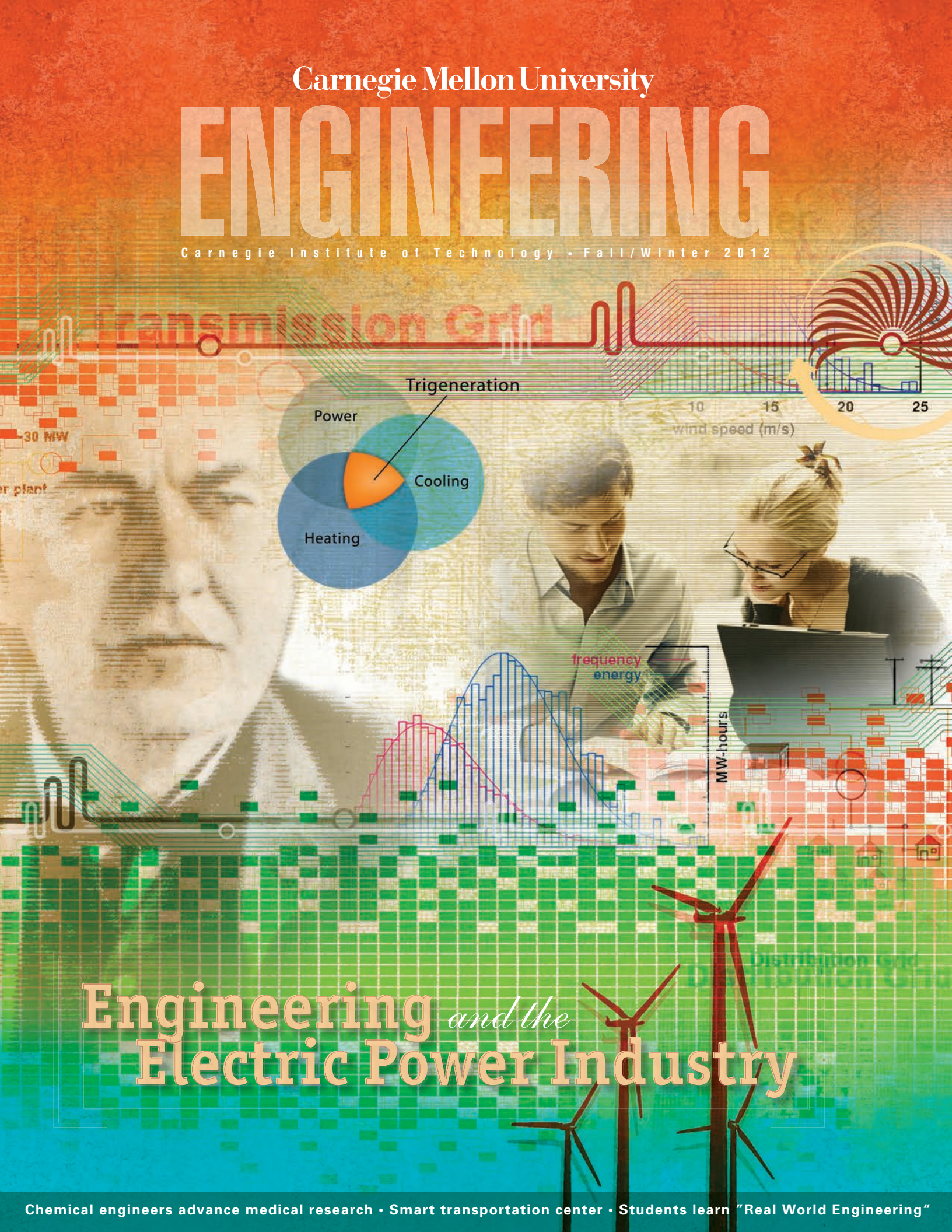
Carnegie Mellon University

ENGINEERING

Carnegie Institute of Technology • Fall/Winter 2012



Engineering *and the* Electric Power Industry

Chemical engineers advance medical research • Smart transportation center • Students learn "Real World Engineering"

We're not Bragging

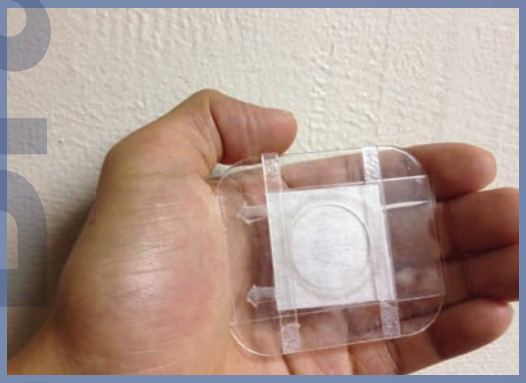
But...

Student Achievements

Senior Project Delivers Prize-Winning Medical Device

An undergraduate Biomedical Engineering (BME) project, "ThinAir: A Novel UltraThin Rescue Inhaler for Asthmatics," won third place in the 2012 National Collegiate Inventors and Innovators Alliance (NCIIA) BMEStart Competition. A prize of $2,500 was awarded to Associate BME Head Conrad Zapanta and his students, David Morse, Alex Chou, Allen Chen, Stephen Tsaur and Deborah Gruner. BMEStart is a competition that recognizes excellence in undergraduate biomedical innovation, design and entrepreneurship. The ThinAir is designed to help asthma sufferers who have active lifestyles. Present rescue inhalers are bulky because they require complex dispersion methods to enable the inhalation of medication. The ThinAir pre-disperses the active ingredient, albuterol sulfate, on a cellulose and polyester cloth. This allows the medication to reach the affected areas of the lungs while maintaining a thin device profile.

ThinAir Rescue Inhaler



SWE Students Organize Major Job Fair

More than 3,600 students and 340 employers participated in the annual Technical Opportunities Conference, or TOC, that took place September 11-12, 2012. Sponsored by the College of Engineering and organized by the Society of Women Engineers (SWE), the TOC is the largest job fair at Carnegie Mellon, and it's specifically focused on technical employment. Career fairs are important to our students. According to data on CIT's Class of 2009, 28 percent of the graduates found jobs through career fairs. If your company is interested in participating in 2013's TOC, visit http://toc.web.cmu.edu.

The TOC is the largest job fair at CMU.

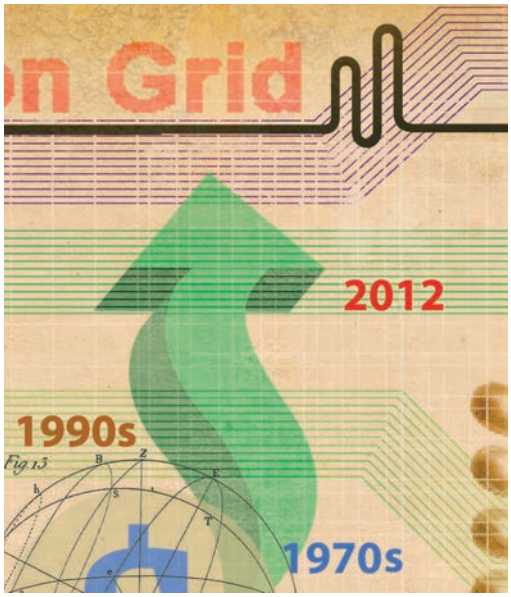
INI Students Develop Winning App

Information Networking Institute (INI) graduate students Shrikant Adhikarla, Ditaya Das and Sanjay Parab competed in the official hackathon of the Sprint Open Solutions Conference on October 23 in San Jose, Calif., and tied for first place in the competition's category for the best use of Sprint Network APIs. During the 24-hour competition, the CMU team designed P2P Connect.me. The application provides an adhoc peer-to-peer way for devices to share information without having to connect to Wi-Fi or the Internet. People can share business or social contacts with multiple users in a single click; the data travels directly from device to device while preserving users' privacy. Hackathons reinforce "learn by doing" education which is a key component of CIT's educational approach.

Carnegie Mellon University ENGINEERING

fall/winter 12

The a cappella group Joyful Noise performed at the CIT Celebrates Diversity Event



Feature/4-9

Engineering and the Electric Power Industry

The U.S. electricity industry generates more than $375 billion in annual sales. The demand for electricity continues to grow as the industry undergoes enormous changes.

Cover and feature illustrations by
STEPHANIE DALTON COWAN

New program, "Real World Engineering" pairs students with mentors./p.21

Change is in the Air

This year has been nothing short of dynamic in the College of Engineering.

As many of you are aware, Pradeep K. Khosla, CIT's dean for eight years, has assumed the role of chancellor at the University of California San Diego. As dean of the College of Engineering, Pradeep strengthened the school in remarkable ways. During his tenure, CIT's total enrollment grew more than 25 percent and master's and Ph.D. students increased roughly 50 percent. Support for students swelled. Ph.D. students receive fellowships their first year and undergraduates have access to scholarships to travel abroad. Major research centers and groups were founded. The college's reach expanded to include the Silicon Valley, Rwanda, Portugal, India and now China. (You can read more about our global activities on pages 16-17.) These feats fortify the college's reputation as a powerhouse in research and education. The college thanks Pradeep for his extraordinary service to Carnegie Mellon and we wish him continued success. Presently, a search is underway for his successor, and during the transition, I am serving as interim dean.

Another momentous event that happened this fall was the groundbreaking for the Sherman and Joyce Bowie Scott Hall, the future home of the Wilton E. Scott Institute for Energy Innovation. (See page 3.) This building is vital to the College of Engineering because it provides much needed space for faculty and students to work together on the complex, multidisciplinary problems inherent to energy. Engineering students comprise roughly one third of Carnegie Mellon's student body, yet the college only occupies 20 percent of the university's academic space. The new building will play a pivotal role in enabling the college to provide salient educational opportunities for students pursuing careers in energy. Further, it will enable Carnegie Mellon to flex its strengths in engineering, computer science, business and policy, and help establish Western Pennsylvania as a world leader in energy innovation. Scott Hall will also allow our Biomedical Engineering (BME) faculty to move to the main campus and pursue closer research interactions with others in CIT and CMU. Another key feature of the building will be the state-of-the-art nanofabrication facility that will be located on the ground floor. We will keep you apprised on both the progress of the new building and the developments underway in the Scott Institute for Energy Innovation.

There's another initiative underway in the college that is of fundamental importance in our educational mission. A committee was formed to examine CIT's undergraduate curriculum and provide direction to infuse "Innovation Across the Curriculum." The college has funded and will continue to fund enhancements to existing courses, the addition of new courses and the expansion of extracurricular learning opportunities all with the goal of graduating students who become leaders that understand technology and know how to drive innovation.

We have accomplished much this year, and I am confident that 2013 will be as remarkable as well.

Sincerely,
Vijayakumar Bhagavatula
Interim Dean, College of Engineering

Important **Announcement**

This magazine was at press when Dr. James H. Garrett Jr., the Thomas Lord Professor of Civil and Environmental Engineering, was appointed as dean of the College of Engineering, effective January 1, 2013.

A member of the CIT faculty since 1990 and a Carnegie Mellon alumnus (CEE '82, '83, '86), Jim has demonstrated leadership in education and research initiatives at Carnegie Mellon and internationally. He is head of the top-ranked Department of Civil and Environmental Engineering and co-director of the Pennsylvania Smarter Infrastructure Incubator. More information about Jim and his accomplishments and service to CMU is available on our website at www.cit.cmu.edu.

Please join us in congratulating Jim Garrett as the new dean of the College of Engineering.

Carnegie Mellon University
ENGINEERING

EDITOR
Sherry Stokes

WRITERS
Lili Ehrlich
Tara Moore (HS 2010, 2011)
Sherry Stokes (HS 2007)
Chriss Swaney
Mike Vargo (MechE 1969)

DESIGNER
Monica Banaszak (A 1984),
Communications Design
& Photography Group
University Advancement

PHOTOGRAPHY
Ken Andreyo, Tim Kaulen,
Communications Design &
Photography Group
Glenn Brookes
David Cochran

Produced for the College of Engineering by the Communications Design Group, December 2012, 12-644.

We want to hear from you.

Send email to
stokes@cmu.edu
Please include your name and, if applicable, major and date of graduation. Letters will be edited for clarity and space.

Where Innovation **Will Happen**

Carnegie Mellon University broke ground for the Sherman and Joyce Bowie Scott Hall on September 22, 2012. Scott Hall will become the home of the Wilton E. Scott Institute for Energy Innovation.

Both the building and the institute represent significant undertakings and opportunities for the university. Along with the Scott Energy Institute, Scott Hall will house the Biomedical Engineering Department and state-of-the-art nanotechnology fabrication labs. The expansive building will physically connect other engineering and computer science buildings on campus, and enable faculty and students to work together under one roof, reinforcing Carnegie Mellon's collaborative culture. In addition to the Scotts, the university received support for Scott Hall from John Bertucci (E'63, TPR '65) and his wife, Claire Ruge Bertucci (MM'65); Jonathan Rothberg (E'85) and his wife, Bonnie Gould Rothberg; and the Eden Hall Foundation. Completion of Scott Hall is projected for spring 2015.

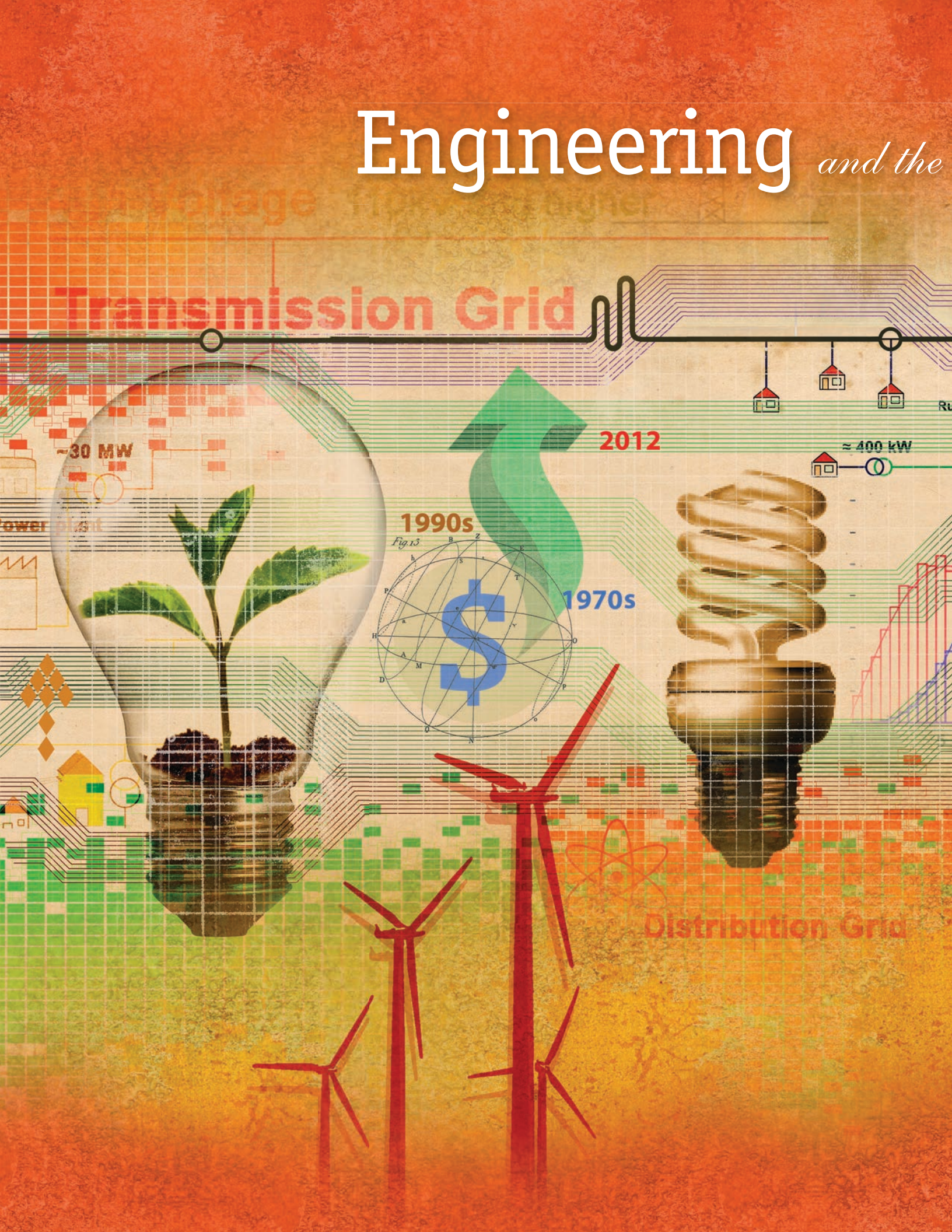
The Wilton E. Scott Institute for Energy Innovation was created through a lead gift from Sherman Scott (E'66), president and founder of Delmar Systems, and his wife Joyce (A'65). The institute bears the name of Sherman's father Wilton.

The institute is a university-wide research initiative focused on developing the technologies, systems and policies needed to make the transition to a sustainable energy future. Exercising the university's expertise in integrated systems and an understanding of the intersection of energy and public policy, the institute concentrates on energy efficiencies and reliability, as well as smart operations, materials and processes.

M. Granger Morgan, the Thomas Lord Professor of Engineering and head of the Department of Engineering and Public Policy will direct the Scott Institute, and Andrew Gellman, head of the Department of Chemical Engineering, is the associate director.

The future home of the Wilton E. Scott Institute for Energy Innovation

Engineering *and the*



ELECTRIC POWER INDUSTRY

BY SHERRY STOKES

In 1882, Thomas Edison threw the switch at the first commercial electric generator near Wall Street, and the electric power industry was born. Today, the U.S. electricity industry generates more than $375 billion in annual sales. Modern life would flounder without lighting, air conditioning, computers and the untold number of devices and services that rely on electricity. The demand for electricity is growing, and the pervasive industry is undergoing enormous changes. This is why Carnegie Mellon is committed to studying electricity.

Smarter Strategies for A SMART GRID

Today's electricity industry faces complex challenges, ranging from an underinvestment in R&D to issues surrounding alternative generation to regulatory wrangles. As these difficulties grow, energy producers, equipment suppliers, policymakers and consumers, virtually everyone in the United States is affected. Circumstances are forcing the industry to transform, and to shape the industry into an enterprise that meets society's needs and grows in competitiveness, is one of the reasons the Carnegie Mellon Electricity Industry Center (CEIC) was formed.

"Our advisory committee tells us that the CEIC is the largest interdisciplinary center in the world studying the problems of the electric power industry," says Jay Apt, CEIC's director and a professor in the Tepper School of Business and College of Engineering's Department of Engineering and Public Policy. Since the center's inception in 2001, it has garnered tremendous respect throughout the industry both in the U.S. and abroad. The center's supporters reflect its prominence: core funding has come from the Sloan Foundation and the Electric Power Research Institute (EPRI) and additional funding sources include the National Science Foundation, the U.S. Environmental Protection Agency, the Department of Energy, the National Rural Electrical Cooperative Association and others. The center's mission "is to work with industry, government and other stakeholders to address the industry's strategic problems," and the centerpiece of this work is research and educational opportunities for Carnegie Mellon students.

The impact of the center's work is far reaching. For example, CEIC researchers played an important role in the debate on deregulating the electric industry. Apt explains that in the mid-1970s, the trucking, airline and railway industries were deregulated. Prices decreased and naturally, people thought that if the electricity industry was deregulated, prices would drop. That didn't happen.

"Electricity prices had been increasing since the early 1970s," says Apt. One reason for this is skyrocketing demand. From World War II through the early 1970s, electricity use rose nearly 8 percent annually, forcing companies to rapidly build power plants. Building the plants proved expensive. For 70 years, steady progress on improving efficiency was made by increasing the temperatures at which the plants operated. By the 1970s, electricity plants were approximately 35 percent efficient but then "they reached the end of the road—we were done with easy thermodynamic approaches in efficiency," says Apt. Compounding the situation was the 1973 OPEC Oil Embargo. While the embargo upped fuel prices, it played a minor role in raising the price of electricity because little oil is used for electricity

COVER & FEATURE ILLUSTRATIONS BY STEPHANIE DALTON COWAN

generation. However, because of these combined factors "the price of power was going up at the same time people were talking about deregulating the industry."

In 1996, California and Pennsylvania became the first states to deregulate electricity. The expectation was that prices for industry customers would drop by 30-40 percent as they did in the trucking, barge and rail industries. When CMU researchers examined the price of electricity in a deregulated environment, they discovered there were no price decreases. "This caused a sea change in the industry. Up to that point, 20 states had restructured their industries and about a dozen more had legislation moving through to restructure. After our first paper came out, and subsequent papers that explained the causes, no state has since deregulated their industry. We [CEIC] made an enormous impact on that debate," says Apt.

The Economics Must Make Sense

Electric utilities do not have strong economic incentives to encourage innovation. The cost of making power is low in most areas of the U.S. and according to Apt, the industry spends less on R&D than the pet food industry.

"We felt that if there was going to be significant innovation, it would likely be on the small scale," says Apt. CEIC researchers turned their attention to studying co-generation known as combined heat and power (CHP). They discovered that with establishments, like hospitals or universities, cogeneration can be economically feasible. Additionally, the heat can be used for evaporative cooling, creating trigeneration or combined heat, power and cooling.

"We examined what the barriers are to this and they basically have to do with the exclusive service territory that electric power companies have," says Apt. As he explains, if a hospital produces power on-site at a CHP plant, it's illegal for the hospital to sell any excess power that's produced because it doesn't have the franchise to do so.

While present legislation and low prices thwart large-scale innovation, environmental issues are forcing changes in the electric power industry. Fossil fuel plants comprise 70 percent of the U.S. electric power generation, and these plants are responsible for 40 percent of the nation's CO_2 emissions. The environmental implications of carbon dioxide have led CEIC researchers to investigate various aspects of underground CO_2 sequestration.

"Granger Morgan and his CEIC colleagues have concluded that the technical concerns [of sequestration] are not the dominant ones, but rather the regulatory ones are," states Apt. CMU researchers worked with colleagues from the Vermont Law School and the environmental law firm Van Ness Feldman and prepared draft legislation for Congress that would enable CO_2 sequestration. While a reduction in CO_2 would benefit the environment, again, economic drivers are absent. "We have spent a fair amount of time characterizing the costs of low carbon

Jay Apt, director of the Carnegie Mellon Electricity Industry Center

> "We felt that if there was going to be significant innovation, it would likely be on the small scale."
>
> JAY APT

power, both coal and natural gas, with CO_2 capture, and we understand that as well as any group in the world. Without a price on CO_2, which this country does not have, carbon capture is not economic except for enhanced oil recovery," states Apt.

Another approach for mitigating CO_2 emissions is through alternative generation, such as wind power. As Apt explains, CMU researchers were pioneers in characterizing the mathematical characteristics of wind and solar power generation. They were able to determine how much additional generation a system needs to account for the variability of wind power caused by variable wind. "We have made contributions in understanding what the costs of those variabilities are and how to minimize those costs," says Apt. Building off this work, CMU researchers have teamed with the University of Vermont and the Vermont Law School on the RenewElec Project (see www.renewelec.org). The $2.5 million project aims to help society transition into using electricity that's generated from variable and intermittent sources of renewable power, and to do so in a way that is economical, reliable and environmentally benign.

Similar to sequestration, the amount of electricity we derive from wind won't be curtailed by engineering challenges. A chief barrier is "whether people will allow large-scale land use for electric power," says Apt, "Wind power is already at 3 percent of U.S. generation and it's getting a lot of pushback from landowners in some states." Looking at the economics, it doesn't make sense to erect a multitude of windmills in the windy belt between North Dakota and Texas and run transmission lines across the country. "The transmission lines are too expensive and people get upset when you string lines through their land. They especially get upset if you string lines over their neighbor's land. They can see the lines, but they don't get any rent," says Apt. Other scenarios develop, too. For example, in Pennsylvania, landowners who collect rent from wind turbines are pitted against "people who operate ski areas and don't want skiers to see an industrial landscape. There are enormous fights. While I think there can be a five- or six-fold expansion of wind power from the current 3 percent we see, it's likely to top out at around 20 percent, and this limit will be set by land use."

Involvement on Many Levels

Hand-in-hand with generation is the related issue of electricity storage. On this front, Carnegie Mellon researchers are taking their successes in the lab to the marketplace. Jay Whitacre, a professor in Materials Science and Engineering and Engineering and Public Policy founded Aquion Energy, a company that is building inexpensive, long-lived aqueous electrolyte sodium-ion batteries intended for large-scale storage. In underdeveloped regions that aren't connected to the grid, the batteries are already storing energy produced by alternative means. In areas supported by the grid, again, the batteries could store alternative energy, and release it into the grid when necessary. Aquion has selected a site in western Pennsylvania for its first manufacturing facility, and full-scale production is slated to begin in 2013.

CEIC collaborates with industry on a variety of projects. Currently underway is a $2 million joint effort with Potomac Electric Company. This project delves into "the economics and behavioral psychology of customers and their knowledge of devices that are connected to smart meters. Utilities are rolling out smart meters, and so we're working with PEPCO to understand what kinds of communications the company should make with customers," says Apt.

Another critical aspect of the electric power industry is maintaining the security of the infrastructure, and the CEIC continues to make pertinent contributions to this effort. "Every year or two, there is someone who comes up with an idea to make the grid invulnerable. So we [CEIC] looked at that from a theoretical standpoint," states Apt. "If someone claims that they can make the grid invulnerable, you have to be able to test the proposed solution to see if it works. To do that with the grid is impossible. There are so many devices in the electric power grid that even if we used the fastest computers to simulate this, it would take longer than the age of the solar system to go through a simulation of the electric power grid exhaustively," says Apt.

Instead of trying to achieve something that is impossible, namely no blackouts ever, the CEIC shifted its focus to making the delivery of electricity more resilient. "What you really want from electricity is the service it provides," says Apt. He explains that in the case of a major blackout, it takes days to restore full power. During the downtime, it's advantageous to keep essentials running, like traffic lights and elevators so people don't get trapped between floors. "All of this can be done very nicely without central station electric power," says Apt. Blackouts occur for a variety of reasons: human error, terrorist attacks, technology failures and natural phenomena such as hurricanes or ice storms. We cannot control everything that affects the grid, "so we have developed the philosophy that it is much better to consider carefully what essentials the grid should provide rather than trying in vain to make the grid invulnerable," says Apt.

This ability to determine what problems are worth solving is another indication of the strategic tack that the CEIC brings to electricity research. As the breadth of the CEIC's research demonstrates, modernizing the electric power industry will require synergies in the areas of technology, security, economics and policy. Education is vital, too, in ensuring that a cadre of well-trained personnel is available to manage the industry. In all these areas and more, the CEIC serves to solidify Carnegie Mellon's reputation as a global leader in electricity research and education.

Modeling Dynamics of ELECTRIC ENERGY SYSTEMS

In 2002, Marija Ilić, an expert on electric power systems from MIT, arrived at the College of Engineering (CIT). She and Carnegie Mellon's (CMU) Lester Lave, one of the nation's leading environmental economists, co-taught a course called "Modern Electric Power Systems." A joint effort between CIT and the Tepper School of Business, the class highlighted the interdependence of engineering, policy and economics and their effect on the electricity industry. Enrollment was small, around 10 students, but that didn't deter the professors. They believed that the rapid restructuring of the electricity industry would create the need for well-educated electric energy leaders, and they were right.

Today, the once-fledging course is called, "Engineering and Economics for Electric Energy Systems," and enrollment has grown to roughly 40 Ph.D., MBA and undergraduate students. Additional energy courses like "Smart Grids and Future Electric Energy Systems" bolster the engineering curriculum, and the university is now the home of the annual CMU Electricity Industry Conference. Ilić has been instrumental in all these activities and more—she founded and directs the Electric Energy Systems Group (EESG) at CMU. She along with other prominent faculty and 30 graduate students conduct multidisciplinary research to forge future electric energy systems.

"The emphasis of the EESG is to think of electric energy systems as complex dynamical systems. You have to model and simulate them to understand their behavior," begins Ilić. To this end, the researchers insert sensing, control and communications intelligence into models. They are learning what logic they must develop so they can determine what information needs to be exchanged between different parts of the grid. Ilić refers to this work as "DYMONDS."

DYMONDS is an acronym for Dynamic Monitoring and Decision Systems. "We want to embed monitoring, control and decision making into electricity users' technologies and into conventional and renewable power plants so they all adjust themselves to the system's needs and interconnect with the system in the best possible way. We call the gadgets embedded into the distributed energy resources DYMONDS, but the aggregator [of information] is another DYMONDS on a higher level," says Ilić. (Distributed energy resources [DER] are small, decentralized energy generation systems, like wind turbines, sited near the place where the energy is used.)

Traditional utility companies encourage central generation—they don't rely on real-time monitoring when they schedule generation or supply power. However, unconventional power providers are now coming onto the grid. "People want to use distributed energy so we have to think about distributed generation and distributed demand response," says Ilić.

No Wind, No Problem

Generally, electricity is generated at very large coal-powered plants. It travels long distances to substations and then to neighborhoods. However, this scenario is changing. Facilities, such as solar or wind power plants are now placed closer to customers. As these small plants come online, we have to embed intelligence into them so they connect reciprocally to the grid. In a perfect world, customers would have power if the plants fail to generate, and if excess power is produced, it goes back into the grid.

"The big question is how we integrate different systems without creating operational problems and at the same time maximize their efficiency so that the whole system remains balanced," says Ilić. "What intelligence should we embed

Marija Ilić, the founding director of the Electric Energy Systems Group

> "We want to embed monitoring, control and decision making into electricity users' technologies and into conventional and renewable power plants so they all adjust themselves to the system's needs and interconnect with the system in the best possible way."
>
> MARIJA ILIĆ

into DER systems? How will that impact performance? What information should the distributed resource exchange with the system operator so that this puzzle works together?" asks Ilić.

As if the situation isn't complicated enough, compounding the technical challenges are economic hurdles. Utility companies aren't inclined to embrace adaptive demand technologies because there aren't economic incentives, but this could change according to Ilić. By scrutinizing customer behavior, we can gauge how electricity loads will change over the long term. Utilities could use this information to determine what types of plants to build in the future, and this would enable companies to save significant money on capital investments. "We need to embrace predictive, look-ahead decision making rather than mere automation, which only reacts to what is happening in real time," says Ilić. This is where computer science enters the picture.

Historically, utility companies forecast system demand and assume that there is no choice on the customer side to adjust demand. "But what we are proposing with DYMONDS, is embedding intelligence into distributed resources so they can say how much electricity they want to sell or buy and at what cost. The aggregators will provide smaller customers with that information. Basically, there will be no surprises, like in California, where they put meters in customers' homes and the bills are still higher than what people expect," says Ilić. In the new scenario, customers would tell companies what they want to pay for electricity. That information along with the supply and demand functions of the energy provider is relayed to a system operator that optimizes it. The system will then have enough information to select the right combination of resources to meet customer demand and minimize costs. Making this happen will take cross-cutting efforts by both engineers and computer scientists. Ilić explains that the synergies between the College of Engineering and CMU's School of Computer Science are already playing an important role in smart grid research.

A Shining Moment: The Pre-Conference Workshop

In March 2012, the 8th Annual CMU Electricity Conference was held on campus. This conference marked a personal turning point for Ilić. Ten years ago, when she and Lester Lave started teaching, they decided to extend their work. They created a research forum that turned into the conference. Each year, the event reflects different industry concerns, and attendance is strong. However, when Lave died in 2011, Ilić considered discontinuing the conference, but a close colleague of Lave's from Cornell University, Professor Richard Schuler, persuaded her to carry on with the assistance of a guest co-organizer (who will change annually). Ilić agreed, but soon another challenge cropped up.

The conference had grown so much that "we needed to rethink how we would manage its growth." She approached the NSF, and they said, "Why don't you make it a national workshop on sustainable energy systems?" She did, and as a result, faculty and students from top schools across the U.S. received NSF funding to travel to the first NSF-SRC Sponsored National Workshop on Data-Driven Sustainable Energy Systems at CMU. The funding came from the NSF's Computer & Information Science & Engineering (CISE) division, which funds computer science initiatives. At first, CISE support for an electricity conference may seem odd, but as Ilić explains, the funding makes sense. "We [CMU] look at the big picture and can link the computer with the physical system. That is not an easy thing to do," says Ilić. She believes that the integration of computer science with engineering will bring tremendous benefits in terms of energy and will open the market for computers, middleware and other technologies.

The Tale of Low-Cost Green Azores Islands

The NSF backing elevated the reach and prominence of the conference, but for Ilić, the most poignant presentation of the three-day event was the Pre-Conference Workshop. There, her students presented the results from a major smart grid research project conducted in the Azores Archipelago by the EESG and other researchers in Portugal, including those in the Carnegie Mellon | Portugal Program. The researchers demonstrated how DYMONDS-based concepts could provide green, cost-effective energy on two islands, Flores and San Miguel.

"For the first time we showed proof of concept. On Flores, you can have a wind power plant, and if you embed the right intelligence, distributed resources can meet energy demands," says Ilić. Research teams developed models and decision-making tools that simulated the integration of wind with other energy sources. Although wind is intermittent, by deploying clusters of electric vehicles on the islands "you can store wind power and then serve it back when the wind doesn't blow." The group showed that quick automation technologies can respond to ensure reliable operation of the grid.

"Resources will operate in a predictive way, and customer demand and electric vehicles will adjust. However, if the wind is not what you predict, then you need automation. We modeled automation, control and the communications that are needed to ensure that the system remains stable," says Ilić. "The experiment shows that on these islands it will pay off to build wind power plants and have clusters of electric vehicles to compensate and balance the system. Over a long time, it will not be more expensive than burning the fuel they use now," says Ilić. Findings of this research appear in a new book, *Engineering IT-Enabled Sustainable Electricity Services: The Tale of Two Low-Cost Green Azores Islands*. Building off their work in the Azores, EESG researchers are conferring with the Electric Reliability Council of Texas (ERCOT), to see if they can repeat the level of automation control in U.S. systems.

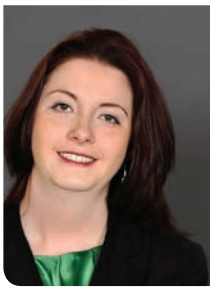
Reflecting on the Pre-Conference Workshop, Ilić beams with pride as she describes the stellar job her students did presenting their research. "I told my colleagues, 'my students know what they are doing,' It was my best day in 30 years of working," says Ilić.

science

A NEW SYNTHESIS

When engineers do medical research, as in chemical engineering, they can bring a new slant to the sciences of healing.

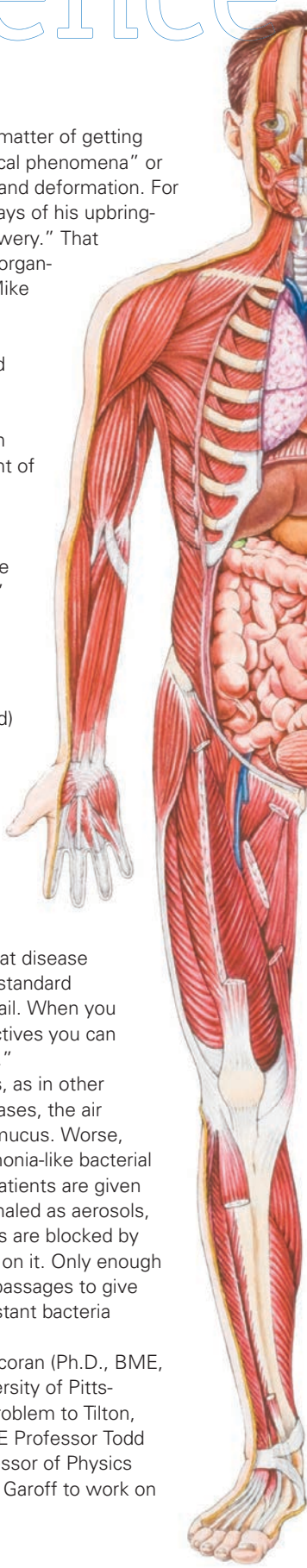
BY MIKE VARGO


Kris Dahl


Mike Domach


Bob Tilton


Jim Schneider



For Kris Dahl, it was a matter of getting interested in "rheological phenomena" or the study of fluid flow and deformation. For Mike Domach, as he says of his upbringing, "My dad ran a brewery." That is a place where microorganisms affect chemical change, so perhaps it was fated that young Mike would start out as an engineer and wind up working with E. coli.

Dahl and Domach are part of a growing group of chemical engineering faculty who focus their research on medical issues and applications. Dahl's work could lead to a deeper understanding of the aging process in humans. Domach's is aimed at growing DNA vaccines. Other research in ChemE, involving a total of a half-dozen key faculty and their students, deals with the diagnosis or treatment of cancers and other disorders.

This is unusual for a traditional engineering department long known for its work with industrial processes and products. "And none of it was planned. We never got together and said, 'Let's have a thrust to study chemical engineering in the service of medicine,'" says Professor Bob Tilton, who is helping to develop an improved treatment for cystic fibrosis.

The group has another distinctive trait. In the past, a lot of medically related engineering has dealt with the making of goods, such as designing instruments and devices, or (in the chemical field) production lines for therapeutic compounds. The Carnegie Mellon ChemEs are among a newer wave of engineers who engage directly, as Tilton puts it, with "biological systems."

These engineers study living organisms, cells and DNA. They use their engineering knowledge to probe how physical life actually works, and bring their engineer's mentality to bear on problems therein. What is emerging, all agree, is a new and useful synthesis.

Where Two Worlds Meet

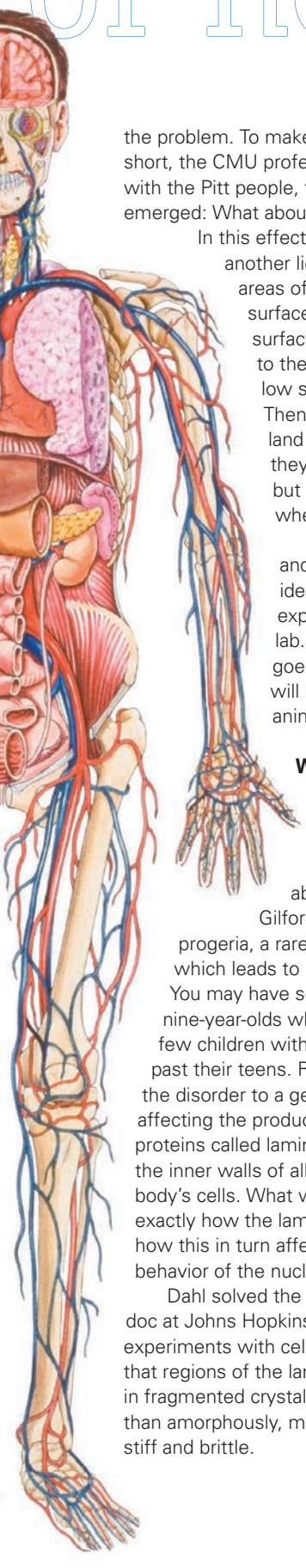
Typically, engineers partner with biologists and clinicians in their research. "It's very important for us to work together, and not just because we have different abilities and knowledge bases," says ChemE Professor Jim Schneider. "We have different ways we go about solving a problem." Schneider, whose research could help in detecting early biomarkers of cancer, likes the way Tilton explains the difference:

"Engineers start from a set of physical principles and branch out, looking for applications," Tilton says. How do the laws of thermodynamics or mass transfer explain what's going on here? How could they be applied to make something else happen? Whereas, by contrast, "the typical approach of a medical clinician is to specialize. They will dig deeply into a particular disease until they really know the progression of that disease and where all of the standard treatments work or fail. When you combine the perspectives you can do interesting things."

In cystic fibrosis, as in other congestive lung diseases, the air passages coat with mucus. Worse, this can allow pneumonia-like bacterial infections to grow. Patients are given potent antibiotics, inhaled as aerosols, but often the droplets are blocked by the mucus or just sit on it. Only enough flows deep into the passages to give partial relief and resistant bacteria develop.

Dr. Timothy Corcoran (Ph.D., BME, 2000) from the University of Pittsburgh brought this problem to Tilton, who recruited ChemE Professor Todd Przybycien and Professor of Physics and ChemE Stephen Garoff to work on

# of healing



the problem. To make a long story very short, the CMU professors brainstormed with the Pitt people, from which an idea emerged: What about Marangoni flow?

In this effect, a liquid sitting on another liquid will flow from areas of lower to higher surface tension. Maybe a surfactant could be added to the antibiotic, to induce low surface tension. Then, when droplets land on globs of mucus, they wouldn't get stuck, but go racing along to where they are needed.

Tilton, Przybycien and Garoff tried the idea in petri dish experiments in their lab. It worked. If all goes well the next steps will be trials at Pitt in animals, then humans.

Why Do the Young Grow Old?

Kris Dahl's story starts farther back. In 2004 she learned about Hutchinson-Gilford Syndrome, or progeria, a rare childhood disorder which leads to premature aging. You may have seen news clips of nine-year-olds who appear to be 90; few children with progeria survive past their teens. Research had traced the disorder to a gene mutation affecting the production of fiber-like proteins called lamins, which make up the inner walls of all the nuclei in the body's cells. What was not known was exactly how the lamins go awry, and how this in turn affects the structural behavior of the nucleus.

Dahl solved the riddle as a post-doc at Johns Hopkins. Through micro-experiments with cell samples, she found that regions of the lamin fibers line up in fragmented crystalline patterns rather than amorphously, making the nucleus stiff and brittle.

Does that explain why our bodies, overall, get stiff and brittle as we grow old? Dahl laughs and says the causal link is not so simple. In her follow-up research at Carnegie Mellon, she is "trying to understand, generally, how cells answer the call to change." Normal cells respond to various stimuli by shifting gears to do what the body requires, such as healing an injury or building muscle, but cells with the stiffened nuclei "are not responsive. We're trying to figure out why that is," Dahl says. Her work could help to treat progeria and shed light on how all of us age.

DNA, RNA: Faster, Faster

While it would be great to slow down the aging process, for some things you want speed. "Let's say there's an epidemic coming. Or you have one, and the virus mutates. You don't need boatloads of vaccine in a hurry," Mike Domach says. "You need shiploads."

The great promise of DNA vaccines is the potential to make huge amounts of a new one quickly. These vaccines—still in very early-stage—would not require laboriously culturing the target virus and isolating the parts needed. Instead they use snippets of viral DNA, which can be "grown" by putting some snippets into benign strains of E. coli bacteria, which multiply rapid-fire. And as they do, so does the DNA you need—ideally.

Domach is one of the world's experts on E. coli. Asking the bacteria to "carry" and make DNA is like loading up a hiker's backpack, he says: "It's extra work. I can only put so much in your backpack until you slow down [i.e., the E. coli don't reproduce as fast]. Then I might have to change your shoes to keep you viable. It's an optimization problem—we're tinkering with the cellular vehicles that produce the stuff of interest, seeing which metabolic pathways have to be jacked up and which have to go down, so we don't crash the system." Working with Dr. Saleem Khan, a molecular biologist at Pitt, Domach is using lab experiments plus computer modeling to get dramatic increases in yield.

"Engineers start from a set of physical principles and branch out, looking for applications."

Jim Schneider's research is all about speed as well. The task here is DNA separation, examining samples of a person's DNA to "profile" it for sequences of various lengths and types, as in criminal cases. This is now done by a cumbersome process that uses special gels. In a lab on the third floor of Doherty Hall, Schneider and his graduate students are "developing ways to do it without gels. We can do it an order of magnitude faster," he says.

The process involves putting a tiny "molecular parachute" on the tail of each strand of DNA, then just placing them in one end of a capillary tube and applying an electrical field, which induces motion. "The long DNAs are able to drag that parachute, while the shorter DNAs get held up by it," Schneider explains, and when you check the results of the contest: bingo, separation.

Patents have been filed and a licensing agreement is being pursued. The first target market will be crime labs. But the longer-term goal is to transfer the technique to microRNAs, which are being explored for use as biomarkers for cancer. "We're going to be there," Schneider says. "And we think our process is going to be much more selective."

Also in ChemE, Professor Nick Sahinidis is doing research in medical imaging informatics, and all of the faculty notice that more and more incoming ChemE students are showing an interest in medical work—even if they don't choose to double in biomedical engineering.

As Mike Domach puts it, "Why not? If you're an idealist, and you're good enough to learn some life science, this is a chance to do something indisputably useful to society and get paid." He laughs. "We're the cowboys in the white hats."

MORE THAN SMART CARS: IT'S SMART TRANSPORTATION

How a new federally funded center is shaping the next wave in mobile IT

BY MIKE VARGO

One hundred years ago, the U.S. and other countries were in the early stages of re-inventing their transportation systems. Motor vehicles were growing more sophisticated and more common, and the infrastructure was changing as well. Whereas all major cities once had tens of thousands of horses—along with myriad stables and a need for constant street cleaning—the period between 1900 and 1914 saw the advent of the first parking garages, filling stations and traffic lights. Trolley cars were being electrified, and an unprecedented wave of bridge-, tunnel- and highway-building was just getting under way.

Raj Rajkumar

Raj Rajkumar says we are entering another transition today, except now it is information technology behind the shift. He notes that we are moving to "smarter vehicles and smart infrastructure." He believes that "autonomous vehicles are inevitable," and that many of the same technologies that will drive our cars will also enable "crowd-sourced management" of traffic flow and infrastructure repair.

Carnegie Mellon is at the cutting edge of this shift. Rajkumar, the George Westinghouse Professor in the Department of Electrical and Computer Engineering, is director of a new interdisciplinary research center called T-SET: Technologies for Safe and Efficient Transportation. T-SET is a University Transportation Center (UTC) which is funded by the U.S. Department of Transportation to enhance multiple R&D efforts in engineering, computer science and public policy. The scope of work is rather wide and some of it may even seem blue-sky. Yet, as Rajkumar points out, different lines of research are converging, and the future may be closer than you think.

Where Hands-Off Driving May Lead

Take autonomous vehicles. Although Carnegie Mellon is clearly a leader in the area, with self-driving cars and light trucks which have won various competitions, these have been one-of-a-kind test

vehicles loaded heavily with custom-built robotics and sensor systems. Surely we are still far from the day when, as Rajkumar envisions, "your car will be taking itself through the Squirrel Hill Tunnels while you are taking a nap, or catching up on your email,"—aren't we?

Think again, the professor says. "Pretty much every car today has cruise control," he begins. "So, okay, we know the car can control the speed while the human does everything else. And now some cars have adaptive cruise control. Using radar, the car will automatically know that there's a slower car in front of you and slow down."

Rajkumar also reminds us that with anti-lock brakes, drivers no longer must learn to "pump" the pedal to avoid skidding. Moreover, luxury cars have begun to feature lane departure systems: "The car 'sees' that you're in a lane, and if you start to drift, it nudges you back. So the gas pedal, the braking and the steering are starting to be partially controlled by the car, some of the time," Rajkumar says. "Eventually the car will be driving itself, and you will no longer be sitting in the driver's seat. It's a revolution in the big picture but it's a very natural evolutionary process over several (car) model years."

One new technology that will advance the process is V2V (vehicle to vehicle) wireless. Research on these ad-hoc mobile wireless networks is being led by Rajkumar himself and by ECE Professor Ozan Tonguz. The basic idea of V2V is to leverage the smart systems that most cars have, letting them literally "talk" to one another to share information on their locations, velocities and directions. As V2V comes online, the benefits will multiply.

For instance, cars could collaborate to move through intersections more efficiently. You wouldn't have to idle needlessly at red lights when there is no cross-traffic. Over time, physically fixed traffic controls would be phased out, giving way to "virtual traffic signals" inside the vehicles that expedite everybody's movements while cutting air pollution and reducing the risk of collision.

Speaking of which, says Rajkumar, let's go back to those Squirrel Hill Tunnels. Currently, tunnels and freeways everywhere are plagued by traffic jams even though they don't have red lights interrupting the flow. Conventional wisdom says to relieve the jams by adding more lanes—"but in a lot of places, there is no land or money to build extra lanes. So technology becomes the solution instead," he says.

He notes that much freeway jamming is due to "people driving at variable speeds." Drivers slow down approaching a tunnel or any change of scene, which makes the cars behind them brake or try to switch lanes. Soon traffic is snarled and often, accidents ensue. With V2V, Rajkumar says, "everyone can stay evenly spaced and be moving through the tunnels at 55 miles per hour," almost like a precision flying team.

Carnegie Mellon researchers will soon be testing V2V concepts in the Pittsburgh area through a "hybrid emulation" approach in which some cars roam the streets equipped with V2V, while interacting with a simulator that models the effect of many vehicles having the technology. And there is more in the works at T-SET.

New Angles on Old Problems

Jim Garrett, head of Civil and Environmental Engineering, is working with CEE Professor Jacobo Bielak and others on new technology to detect the need for bridge repairs. All bridges are prone to structural deficiencies as they age, and with repair funds being sorely limited, it would help to have ways of spotting weaknesses early and prioritizing the fixes. The solution proposed by Garrett et al—soon to move from the lab to field-testing with PennDOT—is technically sophisticated, yet rock-simple in concept and inexpensive. Bridges flex and vibrate under traffic loads. Vehicles fitted with off-the-shelf motion sensors can detect anomalies in this movement. Deploy some sensing cars, evaluate the anomalies, and you'll know where to target the repairs.

Eventually the car will be driving itself, and you will no longer be sitting in the driver's seat.

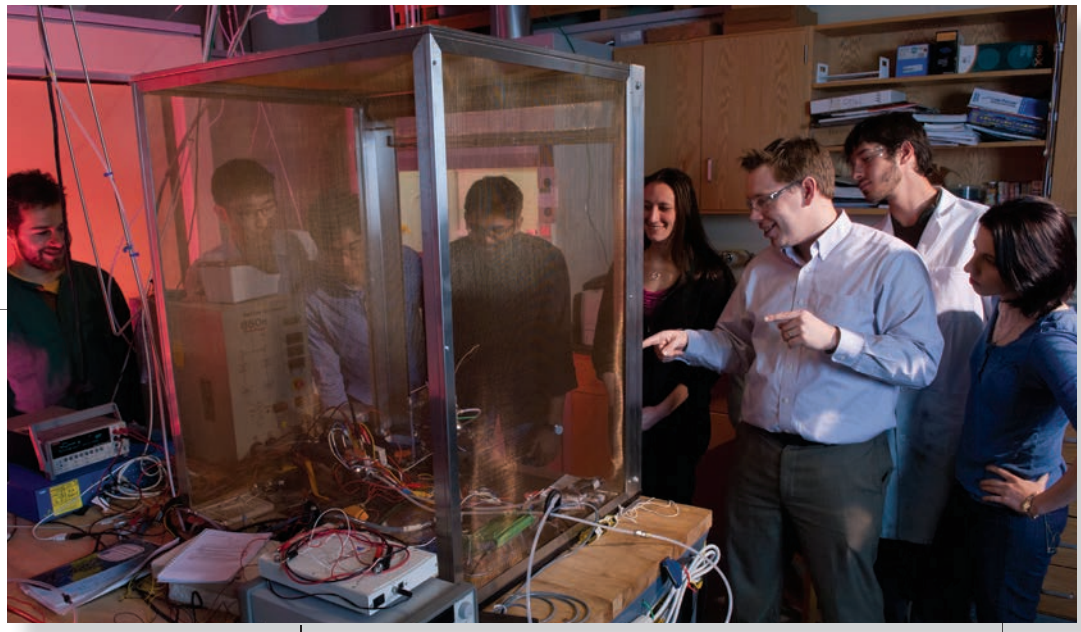
Other initiatives likewise tackle physical problems with IT solutions. Academic units besides CIT, notably Computer Science and the Heinz School of Public Policy and Management, have the lead on many of these. One program already up and running for the public is ParkPGH.org. Parking downtown can be an issue, so instead of building more garages, the ParkPGH team has built an online app that tells you which garages are full and which have spaces. Fixing potholes is fairly easy once their location is known, so a group at the Robotics Institute is trying a variation on the mobile motion-sensor idea to detect and report these perils.

There are research projects for using social media to improve public transit, and for making traffic safer for bicycles and pedestrians, plus a major thrust in using data analytics to learn from the wealth of new data that mobile sensors can give us. CEE Professor Chris Hendrickson is part of a policy group focused on evaluating new transportation technologies and guiding future planning.

Competition was intense for the U.S. DOT funding that created the T-SET UTC. Carnegie Mellon was awarded $3.5 million for an initial two-year period, a significant share of the total pie, and many partners helped the university put in a strong bid. The University of Pennsylvania is a research partner in T-SET; several existing projects came from the local Traffic21 initiative seeded by the Hillman Foundation; others grew out of research backed by entities ranging from NSF to General Motors.

Thoughts going forward? "Pennsylvania with the first turnpike in the country played a big part in the last transportation revolution," says Raj Rajkumar. "We're going to be a primary testbed for this one."

Researchers Address **Fuel Cell Challenges**



Shawn Litster (3rd from right) directs the Laboratory for Transport Phenomena in Energy Systems.

Recent dramatic increases in the availability of natural gas will change the way we convert fuel into energy. Fuel cells are one promising option; these clean, high-efficiency devices may challenge the traditional internal combustion engines used in today's cars. Shawn Litster, a professor in Mechanical Engineering and a 2011 winner of the prestigious National Science Foundation CAREER award, runs a lab focusing on proton exchange membrane (PEM) fuel cell systems research.

"A fuel cell is an electrochemical engine," Litster explains, "We take hydrogen, plus oxygen from the air, and allow them to react over two electrodes, or two metal surfaces. They then produce water and electricity." Unlike internal combustion engines, fuel cells do not create harmful emissions; they have no moving parts and are completely noise-free. Fuel cells also boast the high efficiencies necessary for vehicular applications. "They can give twice the efficiency of an internal combustion engine, and they can offer similar distances as an internal combustion engine, 400 miles," says Litster.

However, there are challenges to overcome before fuel cells are a financially viable alternative to traditional devices. "Fuel cells use a platinum catalyst, which is an expensive metal," says Litster. Another issue is the large voltage losses that occur due to oxygen transport limitations, which hinder the reaction kinetics at the electrode's catalyst. Litster and his graduate researchers are trying to understand these conversion losses at the nano- and micro-scale in order to make fuel cells more affordable.

Litster's group, whose members include an Environmental Protection Agency-STAR fellow and a Department of Energy National Energy Technology Laboratory intern, among others, has gained recognition for their micro-structured electrode scaffold (MES) diagnostics, which allows them to take micro-scale measurements 'in-situ,' or during a fuel cell's operation. These measurements can say a lot about the performance of a fuel cell that theoretical modeling currently cannot. "When we do in-situ measurements we can distinguish what the real limitations are to reaching the full potential of the device," Litster says.

Widespread use of fuel cells may not be far off. Companies like Walmart with large distribution centers are beginning to replace the batteries on their forklifts with fuel cells. "They might have a whole area of the center dedicated to charging lead-acid batteries," Litster says, "What a fuel cell would do is reduce the number of times they would have to switch out batteries and eliminate the entire battery charging facility."

Litster has also worked with Angstrom Power, a Canadian company that produces miniature fuel cell systems for mobile phones. Fuel cells are an attractive prospect for handheld devices due to their combined high power and energy densities. Litster says, "The benefit is that the energy density requirements at the consumer electronics level are unlimited" as the device functionality increases with the power source's capacity. Litster notes that the BIC Corporation recently acquired Angstrom Power. Perhaps someday fuel cells will be as ubiquitous as pens or handheld lighters.

BY LILI EHRLICH
Mechanical Engineering, Ph.D. Student

Informing Capitol Hill about **Plug-In Vehicle Research**

Jeremy Michalek with Prius Plug-in, a small battery pack plug-in vehicle

Instead of relaxing on a Florida beach, Jeremy Michalek, professor of mechanical engineering and engineering and public policy, spent his spring break talking to policymakers on Capitol Hill about electric vehicles. On March 13 and 14, 2012, he met with members of the Congressional Budget Office; the Congressional Research Service; the Senate Majority Committee on Commerce, Science and Transportation; the Senate Minority Committee on Energy and Natural Resources; and the offices of several members of Congress.

Plug-in vehicle policy has received attention from Congress and the President, with proposals that vary from extending to increasing to eliminating the federal tax subsidy currently in place. Right now, the subsidy is tied to battery size: The bigger the battery, the larger the subsidy a consumer receives, with a maximum of $7500 for a battery the size of the Chevy Volt's, which can store enough electricity to drive for 35 miles before switching to gasoline.

However, research that Michalek and his colleagues conducted suggests that this policy is not the most effective way to use limited public funds. Large battery packs "are expensive and heavy (reducing efficiency), they are underutilized when the battery capacity is larger than needed for a typical trip, they require more charging infrastructure and they produce more emissions during manufacturing," they state in their 2011 Proceedings of the National Academy of Sciences paper.

"Our main message is that the federal tax credit structure is misaligned with the actual benefits that these vehicles can offer," he explains. "The policy assumes that larger is better. But our estimates show that even in optimistic scenarios the net benefits of large-battery plug-in vehicles in reducing air pollution and oil consumption costs are not much larger than the benefits of small-battery plug-in vehicles. And they could be much worse when charged with electricity made from coal-fired power plants," says Michalek.

> "This is how I'm trying to reframe the problem: If we have a given amount of money to spend, how can we do the most good?"

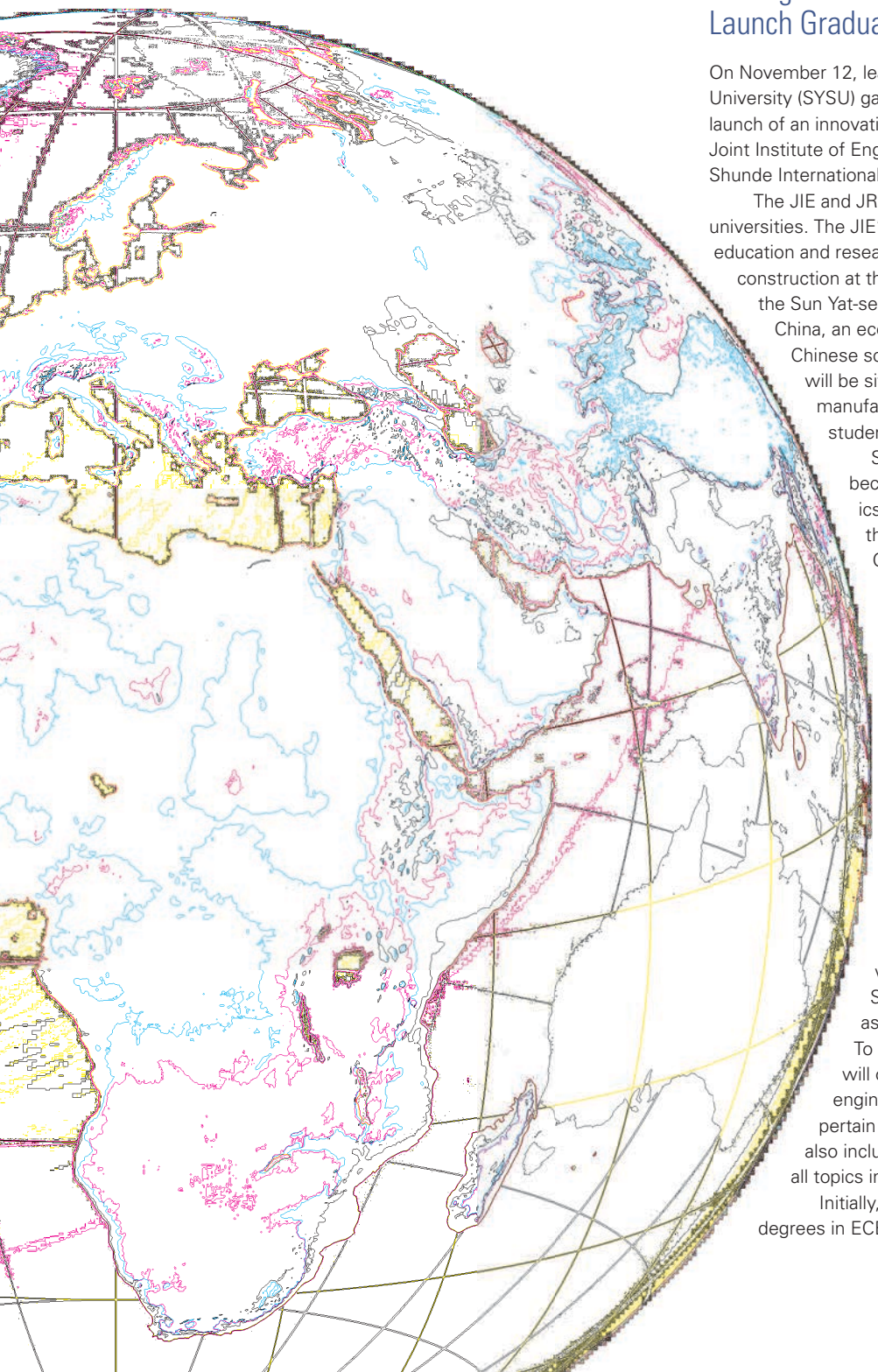
He suggests that a flat subsidy would more closely align with the benefits of electric vehicles. A flat subsidy would not favor small or large battery packs and would therefore allow the market to decide which option is the most cost-competitive way to bring plug-in vehicles into the fleet.

Michalek points out, though, that the best option in terms of economics does not involve a tax credit at all. "The ideal thing to do to get the most environmental good at the least cost would be to simply ask people to pay for the damages they cause to others, such as when drivers release air emissions that cause others to develop health problems," he explains. "It gives a direct incentive to reduce the damages we cause to others. Plus, a fee on the things we want to discourage, like pollution, could be used to reduce taxes on the things we want to encourage, like employment."

Taxing people for the costs they cause to others is preferred in economic theory, but it would mean increasing the price of gasoline, which policymakers know would be politically unpopular. "We have to acknowledge subsidizing vehicle sales is a second-best type of policy that carries some of its own risks and problems," says Michalek.

BY TARA MOORE

Global Updates



Carnegie Mellon and Sun Yat-sen University Launch Graduate Engineering Program

On November 12, leaders from Carnegie Mellon and Sun Yat-sen University (SYSU) gathered in Guangzhou, China, to celebrate the launch of an innovative graduate engineering program, the SYSU-CMU Joint Institute of Engineering (JIE), and a complement program, the Shunde International Joint Research Institute (JRI).

The JIE and JRI present important opportunities for both universities. The JIE's mission is to further world-class engineering education and research in China. A building to house the JIE is under construction at the Sun Yat-sen Guangzhou East Campus. Through the Sun Yat-sen partnership, CMU will broaden its reach into China, an economic powerhouse, and build relationships with Chinese schools and industry. The Joint Research Institute will be sited in Shunde District, Foshan City, a major manufacturing hub, and it will connect faculty and students with industry.

Sun Yat-sen sought to partner with Carnegie Mellon because of its world-class reputation for academics and research and for its ability to train leaders that drive innovation. Another appealing aspect of CMU was its location. Pittsburgh's economy once centered on the steel industry; whereas, today it is diversified and includes higher education, healthcare and technology among other fields. Pittsburgh's vitality exemplifies how higher education can contribute to a region's economy.

Jimmy Zhu, the ABB Professor of Engineering and head of CIT's Data Storage System Center (DSSC) will co-head the JIE, along with Professor Li Wenju, the assistant to the president of SYSU. Expectations for the new programs are high. "The goal is to build a top engineering school in China within 10 years," says Zhu. He explains that instead of trying to excel in a variety of engineering fields, the JIE will follow the CMU model and concentrate on areas where it can make the biggest impact.

Sun Yat-sen has a major medical school and is associated with at least eight university hospitals. To augment this immense medical system, the JIE will offer degrees in electrical and computer engineering and emphasize aspects of the field that pertain to medical applications. Initial subjects of interest also include the smart grid, autonomous driving and MEMS, all topics in which CIT has extensive expertise.

Initially, the JIE will offer master's and doctoral level degrees in ECE, and graduates will have degrees from both

universities. All students will be subject to Carnegie Mellon's admission standards. To broaden cultural competency and experiences, JIE students will study in China and in the U.S. at either Carnegie Mellon in Pittsburgh or the Silicon Valley campus. The first classes in China will start in the fall of 2013.

New Program with Shiv Nadar University Emphasizes Undergraduate Education

Carnegie Mellon has signed an agreement with Shiv Nadar University (SNU) in India to establish a dual degree undergraduate program. Graduates will receive a B.S./B.Tech degree from both schools in either electrical and computer engineering or mechanical engineering.

The bi-country program has been crafted to deliver world-class undergraduate education to top Indian students and enable them to experience best-in-class standards of engineering education both in India and the United States. Indian scholars will split their time studying at SNU in Greater Nodia and Carnegie Mellon in the United States. Classes will start in India in the fall of 2013.

An offshoot of the collaboration between the schools is that SNU is offering 15 scholarships for CMU undergraduates to study at SNU for a semester. This exciting feature aligns with CIT's goal of promoting global experiences in the general education of undergraduate students.

Further strengthening the relationship between SNU and CMU, Shiv Nadar, the founder and chairman of HCL, a $6 billion technology enterprise, and the philanthropic Shiv Nadar Foundation, is endowing the Shiv Nadar Professorship in Engineering at Carnegie Mellon. The recipient of this professorship will be named in the future.

ECE Partners with Portuguese Business School

To educate individuals who will be able to handle the most advanced technologies and yet maintain a business managerial perspective, Carnegie Mellon's Electrical and Computer Engineering Department is partnering with the University of Porto's Business School in Porto, Portugal, to deliver a new double-degree graduate program in engineering and business.

The two-year program enables participants to study for one year at the University of Porto and another year in the United States at Carnegie Mellon. Students must meet academic requirements from both universities to receive a master's of science degree in electrical and computer engineering from Carnegie Mellon and a master's of business administration ("The Magellan MBA") from Porto Business School.

"We have our first students enrolled in the new program, and we expect the initiative to grow as more companies globally seek the problem-solving, managerial and technical skills acquired through engineering and business studies provided by this double MS/MBA experience," said Ed Schlesinger, the David Edward Schramm Memorial Professor and head of Electrical and Computer Engineering.

Classes Begin in Rwanda

On August 25, Carnegie Mellon University-Rwanda (CMU-R) in Kigali officially launched its Master of Science in Information Technology (MSIT) degree program. Carnegie Mellon is the first U.S. research institution offering degrees in Africa with an in-country presence.

"It's inspiring to work with a world-class faculty, creating a new center of innovation and mentoring students who will be leaders in the technological revolution sweeping across East Africa," says Bruce Krogh, the director of CMU-R.

In a 16-month intensive program, students will work alongside award-winning faculty; develop expertise in programming, networking and information security; design and create mobile apps and products; learn how to leverage broadband internet and cloud computing; and explore areas of business management, including market analysis, strategic business planning and entrepreneurship. The goal is to educate the next generation of technology leaders and innovators who will lead the charge to develop the breakthrough ICT solutions needed for the future of Africa.

Celebrating 10 Years of Entrepreneurial Spirit and Innovation

With great pride and equal joy, Carnegie Mellon University Silicon Valley (CMUSV) celebrated its tenth anniversary on June 9, 2012. Hundreds of alumni, faculty, staff, students and industry colleagues gathered on the California campus to celebrate a decade of innovative research, academic excellence and entrepreneurial success.

"We are celebrating not just our academic achievements, but our important role as a change agent in the dynamic eco-system of Silicon Valley," says Martin Griss, director of CMUSV. Since its inception, the campus has launched at least a dozen startups and other regional initiatives in the areas of software engineering, disaster management, robotics and emerging energy technologies.

During the event, university and government officials gave remarks outlining the history of the campus, how it launched Carnegie Mellon's global networking and expectations for CMUSV's future. Other activities included a showcase highlighting the school's research in smart grid technology, cell phone usage for increasing efficiency in healthcare, and other topics. With a nod to the future, items from the campus and the community were placed in a time capsule that will be opened in 15 years during school's 25th anniversary.

Later in the summer on August 12, CMUSV achieved another milestone with its tenth commencement ceremony. Speakers at the event included Edward H. Frank, a vice president at Apple, Inc., and a Carnegie Mellon University life trustee. Sixty-three students received their master's of science degrees, adding to the 600 students who have graduated from the campus since its inception in 2002.

Excellence

CMU President Elected into the National Academy of Engineering (NAE)

Dr. Jared L. Cohon, president of Carnegie Mellon University since 1997, was elected into the National Academy of Engineering, which is one of the highest professional distinctions an engineer can achieve.

Cohon is an authority on environmental and water resource systems analysis, an interdisciplinary field that combines engineering, economics and applied mathematics. He has worked on water resource problems in the United States, South America and Asia and on energy facility siting, including nuclear waste shipping and storage. In addition to his academic experience, he served in 1977 and 1978 as legislative assistant for energy and the environment to the late Honorable Daniel Patrick Moynihan, U.S. senator from New York. President Bill Clinton appointed Cohon to the Nuclear Waste Technical Review Board in 1995 and appointed him as chairman in 1997. His term on the board ended in 2002. President George W. Bush appointed Cohon in 2002 to the Homeland Security Advisory Council, and President Barack Obama reappointed him in 2009.

During his presidency, CMU has continued along its trajectory on innovation and growth. Priorities have included: undergraduate education; new interdisciplinary initiatives in information technology, biotechnology, energy and environment, and the fine arts and humanities; diversity; international initiatives; and the economic development of southwest Pennsylvania.

Career Development Chairs in Engineering

Through their work, these educators raise the level of performance of all around them and bring honor to the College of Engineering.

Faculty Career Development Chairs are professorships of one to three years that recognize young faculty in the college and give them the freedom to engage in creative ventures that are not readily supported by traditional granting agencies.

Shelley Anna

Russell V. Trader Career Faculty Fellow in Mechanical Engineering

Shelley Anna, an associate professor at Carnegie Mellon, holds a joint appointment in mechanical engineering and chemical engineering; and is an affiliated faculty member in the Department of Physics.

Anna's research interests are in microfluidics, interfacial fluid mechanics and microscale transport phenomena. Her papers are well cited, particularly for her work in the emerging area of droplet microfluidics. She has been invited to give more than 30 lectures and seminars on her work. The National Science Foundation, the Gulf of Mexico Research Initiative, the ACS Petroleum Research Fund, the Department of Energy's (DOE) National Energy Technology Laboratory and others, have funded her research.

Maarten de Boer

Clarence H. Adamson Career Faculty Fellow in Mechanical Engineering

Maarten de Boer is an associate professor of mechanical engineering at Carnegie Mellon. Prior to joining CMU, he spent 13 years at Sandia National Labs in the MEMS technology department.

His research interests are in the area of nano- and micromechanics, with an emphasis on enhancing reliability of small-scale micro- and nanoelectron-mechanical systems (M/NEMS) devices, and on developing new actuation and sensing technologies. He has been issued seven patents and has presented 30 invited talks. He has published 45 journal articles, 30 conference articles and 7 book chapters. His journal articles have been cited 1,200 times. De Boer has received funding from the NSF, the DOE and industry.

The Way Mireille Sees Things

By Tara Moore

Officially speaking, Mireille Mobley is the multimedia designer for the Department of Civil and Environmental Engineering (CEE). Unofficially, she is CEE's staff photographer whose stunning photos grace the rooms and throughways of Porter Hall.

Mobley takes pictures of students and faculty at CEE activities, like talent shows or the annual canoe trip. "My photography is useful for the department because now we have this huge recorded history of different events that I don't think we had before," says Mobley. "I enjoy trying to capture the joy or the spirit of the people around me."

Mobley has been snapping photos since her childhood, when she traveled internationally. However, she began taking her photography more seriously around five years ago when she bought a DSLR (digital single-lens reflex) camera. She took a few classes at Pittsburgh Filmmakers, but she is mostly self-taught, having learned through experience and from friends who share her interest. Her favorite type of photography is urbex photography, short for urban exploration photography, which involves taking pictures of abandoned buildings or places that are usually unseen.

"What I like about urbex is that there's this sense that people took for granted that the building they worked in, the house they lived in, will be there forever. There's this real history that's embedded in the walls," says Mobley. "When people see an abandoned building, they think it's an eyesore, but when they look at my photos, my hope is they see there's a beauty that you don't think about, and that's what I like to do. I like to find the beauty within those spaces."

A self portrait of Mireille Mobley. The top photo is an example of Mobley's high dynamic range (HDR) photography, which is a method that strives to achieve the same tonal ranges that the human eye can naturally see. Cameras are limited by their sensors, a problem that photographers can overcome by combining overexposed, underexposed and correctly exposed versions of the same image.

Swish for Science

BY LILI EHRLICH

Mechanical Engineering, Ph.D. Student

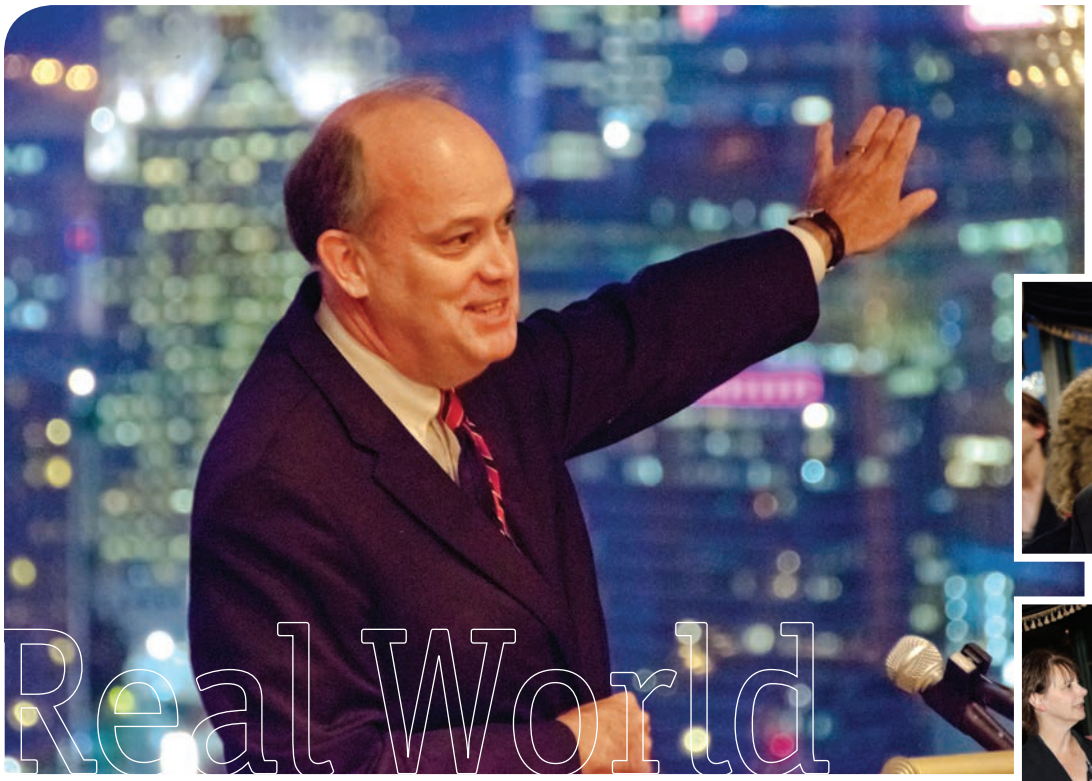
The last few decades in the United States have seen a major need for science, technology, engineering and mathematics (STEM) professionals. This workforce is crucial to our economy and national security, but its population is on the decline.

With this problem in mind, Assistant Dean for Undergraduate Studies Kurt Larsen and mechanical engineering Ph.D. candidate Justin Feig organized Swish for Science, an event designed to empower basketball players aged 11-14 to study STEM subjects when they get to college. "Introducing something like engineering earlier on, not high school—but middle school, makes sense," says Larsen. Serious basketball players in this age group have good things going for them already. "They have what it takes to be successful, they're competitors, they're dedicated, they're organized… and are most likely going to college," Feig explains.

Kids were recruited for Swish for Science with the help of local basketball coach Pete Strobl, and more than 30 middle schoolers participated in the on-campus event held in June. After Strobl led basketball drills, Carnegie Mellon's varsity men's basketball coach Tony Wingen spoke to the kids about what it means to be a scholar athlete at CMU. Then Mechanical Engineering Professor C. Fred Higgs III gave a persuasive argument in favor of an engineering career over an NBA career. He cited statistics regarding probability of success, average salaries, job security and career length of each respective profession.

Afterward, the kids broke off into groups, assembled small catapults and competed to launch ping-pong balls into a distant hoop by adjusting the tension in their catapults. "It was nice to get them thinking about [science] in a context that they're already familiar with, in the arena of basketball," says Larsen. Following came a talk about projectile motion physics from Feig. "We showed them that there are laws that govern what the tension in the catapult should be, and they aren't that difficult to understand. It's much more powerful to quickly calculate it [the tension] than to use trial and error to shoot," says Feig, "Hopefully these young people will see the benefits to an engineering degree."

At Swish for Science, young basketball players shot hoops, built catapults and checked out the Society of Automotive Engineering Race Team's car.



Real World Engineering Pittsburgh

Bill Flanagan used the spectacular view of the city as the backdrop for his presentation on the state of Pittsburgh's high-tech industries.

Classrooms, project courses and labs all play an important role in an engineer's education; however, CIT wants students to understand what engineering is like in the real world. To this end, the college launched a new program called, "Real World Engineering."

The initiative encourages undergraduate students to network with professional engineers in major cities. "Industries vary by regions, and this program will allow students to see what different areas have to offer," says Treci Bonime, associate director for undergraduate studies.

The inaugural event ran from October 18-20, 2012, and the college highlighted its hometown, Pittsburgh. The city was selected because students from around the world live at Carnegie Mellon, yet many of them don't stray from campus. They are unaware of local employment opportunities explains Bonime. A dozen students were chosen for the program based on their essays and professional goals. This information helped the Dean's Office match students with mentors.

To educate students about living and working in Pittsburgh, the Dean's Office sponsored citywide activities, beginning with a networking reception for the students and mentors at the LeMont Restaurant on Thursday evening. Interim Dean Vijayakumar Bhagavatula talked to the group about the educational value that students derive by interacting with Pittsburgh-based engineers. Afterward, Bill Flanagan, host of the television show *Our Local Business* and the executive vice president, corporate relations at the Allegheny Conference, gave a presentation on the city's industrial beginnings and the future of high-tech industry in western Pennsylvania. Flanagan explained that many people left the area during the downturn of the steel industry in the 1980s. Today, however, Pittsburgh is economically strong and the city offers rewarding jobs for engineers.

The students spent the next day, Friday, on the job with their mentors. The mentors came from startups, corporations and the Pennsylvania Department of Environmental Protection, and many were CIT alumni. "The college is in a unique position to provide students access to an influential alumni base that is well connected to industry," says Bonime.

The event concluded on Saturday with the students receiving a private tour of the Warhol Museum, giving them another glimpse of the city's unique attractions. Later, the students and college administrators ate lunch and shared thoughts on the three-day event.

The students responded well to the program's regional focus. "They enjoyed seeing what engineers in Pittsburgh do on a daily basis," says Bonime. The students also noticed cultural and structural differences between smaller companies and corporations, and this exposure helped several students decide which environment would be a good career fit. Networking was valuable to the students, too. "It is important that CIT students know that they are a part of a wide-based community that includes alumni. Students receive many benefits by connecting to this community," concludes Bonime.

The next program, Real World: Washington, D.C. will take place in the spring of 2013.

MEET THE FIRST GRADUATE OF DUAL DEGREE INNOVATION MANAGEMENT PROGRAM

BY MERYL SUSTARSIC

Learn more about career opportunities at Eaton, including the Engineering Technology Leadership Program: www.eaton.com/Eaton/OurCompany/Careers

When Max Franklin graduated from CIT in May 2011, he was in a league of his own—he was the first student to complete the dual-degree master's offered by the Engineering and Technology Innovation Management (E&TIM) program.

"I saw how valuable E&TIM classes were and I thought it would be kind of cool to be the first person to do it. I hoped to be a trailblazer for future classes," he says.

More than a year later, that sentiment still stands. Following graduation, Franklin was hired by Eaton Corporation for a two-year rotation within their Engineering Technology Leadership Program. He works as both a test and design engineer with the Vehicle Technology & Innovation team on high-profile projects related to improving fuel economy in the trucking industry. His next rotation will be as a project engineer in their Aerospace Group.

"I'm very satisfied with my job. I get challenging assignments, working with customers and in different parts of the organization," Franklin says. He attributes his education at Carnegie Mellon for his success in such a versatile position.

"When I came across product marketing, budgeting numbers or stage gate development, it wasn't my first exposure. A lot of the engineering-business experience that I have, you wouldn't get in a regular engineering program," he says.

The E&TIM degree is unique in that it can be earned in two years, like Franklin's, or it can be obtained in one year.

The stand-alone E&TIM master's is a one-year professional degree that diversifies the skills of engineers and scientists by blending management, economics and entrepreneurial courses into a technical curriculum. The goal is to teach students to become leaders of innovation once they enter the workforce by adding to the skill sets they bring to large companies. The program also prepares entrepreneurs for managing technology at their own companies.

For the dual degree, candidates apply for one of CIT's traditional master's programs to pair with their E&TIM degree. These traditional master's programs add a second year to the program, providing additional time for deeper training. According to E&TIM Executive Director Dr. Eden Fisher, the dual degree program was designed to encourage a more flexible timeline.

"We have had very positive student feedback on the E&TIM program since its start. However, one intense calendar year does not offer time to fully explore a technical discipline while developing the understanding of innovation management that is central to E&TIM. Dual degree students have the opportunity to take greater advantage of the excellent engineering offerings at Carnegie Mellon," Fisher says.

As a student, Franklin agreed that the extra time afforded him the ability to get what he wanted out of graduate school. "I tried to put myself in a position where I wanted to be in every class every day, where I was learning what I wanted."

Now, in the workforce, he finds that the dual degree makes him twice as marketable. "There are progressive companies, like Eaton, who value engineering and innovation management. And for those that don't understand it, I let them know about my master's in mechanical engineering."

Other students are realizing the benefits of having multiple points of expertise as well. While more than 50 students have graduated from the E&TIM single degree program since its launch in 2007, enrollment in the dual degree is growing quickly. In May 2012, seven students graduated from the program, and 13 others are projected to graduate in May 2013. When these new alumni begin their job searches, they will be uniquely poised to seek out multidisciplinary positions, just as Franklin was.

"I have the technical depth of an M.S. student, but many of the concepts I was introduced to include innovative methodologies or new ways of looking at product development. It's great," says Franklin.

For more information about the E&TIM program: www.cit.cmu.edu/etim

LISTEN, BUILD, REPEAT

Todd Bernhard (B.S., ECE'88) has created an app that gives voice to people who are unable to speak. He is the creator of the AutoVerbal Talking Soundboard, which won the AARP Silvers Summit Award at the 2012 International CES Conference, the world's largest consumer technology tradeshow. His app enables people who are nonverbal, due to stroke or autism for example, to communicate through Text-to-Speech buttons on their iPad, iPhone or iPod.

The AutoVerbal app features hundreds of photo buttons that speak corresponding words when tapped, while other buttons can be programed to deliver custom messages. Users can also type messages that convert into speech. Even more amazing than the technology is the app's price—it's $10. Further, it's a universal app, meaning you buy it once and it will run on either your iPad or iPhone.

Before Bernhard founded his business NoTie.NET in 2009, he worked as a marketing director for a software firm. Bernhard started making sound effect and ringtone apps for his own amusement and then began to sell them. "The phone is an extension of you and your personality, and AutoRingtone's talking ringtones can be professional or fun," he says. Veering more toward the fun side, Bernhard attracted a healthy number of clients, who wanted individualized ringtones. "Instead of me making their ringtones, I empowered users to make their own," says Bernhard. He sold his customers apps that featured Text-To-Speech Technology, ironically based on technology pioneered at Carnegie Mellon. "You have to listen to your clients – you've got to listen, build, repeat," says Bernhard.

That attitude has garnered Bernhard around 4,000,000 customers – and yes, he quit his former day job. "The neat thing about apps is that you can work anywhere. I don't have to wear a tie (hence the name, NoTie) and I work in my home office and have fun," he says. Although Bernhard enjoys writing apps, he fixates on his clients' needs. He discovered that "customers were using the Text-To-Speech ringtones to communicate, and not just for ringtones." He realized that he could modify his programs to help nonverbal people. Further, he could do it for a lot less than the price of traditional medically marketed devices that cost upward of $3,000. Soon the award-winning AutoVerbal Talking Soundboard was on the market and it became the #1 iPad Medical app.

Todd Bernhard, the founder of NoTie.NET, was the Scotty Dog mascot during his junior and senior years at CMU.

Accepting his award at the CES Conference, Bernhard says, "A highlight was that one of the judges was Professor Daniel Siewiorek, who was my professor in the 1980s!" In a jovial tone that you'd expect from the creator of "Ringtones Uncensored Pro," Bernhard adds, "I knew Dr. Siewiorek wouldn't remember me, as I was not a standout student, so I'm sure there was no favoritism! But it was nice to be able to thank him in my acceptance speech, which was delivered entirely using Text-to-Speech via the AutoVerbal app!"

ALUMNI AWARDS

Carnegie Mellon University's Alumni Association honored four CIT alums for their achievements and service to the university as part of Cèilidh Weekend 2012. Kenneth C. Russell (E'64), Paul C. Rizzo (E'63, '64, '66), and H. Scott Matthews (E'92, TPR'96, '99) received Alumni Achievement Awards, while Jordan J. Green (E'03) received the Recent Alumni Award.

PEOPLE MAKE THE COMPANY

In 1999 Dr. Sanjay Kumar (B.S., ECE'87) founded vCustomer Corporation. Operating in the U.S., India and Philippines, the company provides technical support services and technology solutions that help other businesses grow sales and increase customer loyalty. Since its inception, vCustomer has earned impressive honors: it was #3 in the Inc. 500 in 2004; the #1 Global Technical Support Provider according to the Blackbook of Outsourcing in 2010 and has been recognized as one of the Top 100 Innovative Service Providers by Global Services numerous times in the last 10 years. Further, it was named #1 in Employee Satisfaction amongst Indian outsourcing companies for the last five years by Dataquest-IDC, and in 2009, it ranked among the Top 25 Business Employers in Asia by Hewitt.

When Kumar started vCustomer, it was innovative in the way it leveraged technology, but over time "it evolved into a company that truly leveraged human power" to make a difference. With thousands of employees, the focus became making them successful. This idea increasingly pushed its way to the forefront in 2006 when the results of the first Indian employers satisfaction study were released. India's top 20 companies were named and vCustomer didn't make the cut. "I sat down with my management team and we thought about what we were doing as an institution. Were we communicating well with employees? Were we listening to them? Did they feel we were listening to them? We decided to make fundamental changes in the way we managed the business from the ground up."

One major change focused on the decision-making process. "In Asia, there is a culture of aggregating the decision making at the top of the pyramid. I decided to let management make decisions and encouraged the process to flow down so at every level people felt empowered to make decisions. We had really good results," says Kumar. The company soared to the top of best-employer lists. "To be honest, I don't have a solution in a bottle, but there was a process of change and it had significant impact," he says.

As vCustomer expanded from India to the Philippines they did not know whether vCustomer's people practices would translate as successfully into that workplace environment. Much to their surprise, vCustomer's reputation had preceded them. "And all we had to do was convince our new employees that we would build a similar culture across our Philippine locations," explained Kumar. While the philosophies are similar, in practice there was a lot of adaptation to the local culture. "In the end we listened and learned, and we were fortunate to have found some great early employees who wanted to help build the right culture."

The company learned how to "tie good people decisions to business value." Emphasis was made on recognizing employee contributions in the workplace, providing visible professional growth opportunities and fostering a healthy work/life balance. Productivity increased and attrition levels dropped. "We saw significant returns in our investment. Not just in terms of profits but also in the way people outside perceived us as an organization. We were in the customer service industry and it is all about attitude," says Kumar. When employees are empowered, a positive culture evolves. "Employees are going to say good things about you and recommend you to people they know. Very soon people start to see you as an employer of choice," he says.

Being recognized as the best is great, but perhaps even more commendable is staying there. "Once you are doing something right, you have to find ways to repeat it. There is no point in getting something right and then not inculcating it into your core methodology of running the business. Every time we did something that we believed really worked, we pushed to figure out how to make it happen the next month, the next quarter, the next year. We took great care to measure the success and use it as a yardstick. We didn't let ourselves get complacent once we achieved an objective that we had set for ourselves," says Kumar.

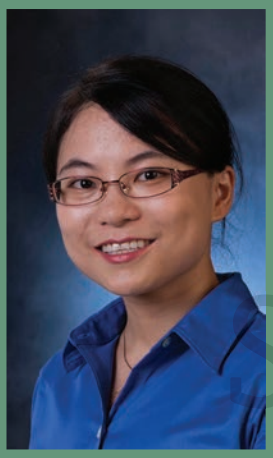
In March of 2012, Kumar sold vCustomer. "The hardest lesson I learned is that while it is difficult to start and grow a company, for me, the bigger challenge was to find the right time to sell it. The question became: when do you sell a company so that you maximize the value from it, and at the same time give the employees the opportunity to stay and continue to grow? How do you balance those things? After all, the company is simply the people who made it happen."

Sanjay Kumar, right, with his family at the Great Wall of China.

FINAL WORDS

What can we do to ensure that our public water systems remain resilient to pressures created by urbanization?

Yujie Ying
Ph.D. Candidate
Department of Civil and Environmental Engineering



We can apply sensing technologies and data analytics to make our public water systems intelligent and resilient. Embedded sensors allow proactive monitoring of structural performance and integrity. Appropriate analysis of the sensed data can enhance our knowledge of the interactions between the water systems and human activities. Communicating with our infrastructure leads to its better understanding and can benefit sustainable planning, design and management of urbanization.

Student

David Dzombak
Walter J. Blenko Sr. Professor of Civil and Environmental Engineering and Director of the Steinbrenner Institute for Environmental Education and Research

A resilient water supply system is one that can adapt to changing conditions while continuously meeting the needs of the community. Changing conditions facing public water systems, in addition to urbanization, include climate change, aging infrastructure, and ever increasing demands for higher quality drinking water. Addressing these interrelated pressures will require sustainable water management, i.e., relying on and stewarding local water sources, preferably multiple sources; matching water quality to water use, using distributed treatment systems for particular uses; and implementing water conservation through incentives and regulation.

Faculty

Kwadwo Som-Pimpong
B.S., MechE; M.S., CEE'11

Progressive, sustainable water solutions will help our water systems remain resilient. We need a community-based approach. Urban runoff due to impervious blacktop can be partially addressed with green roofs and more vegetation within the city. This will limit the flow of storm water and chemicals into our streams, thus reducing erosion and contamination. Individuals need to plant urban gardens, and companies need to support sustainability financially and with how they choose to exist physically in the city. An example of a progressive approach to city existence is PNC Bank's "green living wall." Forward thinking minds will implement solutions like green roofs that will ensure a stable future for our water systems.

Alumni

Carnegie Institute of Technology
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213
www.cit.cmu.edu

Nonprofit Org.
U.S. Postage
PAID
Permit No. 251

HELLO NEW STUDENTS

To recognize the Class of 2016, CIT proudly presented its newest engineers with a t-shirt designed by first-year student Andria Lemus. At the start of the term, the college asked the new students to create a shirt that best represented their class. The designs were posted online and students voted for the design they liked best. We can see why Lemus' bold design won!

Congratulations Andria and welcome Class of 2016!