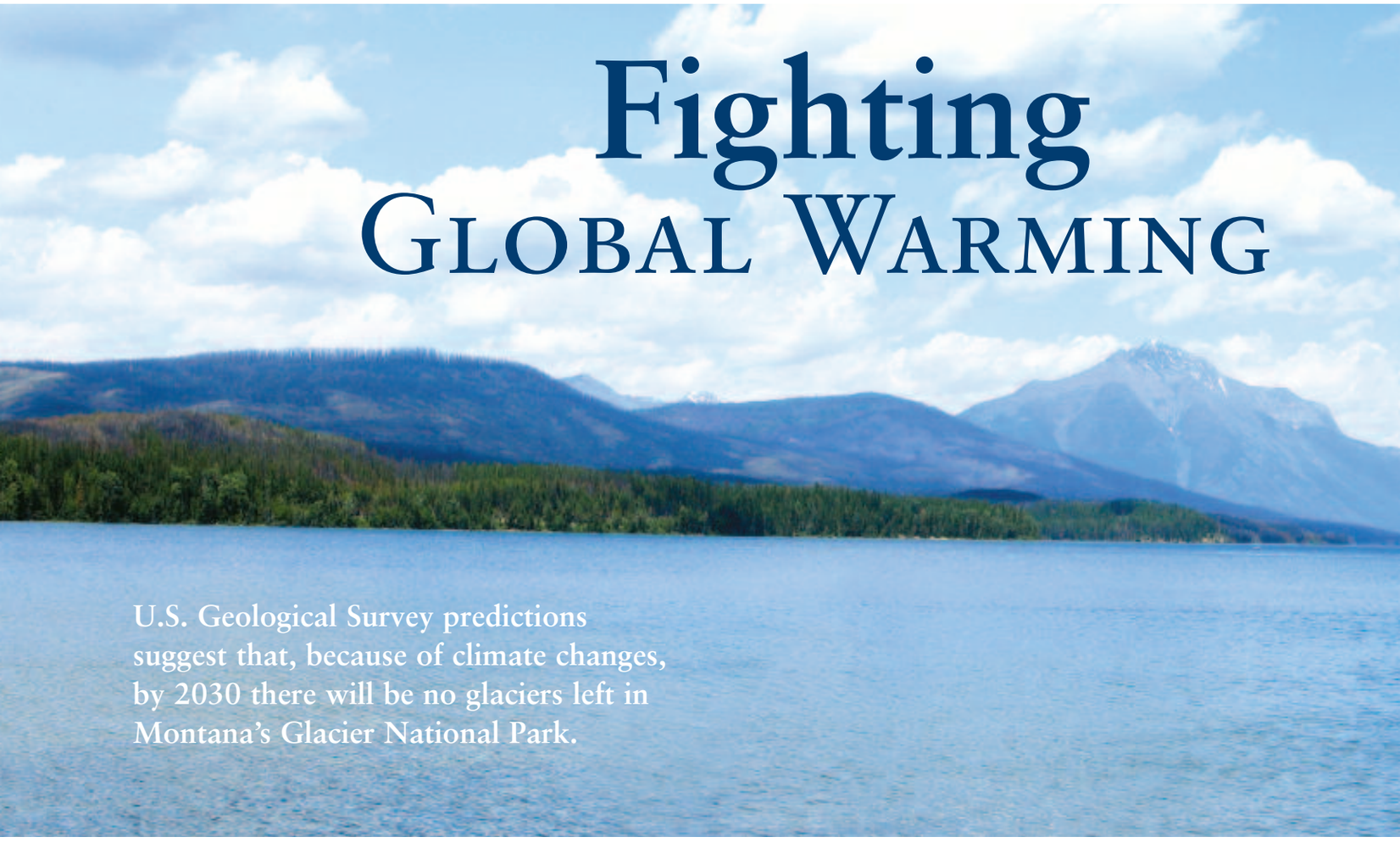
Fighting Global Warming



U.S. Geological Survey predictions suggest that, because of climate changes, by 2030 there will be no glaciers left in Montana's Glacier National Park.

There are many reasons for all of us to be taking a hard look at the amount and types of energy that we use: rising gasoline prices, volatile natural gas prices, high dependence on foreign energy resources, national security issues, smog, and acid rain. While some of these reasons may demand our attention on a daily basis, the most compelling reason to reassess our energy use is undoubtedly the link between global climate change and the burning of fossil fuels. Al Gore aptly brought this link to the attention of the American public with the movie "An Inconvenient Truth."

In the United States, we use approximately 3.4 TeraWatts of energy — roughly one quarter of the energy consumed worldwide. Approximately 85 percent of that comes from fossil fuels — petroleum, natural gas, and oil. We use energy for transportation (e.g., gasoline), for generating electricity, and for heating and cooling, roughly in equal proportions.

There is no single "silver bullet" that will meet our energy challenges. The solution is to pursue all avenues. Conservation — like driving more fuel-efficient vehicles and using compact fluorescent lighting — is vital. Improvements in energy efficiency, both of consumer appliances and industrial processes, are other necessary steps. Capturing and sequestering carbon dioxide (CO_2) from existing and future fossil fuel (coal and natural gas) driven power plants is absolutely critical. Expanding safe production of additional nuclear power, that does not produce CO_2, has even been endorsed by some environmental groups, despite concerns about nuclear waste disposal. Of course, dramatic improvements and growth in renewable energy sources must be the ultimate focus of our efforts.

Currently, renewables comprise only seven percent of our total energy use, with more than 90 percent of that being hydroelectric power and biomass (ethanol and biodiesel). Solar and wind combined meet only about two thousandths of our energy needs.

Even before the Intergovernmental Panel on Climate Change issued its most recent report in February 2007, which shows that scientific data provides very high confidence that global warming has been caused by human activity, Notre Dame was working to develop new, more energy-efficient, and cost-effective methods for capturing CO_2 from power plants. Current

Photo courtesy of Glacier National Park

technology to capture CO_2 would almost double the cost of electricity. Once captured, CO_2 can be used for enhanced oil recovery or stored safely in underground geologic formations. Using some newly developed compounds called ionic liquids, Notre Dame researchers are working with industrial collaborators DTE Energy, Babcock & Wilcox, Air Products, EMD Chemicals Inc., Trimeric, and the National Energy Technology Laboratory on break-through technology to remove CO_2 from flue gas. A $3 million project awarded from the Department of Energy last fall was the largest award given to an academic institution for new CO_2 capture technology development.

The CO_2 capture project is part of the Notre Dame Energy Center (*energycenter.nd.edu*), which also focuses on improvements in energy efficiency, clean coal technology, safe nuclear waste disposal, and renewable energy — especially efficiently capturing wind energy and developing the next generation of solar energy collection devices.

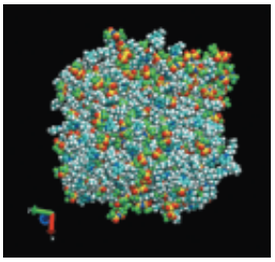
In addition to promoting research, the energy center administers the Slatt Fellowships for energy-related undergraduate research, has an active Student Advisory Board, and works with the University's energy and environmental issues committee (*green.nd.edu*) to implement energy conservation and green energy policies on campus. The energy center was instrumental in securing a donation of solar cells from General Electric for the roof of the new engineering building (see related article on page 25), as well as a microturbine for student research projects from NiSource Energy Technologies. In October, the energy center also hosted an energy conference on campus.

Through the energy center, Notre Dame is doing its part to fight global warming. What about you?

A member of the Notre Dame faculty since 1989, ***Joan F. Brennecke*** *serves as the Keating-Crawford Professor of Chemical and Biomolecular Engineering and director of the Notre Dame Energy Center.*

The Green Party

According to the article "Making Dirty Coal Plants Cleaner" in the July 13 issue of *Science*, emissions from coal-fired plants are responsible for almost a third of the greenhouse gases caused by humanity. In the United States alone, the gases these plants produce surpass the amount generated by cars and all other industries combined. Is it any wonder that finding a way to curb these carbon emissions is a popular idea? **Edward J. Maginn,** professor of chemical and biomolecular engineering, who is quoted in the article, says there are basically three approaches to capturing the carbon dioxide (CO_2) in flue gas: pre-combustion capture, post-combustion capture, and oxy-firing. Maginn, along with **Joan F. Brennecke,** the Keating-Crawford Professor of Chemical and Biomolecular Engineering and Director of the Notre Dame Energy Center, **William F. Schneider,** associate professor of chemical and biomolecular engineering, and a team of Notre Dame researchers are concentrating on post-combustion activities, which apply to the majority of the world's power plants. What's unique about their activities is that they are using ionic liquids (ILs), a relatively new class of chemicals that are liquid at room temperature, to create an environmentally friendly absorption process.



The Notre Dame team uses atomic-scale simulations of ionic liquid-carbon dioxide interactions to complement their laboratory experiments.

"One of the exciting things about research is how pursuing one activity can shed light on another and open totally new avenues of possibility," Maginn says. While the team was working to make green solvents for the chemical industry, they found the CO_2 they were using in the experiments dissolved in the ILs. This led to a few other experiments, and now the team is working on a federally funded project to capture and separate CO_2 in carbon-based electric generation power plants.

In fact, they have established a Cooperative Research and Development Agreement for the project and are working with DTE Energy, Detroit, Mich.; Babcock and Wilcox, Baberton, Ohio; EMD Chemicals, Inc., Gibbstown, N.J.; Trimeric, Buda, Texas; Air Products, Allentown, Pa.; and the National Energy Technology Laboratory, Pittsburgh, Pa. To date they have identified more than 20 new ILs that dissolve CO_2. They also have designed new ILs with enhanced CO_2 solubility and developed advanced molecular modeling capabilities to make quantitative predictions of IL properties based only on chemical structure.

Face Recognition Report Released

In a National Institute of Standards and Technology report released earlier this year, researchers suggested that face recognition technology has improved drastically since Sept. 11, 2001. According to **Kevin W. Bowyer,** the Schubmehl-Prein Chair of the Department of Computer Science and Engineering, and **Patrick J. Flynn,** professor of computer science and engineering, participants in the studies upon which the report was based, false recognition rates in such systems have dropped by 90 percent. Accuracy rates are also now near 99 percent, with the performance of iris recognition systems similar to that of face recognition systems.

Bowyer and Flynn have been researching the feasibility of image-based biometrics and multi-biometrics for several years. With the assistance of students in the department, they have amassed one of the largest databases of faces in the world.

Other organizations participating in the study included the School of Behavioral and Brain Sciences in Richardson, Texas; Schaefer Corporation in Arlington, Va.; and Science Applications International Corporation, headquartered in San Diego, Calif.

The work, supported by the a number of foundations and private benefactors, as well as the National Science Foundation, has proved very rewarding. Silliman believes that this project holds a number of benefits to those involved. "The focus on research as applied to these complex issues in Benin has the potential to impact the local population through helping them better understand and maintain their critical water resources. It also has the potential to impact the students in Benin through providing access to new technologies (techniques in hydrology), as well as to ongoing collaboration with colleagues in the United States. Finally, it has the potential to impact participating Notre Dame students by providing them with a rigorous, multidisciplinary, international research experience, while challenging them to see the talents, strength, and beauty of both their Beninese peers and the Beninese people."

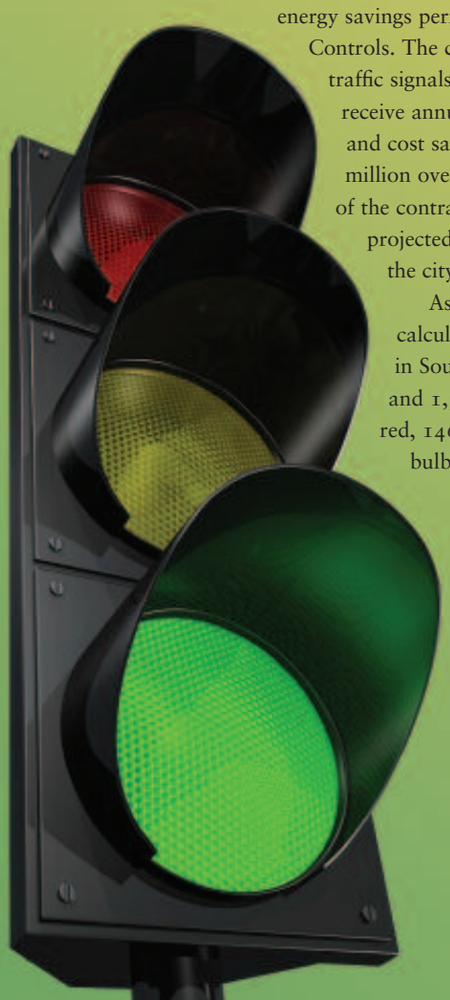
For more information about the college's work in Benin, visit *www.nd.edu/~silliman/Development/benin*.

Photos of Benin supplied by Pamela Crane and Stephen E. Silliman

Another Bright IDEA

Having a university in your backyard has its benefits. Over the last eight semesters, **Douglas C. Hall,** associate professor of electrical engineering, and several teams of undergraduates have been working with the South Bend Public Works and Division of Engineering to quantify the benefits of replacing all of the incandescent bulbs in the city's traffic lights with light-emitting diode (LED) units. The students studied the cost savings (incandescent bulbs must be replaced annually, even if the bulbs are still functioning, and they use more energy) and time savings (when work crews don't have to change bulbs, they can focus on other needs). Another consideration was safety. When an incandescent signal burns out, the whole light is gone. In contrast, LEDs do not suddenly burn out. They can operate for years with slowly decreasing brightness, which eliminates driver confusion and the ensuing chaos that occurs when a signal suddenly fails. Incandescent bulbs typically last 18 months, while LED signals can continue to meet brightness regulations for up to 10 years.

Most recently, Hall and senior **Patrick Cash** were involved in the months-long process as the city reviewed responses to its Request for Quotation to replace the incandescent lights. After in-depth interviews and selection discussions, South Bend chose to pursue a guaranteed energy savings performance contract with Johnson Controls. The company will switch out the city's traffic signals with LEDs, and the city will receive annual audits showing the energy and cost savings, which is projected at $1.97 million over a 10-year period. Under the terms of the contract, if the energy savings are not as projected, Johnson Controls has to pay the city the difference.



As part of the project, students' calculations encompassed all of the bulbs in South Bend: 1,600 red, 1,241 yellow, and 1,586 green bulbs in traffic lights; 99 red, 146 yellow, and 154 green left-turn bulbs; and 1,100 pedestrian signals.

For more information about the students' study and LED technology, visit *www.nd.edu/~leds*.

an update on
Engineering Structures

The 10,000-sq.-ft. engineering facility north of campus complements the University's long history of excellence in aerospace research and design.

CONSTRUCTION NEARLY COMPLETE ON WHITE FIELD

Construction began earlier this year on the 10,000-sq.-ft., $1.9 million facility that will be part of the Center for Flow Physics and Control (FlowPAC). Located north of campus in an area previously used for football weekend parking, the building will house a new wind tunnel, and compressor and turbine facilities.

The $3 million wind tunnel, which was designed by **Thomas C. Corke,** the Clark Equipment Professor of Aerospace and Mechanical Engineering and Director of FlowPAC, and six undergraduates in the Department of Aerospace and Mechanical Engineering, features an 8-ft. diameter fan, weighs 8.5 tons, and requires a 1,750-horsepower motor to operate it. Winds in the 3-sq.-ft. experimental cross-section of the tunnel can reach up to Mach 0.6, all of which make this a unique facility for any university. The tunnel, which is funded by the Air Force Office of Scientific Research (AFOSR), allows Notre Dame researchers to run their experiments at higher speeds, much closer to actual flight conditions. Some of the initial experiments that will be conducted in the new tunnel will focus on the next generation of ultra-efficient airplanes and pilotless aircraft.

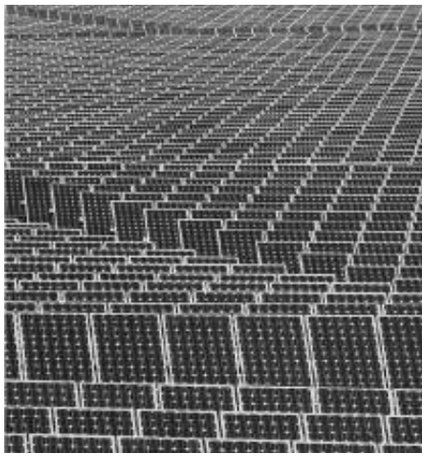
In addition to the new wind tunnel, an existing $.5 million compressor, formerly housed in the Hessert Laboratory for Aerospace Research, and a new $1.8 million turbine will be housed in the new facility. The compressor and turbine were also funded through the AFOSR. Construction is expected to be complete in January 2008.

CAMPUS-WIDE NETWORK UPGRADE HITS ENGINEERING

Several years ago, the Office of Information Technologies (OIT) began recabling the University as part of a campus-wide network upgrade. The College of Engineering had been working with OIT's Integrated Communications Services (ICS) to custom build the engineering portion of the network to not only meet current needs, but also to take the college well into the future. The same type of networking now being installed in Cushing Hall, dedicated in 1932, and Fitzpatrick Hall, dedicated in 1979, will be installed in Stinson-Remick Hall, the new engineering facility currently under construction on Notre Dame Avenue. When the networking upgrade is complete in early 2008, all of the rooms in Cushing and Fitzpatrick will be re-wired with three Category 6 (Cat 6) copper cables and three pairs of 9-micron single-mode fiber. The Cat 6 cables will provide higher bandwidth connections to the campus network infrastructure for all engineering users. The single-mode fiber will allow researchers to build custom interconnections between the research facilities within the college. These connections may be used in many ways: to transport sensitive data between research centers without exposing it to the public campus infrastructure, to quickly transport large volumes of data between research data-collection instruments, and compute/storage locations, to build high-speed connections between research centers on campus where such connections are currently not available, and to facilitate research that would not be possible without the capabilities provided by a fiber infrastructure. The fiber essentially provides unlimited bandwidth and will be able to carry hundreds of gigabits of data per second.

ICS will also be bolstering the engineering wireless infrastructure. The bottom line is that the upgrade supports the high-performance computing research and academic networking needs of the college.

"This contribution provides the students an immediate opportunity for exploration and practical experience, including future engineering curriculum expansion, as they solve the energy issues of the next generation."



Although final specifications for the panels and installation will not be complete until late 2008, the proposed system is rated at 50 kW and will provide an estimated 55,000 kilowatt hours of carbon-free electricity to the building annually.

SOLAR PANELS TO HELP POWER NEW BUILDING AND STUDENT DEVELOPMENT

General Electric (GE) has donated a photovoltaic solar array that will be incorporated into the new Stinson-Remick Hall of Engineering. "With more than 400 Notre Dame alumni, GE is proud to make a donation that will promote awareness of clean technology solutions and support the University's goal to expand and enhance the learning opportunities for our future technical leaders," said **Lorraine Bolsinger,** vice president for ecomagination at GE. "This contribution provides the students an immediate opportunity for exploration and practical experience, including future engineering curriculum expansion, as they solve the energy issues of the next generation."

The array — the first application of renewable energy on campus — will be monitored by a system in the McCourtney Learning Center, where undergraduates will be able to track the energy being generated. This also gives faculty the opportunity to build course curricula around the system.

*A $500,000 in-kind gift of solar panels was announced by **Susan P. Peters,** vice president for executive development and chief learning officer, during the closing reception of the first Notre Dame Energy Week on October 12. Energy Week is a student-run event promoting awareness and responsible use of energy resources;* see related article on page 36.

Faculty Promotions/ Anniversaries

Each year, faculty are honored for their academic contributions and years of service to the University. The following engineering faculty were recognized during the 2007 President's Dinner:

25 YEARS OF SERVICE —

Yih-Fang Huang, professor
Electrical Engineering

J. Keith Rigby Jr., associate professor
Civil Engineering and Geological Sciences

PROMOTIONS —

To Emeritus
John J. Uhran Jr.
Computer Science and Engineering

To Professor
Clive R. Neal
Civil Engineering and Geological Sciences

To Associate Professor with Tenure
Ryan K. Roeder
Aerospace and Mechanical Engineering

To Associate Professional Specialist
Kerry Meyers
EG10111/10112 Course Co-coordinator

New Faculty

Joining the College of Engineering this academic year are:

Marina Blanton, assistant professor
Computer Science and Engineering

David P. Devine, assistant professional specialist and director of undergraduate studies
Civil Engineering and Geological Sciences

Scott Emrich, assistant professor
Computer Science and Engineering

Vijay Gupta, assistant professor
Electrical Engineering

Andrew Kennedy, assistant professor
Civil Engineering and Geological Sciences

Joshua Shrout, assistant professor
Civil Engineering and Geological Sciences

Energy Week

In October, students across the University were challenged to "Get Your Green On" as part of the first ever Energy Week at Notre Dame. Organized by the student advisory board of the Notre Dame Energy Center (and sponsored by the energy center, the University's energy and environmental issues committee, the students for environmental action, the Joint Engineering Council, and Notre Dame student government), the week was full of informational and fun activities. In addition to showing movies such as "An Inconvenient Truth," energy week volunteers showed their fellow students ways to calculate their personal energy footprint. They helped students learn more about renewable energy options, as well as the ways Notre Dame is addressing energy issues. Students also promoted the first campus-wide "lights out," when students, faculty, and staff voluntarily turned their lights off for an hour, resulting in a 2.7 percent reduction in electricity as measured by the Notre Dame Power Plant.

For a recap and video of the of the week's activities, visit *energycenter.nd.edu*.

Battery Drain

It is hard to "serve and protect" when your police car won't even start. According to the South Bend Police Department, the crime-fighting tools carried in squad cars, many of which are electronic devices, can drain a vehicle's battery so much that it can't start. And, it's not just a local problem; police departments across the country are facing a similar challenge.

In addition to the normal electronic devices in a vehicle, police cars also carry a laptop computer, video camera, alarm system, a Global Positioning System, and at least one radio. Batteries that typically last for five years are dying within two, which is a safety issue and drain on a department's budget. But police cars are not the only vehicles affected. Recreational vehicles and many commercial vehicles (delivery and service trucks) face similar issues.

Not to worry. Students in the Department of Electrical Engineering may be close to a solution. As part of their senior capstone project, 2007 graduates **Jason Kulick, Michael Gerardi, Martin Nguyen,** and **Peter VanLoon** developed a device that could monitor and record information about the electrical currents in a vehicle ... as well as control them. According to **Mike Schafer,** the faculty member who teaches the senior design course, the students' invention will automatically turn off devices in vehicle when the battery power gets low.

A prototype device was developed and presented to the police department and the City Safety Board in July. Although more testing will be conducted by another senior design team, it is possible that a commercially viable product could be available within a year, benefitting police departments across the country.

Editor's note: Because of its potential commercial application, the design and related business concept for the students' device recently won first place in the Four Horseman Engineering Entrepreneurship Program's "Engineering Ideas Contest." The students have also made it into the business plan round of the McCloskey Business Plan Competition, sponsored by the University's Gigot Center for Entrepreneurial Studies. Winners will be announced in April 2008.

*Top photo: In July 2007, **Mike Schafer,** middle, and students (not pictured above) presented a prototype of the Notre Dame battery monitor and control device to members of South Bend's City Safety Board. Middle photos: The device was designed by undergraduates in the Department of Electrical Engineering as part of their senior capstone project. It monitors several electronic items in vehicles. Bottom photo: **Jason Kulick** gets ready to demonstrate how the prototype works in a police car.*

Work Hard. Play Hard.

In one of the research projects led by **Surendar Chandra,** assistant professor of computer science and engineering, it might be hard to tell the difference ... even if you're watching the students in action. Chandra, along with **Adele Fleury** and **Adam Lusch,** two engineering undergraduates working on this independent study, have been collecting information to see how people involved in multi-player games using handhelds, such as Nintendo® DS, impact other wireless users.

Wireless networks are ubiquitous in many organizations and most universities. Gamers create a wireless network among themselves without using, or necessarily requesting, permission from network administrators. So it is important to understand the impact of gamers on the rest of the network, in this case, the Notre Dame campus.

During their experiments, the team found that Nintendo DS usage had a negligible effect on User Datagram Protocol (UDP) traffic, one of the core protocols for the Internet. However, interference to Transmission Control Protocol (TCP) traffic was dramatic, as throughput for Web users dropped from just over 5 Mbps to between 2 and 3 Mbps, even though the volume of game data was not high. Fleury and Lusch, with the help of fellow undergraduates, such as **Vincent Thomas** (B.S., CSE '07, shown here), who took time out of their busy schedules to "play," found that the Point Coordination Function (PCF) used by Nintendo to arbitrate channel access interacted with the Distributed Coordination Function (DCF) of typical wireless access points, causing major interference with the wireless traffic of other local network users.

The team's findings will be published in a paper titled "Do Nintendo Handhelds Play Nice? An Analysis of Its Wireless Behavior" in the proceedings of the Sixth Annual Workshop on Network and Systems Support for Games (NetGames 2007). Hosted by the Centre for Advanced Internet Architectures, NetGames will be held September 19-20, 2008, in Melbourne, Australia.


Joseph Basconi


Patrick Brown


Shawn Coleman


Kyle Kron


Felipe Witchger

Plugging into Creative Juices

The Notre Dame Energy Center has named five recipients of the 2007 Slatt Fellowship. They are **Joseph Basconi, Patrick Brown, Shawn Coleman, Kyle Kron,** and **Felipe Witchger.** Created by **Christopher Slatt** (B.S., EE '80) and **Jeanine Slatt,** in honor of his father **Vincent P. Slatt** (B.S., EE 43), the fellowship supports undergraduate research, up to $5,000, in the field of energy systems and processes for hands-on projects.

Selected projects, which began this summer, cover a wide range of topics. For example, Basconi, a sophomore in the Department of Chemical and Biomolecular Engineering, is studying the impact of Daylight Saving Time on energy consumption in Indiana.

Brown, a sophomore, is investigating single-wall carbon nanotube-based photochemical solar cells. He is focusing on the desired properties necessary for harvesting light energy.

Coleman is working on first-principle prediction of active sites for catalytic hydrogenation. His findings will help provide insight into the development of improved catalytic materials and processes. Coleman is a sophomore studying chemical and biomolecular engineering.

Kron, a sophomore in aerospace and mechanical engineering, is performing finite element analyses of SIC-Si_3N_4 nanoceramic composites for high-temperature structural applications, such as earth and space-based power generation systems.

A junior, Witchger's project studies biofuel development and sustainability in Latin America. Witchger is pursuing energy studies and economics.

Brennecke Wins Prausnitz Award

The Conference on Properties and Phase Equilibria for Product and Process Design has awarded the 2007 John M. Prausnitz Award for outstanding achievement in applied chemical thermodynamics to **Joan F. Brennecke,** the Keating-Crawford Professor of Chemical and Biomolecular Engineering and director of the Notre Dame Energy Center.

Brennecke was cited for her pioneering work in molecular thermodynamics of separations with ionic liquids (ILs) and local composition effects on reactions in supercritical fluids during the award presentation at the 11th international conference earlier this year. The Prausnitz award is the most recent in a long line of honors she has received for her research, which focuses on the experimental aspects of thermodynamics and separations.

A faculty member since 1989, Brennecke is a member of the American Chemical Society, American Institute of Chemical Engineers, and American Society for Engineering Education. She also serves on the editorial board of *Green Chemistry* and is chair of the Council for Chemical Research.

Learning from the Best

Kwang-Tzu Yang, the Viola D. Hank Professor Emeritus of Aerospace and Mechanical Engineering, received the Max Jakob Memorial Award in July 2007 during the American Society of Mechanical Engineers (ASME)-Japan Society of Mechanical Engineers Thermal Engineering and Summer Heat Transfer Conference in Vancouver, British Columbia.

Named in honor of **Max Jakob,** a pioneer in the science of heat transmission, the award has been presented annually since 1961. Yang was recognized for a long career of achievement and distinguished service in heat transfer. His research has focused on heat exchanger dynamics, hydronic systems, application of artificial intelligence, oscillating flows, modeling of large fires, tribology, food and materials processing, and technology transfer. He also holds patents for flexible coupling and the wet oxidation of coal for the generation of heat energy. The award is a special honor for Yang as Jakob was his Ph.D. adviser.

A fellow of the ASME and a member of numerous professional societies, Yang is listed in "Who's Who in America," "Who's Who in Engineering" and "American Men and Women of Science." He has served as a faculty member since 1955.

Maziar Named Senior Associate Provost

Christine Maziar, professor of electrical engineering and former vice president and associate provost at the University, has been promoted to vice president and senior associate provost. Prior to joining the University in 2002, she served as provost at the University of Minnesota. As such, she was responsible for academic units, but also oversaw the libraries, information technology, admissions, student affairs, and enrolled student services.

In addition to her most recent responsibilities at Notre Dame, which included administration of budgets, academic space management, and implementation of the University's academic strategic plan, Maziar is now responsible for overseeing the provost's office when **Thomas G. Burish,** the University's provost, is traveling.

Nanotechnology on the Emerald Isle

An endowment created by 1953 graduate **John B. Clark Sr.,** former president and chief executive officer of Brown Plastics Engineering Company, and his wife, **Fidelma,** will support a research and educational exchange program between Notre Dame's College of Engineering and Ireland's University College in Cork and Trinity College in Dublin. Both of the Irish institutions have thriving nanotechnology programs that complement the work being conducted in the University's Center for Nano Science and Technology.

Through a summer research program, participating students will work in Ireland on a variety of collaborative projects designed to give them a deeper insight into one of today's most promising technologies. The research opportunities offered to undergraduates through this program will also give them an advantage when they graduate and compete for positions in industry or graduate school.

James L. Merz, the Frank M. Freimann Professor of Electrical Engineering, and **Wolfgang Porod,** the Frank M. Freimann Professor of Electrical Engineering and Director of the Center for Nano Science and Technology are the principal contacts for Notre Dame. Students wishing to find out more about the new program should contact Merz at *jmerz@nd.edu.*