Melissa Gordon and Mohammad Shahidehpour

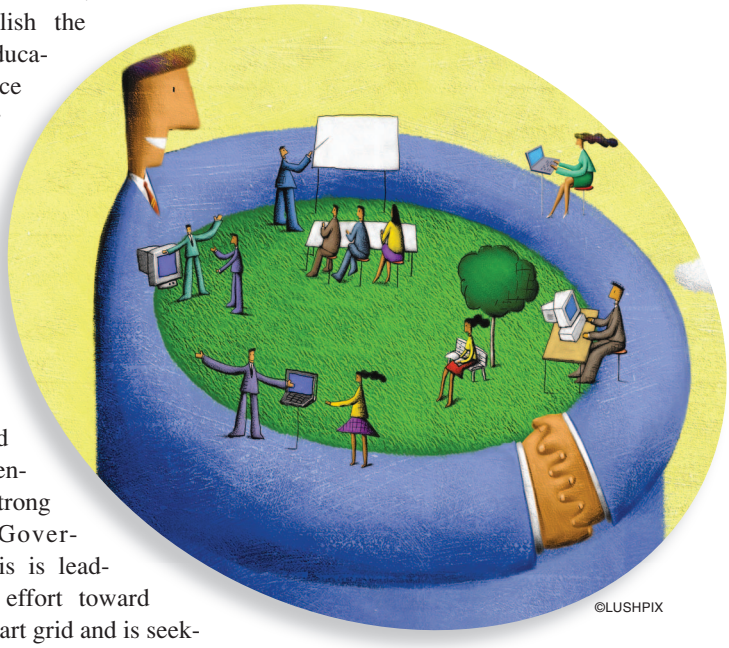
a living laboratory

smart grid education & workforce training at ITT

THE ENERGY INDUSTRY IS AT A tipping point, facing a paradigm shift in the way that energy is produced, delivered, and used. Increased demand for power has put a strain on the aging infrastructure of the U.S. power grid, causing it to become increasingly overloaded and unstable. Reorienting the nation's urban and energy infrastructure around platforms of efficiency, sustainability, and reduced greenhouse-gas emissions represents perhaps the greatest engine for innovation, job creation, and economic productivity growth in coming decades. The U.S. government therefore awarded US$3.4 billion in stimulus dollars to make infrastructure improvements to the grid and to promote smart grid and smart-metering initiatives. According to the U.S. Department of Energy (DOE), this investment is expected to create tens of thousands of jobs across the country including smart-meter manufacturing workers; engineering technicians, electricians, and equipment installers; IT system designers and cybersecurity specialists; data entry clerks and database administrators; and business and power system analysts. As the old grid is rapidly being replaced with smart grid technology, a critical shortfall in workforce training and education has been identified; that is, there is a lack of well-trained, highly skilled electric power sector workers who are vital to deploying and maintaining a national clean-energy smart grid.

To address the workforce shortfall, the DOE, in late 2009, issued a request for proposals to develop training and education programs for the electric power sector. The Illinois Institute of Technology (IIT) responded with a proposal to engage utilities, corporations, labor unions, veterans, K–12 students and educators, universities, and community colleges in a collaborative initiative to train the strongest workforce in the world to meet the global educational challenges in the smart grid, energy independence, clean environment, and sustainable energy. In April 2010, IIT received US$5 million in funding from the DOE, for a total project dollar value of over US$12.6 million, to establish the IIT Smart Grid Education and Workforce Training Center and develop and deploy training programs on smart grid technology.

The State of Illinois is committed to pursuing a smarter, more secure, and more sustainable energy grid. With strong support from Governor Quinn, Illinois is leading the national effort toward developing the smart grid and is seeking to become the model for an effective federal-state-private partnership pursuing the goal of a greener economy. Supplementing the technical and strategic aspects of the IIT plan was the adoption of a collaborative approach that recognized the need for building a pipeline of future workers from every area of society, from kindergarteners to consumers, from union workers to veterans to corporate executives, and from community college to university students. The Center is designed to provide counseling, training, job placement, and retention of employment services to anyone who wants a career in the emerging sectors of the smart grid. The Center is employment focused and calculates its viability and success in one way: the number of persons who receive education, training, and credentials that lead to sustainable employment in smart grid-related areas.



The categories of education and training programs to be offered at the Center include:

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- ✔ preparing IT and telecom professionals to work in the smart grid field
- ✔ communicating the business case for the benefits of smart grid solutions to finance executives and senior management of utilities
- ✔ preparing linemen and utility operations supervisors to work with smart grid distribution and substation solutions
- ✔ demonstrating how distributed generation, renewable generation, and energy storage allow for demand-response reliability and cost savings
- ✔ integrating energy management systems for industrial and commercial properties into the smart grid
- ✔ preparing the utility call center to become a customer contact center that can leverage the information from the smart grid to support the end customer
- ✔ creating a utility program management office to manage a smart grid deployment
- ✔ creating a utility change management process to manage the change and transformation that will occur with the customers and utility when a smart grid is deployed
- ✔ funding and supplementing training programs for existing utility workers
- ✔ providing counseling, training, job placement, and retention of employment services to returning and recently discharged veterans
- ✔ working in close collaboration with labor union leadership to identify gaps in current training programs and to assist in developing training units that can be delivered by union trainers partially at union training facilities and partially through the IIT Smart Grid Education and Workforce Training Center.

Shortage of Engineering Students and Faculty

A report by the U.S. Power and Energy Engineering Workforce Collaborative estimates that there are 800–1,000 undergraduate students graduating each year with an interest in electric power engineering jobs and that the U.S. enrollment for master's and doctoral degree students in power engineering is approximately 550. Approximately 60% of graduate students are international students who may not seek employment in the United States. Electric utilities are predicted to require an estimated 7,000 new hires in power engineering over the next five years. After factoring in the workforce needs of other industries, the power engineering workforce requirement could easily be doubled to 14,000 over the same time frame. Although exact workforce needs can be difficult to project, doubling the number of graduating students over the next five to eight years is a reasonable estimate.

Recruiting, training, and hiring new engineers is complicated by the fact that over the next five years, approximately 45% of engineers in electric utilities will be eligible for retirement. That means that if those engineers must be replaced, there would be a need for more than 7,000 power

engineers by electric utilities alone, with an additional two or three times more power engineers needed to satisfy the needs of the entire growing market. Finally, additional faculty would be needed due to the increase in the number of power engineering students.

There is a growing concern in the United States about the supply of engineers, as there has been a noticeable decline in student interest in science and engineering careers over the past two decades. The number of undergraduate students earning engineering degrees has dropped from 85,000 per year in 1985 to 74,186 recently. This is cause for concern as undergraduate enrollment levels have begun to decline, and only 55% of students who enter engineering programs complete their degrees. These shortages can be addressed through an increased commitment to an intensive, sophisticated workforce development initiative.

The pipeline of students entering engineering disciplines is not large enough to support the urgent and immediate need. Published surveys by KEMA, Inc. indicate that most high school students are not well informed about engineering, and many have insufficient math and science skills to pursue an energy/engineering career. The industry has long-term needs that must be met with future engineers who are currently students in elementary schools. The IIT Smart Grid Education and Workforce Training Center is creating a coordinated effort to reach into the K–12 pipeline to educate teachers and counselors and to inspire students.

Stimulus Investments Drive Workforce Development Initiatives

Funding for smart grid programs supported by the American Recovery and Reinvestment Act of 2009 (ARRA) will modernize the U.S. electric energy system and will contribute to utility investments in the electric power sector. Projects funded through the stimulus are predicted to contribute to job creation, preservation, and economic recovery. These efforts are critical to achieving the nation's ambitions for renewable energy development, electric vehicle adoption, and energy efficiency improvements. Developments in the nation's grid infrastructure will require extensive workforce training. The nation's capability to manufacture new electrical equipment for smart grid implementation and to enhance the research and development needed to launch a national clean-energy mandate hinges on the successful establishment of a highly trained workforce that can support the changing electricity industry. Building and maintaining a highly skilled workforce numerically sufficient to keep pace with demand will be

challenging because of the large numbers of existing power industry workers scheduled for retirement in the next five years.

Collaborative Approach

In designing the organization of the Smart Grid Center, IIT created a policy of inclusion and collaboration. The Center will work closely with the IEEE Power & Energy Society, Argonne National Laboratory, power companies, and independent system operators throughout the country. Also included are other institutions of higher education and community colleges (both in the United States and abroad), agencies of the State of Illinois, associations for the promotion of green jobs, the U.S. military, boards of education, and labor union training organizations.

Those who will receive training through the Center will include members of the broad constituency of partners and stakeholders: power industry employees; union workers and apprentices; energy industry workers; individuals seeking new careers in energy and smart grid technologies; college, elementary, and high school students; high school teachers; government employees; veterans; lawyers; investors; venture capitalists and employees of financial institutions; entrepreneurs; consumers of electricity; and IT and telecom professionals.

Course Offerings

The Center has adopted a multilevel approach to provide smart grid training for employment in various industries. Three levels of training will be provided: fundamental, applied, and advanced. Fundamental training will focus on the concepts of electricity and power, the basics of the smart grid, and the preparation of necessary knowledge for higher level of training. This level will begin with fun and engaging learning units for K–12 students and will accelerate through the 48 community colleges all over Illinois. Applied training will focus on skills necessary to work in the smart grid industry. For those with relevant skills or experience, a layer of training in new energy efficiency and renewable energy skills (e.g., BPI certificated analyst training) will help to maintain existing employment or to transition to new jobs. For new entrants or individuals who face employment barriers, there are opportunities to learn new skills and acquire good jobs without a post-secondary degree (e.g., Illinois Home Weatherization Assistance Program). For small business owners and contractors, short-term energy-related certifications can open new doors (e.g., RESNET certified auditor training that IIT will co-offer in partnership with the Illinois community colleges). Advanced training will focus on individuals seeking a four-year or advanced degree in the smart grid.

The Center has adopted a multilevel approach to provide smart grid training for employment in various industries.

IIT, teaming up with Argonne National Laboratory and community colleges, will offer hands-on training using various existing resources. These include the IIT on-campus perfect power smart grid prototype project, the wind energy consortium project, the wind integration project, the advanced power system operation simulation software, the advanced dispatcher training system, and the distribution management system provided by AREVA.

The Center will also provide access to a wide range of educational opportunities scheduled at times, places, and in formats that fit students' availability and lifestyles—this includes students who live in rural areas as well as

military service people who are overseas. The Center will offer workshops, short courses, and national conferences for educating stakeholders on critical issues related to smart grid development, deployment, and maintenance. The Center will also provide career counseling, job placement, and retention of employment services.

The start date for smart grid curriculum development through the IIT Smart Grid Education and Workforce Training Center has already begun. In the Fall semester of 2010, two graduate-level smart grid and sustainable energy courses were offered, with development of others ongoing.

Assessment of Training Needs

IIT's assessment of needs for workforce training is based on stakeholder surveys as well as existing published data reported by educational institutions, interest groups, labor organizations, and government agencies. IIT's Smart Grid Education and Workforce Training Center is collaborating with leadership within its diverse group of stakeholders to identify the gaps between existing curriculum and training that will be required for the smart grid. Once these gaps have been defined, work will proceed to develop and deploy the appropriate curriculum. The task is to identify specific job classifications to be targeted for training and to understand skill deficiencies that need to be addressed through workforce improvement efforts.

Embracing the diversity of student needs is critical to the success of the program. For example, if a person who has a B.S. in engineering wishes to pursue a master of engineering smart grid degree, the course of study may take two years to complete. However, a person who is a corporate manager wishing to understand how fundamentals of the smart grid and the Illinois and national economies can increase business and international trade prospects may pursue training that might take only days to complete. Further, there is a large group of workers with engineering and electrical experience who will require short smart grid certification courses that build on their existing skills; this group includes labor union members and military veterans.

Community College-Level Courses on the Smart Grid

Community college members of the Center will collaborate with IIT to develop and offer certificate and pre-engineering courses on the smart grid to prepare students for transferring to IIT to complete a four-year degree program. The Center's philosophy maintains a strong focus on encouraging more American, women, and minority students to pursue engineering degrees and careers in energy efficiency and renewable energy.

This collaborative process will provide opportunities for community colleges

- ✔ to work with the Center in understanding the training needs of students
- ✔ to collaborate in creating curriculum and certificate programs
- ✔ to work with IIT to create 2 + 12 articulation programs to facilitate student transition to IIT to pursue a four-year or graduate degree program
- ✔ to collaborate in creating workshops and Webinars.

Labor Unions and Military Veterans

The Center will offer three-to-five day short courses on smart grid technologies, including delivering education programs tailored to meet the needs of corporate and labor union partners. Many of the jobs impacted by smart grid energy efficiency initiatives are occupations that have significant labor participation: electricians, carpenters, sheet metal workers, HVAC, and transportation workers. The Center enjoys the support of the major labor unions in the Midwest region as well as the umbrella organizations that represent them, including the AFL-CIO, the Chicago Federation of Labor, and the Chicago and Cook County Building and Construction Trades Council.

Through partnering with Illinois-based Operation Green Jobs and the

national Helmets to Hardhats program, IIT supports initiatives that connect National Guard, reserve, and transitioning active-duty military members with education, career training, and employment opportunities in the smart grid within the construction and engineering industries. As many of the military occupational specialties match well with civilian engineering and engineering technician positions, veterans make an ideal pool of smart grid candidates. This initiative includes partnerships with the International Brotherhood of Electrical Workers, Sheet Metal Workers Union, Service Employees International Union, the Teamsters, and the Helmets to Hardhats program.

The devastating economic effects of the current recession include historically high unemployment rates, especially for returning veterans in the 20–24-year-old age group whose unemployment rate reaches double the national average. These veterans are returning to the worst economy in decades, and many who are unable to find employment will choose to use their benefits to return to school. Through participating in the Yellow Ribbon Project, IIT recruits veterans who wish to pursue an engineering degree by providing tuition assistance that bridges the gap between what the G.I. Bill provided and the cost of IIT tuition. This amounts to thousands of dollars of tuition assistance per student and helps ensure veterans interested in smart grid training will have access to IIT programs. IIT will also offer flexible distance learning courses to service people who are currently deployed; this means that they can begin planning for civilian transition even before they return.

Training and Continuing Education for K–12 Students and Teachers

IIT has established a partnership with Chicago Public Schools (CPS) to train high school teachers via down-to-earth courses, workshops, and Webinars on the smart grid, plug-in hybrid cars, and sustainable energy topics. With more than 400,000 students in more than 600 elementary and high schools, CPS is the third largest school district in the country. The CPS student population is 91% minority, and over 75% live at or below the poverty threshold. One of the top priorities in CPS and the City of Chicago is to provide unique learning opportunities both inside and outside the classroom. To help CPS accomplish that goal, IIT, in partnership with Siemens Industry, Inc., hosts and supports an eight-week summer program for CPS students who are residents of the Chicago Housing Authority.

The innovative program includes intensive study in science, technology, engineering, and mathematics (STEM) subject matter that results in dramatic scholastic improvements for the participating students. IIT's rigorous and interdisciplinary approach to STEM education seeks to incorporate applied learning experiences and work-based learning opportunities. Curriculum focuses on training students in the smart grid and sustainability issues that prepare students to transition easily to post-secondary study at a community college or university and entry into the workforce. IIT has a long-standing partnership with CPS that includes bringing teachers and administrators to the IIT campus for coursework that includes the introduction of the most recent developments in engineering and technology.

As a continuation of IIT's relationship with CPS, IIT launched the Collens scholarship, an initiative that offers eligible CPS graduates the opportunity to attend IIT as a full-time student with full financial support for tuition, books, and fees. Since the program's launch at the end of the 2006 academic year, IIT has enrolled three classes of CPS graduates. Today, there are more than 70 Collens scholars on IIT's campus.

Stakeholder Outreach and Public Awareness

The ability to establish a successful national effort on the smart grid and

to provide technological and educational resources to accelerate smart grid development is contingent upon the supply of concise information to stakeholders. The public approval of such technology and the engagement of communities at large are a significant part of the development process. Extensive outreach and public awareness initiatives will be introduced by the Center including one- to two-day workshops for promoting public awareness and understanding. Each workshop will include key individuals from local, state, and federal governments; private sector employers; and community organizations to participate and discuss recent events and policy decisions on the smart grid at IIT and elsewhere. The workshops will provide a forum for individuals to educate the public on the benefits of the smart grid and the path to developing the smart grid in the United States and around the world.

Job Creation

Efforts at job creation for smart grid- related occupations in Illinois are dependent upon both the state and the national economies. Illinois faces both recessionary challenges as well as structural changes within its labor force. A precipitous drop in the percentage of workers in manufacturing and construction has been due to business restructuring and closures, although these changes reflect broad shifts across industries. These industries once provided good jobs and sustainable wages to large numbers of Illinois residents without postsecondary education. A plan to combat continued job losses must be one that encourages a more diverse workforce and that takes into account different education and unemployment patterns in different communities. The nascent but growing demand for skilled workers in new green jobs such as the smart grid will require an across-the-board increase in energy-engineering subject matter and specific competencies in renewable energy technology like the smart grid, wind, and solar. The IIT Smart Grid Education and Workforce Training Center is ready to educate students and to train workers in these emerging occupational areas.

A 2009 jobs report prepared by KEMA for the GridWise Alliance indicated that during the next four years, a potential disbursement of US$16 billion in smart grid incentives would act as a catalyst in driving associated smart grid projects worth US$64 billion nationwide. The impact of these projects would result in the direct creation of approximately 280,000 new positions. The KEMA report estimated that nearly 140,000 new direct jobs would persist beyond initial smart grid deployment as permanent, ongoing, high-value positions. According to the Illinois Department of Employment Security and the Federal Bureau of

Labor Statistics, a significant investment in the renewable energy segment could result in the creation of more than 650,000 jobs in ten years and more than 1.4 million jobs by 2025 nationwide.

The Center of American Progress and Political Economy Research Institute found that investments in a green recovery could reduce Illinois' unemployment rate by more than a percentage point. Such investments would create nearly 84,000 new jobs in energy efficiency, transit, smart grid, and renewable energy, with one-third of them targeting low-income and new labor-market entrants. The Renewable Energy Policy Project/Blue Green Alliance found that Illinois could gain 56,000 manufacturing jobs from investments in renewable energy projects between 2006 and 2016. The Illinois Department of Employment Security found that a comprehensive energy plan would generate green jobs in three ways: first by increasing the demand for green occupations, second by raising the green skill requirements for existing occupations (e.g., electrical engineers), and third by creating new occupations altogether (e.g., energy systems specialists). The U.S. Conference of Mayors Report found that Chicago would be the sixth largest beneficiary of green jobs (127,545 between 2006 and 2038) in renewable energy and fuel production.

> The need for smart grid workforce development has received international attention.

IIT—South Korea Partnership

The need for smart grid workforce development has received international attention. The Smart Grids Technology Action Plan, coauthored by Korea and Italy and released by the Major Economies Forum on Energy and Climate in December 2009, notes that an insufficiently skilled workforce is a barrier to smart grid development and deployment. The report comments that:

> At the technical level, new skills and knowledge are required over and above the engineering expertise typically applied to current electricity systems. With the supply of skills falling on one hand, and a huge program of investment in smart grid technologies required on the other, there is a shortfall of critical skills (engineering, business and finance, etc.) to design, plan, and build smart grids and to operate the new system.

In July 2010, the International Smart Grid Action Network (ISGAN) was launched to accelerate the development and deployment of smart electricity grids

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permanent magnets in rotating machines. The affects of saliency and permanent magnetism are addressed separately and jointly.

I would recommend this book for a student's first course on power systems. It is elegant in that it is concise and steeped in the development of applicable equations from the most general forms. This characteristic along with the sheer volume of material covered does not permit thoroughness in all cases.

This book discusses energy conversion, network steady-state analysis, and electric machine starting and operation. The topic of stopping electricity flow is omitted. As a suggestion for the next revision, a Chapter 16 could be added on the topic of circuit breakers. TRV is the major technical problem. Also, some discussion of what happens when the arc fails to extinguish could be included. Calculations from IEEE Std. 1584, *Guide for Performing Arc Flash Hazard Calculations,* could be introduced. Note that they are more heuristic than the information in Dr. Kirtley's text because they are empirical.

In conclusion, Dr. Kirtley's book is an excellent effort and a great addition to the literature.

—Nils E. Nilsson

the business scene *(continued from page 28)*

around the world. Participating governments include Australia, Belgium, Canada, China, the European Commission, France, India, Italy, Japan, Korea, Mexico, Norway, Russia, Sweden, the United Kingdom, and the United States. Workforce skills is one of the five key areas of engagement to be sponsored by ISGAN.

IIT's Smart Grid Education and Workforce Training Center, though based in Illinois, has international partnerships as well. For example, IIT was a partner to the launch of a significant public private partnership that includes the State of Illinois, the Korean Smart Grid Association, the Building Owners and Managers Association (BOMA), and the South Korean LG Electronics and KT Corporation. The project will develop a commercial smart grid pilot project that will sponsor the construction of a virtual generator that will use downtown Chicago buildings as electric grid resources.

IIT, in partnership with ADICA, will use the center training facilities to bring together industry professionals from around the world, functioning as an incubator for creating innovations in smart grid strategies, techniques, and education. In July 2010, IIT and ADICA established a partnership with the Korea Electrical Engineering and Science Research Institute to collaborate on the development of a smart grid workforce in the Republic of Korea and the State of Illinois and prepare individuals to quickly and efficiently develop and deploy smart grid technologies in Illinois. Global partnerships such as this will support international cooperation, foster the emergence of consistent international smart grid training standards, aid in Illinois job creation, and contribute to the long-term sustainability of the Center.

Conclusions

Whether driven by higher energy costs, concern for climate change, or the oil spill in the gulf, the national conversation is no longer a debate regarding whether the smart grid and renewable energy sources should be developed. Rather, the debate has shifted to how and, more importantly, how rapidly they can be implemented. With stimulus dollars available to fund projects and with aggressive renewable energy policy portfolio mandates in place, smart grid projects are being put in place all across the nation.

The development of the IIT Smart Grid Education and Workforce Training Center is well timed to fulfill its mandate of engaging utilities, corporations, labor unions, veterans, K–12 students and educators, and universities and community colleges in a collaborative initiative to train the strongest workforce in the world to meet the global challenges in the smart grid, energy independence, clean environment, and sustainable energy.

Biographies

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