Rutgers Industrial and Systems Engineering is Taking the Lead in Energy Planning for the Future

It has been more than a century since Thomas Edison, working from his famous research lab up the road from New Brunswick, laid the foundation for so much of the high tech-world we know today. The inventor of the record player and the light bulb would hardly recognize many of the critical systems that he helped to create and that we take for granted. We slip our phones in our pockets and use them to connect with people and retrieve information in ways “The Wizard of Menlo Park” could hardly imagine. But when it comes to extraordinary advances to our power generation systems… not so much.

School of Engineering Professor Mohsen Jafari believes that if Edison were alive today, he would certainly agree we are overdue for new energy initiatives—and that Rutgers is well positioned to take the lead in developing solutions.

“The world and the industrial sectors of our economy are coming to the understanding that we must find a better way to design and generate energy,” says Jafari, chairman of the Industrial and Systems Engineering Department (ISE) and a principal faculty member and research program director at the Rutgers Center for Advanced Infrastructure and Transportation (CAIT). “We need to educate the public and build the necessary technologies for this to happen.”

And that’s the problem Rutgers is planning to address. Energy systems that rely on huge, centralized generation stations and conventional distribution systems are often expensive, vulnerable to storms and can put our nation at a significant competitive disadvantage while...
QRE at Rutgers

The Quality and Reliability Engineering teaching and research at the Industrial and Systems Engineering Department at Rutgers University covers four coordinated sets of activities that create, evaluate, and disseminate quality, reliability, and maintainability engineering work. In the Quality Engineering area the faculty are involved in the development of new methods, tools, and approaches for improving quality of products and service. Likewise, in the Reliability Engineering area development of new approaches for assessment of components, products, and systems reliabilities for different configurations and operating conditions are underway. Maintainability Engineering work deals with methods and technology for improving system availabilities through maintenance actions, inspection strategies, and repairs and in the Education and Information Transfer activities the faculty offer MS and Ph.D. degrees focusing on these areas and technical information to students and working professionals through regular courses and experiments and off-campus short courses to industries.

Message from the chair

In today’s fast moving business environment, industrial and systems engineers are increasingly in demand for their valuable system-of-systems thinking approach, quantitative decision making, and depth of knowledge in data analytics, optimization, and automation and control, helping businesses successfully adapt to new technologies and demonstrate resiliency to marketplace volatility and unexpected events.

In the Department of Industrial and Systems Engineering at Rutgers we are preparing students to apply their creativity in solving complex engineering design problems, approach unstructured problems, synthesize and design potential solutions, and evaluate the impact of their solutions in the broader context of the organization or society. Our faculty members have teaching and research strengths in areas that include quality and reliability, production and advanced manufacturing, applied operations research, and transportation. In keeping up with growing concerns related to global warming and advances in medicine, the department has extended its focus in recent years to include energy systems and healthcare.

With opportunities in areas as diverse as automation science, intelligent transportation systems, human-machine interaction, reliability and quality engineering, healthcare systems, supply chain engineering, aviation safety, smart energy systems, advanced manufacturing, security, and risk analysis, I know I speak for all of us when I say I am excited to be part of a dynamic field that is shaping the future.

Mohsen A. Jafari, Ph.D.
Chair, Department of Industrial and Systems Engineering

IIE Fellow Recognition

Professor Thomas Boucher has been elected a Fellow of the Institute of Industrial Engineers for his professional leadership and outstanding contribution to industrial engineering. The Fellow award is the highest rank of membership in IIE. Professor Boucher, who is currently editor-in-chief of The Engineering Economist, was presented the award at the annual conference of the IIE in June.

Smart Chair Technology Makes Sitting Safer

Computers and Internet use have dramatically transformed our lifestyle and exposed us to many significant occupational health hazards including neck, shoulder, and lower back pain associated with sitting for long periods of time. These hazards have become a significant public health problem. Although many lifestyle-related risk factors have been identified, effective monitoring and management is lacking to prevent the occurrence of these diseases in long term.

Assistant Professor Kang Li recently received a grant from NSF to develop a smart active chair to prevent injuries and improve office safety. The first aim of this project is to develop novel algorithms to track dynamic human sitting postures. The second aim is to establish a personalized and real-time intervention strategy based on an upper body, musculoskeletal biomechanical model to reconfigure the chair in real time so that sitting-related injury risks can be mitigated. Li has formed an interdisciplinary team consisting of researchers from industrial and systems engineering, mechanical engineering, computer science, and orthopedic surgery to work on this project.

Using IE Techniques to Minimize Terrorist Threats

Melike Baykal-Gursoy, associate professor and graduate director, was awarded NSF funding for research related to improving security and saving lives in the case of a terrorist threat. Using integrated modeling she will explore improving scientific understanding of human decision-making in adversarial contexts, design policies and best practices for protection of soft targets, including public transit facilities and places of mass gathering, and develop new methods and tools to support real-time emergency management and policy development. This research has a wide range of applications from homeland security and law enforcement to military. The most significant impact of the proposed research is expected to be to public facilities, campuses, school buildings and by providing support for first responders in decision making about prevention and deterrence of terrorist attacks as well as minimization of damage during an attack. Results of the proposed work will be communicated with the major regional players, including NY/ NJ Port Authority, NJ Transit, NJ Department of Homeland Security, and NJDOT.

see page 6 for more faculty news & awards
representing a potential threat to national security.

Rutgers vision is nothing less than remaking energy systems in much the same way that our communication and transportation systems have been overhauled over the last century. It’s no longer just about building more power lines and pipelines. At the macro level, we need to integrate these basic systems with advanced information technology, communication and security systems, while at the micro level we need to analyze energy usage in individual office buildings and homes. And we need highly trained professionals who understand how complex systems work together.

Jafari and his colleagues are moving to address this need by introducing a new Master of Engineering program on Energy Systems for the fall of 2016 and by developing a new laboratory to support this program and augment existing ones.

“Our multidisciplinary approach brings a unique perspective to this issue and is what will help to distinguish this program by bringing together years of research and industry experience in energy systems planning and control to build more resilient and sustainable energy systems,” says Jafari, who has helped to secure more than $21.5 million in research grants and serves as a consultant for many Fortune 500 companies and government agencies.

The new lab will be housed in the Weeks Hall of Engineering when it opens in 2018, and will include a mini smart grid with fuel cell, solar and wind generators, and physical and simulated loads. It will support undergraduate and graduate teaching and research. Part of the lab will provide full situational monitoring and visualization of all buildings across Rutgers and its owned microgrid. In fact, the new building itself will become a teaching tool for energy research and teaching.

In parallel, Jafari and his colleagues recently established the Laboratory for Energy Smart Systems (LESS) which incubates many years of research and industry experience on energy. LESS brings together expertise on advanced control and analytic to tackle complex problems in energy value chain from distributed generation to energy smart built environment. Already, LESS is working closely with industry, with federal agencies such as the Department of Energy and with local governments. The LESS laboratory will be a focus for a number of programs that already exist throughout the university, including the Rutgers Center for Advanced Infrastructure and Transportation (CAIT). LESS also focuses on cyber-physical systems in energy and smart manufacturing.

In particular, LESS focuses on research problems that intend to integrate Distributed Energy Resources (DER) with Demand Side Management (DSM). DSM research covers design, planning and control of distributed energy generation and storage assets and their integration to a macrogrid. DSM covers advanced solutions for energy efficiency and reduction at the points of consumption.

One significant benefit is that our energy research and education programs, says Jafari, will combine theoretical study with practical experience. Indeed, the energy industry needs skilled workers with this expertise, and major universities like Rutgers that are at the cutting edge of engineering and technology are in a position to train them.

“These programs address an unmet need in New Jersey and the United States. They will provide multidisciplinary training for students in key energy-related fields. This is where academia, and Rutgers, can take the lead in solving critical national problems,” says David Coit, a professor in the Department of Industrial and Systems Engineering, who has seen a surge in interest in energy-related fields from his many graduate students.

A multidisciplinary approach is what will be needed to resolve complex issues like the ones he and his students focus on, such as optimizing energy sources, long-range planning for electrical grids in the Northeast, or how to augment the grid with wind turbines while being prepared for those days when there may not be enough wind to generate power.

The combination of the new master’s program and the new research laboratory is expected to generate more interest among students in a field of study that will only become more important for the next generation. Over the last several years, there has already been a steady increase, with some classes having doubled in size.

“I think students have discovered this is a very interesting and valuable program,” says Honggang Wang, an assistant professor. His research and teaching interests touch upon oil and gas exploration and improving energy, water distribution, and environmental systems, including evaluating the long-term storage of carbon dioxide to defer global warming and avoid climate change. “Rutgers can help provide them with a really good career and a future in the energy field.”
A 3D printer for fabricating fiber-reinforced materials; a UAS that can assist with beach cleanup; a fully automated, multi-layer cupcake production machine; a robotic and mobile traffic light; and an oxygen tank that follows a person requiring oxygen and tracks vital signs.

These are just some of the projects that senior students in the Department of Industrial and Systems Engineering presented to faculty, students, and family as part of their capstone course as they prepare to graduate. The annual event held in December is the final showcase of a rigorous yearlong course in which students assess market needs and build systems that can meet those needs in innovative ways.

For the students, it is serious training for careers to come as they not only build machines or models of production lines, they also cooperate with other students and solve unforeseen challenges as they work towards a completed, working product.

Connor Ragsdale, whose team designed a robotic, mobile traffic stop light, said the project challenged him to apply the principles of other engineering disciplines in creating an efficient and technologically sophisticated device.

“It was cool working to construct the robot, from the hardware and wiring to coding and electronics, and actually make it run as an efficient and integrated system,” he said.

Proud family members Arnese Oshel and Marie Bizzaro, mother and grandmother of James Oshel who was part of the team that developed a brass casing collector, were among the invited guests who spent time with the students, learning about the projects.

“A lot of hard work went into these projects,” said Oshel who followed her son’s progress over the past few weeks. “Every time something failed along the way they actually ended up three steps ahead as they worked together to find a solution.”

According to Professor Elsayed S. Elsayed, who oversees the senior design teams along with Professor Kang Li, the senior design projects are open ended and require students to utilize the knowledge and skills learned in previous years to design and construct new products, systems, or machines.

“Students learn how to work with other group members and present their progress to the entire class on a regular basis, which develops their communication skills for real work environments,” he said.
Meet Assistant Professor Weihong (GRACE) Guo

Assistant Professor Weihong (Grace) Guo recently joined the faculty of ISE in September after receiving her doctoral degree from the University of Michigan in industrial and operations engineering. Guo’s chief research interest is in statistical monitoring of manufacturing processes to ensure optimum product quality. As a researcher at the University of Michigan she also studied data fusion for system improvement, sensing, modeling, and monitoring of profile data, and quality-oriented design. Her previous work has included battery manufacturing quality control, monitoring of ultrasonic welding processes, resource allocation, and surgical treatment prediction methods. Her work on the latter earned her first place in the 2014 Institute for Operations Research and the Management Sciences (INFORMS) minority issues forum poster competition. That same year, she was also awarded a Rackham Predoctoral Fellowship.
Q&A

Meet Industrial and Systems Engineering Student Nicole Koplitz ENG’16

Why did you decide to attend Rutgers?
I was one of those kids who said I was not going to stay in New Jersey to go to college, but when I started looking at schools I was impressed with Rutgers. The School of Engineering has a great reputation and it was also more affordable than other schools I was considering; it was really the best option.

How did you become interested in engineering?
In high school I loved math and physics. I didn’t really know what engineering was and hadn’t considered it as a field to study, but my physics teacher talked to me about studying engineering because he thought it would be a good fit. I looked into it and decided engineering would give me a lot career choices.

Why did you choose IE for your major?
I did some research into the different engineering majors and decided that IE most aligned my interests in math and business. I’m really interested in predictive analysis and studying the ways math can help make decisions across just about any field.

Tell me about your internships.
My sophomore year I worked at the Health Systems Engineering Institute at Northeastern developing an optimization model for a Boston-area hospital to better align nurses with operating rooms based on specializations and schedules. During my junior year I interned with Deloitte in Washington, D.C. as part of a systems engineering team managing the Composite Health Care System, a server and repository responsible for the Military Health System’s electronic health records with over 9 million beneficiaries.

What do you plan to do after graduation?
I just accepted an offer with Accenture where I will be a digital and technology consultant.

Which IE professor has had the most influence on you?
Professor Susan Albin. She’s always looking out for me and encouraging me. In her classes, she teaches the material so thoroughly, she’s excited to come to class, excited about IE. You can tell she loves what she’s doing!

What is online site do you look at every day?
Fivethirtyeight.com is all about statistics. It was created by the author and analyst Nate Silver and features stories on current events, politics, and more using statistics.

What is your go-to social media platform?
Instagram—I love seeing the photos posted and posting my own.

How do you plan to celebrate your graduation?
I’m hoping to travel before I start my job. I would love to explore someplace very foreign to me—I’m thinking about Southeast Asia!
Liao began an exciting new chapter in his career as professor and Hefley Endowed Chair Professor of Logistics and Entrepreneurship in the Department of Industrial Engineering at the University of Arkansas – Fayetteville. “I’m thrilled,” Liao said. “Arkansas is very strong in the area of quality and reliability engineering, and they’re a leader in engineering logistics.”

As he began preparing for his new responsibilities, Liao said his Rutgers experience continues to inform his career and shape his vision for teaching and research. He was deeply influenced by his Rutgers adviser and mentor, Elsayed A. Elsayed.

Liao looks forward to continuing his work in reliability engineering and engineering logistics, as well as their integration enhanced by modern sensor technologies.

“I am designing systems with multifunctional entities, game-theoretic models for service contracting, and reliability analysis of nano devices,” he said. “My team is developing a new system design methodology using reliability theory and artificial intelligence techniques to make complex engineering systems operate reliably at the lowest costs possible.”

Christine Falk: Flying High

Christine Falk’s first job out of college with a bachelor’s degree in industrial engineering was as a systems engineer for Electronic Data Systems in Paramus developing automated accounting systems. She liked the job, but she knew after several years the most interesting development aspects of the project would be ending. She decided to attend graduate school in engineering to further her career. She figured she would go part-time.

When she applied, she learned from the Rutgers Industrial and Systems Engineering Department about a fellowship offered by the Federal Aviation Administration (FAA) that would allow her to attend graduate school full-time while working as a research assistant on an interesting project simulating possible changes to the airspace used by jetliners. She jumped at the opportunity, and has been working with the FAA ever since.

“The decision to attend Rutgers was career changing for me. It was a great experience,” said Falk. She has worked as an operations research analyst at the FAA’s William J. Hughes Technical Center outside of Atlantic City, which calls itself the nation’s premier air transportation system laboratory, since earning her master’s in industrial and systems engineering from Rutgers in 1997. “I always liked the idea of simulation work, and my position has allowed me to develop valuable expertise and work with colleagues in Washington and around the world.”

These days she and her team are responsible for making sure commercial airliners on international routes travel safely and efficiently over the vast stretches of the Atlantic and Pacific oceans. While the area seems huge, airliners tend to travel along designated “highways” in the sky and are constantly searching for the best routes where they can take advantage of tailwinds, which can speed them along and produce significant fuel savings. The FAA’s responsibility is to see if airliners can travel more closely in order to maximize the best routes. For example, in the past, an airplane had to stay 80 miles behind the one in front; now, thanks to more sophisticated technology such as GPS navigation, that distance has been reduced to 20 miles.

Her job takes Falk around the globe, as this airspace is controlled by an international organization, the International Civilian Aviation Organization (ICAO). Also she consults with many other countries that are seeking to improve their systems, following the FAA’s model, and she has published a number of technical papers on modeling air traffic. She liked the statistical work of her job so much that she returned to Rutgers to earn a master’s in statistics in 2000.

Falk isn’t certain what the future will bring, but she is confident that with her training and experience, there will be more interesting opportunities on the horizon, and she expects to remain in close touch with her colleagues at Rutgers who have helped her along the way.

“There are opportunities for me to grow within the FAA, and there is also the ability to do more international work helping other countries,” she said. “There is still plenty more work to do. I know it’s important to keep learning new things, and I think I am in a good position to do just that.”
Haitao Liao knew after receiving his bachelor’s degree from Beijing Institute of Technology that he was ready to take a big step. The question was, where? He approached the question in the same way as he does research: He sat down at a computer and searched out the world’s top graduate programs in industrial engineering with focus on reliability and quality engineering. And within a few years, Liao had relocated from his native China to New Jersey to enroll in Rutgers University’s School of Engineering. “I decided to go to Rutgers because of the reputation of its program,” Liao said. “It was one of the best decisions I’ve ever made.”

He earned a Ph.D. in industrial and systems engineering in 2004, as well as two master’s degrees in industrial engineering and statistics, paving the way for a bright career in academia. His research interests cover statistical reliability models, smart maintenance and service logistics, prognostics, probabilistic risk assessment, and analytics of sensor data.

Growing up in China, Liao was drawn to engineering at an early age. “As a kid playing with toys I would open them up to see how they worked,” he said. “I wanted to see if I could get them to work better.” By the time he arrived at Rutgers, he had developed an eclectic background that covered electrical engineering with a focus on signal processing and system reliability, as well as statistics and risk assessment. “At Rutgers, I was able to merge all those important adaptations and components into an integrated educational program,” he said. “That was particularly helpful in starting and focusing my career.”

Since completing his studies, Liao has held faculty positions at Wichita State University, the University of Tennessee, and the University of...