THE GREEN ISSUE

SUMMER 2008

DARTMOUTH Engineer

THE MAGAZINE OF THAYER SCHOOL OF ENGINEERING

Solutions For a Hot Planet

- CLIMATE PROTECTOR CATHY ZOI TH'85
- ENERGY IDEAS FROM ALUMNI
- NON-FOOD BIOFUELS
- NUCLEAR SAFEGUARDS

DARTMOUTH ENGINEER
VOLUME 4 / NUMBER 2

Thayer's Focus on Energy

BY DEAN JOSEPH J. HELBLE

IN LATE WINTER 2007, THE THAYER SCHOOL OF ENGINEERING identified "Energy" as an area for strategic growth of faculty, research, and educational programs. At the time of this decision, oil was trading at approximately $50 per barrel, and concerns about price were constantly in the news. With oil now trading at nearly $130 per barrel, economic concerns are even greater. When coupled with concerns over energy security, climate, and the environment broadly, there is new urgency to the need to develop a more sustainable energy future.

Heightened attention and a longer term view are welcome. A review of changes in the U.S. supply portfolio is a sobering illustration of how little our supply base has changed despite fluctuations in price and an "energy crisis" through part of the 1970s. In 1958, the U.S. obtained 45 percent of its energy from petroleum, 23 percent from coal, and 7 percent from renewable sources. Nearly 50 years later, and after living through the inflationary price shocks of the oil crisis of the 1970s, our energy portfolio (in 2006) remains virtually unchanged: 40 percent provided by petroleum, 23 percent by coal, and 7 percent by renewable sources.

Thayer's selection of "Energy" for focused program growth is an indication of our commitment to preparing students to tackle this critical and interdisciplinary challenge. Over the next year, we will begin expanding our faculty in this area, the first step in building upon our strong research base in biofuels, power electronics, and the environment. We will add a new interdisciplinary course for advanced undergraduates and graduate students in energy supply technology—the second piece of an envisioned three-course sequence in energy supply, energy utilization, and energy systems. We will display our energy consumption on monitors in the MacLean Atrium to induce people to reduce consumption. Thayer's Formula Hybrid International Competition continues to grow, and our student ethanol and hybrid formula racing teams enthusiastically try out new ideas for improving fuel efficiency.

As Thayer moves forward with our work on energy, we are dedicated to preparing the next generation of engineers to lead the world toward sustainable energy solutions.

Editor
Karen Endicott

Design
Wendy McMillan

Assistant Editor
Kathryn LoConte

Alumni News Editor
Theresa D'Orsi

Contributing Editors
Catha Lamm, Elisabeth McDonnell '08, Adrienne Mongan, Lee Michaelides, and Nancy Serrell

Editorial Board
Joseph J. Helble (ex officio), Maria Emory, Harold Frost, Elsa Garmire, Marcia Craig Jacobs, Peter Robbie, Ellen Stein '86, and Jeanne West

Office of Communications
Thayer School of Engineering
8000 Cummings Hall
Dartmouth College
Hanover, NH 03755-8000

E-mail:
dartmouth.engineer@dartmouth.edu
Telephone: (603) 646-3521
Fax: (603) 646-9133
engineering.dartmouth.edu

Address Changes
Thayer School Development Office
8000 Cummings Hall
Dartmouth College
Hanover, NH 03755-8000

engineering.alumni.records@dartmouth.edu

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Photo Illustration: Jun Yamashita / ailead

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Anthony Arch '09 travels on the veggie-oil powered Big Green Bus. Follow it—and four engineering students—at thebiggreenbus.org.
Photograph by Kawakahi Kaeo Amina '09

THE Great Hall

>>NEWS FROM AROUND THAYER SCHOOL

CAR TALK
Allie Fecych '07 Th'08 adjusts Thayer's car at the second annual Formula Hybrid International Competition. In electric-only mode, the car zoomed from zero to 60 mph in 4.5 seconds.

INNOVATIONS

Formula Hybrid Races Ahead

FOURTEEN STUDENT TEAMS TRAVELED FROM around the world to participate in the second annual Formula Hybrid International Competition in May at the New Hampshire Motor Speedway in Loudon, N.H. Founded and run by Thayer School to challenge engineering students to create high-performance hybrid race cars, the event drew five more teams than the inaugural year.

This year's American teams came from Dartmouth, Drexel, Embry-Riddle Aeronautical University, Florida Institute of Technology, Illinois Institute of Technology (two teams), North Carolina State University, University of California-Irvine, University of Vermont, University of Wisconsin-Madison, and Yale. McGill University in Canada, National Chiao Tung University in Taiwan, and MADI State Technical University in Moscow, Russia, also sent teams.

Day one of the three-day competition consisted of technical inspections and design and marketing presentations. Day two featured acceleration runs, the autocross competition, and design finals. The endurance event and awards ceremony were held on day three.

Like last year, McGill placed first overall, Embry-Riddle placed second, and Illinois Institute of Technology finished third.

Dartmouth took first place in presentation, unlimited acceleration, and the electric-only acceleration categories. "When the Dartmouth car did the acceleration run, jaws dropped," says Thayer professor Charles Sullivan, an advisor to the Dartmouth team. "When it's in electric-only mode, it sits on the starting line silently, so it's a shock to see it go 75 meters in under 5 seconds—the equivalent of 0 to 60 mph in about 4.5 seconds."

Thayer School modeled the Formula Hybrid meet after the Formula SAE (Society of Automotive Engineers) competition, in which Dartmouth students have competed for more than a decade. The key difference is that Formula Hybrid limits cars to a fixed amount of fuel. "That's a challenge that proves difficult to master," says Thayer research engineer and Formula Hybrid director Douglas Fraser, who organized the competition with colleague Wynne Washburn.

Formula Hybrid's emphasis on fuel efficiency attracted a growing number of sponsors, including the SAE, the Institute of Electrical and Electronics Engineers (IEEE), Plug In America, Toyota, General Motors, and Chrysler.

The competition provides opportunities for sponsors and students to explore new technological solutions. "We believe that ideas developed for competition today may lead to everyday applications tomorrow," says Fraser.

Students glean advice from one another, too. "McGill had a great car again," says Dartmouth team member Calvin Krishen Th'07. "The main thing, though, is that they spent a lot of time testing it. We finished our car too late to be able to work out all of the quirks." His advice for next year's team: "Leave plenty of time for testing."

The challenge of this course was to make a net-zero community that produces as much energy as it uses.

IN MEMORIAM

Toomas Laaspere (1927–2008)

TOOMAS LAASPERE, 81, DIED JUNE 10 IN Hanover. Born in Estonia, he left his homeland when Russia invaded it in 1944. He spent five years in P.O.W. and displaced person camps in Germany and Belgium before working at a refugee organization in Germany. He came to the U.S. in 1951 to study electrical engineering at the University of Vermont and then earned his master's and doctoral degrees at Cornell. He taught at Thayer School from 1961 to 1989. During that time, he worked on radiophysics with Professor Millett Morgan, carrying out research on wave propagation related to geophysical phenomena. Working on whistlers—audio-frequency radio waves produced by lightning and the aurora—Laaspere and Morgan designed and fabricated satellite sensing devices launched by NASA in the 1960s. An early promoter of energy conservation, during the 1970s Laaspere advocated for efficient generation, distribution, and use of electricity, including technologies for load leveling and electric heat storage.

Laaspere is survived by his wife of 53 years, Suzanne Champagne, his sister, three children, and two grandchildren.

Toomas Laaspere

CLASSROOM

Sustainable Communities

FOR THEIR CLASS PROJECT IN ENGS 44: SUSTAINABLE Design, 20 students aimed to improve not only a nearby community but also the environment. "The challenge of this course was to make a net-zero community that produces as much energy as it uses and contributes no new traffic on the existing main artery," says Professor Peter Robbie, who co-taught the course with Thayer professor Benoit Cushman-Roisin and Dartmouth studio art and architecture professor Karolina Kawiaka.

Student groups worked on a real-life site: 254 wooded acres between Hanover and Lebanon. Designing residential and community space for employees of Dartmouth-Hitchcock Medical Center and nearby businesses, the groups calculated electricity, heating, and cooling demands, conducted feasibility studies on population density and transportation issues, and determined ecological footprints and LEED certification ratings. One team designed a ground-source heat pump, photovoltaic panels, and an innovative woodchip furnace to produce 3500 Mbtu/month. Another suggested community greenhouses, hybrid shuttle routes, and a community bike program. Students proposed a geothermal heat pump, composting toilets, a forced air ventilation system, and structural insulating panels and triple glaze windows for the building envelope design. One group designed a community that mimics the natural topography and devised an ecological wastewater treatment system.

"This course provides a model for integrated design practice that is emerging among the best firms in the country," says Robbie. "An engineer's understanding of what's possible—using technology to make efficient buildings, minimizing use of artificial light, using photovoltaics so that buildings take care of themselves—is completely changing the game."

The course appeared to change the students as well. "Environmental design really resonates among this group of students," says Robbie. "They really see it as a moral issue and know that they can help make a difference." *—Kathryn LoConte*

kudos

>> Professor Reza Olfati-Saber has earned a CAREER Award, the National Science Foundation's top award for young faculty, for his work on mobile sensor networks.

>> Two professors have been named to endowed chairs. Ian Baker, an expert in metallurgy, ice physics, and nanomaterials science, has become the Fairchild Professor of Engineering. Keith Paulsen Th'84, co-director of the Dartmouth Advanced Imaging Center in Radiology, is the inaugural holder of the Robert A. Pritzker Chair in Biomedical Engineering.

>> Ursula Gibson '76 and Brian Pogue have been promoted from associate to full professor.

>> Professor Anatoly Streltsov Th'95 has been elected secretary of the Commission H (Waves in Plasma) of the U.S. National Committee for the International Radio Science Union.

>> Professors Laura Ray and Eugene Santos Jr. are two of three New Hampshire scientists who have been awarded research grant funding from the U.S. Department of Defense totaling nearly $1.6 million. Ray will employ wireless sensor networks to develop and test a theory that could improve the interpretation of sound by humans in remote or battlefield environments. Santos will develop an advanced cognitive-based communication protocol for medical teams to improve decision making and problem solving in trauma environments.

HIT THE LIGHTS
No card, no current.

SERVICE TO HUMANITY

Technologies for Better Living

STUDENTS FROM DARTMOUTH HUMANITARIAN Engineering Leadership Projects (HELP) Worldwide and Dartmouth Engineers Without Borders (EWB) have been working to improve living conditions in Kenya and Rwanda. Here's an update on their projects:

Micro-Hydropower Turbine: Over the next two to three years, students will install a micro-hydropower turbine in the water-rich Banda Village in southwestern Rwanda.The 10kW system is being designed for optimum efficiency, cost, and ease of maintenance.

"One of driving forces behind the Rwanda project is to make a whole system that can be designed and manufactured locally," says 2007–08 HELP/EWB president Benjamin Koons '08. "We're trying to back away from the standard development model where foreign-aid industries bring in first-world components. If you bring a solar panel from Japan and a pump from Germany into a rural village in sub-Saharan Africa, it'll work great until a fuse blows. Then you've got $30,000 of equipment that's sitting around gathering dust."

An overall goal, Koons explains, is to transfer the knowledge of how to repair and sustain the turbine to the community. "If the product is successful, then the knowledge can spread naturally through the framework," he says.

Regional components include modified bike bearings, car alternators adapted as generators, and pipe sections that will be used as buckets for the turbine. "By using locally available materials, we're cutting the kilowatt cost by a factor of 10, which is fairly ambitious," says Koons.

Biogas System: In the summer of 2007, three students traveled to a health clinic in Bisate, Rwanda, to implement a biogas digester system. The project aimed to address contamination and energy issues by converting human waste into sanitized fertilizer and clean-burning fuel.

"The biogas project was a relatively low-cost, low-tech solution," Koons says. "Instead of human waste contaminating ground water by leaching through the soil, it goes into the anaerobic digester, which is essentially a capped concrete form that contains the waste and keeps it oxygen free. When it decomposes in the absence of oxygen, you get methane, CO_2, and trace elements of sulfur—which turns the waste into a great fuel source."

Koons traveled back to Bisate in the winter of 2008 to review project results. "The sanitation system has greatly improved the clinic," he says. "To have clean toilets that aren't contaminating ground water is a pretty obvious improvement."

Water Sanitation Project: For years, Dartmouth engineers have helped improve living conditions in the village of Nyamilu, Kenya. Students installed a solar-powered water pump in 2005 and a gravity-fed water distribution system in 2007. The finished project incorporates a 30,000-liter tank and 6,000 meters of pipe that run a radius of two kilometers around the well. The distribution system brings water to 12 taps serving the primary school, church, town center, and other population clusters, meeting the drinking-water needs of 2,000 people.

Unable to travel to Kenya this summer because of violence in the area, HELP engineers plan to return as soon as possible. Meanwhile, they are maintaining contact with Nyamilu officials to ensure that clean water keeps flowing.

—Kathryn LoConte

A LITTLE HELP FROM THEIR FRIENDS
Nick Edwards '10 and community members lay pipes for distributing clean water in Nyamilu, Kenya.

STUDENT PROJECTS

I Want One of Those!

▲ Hit the Lights

DARTMOUTH STUDENTS USE 8,572 kilowatt hours per day, much of it wasted by leaving on lights and appliances. The "Hit the Lights" system requires students to insert their Dartmouth ID card into a radio-frequency card reader to activate lights and outlets in dorm rooms. No card, no current—except for designated outlets for appliances that need constant power. The foolproof system reduces energy usage up to 33 percent. Creators **Michael Bush '11, Eric Durell '11, Michael Lewis '11, Thomas Mandel '11,** and **Paul Seebacher '11** won the Phillip R. Jackson Award for outstanding performance in ENGS 21: Introduction to Engineering. Their teaching assistant was **Andrew Herchek Th'09.**

"A lot of universities have built prismatically shaped solar greenhouses that no farmer could ever possibly afford."

GREENHOUSE EFFECT
Chris Polashenski '07 Th'07, second from left in group, listens to environmental studies professor emeritus James Hornig at greenhouse dedication ceremonies at the Dartmouth Organic Farm.

REAL-LIFE APPS

Organic Farm Goes Solar

SINCE 2004, CHRIS POLASHENSKI '07 TH'07 HAS bettered the Dartmouth Organic Farm greenhouse one innovation at a time. For an ENGS 190/290 project, Polashenski and Luke Wachter '06 retrofitted the structure to run on solar power instead of fossil fuels. "This greenhouse is typical of what most farmers have, and it's a realistic project," says Polashenski, who is now pursuing his Ph.D. at Thayer School. "A lot of universities have built prismatically shaped solar greenhouses that no farmer could ever possibly afford."

This idea reflects one of their major criteria: every adjustment must be profitable. "Just the fundamental fact that we're trying to make a profit is significant. It's a big step in the right direction," says Polashenski.

The pair constructed the building so that its ridgeline runs east-west. "It therefore has the most area facing south and gathers the most sunlight over the course of the day," says Polashenski. "We're just trying to optimize the process to capture as much heat as possible."

For additional heating, Polashenski sited 12 734-gallon concentric water tanks along the north wall to capture heat during the day and release it at night through a system of manifolds and piping that runs beneath the soil. "Circulating the warm water from those baths into the root zone of the plants is a way to store heat, but also do more with less," says Polashenski. "Agricultural studies show that only the roots need to be heated. Most greenhouses heat the air. They've got it all wrong."

The tanks will also work double duty, letting environmental science majors grow local algae and fish as fertilizer for the greenhouse and as a food source. "Originally, the plan was just to use the tanks as thermal storage," says environmental studies major Tara McNervy '09. "But they also act as a living laboratory for Dartmouth students to research aquaculture and aquatic ecosystems."

For the structure Polashenski and Wachter used insulating concrete forms, pouring concrete between two pieces of Styrofoam. "It's a slick idea," says Polashenski. "In the old method, people would strip the forms down when the concrete hardened, haul them away, and then add insulation. We eliminate that step by using the insulation as the concrete form in the first place."

Planned future additions include a vertical reflector to catch sunlight and a retractable night curtain to trap heat. Even without them, however, the greenhouse works, as Polashenksi verified last winter. "It was unbearably warm inside in late February," he says.

Polashenski is pleased with the progress. "I expect that at some point all of the designs will be done," he says. "Overall, we're posing a problem in a way that no one seems to have done before."

—Kathryn LoConte

THIS PAGE: KATHRYN LOCONTE. OPPOSITE PAGE: TOP, COURTESY OF "HIT THE LIGHTS" GROUP; BOTTOM, COURTESY OF HELP/EWB.

kudos

>> Tom Scanlon, research associate, has been named the third annual Carol Basbaum Memorial Research Fellow by the Cystic Fibrosis Foundation. Scanlon has been working with professor Karl Griswold on enzyme therapeutics for treating complications associated with cystic fibrosis. The two-year fellowship provides $86,100 for new therapeutics for cystic fibrosis.

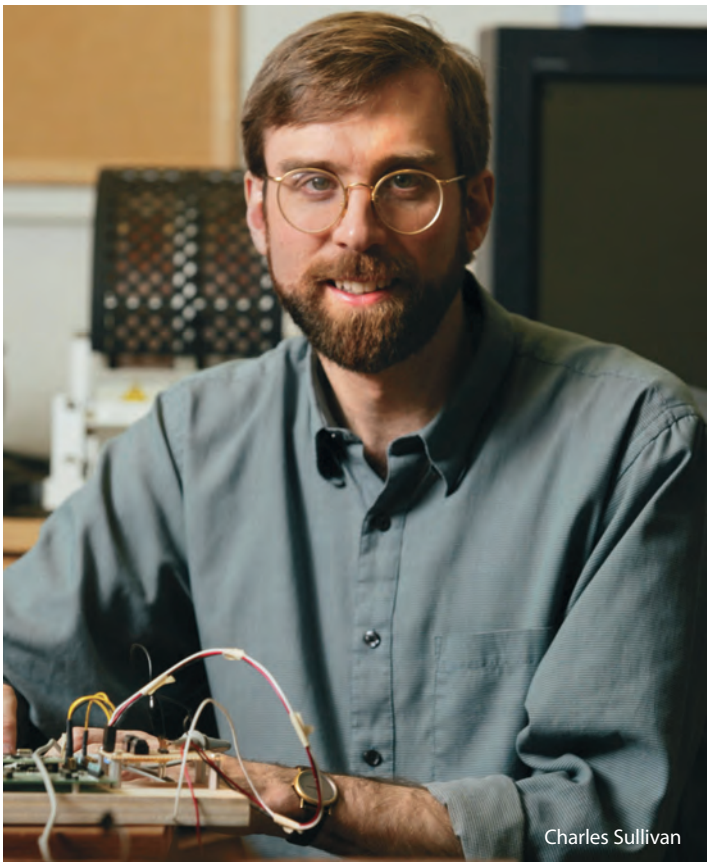
>> Professor Mark Borsuk has received an Early Career Research Excellence Prize from the International Environmental Modelling and Software Society.

>> Thayer School has been awarded a place in the Armed Forces Institute of Regenerative Medicine, a multi-institutional, network developing advanced treatment options, such as tissue engineering, for severely wounded U.S. servicemen and women. "This new program will provide state-of-the-art technologies to help the wounded in the present wars," says Dr. Joseph Rosen, the Thayer principal investigator and an adjunct professor of engineering and Dartmouth-Hitchcock Medical Center plastic surgeon. "It will also have long term dual use for civilian-related problems."

>> Schweitzer Fellows Philip Wagner '09 and Caitlin Johnson '10 organized two events at Thayer in April to introduce kids to robotics. Through Dartmouth's FIRST (For Inspiration and Recognition of Science and Technology) Lego League, Thayer students showed elementary and middle school students how to build and program robots made of Legos.

>> Jessica Ogden '08 Th'08 won first prize in Dartmouth's Christopher G. Reed Science Competition for her research poster on "Toxicity and Efficacy of Iron Oxide Nanoparticles for Cancer Therapy." Her advisor was Thayer adjunct and Dartmouth Medical School radiobiology professor Jack Hoopes.

lab reports


Charles Sullivan

MORE POWER, LESS MONEY

Thayer Professor Charles Sullivan is working to improve the performance of passive high-frequency power components in order to make power electronics more energy efficient and cheaper to manufacture.

According to Sullivan, the passive components are often the limiting factors in improving the efficiency and lowering the cost of high-frequency electronic power converters. His research targets inefficiencies in the inductors, transformers, and capacitors that handle AC-DC, frequency, and voltage conversions required by electronic devices. For example, the power adaptors that laptop computers use to convert 120-volt AC power to lower voltage DC power lose considerable energy in the form of heat.

High-frequency electronic power converters are often problematic due to their size and weight, says Sullivan. Designers, he says, generally know how to make high-frequency power converters more efficient, but the results can be unwieldy and prohibitively expensive. Thus, efficiency often is sacrificed to make converters affordable. Sullivan maintains that innovation in both the application of new materials and the geometric configuration of circuits will improve the performance and cost of passive power components.

He sees advances in information technology as both a model and means for improving power electronics. "Electronic information handling has made it possible to access efficiently exactly the information we need," he says. Applying similar techniques to energy processing would "similarly allow us to use exactly the energy we need where and when we need it, with less waste," he says. "Our goal is to make designing power electronics as easy as designing information electronics, so that we can see the same rapid advances in energy applications as we've seen in information applications."

—Elisabeth McDonnell '08

POLLUTION-DETECTING MOLECULES

Thayer Professor Ursula Gibson '76 and researchers at the University of New Hampshire are collaborating on a new method of monitoring watershed pollution: using molecularly imprinted polymers to detect contaminant molecules. Designed to recognize organic solvents, the polymer films can target a pollutant and generate a signal based on its concentration. An array of such sensors could be used to detect spills and locate their sources.

Gibson's team is currently developing the polymer coatings and investigating how to arrange them in the most sensitive configuration. Once they accomplish this, they will work on integrating specific coatings into an autonomous sensor package capable of identifying pollutants and reporting their levels for extended periods. *—E.M.*

ADVANCES IN ETHANOL

The nation's thirst for gasoline alternatives is driving new rounds of investment in Mascoma Corp., the cellulosic biofuel company co-founded in 2005 by Thayer Professors Lee Lynd Th'84 and Charles Wyman. The three-year-old start-up recently reached $100 million in equity investment and received commitments for another $100 million in state and federal grants, including a $26-million grant from the U.S. Department of Energy.

Using proprietary microorganisms developed at the company's laboratories in Lebanon, N.H., Mascoma is pioneering new ways to turn non-food, renewable biomass—including wood, straw, switchgrass, paper pulp, and agricultural wastes—into ethanol and other biofuels. Lynd, recipient of the first Lemelson-MIT Award for Sustainability in 2007, is championing a single-step process for converting cellulose to ethanol—he calls it Consolidated Bioprocessing (CBP)—that is designed to be faster, cheaper, and more efficient than current methods. Mascoma is testing its CBP technology and expects to begin ethanol production later this year at the demonstration plant it is constructing in Rome, N.Y.

Investors in Mascoma, whose corporate office is in Boston, now include Marathon Oil Corp., General Motors, Khosla Ventures, Flagship Ventures, Atlas Venture, General Catalyst Partners, Kleiner Perkins & Byers, Pinnacle Ventures, and Vantage Point Venture Partners.

For Lynd's views on the viability of cellulosic ethanol as an alternative to corn-based ethanol, turn to page 18.

investiture

CEREMONIAL GESTURE
Professor Erland Schulson places a hood on B.E. graduate Allie Fecych '07 Th'08 as Professor Robert Graves looks on.

Investiture speaker Richard W. Couch '64 Th'65

MARK WASHBURN

CLASS OF 2007
Engineering Graduates

12	Doctor of Philosophy
13	Master of Science
36	Master of Engineering Management
54	Bachelor of Engineering
60	A.B., Engineering Sciences

THE INVESTITURE CEREMONY honoring Thayer School's Class of 2008 was held June 9 in Spaulding Auditorium at the Hopkins Center. Presiding over the presentation of hoods, caps, and awards to 115 recipients of Bachelor of Engineering and graduate degrees, Dean Joseph Helble told graduates, "I hope during your years here you have learned a little from the faculty and staff. We have certainly learned from you. We have been inspired by you."

The recipient of Thayer School's Robert Fletcher Award for distinguished achievement and service was Richard W. Couch '64 Th'65, CEO and Chairman of the Board of Hypertherm, the plasma cutting systems company he co-founded with former Thayer professor Robert Dean. "To receive the same award as my mentor and advisor, Myron Tribus, dean of the engineering school when I was here, is a wonderful recognition," Couch said in his Investiture speech. He went on to tell graduates, "The advantage of a Dartmouth engineering education is its breadth. The disadvantage is you will have to explain many times that you don't have an electrical or mechanical degree, you have an engineering degree from Dartmouth."

The ability to straddle fields is crucial, he said. "Many of the most challenging engineering problems are multidisciplinary. At Hypertherm, we design and manufacture plasma cutting equipment—an electric arc process for cutting steel. Deep knowledge of heat transfer, material properties, physical chemistry, and electronics are necessary to design our equipment. Our core competency is the intersection of plasma process design and high-power electronics. You need both to be successful. There are many organizations that have capability in one or the other, but not many with both."

For Couch's speech and more photos from Investiture, visit engineering.dartmouth.edu/alumni/investiture/2008/index.html.

honors

>> The Dartmouth Society of Engineers Prize for outstanding B.E. project: Christina Behrend '07 Th'08, Shiraz Cassim '07 Th'08, and Matthew Pallone '07

>> The Dean's Service Award for outstanding service to Thayer School, Dartmouth, or the broader world: Laura B. Weyl Th'08

>> The Charles F. and Ruth D. Goodrich Prize for outstanding achievement: Luke Wachter '06 Th'07, '08

>> The Caroline Henderson Prize for best M.E.M. project: Matthew Malvezzi '06, Th'07, '08

>> The Thayer School of Engineering Corporate Collaboration Council Engineering Design Prize for best performance in ENGS 190/290: Drew Branden Th'08, Scott Newbry '08 Th'08, Augusta Niles '07 Th'08, Kevin Olds '07 Th'08, Eric Trautmann '07 Th'08, and Michael Zargham '07 Th'08

>> The Thayer School of Engineering Faculty Award for Academic Excellence in B.E. course work: Kevin Olds '07 Th'08 and Michael Zargham '07 Th'08

>> Special Faculty Award for Engineering and Service to Humanity: Kristen Lurie '08 Th'08

>> The Brieanna S. Weinstein Engineering Design Prize for new technologies, systems, or devices addressing physical or developmental disabilities: Jessica Ogden '08 Th'08 and Jennifer Tate '08

>> The John C. Woodhouse Engineering Design Prize for cost-effective designs of experimental equipment: Summer Gibbs-Strauss Th'08

>> The John C. Woodhouse Environmental Engineering Prize for outstanding work in environmental study or research: Benjamin Koons '08

>> Excellence in Teaching Award: Benoit Cushman-Roisin

>> Outstanding Service Award for Faculty: Eric Hansen

>> Outstanding Service Award for Staff: Mark Franklin '83 Th'85 and Tracy Rounds

HEEDING THE CALL
Cathy Zoi Th'08, on a beach in Australia, left her down-under home when Al Gore asked her to head the Alliance for Climate Protection.

MOTHER EARTH'S Best Fri

FROM LIVE EARTH TO "WE CAN SOLVE IT," ALLIANCE FOR CLIMATE PROTECTION CEO CATHY ZOI TH'85 LEADS THE CHARGE FOR CHANGE.

end

Americans pay good money to sit in the dark, watching a superhero or rogue secret agent save the earth from the doom du jour: killer aliens, nuclear holocaust, maybe a planetary death ray. In Hollywood, saving the earth is everyday business—strictly fictional, of course. But for Cathy Zoi Th'85, saving the earth is literally her daily, all-consuming job. Her story line may unfold from a low-key, nondescript office building in Silicon Valley, but her mission is decidedly dramatic: she's got three years and a $300-million budget to convince the American public that climate change is an urgent and solvable problem that our lawmakers must address now to avoid catastrophic consequences.

Zoi is CEO of the Alliance for Climate Protection, a non-profit started in 2006 by former Vice President Al Gore—"my boss, Al," as Zoi says in casual conversation. At the center of its work is the grassroots public awareness campaign "We," as in "We can solve the climate crisis," designed to empower and empassion 10 million members to pressure legislators to make the right decisions for our environment. If the public doesn't loudly voice concern about climate change, says Zoi, politicians have little incentive to take painful, yet critical steps such as taxing carbon emissions or incentivizing utilities to sell fewer kilowatt hours.

Where do Americans presently rank climate change on the priority list of issues including the economy, social security and health care? Near the bottom. Making it a top three issue—the Alliance's goal—won't be easy, but Zoi is uniquely qualified for the job, with experience in the Clinton-Gore White House's Office of Environmental Policy and having already been through a trial run in Australia. Between 1995 and 2006, Zoi held numerous governmental, non-profit, and private sector jobs in Australia which raised the national consciousness about climate change.

"The election that happened last November in Australia was probably the first national climate change referendum

BY JULIE SLOAN '99

PHOTOGRAPH BY PETER MORRIS / THE SYDNEY MORNING HERALD

> "It's not individuals who are making decisions on new power plants. We're educating people that we've got to make our voices heard in a policy context."

election in the world," says Zoi. "The guys who made a commitment to solve the climate crisis got elected. We would love for that to happen here." The U.S., she concedes, is larger and more complex, but then so is the We campaign's strategy.

Among environmental education efforts, the We campaign is groundbreaking for its scale and tactics, using online mobilization through its website, wecansolveit.org, innovative grassroots organizing, and a blitz of traditional media. The Alliance's television commercials, which have been running since April, feature improbable duos like Nancy Pelosi and Newt Gingrich or the Rev. Pat Robertson and the Rev. Al Sharpton seated on the same couch. The idea: They don't agree on much, but they do agree we must take action to prevent climate change. The Alliance is also running print ads in national magazines and newspapers with eye-catching headlines like, "You can't solve the climate crisis." Working together, it continues in smaller type, we can.

To date, the alliance has 1.2 million members. Zoi and her team are reaching out to diverse groups, from farmers to evangelical Christians to steel workers to Girl Scouts. And despite being founded by a high-profile Democrat, the Alliance is consciously non-partisan, with at least half of its board comprised of prominent Republicans, such as Brent Scowcroft, former National Security Advisor to Gerald Ford and George H.W. Bush, and Lee Thomas, who headed the Environmental Protection Agency under Ronald Reagan.

The Alliance's message isn't about small, everyday changes like switching to reusable shopping bags and energy-efficient compact fluorescent light bulbs—not that those aren't helpful. It's about gathering enough voices to effect the big changes.

"There are more than $100 billion worth of proposed new dirty coal plants on the books right now," says Zoi. "Once those plants get built, they will run for 50 years. It's not individuals who are making decisions on new power plants. We're educating people that we've got to make our voices heard in a policy context."

AS AN UNDERGRADUATE AT DUKE UNIVERSITY, Zoi studied geology. Ahead of her was a well-worn path for geology majors to land lucrative jobs in the oil industry. Between her junior and senior years, Zoi tested those waters with an internship at an oil company. As part of her job there, she pored over parcels of land in Texas and South Dakota, the same ones oil companies had been scouring for years. "I felt like there had to be a different sort of energy future," says Zoi, "one that's sustainable and not limited."

Upon graduation from Duke in 1983, Zoi decamped for a unique, multidisciplinary two-year master's program at Thayer's Resource Policy Center (which later became incorporated into environmental studies at Dartmouth). The program combined the rigor of quantitative analysis with resource and energy policy. Students even took a class in communications.

Bryant Patten '82 Th'85, Zoi's classmate in the program, isn't surprised that Zoi has gone on to accomplish great things.

"When we landed in Hanover, we all spent a few weeks getting our bearings in a new town, trying to figure out where everything was," says Patten. "Meanwhile Cathy had found where the local food bank was, volunteered there, and talked another classmate into going with her. We were sorting out housing and books. Cathy's immediately thinking, 'How do I volunteer and make this community better?' That is Cathy in a nutshell."

Zoi took the Resource Policy Center's multidisciplinary approach to heart, pursuing unique fellowships in her time off. During one break, she reported for Wisconsin Public Radio as part of a project aimed at connecting scientists with mass media outlets to enhance the public's understanding of science. In another fellowship sponsored by Dartmouth's Dickey Endowment, Zoi spent several months in Vienna working for the UN on an energy-for-Africa project.

"Each of those experiences, even if they were only three or four months long, allowed me to be able to connect dots, to be a better communicator, and to understand different points of view," says Zoi.

After leaving Dartmouth, Zoi worked as an analyst for Pacific Gas & Electric before moving to Washington, D.C., to do energy modeling for the consulting firm ICF. In 1989, she joined the Environmental Protection Agency where, among other things, she launched the Energy Star program, the labeling system that today brands everything from dishwashers to roofing products as energy efficient. At the time, says Zoi, the intent was to tackle computer equipment.

"In 1988 and '89, everyone was getting a desktop computer, and they were afraid of losing their data, so they left them on all the time," says Zoi. By encouraging computer makers, including IBM and Apple, to use power-saving "go to sleep" technology from laptops in their desktops—thereby saving consumers money and getting what Zoi calls "an environmental good-guy sticker"—they could sell more computers.

Her EPA work also put her in touch with a senator who was holding hearings on the climate crisis: Al Gore. When Senator Gore became Vice President, he elevated the status of the White House's Office of Environmental Policy, where Zoi served as Chief of Staff.

During that time, Zoi learned an important lesson about the will of the masses. In 1997, Gore flew to Kyoto and committed to the now-famous international treaty on climate change. But when he returned, the Senate wouldn't ratify the treaty for lack of public will to make the changes the treaty would require. "We don't have time for a re-run of that," says Zoi.

After several years in the White House, Zoi, her energy consultant husband, Robin Roy, and their two children moved to Australia for what was to be a one-year government-to-government exchange. The Roy-Zoi family, as some friends call them, fell so in love with Australia that they stayed for 12 years.

In Australia, Zoi was the Assistant Director General of the New South Wales EPA; the founding CEO of Australia's Sustainable Energy Development Authority, a government-owned venture fund to invest $50 million in companies that would commercialize and mainstream greenhouse-friendly technologies; and a founding board member of the Climate Institute, whose mission is not unlike that of the Alliance for Climate Protection: to focus the public's attention on climate change and make it a national priority. From 2003 until she left in late 2006, Zoi was Group Executive Director at Bayard Group, a billion dollar company which makes smart meters, devices inside the home that show consumers how their energy is being used and how they might save money by using it differently.

Zoi reconnected with Gore when he came to Sydney to launch his movie, *An Inconvenient Truth*. "I think that's when he realized, 'Ah! Maybe this woman can come back and help us in the U.S.,'" says Zoi. "I had been gone for so long."

The move was, Zoi's friends say, a big sacrifice. Zoi and Roy had become very settled in their home overlooking Sydney harbor. Their two children even have Australian accents. Roy must now commute "via mouse" to Sydney to

Cathy Zoi Th'85 discusses climate-protection goals at a press conference for 2007's Live Earth concert along with concert organizers Kevin Wall, left, and Al Gore.

MICHAEL LOCCISANO / FILM MAGIC

We Can Solve It

Cathy Zoi's advice on how individuals can protect the climate.

- Advocate for change. Demand that your country take leadership to solve the climate crisis. Tips for how to advocate in your own community can be found at wecansolveit.org/content/advocate/.
- Join the We campaign. Sign our petition at wecansolveit.org/content/actions/.
- Engineer a cleaner environment. From energy efficiency and smart design to urban planning and nanotechnology, the engineering professions play a significant role in building a renewable future. Don't be afraid to redefine the way you and your company do things. In many cases, the green solution can bring cost savings as well.
- Green your own home. Invest in energy efficient appliances and equipment to minimize your impact and reduce your home energy bills. For a list of things you can do around the home, visit climateprotect.org/ah5.
- Know your own power. Find out where your electricity is coming from and demand that your local utilities and elected officials offer cleaner sources of electricity. Support initiatives that will level the playing field for renewable energy.

manage his consulting business, Next Energy. But the Alliance was simply too big an opportunity to pass up.

Since she arrived in February 2007, Zoi told an audience at Thayer in October, "it's just been 900 miles an hour." She's hired 20 staff members in that time. For the first six weeks, the initial team worked on laptops in and around her Los Altos Hills home. Their first project was no small potatoes: they had five months to work on the environmental messaging for the Live Earth concert as well as greening the concerts themselves. The Alliance was the charitable beneficiary of Live Earth, and also received Al Gore's share of the proceeds from *An Inconvenient Truth*, both the book and the movie, and his Nobel Peace Prize. (The latter sum, $750,000, Gore personally matched.)

THE WORD FROM SCIENTISTS WHO STUDY climate change is that in order to avert catastrophic climate change, global emissions need to drop by more than 50 percent from their 2000 levels by the middle of the century. It's a major change rivaled only in magnitude by the consequences of not changing.

"The cold hard reality is that most people do not adequately appreciate what is happening to the planet in terms of climate change," says David Nemtzow, an energy efficiency consultant in Santa Monica, Calif. and long-time colleague of Zoi's in both Washington D.C. and Australia. "Some people don't know what's going on, some don't care, some think we'll just figure something out. Under some scenarios, one-third of species currently alive will disappear in several decades. Most Americans don't get the gravity of what we're up against."

The Alliance's strategy is to emphasize urgency of the problem, but also solvability. Zoi lights up when asked about currently available green technologies that hold promise for the U.S. Ecometers, a product made by her former employer in Australia, sit inside the home and tell residents how much energy they're consuming. "We found just by giving people real-time information in their kitchen, there is a five-percent energy conservation," says Zoi. "Otherwise power usage is invisible. It's like having to drive on a road with a speed limit, but you have no speedometer." California will be rolling out ecometers, says Zoi, and is among a few places that has legislation in place to reward utilities for electrons they don't sell. "We need more schemes like that."

She also sites concentrated solar thermal technology, in which curved mirrors gather energy from the sun. "You could fill up a 94-mile by 94-mile parcel in the southwest with curved mirrors and generate enough electricity for America," says Zoi. "And it's pretty affordable, especially if you've got an investment tax credit in place."

Both 2008 presidential candidates, John McCain and Barack Obama, have voiced a commitment to putting a legislative cap on carbon, but Zoi's political experience tells her it isn't enough. "They also have policy positions on dozens of things," she says. "The question we have is: Will they make it a top priority issue?"

According to those who know her, Zoi has long been good at pushing the issue without pushing buttons. "Cathy's known for being dynamic, intelligent, engaged, and committed," says Nemtzow. "She wants to get the right answer and get things done. Plus she's extremely likeable—that definitely helps."

Zoi's work brings her into the orbit of celebrities, politicians, and high-powered people, but when Thayer classmate Bryan Patten met up with Zoi last year after years apart, he recognized the same old Cathy. "She sort of laughs at the star power stuff," he says. "She has an incredible head on her shoulders and she feels really lucky."

"I'm impatiently joyful, or joyfully impatient," says Zoi. "I know the clock is ticking, but I also know this is an enormous opportunity." While an economic recession poses economy-wide challenges and impacts us all negatively, Zoi hopes that it may serve to galvanize the country behind clean, sustainable energy.

"The technology has been there for 20 years—not using it is like leaving $5 bills on the sidewalks," she says adamantly. "Now maybe we'll get organized to act." □

Julie Sloane is a freelance writer based in San Francisco.

IDEAS FOR SOLVING THE ENERGY PUZZLE

NINE ALUMNI EXPERTS OUTLINE THE CHALLENGES AND OPPORTUNITIES.

ENERGY AND CLIMATE CHANGE ARE TWO OF THE MOST PRESSING PROBLEMS IN NEED OF ENGINEERING EXPERTISE. NUMEROUS THAYER SCHOOL ALUMNI ARE WORKING ON A WIDE RANGE OF INTERSECTING AND COMPLEMENTARY SOLUTIONS. WE'VE ASKED NINE OF THEM TO SHARE THEIR EXPERTISE ON TECHNOLOGIES BOTH OLD AND NEW. THEIR VERDICT: TECHNOLOGY, ECONOMICS, AND PUBLIC POLICY ALL PLAY VITAL ROLES IN THE QUEST FOR MORE AND GREENER ENERGY.

BY LEE MICHAELIDES

ANN CUTTING/ PHOTONICA

SOLAR ENERGY

ROB WILLS TH'83
CTO, Citizenre
citizenre.com

Rob Wills has worked in the solar-energy industry for the last 25 years, specializing in power electronics and control. Citizenre is a solar-energy start-up.

SOLAR PANELS FOR ALL

Citizenre aims to become "the McDonald's of photovoltaics." We want to power 25 percent of the U.S. residential electric market by 2025. To get there, we plan to build the world's largest solar panel factory. It will have the capacity to manufacture enough panels for 100,000 homes a year.

RENT, DON'T BUY

Our approach is to rent complete solar power systems to homeowners. We'll install and operate the system. Homeowners will recoup the rental cost by not buying power from their electric company—and they'll pocket any money resulting from sales of solar power to the electric company.

QUICK INSTALLATIONS

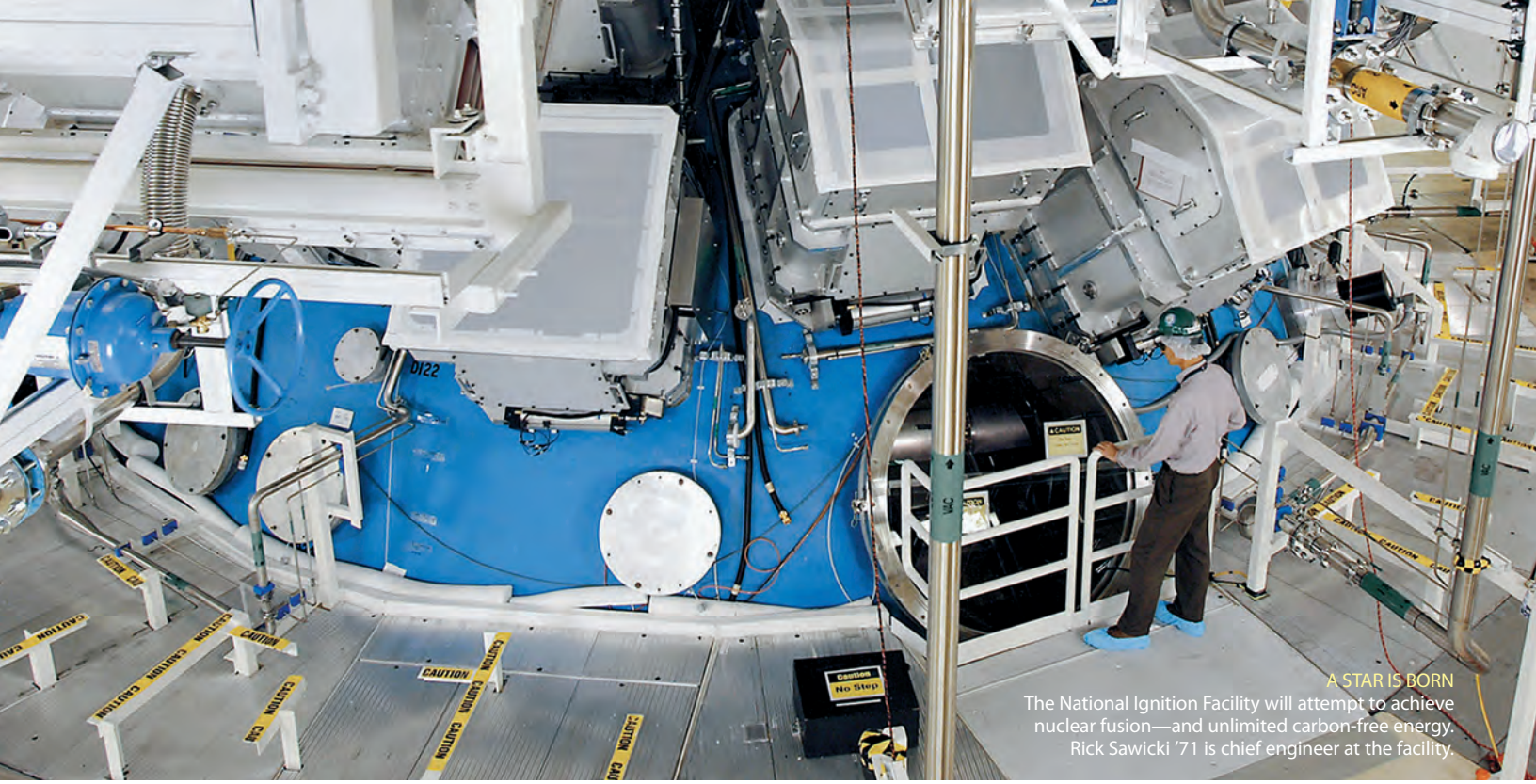
Our systems can typically be installed in just four hours. What makes that possible? Clever design, standardized components, and lifting equipment.

POLICY MATTERS

It is astounding that federal tax credits for solar and wind have had such a tough time getting passed. Research here is lagging. It may already be too late. Some of the best research isn't being done in the United States.

OPPORTUNITIES FOR ENGINEERS

A limiting factor for solar power is a shortage of solar-grade silicon. We need engineers to develop an alternative silicon production process that is less energy intensive and less toxic. We also need new materials to make solar panels more efficient. Today's panels are 20–30 percent efficient. If they were 50 percent efficient, rooftop panels the size of a couple of skylights could power an entire home.



A STAR IS BORN
The National Ignition Facility will attempt to achieve nuclear fusion—and unlimited carbon-free energy. Rick Sawicki '71 is chief engineer at the facility.

OIL PRODUCTION

CHARLES NEARBURG '72 TH'73

Founder and President,
Nearburg Producing Company
Nearburg Exploration L.L.C.
Rincon Exploration LLC

Nearburg started his first oil and gas exploration company in 1979. With offices in Midland and Dallas, Tex., and Denver, Colo., Nearburg Producing has garnered two environmental awards from the U.S. Bureau of Land Management.

THE ROLE OF INDEPENDENTS

About 2,000 independents produce 68 percent of the oil and 82 percent of of the natural gas in the U.S.

CHALLENGES FOR INDEPENDENTS

The cost of drilling wells has at least doubled over the last three years. The wells we drill range from $0.75 million to $17 million. There's competition and/or shortages of virtually everything: professional engineers and geologists, equipment, drilling rigs, service contractors, and production workers. This is the most challenging exploratory environment I've ever experienced.

NEW WELLS TAKE TIME

We are an exploration company, and from the start of the scientific process to hopefully drilling a successful well to produce, can take five or six years. The drilling is the shortest part of the process. On federal land, especially in the West, you virtually cannot work on sites during winter or during environmentally sensitive periods such as raptor nesting season. That may just leave a three-month work window each year. The result is you can't quickly increase exploration and production to meet demand.

UNCONVENTIONAL RESOURCES

It's now economically feasible to develop more unconventional resources, such as oil and gas shales. Ten to 15 years ago it wasn't.

FROM OIL TO GAS

From the first well drilled approximately 100 years ago up until the 1960s, oil was the primary exploration target because there was no infrastructure to distribute natural gas. In the "old days" if a well found gas, it would be plugged. Oil is much harder to find than natural gas.

THE ECONOMICS OF GAS GUZZLING

It has been my experience, from my days as a sales engineer for heat pipe heat exchangers, that most companies and people will not focus on conservation until it hits them in the pocketbook. Until recently energy prices were low enough that people weren't conserving.

STILL DEPENDENT ON OIL

Oil is a depleting asset, as we all know, but for the next 30 years our economy will still be run on fossil fuel, and it is important that we continue to develop it and try to make it more efficient and environmentally friendly.

OPPORTUNITY FOR ENGINEERS

The oil and gas business covers a huge spectrum of technology and business. The new paradigm for the oil business is collaborative research, which is a Thayer School strength. And because many of today's geoscientists will be retiring over the next several years, there's plenty of room for today's students.

Download Nearburg's recent Thayer School Jones Seminar on oil and gas exploration at engineering.dartmouth.edu/news-events/lecture-series/jones/2008/CharlesNearburg.html.

NATURAL GAS

BENJAMIN SCHLESINGER '67 TH'68

Founding President,
Benjamin Schlesinger & Associates
bsaenergy.com/

Schlesinger has worked in the energy field for more than three decades and is a former vice president of the American Gas Association. His firm specializes in gas and electricity marketing, pricing, infrastructure, trading practices, strategic planning, and power plant development.

SUPPLYING DEMAND

Because it burns so cleanly and emits only about half the carbon dioxide of coal-electric plants, gas demand is already rising. We're working on liquefied natural gas (LNG) projects so that gas supplies from overseas can be delivered economically to the U.S. Until coal gasification and nuclear electric power plants get built, our big challenge will be to get enough natural gas delivered to where it's needed.

THE RISE OF UNCONVENTIONAL GAS RESOURCES

Our country's proven gas reserves have in-

creased almost every year since the mid-1990s, and will probably keep rising through the next decade. Why? Today's gas supplies are increasingly coming from high-cost unconventional resources, such as natural gas embedded in shale, tight sands, and coal seams. These resources were passed up in the 1980s and 1990s when gas prices were low, but now they're more than economical. Engineers are needed more than ever to help unlock these clean gas resources, and to help markets use gas as efficiently as possible.

ENERGY WORK

Thayer grads can not only find work in energy engineering and consulting firms, but also in companies that produce and transport energy, banks and investment firms that finance energy projects, and even law firms. We've consistently hired Thayer and Thayer-like grads who are grounded in both engineering and arts, and economics—these are the most valuable engineers.

NUCLEAR FUSION

RICK SAWICKI '71
Chief Engineer
National Ignition Facility
lasers.llnl.gov/

The National Ignition Facility (NIF) will attempt to create a miniature star through nuclear fusion. The project, started in 1995 and nearly complete now, includes a 705,000-square-foot facility at the Lawrence Livermore National Laboratory (LLNL). Scheduled to begin fusion experiments in 2009, NIF may set the stage for an unlimited carbon-free energy source.

THE SCIENCE

At LLNL we have been developing the technologies to achieve nuclear fusion through the process called inertial confinement fusion. This process utilizes very high-power laser beams to bathe a small spherical target, the size of a BB, containing the hydrogen isotopes deuterium and tritium with an intense energy pulse. If this energy can be deposited uniformly enough and with enough power density, then the surface of the target will rapidly heat up and blow off. The reaction of the blow-off will compress the remaining capsule to a fraction of its original size. When successful, we will compress the capsule to more than 20 times the density of lead, creating extreme temperatures and pressures in the deuterium-tritium mix—equivalent to conditions at the center of the sun. These conditions will enable the fusion process to ignite, releasing huge amounts of energy in the form of neutrons, x-rays, and gamma rays and creating, in effect, a miniature star in the laboratory.

PUSHING THE LIMITS

NIF is a dream challenge. We pushed the state-of-the-art in many areas to extremes that had not been achieved anywhere before. The construction project itself demanded that we build 192 identical lasers capable of delivering more than four megajoules of infrared laser light, which is frequency converted to nearly two megajoules of ultraviolet light, in a pulse lasting only a few billionths of a second—the equivalent of 500 trillion watts of power.

THE ROAD TO FUSION ENERGY

NIF is a major step forward along the path to fusion energy. We will demonstrate the ability to create self-sustained nuclear fusion in the laboratory, producing many times more energy than the amount of laser energy required to initiate the reaction.

ENGINEERS WANTED

We need the next generation of engineers to take the next step—developing an actual fusion power plant. Such a facility offers us an unlimited, carbon-free energy source for the future. We have to make this advance.

FUEL CELLS

LUKE T. DALTON '99 TH'01
Program Manager,
Proton Energy Systems
distributed-energy.com/hydrogen_generation.html

Dalton works on one of the key challenges of hydrogen fuel cell technology: producing hydrogen—without producing greenhouse gases.

SPLITTING WATER

At Proton Energy Systems, we generate hydrogen through the process of splitting water, called water electrolysis. Our equipment requires only water and electricity. If that electricity comes from photovoltaic cells, wind turbines, or hydroelectric turbines, then the hydrogen is produced with no greenhouse gas emissions. Water electrolysis powered by renewable electricity is one key pathway to a carbon-neutral, greenhouse gas-neutral energy economy.

FOCUS ON THE FUEL

Fuel cells by themselves don't accomplish much. Though more efficient than combustion engines, they are just energy conversion devices. Making the fuel renewable, sustainable, and carbon-neutral is as important, if not more so, if our primary concern as a society is the diminishing supply of fossil fuels, human-caused global warming, or energy security.

THE LONG VIEW

The focus in the industry has shifted from a rapid, wholesale changeover from combustion to fuel cells to a more gradual, realistic approach. The fuel cell industry has identified a few smaller premium power markets where the "high cost" of the fuel cell is actually quite competitive. Just because experts were smart enough a few years ago to see that a fuel cell is more efficient than an internal combustion engine doesn't immediately make it a better, more cost-effective product. The internal combustion engine has been refined for over 100 years. The fuel cell won't need 100 years to catch up, but it will need a few.

CHALLENGES FACING THE INDUSTRY

The first is building hardware that is sufficiently robust and cost-competitive. The second is to get the infrastructure in place to provide hydrogen to fuel cells. One option is to make hydrogen on-site via water electrolysis, minimizing the need to truck it around.

INTERDISCIPLINARY ENGINEERING

Fuel cells and renewable fuel generation are very interdisciplinary fields. The fuel cell core represents a confluence of chemical, mechanical and electrical engineering, and the surrounding system requires electronic controls, software, power conversion, fluids, and heat management. A Thayer School engineer has a tremendous advantage in bringing all of these fields together to produce one integrated system. Thayer School's interdisciplinary curriculum is a real asset.

PHOTOGRAPH COURTESY OF RICK SAWICKI '71, ICONS: ISTOCK

RECYCLED ENERGY

SEAN CASTEN TH'98

President and CEO
Recycled Energy Development (RED)
recycled-energy.com/

RED captures "waste" industrial energy to produce electricity and thermal power. Casten has worked in the power industry for ten years. He has chaired both the U.S. Combined Heat and Power Association and the Northeast Combined Heat and Power Initiative, organizations dedicated to energy advocacy.

TOO MUCH ENERGY GOES UP IN SMOKE

Manufacturing processes and electric power generation convert only a portion of their available energy input into useful work. Both discard the remaining potential energy. The U.S. electric power generation system, on average, discards two thirds of its input energy as waste.

RESCUING ENERGY

Recycled energy is useful energy derived from exhaust heat from any industrial process or from electric power generation; industrial tail gas that would otherwise by flared, incinerated, or vented; or pressure drop in any gas.

A HOT IDEA

Thermal energy, the form of much of present waste, does not travel far without losing its value. On-site cogeneration converts fuel to electricity and then reuses the "waste" heat.

POTENTIAL ENERGY

Cogeneration and energy recycling have the potential to generate 40 percent of our nation's electricity, slashing power costs, and greenhouse gas emissions.

INCENTIVIZE EFFICIENCY

Our regulations reward monopoly utilities for investing capital, but provide no reward should they find ways to generate cheaper power. We need to confront the elephant in the room: a regulatory model that is hostile to efficient power generation.

BACK TO BASICS

There is a huge graying-of-the-workforce problem. You can't hire a mechanical engineer with a good grounding in steam cycles. That is a big problem because 75 percent of our electricity is produced in some variant of the steam-based Rankine cycle—whether powered by coal, nuclear, or biomass—and all our electricity is produced in medium- to high-voltage power plants.

CARBON REDUCTION

MICHAEL V. DEFELICE '83

CEO
Carbon Financial, Inc.
carbonfinancial.com/

Carbon Financial is the developing sponsor of a carbon trading platform through which it provides carbon brokerage services and trades carbon as a principal.

CONNECTING CARBON TRADING AND ENGINEERING

The global carbon market is highly technical at both the financial and technology levels, with extraordinary numbers of variables and participants. Numerous governmental entities—from nations to municipalities—regulate carbon emissions. In the U.S. alone, at least 29 states and more than 100 municipalities have some form of regulation on renewable energy, carbon emissions, or related emissions. As the market develops, there probably will be increased conformity to common standards. Defining those standards in a way that maximizes the overall result requires a depth of understanding of complex, multivariable, dynamic systems. This is an ideal environment for engineers to participate at the policy and regulatory levels to be sure we "get it right." Ultimately, a credit traded in the marketplace is only as good and as valuable as the underlying technologies and risk variables— factors engineers know how to assess.

CARBON SEQUESTRATION CAN'T ELIMINATE EMISSIONS

People are exploring a variety of carbon sequestration methods—including diverting carbon into the ground or oceans—that would reduce emissions, but the techniques have not yet been proven technologically or economically. Even under the most aggressive of assumptions, sequestration would only slow the rate of growth of carbon emissions, not stop the growth or reverse the trend. If we're serious about reducing emissions, we must develop alternative sources of energy that do not have the same kind or level of environmental cost that traditional fossil fuels have.

PATHS TO CLEANER COAL

A truly clean and cost-effective coal technology could satisfy our energy needs for a long time. Several technologies are in development, but none has yet proven significantly cleaner or cost-effective. The most advanced is Integrated Gasification Combined Cycle (IGCC) power. It is more efficient than conventional technologies in converting the energy content of coal, but is much more expensive, and there is some controversy over whether it is actually cleaner. In combination with sequestration, IGCC may be a good solution in the medium term. An exciting variation on this concept is still in the early stages of technical testing. We are working with a company in Europe that has developed an underground gasification process that would combust coal in situ to create syngas. The resultant CO2 effluent would be separated and trapped in the combustion "chamber" and the syngas brought out heated and under pressure. We are optimistic about the potential, but we are a long way from proving this out, and it still relies on an as-yet-unproven sequestration technology to reduce carbon emissions.

ENGINEERS ARE IN DEMAND

Every step along the chain of development from fundamental research to commercial installation and operation is hiring technical talent in thermodynamics, mechanical design, material science, biology, biochemistry, systems and software, transportation, and on and on. The most critical step in each of these areas is in commercial scale-up—transitioning technology from the lab to the commercial marketplace.

VENTURE CAPITAL FOR ENERGY

SCOTT SANDELL '86

General Partner,
New Enterprise Associates (NEA)
nea.com/InvestmentStrategy/EnergyTechnology/

NEA is a venture capital firm with $8.5 billion in committed capital. Sandell, who majored in engineering and now focuses on investments in information technology and alternative energy, was ranked #41 on Forbes' *2007 Midas List.*

A BRIGHT IDEA

I am a big believer in solar power. Wind is more economical today, and nuclear power is certainly more proven at scale, but only solar power taps an unlimited resource: the sun. There are 89,000 terawatts of solar power hitting the earth's surface every day, and the entire global consumption of energy is 13 TW. We don't have to capture much, and the rate of technical innovation to make solar cost-competitive with coal—the prime source of electricity in the U.S. today, and the most polluting—is very high.

TIMEFRAMES

We have several portfolio companies that

WILD BLUE YONDER
Imaginative grid configurations are on the way.

think they can beat coal in the next five to ten years, without assuming a carbon tax. And even the power companies and the banks that finance coal-fired power plants are starting to plan for a carbon tax. So that timeframe could be sooner. When you consider that it takes nine years to plan and build a nuclear power plant, I think solar will be a big part of the solution to surging demand for energy, especially clean energy.

TECHNOLOGIES TO WATCH

Beyond solar, I am very excited about several other technologies in our portfolio which are in stealth mode, so I cannot discuss them here. On the flip side, I think it is going to be a long time before ethanol makes sense, because it needs to be cellulosic ethanol to make a real difference, and the technologies to convert cellulosic ethanol to gasoline are a ways off. I do think that using ethanol as an input to create higher value chemical products, which are clean by virtue of their ingredients, has promise.

THE BIG RETURN ON INVESTMENT

We shouldn't forget about the conservation side of the equation. Most studies show that the greatest return on investment comes from saving energy, rather than producing more of it.

CARBON MANAGEMENT

KEITH DENNIS '03 TH'04
Engineer
Carbon Management Solutions Team
Pace Global Energy
paceglobal.com

Dennis develops and implements strategies that help companies adapt to the evolving political, regulatory, and financial landscape surrounding climate change. He has created greenhouse gas emissions inventories for power plants, mining operations, landfills, and cattle ranches.

CARBON CREDITS

More and more companies realize that getting ahead of the curve on climate change is to their advantage, both from a financial and social responsibility standpoint. Some projects can generate carbon offset credits, which can be used to help finance the projects.

THE NEW WILD WEST

Given the young nature of the business, the world of carbon credits is termed the "Wild West" of climate change. I work to ensure that client projects meet the highest standards of quality, something that everyone who is serious about this profession must do to ensure that offset markets remain credible.

A GROWING MARKET

The carbon market is poised to explode. As public demand for action on climate change increases, governments and companies are taking notice. There is, to some extent, a gold rush into carbon markets. However, it is important that we address the problem of climate change with deliberate, well-planned solutions. We must also be vigilant so that we do not let a few bad apples discredit new markets and disrupt the path to success.

DON'T EXPORT THE PROBLEM

The scientific consensus is that we face potentially devastating consequences if we do not stabilize and significantly reduce greenhouse gas emissions in both the short and long term. Policymakers must create the correct incentives to spur innovation and adoption of clean technologies without harming our economy and causing industrial jobs to move overseas where regulation is lax.

CHALLENGES FOR ENGINEERS

No matter your political views or thoughts on the science, meeting the reduction goals being set by the international community will perhaps be the single greatest challenge facing the next generation of engineers. □

Lee Michaelides is a contributing editor at Dartmouth Engineer.

ANSWERS TO

THE GROWING FUEL DEBATE

BIOFUELS DON'T HAVE TO COMPETE WITH FOOD.

BY NATHANAEL GREENE AND PROFESSOR LEE LYND TH'84

Biofuels were riding a wave of popularity only a few months ago, but now suddenly they're being roundly condemned in light of rising food prices and recent studies showing that biofuel production can exacerbate climate change. While these concerns should motivate greater efforts to do biofuels right, we must not throw the biofuels baby out with the bathwater—especially given the dearth of viable alternatives to power a sustainable and secure transportation sector. Rather than retreating from current policies, which do more for smart biofuels than many realize, the nation should follow California and Massachusetts in building on this foundation.

The current rise in food prices is causing a humanitarian crisis that we must address. But if we want to fix the problem, we first need to understand what's behind it. Biofuels are a modest part of the food price picture, consuming only four percent of world grain, and there is little evidence that food prices would be much lower if we did not produce biofuels. The primary reasons for skyrocketing food prices include our rising energy costs, increased demand for meat in developing countries, drought, and misguided national and international agricultural policies.

Global warming is also a crisis, and two recent papers in *Science* identify issues that we must pay attention to if biofuels are going to contribute to lowering global warming pollution. The papers point out that if the demand for biofuels causes unmanaged forests or grasslands to be converted to row crops, we must account for the global warming pollution released during that conversion, and that these emissions can overwhelm the benefits of displaced gasoline or diesel consumption. There are solutions, however.

We can make biofuels from non-food biomass (woody material, grasses, stalks, and stems), while also producing this "cellulosic" biomass in ways that neither compete with food production nor cause increased global warming pollution that comes from converting wild landscapes to row crops. In other words, using the right part of plants and producing them in the right ways take biofuels out of the food price equation and makes them part of the solution to global warming.

Such cellulosic biomass is available from a greater diversity of sources than row crops, including wastes, land that cannot grow food crops or is not needed for food production, and new approaches that coproduce food and biofuel feedstocks. Several studies have shown that wastes from the forest-products industry, crop residues, and winter cover crops could provide hundreds of millions of tons of biomass annually—and certainly enough to comply with the recently adopted 21-billion-gallon federal renewable fuel standard for "advanced biofuels."

The renewable fuel standard, signed into law in December 2007 as part of the Energy Independence and Security Act (EISA), is the first biofuels policy to mandate a shift in our production practices in a way that directly addresses global warming pollution. And by promoting sustainable cellulosic biofuels, it will indirectly address the food production challenge. EISA establishes minimum global warming pollution standards for biofuels and critical land-use safeguards. New biofuels projects that increase global warming emissions—including emissions from land conversion—are not permitted. Most of the mandated 15 billion gallons of corn ethanol production capacity required by the act is already in place or under construction. As expansion beyond this level is unlikely to be favored by either market forces or regulation, the ceiling of corn ethanol production appears to be in sight.

The low-carbon fuel standard, first embraced by California and recently by Massachusetts, goes beyond setting a minimum standard and rewards the best solutions. This approach requires that oil companies reduce the average global warming pollution of their fuels, but lets the market decide the best mix of options. Biofuels that provide the most reductions will certainly play a big role, but so can other technologies, such as vehicles that use electricity or natural gas.

But along with reducing demand for liquid fuels, we need to find new ways to sustainably produce them. A major focus of the renewable fuel standard is expanded production of cellulosic biofuels. Farmers and producers involved in the existing biofuel industry are generally open to such an expansion, as long as they are not left holding the bag.

Building on the renewable fuel standard and state-level leadership, the nation should establish a federal low-carbon fuel standard as part of comprehensive climate legislation. We also need to realize that better biofuels policies are no excuse for not addressing world hunger head on through better agriculture and food aid policies. More generally, we should go beyond all-or-nothing headlines and pursue a transition to biofuel strategies that realize the compatible objectives of replacing oil, expanding opportunities for existing producers, and securing both food supplies and a sustainable future. □

Nathanael Greene is a senior policy analyst for the Natural Resources Defense Council. Thayer Professor Lee Lynd is co-founder and chief scientific Officer of Mascoma Corp., a start up that is working to produce cellulosic ethanol efficiently and cost-effectively.

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SAFEGUARDING NUCLEAR ENERGY

PROFESSOR GRAHAM WALLIS, FORMER ADVISOR TO THE NUCLEAR REGULATORY COMMISSION, ON WHERE WE ARE NOW AND WHERE WE SHOULD BE.

INTERVIEW BY ADRIENNE MONGAN

Graham Wallis, Thayer School's Sherman Fairchild Professor of Engineering, Emeritus, served on the Advisory Committee on Reactor Safeguards (ACRS) of the Nuclear Regulatory Commission (NRC) from 1998 to 2007. The NRC oversees safety, licensing, and waste management for nuclear reactors.

Can nuclear reactors be made safer?

The safety standards and regulations established by the NRC are quite stringent, and all nuclear reactors must comply with them. The new reactors that are coming before the NRC have been designed with improved safety features. For example, new reactors require less human intervention during an accident, which will possibly reduce the amount of human error, though trained operators may still take appropriate action when necessary. The new reactors are designed to have passive emergency coolant systems relying on gravity, so pumps do not have to function following an accident to ensure that the reactor temperature does not rise above a level which could damage the fuel and release radioactive fission products. Large tanks of water are located above the level of the reactor, and the passive coolant system provides enough water to keep the reactor core cool until a stable, controlled safe state is established. Additionally, the new systems are heavily computerized, contain many redundancies, and provide up-to-date displays to provide better data to operators.

Even though there is a lot of interest from the utilities in purchasing the new reactors, none have been ordered yet in the U.S., perhaps due primarily to the steep cost—several billion dollars per reactor. However, several utilities have obtained NRC approval of sites for new nuclear generating plants, and a few have made preliminary commitments to specific designs. The NRC has established a new division to handle applications for future reactors and expects to approve several for construction in the U.S. during the next decade.

How is nuclear waste handled?

Radioactive fuel that has undergone the usable amount of nuclear fission is removed from the reactor every one or two years and transferred to a used-fuel pool, where water keeps the fuel cool and provides shielding against radiation. The fuel is stored there for several years until it has a reduced level of heat and radioactivity. Next, the used fuel is placed in dry-cask storage, a stainless-steel vessel that is placed inside a concrete chamber and air cooled. Given that there is no national repository for nuclear waste—although the U.S. government promised to have one years ago—individual plants are building dry-cask storage facilities on their own sites.

The current administration in Washington has questioned whether we should consider reprocessing the used fuel, as is done in Europe. Reprocessing can separate the most radioactive and long-lived fission products and also enable uranium and plutonium fuel to be recovered for future use. The main issue with reprocessing is that it could lead to nuclear proliferation, which is why President Carter stopped it in the 1970s and why it remains unavailable in the U.S.

In decommissioned nuclear power plants, the spent fuel remains on the premises and is guarded and monitored continuously.

Have security measures changed?

Nuclear power plant security has always been a critical issue for the NRC, but the September 11 terrorist attacks prompted the agency to further tighten up its security requirements. Among the areas impacted by the NRC's increased security rules are the requirement of watch towers at each plant, increased number of security guards and the types of weapons that they can use, increased number and height of fences surrounding the plants, and many different types of electronic security devices. In addition, more attention has been focused on the strength of the containment structure surrounding the reactor and its control and cooling systems. Originally, the containment structure was primarily used to keep things in, as in the Three Mile Island accident in which the reactor was severely damaged but very little radioactivity was released through the containment to the environment. But now the structure may also serve to keep things out, including airplanes.

What are NRC's concerns about the future?

A significant concern at the NRC is the disappearing technical expertise in the field of nuclear energy. Most of the key technical work—understanding of materials within the reactors—was done in the 1960s and 1970s. The scientists and researchers who performed this work and wrote the regulations for reactors are retiring, so a huge knowledge base is disappearing. The nuclear engineering field is trying to recruit smart, interested individuals. One major manufacturer recently stated that it was looking for several thousand new nuclear engineers. Nuclear engineering departments in universities are presently undergoing a renaissance.

Another question is: who will be building the new reactors, since the U.S. has all but lost its manufacturing capabilities. Some key parts, such as the reactor vessel, will probably be made overseas, which may raise questions of quality assurance.

The NRC is also concerned with how to develop and apply regulations to new reactor designs that may use different fuels and cooling systems than the traditional light water-cooled reactors, which make up the present fleet of about 100 installed in power stations across the U.S. There has been an effort to make the regulations simpler and "technology neutral" so that the methods and evaluation criteria could be applied to any design, and the principles on which they are based would be more clearly understood by the public. □

PROFESSOR ELSA GARMIRE:

WE NEED NUCLEAR POWER.

INTERVIEW BY ADRIENNE MONGAN

Elsa Garmire, the Sydney E. Junkins Professor of Engineering Sciences, is a member of the American Academy of Arts and Sciences and has been an advisor to the Department of Energy. She spent the past year as a Jefferson Science Fellow at the U. S. Department of State.

Where does nuclear power fit into the energy matrix?

There is no such thing as free energy. Every source has drawbacks and will harm the environment in some manner. Coal mining produces large amounts of greenhouse gases and acid rain and poses dangers to miners. Hydroelectric dams disrupt the natural environment for many types of wildlife. Renewable energy sources, such as wind and solar, can be unreliable given weather conditions. And as we haven't yet developed good storage for renewables, we cannot depend on them at this time to meet all of our large-scale energy demands.

Over the next 50 years we will see a doubling of energy usage and a tripling of electrical usage. Unless patterns change dramatically, energy production and use will contribute to global warming through large-scale greenhouse gas emissions, with hundreds of billions of tons of carbon being emitted. Nuclear power provides the ability to help meet large-scale energy demands without producing carbon. Given this, I believe there is no way to plan for meeting future energy needs without nuclear power.

What are the advantages of nuclear energy?

Nuclear power is the most efficient energy source currently available. Uranium-235, the isotope used in nuclear reactors, can produce 3.7 million times as much energy as the same amount of coal. Uranium is abundant in several countries, including the U.S., South Africa, Australia, Canada, and Nigeria, and therefore is accessible. Nuclear energy also provides benefits beyond electricity generation. Radioactive materials, produced in reactors, are used in diagnostic and therapeutic treatments in medicine, weld inspection (radiography), power sources in remote locations and space applications, and food irradiation.

What about the negatives?

Fuel cycles that involve the chemical reprocessing of spent fuel to separate weapons-usable plutonium and uranium enrichment technologies are of special concern. New technologies are being suggested to recycle spent fuel in a manner that renders the material unsuitable for use in nuclear weapons, a huge advancement in safety.

Radioactive waste is a difficult issue. Although all spent fuel and its plutonium belong to the U.S. government, the U.S. does not have a long-term waste management system. In the 1960s and 1970s, utilities expected to send spent fuel to a reprocessing facility after a couple of years of storage in cooling pools on-site. President Carter restricted this option because of concerns about plutonium proliferation, and utilities have had to expand their storage space on-site.

There is no doubt that nuclear power is dangerous. The question is whether the huge benefits derived from nuclear power are worth the risks.

What are the challenges to expanding nuclear power production in this country?

The most significant challenge is the lack of innovation in nuclear technology since the 1960s. In the 1970s, fear of nuclear proliferation resulted in a turn against nuclear power. Fewer domestic institutions of higher education offered nuclear engineering programs, leading to a decline in research and new knowledge.

Other countries, such as France and Japan, have used nuclear power safely for decades, while the U.S. has lagged behind. To solve our energy needs, this country must undertake a complete rejuvenation of education and train a new generation of engineers in safe nuclear technology. We must also find a way to finance and regulate a next generation of safe nuclear power plants, not just build more of the same. □

Adrienne Mongan is a contributing editor at *Dartmouth Engineer*.

Alumni News

spotlights

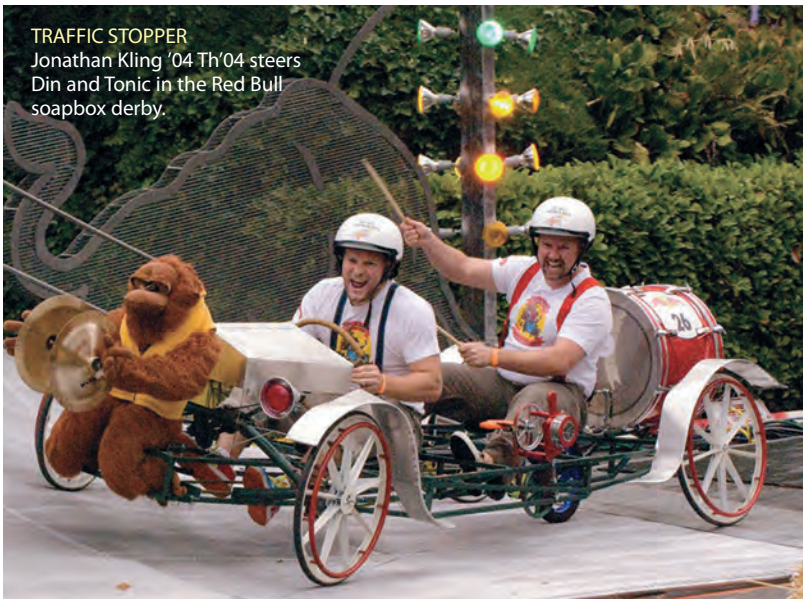
LIVE WIRE
John McNeill '83, left, gets raves from his students at Worcester Polytechnic Institute.

Electrical engineering professor **John McNeill '83** is charging up his students at Worcester Polytechnic Institute. "He's unbelievable in terms of not only bringing the practical, but also making it so that you can understand the material," senior Charles Gammal told the *Worcester Telegram & Gazette* this spring. Under McNeill's guidance, Gammal and fellow students are designing a low-power integrated circuit for handheld biomedical applications such as portable ultrasounds. The project placed in the top five out of 47 teams in a design contest sponsored by the Semiconductor Research Corp. and will be presented at an industry conference in Austin, Tex., this fall. Another of his student teams recently demonstrated a design modification to standard wall adapters— dubbed "wall warts"—which have losses in the transformer magnetics, regardless of whether they are powering anything. "Put ten or 20 of these in a house and this can add up to a significant fraction of total power usage," says McNeill. His students developed a modification that detects when there is no device attached to the wart and disconnects the adapter from AC power to avoid transformer losses. "In addition to the technical problem," he says, "the students also researched the social and economic implications to determine how much of a problem there is from power losses in the existing design (significant!), what additional cost would be feasible in the market, brainstormed several approaches, then chose one and designed a solution that worked—and beat the target cost."

Scott Sabol '88 Th'88, a Vermont Technical College professor and chair of the architectural and building technology department, received the school's Henry G. Wirtz Master Teacher Award in May. The honor recognizes him as a role model for other faculty and as an exceptional teacher.

Three Thayer alums are finding greener transportation solutions throughout the Upper Valley—and beyond. "Our work is focused on transportation solutions that reduce the amount of driving, energy consumption, and greenhouse gas emissions by shifting travel to walking, biking, transit, and shorter car trips," says **Norm Marshall Th'82**, a principal along with **Lucy Gibson Th'88** and engineer **Sandy Beauregard Th'07** of Smart Mobility in Norwich, Vt. The company (smartmobility.com) recently developed a new transportation plan for Burlington, Vt., and is now helping Chicago consider multimodal transportation networks and strategies, helping Austin and Baltimore develop more efficient land use and transportation, and aiding citizens groups and townships in several states as they face highway expansion proposals. "Our practice focuses on activities that promote sustainable transportation alternatives—we do not work on building new highways or construction of new big box stores," says Gibson.

"America's biggest drinking problem isn't alcohol, it's lawn watering," according to **Amy Vickers Th'86**. Vickers is an Amherst, Mass.-based water conservation consultant, author of the water efficiency requirements for plumbing fixtures adopted under the U.S. Energy Policy Act of 1992, and author of the *Handbook of Water Use and Conservation: Homes, Landscapes, Businesses, Industries, Farms* (waterplowpress.com). She made her case for water conservation in a *Boston Globe* opinion piece last summer. "The extent to which our culture's irrigation-fueled lawn watering binge is acting like a wrecking ball in our rivers, streams, and lakes is a specific challenge to the security of our water supplies, even here in 'water rich' New England," she writes. She advocates two immediate actions: limiting the number of watering days allowed per week and enforcing watering rules no matter the water source—public supplies or private wells. "If Massachusetts and other New England states act soon, we need not be fated to the long-term water shortages and chronic droughts now predicted for much of the nation." Read the full article at boston.com/news/globe/editorial_opinion/oped/articles/2007/06/10/lawn_binge/.



TRAFFIC STOPPER
Jonathan Kling '04 Th'04 steers Din and Tonic in the Red Bull soapbox derby.

THIS PAGE: OOYOO/ISTOCKPHOTO.COM. OPPOSITE PAGE: LEFT, PHOTO COURTESY OF THE *WORCESTER TELEGRAM & GAZETTE*; BELOW: COURTESY OF JONATHAN KLING '04 TH'04

The Din & Tonic racer barreled down Freemont Avenue in Seattle, Wash., last fall with driver **Jonathan "Kling-a-Ling-a-Ding-Dong" Kling '04 Th'04** at the wheel. While the soapbox racer never crossed the finish line—it crashed into hay bales lining the half-mile race course after losing all four of its wheelchair tires—its bells and whistles were one of the highlights of the 2007 Red Bull Soapbox Race. Kling, who rallied coworkers to assemble the soapbox car, was one of 36 contestants in the human-powered race. "As employees of Synapse Product Design in Seattle, these teammates are used to creating buzz in the world of medical devices and consumer products with their design solutions, and now they're ready to just create some buzz…literally… with noisemakers," according to the race website (redbullsoapboxusa.com/seattle-2007/teams-dinandtoic.aspx). Inspired by kinetic pieces displayed in the Tinguely Museum in Basel, Switzerland, which he saw last summer on a biking trip across Europe with **Bing Knight '05 Th'06, Jeff Hebert '04 Th'06,** and **Joe Horrell '04 Th'06,** Kling designed a gravity-powered racer that drove a bass drum, a stuffed gorilla banging cymbals, and two air-raid sirens that peaked at 120 decibels as the car reached top speed, all while the co-pilot was banging out a tune on blocks, cowbells, and Kling's helmet! While his building philosophy may be a bit offbeat, Kling knows what it takes to construct a quality car—his racing resumé includes assembling a few Society of Automobile Engineers (SAE) race cars while at Dartmouth. Although Kling and his team lament the use of non-pneumatic tires, they still placed 14th, ahead of many cars that did finish the course, because of high marks in showmanship and creativity. RedBull moves the city of the SoapBox race every year, but there's rumor of a RedBull Flugtag (a race of human-powered flying craft) in Portland, which Kling and Synapse have already been invited to enter.

just one question

Q. What energy or climate-related work are you doing?

I am the oldest member and former president of The Economic Round Table of Los Angeles. This is a group of prominent executives who meet once a week to discuss world affairs and economics. My talk on energy was an urgent warning that we need to do something now since nuclear, clean coal, solar, and all the other forms of energy take years to put into place. Also, well-meaning citizens are preventing us from using all the gas and petroleum resources we have on this continent.

—Henry C. Keck '43 Th'44 Tu'44

I am the CEO of Angeli Parvi, a non-profit dedicated to entrepreneurship at Dartmouth. We just invested $200,000 in Advanced Transit Dynamics (atdynamics.com), which has developed a clever airfoil to attach on the rear of large trailers. This improves the aerodynamics sufficiently to improve gas mileage by approximately six percent. ATD's founder is **Andrew Smith Tu'07**, and the two leading technologists are Thayer graduates **Chuck Horrell '00 Th'01** and **Jeffrey Grossmann '06 Th'07** [see photo on page 29]. Thus far execution has been excellent, and we can reasonably expect good financial and good environmental and energy performance.

—John Ballard '55 Th'56 Tu'56

My main focus, vocationally and avocationally, has been on alternative energy since the late 1970s. The list of my activities includes: consulting to cities to install waste-to-energy plants, developing a 3-megawatt landfill gas power project, and writing several reports for the EPA's Coalbed Methane Outreach Program (upgrading coal mine methane to pipeline standards, and capturing and using ventilation air methane for power production). Currently I am part of a startup renewable energy cooperative in Addison County, Vt., that hopes to establish a biodiesel production business. My wife and I burn wood from our woodlots—more than 10 cords a year—to heat our 4,600-square-foot home, and we installed two solar collectors for hot water.

—Peter Carothers '57 Th'60 Tu'60

Our firm, Mohr, Davidow Ventures in Menlo Park, Calif., is a leading investors in alternative energy early stage companies. I am supporting environmental research, much of which focuses on climate change.

—William Davidow '57 Th'58

I am an independent consultant who works with companies to help them be more sustainable. I deal primarily with the prudent use of energy. I also teach courses on sustainable business practices in the M.B.A. program at Ohio State; I started that in 2004 and had 15 students. This year I have 70 students. Topics covered include the status of fossil energy, alternate energy technologies, and climate change. Interest in these topics demonstrated by future business leaders is phenomenal.

—Neil Drobny '62 Th'64

Until I retired three years ago, I worked for 38 years in the nuclear power industry—nuclear fuel manufacturing primarily—for both General Electric and Westinghouse Electric. I have not been involved other than reading the news about nuclear energy or energy in general since I retired.

—Rhod Hawk '62

I am the general manager of Southwestern Drilling Co., a small, privately held company that leases equipment and crews to large and small oil and gas exploration companies. Our work has been concentrated on drilling for natural gas. I have 37 years experience in providing such services for the domestic oil and gas industry. As a result, I doubt very much whether Dartmouth would have any interest in hearing what I have to say, as most academicians believe I work in an industry that wants to intentionally ruin our world. They tend to believe the solution is a combination of riding bikes to work each day, having windmills

on every square inch of the U.S., and using every available arable acre to grow corn for ethanol subsidized by my taxes. Surely I'd be dismissed as a polluting kook!

—Richard Zartler '62 Th'63

The thermoeconomics course taught by Dean Myron Tribus during the mid-1960s—with its emphasis on balancing economic, energy, and resource factors in making decisions—was well ahead of its time. Would that all managers and engineers have had the course and lived up to its principles. The world would be a different place by now.

—Steve Brenner '63 Th'64

Fafco, where I am president and CEO, is the oldest and largest solar thermal panel manufacturer in the U.S. Recently we introduced the next-generation, all-polymer solar hot water heating system, which we developed in conjunction with the U.S. Department of Energy during the last 10 years (fafco.com). The neat thing about the recent introduction is that the entire system comes in a box, which can be shipped for $50 and which, when installed, will do up to half the hot water heating requirement.

—Freeman Ford '63

In 1997 I bumped into an article in the London *Financial Times* that described the redistribution of the old Soviet oilfields. As a result I invested in Canadian oil companies that acquired obscure fields in Kazakhstan. For years then, I read everything I could find that hedged my risk in oil. *Hubbert's Peak* by Ken Deffeyes opened a vista into a future with ever more expensive oil and seemed to vindicate my positions. I made a bundle. Now I follow the geophysicists who believe that oil production has or will soon have peaked forever. Were I younger I would be obsessive about inventing alternative energy sources. Hybrid fission/fusion?

America and the developed countries have designed a world for themselves in which oil is essential. Suburbs, interstates, air travel, fresh produce, human mobility, large warm houses in the north, and large cool houses in the south all require cheap energy. How do we fuel the transition from this lifestyle to a new lifestyle? Can Thayer create graduates who can engineer new global behaviors integrated with new machines?

—Bob Prescott '64 Th'67

I am on the other end of the spectrum: The airplane I am working on (as systems engineer) has big huge engines that drive it to speeds way over 1,000 mph. The only energy savings thing about it is that instead of the 500- and 1,000-pound bombs that I used in combat, this plane drops 250-pound bombs. Supposedly they are so accurate that they do more damage than those old ones. In a fight with another aircraft, our F-22 supposedly can see them before being seen and launch a missile for a kill. This saves fuel because there's no churning and burning dogfight.

—Ward Hindman '65 Th'68

I'm CEO of a commercial plumbing and HVAC contractor in southeastern Pennsylvania and southern New Jersey. We routinely deal with green buildings, Leadership in Energy and Environmental Design (LEED) certification, building energy conservation, and system efficiencies. Our niche is in a micro-environment rather than big-picture systems. In the early 1980s I owned a solar installation company that failed when oil prices dropped in the mid-1980s. The foreign oil cartel always has the ability to bankrupt alternative energy sources by reducing the cost of oil, destroying their economic viability.

—Harry Santangelo '66

I am working on an adsorbent to remove NOx, SOx, and Hg from stack gas in coal-fired power plants and other similar applications. Unfortunately, the market is not very strong and way too many utilities have jumped behind the CO_2 hype and nearly everyone has forgotten about mercury. Of course they know that CO_2 is an impossible task and probably just a natural cycle, but it does allow them to do nothing now.

—D. Dean Spatz '66 Th'67

I am retired but retain a keen interest in energy issues, particularly petroleum consumption. I have been writing on this subject for a local newspaper on occasion. I am convinced that major inroads on the problem await our adoption of electric motor drives for highway vehicles energized with rechargeable batteries off the grid. There have been multiple demonstrations that this is commercially ready and will yield 100-plus miles per gallon. I don't think the hydrogen route will ever be commercialized. I think ethanol is ill suited as a major energy source. We should redirect our engineering resources to expand wind farms, cost-reduce solar systems, and clean up coal-fired steam generators.

—Dick Livingston '68 Th'69

One start-up company in which I am involved, Sanderson Engine Co., is developing a new way to convert reciprocating motion to circular motion, which appears to have great benefit in improved efficiencies and emissions. The technology applies to all engines, pumps, and compressors, and one potential application would make the generation of wind power more practical. I am an investor in this initiative and have provided some consulting from time to time. They are currently in talks with some very well-known companies that have large applications for this technology.

—Bill Holekamp '70

I'm working on a real estate development project, Forge Village in Westford, Mass. It's a conversion of a group of mill buildings from industrial to residential use. The energy aspect of the project is twofold: the heating system will take heat out of canal water rather than burning fossil fuels, and the old hydroelectric generator will use water flow to generate electricity.

—Chris Yule '70

We had discussions back in 1973 at Thayer bemoaning our dependence on imported oil and the growth rate of oil consumption. At that time we were advocating investment into fusion energy as the only real alternative, even to the point of a program not unlike that of John Kennedy's landing a man on the moon by the end of the 1960s. Too bad it never happened. I would love to see something along this line: A truly "pollution free" solution (ignoring heat, but that's another issue) with potential for unlimited energy supply. It beats

ENERGY TO GO
Dave Wolff '79 sells Proton Energy Systems electrolysis equipment for making hydrogen.

COURTESY OF DAVE WOLFF '79

all the others, including wind, solar, and geothermal!

—Jim Bartlett '72 Th'73

A significant portion of my consulting business is directed at alternate energy sources and strategies, hydrogen systems, including vehicles, and CO_2 sequestration.

—John Boyle '73 Th'79

I am working with the Alberta Oil Sands, the largest reserve that exists in the world after Saudi Arabia. There are 177 billions barrels of oil that are recoverable using existing technology. There are issues with carbon capture and sequestration and with efficiencies.

—Dennis Dembicki '73

I have had some interesting dialog with the California Coastal Commission (CCC) and Sierra Club regarding the effects that global warming is supposedly having on the location of the Mean High Tide Line (MHTL) in front of our resort, La Jolla Beach & Tennis Club. Both want to take away our private beach on the theory that ocean waters are rising. There are many physical observations that contradict the Sierra Club's theory. There is now a technology that allows determination of the MHTL by flying over an area with radar-sensing instruments. The resulting data can be converted to a line on a map that shows the MHTL at the time of the flyover. Readings are routinely taken twice a year, and there are now multiple years of data available. We are contemplating a project to determine our "ecological footprint" on our community.

—Bill Kellogg '73

I work with a group within JPMorgan that invests in alternative energy as well as conventional electrical generation and oil and gas production. We are one of the largest tax equity investors in wind power with investments in more than 44 wind farms in the United States and the largest operating solar power plant built in the last 15 years. Climate change issues affect almost everything that we do.

—Geoffrey Bratton '74 Th'78

I am a partner in Konover Construction Corp. in Farmington, Conn., and Columbia, Md. We are a full-service construction organization providing design/build, preconstruction, construction manager, general contracting, and owner's rep services across the Northeast and Mid-Atlantic states. Our work-in-place volume for 2007 was about $350 million. Sustainable design practices are in high gear in the construction industry. Konover has two LEED "basic" projects that have achieved certification, and we are involved in several others large projects seeking "silver" certification. But many of our other projects incorporate sustainable design elements/practices without seeking certification.

—Simon Etzel '74 Th'75

I do work on battery life optimization for cell phones at Motorola.

—Wayne Ballantyne '77 Th'78

Since completing my graduate degree at MIT, I have been working at Chevron for the last 25-plus years, recently focusing on developing natural gas in West Africa for the North American and European markets. Since 2005 I have been involved with the Olokola Liquefied Natural Gas Project (OKLNG). OKLNG is joint venture enterprise that plans to build a multi-train liquefied natural gas (LNG) plant on the coast of Nigeria and export LNG, propane and butane, and stabilized condensate (a light hydrocarbon liquid used as a refinery or petrochemical feedstock). The overall project will involve development of new offshore and onshore gas production fields, large-diameter gas transport pipelines, the LNG process plant, and a marine export terminal. OKLNG will build, own, and operate the LNG facilities, which will be located in an area of Nigeria that has no industrial infrastructure at present. It will be a multi-billion dollar investment. I was first assigned as the manager of planning and integration for the joint venture project team. Over the last few years I've served as Chevron's OKLNG project coordinator, reviewing the work on concept selection, front-end engineering, contracting strategy, and development planning. My work on OKLNG has meant frequent travel between the U.S., London (where the project team has been located since late 2005), and Nigeria. As a result, earlier this year I relocated to London to be able to work more closely with the project team, communicate with the other shareholder companies, and reduce the amount of time I am spending on airplanes.

—Will Fraizer '78

I work directly with energy issues on a global basis as president of the drilling and evaluation division of Halliburton. The fundamental issue is that worldwide energy demand is growing at a fast rate, supply is no longer able to keep pace, and there is not sufficient investment in new sources of conventional or alternative energy.

—Cris Gaut '78

I work for Butler Manufacturing Co., a subsidiary of BlueScope Steel, an international steel solutions company, in its Kansas City, Mo., office. We make steel or metal buildings that are used for everything from the quintessential farms shop to warehouses to facilities like the new indoor track facility at Tufts University in Massachusetts. While mostly misunderstood and suffering from a "tin can" image, most people have overlooked some basic facts about steel buildings. Our LEED data sheets demonstrate that 30 to 75 percent of our raw material is comprised of recycled steel and our finished product is easily designed for deconstruction and recycling. Also, the company earned a Green Globe Award in 2006 for investing more than $20 million to recycle wastewater and use it in steel production, saving millions of gallons of fresh water daily in an area of Australia that has suffered from severe drought for more than 10 years (csereport2007.bluescopesteel.com/environment/water.html).

—Ron Miller Th'79 Tu'79

I sell on-site electrolysis equipment for Proton Energy Systems that is

used to make hydrogen for applications such as hydrogen fueling.

—Dave Wolff '79

As a professor of Earth and planetary science at Berkeley I have been working on climate change impacts on hydrologic systems. I am also currently the director of the Swiss Federal Institute for Forest, Snow, and Landscape Research, where we do a lot of work on wood energy resources and forests as CO_2 sinks, as well as on climate change effects on ecosystems and natural hazards (floods, avalanches, etc.).

—James Kirchner '80 Th'83

I'm working at Burns & McDonnell, an international engineering, architecture, and consulting firm based in Kansas City, Mo. My consulting projects revolve around public "sustainability reporting," helping clients (many of them in the utility field) explain their actions/plans related to energy. Here's a random sample of what we're working on across this industry: transmission (especially for wind), infrastructure development, pollution control (coal plants), greenhouse gas inventories, combined heat and power plants, energy performance contracts, exploring biofuels, wetlands design and rehabilitation, geological consulting, and green building (LEED) facilities for aviation and health care.

—Steve Murphy '80

I run a strategic marketing team for Autodesk, which makes software used for designing buildings. Our most advanced software is in building information modeling (BIM), a category we pioneered in the early 2000s. BIM is an integrated workflow built on coordinated, reliable information about a project from design through construction and into operations. By adopting BIM, architects, engineers, contractors and owners can easily create coordinated, digital design information and documentation; use that information to accurately predict performance, appearance, and cost; and reliably deliver the project faster, more economically, and with reduced environmental impact. I am responsible for an initiative to support sustainable design through our software by making the environmental impacts of the building design more available to the designer earlier in the design process, when small design decisions can have a big impact. Our vision for the future is at autodesk.com/greenresearch.

—Richard Rundell '80

My environmental engineering major continues to help in my work as an environmental litigator at the U.S. Department of Justice. We are seeing more and more climate change cases, including a recent U.S. Supreme Court case interpreting the Clean Air Act.

—Jim Payne '81

I work for a consulting firm specializing in energy and environmental policy analysis, OnLocation Inc., in the Washington, D.C., area. We build, maintain, and run a variety of computer models to examine potential energy trends, impacts of proposed government policies, and the associated financial and economic impacts of energy-related investment decisions. Currently, the key areas of interest are potential climate change legislation to limit emissions of greenhouse gases, policies to reduce oil consumption and imports, and impacts of R&D programs. Our clients include the Department of Energy, EPA, several non-governmental organizations and foundations, and various corporations.

—Frances Wood '81

This is what I am doing with respect to energy: founder and executive committee member of the New England Clean Energy Council; founder and president of the Massachusetts Hydrogen Coalition; co-host of the annual Conference on Clean Energy (mattcenter.org/cceconf2007/ce-conference.html); president of Velerity Management Consulting, consultant to energy-related companies; and founder and CEO of Blue Sky Green Planet, a development-stage company focused on helping consumers reduce their carbon footprint.

—Brad Bradshaw '82

In my work at the Delaware Valley Regional Planning Commission, the federally designated metropolitan planning organization for the 5.5 million-plus population of the greater Philadelphia region, I am managing our newly established climate change initiatives program area. Our most recent task is to prepare a regional greenhouse gas (GHG) inventory, working with the Environmental Protection Agency with the intent of using our work to develop a standard protocol for metropolitan areas to carry out such inventories. During the next year I'll be leading the development of a regional GHG reduction action plan for greater Philadelphia. I'm also involved on the board of the region's Smart Energy Initiative, which is working to build the green energy sector in our region. I'm speaking to planning graduate students at UPenn on these issues, as well as to the American Bar Assocation's environmental group and to the Pennsylvania Association of Environmental Professionals. I'm working with our transportation modelers and those putting together our 2035 long-range plan to evaluate the energy implications of various land use and transportation infrastructure scenarios. I also serve on the climate change/GHG-reduction task forces in two counties and one municipality (Haverford Township).

—Robert Graff '82

I have recently become very involved in renewable energy through the installation of a photovoltaic solar system at my home in Kennebunk, Maine. What is unique about this system is that it not only produces electricity (rated at 4.4 kilowatts) but also captures the thermal energy absorbed by the photovoltaic panels. In fact, by cooling the array and removing heat energy from the PV solar cells, the electrical production is increased as the photovoltaic cells are cooled. It has been a very gratifying project. Not only do I receive electrical power from the sun, but I also get space heating in the winter with preheated fresh air and hot water heating. In the summer my pool is now using the sun to extend the season rather than propane. My home is one of six test locations around the country using this system and can be seen at the pvtsolar.com in the picture gallery. It is my firm belief that distributed energy production is a significant part of the solution to the global energy problem. This project has been a lot of fun, as I handled most of the installation myself with some help from some expert roofers and a plumber. My array was the first in my local power district to tie into the grid, which was an education in itself for the local power company.

—Art LeBlanc '82 Th'84

As a private equity investor since 1990, I have had the opportunity to be involved with investments in a number of exciting alternative energy technology companies, including fuel cells, advanced batteries, solar cells, superconducting magnetic energy storage rings, advanced flywheels, lighting ballast technologies, and energy service companies. I have also invested in process software to manage petrochemical plants to make them run more efficiently. I recently invested in an energy trading and risk management company called Allegro (allegrodev.com/index.asp) that helps

BRIGHT FUTURE
Michael Müller Th'95 is senior manager of project procurement for RWE, which is planning to build the world's first zero-CO_2 power plant.

large users of energy manage their energy costs and physical inventory of energy products. For the last eight years I have been on the board of Veeco Instruments (veeco.com), a leading manufacturer of a wide range of process equipment used in the manufacture of solar cells and LEDs. As the world moves toward LEDs for general lighting applications, Veeco will be at the forefront of manufacturing technology. I recently started a new private equity firm called North Bridge Growth Equity, which focuses on investing in private companies in technology and technology-enabled industries, including energy-efficient technology. We are affiliated with North Bridge Venture Partners, a leading early-stage venture capital fund. One of North Bridge Venture Partners' most interesting investments is an advanced battery company called A123 (a123.com), which uses nanotechnology to create the next generation of lithium ion technology. Applications include hybrid vehicles, power tools, aviation, backup power to replace lead acid, and the military. It is an indisputable fact that the United States currently leads the world in developing green technologies and will continue to do so into the indefinite future. This fact is grounded in both the ingenuity and profit motive of American business. We are not going to solve the environmental and energy challenges of the next 50 years by nonsensical initiatives such as carbon offsets. Rather, we are going to continue to raise the standard of living of all people on earth by developing innovative technologies that increase energy efficiency, decrease the need for oil, and create less pollution. I hope I can play a small part in that ongoing process.

—Doug Kingsley '84, Th'85

I am president of Accuware, a software development company with five employees and additional contractors overseas. We have developed a software solution for EPV Solar to interface its solar panel testing equipment with its packaging/inventory areas. This is an improvement in their process management to improve quality and accuracy in what they produce for panels (accuware-inc.com/epv.htm).

—Steve Morris '84 Th'85

I am the director of Resource Systems Group's environmental services division, based in White River Junction, Vt. We conduct noise-impact studies for wind farms and biomass energy plants and air pollution studies for biomass energy facilities, and we calculate the air emissions offsets related to renewable energy. An example of a local project we are working on is the air pollution permit for a wood pellet boiler at Dartmouth's graduate student housing project in Sachem Village. We also did the permitting work for Hanover high and middle schools' wood chip boilers. These biomass projects are very satisfying in that they have close to net-zero greenhouse gas impacts, rely on a local and renewable fuel source, and save money—especially in these times of high oil prices.

—Kenneth Kaliski '85

I've done legal work for a gas-fired 720-megawatt energy plant in New Hampshire (I deal with air regulations and permit requirements) and work with a team of lawyers that is doing the legal work for several wind farm projects.

—Lisa Wade '85

I am working with a Hong Kong-based Asian private equity fund, Olympus Capital, to invest capital in the environmental sectors in India. This includes renewables, of which biomass and small hydro, followed by wind, offer most promise. Energy efficiency, smart lighting and metering would also be included, though there are few opportunities in India to find the right platforms at this time.

—Himraj Dang '89 Th'89

I am currently managing assets for New Energy Capital (newenergycapital.com), a private equity firm in Hanover that develops, owns, and operates renewable energy projects. I am currently managing an 18-megawatt biomass power plant in Maine and three 2-megawatt cogeneration facilities for a commercial food processor with locations in Massachusetts and California. Our areas of focus for new project development include biomass to power, biofuels, cogeneration, waste to energy, and solar thermal power generation. Previously I worked for Northern Power Systems, a contractor in Waitsfield, Vt., that designs and builds on-site power systems in addition to producing a 100-kilowatt wind turbine for small wind applications. While there I developed and managed projects ranging from remote power systems in Antarctica for solar-powered runway lighting and Nuclear Test Ban Treaty monitoring to a complete power generation and 4,160-volt distribution system for the Island of Mohegan, Maine. In 1999 I helped to create the distributed generation group at Northern Power Systems to develop turnkey cogeneration and critical load support systems for grid-connected commercial and industrial customers. I have worked on projects ranging from 30-kilowatt to 30-megawatt utilizing solar power, microturbines, fuel cells, reciprocating engine gensets, and combustion turbines.

—Jim McNamara Th'89

I have just started as technical director of the Swiss watch firm IWC (which was founded by an American engineer in 1868) in Schaffhausen, Switzerland. We are the first watch manufacturer who tries to offset its CO_2-footprint.

—Olaf Eichstädt '90

I am an associate professor of chemical and biomolecular engineering at the University of Akron working on National Science Foundation-sponsored research involving thermophotovoltaic energy conversion. The devices we are building convert thermal energy into electricity using rare earth oxide fiber structures. We are developing an understanding of the effects of microstructure (crystal structure, grain size, defect density) and macrostructure (fiber diameter, fiber packing) on the narrow band emission of these materials. Our hypothesis was that nanofibers-based emitters should be more efficient than other forms. We have shown that this hypothesis was correct. We are now working on developing prototype devices. We hope that someday these devices could recover 10 percent of the wasted energy in every vehicle, translating to lots and lots of gasoline savings—14 billion gallons in the U.S. alone.

—Ed Evans '91

Until recently I worked for General Mills, and I now work for Campbell Soup. As we talk about corporate social responsibility and sustainability, energy and carbon footprints are certainly part of the discussion. In addition, the impact energy prices and biofuels production is having on food prices is pretty dramatic. Since diesel fuel prices have skyrocketed, and therefore it has become far more expensive to ship raw materials and finished products between our facilities and to our customers, we have had to consider raising the price of our products to compensate.

—Brett Buatti '92 Th'94

My entire career since graduating in 1992 has been in energy. I am currently a principal with U.S. Renewables Group, one of the only (for the

COURTESY OF MICHAEL MÜLLER TH'95

moment) private equity firms in the United States focused exclusively on investments in assets in the renewable energy sector.

—**Scott Gardner '92**

I am on a volunteer committee for the City of Solana Beach, Calif., called the Clean and Green Committee. We are developing a climate action plan right now, which is a blueprint for the city, based on a mayor's agreement with 12 objectives that the city signed onto in 2007.

—**Annie Kaskade '92**

I work for Ballard Power Systems (ballard.com) in Burnaby, British Columbia, which develops proton exchange membrane (PEM) fuel cells for use in a variety of power applications. PEM fuel cells produce electricity from hydrogen fuel and have high efficiency and no emissions. Most notably, we are working together with Ford and Daimler on their fuel cell vehicle programs. My husband and I are also quite focused on conservation at home. Last September, we installed two kilowatts of photovoltaic panels on our roof, and we expect to generate 30 to 40 percent of our annual electricity needs via the sun. I was president of the Dartmouth solar racing team for a few years, so it feels great to be harnessing the sun yet again on a daily basis.

—**Laura Iwan '93 Th'94**

After leaving Dartmouth, I pursued an international master's degree at the Royal Institute of Technology in Sweden in sustainable energy engineering with a focus on sustainable power generation. I'm now completing this degree by working on my master's thesis at the National Renewable Energy Laboratory out in Colorado. I have just started a six-month thesis project where I am working on a wind-to-hydrogen project, using wind (and photovoltaic solar) electricity to produce hydrogen through electrolysis. I am specifically working on a cost analysis subproject, but I am taking part in a variety of areas and learning a lot about the integration issues of renewable energies and hydrogen production.

—**Genevieve Saur '93**

I'm the chair of the Concord (Mass.) Comprehensive Sustainable Energy Committee. We're working to promote energy conservation and efficiency as well as renewable energy in the town for residential, commercial, and municipal sectors. Right now we're focusing on municipal issues because we have a budget for town buildings and there are fewer decision makers involved. I'm also leading a high-profile team of local politicians and notables in something called the Low Carbon Diet, which is run by the Mass Climate Action Network.

—**Brian Crounse '94 Th'95**

I am a consultant with IBM and I am involved with green supply-chain solutions. IBM research developed a carbon analyzer tool. We modified it for a heavy equipment manufacturer's forest products division. The tool can measure the carbon emissions created in the supply chain. Currently we can assess inbound and outbound transportation, and it will be able to assess facility carbon creation. The tool also allows scenario analysis to understand how you can decrease carbon emissions while also calculating transportation and inventory metrics. This allows trade-off analysis of carbon, inventory turns and cost, transportation cost and frequencies, service level agreements, and packaging costs.

—**Chad Boucher '95 Th'96**

I am a research engineering specialist with ExxonMobil Upstream Research Co. in Houston, Texas. I work at ExxonMobil R&D, in particular the offshore and Arctic division. My previous role was metocean (meteorological and oceanographic criteria) team leader, and now I am leading a research project in the Arctic section.

—**Oleg Esenkov Th'95**

I am responsible for the procurement of new power plant projects at RWE Power in Essen, Germany. We are currently facing an investment program of 9 billion Euros until 2014. The investment program includes: one 2,100-megawatt lignite, one 800-megawatt combined cycle gas turbine, and two 1,600-megawatt hard coal fired power plants with the most advanced efficiency; the world's first zero-CO_2 power plant (integrated coal gasification and carbon capture and storage); fluidized bed drying for increased efficiency of future lignite power plants; a CO_2 scrubbing prototype; and clean development programs.

—**Michael Müller Th'95**

My wife, **Kirsten Glass '95**, a large-animal veterinarian in Lyme, N.H., just finished sponsoring a B.E. project at Thayer to make her truck more efficient and environmentally friendly.

—**Brian Spence '95 Th'96**

I'm working as a research analyst for a boutique investment bank in Atlanta. I see a lot of interesting ideas in the energy space, ranging from hydrocarbon sources such as natural gas, oil, and coal-bed methane to alternatives such as wind projects. The difficulty in finding new sources—along with global geopolitical issues and the need for the U.S. to become more self-sufficient and greener at the same time—have brought the U.S. energy market back to life in the last few years following decades of underinvestment.

—**Patrick Orie '96**

I work for a company, Bensonwood Homes, that designs and builds timber frames. Working with the Open Prototype Initiative (openprototype.com), we are building a net-zero house.

—**Christopher Carbone '97 Th'99**

I work for the venture capital team at GE focused on the energy and water markets. We are solely focused on investing for GE in early-stage companies in the renewable energy, energy efficiency, water technologies, and the traditional energy markets (oil and gas, energy generation, carbon capture).

—**Andrew Lackner '97 Th'99**

I work for Tesla Motors (teslamotors.com). We are making a high-performance electric sportscar. Two other Dartmouth alums work here, too: **Krispin Leydon '99 Th'01** and **Diarmuid O'Connell '86**.

—**Matt Senesky '98 Th'99**

I do Fluent CFD simulation work for Fuel Cell Energy in Danbury, Conn. (fce.com). We build 1- to 3-megawatt molten carbonate fuel cell power plants. We also do solid oxide fuel cell research. I do gas flow simulations to support both the research and manufacturing groups in the company.

—**Joe McInerney Th'99**

I'm a research assistant professor at the University of New Hampshire environmental research group. We are working on sustainability in the highway environment, which focuses on conserving energy, water, and materials while reducing emissions into the environment.

—**Jeffrey Melton Th'99**

As an analyst at Forrester Research, I spend a majority of my time studying the major trends and drivers of new technology adoption. I focus most of my research on software applications that support product development. Tools that support better energy-efficient or environmen-

KINGS OF THE ROAD
Advanced Transit Dynamics' TrailerTail®makes trucks more aerodynamic. The design team, from left, Jeff Grossman '06, Chuck Horrell Th'07, and co-founder and CEO Andrew Smith Tu'07, display a prototype they worked on in Thayer's machine shop.

tally compliant decision making are definitely a hot area right now. Since a large percentage of a product's energy performance is committed during the concept and design stages of a product's life cycle, these types of applications can help designers make a big difference in terms of a product's environmental impact once its being used in the marketplace.

—**Roy Wildeman '99 Th'99**

I'm leading the product development at a company called Advanced Transit Dynamics (atdynamics.com). We are working on bringing to market products to make the world's trucking fleets more fuel-efficient. Our CEO is **Andrew Smith Tu'07**, and we have **Jeff Grossmann '06 Th'07** working with us as well.

—**Chuck Horrell '00 Th'01**

I'm a director for the Technology Transition Corp., which manages the National Hydrogen Association and the Carbon Management Council. Separate from my day job, I've helped to put together a team that will be competing to win the four-person division of the Race Across America. We race this June to bring attention to alternative modes of transportation and carbon-neutral choices. Our goal is to make it from Oceanside, Calif., to Annapolis, Md., in under seven days of 24/7 riding and get as many people as we can to pledge to live carbon-free during the week that we race (xtreme4.com).

—**Patrick Serfass '00**

I recently defended my Ph.D. thesis on infrastructure requirements and impacts for ethanol and hydrogen at Carnegie Mellon. My most interesting project involved modeling ethanol production and distribution in the U.S. The goal was to figure out where it should go, how much it would cost, and emissions from transportation in an optimal scenario. The project showed that ethanol should be used regionally, near where it is produced. High blends (E85 as opposed to E10) should be sold in order to maximize regional use. If ethanol is produced in the midwest and shipped for use in California (this is the case for much of our current production), there are no economic or environmental benefits from using ethanol instead of gasoline.

—**Heather Wakeley '00 Th'02**

Before going to graduate school in architecture, I worked for Redefining Progress on ecological footprint modeling (which seems largely driven by the carbon cycle and fossil fuel consumption), and for Energy Nevada and Nordic Windpower (related enterprises developing utility-scale wind power). I am currently finishing my master's degree in architecture at UC Berkeley, where I am a teaching assistant for an energy and environment course. My design thesis is partly about importing resource footprint into urban areas through facade-implemented growing of food and biomass.

—**Christian Cutul '01**

I work on energy conservation for the Harvard Green Campus Initiative (greencampus.harvard.edu). I manage new construction services, a group that works with new construction and renovation projects at Harvard. We review designs, work with design teams to incorporate green features, and manage the LEED certification process.

—**Jesse Foote '01 Th'02**

I am an assistant professor at Elizabethtown College in Pennsylvania and am involved in research into energy storage for renewables, as well as stand-alone solar and wind installations (etown.edu/solarcabin). I also am involved with an entrepreneurial research project in collaboration with two Ph.D. students at Thayer, **Dax Kepshire Th'06** and **Ben Bollinger '04 Th'04**. This project, which is being developed through the start-up company SustainX, involves a new method of compressed air energy storage. I will be spending six weeks this summer at Hanover working on this research with Dax and Ben.

—**Troy McBride Th'01**

I'm working now as a project coordinator for Lifewater International. We do international water development by training indigenous organizations in shallow well drilling, pump repair, sand filter construction, latrine design and promotion, and hygiene education. I'm the manager for all work in Zambia and Mozambique. I got a master's from Cal Poly San Luis Obispo last year and have been simultaneously working for Lifewater since July 2005. I hope that my research can be a foundation for biodiesel fuel production from wastewater treatment algae. The research I did showed very positive results in terms of potential lipid oil yields, and since the main food source for the algae is human and animal waste, it's really a win-win situation. It's going to be published, I hope, in a special renewable energy issue of the *Journal of Environmental Engineering*.

—**Adam Feffer '02 Th'03**

My new company, VisibleEnergy (visibleenergy.blogspot.com), will provide residential power consumers with an energy-monitoring device and an online community. The monitoring device will deliver a low-cost data feed from the consumer's electricity meter to the VisibleEnergy data processing center. Our website will translate usage into meaningful terms, allow users to compare their consumption with similar homes, and provide tailored recommendations for cost and energy savings. Our team (my wife, **Sarah Kate Fishback '02,** and I) recently won the $5,000 top prize in the consumer division of the Duke Startup Competition.

—**Luke Fishback '02 Th'03**

I volunteer to help run an energy conservation program in our elementary school in Rockville, Md. It is done by fifth-grade students, and I am their leader. We do an energy patrol, celebrate the classrooms that conserve the most, and study energy issues, sources, and conservation benefits. Lots of success.

—**Katya Kovalskaia Th'02**

I work as a consulting engineer for the energy and resources team of the Rocky Mountain Institute (rmi.org), a nonprofit that does consulting and research work in all aspects of energy and resources. I have only been with RMI for a few months (I was doing energy analysis for green building design for an HVAC firm prior to this), and am currently working on a research project called Next Generation Utility, which looks at the need for a new electric utility paradigm.

—**Kendra Tupper '02 Th'03**

I joined ExxonMobil five years ago after receiving my degree at Thayer. Last fall I transferred to a position in Doha, Qatar, within our liquefied natural gas (LNG) business. We work on the global development of marketing plans to monetize natural gas reserves, as well as day-to-day marketing of associated products and related businesses. I am currently living and working in Qatar, the world's fastest growing economy, working on the world's largest and most technically complex natural gas projects. We are (probably) in the "golden age of natural gas," as once-regional markets for domestic pipeline natural gas become interlinked globally by the emergence of

COURTESY OF CHUCK HORRELL '00 TH'01

a growing LNG business. The use of natural gas as a fuel, particularly in power generation, is important component within plans that consider the use of cleaner burning fuels as a way to reduce emissions, including CO_2. The growth of the LNG business makes this increasingly more possible across the globe.

—Garth Castren Th'03

After Thayer I got my master's in technology and policy, and civil and environmental engineering at MIT. There I worked on modeling renewable energy technologies (wind and solar specifically) and economic policies (renewable energy portfolio standards, tax subsidies, guaranteed government buy backs) for the MIT Climate Change modeling research program. I am currently teaching math and science in a public school in New York City and often include energy topics in my courses. I have offered a renewable energy elective and a course on energy use and the environment.

—Alan Cheng '03 Th'03

I am working on an energy problem as part of my thesis here at Stanford (I graduate from the master's program in June). I have teamed up with a fellow product design grad student and together we are exploring the world of solar from new perspectives. What if everyone, even renters, could own small-scale solar and do their part? We have been researching perceptions around energy and environmentalism and have found an opportunity to create products in the solar sector that allow young, environmentally conscious people to express their individuality and empower optimism around energy choices. We aren't trying to increase solar efficiency or reach grid parity, instead we're trying to celebrate the possibilities of solar.

—Emilie Fetscher '03 Th'04

I work at SunPower Corp. (sunpowercorp.com) doing design engineering for domestic systems in California and New Jersey and international in Italy and Korea. The sun is so hot right now! Being in the renewables market, it is interesting to see how little the environment is involved in the day-to-day working life. I have overheard many say how we are in competition with wind, and comments like this make me realize how large a role policy has in creating this new marketplace for all sustainable technologies to exist. We've just moved into an old Ford factory in Richmond, Calif., and the company is about to install one megawatt of solar on its rooftop to become off-grid. Taking on a vertically integrated approach, the company designs and manufactures the solar panels, and designs and installs arrays. Making the simple design/build process more convoluted is the concept of financing, as many large power plant systems are priced such that outside financiers purchase and sell solar electricity to the customer. In trying to balance the multi-variable design and sales constraints, I often think back to my operations research class, and realize that behind this multivariable system of equations, I am offsetting carbon each time I turn on my computer.

—Adam Han '03 Th'04

For two years I was working at a consulting firm within their energy and environment business consulting group. There we did a lot of work with utilities, ranging from energy sources (coal, gas, etc.) to transmission lines to distribution networks. A bit of work I did was in the photovoltaic and wind arena. For the past year I've been working at a private equity fund on their U.S. and natural resources private equity team. Although I've spent the bulk of my time working on more general private equity managers, I've had some exposure with natural resources managers ranging from oil and gas to clean tech.

—Ethan Levine '03 Th'05

I work for a management consulting firm in Atlanta, Ga., and we do about 80 percent of our work with energy clients, mainly large utilities and government entities. I've been involved in the energy industry in an organization redesign for the country's largest state power authority, new generation development and resource planning for a top-ten utility, and I authored a white paper on carbon capture and storage (scottmadden.com/news-and-research/articles.aspx?id=35).

—Bob Neill '03

I'm doing doctoral work in the natural resources and earth system science program and part of the ocean process analysis laboratory at the Earth, Oceans and Space Institute at the University of New Hampshire. I hope to be able to use my research to help site offshore wind farms. I work on a sensor called SeaWinds on the QuikSCAT satellite. This instrument is called a scatterometer and is basically a space-borne radar that measures backscatter, the signals reflected off centimeter-scale waves on the ocean surface. These little waves are generally caused by wind, so the strength of the backscatter signal can be interpreted through a geophysical model function to derive wind speed and direction. I'm still in the evaluation phase, but if I have good results, I'll begin developing a high resolution wind climatology with a web-based interface. This would provide useful information for companies and communities interested in the offshore potential of their area. Some of the major wind energy companies in Europe already use satellite data for siting purposes, and one (Garrad Hassan) has shown interest in my work. Additionally, the nine-year record of data from QuikSCAT means that this research might have additional climate change-related impacts—I could attempt to look for any significant differences between the overall wind patterns in 1999-2000 vs. those in 2007-2008, for instance.

—Amanda Plagge '03 Th'04

I'm a second-year Ph.D. student at Purdue University and part of a research group that is working on GaN-based white LEDs. The project is sponsored by the U.S. Department of Energy as part of its solid-state lighting initiative. My part of the research group does the characterization work, which is mainly transmission electron microscopy.

—Patrick Cantwell '04

I'm a student at MIT, and my research is on how renewable generators fit into modern electricity markets. I'm writing a thesis on how different ways of pricing electricity would change revenues of renewable generators, and I also do some work in quantifying the avoided emissions that can be attributed to new renewable generators or energy efficiency projects. We start with data that the EPA collects for its Continuous Emissions Monitoring system. They measure the CO_2, SO_2, and NOx coming out of every electricity generation unit in the country by hour. We want to figure out which of those plants are "on the margin"—for example, if someone turns on or off an air conditioner or we install some wind generation, which fossil generators will reduce their output in response. We have a simple program that identifies those generators for each hour (currently we do it from 1999 to 2006) and we take an average of their emission rates as the system's marginal emission rate for that hour. Then we can compare that emission rate to historical wind speeds by hour for any site. Basically we are answering the question, "If we built a

wind turbine in this location in 1999, how much CO_2, SO_2, and NOx would have been saved?" The main insight/surprise that we have had is that the hour-by-hour operation of the power system is so complex that looking at aggregate numbers (such as annual emissions or renewable generation) can give misleading results. We found that emissions rates on the margin (i.e., from the most expensive plants that are operating at any instant) are much more variable and on average larger than average emission rates; and emissions have seasonal and daily patterns, so it is important to see how they line up with hourly wind speeds or sunniness. The work I have been doing with a research group includes applying this to some test cases in New England. The project I've been doing on my own is "Effects of Real-Time Electricity Pricing on Renewable Revenues and System Emissions." Real-time pricing (RTP) would mean that the price of electricity that you and I pay would vary by hour, depending on how expensive it is to generate in real time (we would have a meter in our house to give us the price). I modeled the effect that this would have on solar and wind generators by looking at how wind speeds and solar radiation line up (hour-by-hour) with price changes due to RTP. We found that the effect isn't much different than the effect on the average fossil generator (for the four New England test cases I considered). The price for electricity and the wind/solar generation are more random, hour-by-hour, than I expected.

—J.P. Connolly '04 Th'04

I work for Northern Power in Barre, Vt., which designs and builds wind turbines. Right now we are selling a 100-kilowatt wind turbine and will be producing a 2.2-megawatt turbine in one to two years. The wind market in the U.S. is just starting to develop and grow. Over the next few years I believe we'll see large increases in wind farms across the country. My job focuses on the power conversion from the wind turbines rotor to grid. Efficiency is key in this area, since typical wind turbine applications stack up turbines and that can eventually lead to large power losses. The "lossiest" components in the converter are typically the magnetics and switches. My design focus is on the magnetics that are used to boost the voltage to a level needed for the grid. To figure out what design changes are worthwhile in the magnetics, we often attach an effective initial cost to any changes to see what the upfront financial cost is and when it would be paid back.

—Magdalena Dale Th'05

I have been working for GE Energy for the last two years, on both the gas turbine compressor and wind turbine aerodynamics teams. I had the pleasure of working with several Thayer grads, including **Gunnar Siden Th'85, Dale Apgar '04 Th'05,** and **Ryan Conger '05.** Most of my work focused on building 2-D or 3-D computational fluid dynamic models. Efforts for the wind team dealt with enhancing prediction capability to improve blade acoustics and general performance. Recently, I focused on power plant mechanical control upgrades to improve optimization and control. I just completed a large upgrade on one of the world's largest geothermal power plants in Mexico. I just took a leave of absence from the company to explore other avenues of energy and climate change and complete my master's in mechanical engineering.

—Eric Fitz Th'05

I recently graduated from Stanford with a master's in civil and environmental engineering, focusing on atmosphere/energy issues. I am now working at an energy engineering/consulting firm in San Francisco. My work focuses on feasibility studies, project scoping, and implementation support for energy efficiency and renewable energy projects. Recently I have also been working on calculating greenhouse gas emissions reduction potential for renewable energy and energy-efficiency projects.

—Tia Hansen '05

I work for DC Energy along with other Dartmouth engineers **Steven Hsu '01 Th'02, Lauren Cecere '06,** and **Albert Kang '06.** We trade in the energy markets, with our key focus on the deregulated electricity markets, but also in natural gas. Our activities aid in driving pricing efficiencies for producers and users of power alike. The markets provide a means for aiding in economic dispatch of generation units to meet the demand of the system across the transmission grid.

—Daniel Hassouni '05 Th'05

I'm a project manager for Tamarack Energy (tamarackenergy.com), a developer of renewable energy projects, in Essex, Conn. Tamarack primarily focuses on developing utility-scale biomass (clean waste wood) power plants. We are working on several such projects on the East Coast. Clean waste wood is a carbon-neutral (or carbon negative), renewable, low-cost, and environmentally friendly source of power. We are also working on several wind projects in northern New England.

—Cliff Orvedal '05

I am currently working in the alternative energy field, doing research and development for Mascoma Corp. in Lebanon, N.H., along with a number of other Dartmouth and Thayer School alumni. My work focuses on feedstock pretreatment for the production of cellulosic ethanol.

—Matt Richards '05

I'm currently in the first year of my master's at the University of Texas in Austin—my graduate research is actually on wind turbine control systems. I'm also interning this summer at in GE's Power Systems group in Schenectady, N.Y., working on a study of high wind and solar penetration in the western U.S.

—Dave Burnham '06

I work at Manasc Isaac Architects, which is located in Edmonton, Alberta, Canada. My work is funded by a provincial agency (Alberta Ingenuity) that has a mandate to increase the amount of R&D in our province's economy. I am conducting research with the intent of improving buildings that, among other things, use daylight and energy efficiently. I'm looking at how engineering analysis can be integrated into the architectural design process to achieve this end. I'm learning how to use and evaluate the widely disparate array of software packages available to facilitate the analysis of a building's energy consumption. I'm also familiarizing myself with the design process of a sustainable building—which differs from the design of a standard building, primarily in the degree of coordination between members of the design team—to see how these tools can be integrated into that process. I've done a number of studies for several buildings that have been successfully used to convince clients of the benefits of design features that would optimize the amount of natural light in a space.

—Josh Kjenner Th'06

I work for Rumsey Engineers in Oakland, Calif. We design HVAC systems for energy-efficient buildings. We also serve as consultants to PG&E's Savings By Design Program, which offers incentives for high-tech facilities that incorporate energy-efficient measures into their design. We perform the energy analysis for this program. The incentives are awarded based on the calculated energy savings.

—Hillary Price Th'07

inventions

PEDAL TO THE MEDAL
Brian Mason '03 Th'04, '05, in red shirt, and his Aquaduct colleagues created a winner.

AQUADUCT

>> INVENTOR:
BRIAN MASON '03 TH'04, '05

In many parts of the world, people have to walk or motor miles to collect water. Then they have to boil it to purify it. The process not only consumes time but fuels.

Brian Mason '03 Th'04, '05 and four colleagues at IDEO, a design firm in Palo Alto, Calif., came up with a better idea. They invented the "Aquaduct," a mobile filtration vehicle that makes it possible for people in the developing world to fetch and transport a family's daily supply of water. By the time riders pedal home, some of the water is already filtered and ready to drink. The rest can be filtered later by stationary cycling.

The idea was so good that it recently won the grand prize in Google's first Innovate or Die Pedal-Powered Machine Contest, which challenged teams across the country to create pedal-powered solutions to offset climate change. The Aquaduct beat out 101 other entries.

The ingenious bike attaches a peristaltic pump to the pedal crank to draw water from a large tank and filter it into a removable dispenser. Mason says that the project reminded him of Thayer School's hands-on introductory course. "It was like working on ENGS 21 but in the real world," he says.

Mason and his teammates donated their $5,000 prize money to KickStart, a nonprofit that develops and markets new low-cost technologies in Africa.

The bike hasn't yet made it into production, but Mason is hopeful. "We are working to find funding to continue the project, as it needs more development," he says. "It has received lots of press and excitement from around the world."

More than 750,000 people have already watched the team's winning presentation on YouTube. View it at youtube.com/watch?v=-U-mvfjyiao.

COURTESY OF BRIAN MASON '03 TH'04, '05

RANDOM WALK

Formula Hybrid isn't the only race car at Thayer School. Dartmouth Formula Racing (DFR) students have also created an E-85 car, which runs on 85 percent ethanol and 15 percent gasoline. "E-85 cars stand out from other race cars because they generally produce more horsepower," says DFR's Calvin Krishen Th'07, ' 08, left, pictured with Scott Lananna '08 (center), and Mark Criscimagna '07 Th'08 (right). E-85 cars, which compete against gas-powered cars in SAE competitions, also require various adaptations. "Certain parts of the engine have to be treated to protect them from corrosion. The engine's computer must also be reprogrammed to account for its different burning properties," says Krishen. The car has driven Krishen to anticipate future advances in fuels and technologies. "Most every alternative source can be proven feasible given the time and resources," he says. "There may be an even better fuel-alternative around the corner, and it just takes some open-minded engineers to learn how to use it."

THAYER SCHOOL OF ENGINEERING
DARTMOUTH COLLEGE
8000 CUMMINGS HALL
HANOVER, NH 03755-8000

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