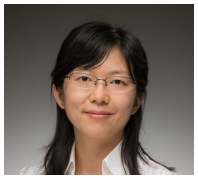
Jason Hicks, associate professor in the Department of Chemical and Biomolecular Engineering, and **Scott Morris**, professor in the Department of Aerospace and Mechanical Engineering, have received **Rev. Edmund P. Joyce, C.S.C., Awards for Excellence in Undergraduate Teaching**. (May 17, 2017)

Jason Hicks

Scott Morris

The **National Science Foundation (NSF)** has recognized **Jennifer Schaefer**, assistant professor in the Department of Chemical and Biomolecular Engineering, and **Na Wei**, assistant professor in the Department of Civil & Environmental Engineering & Earth Sciences, for their excellence in research with **Early Career Development (CAREER) Awards**. (May 17, 2017)

Jennifer Schaefer



Na Wei

Notre Dame International provided funding to support the University's broader strategy to engage Mexico and Latin America by building upon existing partnerships and creating new opportunities for research, scholarship, and graduate training. **Robert Nerenberg**, associate professor in the Department of Civil & Environmental Engineering & Earth Sciences, and **Jonathan Whitmer**, assistant professor in the Department of Chemical and Biomolecular Engineering, were among the award recipients. (August 4, 2017)

Robert Nerenberg

Jonathan Whitmer

RESEARCH AWARDS AND RECOGNITIONS

The Office of Science of the **Department of Energy** has named **Amy E. Hixon**, assistant professor in the Department of Civil & Environmental Engineering & Earth Sciences, a **2017 Early Career Award winner**. She is one of only 59 honorees this year. (August 18, 2017)

David Go, the Rooney Family Associate Professor of Engineering in the Department of Aerospace and Mechanical Engineering, and **Scott Morris**, professor in the Department of Aerospace and Mechanical Engineering, received awards from the Department of Defense (DoD) **Defense University Research Instrumentation Program (DURIP)** to purchase a tunable laser system and equipment for transonic wind tunnel research, respectively. (August 18, 2017)

Ruilan Guo, assistant professor of Chemical and Biomolecular Engineering, has been named to the Industrial and Engineering Chemistry (inaugural) **2017 Class of Influential Researchers**. (October 5, 2017)

Colin Jessop and other members of the University's High-Energy Physics team received $1.2 million over four years from the **Department of Energy** to develop radiation-resistant optical devices that can be used in a wide variety of scientific and technical applications, including experiments at the world's largest particle accelerator, located in Geneva, Switzerland. Led by Notre Dame, this project includes researchers from the California Institute of Technology, the University of Iowa, and the University of Virginia. (October 10, 2017)

Kenneth T. Christensen, professor and collegiate chair in fluid mechanics and chair of the Department of Aerospace and Mechanical Engineering, has been named fellow of the **American Association for the Advancement of Science (AAAS)** for his contributions to the field of experimental fluid mechanics, particularly laser-based measurements of turbulence interactions with complex topography. (November 21, 2017)

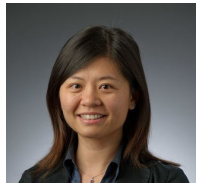
Prashant V. Kamat, Rev. John A. Zahm Professor of Science, has been named to **Clarivate Analytics' 2017 Highly Cited Researchers** list. Clarivate's list identifies the scholars who published the most articles that are in the top one percent of the most-cited articles. (December 18, 2017)

Sylwia Ptasinska, associate professor in the Department of Physics, has been awarded a **Luksburg Foundation Collaboration Grant** for her project titled "Efficacy of copper-based oxide materials involved in energy-related processes" with Pontificia Universidad Católica de Chile (PUC) faculty in Santiago, Chile. (December 5, 2017)

Amy Hixon

Scott Morris

David Go



Ruilan Guo

Colin Jessop

Ken Christensen

Prashant Kamat

Sylwia Ptasinska

Looking Ahead to 2018 RESEARCH SYMPOSIUM

On April 18, ND Energy held its inaugural research symposium, celebrating the recent accomplishments of its affiliated faculty and their energy-related research programs at Notre Dame.

Peter C. Burns, Henry Massman Professor of Civil & Environmental Engineering & Earth Sciences and director of ND Energy, welcomed participants and gave a brief presentation on the state of ND Energy. After his address, keynote speaker Sally M. Benson, co-director of the Precourt Institute for Energy at Stanford University, presented "The Global Climate and Energy Challenge".

In her presentation, Dr. Benson discussed emerging solutions to provide secure, affordable, and sustainable energy for the nine billion people expected on Earth by 2050. She described the challenge of meeting the world's growing energy needs while also finding ways to reduce carbon dioxide emissions. She also highlighted game changers that have brought low carbon and low cost energy, such as natural gas, wind turbines, and photovoltaics. She also looked ahead to new technologies for renewable integration and decarbonizing transportation. Stressing the importance of research and development in the creation of the next generation of energy solutions, Dr. Benson concluded that leadership, innovation and persistence are the keys to a sustainable energy future.

Following the keynote presentation, the focus of the symposium shifted to the following presentations on specific research programs by affiliated faculty who recently received early career and large-center awards:

- *Unprecedented Chain-growth Polymerization Method to Access Structurally Defined Hyperbranched Polymers,* Haifeng Gao
- *Understanding the Chemical Complexity of Multi-Component Systems: Uranium Polyoxometalates as Nanosorbents*, Amy Hixon
- *Thermal Transport across Hydrogen-Bonded Hard-Soft Interfaces*, Tengfei Luo
- *Renewable Biocatalysts for Degradation of Persistent Organic Contaminants Using Synthetic Biology*, Na Wei
- *Fundamental Materials Studies on Fast Ion Diffusion in Model Side-chain Ionomers,* Jennifer Schaefer
- *Nucleophilic, Radical, and Electrophilic Palladium Carbene Complexes: New Types of Reactivity for Palladium,* Vlad Iluc
- NSF Center for Innovative and Strategic Transformation of Alkane Resources (CISTAR), William Schneider
- Extremely Energy Efficient Collective Electronics (EXCEL), Michael Niemier
- Actinide Center of Excellence (ACE), Peter C. Burns

Earlier in the day, 24 associated graduate students and postdoctoral scholars presented their energy-related research projects during the poster session. While all projects were well-received by the judges, three outstanding posters were recognized at the conclusion of the event. Award winners were:

- Nick Kempf, *A Robust High-sensitivity Scanning Thermal Probe for Simultaneous Microscale Thermal and Thermoelectric Property Mapping* (Zhang Laboratory)
- Rebecca Scheidt, *Modulation of Charge Recombination in CsPbBr3 Perovskite Films with Electrochemical Bias* (Kamat Laboratory)
- Brooke Stemple, *Enhanced Ionic Liquid Tolerance of Yarrowia Lipolytica Through Evolutionary Engineering for Simultaneous Saccharification and Fermentation of Lignocellulosic Biomass* (Wei Laboratory)

MATERIALS CHARACTERIZATION FACILITY

ND Energy's Materials Characterization Facility (MCF) provides world-class, state-of-the-art equipment and instrumentation to support scientific advancements and new or improved sustainable energy technologies and systems. Managed by Dr. Ian Lightcap, ND Energy's Research and Facilities Program Director, the MCF has capabilities in the following major areas:

- **General Materials Characterization —** modern instrumentation and expertise for solid, liquid and gas characterization by spectroscopic, thermal, X-ray, BET, and spectrometric analytical methods
- **Photovoltaic and Electrocatalyst Characterization —** two catalyst and photovoltaic testing stations that include solar simulators, automated gas sampling loops for in-line GC evolved gas detection, and a potentiostat with electrochemical impedance and rotating disc electrode capabilities
- **Crystallographic Characterization —** powder and single crystal X-ray diffractometers for a wide range of structural characterization

The MCF's mission is to provide researchers with high quality data, driving every aspect of the MCF, including its major goals to provide excellent training, customer service, education, and instrument acquisition.

In support of the MCF mission, Dr. Lightcap conducts individual training sessions and group workshops on specific instruments. Workshops are designed to provide fundamental technical principles and practical sample preparation and measurement tips that are required to acquire high quality data. Time for running user samples and practicing sample prep skills and data acquisition and analysis are also key components of the workshops. The following workshops were conducted in 2017:

- **ASAP 2020- Physi/chemisorption** — Surface Area and Porosity Analysis: How to Combine the Right Gas, Temperature and Model for Accurate Data
- **AFM - Atomic Force Microscopy** — Fundamentals and Practical Applications
- **Rheology Fundamentals** — The Study of Flow and Deformation of Materials

NEW INSTRUMENTATION

Four additional instruments were added to the MCF this year, making this already robust research facility a major asset for researchers. The MCF has 30 instruments in total and while most of them are for characterization (spectroscopy, surface analysis, thermal analysis, crystallography, electrochemistry, polymer/particle analysis, and gas analysis), a few are for syntheses.

Asylum AFM, located in B31/B32 Fitzpatrick Hall

Built-in 3D real-time rendering, nanolithography/ nanomanipulation, and dual resonance and harmonic imaging

Park AFM, located in B31/B32 Fitzpatrick Hall

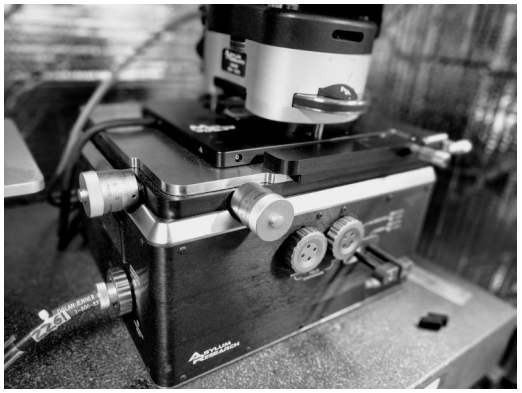
Data production at the highest nano resolution with unparalleled accuracy and resolution

FTIR Microscope, located in 132 Nieuwland Science Hall

Small sample surface analysis, fully automatic with ability to capture and store images during analysis

Rheometer, located in 132 Nieuwland Science Hall

Dynamic mechanical testing, humidity control, and tribology testing capabilities



A complete list of instruments and capabilities can be found on the MCF website.

mcf.nd.edu

STUDENT RESEARCH FELLOWSHIPS

ND Energy offers research fellowships to undergraduate and graduate students that provide unique opportunities to enhance their knowledge and research capabilities in energy. Undergraduate fellowships were first offered in 2006, while graduate fellowships began in 2012. Each opportunity asks students to submit a collaborative research proposal with their faculty advisor explaining their research objectives and demonstrating their academic achievements and capabilities to accomplish their goals.

The Vincent P. Slatt Endowment for Undergraduate Research in Energy Systems and Processes

The Vincent P. Slatt Endowment for Undergraduate Research in Energy Systems and Processes provides support for students interested in conducting energy-related research to advance new technologies in energy systems and processes and help improve America's energy future.

Since 2006, 107 Slatt fellowships have been awarded to undergraduate students, totaling $484,488.

In 2017 alone, twelve awards were made, totaling $56,000. A list of the scholars and their research projects are highlighted in the adjacent chart.

The Forgash Student Fellowship in Solar Energy Research

The Forgash Student Fellowship in Solar Energy Research provides financial support to an undergraduate or graduate student interested in solar energy collection/conversion technologies through research and development at Notre Dame.

Since 2009, eight fellowships have been awarded, totaling $16,000.

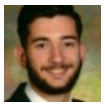
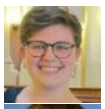
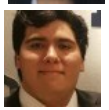
The 2017 award was made to Margaret Tucker, an undergraduate student in the Department of Civil & Environmental Engineering & Earth Sciences, whose project entitled "Polymer-Templated, Quantum Dot Rainbow Solar Cells" was conduced under the supervision of Dr. Ian Lightcap.

The Vincent P. Slatt Endowment for Undergraduate Research in Energy Systems and Processes is made possible through the generosity of Christopher (ND '80) and Jeanine Slatt in honor of Vincent P. Slatt, Notre Dame Class of 1943.

2006-2017
107 Awards
$484,488

The Forgash Undergraduate Student Fellowship in Solar Energy Research is made possible through the generosity of John (ND '00) and Karla Forgash.

2009-2017
8 Awards
$16,000

	2017 Slatt Scholar	Major/Minor	Faculty Advisor	Project Title
	Santiago Calderon Novoa	Chemical and Biomolecular Engineering	Eduardo Wolf	Study on the Catalytic Conversion of Methane and Carbon Dioxide into Hydrogen Gas using Ni-SiO2 Catalysts, and its Impact on the Energy Field
	Lukas Cepkauskas	Chemical and Biomolecular Engineering	Ruilan Guo	Segmented Copolymers of Triptycene-containing Hydrophobic Oligomers for Increased Mechanical Stability and Proton Conduction
	Luis Fernandez	Aerospace and Mechanical Engineering	Joe Fernando	Mapping Wind Flows in Perdigão *(field study in Portugal)*
	Sheridan Foy	Chemical and Biomolecular Engineering	Edward Maginn	Gas Solubility of Nonvolatile Separation Solvents
	John Higham	Chemical and Biomolecular Engineering Energy Studies Minor	William Phillip / David Go	Throughput and Permeability Effects of PT-Spraying High Performance Copolymer Membranes for Water Treatment Applications
	Elisabeth Kerns	Chemistry-Business Energy Studies Minor	Prashant Kamat	Perovskite Halide Exchange for Better Solar Cells
	Brady McLaughlin	Physics in Medicine Energy Studies Minor	Abigail Mechtenberg	[Re]-Evaluating the Cost of Electricity due to Death at Hospitals with Unreliable Energy Systems-VSL/E Metric *(field study in Uganda)*
	Hannah Naguib	Chemistry and Biochemistry	Haifeng Gao	Synthesis of Hyperbranched Polymers with Post-Functionalization Specificity
	John Salvadore	Aerospace and Mechanical Engineering Energy Studies Minor	Joe Fernando	Perdigão Wind Energy Field Study *(field study in Portugal)*
	Miles Wood	Business Analytics and Applied & Computational Mathematics & Statistics	Abigail Mechtenberg	Empowering Ugandans to Power Uganda: Exploring the Social Return on Investment (SROI) of the Business of Energy in Uganda *(field study in Uganda)*
	Anthony Zappia	Aerospace and Mechanical Engineering	Tengfei Luo	Plasmonic Enhancement of Solar-thermal Water Desalination in a Functionalized Au-SiO2 Shell-core Nanoparticle-loaded Porous Membrane
	Aristotle Zervoudakis	Chemical and Biomolecular Engineering	Jonathan Whitmer	Modeling Phase Behavior of Complex Coacervates to Engineer Smart, Responsive Materials

The Patrick and Jana Eilers Graduate Student Fellowship for Energy Related Research

The Patrick and Jana Eilers Graduate Student Fellowship for Energy Related Research provides financial support for graduate students to enable their work in energy-related research.

Since 2012, sixteen fellowships have been awarded, totaling $149,946.

In 2017, four graduate students received awards totaling $32,400. The recipients and their research projects are highlighted below.

	2017 Eilers Fellow	Department	Project Title
	Hanyu Ma *Advisor: Peter Burns*	Civil & Environmental Engineering & Earth Sciences	Size Effect on Ruthenium Nanoparticle-Catalyzed Hydrogen Generation from Hydrazine Borane
	Randall Marks *Advisor: Kyle Doudrick*	Civil & Environmental Engineering & Earth Sciences	Selective Conversion of Nitrate to Ammonia Using Earth-abundant Hydrogenation Catalysts
	Triet Nguyen *Advisor: John Parkhill*	Chemistry and Biochemistry	Rationalizing the Size-dependent Stoke Shifts in Cesium Lead Bromide Perovskite Nanocrystals
	Jize Zhang *Advisor: Alex Taflanidis*	Civil & Environmental Engineering & Earth Sciences	A Comprehensive Computational Framework for Layout Optimization of Wave Energy Converters that Addresses Large Dimensional Arrays, Causal Control and Uncertain Wave Environments

The Patrick and Jana Eilers Graduate Student Fellowship for Energy Related Research is made possible through the generosity of Patrick (ND '90) and Jana Eilers. Since 2013, the *Fitzpatrick Endowment for Excellence in Energy*, made possible through the generosity of Edward Fitzpatrick, Jr. (ND '54), and since 2015, the *Michael A. O'Sullivan Endowment for Excellence in Energy Research*, made possible through the generosity of Michael O'Sullivan (ND '82), have been combined with the *Eilers fellowship* to provide greater financial support to students.

2012-2017 16 Awards $149,946

ND ENERGY POSTDOCTORAL FELLOWSHIPS

Starting in 2014, ND Energy has offered fellowship opportunities to postdoctoral scholars to support the enhancement and development of research programs in energy at Notre Dame. Fellowship awards provide support for the use of core research facilities at Notre Dame, travel to attend professional conferences, and funds for salary/benefits. Listed below are the 2017 fellows and their research projects.

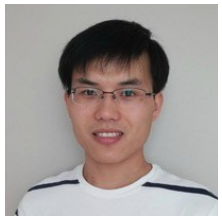
Jacob Weidman

Maksym Zhukovskyi

Gary Zaiats

Yi Shi

Ashkan Zeinalzadeh



Yaofa Li

Jarrod Schiffbauer

Tyler Spano

Postdoctoral Fellow	Department	Faculty Advisor	Research Project
Jacob Weidman	Chemical and Biomolecular Engineering	William Phillip	Elucidating the Effects of Nanoscale Structure and Chemistry on Water and Salt Transport Through Charge Mosaic Membranes
Maksym Zhukovskyi	Chemistry and Biochemistry	Ken Kuno	Single Particle Screening of Photocatalytic Events in 2D Metal Chalcogenide Nanostructures
Gary Zaiats	Chemistry and Biochemistry, Radiation Laboratory	Prashant Kamat	Photovoltaic Aspects of Metal Decorated $CuInS_2$ and ZnS-$CuInS_2$ Nanostructure Thin Films
Yi Shi	Chemistry and Biochemistry	Haifeng Gao	Construct Dendritic Polymers with Layered Structures for Light Harvesting
Ashkan Zeinalzadeh	Electrical Engineering	Vijay Gupta	Real Time Pricing in the Presence of High Penetration of Solar Energies
Yaofa LI	Aerospace and Mechanical Engineering	Kenneth Christensen	Ensuring Long-Term Security of Stored CO_2: Fundamental Studies of the Multiphase Flow of Water and Liquid/Supercritical CO_2 in 2D Heterogeneous Porous Micromodels
Jarrod Schiffbauer	Aerospace and Mechanical Engineering	Tengfei Luo	Plasmonic Enhancement of Solar-thermal Water Desalination in a Functionalized Au-SiO_2 Shell-core Nanoparticle-loaded Multi-layered Microporous Wick
Tyler Spano	Civil & Environmental Engineering & Earth Sciences	Antonio Simonetti	Tracer Methods for Nuclear Forensic Applications

EDUCATION

Providing exceptional education and resources for undergraduate students that support stronger communities and foster broader career options remain high priorities for ND Energy.

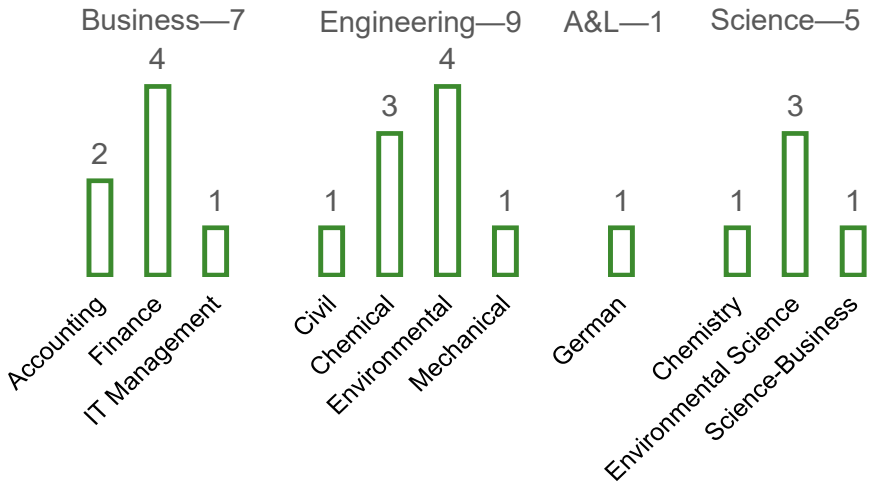
ENERGY STUDIES MINOR

The Energy Studies Minor (ESM) is open to undergraduate students in all majors and colleges at the University of Notre Dame. The minor is intended to prepare students to become successful leaders who understand the complexities of energy challenges and can help move the country and world toward a more sustainable energy future. Requirements of the minor are the successful completion of three required courses focusing on energy and society, the business of energy, and a capstone that encompasses the use and understanding of several major elements in energy. Students also take three electives from an approved list of technical and non-technical courses.

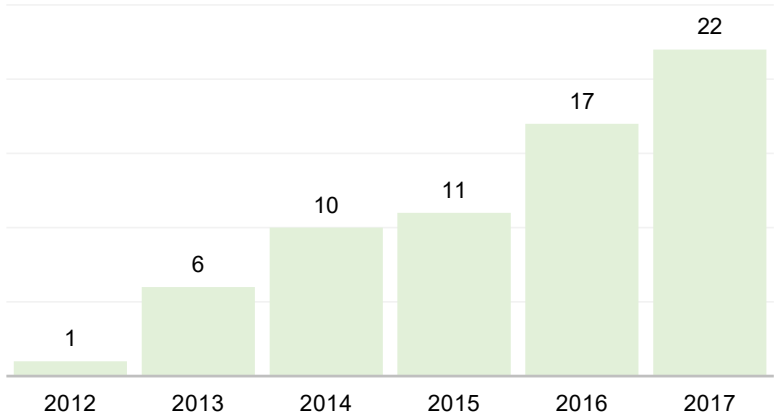
The capstone credit for the course continues to offer the option of participating in an energy-focused, one-week seminar with the Center for Social Concerns (CSC) or enrolling in a semester-long class on campus. Both emphasize involvement in a hands-on experience. Students who choose to travel with the CSC to Washington, DC meet with various advocacy groups, government officials, and industry leaders to learn about the complexities of developing energy policy. Other students spend a week in Appalachia, learning about the impact of coal on the lives of the citizens. Those who participate in the more traditional course on campus use internships, laboratory experience, or individualized projects to learn about energy in a dynamic way.

For the first time, ND Energy hosted a graduation recognition ceremony for its twenty-two seniors. This number represents the largest cohort to-date. The minor continues to draw interest from every college as students become more aware of the importance of energy to their futures.

Number of 2017 Graduates by College and Major



Total Graduates by Year



2017 GRADUATING CLASS

ND Energy celebrated twenty-two graduates completing the requirements for the Energy Studies Minor in 2017. A reception and certificate ceremony was held in the Atrium of Stinson-Remick Hall Friday afternoon, May 19. The graduates and their families and friends were greeted by Yih-Fang Huang, senior associate dean for education and undergraduate programs, College of Engineering, and Peter C. Burns, Henry J. Massman professor of Civil & Environmental Engineering & Earth Sciences, director of ND Energy, and academic advisor for the minor. The invocation was led by Rev. Terrence Ehrman, C.S.C., assistant director for life sciences research and outreach, Center for Theology, Science, and Human Flourishing.

Below are the names of the graduates, their academic majors, and future plans.

Michael Joseph Carillo, Accountancy, *Auditor at Deloitte*
Tessa May Clarizio, Environmental Engineering, *master degree in water, waste, and environmental engineering at University College Dublin*
Matthew Joseph Colturi, Civil Engineering, *Building Technology at Simpson, Gumpertz, & Heger, Inc.*
Adam Daniel Conrath, Information Technology Management, *Technology Consultant at PricewaterhouseCoopers*
Andrew Joseph DeSantis, Chemical Engineering, *a career in manufacturing*
Kathryn Margaret Georgi, Environmental Science, *Consultant at Enterey, Inc.*
Mark Grasberger, Finance, *Investment Banking Analyst at Credit Suisse*
Sarah Gwenevieve Jen, Finance, *Financial Management Program with General Electric*
John Karas, Accountancy, *Audit Assistant at Deloitte*
Patricia Eileen Kay, Chemical Engineering, *service with AmeriCorps and Grow Ohio Valley in Wheeling, WV, then employment as an engineer*
Erik Johann Maag, German and Environmental Science, *researching renewable energy in Germany*
Brian J. McCurren, Mechanical Engineering, *Product Development Engineer at Ford Motor Company*
Nicole Brooke Micelotta, Environmental Science, *environmental consulting, energy auditing, or renewables*
Grace Ballentine Muller, Finance, *Analyst at Goldman Sachs*
Ryan Scott Schools, Chemical Engineering, *an engineer in the manufacturing or development of sustainable energy technologies*
Caroline Renn Skulski, Science-Business, *Clinical Informatics Specialist at Oak Street Health*
Wynn Michael Stoxen, Environmental Engineering, *Construction Engineer at Clark*
Andrew Thomas, Environmental Engineering, *Construction Engineer at Clark*
Isaac Nathaniel Wappes, Chemistry, *graduate school in materials chemistry at University of Chicago*
Jonathan Kelly Winkel, Finance, *Corporate Finance Advisory Associate in Valuation Services at Grant Thornton*
Kimberly Marie Wojcik, Environmental Engineering, *an environmental engineering position focused on water resources management, sustainable urban development, or environmental remediation*
Madeline Marie Wroblewski, Environmental Science, *service with AmeriCorps and then research in ecology*

MISHAWAKA HIGH SCHOOL RESEARCH INTERNSHIP

Back in spring 2013, Prof. Peter C. Burns was asked how he could help his community. His response was, “I could work with the local high school in Mishawaka and get students into the research laboratories affiliated with ND Energy. This would give them the experience of a lifetime.” This was the start of the Mishawaka High School Research Internship program, which engages up to ten students annually in energy-related research. Over the past 4 years, students have participated in 30 different research projects, while receiving credit from the high school for their participation.

Each fall, these young interns are welcomed into assigned laboratories and begin working on energy-related research projects with graduate students and postdoctoral mentors. At the end of the fall semester, students are assigned an energy topic that they are required to research and present orally to their peers at Mishawaka High School. During the spring semester, students continue to work on their research projects in the laboratories, and at the end of the semester, present their findings during a poster presentation held at Notre Dame.

During the 2016-2017 academic year, nine students completed the fall semester and six students completed the spring semester. These highly motivated students came to campus twice a week for laboratory work and to participate in supplemental meetings that focused on sharing their research with fellow interns and learning about current energy topics.

The spring semester wrapped up Thursday, May 25, with a reception and poster presentations by the student interns on their research to friends and family members, Mishawaka High School officials, research group members, and others who had an interest in the program. The student presenters and their research topics were:

- **Grace Carpenter**, Senior, Synthesis of U20V20 and a Novel Nuclear Forensic Tool Involving Deposit Type Normalized Rare Earth Element Signatures (Peter Burns Laboratory)
- **Savonnah Fox**, Senior, Functionalized Membranes for Separations by Chemical Affinity (William Phillip Laboratory)
- **Devonee Freet**, Senior, Ewingite (Peter Burns Laboratory)
- **Sydney Jablonski**, Senior, Hydrogen Bonding Effects of Interlayer Spacing of Uranyl Sulfates (Peter Burns Laboratory)
- **Zoe Little-Wishmeier**, Junior, Designing Alternative Polyelectrolyte Membranes for Fuel Cells (Ruilan Guo Laboratory)
- **Kylie St John**, Junior, Characterization of Zeolite Catalysts Using Different Techniques to Test for Their Application in Carbon Coupling Reactions (Jason Hicks Laboratory)

UNDERGRADUATE SUSTAINABILITY RESEARCH AND EDUCATION EXPO

Over a hundred undergraduate students attended the annual Undergraduate Sustainability Research and Education Expo on January 31 in the Ballroom of LaFortune Student Center. Drawing a wide variety of campus and community groups and organizations, students met with faculty, educators, and community leaders regarding research and educational opportunities focused on energy, the environment, and other sustainability topics. Representatives from the following groups and organizations participated in this year's event.

Bertrand Farm
Burns Research Laboratory
Environmental Change Initiative – Fellowships and Ambassador Program
Environmental Radiochemistry/Actinide Chemistry Research Laboratory
Food Rescue US
Go Research Laboratory
Great Lakes Project
GreeND
GreenScale Research Project
Guo Research Laboratory
Hixon Research Laboratory
Jones Research Laboratory – Freshwater Ecology
Kellogg and Kroc Institutes – Research Grants, International Scholars Program, International Development Studies Minor
Lightcap Research Laboratory – Making Fuels with Sunlight
Master of Global Affairs
Medvigy Research Laboratory
Minor in Sustainability
Molecular-level Energy and Mass Transport (MEMT) Research Laboratory
ND Energy – Energy Studies Minor, Student Energy Board, Slatt Research Fellowships
Notre Dame Career Center
Prairie Winds Nature Farm
Regional Environmental Action Network, IU-South Bend
Reilly Center, GLOBES Program
Renewable Energy Policy in Various Countries - Student Research Project
UNDERC
Unity Gardens
Urban Forestry Sustainability
W.A.T.E.R. Research Laboratory

WHAT'S IT REALLY LIKE?: ENERGY CAREERS

Throughout the month of February, undergraduate students met with energy professionals to learn about everyday life in their careers, how they got to their current positions, the current climate in their fields, insights into the future, and anything else students wanted to ask. Designed to be small, informal group sessions, students were able to engage more deeply with each of the following professionals:

- February 1 - Lisa Zyonse, Pennie Waggener, and Jordan Ridenour: Consumers Energy
- February 2 - Margaret Merkel, Naval Nuclear Lab, and Sean McCloskey, Reactor Safety
- February 3 - John Kinney- Director, Advanced Technology Business Development, General Electric Aviation
- February 7 - Therese Dorau, Director of Sustainability, City of South Bend
- February 10 - Vince Barletto, Sr. Project Engineer, Cypress Creek Renewables
- February 13 - Subhash L. Shinde, Associate Director of ND Energy; formerly Research and Development Manager at Sandia National Labs and Senior Scientist/Engineer at IBM
- February 24 - Thomas Degnan, Tony and Sarah Earley Professor of Energy and the Environment
- February 27 - Katie Otterbeck- Campaign Organizer at Impact/Environment Colorado

SCIENCE ALIVE!

Sponsored by the St. Joseph County Public Library and held in its downtown branch, this annual winter event gives Notre Dame researchers and students the opportunity to share their knowledge of energy with the local community. ND Energy labs from across campus prepare enough hands-on activities and demonstrations to fill a room. This annual event also provides ND Energy the opportunity to teach children and their parents about energy-related issues and topics.

During the 25th anniversary of Science Alive in 2017, ND Energy had ten affiliated labs participating, creating an overflow from its traditional, single "energy" room into the third floor lobby. Over 850 community members participated in educational hands-on exhibits. While the activities were aimed at younger participants, posters and researchers answered many questions about their work and the future of energy to adults. The ND Energy affiliated laboratories that participated were those of faculty members Kyle Doudrick, Haifeng Gao, David Go, Prashant Kamat, Abigail Mechtenberg, Svetlana Neretina, William Phillip, Jennifer Schaefer, Bill Schneider, and Jonathan Whitmer.

NORTHERN INDIANA REGIONAL SCIENCE AND ENGINEERING FAIR (NIRSEF)

Hundreds of area K-12 students gathered in Notre Dame's Stepan Center on Saturday, March 4, to participate in the Northern Indiana Regional Science and Engineering Fair (NIRSEF). Among those in the early morning throng were six volunteers from ND Energy's Student Energy Board (SEB). These undergraduates interviewed junior and senior level energy-related projects to determine the quality of the work and the energy IQ of the presenters. By noon, two projects were chosen as winners of the 2017 Energy Award.

On the junior level, Cole Klinedinst, a sixth grader from Discovery Middle School in Granger, won for his project, "Capacitors- How Much Energy Can a Leyden Jar Store?". Cole was inspired to experiment with Leyden jars after researching Benjamin Franklin for a school assignment. Franklin was the first to use the word "battery" to describe connecting jars to build up more storage capacity. Like the researchers at ND Energy, Cole was trying to maximize energy storage.

The senior award went to a team from Elkhart Memorial High School, Romikumar Patel and Diego Reynoso, for their experimentation on "Artificial Photosynthesis." As part of a brand new research class at their school, the pair ran over 100 tests in search of an effective catalyst. They were very knowledgeable of ongoing photosynthesis research and enthusiastic about the future potential of using sunlight to reduce air pollution and create new biofuels.

SEB members who helped with the judging were Justin Blake, Yilong Yang, Emily Black, Shane Andersen, Beruchya Dao-Bai, and Francie Fink. The SEB helps to educate the community about progress being made at Notre Dame toward renewable energy by volunteering in local schools and at events such as the science fair.

JUNIOR PARENTS WEEKEND

On Saturday, February 18, junior engineers and their parents were invited to an open house in Stinson-Remick Hall. Several groups took a self-guided tour of the clean room, chapel, classrooms, and laboratory space located on the first floor. About 35 participants formed smaller groups that were escorted to the Peter C. Burns laboratory on the third floor to learn about nuclear research and the materials science of actinides.

YOUNG CAMPERS USE BERRIES TO EXPLORE MATERIALS SCIENCE

Over the two-day Art 2 Science summer camp, ND Energy helped more than two hundred K-12 campers imagine a future where renewable energy would help air-condition their homes and propel their cars. Sponsored by the Joint Institute for Nuclear Astrophysics, Center for the Evolution of Elements (JINA-CEE), Art 2 Science is an annual summer event that focuses on teaching young students about math, science, and engineering through creative hands-on projects. ND Energy sponsored one of the twelve stations set up for the campers.

While discussing renewable energy options, students learned that simple solar cells can be made with raspberry juice. The discussion of how this might have been discovered evolved into an exploration of materials science and engineering being done at Notre Dame by researchers looking for the next new ground-breaking combinations of chemicals. In keeping with the art-theme of the camp, students were asked to create paints using berries and spices, adjusting the textures and colors and naming their favorite outcomes. They were encouraged to write down their “secret formulas” in case they came up with award-winning results.

An added bonus was the opportunity for young campers to interact with graduate students who are working with ND Energy affiliated faculty on cutting-edge research in energy. These graduate students interacted with participants and helped them to understand the science behind their art projects. Volunteers were Roy Stillwell (Fay group), Jessica Zinna (Kuno group), Nicole Moore (Hixon group), Andrew Schranck (Doudrick group), and Gary Zaiats and Jeff DuBose (Kamat group).

GETTING TO KNOW OUR NEIGHBORS

After weeks of meeting in small working groups to brainstorm about ways to explain energy to fourth graders, fifteen members of GreeND and ND Energy’s Student Energy Board spent a Friday morning at James Madison Primary Center in downtown South Bend translating physics into reality. Small groups of junior researchers rotated around to different stations, using infrared thermometers, solar cars, ultraviolet flashlights, fluorescent crayons, and a radiometer to better visualize and experiment with energy transformation. They were encouraged to dream big and become the next generation of scientists and engineers who would work toward evolving clean, renewable energy choices.

ND Energy began its partnership with its young neighbors last year by first visiting the students at Madison and then inviting them for a day on campus. Although the schools are less than two miles apart, most Madison students only come to campus through university-sponsored outreach programs and rarely do Notre Dame students get to visit area schools. This experience resulted in both sides learning a lot and developing what we hope will become a long-term, standing relationship.

ALUMNI WINTER SPORTS WEEKEND AND LEADERSHIP CONFERENCE

ND Energy participated in the Alumni Association's roll out of "ND for the Environment" on Saturday, January 7, during the annual "Winter Sports Weekend" on campus. Before heading to the men's basketball victory over the Clemson Tigers, 250 visitors stopped by the Jordan Hall of Science to learn about energy research on campus and other sustainability efforts. Graduate students affiliated with ND Energy provided hands-on activities related to their solar and fuel cell research and demonstrated separation techniques and their usage to create new materials. ND Energy's popular "smoothie bike" gave visitors the chance to transfer some of their energy into a blender for a delicious treat.

On Thursday, April 20, the Alumni Association held its annual Leadership Conference on campus. ND Energy welcomed participants with an opportunity to interact with group members from four different ND Energy-affiliated laboratories and to test their physical endurance by pedaling their way to a scrumptious smoothie on the ND Energy smoothie bike. ND Energy research participants were Gary Beane (Hartland laboratory in Chemistry), Michael Humbert (Maginn laboratory in Chemical and Biomolecular Engineering), Tyler Spano (Burns laboratory in Civil & Environmental Engineering & Earth Sciences), and Hunter Ford and Laura Merrill (Schaefer laboratory in Chemical and Biomolecular Engineering).

Christopher (Chris) Simms ('88) President-Elect of Alumni Association Board took time out to show his support and gear up for the smoothie taste test!

MARCH FOR SCIENCE

The largest event was South Bend's March for Science on Saturday, April 22, with over 1,100 citizens attending. Among the exhibits at the end of the march was the ND Energy table that provided a solar charging station for phones and other electronics, as well as information about government sponsored research programs in energy at Notre Dame.

"DESIGNING SMART CITIES: MAYORS TAKING ACTION"

A conversation with Mayor Pete Buttigieg and Mayor James Brainard

On September 28, well over a hundred community members joined ND Energy for a conversation with Mayor Pete Buttigieg (D-South Bend, IN) and Mayor Jim Brainard (R-Carmel, IN) about how the U.S. can meet its climate goals through action on a local level. They covered aspects of urban architecture, public policy, politics, economics, and environmental considerations. Both mayors opposed President Trump's withdrawal of the United States from the Paris Climate Agreement and have committed to reducing greenhouse gas emissions, implementing new "smart city" designs, creating walkable cities, promoting bike riding, and switching to hybrid or alternative fuel vehicles in their cities. They believe that these changes are part of a plan that is good for the earth, the economy, public health, and national security. With metropolitan areas housing 80% of the U.S. population, both mayors are committed to the belief that local policies can help offset a lack of action on the national level.

Mayor James Brainard is the six-term Republican mayor of Carmel, Indiana. During that time, his city of 91,000 was awarded the *Climate Protection Award*, voted *#1 in American's Best Places to Live,* and won *Best Cities to Relocate to in America*. In a recent interview on NPR, Brainard spoke out against President Trump's withdrawal from the Paris Agreement, pointing out that over 1200 mayors from both parties have signed the U.S. Conference of Mayors Climate Protection Agreement, beginning as far back as 2005. Brainard has worked with mayors in cities around the world to move forward on environmental issues that their central governments are not willing or able to do. In November of 2013, he was appointed to the *Task Force on Climate Preparedness and Resilience* by President Obama. He often advises other cities on urban design and development and was named as one of the "Most Powerful Hoosiers in the World" by the Indianapolis Monthly.

Mayor Pete Buttigieg, second-term mayor of South Bend, was recently in the national limelight as a candidate for the Democratic National Committee chairmanship and as a guest on Seth Meyers' "Late Night." But to many in South Bend, "Mayor Pete" is the local boy who graduated from St. Joseph High School, attended Harvard, became a Rhodes Scholar, and returned to his hometown to give back. The youngest mayor of a city its size, Buttigieg was called "the most interesting mayor you've never heard of" by the Washington Post. His conviction that many problems are best solved locally has motivated his work on transforming South Bend into a "smart city," allowing more space for pedestrians and bikes while creating energy-efficient traffic patterns. He joined 80 other mayors in signing the Mayor's Climate Action Agenda, opposing President Trump's actions against the Paris Climate Agreement, and pledging to uphold the emissions goals set by the accord. South Bend has joined cities around the country in storing and publishing climate change data that was removed from the EPA's website in April as a gesture to the city's commitment to the issue.

ENERGY WEEK 2017

ND Energy's eleventh annual Notre Dame Energy Week morphed into a 10-day event when some very special guests needed to move their event to September 28, providing a grand entrance to an incredibly productive week ahead. Mayors Pete Buttigieg (D-South Bend) and Jim Brainard (R- Carmel, IN) entertained and informed a full house in the first Distinguished Lecture of the year, Designing Smart Cities: Mayors Taking Action.

Five more presentations were offered during the week of October 2-6. Three sponsored by ND Energy included Joni Hamson of EDF Renewable Services who shared her career path and the future of renewable energy in the U.S.; Victoria Trauger from the Notre Dame Career Center familiarized students with online tools they can use to find internships and careers in energy; and T.J. Kanczuzewski, CEO and President of the local solar company, Inovateus, spoke on his new book, *Building a Brilliant Tomorrow: Growing Solar*. Two co-sponsored events were "Environment, Oil, and Africa" presented by Jonny Auestad about Norway's leadership in helping Uganda develop their oil industry in an environmentally responsible way, and a conversation with Anthony Ingraffea and Adam Briggle on fracking policies in New York and Texas.

A new partnership between ND Energy and EDF Energy provided a full day with multiple opportunities for students and faculty to interact with energy professionals. EDF held its annual gathering at the Conference Center on October 3, providing an "Energy Corridor" with booths of information on a variety of career possibilities. Students were invited to attend presentations and network with EDF representatives and other entities over lunch. Many students who participated said they benefited greatly from the opportunity to have one-on-one conversations with people who are already working in the utility and supply side of energy.

Other events included the traditional favorite, tours of Notre Dame's power plant. New this year was a tour of the LEED features of the Jenkins and Nanovic Halls, home to the new Keough School of Global Affairs. A documentary, co-sponsored with the Center for Social Concerns, *From the Ashes*, examined the history and future of coal from many points of view. A special Mass in honor of the Feast of St. Francis was organized by the Sustainability Minor and Campus Ministry. Members of the Student Energy Board provided energy-related trivia questions and prizes for Legend's weekly Trivia Night. The week was capped off by the Sustainability Festival, co-sponsored with the student group GreeND. ND Energy's famous smoothie bike attracted a crowd of students interested in using pedal power to create a cool drink.

SOLAR SERIES

In response to a student survey where over 90% of the respondents said they were interested in learning more about solar energy, ND Energy hosted a 4-part series, starting on October 4 with a panel discussion during the 2016 Notre Dame Energy Week. Prof. Randall Ellingson from The University of Toledo, Nicholas Strevel from First Solar, and Joseph Karrasch from American Electric Power, presented “A Solar Panel: Making Solar Power a Reality” and discussed the technological, business, and policy sides of the future of solar power.

Randall Ellingson and Nicholas Strevel

Next was “Got Married, Bought Solar: Which Was the Bad Decision?”. On November 14, George S. Howard, PhD, professor emeritus in Notre Dame’s Department of Psychology, explored the complexities of convincing ourselves to invest in solar as individuals and as a society.

On February 8, Dr. Subhash L. Shinde, ND Energy Associate Director, presented “Concentrating Solar Power”. Dr. Shinde shared the knowledge he gained working at Sandia National Laboratories and addressed the different CSP technologies and plants currently operating in the U.S., highlighting the research and development activities to increase efficiency and reduce cost and risk.

The fourth and final of ND Energy's solar series was held on March 22 with Dr. Prashant Kamat, Rev. John A Zahm Professor of Science in the Department of Chemistry and Biochemistry, Radiation Laboratory, and Concurrent Professor in the Department of Chemical and Biomolecular Engineering, discussing the next generation of photovoltaics and his research in nanostructure architectures for energy conversion and environmental remediation.

George Howard

Subhash Shinde

Prashant Kamat

LARGE CENTER PROPOSAL PANEL DISCUSSION

A panel discussion was held in April with Notre Dame faculty who had won large-center grants and were eager to share their experiences with other faculty and researchers who were just as eager to learn about the submission process, administering large-center funds, and managing large-center research goals and objectives. Moderated by Subhash L. Shinde, ND Energy Associate Director, panelists were:

- Dr. Paul Bohn, former co-PI on the NSF Science & Technology Center (STC) – The Center of Advanced Materials for Purification of Water with Systems (The Water CAMPWS) with lead organization University of Illinois Urbana-Champaign (Class of 2002).
- Dr. Peter C. Burns, lead PI on the DOE Energy Frontier Research Center (EFRC) – Materials Science of Actinides (MSA) — established in 2009 and renewed in 2014.
- Dr. William Schneider, co-PI on an NSF Engineering Research Center (ERC) – Center for Innovative and Strategic Transformation of Alkane Resources (CISTAR) with lead organization Purdue University — established in 2017.

COLLABORATING WITH NATIONAL LABORATORIES

On June 29, Dr. Michael Valley, senior manager of the Materials Science R&D Group at **Sandia National Laboratories** presented a talk titled “Sandia Materials Science Overview and Research Interests”. Dr. Valley discussed Sandia’s Materials Science Research Foundation (MSRF) that promotes expertise across a broad spectrum of materials and encourages collaborations with academia to conduct revolutionary research. MSRF is structured around four discipline areas: Structural (ductile, brittle) Materials, Soft (organic and biological) Materials, Electronic and Optical Materials, and Material Surfaces and Interfaces. He also presented a general overview of Sandia and its research portfolio, as well as the research objectives of the MSRF disciplines, including key enablers such as computational materials and data analytics, materials characterization and diagnostics, and advanced/additive manufacturing. He concluded by sharing sample research programs in energy technologies and DOE Office of Science (BES, OE, EERE, AMO, etc.) sponsored research, and spent additional time answering specific questions from faculty and students expressing interest in partnering with Sandia.

On October 24, Dr. Brian Stephenson presented “Research Directions and Opportunities at Argonne National Laboratory”. Argonne is the U.S. Department of Energy's multi-purpose science laboratory in the Midwest with divisions spanning the full range of physical, biological, and computer science and technology, as well as major user facilities. Dr. Stephenson presented an overview of Argonne, focusing on activities in materials science, chemistry, and x-ray science, and outlined opportunities for engagement between Argonne and the faculty, students, and leadership at Notre Dame.

In addition, Dr. Carol Thompson from Northern Illinois University presented “Coherent X-ray Scattering Studies of Dynamic Crystal Surfaces". She described the new developments in x-ray studies and the Argonne-NIU collaboration, which is exploring how coherent x-ray studies can be applied to studies of crystal growth. Dr. Thompson’s work is supported by the U.S. Department of Energy, Office of Science, Basic Energy Sciences, Division of Materials Sciences and Engineering.

Partnerships

Developing strong relationships are essential to advancing energy research and educating students and community members about the most critical energy topics and issues facing the world today.

The success of ND Energy can be measured easily by the number of programs and publications it has and the amount of proposals and awards it receives. Yet, the most important metric contributing to its success can be difficult to measure, which is the “people” associated with these activities. These are the groups and individuals who help shape our mission and fulfill our goals. Over the years, ND Energy has built a strong community of supporters, advocates, and contributors who partner with us on every front. You will meet many of these experts in the coming pages. However, there are those who step in and out of our organization leaving an indelible effect on the success of our mission that are not captured here.

MEET THE LEADERSHIP TEAM

A CORE GROUP OF FACULTY AND STAFF WHO DIRECT THE OPERATIONS OF ND ENERGY AND SUPPORT THE STRATEGIC RESEARCH INITIATVES AND OTHER SCHOLARLY ADVANCEMENTS OF RESEARCHERS AND EDUCATORS INTERESTED IN ENERGY

Dr. Peter C. Burns
Director

Dr. Subhash L. Shinde
Associate Director

Dr. Ginger E. Sigmon
Managing Director

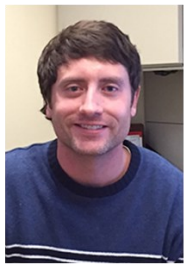
Dr. Abigail Mechtenberg
International Sustainable Development Researcher

Dr. Ian V. Lightcap
Research & Facilities Program Director

Dr. Ian Steele
Microprobe Laboratory Program Manager

Barbara A. Villarosa
Business & Communications Program Director

Anne Berges Pillai
Education & Outreach Associate Program Director



Koby G. Keck
Administrative Coordinator

A BIT MORE ABOUT OUR NEWEST TEAM MEMBERS …

Abigail Mechtenberg

Abigail Mechtenberg joined ND Energy in July 2017. As the International Sustainable Development Researcher for ND Energy, she will continue to develop her research program in Uganda in partnership with Ugandan stakeholders and will also lead and actively participate in other international activities that support the University's mission and Catholic identity, as well as ND Energy's vision to create a more sustainable energy future for all. This new appointment supports ND Energy's goal to have a stronger presence internationally in both research and other scholarly engagements. Abigail is also an ND Energy affiliated faculty member and an Assistant Teaching Professor and Physics Laboratory Coordinator for the Department of Physics. For more information, visit Abigail's research lab: Energy and Sustainable Development with Design (ESDD).

Ian Steele

Ian Steele joined the University of Notre Dame in 2014 working in the Notre Dame Integrated Imaging Facility (NDIIF). Currently he is the program manager of the Electron Microprobe (EMP) in ND Energy's Materials Characterization Facility. In brief, an EMP is an electron beam instrument for the chemical analysis of samples with resolution on the order of one to five microns. The EMP instrument is a Cameca SX-50, which can be used to conduct fundamental research in varied research disciplines, such as securing our nation's energy future as in battery studies; understanding the origin and evolution of Earth, Moon and meteorites; mining and metallurgy; the role of biomineralization in the transport of heavy metals and radionuclides in the environment; nanoscience; understanding human bone degradation; and nuclear forensics analysis. Ian formerly conducted research at the University of Chicago and came to Notre Dame with vast experience and expertise in EMP-related research acquired over the past forty-five years.

Koby Keck

Koby Keck joined ND Energy in November 2017 as the Administrative Coordinator. Prior to joining ND Energy, Koby worked for six years in retail sales as a Merchandiser for Lewis Bakeries. He has also served as the Editor and Publisher of the *New Carlisle Gazette*, a biweekly newspaper publication. An active community member, Koby was instrumental in the creation and development of the nonprofit organization New Carlisle Hometown Days, Inc. Through his volunteer work with Hometown Days, he has over ten years of experience coordinating and executing events. Koby received his Bachelor of Arts in Political Science from the University of Notre Dame in 2011. He is currently responsible for procuring laboratory supplies and equipment, preparing financial transactions, coordinating event logistics, creating promotional materials, maintaining web and social media content, and gathering data for annual reports and metrics.

MEET THE AFFILIATED FACULTY

REPRESENTING ALL COLLEGES AND SCHOOLS AND CREATING AN ENVIRONMENT CONDUCIVE TO ADVANCING MULTI-DISCIPLINARY, INNOVATIVE RESEARCH AND SCHOLARLY INITIATIVES TOWARD NEW DISCOVERIES AND TECHNOLOGIES THAT CONTRIBUTE TO ACHIEVING SUSTAINABLE ENERGY SOLUTIONS

Working closely with affiliated faculty is an integral function of ND Energy and ensures that faculty have the resources they need to create new technologies and scientific advancements in energy production and use. This also allows ND Energy to facilitate other scholarly initiatives in ways to further their research objectives and pedagogy in energy. ND Energy welcomed nine new faculty members this year, raising the total from 71 to 80.

80 Faculty

12 Departments

5 Colleges/Schools

A BIT MORE ABOUT OUR NEWEST FACULTY MEMBERS …

Stefano Castruccio

Assistant Professor, Applied and Computational Mathematics and Statistics

Interests: Energy Conversion and Efficiency

Paola Crippa

Melchor Assistant Professor, Civil & Environmental Engineering & Earth Sciences

Interests: Energy Conversion and Efficiency, Transformative Wind

Suman Datta

Chang Family Professor, Electrical Engineering

Interests: Energy Conversion and Efficiency, Smart Distribution and Storage

ND ENERGY RESEARCHERS MAKE NEW DISCOVERIES, SCIENTIFIC ADVANCEMENTS, AND TECHNOLOGICAL BREAKTHROUGHS THAT EMPOWER STUDENTS AND FACULTY TO INNOVATE, EDUCATE, AND INFLUENCE THE WORLD TOWARD A MORE SUSTAINABLE ENERGY FUTURE.

A BIT MORE ABOUT OUR NEWEST FACULTY MEMBERS …

Alexander Dowling

Assistant Professor, Chemical and Biomolecular Engineering

Interests: Energy Conversion and Efficiency, Smart Distribution and Storage, Sustainable Bio/Fossil Fuels, Transformative Solar

Rosemary Kelanic

Assistant Professor, Political Science

Interests: Energy Politics

Scott Morris

Professor, Aerospace and Mechanical Engineering

Interests: Energy Conversion and Efficiency, Smart Distribution and Storage

Casey O'Brien

Assistant Professor, Chemical and Biomolecular Engineering

Interests: Energy Conversion and Efficiency, Sustainable Bio/Fossil Fuels

Emily Tsui

Assistant Professor, Chemistry and Biochemistry

Interests: Energy Conversion and Efficiency, Sustainable Bio/ Fossil Fuels

Yanliang Zhang

Assistant Professor, Aerospace and Mechanical Engineering

Interests: Energy Conversion and Efficiency, Sustainable and Secure Nuclear, Transformative Solar

MEET THE STUDENT ENERGY BOARD

A DIVERSE STUDENT GROUP WHO UNDERSTANDS THE IMPORTANCE OF RAISING AWARENESS AND INCREASING KNOWLEDGE OF KEY ENERGY ISSUES AND TOPICS AND WHO WORKS TO PROVIDE ENERGY-RELATED EDUCATON AND OUTREACH PROGRAMS THROUGHOUT NOTRE DAME AND THE SURROUNDING COMMUNITY

There are students at Notre Dame who would like to enroll in the Energy Studies minor but are unable to due to their current class schedules. Engineers in particular have a heavy course load with little room for courses outside of their requirements. In order to serve this group, the Student Energy Board (SEB) has expanded beyond the traditional advisory capacity to include more opportunities in education and outreach for students. This year's board is comprised of 16 "core" leaders plus 33 additional members who participate as they are able. Every college and class is represented.

In addition to its traditional role in planning and implementing Energy Week, this year the SEB provided judges for the Northern Indiana Regional Science and Engineering Fair, developed energy-related lesson plans for use with K-12 students, taught energy transformation in a local fourth grade classroom, and volunteered at Science Alive! in downtown South Bend and at the Undergraduate Sustainability Research & Education Expo on campus. A committee helped with the organization and implementation of What's It Really Like? in February, ensuring that participants knew where and when to attend nine different discussions on careers in energy. The newest initiative has been a discussion group that meets to discuss various current energy topics, including a recent "documentary watch."

Below are the members of the 2017 Core Leadership Board:

Alex Baumann, '19, Business
Emily Black, '20, Engineering
Justin Blake, '19, Engineering
Matthew Chamberlain, '19, Engineering
Marion Delaney, '19, Engineering
Allie Hidalgo, '19, Business
John Higham, 18, Engineering
Christopher Hume, '18, Engineering
Patricia Kay, '17, Engineering
MacKenna Kelleher, '18, Business
Erika Kim, '20, Engineering
Ellen Londergan, '18, Engineering
Stephen Muldoon, '18, Business
Natalie Rivas, '20, Engineering
Tansy Wang, '19, Engineering
Kevin Weaver, 18, Engineering
Yilong Yang, '18, Arts and Letters, Science

MEET THE SUSTAINABLE ENERGY NETWORK

COMPRISED OF MEMBERS FROM THE NOTRE DAME COMMUNITY WHO HAVE COMMON INTERESTS IN SUSTAINABLE ENERGY ISSUES AND TOPICS AND PROVIDE A MEANS FOR IMPORTANT INFORMATION SHARING AND COLLABORATIONS

The Sustainable Energy Network consists of departments and organizations across campus who have common interests in sustainable energy issues and topics. The goal of the network is to provide an avenue for important information sharing and collaborations with a strong focus on combining resources to strengthen University-sponsored initiatives and events and create a greater impact on local, regional, national, and international relationships. The network broadens as the University continues to demonstrate its interest in the growing concerns about energy, the environment, and related health and policy issues. Currently, members of the network include representatives from each of the departments and organizations listed below.

Center for Ethics and Culture
Center for Social Concerns
Center for Theology, Science, and Human Flourishing
College of Arts & Letters
College of Engineering
College of Science
Committee on Sustainability
Department of Chemical and Biomolecular Engineering
Department of Chemistry and Biochemistry
Department of Physics
Energy Engineering Minor
Energy Studies Minor
Environmental Change Initiative
Facilities Design and Operations–Utilities
Flatley Center for Undergraduate Scholarly Engagement
GLOBES
GreeND
IDEA Center and Innovation Park
Initiative for Global Development
Initiative for Global Development
Institute for Advanced Study
Institute for Flow Physics and Control
Kellogg Institute
Kroc Institute
LEAST
Mendoza College of Business
Minor in Sustainability
ND Research
ND Nano
Office of Sustainability
Radiation Laboratory
Reilly Center for Science, Technology and Values
School of Architecture
Student Energy Board
Student Government
Sustainability and Resiliency Minor

MEET THE ALUMNI ENERGY BOARD

COMPRISED OF NOTRE DAME ALUMNI WHO ARE LEADERS IN THE ENERGY FIELD OR HAVE INTERESTS IN ENERGY AND PROVIDE ADVICE AND COUNSEL ON THE STRATEGIC GROWTH AND FINANCIAL DIRECTION OF ND ENERGY

The annual Alumni Energy Board meeting was held September 1 and covered specific topics for thoughtful discussion and feedback by the board. The meeting began with a presentation by Dr. Vijay Gupta, professor of Electrical Engineering, titled "Renewables and the Grid: A Systems Approach". Dr. Gupta discussed his research and the need to develop executable policy prescriptions and market mechanisms for the smooth and efficient transition to a diverse energy production base with large scale integration of renewable energy sources, while ensuring sustained economic growth.

Next, Anne Pillai, ND Energy's associate program director for education and outreach, provided an overview of the Energy Studies Minor and its program requirements. Her talk was followed by undergraduate students in the program sharing their personal experiences. The board expressed gratitude to the students and encouraged the continuation of the minor as a means for ensuring a talented and well-prepared workforce in energy.

Last up was an overview of the Materials Characterization Facility by Dr. Ian Lightcap, ND Energy's program director for research and facilities, who emphasized the desire to increase opportunities for industry without access to characterization capabilities. The board cautioned against this type of activity due to the demands placed on the University for consultation time, effort, and cost.

Anthony F. Earley, Jr.
Pacific Gas and Electric Co.

John M. Kelly, Jr.
Vanguard Oil and Gas

Robert N. Schleckser
ExxonMobil Corporation

Edward B. Fitzpatrick, Jr.
P.E. Consulting

Michael A. O'Sullivan
NextEra Energy Resources

Richard L. Stanley
GE Energy

MEET THE TECHNICAL ENERGY BOARD

COMPRISED OF FACULTY MEMBERS FROM MAJOR UNIVERSITIES AND RESEARCH SCIENTISTS FROM NATIONAL LABORATORIES WHO PROVIDE ADVICE AND COUNSEL ON THE RESEARCH INITIATIVES AND SCHOLARLY ADVANCEMENTS OF ND ENERGY

Members of the Technical Energy Board are external experts who provide advice to ND Energy on current and future research initiatives and other scholarly advancements. Meetings of this group will resume in the near future as additional members are identified.

George W. Crabtree
Argonne National Laboratory

Michael R. Wasielewski
Northwestern University

Impact

Impactful research and other scholarly initiatives influence important discussions and actions toward a more sustainable energy future.

ND Energy facilitates interdisciplinary research in energy-related areas at the University of Notre Dame by providing proposal preparation and award management services to Notre Dame faculty and associated researchers. In cooperation with Notre Dame Research, ND Energy staff are available to consult with faculty and associated researchers at every stage of the proposal and award process.

BUSINESS DEVELOPMENT AND PROPOSAL PREPARATION SERVICES

- Identify RFPs relevant to faculty expertise, brainstorm new ideas, and identify internal and external collaborations.
- Coordinate proposal development activities – create checklist and timeline, organize meetings, and gather information.
- Write, review, and edit technical and non-technical sections of the proposal in accordance with the FOA guidelines.
- Gather supporting materials and documents, and prepare budget and sponsor forms as needed.
- Provide letters of support from ND Energy for core research facilities, broader impacts, and other related services.

EDUCATION AND OUTREACH DEVELOPMENT SERVICES

- Consult with faculty to assess outreach needs and opportunities within research scope and make connections with existing programs.
- Develop new education and outreach programs to address specific requirements of the “broader impacts” of the research proposal.
- Write or provide descriptions of outreach opportunities for the “broader impacts” section of the proposal.
- Communicate, promote, and help execute existing and new education and outreach programs.
- Maintain a list of faculty interested in various outreach events to best match faculty interests to outreach opportunities.

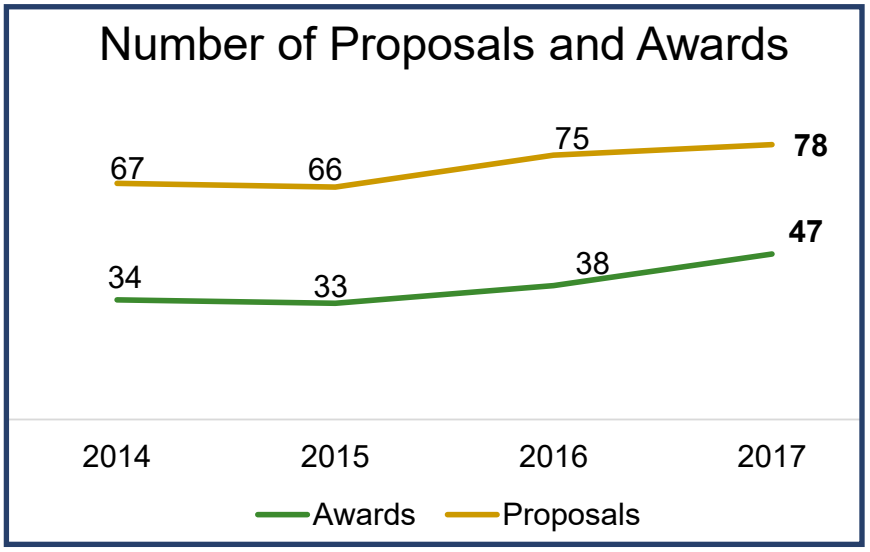
BUDGET MANAGEMENT AND FINANCIAL COORDINATION SERVICES

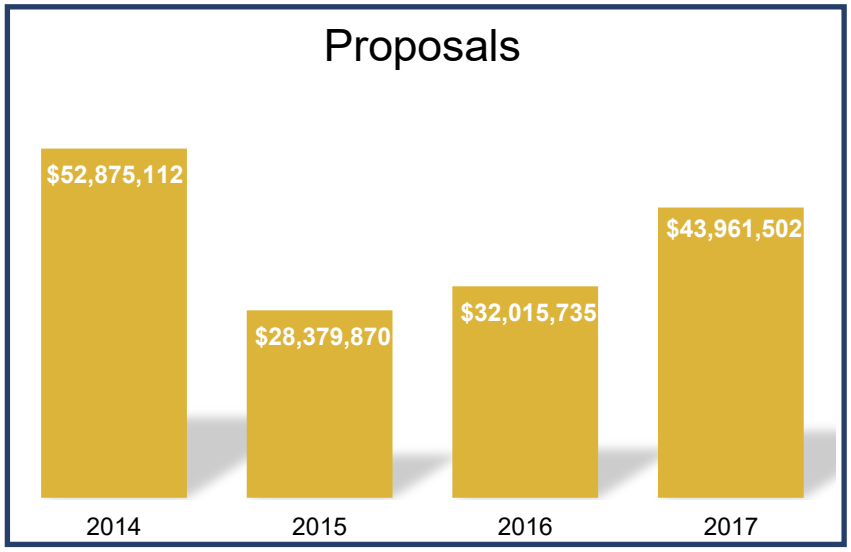
- Manage all aspects of the grant budget, interfacing with Notre Dame Research and Sponsored Programs Accounting.
- Coordinate the hiring of researchers on the project with appropriate department personnel.
- Organize and coordinate group meetings to assess progress on the project.
- Assist with quarterly progress reports and production.
- Consult with PIs on monthly budget reports and areas requiring attention.

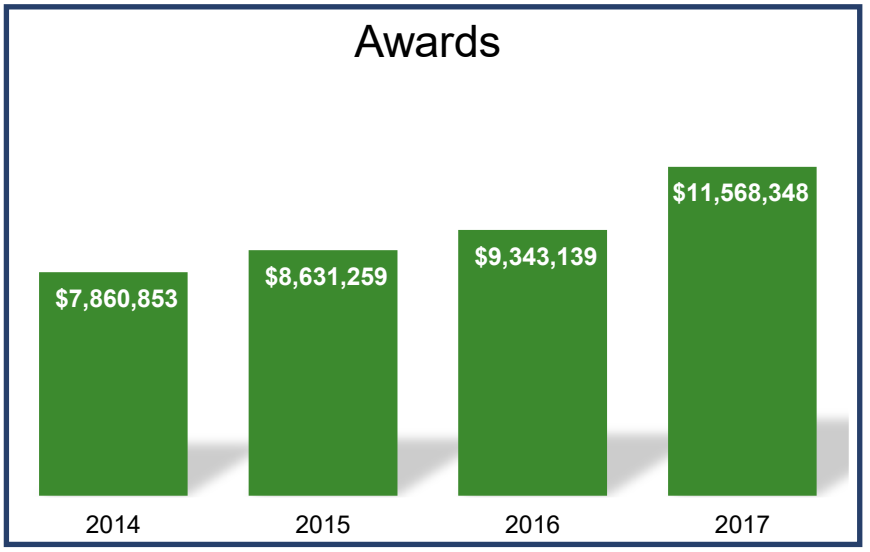
PROPOSALS AND AWARDS IN ENERGY

ND Energy provides support for proposal preparation and award management to enable and advance energy-related research at Notre Dame. This includes conducting brainstorming sessions to develop new ideas, recruiting internal and external collaborators, providing feedback on technical and non-technical sections, and providing administrative support to meet project objectives and other award requirements.

The charts shown here highlight the proposals submitted and awards received from CY2014 through CY2017, demonstrating a steady increase in both areas over the years. Most notable is the 24% increase in the number of awards from 2016 to 2017.



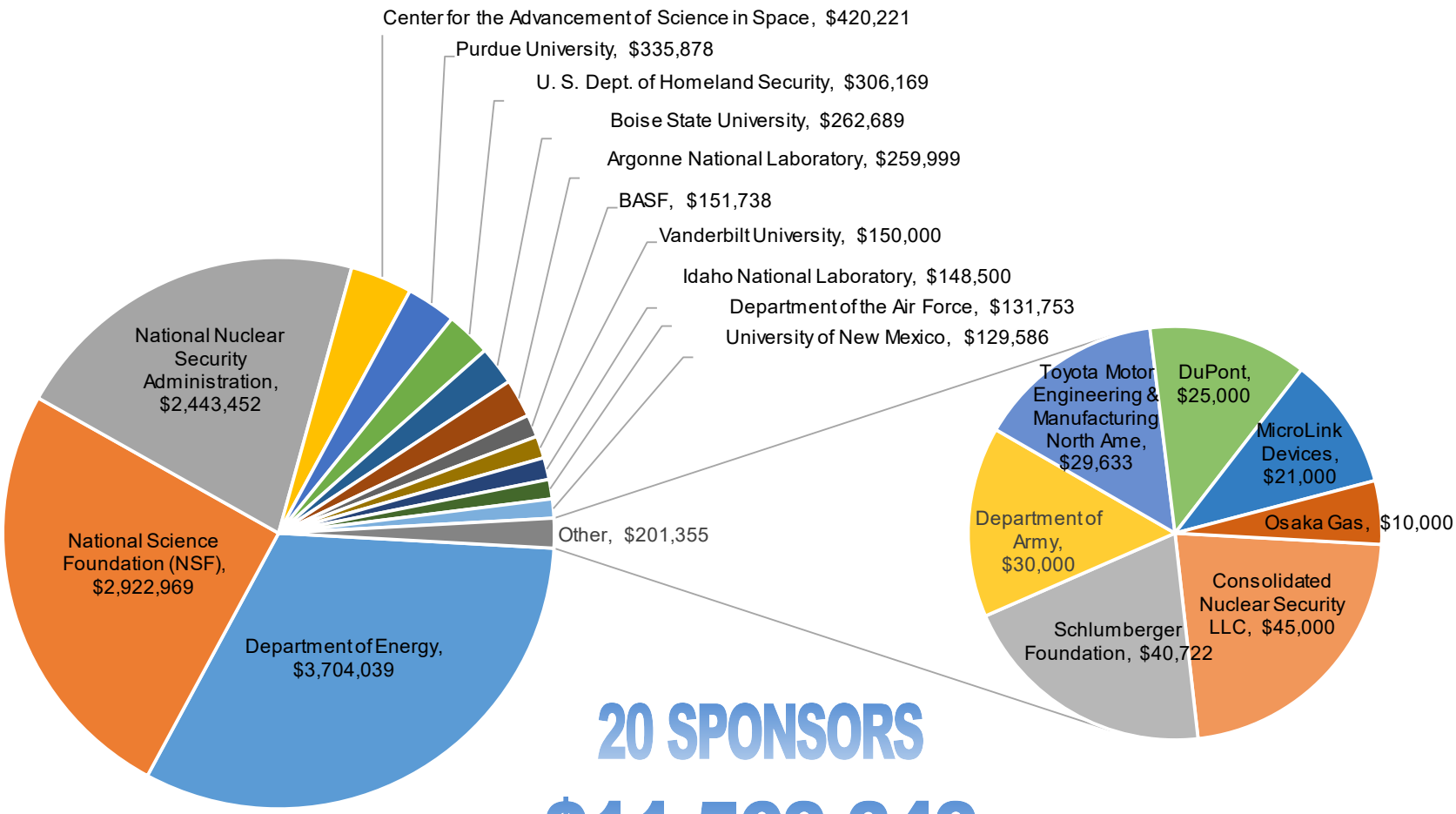




2014 includes the $20M proposal to the U.S. Department of Energy for the renewal of the Energy Frontier Research Center—Materials Science of Actinides.

TOTAL AWARDS BY SPONSOR—CY2017

During 2017, energy-related awards were funded by twenty different agencies, totaling $11.5M. The charts below show each of the sponsors and the total amounts awarded for the year. As shown, the most funding came from the U.S. Department of Energy, the National Science Foundation, and the National Nuclear Security Administration.

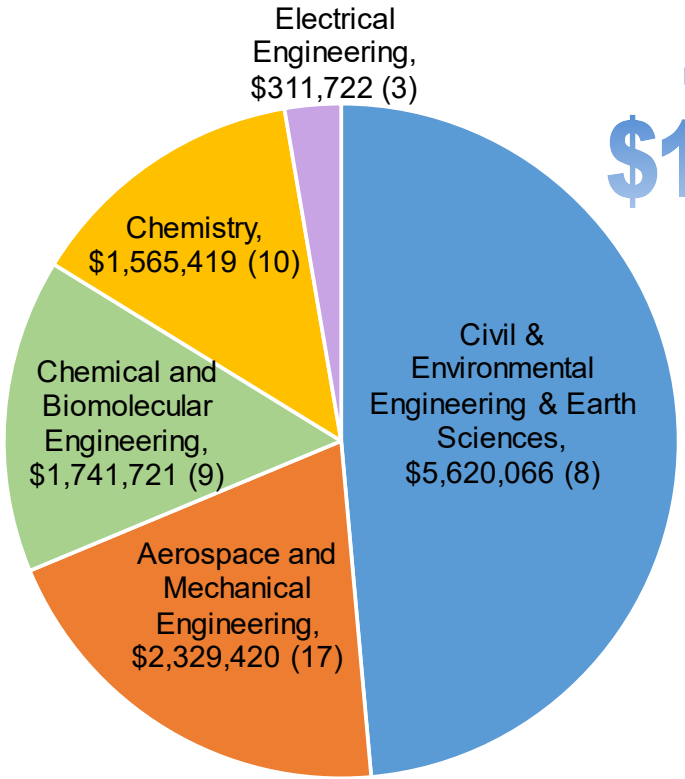


20 SPONSORS

$11,568,348

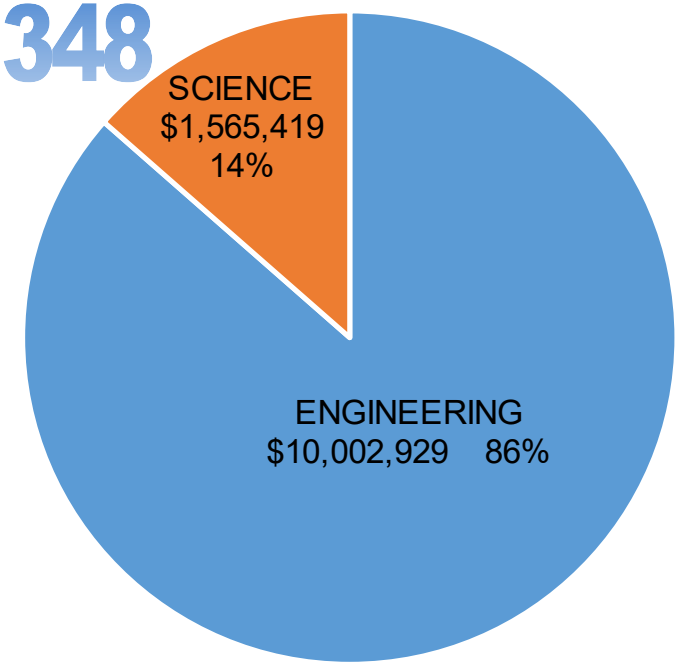
AWARDS BY DEPARTMENT—CY2017

During 2017, 47 awards were made in energy-related research, totaling $11.5M. The charts below show the award amounts by department and by college. As shown, the College of Engineering received 37 awards and 86% of the total funding, while the College of Science received 10 awards and 14% of the funding.



Total Award Amounts and Number by Department

47 AWARDS
$11,568,348

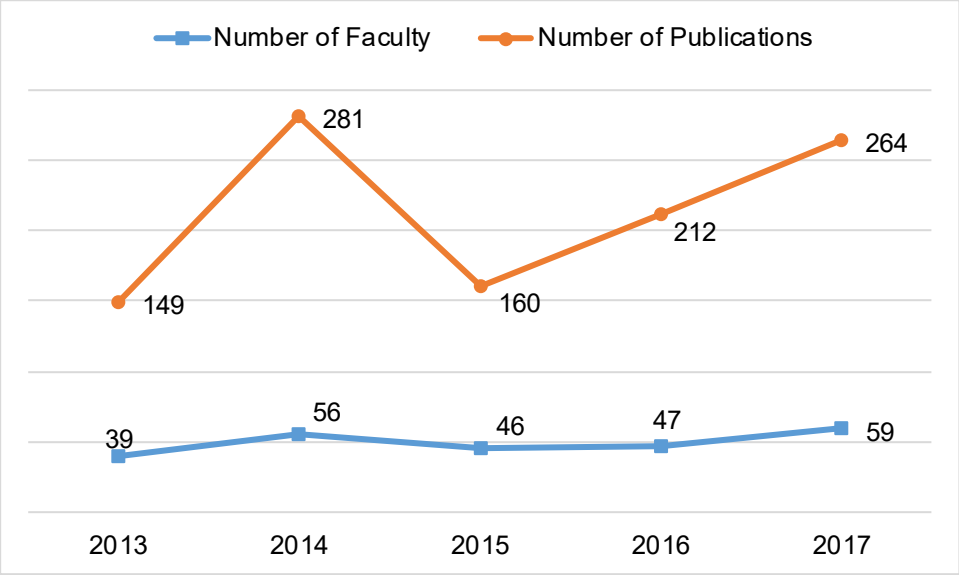


Total Award Amounts and Percentage by College

ENERGY-RELATED PUBLICATIONS

A key metric for ND Energy is the number of energy-related publications. The chart below shows the number of publications for each year from 2014 to 2017. In 2017, there were a total of 264 publications from 59 affiliated faculty. The top ten faculty having the most energy-related publications in 2017 are listed in the adjacent table.

CY2017 **264** **PUBLICATIONS**



This chart shows the total number of affiliated faculty with energy-related publications and the total number of publications by year.

TOP TEN FACULTY WITH THE MOST NUMBER OF ENERGY-RELATED PUBLICATIONS IN 2017

Faculty	Department	Number of Publications
Peter Burns	Civil & Environmental Engineering & Earth Sciences	28
Suman Datta	Electrical Engineering	17
Prashant Kamat	Chemistry and Biochemistry	12
John LoSecco	Physics	12
Tengfei Luo	Aerospace and Mechanical Engineering	12
William Schneider	Chemical and Biomolecular Engineering	10
Ani Aprahamian	Physics	9
Masaru Kuno	Chemistry and Biochemistry	9
Grant Mathews	Physics	9
Ruilan Guo	Chemical and Biomolecular Engineering	8

MATERIALS CHARACTERIZATION FACILITY

MCF USERS

The MCF has 240 users from various departments and centers/institutes across campus. Another key indicator is the number of principal investigators (PIs) with group members using facility resources. The chart shown here identifies the total number of PIs by department/center since the MCF opened in 2012. The number of PIs in 2017 totals 62, a similar number to the previous year.

240 USERS **62 PIs**

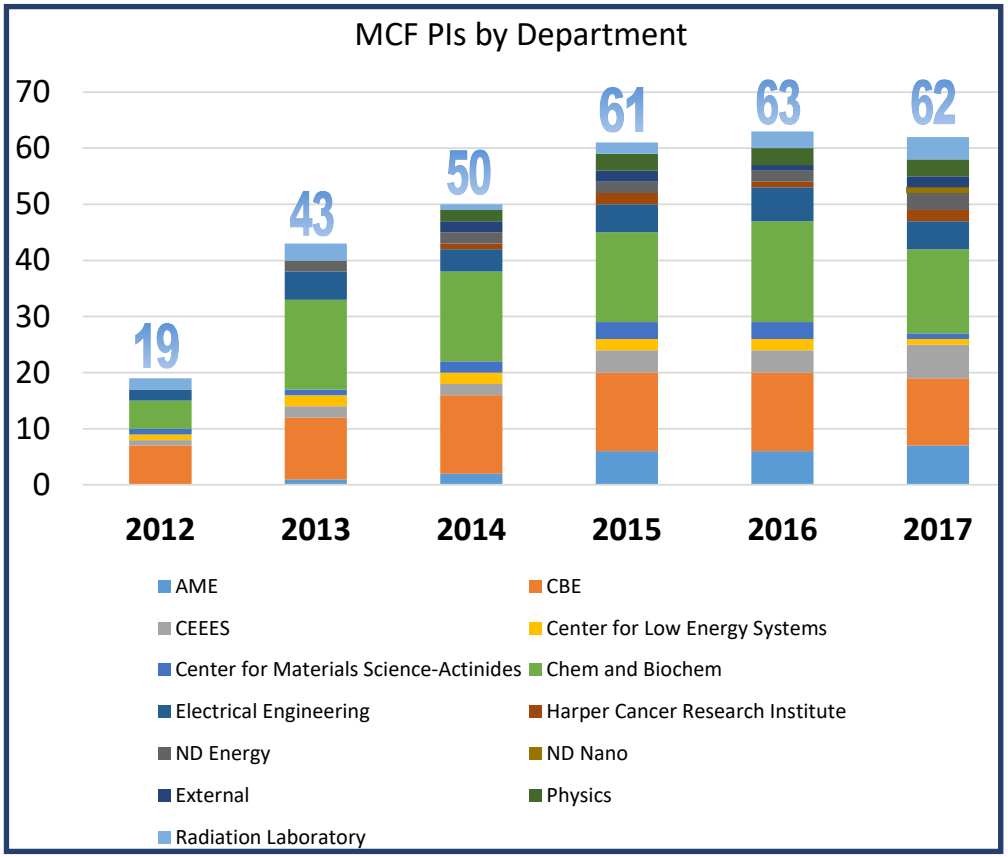
MCF PUBLICATIONS

Publications are another key indicator for the MCF. Data from MCF instruments were used in an estimated 219 publications from 2012 to 2017. PIs reported an estimated total of 47 publications referencing data from the MCF in 2017.

219 PUBLICATIONS 2012-2017

47 PUBLICATIONS IN 2017

PRINCIPLE INVESTIGATORS



MCF AFFILIATIONS

The MCF is one of 30 core facilities at Notre Dame. In 2017, the number of affiliated proposals and awards for all core facilities totaled 543 and 130, respectively. Of these totals, 30 proposals and 7 awards were affiliated with the MCF, representing 6% of the overall proposals and 5% of overall awards.

30 PROPOSALS 6% of total

7 AWARDS 5% of total

CAMPUS AND COMMUNITY OUTREACH

LABORATORATIES REPRESENTED

There were 6 major outreach activities in 2017 involving 35 research groups from the Colleges of Engineering and Science and the School of Architecture. Of these groups, there were 24 different laboratories represented, each with multiple group members engaging campus and community participants in information about energy-related research at Notre Dame.

EVENTS

Mishawaka High School Internship
(4 groups)

Science Alive!
(10 groups)

Art2Science Summer Camp
(5 groups)

Alumni Association Leadership Conference
(4 groups)

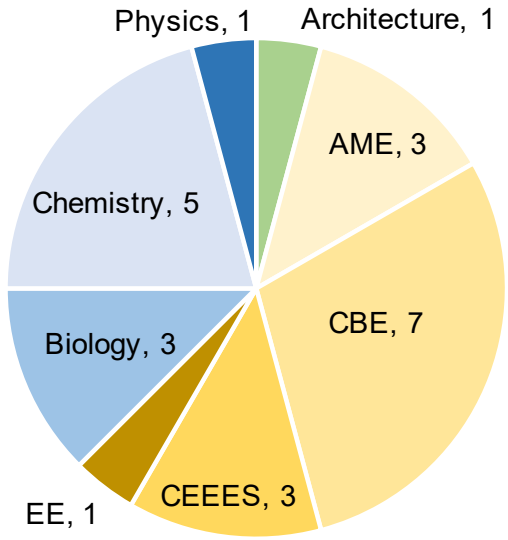
Junior Parents Weekend
(1 group)

Undergraduate Sustainability Research and Education Expo
(11 groups)

RESEARCH GROUPS

Belovsky, Biology
Buccellato, Architecture
Burns, CEEES
Doudrick, CEEES
Fay, EE
Gao, Chemistry
Go, AME
Guo, CBE
Hartland, Chemistry
Hicks, CBE
Hixon, CEEES
Jones, Biology
Kamat, Chemistry
Kuno, Chemistry
Lightcap, Chemistry
Luo, AME
Maginn, CBE
Mechtenberg, Physics
Medvigy, Biology
Neretina, AME
Phillip, CBE
Schaefer, CBE
Schneider, CBE
Whitmer, CBE

NUMBER OF RESEARCH GROUPS BY DEPARTMENT

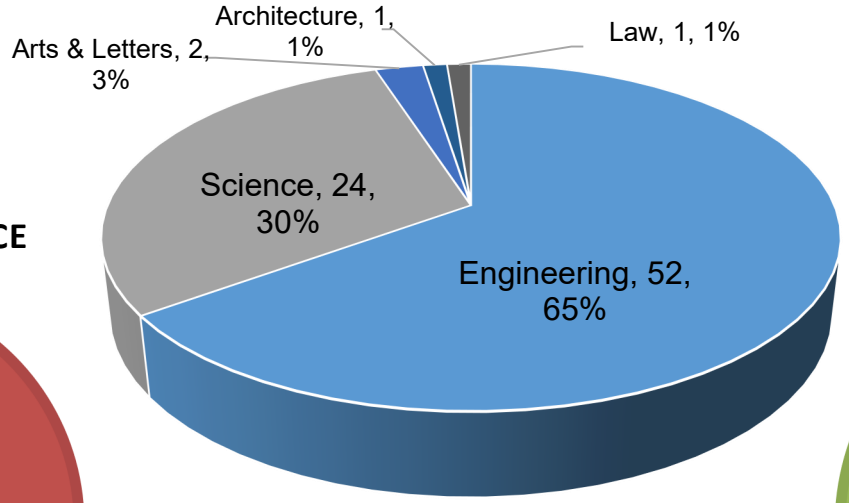


This chart represents the 24 different laboratories by department engaged in the 2017 outreach activities.

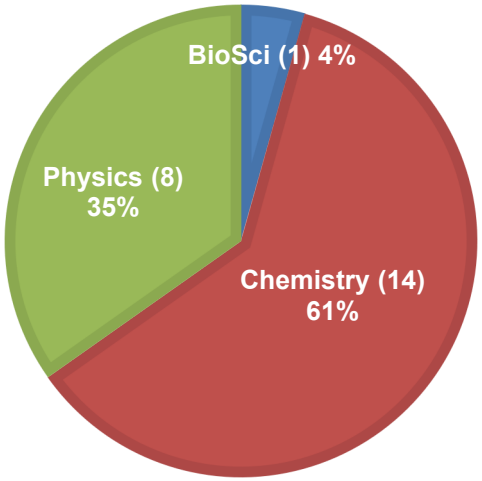
AFFILIATED FACULTY

Faculty are an important group within the ND Energy community. Their contributions in energy-related research and education are key to fulfilling the ND Energy mission. Representing 5 colleges and schools — College of Arts & Letters, College of Engineering, College of Science, Notre Dame Law School, and the School of Architecture — there are 80 faculty within 12 departments that support the mission to create a more sustainable energy future for all. As shown below, the Colleges of Engineering and Science have the highest number of affiliated faculty with most of them from the departments of Chemical and Biomolecular Engineering and Chemistry.

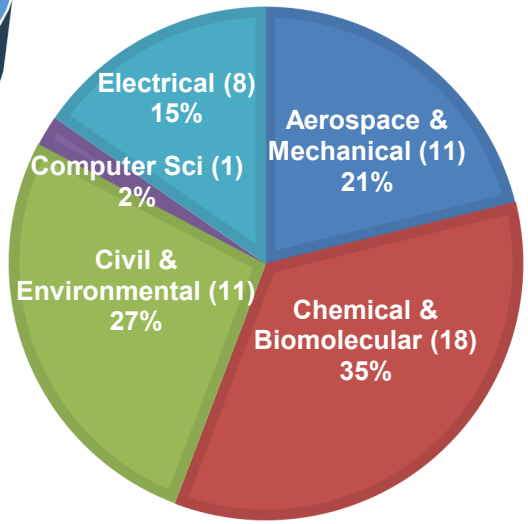
80 Faculty



FACULTY IN SCIENCE



FACULTY IN ENGINEERING



Faculty in Other Departments

1—Economics

1—Political Science

1– Notre Dame Law School

1– School of Architecture

12 Departments
5 Colleges/Schools

FACULTY SEMINARS

ND Energy hosts monthly luncheon seminars for affiliated faculty. These seminars are conducted by faculty to foster cross-disciplinary research collaborations and to facilitate a better understanding of the expertise in energy-related research at Notre Dame. These meetings allow faculty to also discuss current challenges and opportunities in research and seek clarification and advice on best practices to improve and enhance their research capabilities. Below are the seminars that were held in 2017.

2017	Presentation Title	Faculty Presenter
January 19	"Energy-Efficient Wastewater Treatment with the Membrane-Aerated Biofilm Reactor"	Rob Nerenberg, Civil and Environmental Engineering and Earth Sciences
February 22	"Effects of Climate Change on Urban Areas"	Harindra Joe Fernando, Civil and Environmental Engineering and Earth Sciences
March 23	"Micro-Fiber Coating for Drag Reduction - looking for an application to wind turbine"	Hirotaka (Taka) Sakaue, Aerospace and Mechanical Engineering
April 20	"Combustion Synthesis of Nanomaterials for Catalytic and Other Applications"	Alex Mukasyan and Eduardo Wolf, Chemical and Biomolecular Engineering
May 31	"Evaluating the Cost of Electricity due to Deaths at Hospitals with Unreliable Energy Systems"	Abigail Mechtenberg, Physics
August 16	ND Energy Faculty Meeting on International Engagement	Peter C. Burns, ND Energy
September 27	"The Use of Dendritic Polymers with Layered Structures for Mimicking Light-Harvesting Process"	Haifeng Gao, Department of Chemistry and Biochemistry
October 25	"Bridging the Information Gap: WebGIS and remote sensing to support rural electrification in remote regions"	Marc Muller, Department of Civil & Environmental Engineering & Earth Sciences
November 29	"Sensing hydrogen gas from atmospheric pressure to a hundred parts per million"	Svetlana Neretina, Department of Aerospace and Mechanical Engineering

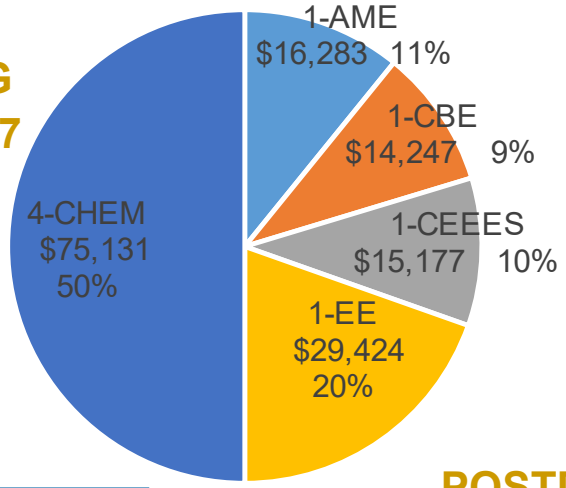
POSTDOC AND GRADUATE STUDENT SEMINARS

ND Energy hosts monthly luncheon seminars for postdoctoral scholars and graduate students associated with ND Energy affiliated faculty. Seminars are presented by postdoctoral scholars and graduate students about their research projects to facilitate cross-disciplinary research collaborations and to gain a better understanding of the energy-related research programs at Notre Dame. Speakers can choose to have their presentations evaluated by the audience through the completion of a rubric designed to provide feedback on the delivery of the project as well as the effectiveness of the data presented. Below are the seminars that were held in 2017.

2017	PD or GS	Affiliated Faculty/Department	Presentation Title
January 18	Peng Gao	Dr. William Phillip, Chemical and Biomolecular Engineering	“Elucidating the Effects of Nanoscale Structure and Chemistry on Water and Salt Transport through Charge Mosaic Membranes"
	Lei Zhang	Dr. Peter Burns, Civil & Environmental Engineering & Earth Sciences	“The First High Temperature Oxide Melt Calorimetry of Transuranic Materials - Np2O5 and NpO2”
March 15	Maksym Zhukovskyi	Dr. Masaru Kuno, Chemistry and Biochemistry	“Single Particle Screening of Photocatalytic Events in 2D Metal Chalcogenide Nanostructures”
	Matt Jerry	Dr. Suman Datta, Electrical Engineering	“Nanoscale Devices for Neural Network Hardware Accelerators”
May 17	Greg Horne	Dr. Jay LaVerne, Physics	"Radiation Chemistry of Transuranics in Nitric Acid”
	Jize Zhang	Dr. Alexandros Taflanidis, Civil & Environmental Engineering & Earth Sciences	“Wave Energy-computations”
September 20	Triet Nguygen-Beck	Dr. John Parkhill, Chemistry and Biochemistry	"Rationalizing the Size-dependent Stoke Shifts in Cesium Lead Bromide Pervoskite Nanocrystals”
	Yaofa Li	Dr. Kenneth Christensen, Aerospace and Mechanical Engineering	“Ensuring Long-term Security of Stored CO_2: Fundamental Studies of the Multiphase Flow of Water and Liquid/supercritical CO_2 in 2D Heterogeneous Porous Micromodels.”
October 18	Randal Marks	Dr. Kyle Doudrick, Civil and Environmental Engineering and Earth Sciences	“Earth Abundant Hydrogenation Catalysts for the Reduction of Nitrite”
	Ashkan Zeinalzadeh	Dr. Vijay Gupta, Electrical Engineering	“Electricity Market and Renewable Energies”
November 15	Joseph Aboki	Dr. Ruilan Guo, Chemical and Biomolecular Engineering	“Highly Proton-conductive Tritypcene-containing Polyelectrolyte Membranes (PEMs) with Supermolecularly Suppressed Water Swelling”
	Yingyin Chen	Dr. Na Wei, Civil & Environmental Engineering & Earth Sciences	“Engineering Robust Yeast for Enhanced Biofuel Production from Renewable Lignocellulosic Biomass”

POSTDOCTORAL FELLOWSHIPS

POSTDOCTORAL FUNDING BY DEPARTMENT FOR 2017

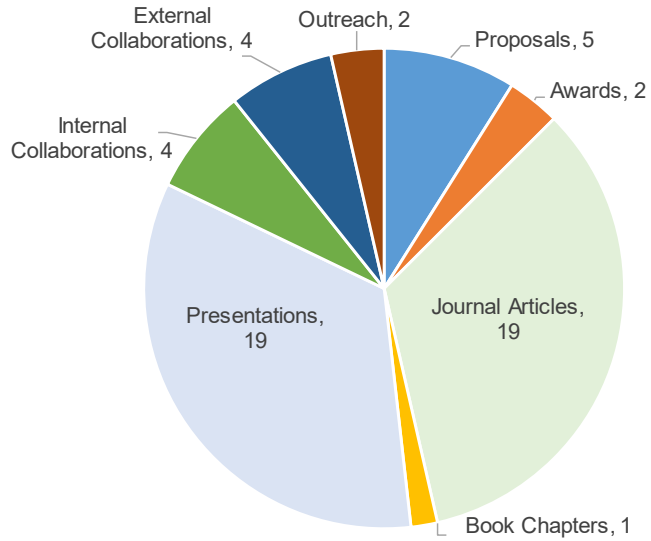


8 Active Awards

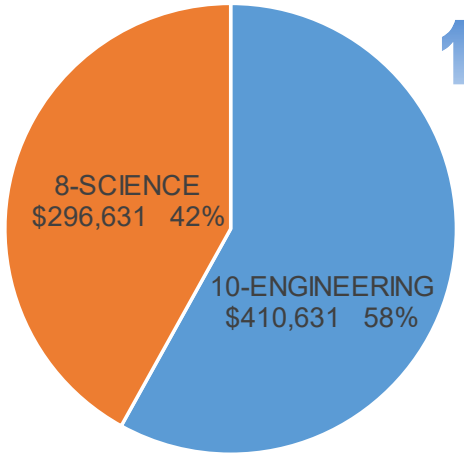
$150,261

$12,998 to Core Facilities

CY2017 Output



POSTDOCTORAL FUNDING BY COLLEGE FOR 2014—2017



18 Awards

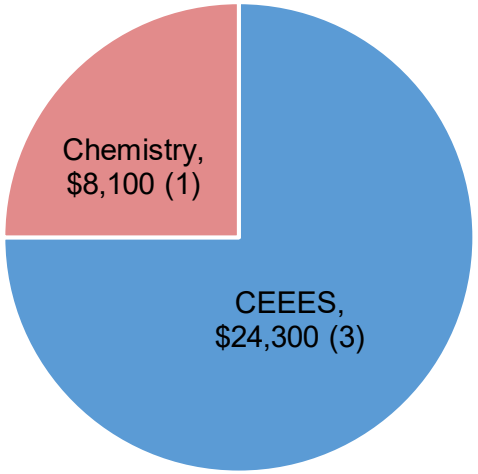
SCIENCE	
1	BIO
6	CHEM
1	PHY
ENGINEERING	
4	AME
2	CBE
2	CEEES
2	EE

$707,262

GRADUATE FELLOWSHIPS

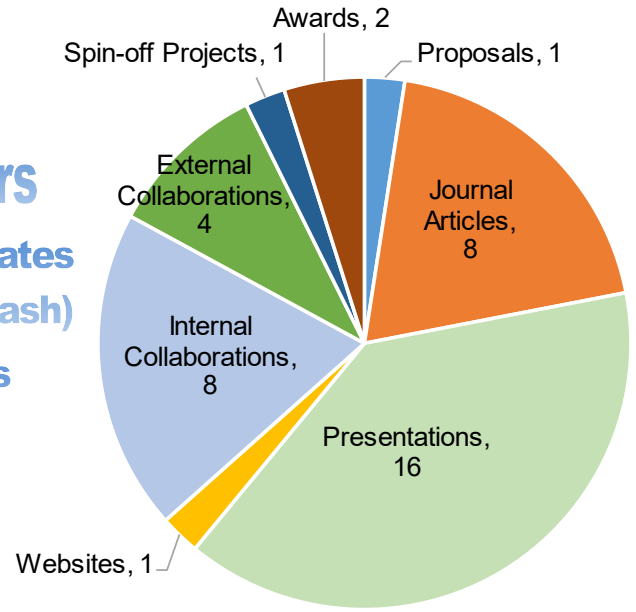
EILERS FUNDING BY DEPARTMENT FOR 2017

4 Awards
$32,400

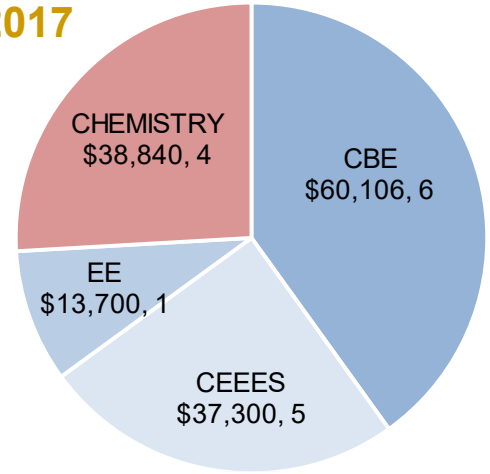


CY2017 Output

17 Scholars
13 Undergraduates (Slatt and Forgash)
4 Graduates (Eilers)

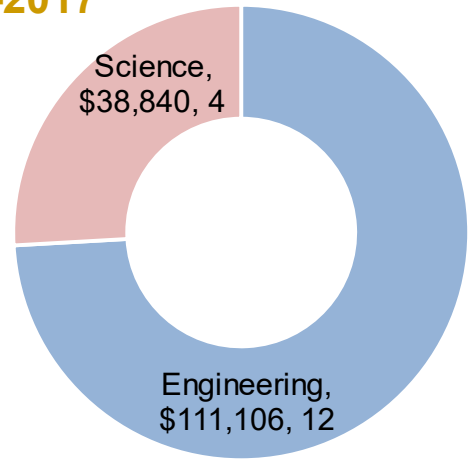


EILERS FUNDING BY DEPARTMENT 2012—2017



2012-2017
16 Awards
$149,946

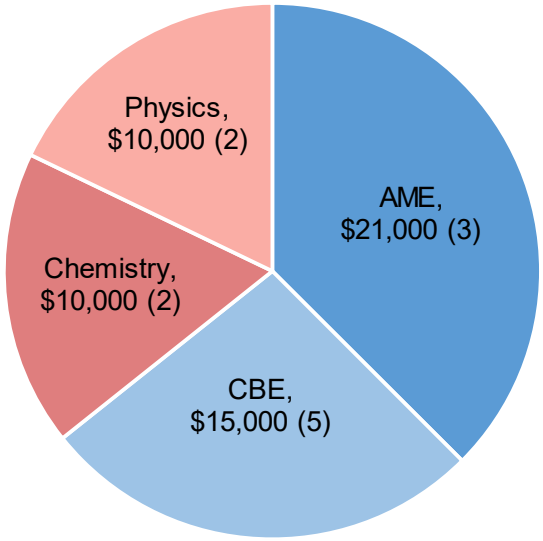
EILERS FUNDING BY COLLEGE 2012—2017



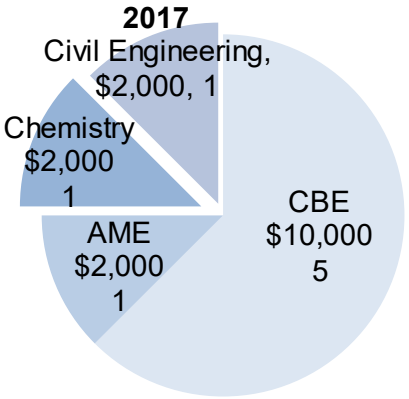
UNDERGRADUATE FELLOWSHIPS

SLATT FUNDING BY DEPARTMENT FOR 2017

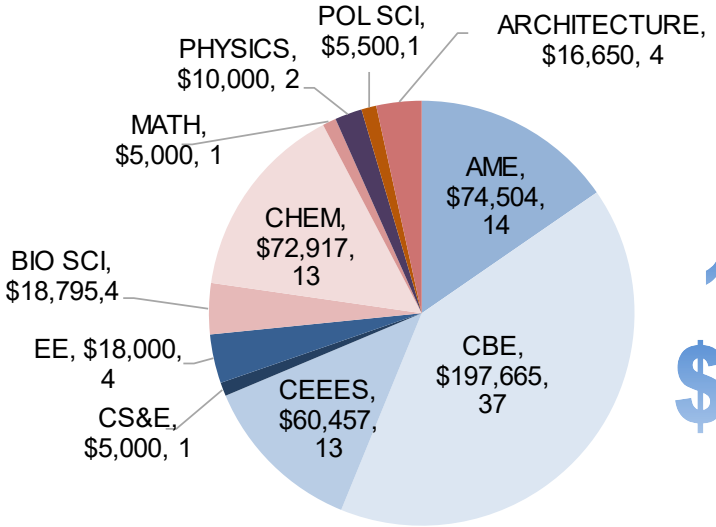
12 Awards
$56,000



FORGASH FUNDING BY DEPARTMENT 2009—2017

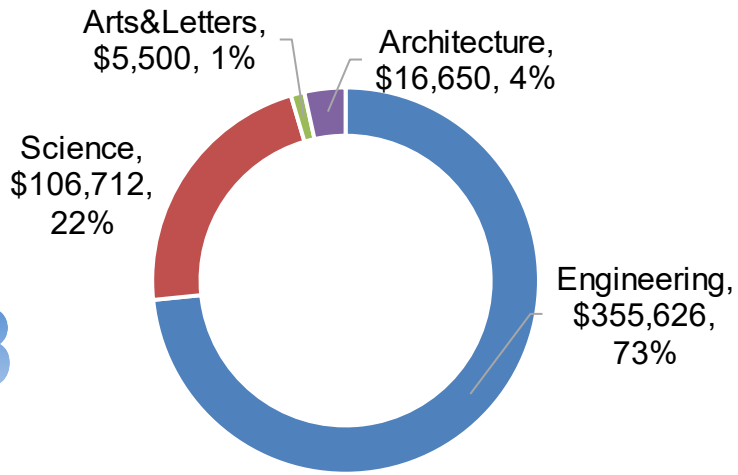


SLATT FUNDING BY DEPARTMENT 2006—2017



2006-2017
107 Awards
$484,488

SLATT FUNDING BY COLLEGE 2006—2017



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