From the hydrogen bus that shuttles students across campus, to a model energy savings program that’s gaining international momentum, the University of Delaware is putting numerous clean, green initiatives in motion on the path to a new energy future.

And now UD has a brand-new powerhouse to help coalesce, integrate, communicate, and advance these efforts on an even larger scale — the University of Delaware Energy Institute (UDEI).

Officially launched last September, UDEI is now the driving force for interdisciplinary research and education on alternative energy at the University, a critical step in UD’s Path to Prominence™ strategic plan, which includes among its six milestones the “Initiative for the Planet.”

UDEI’s mission is to marshal and expand the University’s science, engineering, and public policy expertise in emerging energy technologies and, with industry and government partners, use this research to address the challenges posed by future energy needs, according to Mark Barteau, senior vice provost for research and strategic initiatives. Barteau is UD’s Robert L. Pigford Chair of Chemical Engineering and the institute’s founding director.

“Energy is, as the National Academy of Engineering declared, one of the grand challenges of our time,” says Barteau, who was inducted into the distinguished group in 2006. “You can’t look at the problem through any single prism to solve it. It’s much more complex than that,” he notes.

(See Energy for the Future, continued on p. 4)

Photovoltaic solar cells convert sunlight directly into electricity. They are made of semiconductor materials similar to those in computer chips.

As part of that initiative, UD is committed to leading path-breaking environmental research, becoming ‘The Green University,’ developing and demonstrating alternative energy technologies, and integrating environmental programs into the curriculum.

From left, researchers Ujjwal Das and Stuart Bowden and director Robert Birkmire display high-efficiency silicon solar cells made at UD’s Institute of Energy Conversion. The facility was designated a University Center of Excellence for Photovoltaic Research and Education by the U.S. Department of Energy and the National Renewable Energy Laboratory in 1992.
Energy for the Future, continued from p. 3

Barteau, who participated in the National Academies’ Summit on America’s Energy Future last year, quotes sobering statistics about energy usage and what lies ahead.

World energy consumption has reached 400 quads per year, or 13.5 terawatts. U.S. energy consumption represents about one-quarter of that total. Seventy percent of the petroleum we use (more than 60% is imported) is for transportation, while coal-fired plants supply most of our electricity.

As world population grows, a tripling of energy use is predicted by the end of this century, with the additional challenge to decrease carbon dioxide emissions from current levels.

“There is no silver bullet. No single resource can meet our energy needs,” Barteau says. “Conservation, natural gas, ‘clean coal,’ nuclear, solar, wind, geothermal, bioenergy, and others can contribute significantly. There are economic, environmental, and societal trade-offs among these, but regardless of how we consider them, we will need a diverse portfolio,” he notes.

While the challenges may seem daunting, Barteau sees increasing opportunities for UD, which now has more than 250 faculty, postdoctoral researchers, and graduate students engaged in energy research, not to mention dozens of undergraduate students.

“An increasing share of our future energy needs will be met by technologies that are now in the research or development stages,” Barteau notes.

The United States uses about 25% of the world’s energy supply.

CURRENT U.S. ENERGY PORTFOLIO:

| Oil — 40% |
| Coal — 23% |
| Natural gas — 22% |
| Nuclear power — 8% |
| Renewables — 7% |

(The renewables are represented primarily by hydropower and biomass sources such as wood, crops, and municipal waste.)

For nearly four decades, UD has been leading research on solar cells, catalysts for fuel production, lightweight composites for fuel-efficient vehicles, and energy and environmental policy. Today, UD is expanding on these strengths and building new research programs and collaborations across the energy spectrum, including wind power, vehicle-to-grid technology, biofuels, hydrogen storage, magnetics, and other areas, according to Jingguang Chen, Claire D. LeClaire Professor of Chemical Engineering. Chen is serving as interim director of UDEI while the search for an endowed chair is under way.

“The University also is developing the curricula and hands-on training essential to educating a new generation of energy science and policy leaders,” Chen says, noting that faculty created the world’s first graduate course on offshore wind power, as well as an Industrial Assessment Center to improve the energy efficiency of Mid-Atlantic businesses. Additionally, with support from the National Science Foundation, UD conducts an Integrative Graduate Education and Research Traineeship (IGERT) in Sustainable Energy from Solar Hydrogen and a Research Experiences for Undergraduates (REU) program on alternative energy that attracts students from across the United States.

Recently, the U.S. Department of Energy selected UD to be the home of a new Energy Frontier Research Center. UD’s center is one of 16 to receive funding from the American Recovery and Reinvestment Act, where a primary criterion is job creation.

“This award is an outstanding recognition of the ability and vision of our faculty,” Barteau says. “Beyond establishing world-class programs on campus and partnerships with top researchers in other universities and national labs, our faculty have been actively involved in building the foundation for energy research in the United States. We started UDEI because we have the commitment,” he notes. “Failure is not an option. Our researchers know the future is now.”

On the path to a new energy future

Built at UD with support from Delmarva Power and Light Co., and dedicated in 1973, SOLAR ONE was the first experimental house to directly convert sunlight into both heat and electricity for domestic use.
UD a leader in solar research

Founded in 1972, the brainchild of Karl Böer, UD Distinguished Professor Emeritus of Physics and Solar Energy, years before the first oil embargo and the formation of the U.S. Department of Energy, UD’s Institute of Energy Conversion (IEC) shines in solar-cell research. Its scientists conduct fundamental studies of thin-film photovoltaic solar cells, as well as manufacturing-scale projects, in collaboration with universities and companies around the globe.

Photovoltaic-based solar cells convert sunlight directly into electricity and are made of semiconductor materials similar to those used in computer chips, explains Robert Birkmire, director of IEC. When these materials absorb sunlight, the solar energy knocks electrons loose from the atoms, allowing the electrons to flow through the materials to produce electricity.

IEC is the only laboratory in the world to have fabricated thin-film solar cells with efficiencies between 10 to 20 percent using four different absorbing semiconductors: amorphous silicon (a-Si), cadmium telluride (CdTe), copper-indium-diselenide (CuInSe2), and copper sulfide (Cu2S).

Researchers Erten Eser (left) and Shannon Fields check a flexible solar panel manufactured at UD’s Institute of Energy Conversion.

An efficiency of 10 percent means that a solar module can convert 10 percent of incoming sunlight into electricity. A typical solar module of about 10 square feet would generate 100 watts of electricity.

IEC also first demonstrated the viability of roll-to-roll technology for manufacturing flexible solar cells in long sheets, like newsprint from a printing press, opening the door to the manufacture of lightweight solar panels for roofs, spacecraft, and other applications.

Currently, IEC leads the nation in competitive university research funding awarded from the U.S. Department of Energy’s Solar America Initiative, which seeks to make solar energy cost-competitive with conventional forms of electricity by 2015.

As part of that initiative, awarded in 2008, IEC is expanding its pioneering research on flexible copper-indium-gallium-diselenide (CISG) solar cells in a joint project with Dow Corning. The team also is working with Silicon Valley-based SunPower to couple thin-film and crystalline silicon technologies to increase the conversion efficiencies of solar cells beyond 26 percent.

In recent years, IEC researchers have developed 10 new technologies, eight of which are now patented. So far, 60% of these solar innovations have been licensed, all to U.S. companies.

The broad scope of IEC’s research offers students, postdoctoral fellows, and visiting scholars unique educational opportunities in physics, chemistry, materials science, chemical engineering, mechanical engineering, and electrical engineering, as well as collaboration with industry groups.

“We’ve developed a great group of people here — an integrated team of scientists and students from different disciplines, which is critical to this research,” Birkmire notes.

(See Energy for the Future, continued on p. 6)

Sun and engineers bring clean water to African village

With help from the sun, UD’s chapter of Engineers Without Borders (UD-EWB) is bringing clean water to Bakang, a village of 3,000 people in western Cameroon.

The remote village has no electricity and previously has had to rely on muddy creeks and open wells for drinking water.

UD-EWB recently won a prestigious Outstanding Commitment Award from the Clinton Global Initiative of the William J. Clinton Foundation, which included a $10,000 grant from the Wal-Mart Foundation to support the chapter’s solar water pumping project in Bakang.

The grant funded the UD-EWB chapter’s fifth expedition to Cameroon, a three-week trip in June, led by adviser Steve Dentel, professor of civil and environmental engineering, and former chapter president Sarah O’Neill, the primary author of the grant application. Students Ramsey Hazbun, Alyssa Serra, Taylor King, and Matt Lindemer completed the UD contingent. The team installed solar-powered water pumps in two new wells with 6,000 liters of tank storage for the village.

To show their appreciation, the chief of Bakang promoted Dentel to the rank of prince in front of a gathering of villagers.

“Thing is, I don’t deserve this,” Dentel blogged from Bakang. “Firstly, it’s the students who make this possible, and there are lots of them who have been to Bamendjou and Bakang to help, and others who provide the behind the scenes support, including tireless fundraising work. And of course there are LOTS of folks who provide the finances that underwrite our efforts. You *all* deserve this recognition.... But I did call my wife to tell her that her husband is now a prince and a village Notable,” he wrote. “She said these titles will not apply in Delaware. But they do send a “message” to Delaware,” he noted. “They really love what we do!”

UD professor Steve Dentel is made a prince in Bakang, Cameroon, in honor of UD-EWB’s efforts to bring clean drinking water to the village.
Sun powers poultry house in novel project

Delmarva’s economy is linked to a thriving poultry industry, which encompassed over 1,700 growers, 5,000 chicken houses, 570 million chickens, and a wholesale value estimated at more than $2.1 billion in 2008.

One of the biggest challenges facing poultry growers is the cost of energy to maintain the carefully controlled temperatures and ventilation needed to raise day-old chicks to maturity. To assess the economic feasibility of powering poultry houses with solar energy, UD, in conjunction with numerous project partners, installed a 42-kilowatt photovoltaic system on an Allen Family Foods poultry farm near Laurel, Del., in 2007.

The ground-mounted system is divided into a 12-kilowatt net metering system and a 30-kilowatt demand management system connected to the farm’s diesel generator and to Delmarva Power, the farm’s commercial supplier of electricity. In a net metering program, the electric company allows a customer’s meter to actually run backwards if the electricity generated by the customer is more than the energy used.

During daylight hours on sunny and even cloudy days, the photovoltaic system converts light into electricity. When the system’s output does not meet the power needs of the poultry house, the balance of power is supplied by Delmarva Power. When the system produces more power than needed, the excess power is directed to a back-up battery bank and to the utility via net metering. Battery-stored power can be used on demand, including times when peak electric rates apply.

Delmarva Power provides retail credit at the current market rate for energy sent to its grid. Inverters automatically decide whether to buy from or sell to the utility depending on the amount of solar energy being captured and the power needs of the poultry house.

The pilot photovoltaic system cost approximately $500,000 to install, half of which is eligible for rebates through a combination of state and federal tax credits, including the Delaware Green Energy Fund, the Federal Tax Credit for Energy Efficiency (30 percent), and renewable energy credits (RECs). Poultry growers are eligible for the same incentives and may be eligible for special loans.

In the first year of operation, the system showed a savings of 56,000 kilowatt hours, or $7,500, and has demonstrated the technical feasibility required for growers applying for U.S. Rural Development Grants, according to Robin Morgan, dean of the College of Agriculture and Natural Resources.

“The University of Delaware is well known for its poultry research programs and is a leader in solar technology,” says Morgan. “Putting these two strengths together has the potential to help the state’s economy by strengthening one of our largest and most important industries as well as stimulating a newly emerging one.”

Detailed information about the project, including “An Investment and Cost Guide for Delaware Poultry Growers,” is available at ag.udel.edu/anfs/solar/index.html.
Wind energy is beginning to play a larger role in our energy supply. The sun is not shining or the wind is not blowing, as solar and non-polluting “green” energy available to power our needs when the sun is not shining or the wind is not blowing, as solar and wind energy begin playing a larger role in our energy supply.

New fuel cell center driving novel research

“Delaware is a great place to start a fuel cell center,” says Ajay Prasad, UD professor of mechanical engineering, and the director of UD’s new Center for Fuel Cell Research, which launched last fall.

“We have a large number of people here at UD doing work related to this subject, and many of the major players in the fuel cell market are within a 50-mile radius of the University,” Prasad notes.

A fuel cell is like a battery that doesn’t “go dead” — so long as hydrogen and oxygen constantly flow into the cell, it will produce electricity. Its one byproduct is water.

The center’s goal is to improve the understanding of fuel cells and address critical issues and barriers to commercialization of this potential source of clean energy that uses hydrogen as its fuel. The center also will provide students with opportunities for research.

Housed in the Department of Mechanical Engineering in the College of Engineering, the center includes some 25 faculty members from that college, as well as the colleges of Arts and Sciences, and Earth, Ocean, and Environment.

Traditionally, fuel cell research was the domain of electrochemists, but Prasad says there are tremendous opportunities for engineers and materials scientists as well.

“It is also necessary to involve diverse fields like biotechnology,” he says. “For example, photobiological water splitting using certain types of bacteria and sunlight might offer an exciting, renewable way to produce hydrogen in the future.”

Important components of the center’s mission are technology transfer to industry and public engagement. And for the latter, what could be more cool than a hydrogen fuel cell bus that operates on campus?

Prasad is the principal investigator on the project, which is sponsored by the U.S. Department of Transportation and the Delaware Department of Natural Resources and Environmental Control.

(See Energy for the Future, continued on p. 8)

Car generates electricity — and cash!

Most new cars begin depreciating as soon as you drive them off the lot, but not this one.

The University of Delaware and industry partners have developed a novel system known as “Vehicle-to-Grid” (V2G) that transforms an electric car into a mini-power plant, capable of sending the electricity stored in its batteries back to utility companies, putting cash back in its owner’s pocket.

The vehicle doesn’t take any gas to run. It doesn’t generate any exhaust, which is good for the environment. And it offers a way to sustain the supply of non-polluting “green” energy available to power our needs when the sun is not shining or the wind is not blowing, as solar and wind energy begin playing a larger role in our energy supply.

The research, led by marine policy scientist Willett Kempton in the College of Earth, Ocean, and Environment, with colleagues in mechanical engineering and business administration, made an exciting surge forward on Jan. 9, 2009, when the City of Newark, Del., home to UD’s main campus, became the first electric utility in the United States to approve the use of an electric vehicle to store and provide power for the local electric grid.

Newark’s approval paves the way for larger-scale adoption of V2G electric vehicles nationwide, helping to advance the electric grid infrastructure and reduce consumption of oil.

The Delaware Department of Natural Resources and Environmental Control provided the initial funding for the project. Additional funding has since been provided through a Google RechargeIT grant and from Delmarva Power’s parent company, Pepco Holdings, Inc., which also is an industrial partner along with PJM, the regional grid operator, California-based electric vehicle manufacturer AC Propulsion, and others. The project is a continuing focus of UD’s new Center for Carbon-free Power Integration, which Kempton directs.

Kempton and his team of researchers plan on having a fleet of six vehicles by the end of 2009, two at the University of Delaware and four operated by the state of Delaware. For more information, visit www.udel.edu/V2G.

On the path to a new energy future

The University of Delaware Energy Institute (UDEI) — a portal to UD’s energy research and education programs — seeks to create and integrate new solutions to challenges in energy efficiency and sustainability. Over 250 researchers at UD are working on energy issues.
Model program saves energy, cuts CO2

UD's first fuel cell bus, which rolled into service in 2007, transports 100 students per day, on average. It emits no greenhouse gases, is much quieter than a typical diesel transit bus, and gets better gas mileage.

"By 2011, we should be up to four buses," Prasad says, "and we also have plans to build two more hydrogen refueling stations, one in Wilmington and one in Dover." Newark already has a station.

Prasad says the new center will work to tackle three barriers to widespread adoption of fuel cell technology: cost, durability, and lack of a hydrogen infrastructure.

"Public acceptance is also an important issue," Prasad notes, "and the bus project has helped by increasing awareness. The presence of three filling stations in the state also has the potential to contribute to future efforts to attract fuel cell related research and demonstration projects to Delaware."

Winds of change

While Europe has offshore wind farms, there are none in the United States.

Sweeping changes are under way, however, with the approval of an offshore wind farm for Delaware and the U.S. government's recent issuing of offshore exploration leases for wind energy production off Delaware and New Jersey.

The SEU aims to reduce Delaware's energy use by 30% by 2015 and cut the state's CO2 emissions by 5.5 million metric tons by 2020, which is 33 percent of the state's current carbon footprint.

How does it work? Delaware's SEU is funded by a $30-million tax-exempt bond issue. Unlike a traditional government bond, however, this one is paid through the "shared savings" received by Delawareans from SEU investments.

The utility provides families and businesses with upfront capital to purchase high-efficiency appliances. In turn, the participant shares an estimated 35 percent of the total energy costs saved for three to five years, after which all savings accrue to the participant. A similar initiative will support energy-efficient remodeling or purchase of a hybrid car.

For residents and businesses interested in renewable energy, the SEU will support up to 50 percent of the capital cost through bond financing and recover the investment from 25 percent of the renewable energy credit (REC) revenues that local utilities are required to pay in Delaware. After the bond investment is paid off, the participant receives 100 percent of the REC revenue.

Delaware became the first state to establish a nonprofit utility with the sole mission of promoting efficiency and renewable energy when the Delaware Sustainable Energy Utility (SEU) was signed into law in June 2007.

It has been cited by the Institute for Electrical and Electronics Engineers as the "most comprehensive energy savings and distributed renewables program in the United States."

“What makes Delaware’s SEU unique is that it serves as an independent organization with the sole purposes of saving energy and reducing greenhouse gas emissions,” says the measure’s chief architect, John Byrne, Distinguished Professor of Energy and Climate Policy and director of UD’s Center for Energy and Environmental Policy. Byrne also is a member of the Intergovernmental Panel on Climate Change (IPCC), which shared the Nobel Peace Prize in 2007.

(Vice President Joe Biden, a UD alumnus, visited the campus in May to recognize the University’s leading research in offshore wind power. At the podium is Willett Kempton, director of UD’s new Center for Carbon-free Power Integration.)

No one had done a definitive study of the size of the Mid-Atlantic offshore wind resource until professors Willett Kempton and Richard Garvine and
graduate student Amardeep Dhanju in UD’s College of Earth, Ocean, and Environment published their findings in the scientific journal Geophysical Research Letters with colleagues at Stanford University in 2007. They concluded that offshore winds are capable of producing 330 gigawatts of electricity, which could supply the energy needs of nine states from Massachusetts to North Carolina, plus the District of Columbia — with enough left over to support a 50 percent increase in future energy demand.

“For the whole Northeast, the resource is large enough to displace all electricity, all heating fuels, and all gasoline,” says Kempton, “and it’s clean energy.”

UD’s new Center for Carbon-free Power Integration, which Kempton directs, also is exploring vehicle-to-grid (V2G) technology, a way to transform an electric car into a “mini-power plant” by sending the energy stored in its batteries to utility companies. Besides netting cash for the owner, the technology could contribute power to “fill in” when renewable sources such as wind are intermittent.

Kempton and Jeremy Firestone, associate professor of marine policy and legal studies, also have conducted public opinion surveys, provided objective information to decisionmakers, and developed the nation’s first course on offshore wind power to train students for the potential U.S. industry.

Last fall in Delaware, UD President Patrick Harker opened the nation’s first industry conference on offshore wind, which was organized with UD support.

During a visit to campus this spring, Vice President and UD alumnus Joe Biden and Secretary of the Interior Ken Salazar underscored the importance of alternative energy development, especially offshore wind resources, and recognized UD’s leadership. “Because of the history that the University of Delaware and [the state of] Delaware have with respect to wind power,” Salazar said, “I expect that Delaware will be at the point of the spear in terms of making this new energy source a reality.”

In July 2009, the University and Gamesa Corporación Tecnológica signed a memorandum of understanding that could facilitate the installation of a utility-scale 2.0 MW Gamesa wind turbine at the Lewes campus next year. Delaware Gov. Jack Markell, who attended the signing event, said, “This agreement is a significant step forward in Delaware’s efforts to seize the economic development opportunities presented by our nation’s commitment to energy independence and the concern over climate change.”

UD exploring wind energy on Lewes campus

UD is exploring wind power for the Hugh R. Sharp Campus in Lewes, which is home to several academic programs and research labs of the College of Earth, Ocean, and Environment, as well as the home port for the University’s 146-foot research vessel Hugh R. Sharp.

Last year, a temporary tower was installed and outfitted with electronic gear to provide information about local wind speed and duration to help determine whether one or more wind turbines on the property could someday supply the campus with cheap, clean energy. The study, the results of which were shared in a public forum, was inspired by the work of professors Jeremy Firestone and Willett Kempton who have researched the amount of power supplied by Delaware’s offshore winds as well as public reaction to and policies for wind-energy use.

The SEU’s goal is to enable households and companies to reduce their annual energy use by 30 percent, which translates into energy bill savings of $1,000 to $3,000 per year for households alone.

The SEU will double the number of weatherized homes in Delaware, while promoting 300 megawatts of customer-sited renewable energy applications, such as solar and geothermal installations.

Washington, D.C., has passed legislation to create the nation’s second SEU, and Byrne is now assisting Maryland, Philadelphia, Seoul and Daegu in South Korea, and Bermuda in designing programs. The April 2009 special issue of the Bulletin of Science, Technology and Society is devoted to implementation of the SEU in Asia, Africa, and Europe.
The University of Delaware is the home of a new Energy Frontier Research Center (EFRC) that will develop innovative catalytic technologies to efficiently convert biomass such as trees and grasses into chemicals, electricity, and fuels.

The U.S. Department of Energy Office of Science plans to invest $777 million in EFRCs over the next five years. Forty-six were selected for funding from some 260 applications. UD’s center is one of 16 chosen to receive funding from the American Recovery and Reinvestment Act, where a primary criterion is job creation.

The grants were announced by the White House in conjunction with a speech by President Obama at the 2009 annual meeting of the National Academy of Sciences in April.

“This represents the largest commitment to scientific research and innovation in American history,” Obama said. “In no area will innovation be more important than in the development of new technologies to produce, use, and save energy.”

The UD EFRC, to be funded initially by a five-year, $17.5-million federal grant, will be led by Dion Vlachos, Elisabeth Inez Kelley Professor of Chemical Engineering and director of the Center for Catalytic Science & Technology.

Jingguang Chen, Claire D. LeClaire Professor of Chemical Engineering and interim director of the University of Delaware Energy Institute, and Raul Lobo, professor of chemical engineering, will serve as co-directors.

According to Vlachos, the center’s mission is to develop the science base that will enable the operation of future biorefineries and prepare the workforce for such jobs.

“We are very excited about the opportunity to tackle some grand challenges in the utilization of renewables that can impact the state of Delaware and U.S. energy independence,” Vlachos said.

The team plans collaborations with scientists at Lehigh University, California Institute of Technology, and the universities of Massachusetts, Minnesota, Pennsylvania, and Southern California. It also will utilize the National Synchrotron Light Source at Brookhaven National Laboratory and several U.S. Department of Energy Office of Science computational facilities.

Outreach and education also will be cornerstones of the center, which will foster students’ ability to work in multidisciplinary teams and will offer short courses, webinars, and seminars to graduate and undergraduate students, as well as to industry and government employees. High school teachers and other education professionals also will be involved in the center’s activities to raise awareness about the importance of biomass as a source of sustainable energy for the future.

“These centers will mobilize the enormous talents and skills of our nation’s scientific workforce in pursuit of the breakthroughs that are essential to make alternative and renewable energy truly viable as large-scale replacements for fossil fuels,” said Secretary of Energy Steven Chu. “Meeting this challenge will require significant scientific advances.”