Balancing Supply and Demand in Tomorrow’s Electric Grid
Alumni gifts provide critical financial assistance for our students. In today's economy, more students and their families are faced with economic hardship. We remain unwavering in our commitment to admit outstanding students who demonstrated intellectual potential, strength of character, and love of learning, regardless of their ability to pay. We endeavor to make Cornell education affordable for all admitted students. It is you who help to make this possible.

Alumni gifts help us to attract the finest faculty. We must compete with other top engineering schools in our efforts to attract and retain these outstanding individuals. Your gifts help equip modern research labs and support our outstanding graduate students.

Alumni gifts are essential to having top-notch facilities. The importance of having well equipped labs for teaching cannot be underestimated. They are where students gain their hands-on experience that make them true engineers. Even a few hundred dollars can put a piece of equipment on a lab bench, and we put the donor’s name on it.

Likewise, our faculty and student groups depend on technology that enables them to be effective and efficient, and on offices and meeting spaces that facilitate easy interactions and generate and grow ideas. Good examples are addition of the MEng lounge and planned addition of other meeting places for students. Your support helps to provide the facilities we need.

Whether you are able to make a large gift or small one, we need your support for our students, faculty, and facilities. Every gift matters. Individually and collectively, you are instrumental in making Cornell ECE a strong, vibrant school that produces fine engineers and essential knowledge.

For more information on how to make your gift, please visit: www.ece.cornell.edu/support.cfm.

For up-to-the-minute information, look for Cornell ECE at: www.twitter.com/CornellECE or www.facebook.com/CornellECE
Once again, it’s my pleasure to update you on the accomplishments, initiatives, and ongoing work here in ECE.

One of our major recent efforts has been plotting the future of our department and, more broadly, our discipline. How can ECE have the greatest societal impact? After much discussion, we decided on three directions that hold the most promise: human life, energy, and data. In our last issue we highlighted the new field of bioelectrical engineering and its tremendous potential to improve health and life. In this issue you can read about our faculty working in the energy area (see page 6).

I am pleased to welcome two new faculty members whose expertise will advance us in our strategic areas: Eilyan Bitar, and Zhiru Zhang. Another boost comes from alumnus Charlie Sporck, ’51, whose generous gift has created a number of graduate fellowships in analog circuit design. Read more about Charlie’s gift on page 4. What can be more exciting than Cornell winning the competition to build a new campus in New York City? ECE’s being among the first four departments to develop programs for the new campus. So that there’s no confusion, let me be clear that ECE will not be moving completely to NYC. Ithaca will remain our home base, with the NYC campus serving as an excellent opportunity to grow our faculty and academic programs into an urban environment. We are already recruiting new faculty members for the new campus. Leveraging our success with the MEng program in Ithaca (this coming fall, we are expecting the largest MEng class ever), we have also begun to develop that program for the NYC campus, aiming at welcoming the first class of students one year from now. Finally, as reported in the last issue, many thanks to alumnus David Duffield ’62, BEE ’63, MBA ’64, who made possible the renovation of our Phillips Hall lounge. Now complete, the beautiful new lounge has quickly become a popular meeting spot for students, staff, and faculty. Other ECE spaces due for facelifts are Rhodes Hall conference rooms, several student offices, and teaching labs. We look forward to your continued support so that we can move ahead on these and other department improvements.

Tsuhan Chen, Director
PECASE Awards

Two faculty members of the School of Electrical and Computer Engineering—assistant professors A. Kevin Tang and Salman Avestimehr—have received the prestigious Presidential Early Career Award for Scientists and Engineers (PECASE).

PECASE is the highest honor bestowed by the United States on science and engineering professionals in the early stages of their research careers. Along with cachet of the award itself, winners also receive funding to help further their investigations.

Tang received the 2012 PECASE after being nominated by the Department of Defense for his fundamental contribution to control and optimization of engineering networks, such as the Internet. Tang’s research has paid special attention to obtaining compact global understanding, providing predictions that can be quantitatively compared with experimental data, and designing scalable distributed algorithms.

He was also honored by PECASE for his supportive advisory role to graduate, undergraduate and high school students. For example, he worked with Cornell’s Curie and Catalyst academies, where for the last four years, together with professors Al Molnar and Ed Suh, he volunteers to teach female and minority high school students, encouraging them toward careers in math, science, and engineering.

Tang joined ECE in 2007. He earned his M.S. in 2002 and his Ph.D. in 2006 from the California Institute of Technology.

Avestimehr received his PECASE in 2011. He was nominated by the National Science Foundation for “pushing the frontiers of information theory through its extension to complex wireless information networks.” His research interests include information theory, the theory of communications, and its applications such as wireless communication systems and networks.

“We are working on developing novel tools to make progress on several long standing open problems in network information theory,” Avestimehr says. “We want to know the limits of information transfer over complex wireless networks and understand how it is affected by network dynamics. We are developing new approaches to approximate that.”

Avestimehr joined ECE in 2009. He received his M.S. in 2005 and his Ph.D. in 2008 from the University of California, Berkeley.

Teaching Awards
Michael Tien Excellence in Teaching Award
David Albonesi
Ao (Kevin) Tang

Ruth and Joel Spira Excellence in Teaching Award
Aaron Wagner (2012)

DARPA Young Faculty Award
Christopher Batten

Research Awards
NSF Early CARRER Award
Christopher Batten
Alyosha Molnar

US Air Force Young Investigator Research Award
Ao (Kevin) Tang

Presidential Early Career Award for Scientists and Engineers (PECASE)
A. Salman Avestimehr
Ao (Kevin) Tang

Recognitions
Optical Society of America Fellow
Clifford Pollock

Promotions
Amit Lal has been promoted to the rank of Full Professor, effective April 1, 2012.

Ehsan Afshari has been promoted to the rank of Associate Professor, with tenure, effective July 1, 2012.

Aaron Wagner has been promoted to the rank of Associate Professor, with tenure, effective July 1, 2012.

Graduate Student Awards
Director's Ph.D. Thesis Research Award
Albert Wang (Advisor Al Molnar).

Left to right: Tsuhan Chen, Albert Wang

Director's Ph.D. Teaching Assistant Award
Hadi Hosseinzadegan (Advisor Amit Lal)
Ji Kim (Advisor Christopher Batten)

Left to right: Tsuhan Chen, Hadi Hosseinzadegan, Ji Kim and Edwin Kan
Eilyan Bitar is working to transform the way our electrical grid is operated to achieve deep integration of renewable energy resources. Traditionally, the grid is operated such that generation is tailored to match uncertain consumer demand on a second-by-second basis. At issue is the fact that renewable resources like wind and solar are highly dependent on the weather. They are hard to predict, highly intermittent, and largely uncontrollable.

“These energy resources are inherently variable,” Bitar says. “How can we efficiently accommodate large amounts without throwing the grid out of balance? This is the basic challenge we aim to address.”

One possible solution resides with the consumers themselves. According to Bitar, “there is a tremendous amount of consumption flexibility in the demand side that until today remains largely untapped.” Perhaps residential consumers can be coaxed into changing their consumption patterns, for example, to accommodate variability in supply. Simply making power cheaper during off peak hours, though, won’t do the trick – the monetary incentives are too small. “Even if the average home owner behaves optimally, their savings will at best amount to five percent on their bills. So on a $100 bill, the user would save at most $5.”

By designing novel incentive mechanisms and real-time control algorithms to simultaneously manage millions of end-use devices in the distribution system, Bitar aims to transform the role of consumers from passive recipients of energy to active participants in the distribution system, Bitar aims to transform the role of consumers from passive recipients of energy to active participants in the distribution system, Bitar aims to transform the role of consumers from passive recipients of energy to active participants in the distribution system.

Although he’s a native Californian and as such is used to more temperate weather, Bitar didn’t hesitate to accept Cornell’s offer. The School of Electrical and Computer Engineering has a deep and rich history of research in electrical power systems and information science, he says.

“It’s a truly scholarly place, with a collegial and brilliant faculty,” he says. “I see a genuine opportunity for stimulating discussion and collaboration, which will hopefully give birth to exciting and innovative research projects.”

Zhiru Zhang
Asstistant Professor
Ph.D, University of California, Los Angeles, 2007
Co-Founder, Director of Research and Development, AutoESL Design Technologies, Inc., 2006-2011
Software Development Manager, Xilinx Inc, 2011-2012

Today’s cutting-edge computer chips can house up to six or seven billion transistors, a number roughly equal to the world’s population. While the comparison isn’t perfect—duplications, for example, would lower that number somewhat—the main point is the same: embedded systems are mind-bogglingly complex. And as the history of the semiconductor industry shows, they’re only going to get more complex every few years.

The research of assistant professor Zhiru Zhang, who joined the ECE faculty this fall, seeks to create tools to optimize system-on-a-chip design, particularly through automated synthesis.

“My research is at the behavior level,” explained Zhang. “I want to develop efficient compilation tools, so we can use software languages to create efficient hardware. I think it’ll be a big step forward, and of course there are many open research challenges that make this area fascinating.”

In 2006, Zhang co-founded a company, AutoESL Design Technologies, Inc., which provided high-level synthesissolutions for designing and implementing application-specific integrated circuits (ASICs) and field-programmable gate arrays. Its main product, AutoPilot, has been adopted by leading semiconductor and systems companies to enhance design productivity and quality for video, wireless, and high-performance computing applications. In 2011, AutoESL was bought by Xilinx.

Commercializing part of his research and making it available to a wider audience, Zhang said, was a valuable experience, and one that will align well with the entrepreneurialism that ECE Director Tsuhan Chen wants to emphasize at the new campus in New York City. As Zhang notes, many engineering professors also start companies on the side. In the semiconductor industry especially, where technology evolves quickly and the research/product cycle is very short, it can be very helpful to have a foot in each world, he says. Zhang himself will be a full-time academic now, but he’ll draw on the knowledge and skills he gained while working in industry. The heart of entrepreneurialism, after all, is creating something new and valuable, an experience Zhang encourages any engineer to seek out.

“Whether you want to be a professor or develop a company or find a job in a company,” he says, “having an entrepreneurial spirit will help in almost every case.”
In creating an ECE graduate fellowship in analog circuit design, alumnus Charlie Sporck, ’51 BME, hopes to ensure the continued viability and leadership of the U.S. semiconductor industry, and to make Cornell’s name synonymous with analog circuit design expertise.

The Excellence in Analog Circuit Design Graduate Fellowship Endowment Fund will support PhD students and make possible an industry field experience with selected corporate partners. During the field experience, they will work on real life projects, given to them by the companies, to advance developments in analog design in ways that address industry needs.

As a pilot effort last fall, two doctoral students worked with Summit Microelectronics on an analog circuit design battery project. Now the school is identifying other potential corporate partners, as well as discussing the formation of a consortium through which member companies could participate in assigning projects to PhD students. The arrangement is meant to benefit all sides: students gain valuable field experience, while companies gain access to a research university’s innovative ideas.

The consortium model made possible by Sporck’s gift, says ECE Director Tsuhan Chen, gives the department “the opportunity to maximize industry connections and research opportunities for our faculty and students, which are absolutely consistent with Charlie’s goal to ensure that our work remains relevant and visionary.”
Sporck says the gift satisfies his twin desires to support his alma mater and bolster the industry very near and dear to him.

Few people know more about, or have been more influential in, the semiconductor industry than Charlie Sporck. He worked at Fairchild Industries in the era of Robert Noyce and Jean Hoerni; their developments of the integrated circuit and planar process laid the groundwork for the rise of Silicon Valley. Sporck eventually became vice president and general manager of Fairchild. From 1967 to 1991, he was CEO of National Semiconductor. A struggling company when he took over, National Semiconductor went on to be the world’s first billion-dollar computer chip maker. He also was a founder and the first president of the Semiconductor Industry Association.

While the U.S. leads the world in analog design, Sporck said, most chip manufacturing has moved overseas. Sporck doesn’t object to that, but he worries that once manufacturing goes, it’s all too easy to move design overseas as well.

“I feel strongly that it’s important to reinforce our current leadership position,” he said. “To me, design is the most important part of the semiconductor industry today.”

While we live in a digital world, that world rests on an analog foundation. Analog systems interface with humans and translate our complex signals into the digital language of 0s and 1s. “We basically tend to be analog beings, as opposed to digital,” Sporck says. “Our bodies and thinking are not made up of 0s and 1s.”

Analog circuit design has vast potential for numerous applications, such as health care, consumer electronics, manufacturing, and military. Industry leaders are coming to see this, Sporck says. Texas Instruments, for example, last year purchased National Semiconductor for $6.5 billion, and the head of TI has an analog background. “They’re basically saying that analog is important to their future,” says Sporck.

Excellent design will be essential to success. Sporck ruefully recalls the many companies that were in the semiconductor business in the 1950s and ’60s,—GE, Philco, RCA, Westinghouse, Kodak—that have either disappeared or dramatically changed. “They did not address the competition, the world competition, in a meaningful manner,” Sporck says. “I wasn’t in top management at the time, but I suspect that they just plain thought that they would be able to weather the storm. That was not a good enough answer.”
The power grid as we know it began in the 1870s as a series of isolated power generation systems which joined together in the early 20th century to form a national grid. Much of the present infrastructure of the electric power grid is almost a half century old. That equipment has successfully, but not optimally, accommodated all the needs of our growing population and evolving technology.

Technology has changed the way consumers use energy — from simple programmable thermostats to smart energy meters to electric cars, businesses and homeowners have great control over when and how they use electricity. All load sources, from laptops to electric vehicles, share a common root — they draw power from the grid, albeit at varying times and intensities. This consumption variability makes delivering electricity a complicated process. Wind and solar power add further complications due to their variable energy output. Research is underway to improve our power grid, now coined “smart grid”, so it can meet challenges and growing expectations of the modern world.

Over the decades, ECE faculty and students have continued to contribute to the knowledge and best practices in the science of moving electric power from generating sources to consuming users. In 1883, Cornell University, introduced the world’s first course of study and first degree in Electrical Engineering. “Cornell has always been a key resource in all facets of the grid,” says ECE Professor Emeritus Robert Thomas. “Even back when Edison was busy with his inventions, Cornell has always had courses in the field.”

With such a rich history in the field, it is no wonder that ECE faculty and students continue adding novel solutions and ideas to the smart grid with research that benefits users today and tomorrow.

Preventing Power Grid Blackouts

Increased load demands and market economics are pushing power systems closer to their operational limits, making the operation of power systems increasingly difficult and complex. Power outages and interruptions have significant economic consequences for society. For example, in 2003, the Northeast blackout left 50 million customers without electricity and the financial loss was estimated at 6 billion dollars.
The ability to monitor and control the physical behavior of the power grid is of utmost importance and can save the grid from many catastrophes. Professor Hsiao-Dong Chiang and Emeritus Professors James Thorp and Robert Thomas all have made significant contribution in these areas. As a result of their research Cornell owns several patents related to power system voltage stability.

Professor Chiang has been involved in the development of software tools for power grid on-line transient stability assessment (TSA). The on-line TSA tool is designed to provide system operators with critical system stability information like accurate utilization of transmission capacity, determination of available transfer capability, or assessment of dynamic system security. The tool is widely used in the power industry and has provided substantial savings in operating costs for many power companies.

Another of Professor Chiang’s tool for real-time assessment of transient stability is the so-called BCU method. A system based on the BCU method was installed by the Regional Transmission Organization PJM. It ensures the reliability of the high-voltage electric power system serving 54 million people in the North and Mideast regions of the US.

Renewables

Renewable energy, predominantly wind and solar power, has added a challenging and dynamic problem to system operators and researchers: how to incorporate a variable supply of power onto a grid historically run by steady generations source. Feeding those resources into the current grid requires new methods for assessing when and how these new supplies will produce their energy and how to harmonize them with existing dispatchable resources.

“Currently, renewables make up only about 5 percent of our power” says Professor Thomas. If renewable resources are to eventually contribute a large percentage to our supply, the grid will need some sort of large-scale energy storage to support, balance, and stabilize the power system.

The stochastic nature of renewable energy sources introduces additional uncertainty into the power system and hence makes monitoring of the system more challenging. A research team, led by Professor Chiang is working with California Independent System Operator (ISO) on voltage stability analysis when renewable energy is incorporated into the grid. The group is developing a tool for comprehensive analysis and control of power systems with high penetration of renewable energy sources.

Assistant Professor Eilyan Bitar is working to transform the way our electric grid is operated to facilitate the deep integration of renewable energy resources. “Under the current modus operandi, generation is tailored to follow an uncertain demand,” he says. However, “wind and solar generation resources are inherently variable. How can we efficiently accommodate large amounts without throwing the grid out of balance? This is the basic challenge we aim to address.”

One possible solution resides with the demand side. By designing novel incentive mechanisms and real-time control algorithms to simultaneously manage millions of end-use devices in the distribution system, Professor Bitar aims to transform the role of consumers from passive recipients of energy to active participants that willingly serve the systemic needs of the electric grid.

EVs and Data Centers

One of upcoming power needs will be the ability to charge millions of future electrical vehicles (EVs). The load of an EV can equal the load of an entire house, which poses a significant issue for substations and distribution grid if every EV were to charge at the same time. The problem of scheduling when, where and how to charge is being addressed by the group led by Professor Lang Tong.
An analogous problem to charging EVs is the problem of reducing energy consumption of large data center networks. The level of consumption is growing at an annual rate of 15%. Assistant Professor Kevin Tang and his team are working on a joint project with the California Institute of Technology, funded by the Department of Energy, to develop power aware data center networks. The project aims to reduce energy consumption by creating power optimization technology. The technology utilizes server speed scaling and load balancing approaches.

For example, a data center processing light jobs has lower power needs, therefore a number of servers can be shut down to save energy. When usage is high, jobs can be routed to other less busy processing stations or to locations where electricity prices are cheaper. The initial estimates indicated that the technology being developed by Professor Tang’s team can save between 15% to 50% power depending on the peak-to-mean ratio (the ratio between the highest demand and the average demand) of the workload.

Load balancing, rerouting and scheduling will require a more efficient distribution network and advanced logistical systems. But the more intelligent the system, the more data can be collected about the end user, increasing privacy concerns.

Professor Stephen Wicker and his crew are exploring the privacy and security issues surrounding smart meters, which are digital meters that allow for automated meter reading, load control, and dynamic pricing plans. The meters collect consumption data on an intervalled basis as fine as one minute, thus allowing for fine granularity pricing. Professor Wicker and his students have shown, however, that fine granularity power consumption data creates a serious privacy concern, as it can be used to predict the behavior, beliefs, and preferences of the consumer.

“Fine-grained consumption data is certainly useful in motivating efficient energy usage, but the potential privacy and security problems are a strong motivator for a privacy-aware architecture that minimizes the centralized collection of data,” Professor Wicker says. He has begun developing architectures that prevent the collection of fine-grained data that can be attributed to an individual, while still retaining the benefits of demand response. The proposed architecture combines a tiered collection strategy and public-key infrastructure to insure customer control over personal information.

**Energy Generation**

The average power required by a person to accomplish common physical tasks is 100 watts, equivalent to the power required to run an incandescent light bulb. A central air conditioning unit uses the same amount of energy as 40 people, a car uses the energy of 400 people, a truck 4,000 people and a locomotive 40,000 people. Modern societies require significant energy use to function at its current level. Put simply — we need power plants. Unfortunately, conventional power plants, such as coal, natural gas or nuclear fission, have great impact on our environment. If energy consumption cannot be reduced, then we need to change the way energy is generated. Renewable energies are one possible route to alleviate some of the problems generated by conventional plants, such as greenhouse gases and nuclear waste. However, the operating principles of power plants based on conventional energy sources are completely different from power plants based on renewable energy. New approaches for the latter are being addressed by ECE researchers.

**Harvesting Solar Energy**

Imagine a day when you can go to your favorite hardware store and purchase lightweight tiles to make your own solar power system without the need for specialized installers, costing a fraction of solar prices today. This is the vision pursued by the Cornell SonicMEMS Lab, led by Professor Amit Lal.

Traditional heliostat technology used in solar power systems consists of mirrors made as large as possible to minimize fixed costs such as those of pedestal support and drive motors. Large mirrors, however, increase weight and wind loading, necessitating the use of thick material and structural rigidities, making system weights and expensive.

To circumvent these problems the SonicMEMS Laboratory has developed a novel planar heliostat technology. This technology, called the S-Tile technology, consists of an array of centimeter scale mirrors within platforms that have form factors akin to those of photovoltaic modules (approximately 1 meter by 1 one meter by 10 centimeters). The lab has worked on progressively more powerful S-Tile based prototypes. These prototypes use metallic plastic films as reflectors. Since the weight of the mirrors can be very small, the
motor size required for moving the mirrors can also be very small. The S-TILEs can be self-powered and wirelessly controlled. The weight of the tiles is small enough so that one person can carry and install them like picture frames. Moreover, the system is projected to reduce the cost of solar energy from its current value 21c/kWh to 6c/kWh in the future.

**Fusion**

The fusion of hydrogen to form helium occurs at the rate of 600 million metric tons per second in the sun. On earth, it is possible to fuse heavy atoms of hydrogen, called deuterium and tritium, to form helium at the rate of 1-gram/s in 40% efficient electric power plants, which would produce 10GW of electric power. Neither long-lived nuclear wastes nor green house gases would be produced by these reactors. The energy reserve on earth for this resource is over one million years. While fusion has happened many times in laboratory experiments around the world, the efficiency of these machines were not sufficient enough to yield economical fusion reactors. Fortunately, the worldwide commitment is strong and two potentially economical approaches to fusion power which are being pursued today.

The Laboratory of Plasma Studies (LPS) in the School of Electrical and Computer Engineering uses steady state magnetic fields to hold hydrogen long enough for fusion reactions to occur, hence the name magnetic fusion confinement. The lab is led by Professor David Hammer with ECE Professors Charles Seyler and Pierre-Alexander Gourdain also associated with the lab.

Professor Seyler has developed a plasma fluid simulation method using waves that show the behavior of high energy density plasmas in more detail. The method offers much richer physical content than models previously used while retaining computational efficiency. By conducting experiments and computer simulations the lab has demonstrated that the price of magnetic confinement fusion reactors can be reduced by a factor of four while maintaining constant fusion power.

The other approach to fusion power investigated in the lab uses pulsed power to generate fusion reactions faster than the fuel can cool, hence the name inertial fusion confinement. Professor Hammer’s team in cooperation with Sandia National Laboratories is engaged in research aimed at developing the Magnetized Liner Inertial Fusion, or MagLIF concept. The investigators study the fundamental properties of matter under conditions approaching those that would be achieved in a MagLIF fusion system. For this purpose the lab makes use of a 1 million ampere pulsed power machine called COBRA. Both theoretical and experimental approaches to magnetic fusion in the LPS give ECE students the opportunity to work on the forefront of fusion energy research at Cornell University.

Looking into future, the international Thermonuclear Experimental Reactor (ITER) project in the south of France, under construction today, will produce its first plasma in 2025 and produce energy from fusion reactions in 2035. A demonstration power plant is planned for operations in 2050. “We can eventually create an infinite amount of fusion energy,” says Professor Gourdain. “That’s the way to solve the energy resource problem.”
In 2009, the substation that supplies power to most buildings on Cornell University’s campus was completely revamped, providing not only a cleaner sources of electricity but also an opportune moment to research possibilities for greater efficiency of distribution systems, renewable energy, and sustainability.

The Smart Electric Distribution Grid project, now in its second year, seeks to do just that. The project involves a large number of ECE undergraduate and Master of Engineering students and is directed by Professor Hsiao-Dong Chiang, lecturer John Belina, and former MEng student Jeremy Keen. Students in the smart grid research group work closely with staff members from the Cornell Facilities and Energy and Sustainability unit. Essential assistance has also come from Bigwood Systems, an Ithaca firm founded by Professor Chiang in 1995 that provides advanced software solutions for utilities.

Cornell purchases electricity from the power company NYSEG. At the campus substation, transformers lower the voltage and distribute electricity out to individual buildings. Cornell’s distribution system provides a real-world test bed for the questions the group is studying, an educational opportunity that appeals to students who choose the energy systems specialization in ECE’s Master of Engineering program, says Belina. Anything tested on Cornell’s distribution grid, says Belina, would be transferable to any power company, all of which have an interest in improving efficiency and reliability.

The group’s projects fall into two broad categories — state estimation and other novel smart grid applications, says Keen. State estimation generally means monitoring. “If you don’t understand what’s happening on the system, it’s hard to do any kind of analysis or control to make it better,” says Professor Chiang. One student project involves creating a Google map with all of the system’s power lines and transformers and their properties. The map will improve the ability to monitor and control distribution grids.

Once a power system’s monitoring backbone is in place, analysts can play around with the data, such as running simulations on how the system might behave...
for the next fifteen minutes or, if a wind energy element were added down the road, what happens when the wind dies down, or how energy loads vary by season. This is power flow, and this is where a lot of the smart grid group’s activity is focused now, says Keen.

State estimation and power flow by themselves don’t save money, but they provide the groundwork for applications that can. Last year a student worked on an algorithm that minimizes power loss through network configuration. Distribution lines have a lot of switches all along them, Keen explains, and each switch is an opportunity for power to leak out. But if branches could be moved around and connected in different ways, loss would be minimized. The algorithm uses a heuristic which finds a configuration with minimal loss.

Numerous Smart Grid projects that continue apace all are underpinned by an interest in efficiency that will save energy and money. In conjunction with Bigwood, some students are participating in development of a “smart plug.” This is a monitor that could be plugged on one side into a typical wall outlet and on the other side into any compatible electrical device. Employed on a wide scale, these monitors can show when, where and how much power is used throughout a building and send that information to a control center which can be a website. The data can then be fed into optimization algorithms which would calculate when the devices should be turned on or off so energy is conserved — the smart plug itself will flip the switches as desired.

Since monitoring equipment can be quite costly, the group is working to come up with creative algorithms that can reduce the number of measurement devices by 80 percent. “It’s an incredible possibility,” says Belina. He hopes they soon will have a prototype to test. “Cornell can be seen as a microcosm, trying out some of the technology and showing that it works,” he adds. One of the group’s new project is to develop a dashboard that constantly displays the current state of the power system and allows for easy monitoring, analysis, tweaking and adjustments.

Another project involves the distribution network. The distribution issues have not been studied as thoroughly as the high-energy transmission portion of power systems which is generation plant to substation. “For most people, that was considered simply a wiring issue,” Belina said. “But now most people see that that’s the place where renewable energy can be injected, so it’s filled with wonderful problems for students to work on for thirty or forty years to come.”

Additionally, a study a few years ago reported a large population of power industry workers on the verge of retirement. “So the number of job opportunities are going up tremendously,” Belina says. Not a bad career outlook for someone in engineering school.
Chen: You became associate director of the school two years ago, and a top priority has been building community among ECE students, particularly undergraduates. Describe some of the things you’ve initiated.

Hemami: We want our students to feel that they had an identity not only as electrical and computer engineers, but as Cornell electrical and computer engineers. Our students are so involved in extracurricular activities, though—research, project teams, community service—that it was a challenge to put events together that engage students on a time schedule that works for them and for faculty, another group difficult to schedule. A couple of years ago you started ECE Day, which is a combination party/technical poster session at the end of the spring semester. I wanted something like that in the fall, so this year we had our first ECE Mid-term Bash. To lure students, we raffled off three iPods, some $50 Amazon gift certificates, and a broken oscilloscope. That was the booby prize, and we got a lot of press about that. We set it all up in the Duffield atrium, and we were thrilled with the turnout—about 150 students were waiting in line to get in. About 20 faculty members came as well. There was faculty bingo: I had asked each of the faculty members to send me a two-sentence description about their research, but I didn’t tell them what it was for. Then I created bingo cards with words from their descriptions. At the event, I had each member talk for exactly 60 seconds on their research, while the students checked off words on the cards. Unfortunately, I’m going to lose the element of surprise next year, so I’ll have to come up with something else. We had planned to play Resistor Twister but didn’t get to it, so that’s something we’ll definitely do next time.

Chen: Our community building efforts are reaching all the way out to new and prospective students, is that right?

Hemami: Yes. Every spring, campus is inundated with high school students and their parents, many of whom want to meet with professors or sit in on classes. That’s great, but it’s really not feasible to accommodate everyone individually. I had the idea my first year here that if we could designate certain classes and office hours where visitors are welcome, and then put the burden on our guests to schedule their visits during those times, that would give everyone a better opportunity to meet. So now that’s what we do. Every semester I collect from faculty all the courses that welcome visitors—and that’s nearly every course—as well as their open office hours, and we put that calendar on our website. There’s no more sending emails, scheduling, making time on calendars; it’s much easier for us. As a result, there are many, many more opportunities for visitors to meet with faculty, and I think a lot more people coming in and having personal, positive interactions with faculty.

Chen: When you say you want students to feel their identities as specifically Cornell electrical and computer engineers, what do you mean?

Hemami: The pride that I and all faculty feel about Cornell, our students, and our discipline. Look, I’m very parochial: I think if everyone was an electrical engineer, the world would be a better place. And I think ECE is the best, most versatile major. Students can go on to just about any career or discipline. Our material is extremely broad, spanning pure math to pure physics. That’s a source of pride among the faculty. We are also very proud of our undergraduate students. They really walk on water. Fifty percent of our undergraduate students go on to graduate study. That is much higher than any other department in the college and very high for ECE departments. And they don’t only go into engineering; they go into law, medicine, and business.

They’re also very involved in research. Faculty love to work with them, because they deliver. We actually have a new department motto: Cornell’s ECEs can do everything. We really believe that. And in fact, we’re now getting some applications from transfer students quoting it, so word must be getting out!

Chen: Along those lines, you’ve also recently instituted some curriculum changes geared toward providing freshmen with a more solid grounding in ECE.

Hemami: All freshmen have to take one Introduction to Engineering course, from any department—chemical engineering, civil, whichever discipline they think they might be interested in. Students don’t declare majors until the end of their sophomore years, so this is a time for them to explore. ECE, as I’ve said, is very broad, the broadest field in the school. The
courses we offer look very different. So part of our mission is to educate students about breadth of ECE, but at the same time, we want to use our courses as recruiting devices. I wanted our intro courses to make it clear to students that they were taking a freshman version of the material, and they could clearly see what senior courses those freshman courses corresponded to. I call it “book-ending the curriculum.” For example, students taking an intro course on telecommunications could see that it leads to a senior course on visual communications and receiver design. In hindsight, this sounds obvious; why wouldn’t you have your courses like this? But teaching freshmen really requires a special gift. Many of us can’t remember how to teach students who don’t yet have college-level backgrounds in math, chemistry, and so on. We’re now in the second year of this approach, and we’ve applied for a National Science Foundation grant to support it.

Chen: One strength of our department is the rigorous and in-depth lab work that accompany courses from sophomore year on up. What are some of the department’s most pressing equipment needs?

Hemami: There’s always something. We go through a lot of equipment. We just replaced our 20-year-old oscilloscope. Things have finite lifespans. For any alumni who think their donation is too small to make a difference, I’ll tell them what we’re going to do with that small donation: We’re going to buy a new digital signal source and it’ll be used by literally hundreds of students for thousands of hours, creating new, patentable research. And that little signal source will have a plaque on it to say who gave it. We’re also building a new laboratory for a junior design course, and that needs to be filled with equipment. So this is a wonderful need for alumni to support, and believe me, every donation will go to excellent use!

Chen: Of course, in addition to all your work as associate director, you are a very distinguished engineer. Tell us about your background and work.

Hemami: I did graduate work at Stanford, from 1990 to 1994. The last year I was on staff at HP Labs as a member of technical staff. Then I came here on January 1, 1995. I am a multidimensional signal processing person, which in English means that I do math related to digital images and videos as perceived by humans. I don’t care about computers doing detection; I really care about how we should process and manipulate signals when the end goal is that they’ll be visually consumed. What is the right math to do? How do we manipulate the images? This is controlled by how we see, so I’ve published papers in traditional ECE journals as well as more psychology-oriented journals. I look at modeling the visual system not as a neuroscientist or psychologist, but as an engineer.

Chen: And tell us about your contributions to the field, including being named an IEEE Distinguished Lecturer.

Hemami: The IEEE selects five or six distinguished lecturers each year. Basically, we’re cheap dates. We travel around the world and give talks in many places where people are technically active but don’t have resources to bring a distinguished member of the community to visit and give a talk. The DL program provides those means; any chapter of the society can invite the DL to give a talk. It’s community building for the society around the world, and a wonderful way to find out what people are doing and share information. I went to Purdue, and the University of British Columbia. I gave four talks in India, at three universities and a company, and three talks in Morocco. I spent a week in Tunisia as a visiting professor.

You were also a distinguished lecturer a few years ago, Tsuhan, so you’ll understand when I say that it’s really a dream job. You get to travel all over the world, meet people, and talk about the work you love to do. And this year I’m a technical program co-chair for the International Conference on Image Processing, sponsored by the IEEE Signal Processing Society, which will be at the end of September in Orlando. It’s a huge conference—about 1,000 papers, with more than 2,000 submitted. I’ve been in charge of getting those papers reviewed and accept/reject decisions made. It’s a thankless job, but we’re almost done. I invite all alums attending the conference to stop by. I’d like to coordinate opportunities to speak with students about their career trajectories and to continue to build community of current, past, and future Cornell ECEs.
ECE Day 2012