

IEEE

Volume 9 • Number 1 • January/February 2011

# power & energy magazine

for electric power professionals

## Working Together

Illinois and Korea Collaborate  
on Smart Grid Technology



*Smart Grid Benefits*

Part of Economic Strategy

*Fun for All*

2010 Annual Meeting Highlights



Power & Energy Society®





## features

- 32 **Power of Two**  
*By Bruce Hamilton, Yeoung Jin Chae, Matthew Summy, Jordan Cutler, and David Kolata*
- 40 **A National Vision**  
*By Jinho Kim and Hong-Il Park*
- 50 **If These Walls Could Think**  
*By Mike Munson, Grant Jaskulski, and Chris Thomas*
- 56 **Plug into the Future**  
*By Joshua Milberg and Ann Schlenker*
- 66 **Local Green Teams**  
*By I.-K. Song, K.-D. Kim, J. Kelly, and C. Thomas*
- 75 **A Model of Stability**  
*By Jinho Kim and Jong-Hwan Lee*
- 82 **The Green Defenders**  
*By Jung-taek Seo and Cheolwon Lee*



## columns & departments

- 4 From the Editor
- 8 Leader's Corner
- 18 The Business Scene
- 29 Guest Editorial
- 92 Society News
- 97 Book Review
- 100 Calendar
- 104 In My View

# a smart grid partnership

## international efforts in Korea and Illinois

**S**MART GRID, A UBIQUITOUS AND globally used term, appears to be at the forefront of thoughts for the future. In the United States, the restructuring of the electrical grid to produce a system that offers efficiency, sustainability, and reduced greenhouse-gas emissions represents a great challenge as well as an opportunity for innovation, job creation, and economic productivity growth in coming decades.

The Republic of Korea was selected by the Major Economics Forum to partner with Italy in leading an international effort related to advancing smart grid technology. In 2010, a partnership between Korea and the State of Illinois was established to spearhead the collaborative efforts on aspects of smart grid technology such as demand response, electric vehicles, load control, and the integration of distributed generations and renewables. Our issue provides an in-depth look into many of these efforts, both in South Korea and in the United States (Illinois).

### In This Issue

Guest Editors Bruce Hamilton and Mohammad Shahidehpour have assembled seven feature articles for this issue that offer an overview of the joint project and an insight to the myriad of technological issues that play such a critical role in the application of the smart grid. These articles emanate both from South Korea as well as from the United States. As is our practice, I will defer to Bruce and Mohammad to introduce each of our feature articles in the “Guest Editorial,” but I will summarize them by title, author(s), and in order of their appearance:

- ✓ “Power of Two” by Bruce Hamilton, Yeoung Jin Chae, Matthew Summy, Jordan Cutler, and David Kolata
- ✓ “A National Vision” by Jinho Kim and Hong-II Park
- ✓ “If These Walls Could Think” by Mike Munson, Grant Jaskulski, and Chris Thomas
- ✓ “Plug into the Future” by Joshua Milberg and Ann Schlenker
- ✓ “Local Green Teams” by I.K. Song, K.D. Kim, J. Kelly, and C. Thomas



©FOTORESEARCH

Digital Object Identifier 10.1109/MPE.2010.939417  
Date of publication: 21 December 2010



**DELTA STAR**  
INCORPORATED

**Delta Star, Inc.**

Delta Star has been in the electrical manufacturing industry for over 100 years. Our century of expertise is built into every power transformer and mobile substation we produce.

Delta Star is the innovation leader in custom-engineered design. Each transformer is handmade by craftsmen who understand that quality has made Delta Star the choice for power companies around the world.

East Coast Operations 3550 Mayflower Drive Lynchburg, VA 24501 800.368.3017	West Coast Operations 270 Industrial Road San Carlos, CA 94070 800.892.8673
--	--

[www.DeltaStar.com](http://www.DeltaStar.com)

**WE WANT**

Share your thoughts about this magazine.

**TO HEAR**

Send an e-mail to [potentials@ieee.org](mailto:potentials@ieee.org).

**FROM YOU!**

Letters may be published in future issues and edited for style.

- ✓ “A Model of Stability” by Jinho Kim and Jong-Hwan Lee
- ✓ “The Green Defenders” by Jungtaek Seo and Cheolwon Lee.

### Smart Grid Training

Our issue’s “Business Scene” by Melissa Gordon and Mohammad Shahidepour of the Illinois Institute of Technology reviews the creation of the IIT Smart Grid Education and Workforce Training Center and the scope of its curriculum. The categories of education and training programs to be offered at the Center include the following:

- ✓ 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 with 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.

All in all, a complete business case is presented to the reader.

### Economics of the Smart Grid

The “In My View” column by Bruce Hamilton and Matthew Summy is titled “Benefits of the Smart Grid.” The summation of that column states, “The smart grid is a transformative set of technologies and business models. With mutually supportive private and public investment and with governmental policies that accommodate entrepreneurial smart grid innovations, we can grow our economy, create new high-paying jobs, and help protect our environment. The convergence of these diverse benefits represents an unparalleled opportunity for policy makers to advance an agenda based on research and development, on innovation, and on economic development. Through continued advancement of the Illinois Smart Grid Regional Innovation Cluster, the state is positioned to be a leader in the development and deployment of smart grid enabling strategies, services and technologies.” The column itself makes a compelling argument for each of the cited parameters.

### Farewell and Hail

The composition of our Editorial Board, as shown on the masthead page, has undergone some change. Leo Grigsby and John Paserba will be leaving the Board after having made significant contributions during their years of service. Joining us, beginning with this issue, are Lalit Goel (Singapore), Nikos Hatzigiorgiou (Greece), and Mark O’Malley (Ireland). They will not only provide technical expertise but also offer perspective from their areas of the world. With sincere thanks to Leo and John, we offer a hearty welcome to Lalit, Nikos, and Mark. 

# working together

## *international smart grid collaboration*

THE STATE OF ILLINOIS HAS received international recognition as an ideal partner for smart grid development and deployment. Global partners are attracted to the wide array of smart grid and renewable energy projects in Illinois and to the state's advanced research capabilities at national labs and universities. They want to develop and deploy emerging technologies in a part of the world that has a lucrative market conducive for smart grid implementation. International collaboration on smart grid solutions in Illinois is expected to stimulate economic development, reduce energy costs, improve electric grid reliability, and enhance environmental quality.

The Republic of Korea has also provided leadership in the area of the smart grid. In 2009, the Major Economies Forum (MEF) on Energy and Climate selected Korea to partner with Italy in spearheading international efforts regarding the advancement of smart grid technology. In consultation with MEF partners, the two countries prepared a technology action plan on smart grids, which stresses the importance of global collaboration to accelerate smart grid development and deployment.

In 2010, Illinois and Korea established a partnership to jointly develop and deploy smart grid and green technologies and business models. This issue of *IEEE Power & Energy Magazine* introduces the growing Illinois Smart Grid Regional Innovation Cluster and highlights how Illinois and Korea are

collaborating on market participation strategies for demand response, load control, electric vehicles, and integration of distributed and renewable energy resources.

The first article, "Power of Two," describes how a common desire to provide leadership amid the global push for a clean, reliable, and efficient supply of energy fostered the formation of partnerships and mutually beneficial cooperation between the United States and Korea. The Statement of Intent for smart grid collaboration signed by U.S. Department of Energy (DOE) Secretary Stephen Chu and Korea Ministry of Knowledge Economy (MKE) Minister Choi Kyunghwan, in April 2009, was a catalyst for focusing high-level government attention on the establishment of international public and private sector partnerships for the development, testing, and implementation of smart grid technologies.

In 2010, the MKE and the Illinois Department of Commerce and Economic Opportunity (DCEO) agreed to take actions for deploying smart grid-tested business models and technologies; conducting joint R&D in the development of smart grid and green technologies; and fostering information, technology, and human resource exchanges among government agencies, businesses, and research institutions. Four of the initial collaboration projects, announced in July 2010, are expected to provide more than US\$20 million of foreign investment to improve grid cybersecurity, develop technological infrastructure, deploy energy optimization solutions, and

create a workforce ready to develop next generation energy solutions.

The second article, "A National Vision," offers an overview of the national vision and development progress for the smart grid in Korea. To achieve a national goal of obtaining 30% reduction in greenhouse-gas emissions by 2020, Korea intends to build a national smart grid infrastructure as a fundamental enabler for expanding the supply of renewable energy and the use of electric vehicles. By 2030, a total of KRW 27.5 trillion (approximately US\$25 billion) of investment is expected to support smart grid implementation in Korea, with 90% secured through private investment and 10% through the government. The Korea Smart Grid Roadmap calls for a staged implementation with a smart grid test bed constructed at Jeju Island during 2010–2012, expansion into metropolitan areas from 2012 to 2020, and completion of a nationwide intelligent power grid by 2030.

The third article, "If These Walls Could Talk," discusses how emerging information-based technologies and operational strategies can enable large commercial and residential buildings in Chicago, and other major metropolitan cities, to mitigate rising energy costs through energy-efficiency improvements and participation in demand-response programs. The article explains how new revenue streams, accessed through this system without a noticeable impact on building tenants, can create benefits for consumers and society as a whole.

The fourth article, "Plug into the Future," highlights the important

role of electric vehicles as a building block for environmental sustainability and describes actions taken by the City of Chicago and Argonne National Laboratory to support the development of an electric vehicle marketplace. The authors note several factors that contribute to the Chicago region providing an excellent marketplace for electric vehicles, including a concentrated population, Chicago climate action plan goals for carbon reduction, a plentiful supply of inexpensive electricity from nuclear power, and support of the local utility as well as from the federal, state, and city government. The article goes on to discuss efforts led by the Chicago Department of Environment to work with key stakeholders in developing a strategy for vehicle electrification and implementing a first-phase infrastructure project to construct electric vehicle charging stations. The article also comments on the accomplishments that place Argonne National Laboratory at the forefront of applied research in hybrid and electric vehicles and led the DOE's Office of Vehicle Technologies to designate Argonne as the lead national laboratory for the simulation, validation, and laboratory evaluation of plug-in hybrid electric vehicles.

The fifth article, "Local Green Teams," provides an explanation of how smart grids offer new opportunities for local communities to support sustainability and economic development initiatives. The authors suggest that local microgrids can be used to create a new model for the generation, use, and delivery of electric power that is more efficient, sustainable, robust, flexible, and environmentally sound and that encourages a much higher level of consumer participation and control. The article points out that local communities in Illinois are seeking sustainable economic development approaches that offer real, lasting benefits to the local environ-

ment and improve the quality of life in the community. Together, Korea and Illinois are exploring shared opportunities for smart grid development and deployment that can support local community sustainability initiatives and bring the desired benefits to citizens of both countries.

The sixth article, "A Model of Stability," summarizes the long-term plan and current status to establish a smart infrastructure that enables stable operation of dispersed renewable generation sources. The Korea Smart Renewable Technology Roadmap is presented, including the envisioned timing for different stages of technology R&D, renewable device and system commercialization, and needed modifications to power system legislation. The current status of smart renewable develop-

ment in Korea is articulated through a description of several projects completed by a consortium led by the Korea Electric Power Corporation at the Jeju Island Smart Grid Test Bed.

The final article, "The Green Defenders," gives additional detail on potential cyberthreats to the electricity system, further vulnerabilities for new smart grid infrastructure, and efforts in Korea to introduce cybersecurity measures to identify and remove these threats. The authors introduce a smart grid security model that helps protect the smart grid from cyberattack by means of a multilevel architecture that implements different lines of defence for control system security, operation system security, and field device security.

p&e

## Call for Papers

10<sup>th</sup> International Workshop on  
**Large-Scale Integration of  
Wind Power into Power Systems  
as well as on  
Transmission Networks for  
Offshore Wind Power Plants**

**25 - 26 October 2011**  
**Aarhus, Denmark**



**ENERGINET/DK**

Plus Energinet.dk day

[www.windintegrationworkshop.org](http://www.windintegrationworkshop.org)

# Power of Two

## Illinois and South Korea: A Model Partnership for Smart Grid Collaboration

**Bruce Hamilton,  
Yeoung Jin Chae,  
Matthew Summy,  
Jordan Cutler,  
and David Kolata**

Digital Object Identifier 10.1109/MPE.2010.939160  
Date of publication: 21 December 2010

©PHOTODISC





**U**S. PRESIDENT BARACK OBAMA CAME to office with a commitment to act quickly and boldly in charting a new energy future that embraces alternative and renewable energy, ending the country's addiction to foreign oil, addressing the global climate crisis, and creating millions of new jobs in the clean-energy economy. Concurrently, on the other side of the globe South Korea President Lee Myung-bak unveiled what he called a "national strategy for green growth"—a new paradigm built on energy security, economic efficiency, and environmental protection. A common desire to provide leadership amid the global push to decarbonize has fostered the formation of partnerships and mutually beneficial cooperation between the two countries.

### **International Collaboration on Distributed Energy**

Several economic, reliability, and environmental factors make distributed energy resources (DER) an important option for managing energy prices, ensuring secure and reliable power, and reducing the need for additional power generation, transmission, and distribution equipment and infrastructure. DER have the ability to serve or manage on-site load and encompass distributed generation, demand response, and energy efficiency. In July 2008, the Korean government funded a three-year program of international collaboration on DER to be conducted by ADICA, LLC, in partnership with the Korea Power Exchange (KPX). ADICA is a global energy software and consulting company committed to empowering individuals, companies, and nations in the pursuit of sustainable development. Consistent with this goal, ADICA has organized projects to address energy-planning needs in Africa, Asia, the Caribbean, Europe, Latin America, and North America. The major objectives of the international collaboration program on DER are to:

- ✓ develop human resources in Korea for power planning and policy-making support in the area of DER
- ✓ facilitate KPX's cooperation and business relations with federal and regional organizations, research institutes, and universities renowned for the planning, analysis, and implementation of DER.

The activities carried out under the international collaboration program include arranging for Korean collaboration with the U.S. Federal Energy Regulatory Commission (FERC), Mid-Atlantic Distributed Resources Initiative (MADRI), PJM Interconnection, and Illinois Citizens Utility Board (CUB); reporting on the integration of DER

This globally connected public-private partnership between Illinois and Korea combines industry innovators, visionary government leadership, and sophisticated nongovernmental organizations.

into U.S. energy markets; and assessing demand response business models and the role of the independent system operator (ISO) in a smart grid environment. ADICA's Smart Market software was also applied to assess the impact of smart grid-enabled programs in Korea and the U.S. state of Illinois on consumer behavior, electricity prices, plant operations, generating company profits, and carbon emissions.

### **A United States–South Korea Smart Grid Collaboration**

In April 2009, ADICA facilitated the visit of a delegation led by the Korean Ministry of Knowledge Economy (MKE) to U.S. Department of Energy (DOE) headquarters, with the goal of discussing opportunities for smart grid collaboration. On this occasion, the Korean delegation presented a letter from Minister Choi Kyunghwan of the MKE to Secretary Stephen Chu of the DOE. The letter expressed Korea's desire to expand and promote bilateral cooperation in the areas of smart grid-related policy, technology standards, and R&D, along with enhanced cooperation in the private sector, including universities, research institutes, and companies. Two months later, during a summit meeting between Presidents Lee and Obama in Washington, D.C., Minister Choi and Secretary Chu signed a statement of intent for smart grid collaboration.

### **The Illinois-Korea Smart Grid Partnership**

The DOE-MKE agreement was a catalyst for focusing high-level government attention on the establishment of international public- and private-sector partnerships for the development, testing, and implementation of smart grid technologies. In November 2009, ADICA prepared a feasibility report titled "A Smart Grid and Green Technology Development Initiative Between the State of Illinois and Korea." In recommending Illinois as an ideal location and partner for smart grid development and deployment, ADICA noted the following key considerations:

- ✓ cutting-edge work being done at Illinois's world-class universities and federal laboratories
- ✓ Illinois's collaborative approach to the smart grid, which involves and engages communities across the state
- ✓ a wide array of smart grid and renewable-energy projects under way in the state
- ✓ supportive public policy, state and local governments, utilities, and consumers

- ✓ well-developed proposals for innovative smart grid implementation projects prepared for consideration of federal stimulus grant funding.

### **Cutting-Edge Smart Grid Research in Illinois**

The Argonne National Laboratory (ANL) is one of the DOE's largest national laboratories for science and engineering research. With more than 3,000 employees and an annual operating budget of around US\$630 million, ANL conducts cutting-edge research that seeks solutions to pressing national problems in the areas of energy, environmental systems, and national security. ANL is a recognized global leader in the development of transformational energy storage systems, alternative energy sources, and advanced power systems analytics. As the smart grid moves from concept to reality, ANL is helping to ensure this technology will interact seamlessly with the emergence of plug-in hybrid electric vehicles (PHEVs) through R&D in battery technology, "open" charging stations, vehicle instrumentation, data communication, customer behavior, and grid impacts.

Illinois Institute of Technology (IIT) is focused on enhancing the performance and security of the U.S. electric power infrastructure through a groundbreaking smart grid initiative known as the "perfect power" project. IIT partnered with the Galvin Electricity Initiative and the DOE, in collaboration with S&C Electric, Endurant Energy, and ComEd (Commonwealth Edison), to develop a perfect power system design for IIT's main campus. IIT wants this project to establish the institute as the undisputed leader in microgrid demonstration. In addition, IIT has signed a memorandum of understanding (MOU) with KPX regarding collaboration on graduate-level training on electricity markets.

Northwestern University (NU), with more than US\$475 million in sponsored research, often partners with ANL, Fermilab, and local universities to solve society's problems and facilitate commercial use of their innovations. In the university's economics department, research focuses on regulation, restructuring, retail competition, and technological change in the electricity industry. Experimental economic research in electricity markets investigates the impact of market design and regulatory policy. Research results are communicated to policy makers to enhance their understanding of market processes in energy industries.

The University of Chicago (UC) is one of the world's preeminent research universities. It is home to internationally renowned scholars, researchers, and intellectual pioneers. In

## The Korean and Illinois PMOs have communicated weekly since January and have held a number of face-to-face meetings.

the last century, UC produced more than 70 Nobel laureates. As one of six professional schools at UC, the Harris School of Public Policy Studies strives to understand and influence public policies by conducting policy-relevant research and preparing talented individuals to become leaders and agents of social change.

The University of Illinois at Urbana-Champaign (UIUC) is one of the largest research institutions in the world. Researchers in UIUC's Department of Electrical and Computer Engineering (ECE) collaborate with industry, government, and peer institutions in the search for solutions on a broad array of projects. Specific areas of interest include the dynamics and stability of power systems, energy and power system economics, and power system computational and visualization techniques. The Information Trust Institute (ITI), also based at UIUC, provides international leadership combining research and education with industrial outreach in trustworthy and secure information systems, including the electrical grid. ITI is home to the DOE-funded Trustworthy Cyber Infrastructure for the Power Grid project.

### Illinois's Collaborative Approach to the Smart Grid

Smart grid development efforts in Illinois began in 2008 when the Center for Neighborhood Technologies (CNT) formed the Illinois Smart Grid Initiative (ISGI), a public-private working group chaired by Chicago Mayor Richard M. Daley and former speaker of the U.S. House of Representatives J. Dennis Hastert. The purpose of the ISGI was to engage Illinoisans in an examination of the nature and potential benefits of a modernized electric grid and to map a policy path for achieving those benefits for consumers and the economy. The ISGI held a series of roundtable meetings featuring presentations and discussions about the smart grid concept and subsequently focused on public policy formulation. A final report was issued in April 2009.

The utility regulator, the Illinois Commerce Commission (ICC), then ordered the establishment of collaborative smart grid efforts in Illinois. The ICC evaluated a smart grid deployment proposal made by ComEd and based on a proposal made by the CUB and determined that the public interest could best be served by developing pilots and strategic plans for smart grid deployment in Illinois collaboratively. Two specific efforts were initiated. The first was a series of workshops evaluating advanced metering infrastructure (AMI) and tasked with developing AMI project goals, timelines, and evaluation criteria. The workshops resulted in an AMI pilot project with approximately 131,000 smart meters

operating in ComEd's service territory during 2010. The second effort was the more comprehensive Illinois State-wide Smart Grid Collaborative (SSGC), whose purpose was to consider the potential costs and benefits of smart grid implementation and develop a strategic plan for such implementation. The ICC developed the following policy objectives for the SSGC to evaluate and report on before the end of 2010:

- ✓ definition of a smart grid and its functionalities
- ✓ principles Illinois should use to guide smart grid planning and deployment—for example, interoperability, open architecture, and nondiscriminatory access
- ✓ uniform standards
- ✓ methods of estimating, calculating, and assessing benefits and costs, including evaluation of nonquantifiable benefits (and costs), and implications of smart grid technology for future policies regarding rate design, consumer protection, and customer choice
- ✓ the effect of statutory renewable resource, demand response, and energy efficiency goals on smart grid planning and implementation
- ✓ consumer education and dissemination of information about smart grid technologies, demand response programs, and alternative rate structures
- ✓ access by electricity market participants to smart grid functionalities
- ✓ data collection, storage, management, security, and availability to third parties
- ✓ standards for interconnection of third-party equipment
- ✓ mechanisms for flowing any utility smart grid revenues through to customers
- ✓ adoption of new demand response programs
- ✓ open architecture and interoperability standards for technological connectivity to the regional transmission organization (RTO) and/or independent system operator (ISO) to which a utility may belong.

### Federal Stimulus Funding

The American Recovery and Reinvestment Act of 2009 (ARRA) included two DOE grant programs directed to stimulate the deployment of smart grid development and deployment in the United States. A US\$3.375 billion Smart Grid Investment Grant program (SGIG) provides matching grants of up to 50% for investments planned by electric utilities and other entities to deploy smart grid technologies. In addition, a US\$615 million smart grid

demonstration grant program provides funding for smart grid demonstration projects that demonstrate regional benefits, utility-scale energy storage technologies, and grid-monitoring capabilities. Some of the grant project proposals submitted by organizations in Illinois following the enactment of ARRA are discussed below.

### **ComEd**

ComEd submitted a proposal for US\$175 million to support a comprehensive project involving customer systems, AMI, electric distribution systems, and electric transmission systems. The proposed project would complement the ComEd AMI pilot with the following additional investments:

- ✓ the installation of an additional 120,000 AMI meters to complete deployment of meters throughout the Maywood operating center
- ✓ the installation of 19,000 advanced two-way air conditioning control switches capable of communicating with the AMI meters
- ✓ the installation of 2,000 advanced meters as part of a joint project with the Building Owners and Managers Association of Chicago (BOMA/Chicago) to test the ability of large office buildings to aggregate demand response
- ✓ the installation of 59,000 AMI meters in two Chicago communities that would be integrated with available energy-efficiency services and associated environmental initiatives in those communities permitting the demonstration of the smart grid's ability to advance community climate action and economic development strategies
- ✓ the deployment of up to 50,000 in-home devices in residences in these two Chicago communities
- ✓ the deployment of a full suite of smart grid technologies, including 700 distribution automation switches, four intelligent substations, the installation of dynamic voltage management and conservation voltage reduction (CVR) technology in two of the substations, a fiber ring, and a supervisory control and

data acquisition (SCADA) core network upgrade to provide a template for the future rollout of the smart grid throughout the ComEd service territory.

### **BOMA/Chicago**

BOMA/Chicago, a trade association for the commercial real estate industry in Chicago, proposed the first commercial office building smart grid program in the United States. BOMA/Chicago applied for US\$92.7 million in SGIG matching funds for a 30-month, US\$185.4 million project designed to retrofit buildings to participate fully in energy markets. The installation of devices such as variable-frequency drives, the updating of building automation systems, and the creation of a network operations center would let buildings optimize their operations by means of price signals in the capacity, energy, and ancillary services markets operated by PJM interconnection, the RTO for the Chicago area. The initial proposal was for 50 buildings in downtown Chicago, including the Hancock Center, the Aon building, and the Willis Tower (formerly the Sears Tower).

### **IIT and UIUC**

IIT and UIUC jointly applied for a US\$60 million demonstration project grant to help finance a proposed US\$120 million statewide project. Their joint plan was (and remains) making Illinois an international center for innovation, validation, deployment, and evaluation of new smart grid technologies. IIT led the initial proposal effort with UIUC; other participants included the State of Illinois, the City of Chicago, the Village of Oak Park, the Galvin Electricity Initiative, ComEd, Ameren, and more than 50 private companies. The four primary components of the project are:

- ✓ IIT's perfect power system, which is to be a complete, reproducible, and scalable demonstration of a reliable microgrid



**figure 1.** The Korean delegation visit to Illinois in January 2010 with executives from industry giants KEPCO, KT, LG Electronics, SK, and LG Chemical along with senior officials from MKE, KOTRA, KSGA, KSGI, KDN, and KERI.



figure 2. Signing of the MOU in Seoul, Korea, on 20 January 2010.

- ✓ Oak Park's community demonstration project, which would showcase the technological, financial, and policy investments communities can make right now, including smart metering infrastructure
- ✓ IIT's Smart Grid Demonstration Center, a comprehensive technology development, demonstration, and evaluation program for smart grid technologies that would let companies hook up to an existing smart grid and accelerate development of their own technologies and services
- ✓ UIUC's Smart Grid Validation Facility, which would be an incubator, research center, and test bed for companies that want to evaluate their smart grid technologies in terms of cybersecurity and interoperability standards before implementation.

On 27 October 2009, the IIT/UIUC projects were denied funding under ARRA, creating an opportunity for supplemental funding from alternative sources within the United States and abroad. However, each university has since been able to advance elements of its proposals through other funding sources, including support from the State of Illinois.

### Illinois: A Growing Center for Smart Grid Development and Deployment

Over the last two years, more than US\$500 million has been captured in the state for energy efficiency or green development, including nearly US\$120 million in smart grid R&D and demonstration projects in 2009 and 2010, highlighted by:

- ✓ US\$25 million to the Chicago Metropolitan Agency for Planning and the City of Chicago for design and execution of an energy-efficiency retrofit program
- ✓ US\$24 million in ARRA funds awarded to Beacon Power Corporation to construct a 20-MW flywheel energy storage plant in Chicago
- ✓ US\$18.8 million over five years to the ITI at UIUC by the DOE to extend its Trustworthy Cyber Infrastructure for the Power Grid initiative

- ✓ US\$12.6 million including US\$5 million in ARRA funds and US\$2.5 million in state funds, to IIT to establish a Smart Grid Education and Workforce Training Center (the largest university award in the ARRA project category)
- ✓ US\$11 million in ARRA funds to Naperville, Illinois, for AMI installation
- ✓ US\$8.8 million to ANL for advanced battery and energy storage R&D, setting the stage for mass electric vehicle adoption
- ✓ US\$5.1 million in ARRA funds to S&C Electric for a distributed generation project.

### Illinois-Korea Smart Grid Collaboration MOU

In December 2009, Minister Choi of the MKE and Governor Pat Quinn of Illinois entered into a dialogue concerning opportunities for mutually beneficial collaboration on smart grid and green technology. While noting that Korea is on the leading edge of smart grid technology development and Illinois is a top-tier state in making advancements in smart grid implementation, Minister Choi proposed that the two form a sustainable business alliance for the developing, testing, and deploying of smart grid and green technology to establish a world model for collaborative practices.

Governor Quinn noted that Illinois and Korea have a long history of collaboration and are united by a strong desire to solve the problems of the 21st century. Illinois's renowned universities—in partnership with the state, local governments, and utilities—have already launched innovative projects to demonstrate, test, and improve smart grid technologies. Implementing a smart grid throughout the state would help create jobs and ensure that Illinois families and businesses have access to technology that can lower their energy consumption and energy costs while yielding significant environmental benefits. Governor Quinn proposed a meeting of representatives from Korea and Illinois to



**figure 3.** MOU signing in Chicago, on 21 July 2010, by ISTC CEO Matthew Summy and KETEP President Jung Hyun Lee.

discuss how to move forward with a partnership on these important issues.

In early January 2010, a delegation of approximately 20 Korean business leaders and government officials met with officials in Illinois to explore opportunities for collaboration (see Figure 1). Based on the success of these meetings, a delegation from Illinois, led by Illinois Department of Commerce and Economic Opportunity (DCEO) Director Warren Ribley, attended the World Smart Grid Forum in Seoul where, on 20 January 2010, a memorandum of understanding was signed between Korea and Illinois agreeing to cooperate on smart grid and green technology development and deployment (see Figure 2). Minister Choi Kyunghwan of the MKE and DCEO Director Warren Ribley signed the MOU, pledging to take actions to deploy smart grid–tested business models and technologies, conduct joint R&D in the development of smart grid and green technologies, and foster information, technology, and human resource exchanges among government agencies, businesses, and research institutions.

Korean and Illinois businesses are expected to develop effective partnerships for pursuing emerging markets that include demand response, electric vehicles, energy management, and advanced battery technology. “With the MOU, South Korea gained a foothold in the giant U.S. energy grid sector, while giving Illinois a chance to attract business investments and create jobs,” a ministry official was quoted as saying by Korea’s Yonhap News Agency.

## Collaboration Counterparts and Timeline

A Smart Grid and Green Economy Committee (SGGEC) has been established to direct and supervise the cooperation, with Korea and Illinois each designating representatives to serve in a program management office (PMO) capacity. MKE appointed the Korea Smart Grid Institute (KSGI) to lead the Korean PMO, and DCEO appointed the Illinois Science & Technology Coalition (ISTC) to lead the Illinois PMO. KSGI is a government agency, established in 2009 to contribute to the implementation of Korea’s green-growth, low-carbon initiative by comprehensively managing the government’s smart grid road map, operating a smart grid test bed, and extending other policy support for smart grid–related issues. ISTC is a nonprofit organization committed to cultivating economic development in Illinois by fostering public-private partnerships to develop and execute R&D projects, advocating for R&D funding initiatives, and collaborating with public and private partners to attract and retain R&D resources and talent in Illinois. Other Korean partners in the collaboration include the Korea Smart Grid Association (KSGA), Korea Business Center Chicago of the Korea Trade-Investment Promotion Agency (KOTRA), and Deloitte-Korea. In Illinois, partners include the State of Illinois, Illinois DCEO, Chicago Department of Environment, CUB, ADICA, University of Illinois, IIT, Illinois Commerce Commission, BOMA/Chicago, Metropolitan Energy, Holland & Knight LLP, and TechAmerica Midwest, among others.

## Collaboration Activities

The Korean and Illinois PMOs have communicated weekly since January and have held a number of face-to-face meetings. Face-to-face meetings were held in April, May, and June of 2010. These meetings gave partners from Korea and Illinois the opportunity to develop a set of initial, or phase 1, collaborative projects that will further the goals established by the MOU.

In July 2010, Minister Kyunghwan Choi of the MKE led a delegation of nearly 50 Korean business and government leaders to Illinois. Meetings were held with leaders from multiple Illinois smart grid–related industries, including utilities and electric vehicles, as well as with Illinois Governor Pat Quinn and Chicago Mayor Richard Daley. The purpose of the visit was to announce MOUs to formalize several phase 1 projects (see Figures 3 and



**figure 4.** Illinois DCEO Director Ribley presents memento of productive collaboration to Minister Choi of the MKE on 21 July 2010.

4). Four of the initial projects are expected to provide more than US\$20 million to improve grid cybersecurity, develop technological infrastructure, deploy energy optimization solutions, and create a workforce ready to develop next-generation energy solutions. At a networking dinner with more than 120 government and industry leaders (see Figure 5), the following projects were announced:



**figure 5.** Illinois governor Pat Quinn addresses more than 120 government and industry leaders involved in the Illinois-Korea Smart Grid Initiative.

- ✓ **Cybersecurity and grid trustworthiness:** UIUC's ITI will partner with the Korean National Security Research Institute on R&D initiatives to improve cyber- and grid security and network resiliency.
- ✓ **Global workforce training and development:** IIT and ADICA will build out professional training and development programs in this sector to solidify Illinois as a hotbed for education and training opportunities in the smart grid sector. Through a global partnership with the Korea Electrical Engineering and Science Research Institute, this center will bring industry professionals from around the world to IIT to develop new strategies and techniques for business innovations that will result from the deployment of a smart grid.
- ✓ **Illinois Smart Buildings Initiative (ISBI):** Supported by BOMA/Chicago and CUB, this project will include deep energy audits on Loop-area high-rises in order to set up a multibuilding regulation services and energy-efficiency project. By installing new technologies to network buildings and enable smart grid strategies—such as demand response and variable operations of building systems—large properties like the AON Center can optimize their energy usage to reduce costs by hundreds of thousands of U.S. dollars per year and decrease their carbon footprint. This project has support from the KSGA, Korea Telecom, and LG Electronics.
- ✓ **Building energy management systems and DER integration:** IIT will sign two agreements to conduct R&D to improve building energy management systems, develop distribution automation strategies, integrate renewable energy sources and energy storage technologies into the smart grid, and increase power systems reliability. KSGI and the Korea Electrotechnology Research Institute are supporting these projects.

Following these announcements and MOU signings, partners from Korea and Illinois have worked to develop contractual business arrangements that will formalize their

relationships and create lasting partnerships. To date this work is still ongoing, and project teams and engineers from Korea visited Chicago during the months of August and September 2010. The purpose of these visits was to continue the process of refining project scopes and to gather further information about the collaborative opportunities the partners are developing. In addition, as the phase 1 projects are being initiated, the partners have begun the identification and development of potential phase 2 projects.

### Illinois-Korea Collaboration Results

This globally connected public-private partnership between Illinois and Korea combines industry innovators, visionary government leadership, and sophisticated nongovernmental organizations working together to produce smart grid clusters in Illinois and South Korea that will yield economic development, create jobs, and accelerate product development.

In November 2010, during the G-20 summit in Korea, an event titled Korea Smart Grid Week was held on Jeju Island to execute documents to transition MOUs into contracts and establish a sister-state agreement between the Jeju Special Self-Governing Province and the State of Illinois.

In addition, the development and execution of phase 1 projects represent an important milestone in this unique collaboration. Discussions are ongoing, and the partners have begun to identify a number of other opportunities for future collaboration. Additional project opportunities are being evaluated in the areas of smart buildings, smart transportation, smart communities, and R&D. Dignitaries in Illinois and South Korea affirm the mutual benefits of this model partnership for smart grid collaboration. Additional information is available at [www.smartgrid.or.kr](http://www.smartgrid.or.kr) and [www.adica.com](http://www.adica.com).

### Acknowledgments

The authors would like to express their appreciation to the KSGA, ISTC, and IIT for granting permission for the use of their photographs.

### Biographies

*Bruce Hamilton* is with ADICA, LLC.

*Yeoung Jin Chae* is with KPX.

*Matthew Summy* is with the ISTC.

*Jordan Berman-Cutler* is with the ISTC.

*David Kolata* is with CUB.



# benefits of the smart grid

## part of a long-term economic strategy

**THE SMART GRID IS NOT JUST A** new form of infrastructure; it can be part of our long-term economic strategy. In addition to stimulating economic activity directly through significant new capital investment for its design, development, and construction, follow-on innovations using this powerful enabling technology are expected to multiply its short-term economic impacts.

It will take time, both public and private resources, and coordinated economic policies to achieve the anticipated benefits of smart grid development and deployment. But the emergence of this transformational technology at a moment calling for a dramatic restructuring of America's energy economy and environmental policies provides a once-in-a-generation opportunity to grow our economy, foster business opportunities, and generate jobs while advancing societal imperatives. Illinois has seized this opportunity. Among other efforts, we in Illinois formed a public-private partnership to help position our communities, corporations, universities, and laboratories to leverage the opportunities of this infrastructure transformation.

This public-private partnership has laid the foundation for a growing Illinois Smart Grid Regional Innovation Cluster that brings together the talent, resources, and ambition required to define, develop, and advance smart grid-enabling strategies. In this approach, research and development conducted across multiple disciplines by Illinois's renowned laboratories and universities

are clustered and focused on market-changing solutions, entrepreneurs and businesses are encouraged and supported to commercialize these innovative technologies, and programs are implemented to match a well-trained and highly skilled workforce with the installation and management needs of a smarter grid and of the innovative businesses built using that platform.

This effort is facilitated by the convergence of diverse economic and political forces that recognize the smart grid as a viable path to achieving environmental benefits, creating new business opportunities, and growing the Illinois and national economies. Realizing the promise of the smart grid will, however, require additional preparation to identify investment tools needed to spur new enterprises utilizing smart grid capabilities, implement economic and regulatory policies to accommodate new smart grid business models, and encourage informed customer participation.

### Market Potential

A smart grid and the new services it can enable will require (and attract) substantial capital, especially for early adopters and innovators. Industry reports project the market for smart grid enabling technologies in the United States to increase to US\$17 billion per year by 2014, up from an estimated US\$6 billion currently. Globally, the market for smart grid technologies is expected to grow to US\$171 billion by 2014, up from US\$70 billion today.

Direct investment in the smart grid and related new businesses can grow

our economy. Based on an industry jobs report, each US\$1 billion invested in smart grid technology is projected to propel US\$100 billion in gross domestic product growth. Greater consumer control over power consumption could add US\$5–7 billion annually to the United States by 2015 and US\$15–20 billion per year by 2020. The Galvin Electricity Initiative notes that distributed generation technologies (electricity produced at or near the site where it will be used) and smart, interactive storage for residential and small commercial applications could potentially add another US\$10 billion per year if 10% penetration is achieved by 2020.

Technology investments of this magnitude can reasonably be expected to result in increased job creation globally, nationally, and locally. To the extent that Illinois' technology firms are early entrants in manufacturing and construction/installation, that economic activity can be localized. Analysts note that the value creation associated with the smart grid's "green" capabilities can outpace more traditional energy investments. For example, clean-energy investments are estimated to result in 16.7 jobs for every US\$1 million in spending, while spending on fossil fuels is estimated to generate 5.3 jobs per US\$1 million in spending.

### Environmental Benefits of the Smart Grid

Aside from the economic gains from added investment and customer benefits, the integration of smart grid

*(continued on page 101)*

capabilities into the grid and consumer management of energy consumption is expected to produce environmental benefits. Environmental advocates, therefore, can be key elements of support for the emerging Illinois Smart Grid Regional Innovation Cluster.

Coupled with plentiful renewable energy resources in Illinois, the smart grid can dramatically advance our efforts to combat climate change. A recent U.S. Department of Energy report suggests that 100% penetration of smart grid technology in the United States could lead to an 18% reduction in carbon dioxide emissions by 2030. It has been estimated that if the electrical grid were simply 5% more efficient, the efficiency gain could displace the equivalent of 42 coal-fired power plants, and that would equate to permanently eliminating the fuel and green house gas emissions of 53 million cars.

In the United States, buildings account for an estimated 72% of U.S. electricity consumption and 38% of all U.S. carbon dioxide emissions. LEED certification is awarded by the U.S. Green Building Council for new buildings constructed to have less impact on the environment. Chicago is home to more LEED-certified buildings than any other city and is leading the efforts to reduce building energy usage. The smart grid can bring the energy management sophistication of Chicago's leading-edge buildings to small businesses and residences. The potential environmental benefits also could be accompanied by direct economic value if/when a price for carbon is established. The smart grid would enable timely, accurate measurement of usage reductions (carbon output requirements), which (once monetized as credits) can be bought, sold, or traded creating new revenue streams for consumers, building owners, and local governments. If small business and residential consumers are effectively engaged in managing their energy using smart grid capabilities, the eco-

nomics provided by its real-time communications and usage/pricing data could further realization of environmental benefits.

### **Illinois and Korea: Working Together to be Market Leaders**

Smart grid interest and potential is global. Just as in the domestic market, those who act first and meet the standards and needs of multiple markets will be positioned to capture market share. With this in mind, the State of Illinois and the Republic of Korea have entered a partnership to foster the development of strategies and projects that can be deployed in both environments. To date, this work has been managed through four channels:

- ✓ policy and business model development
- ✓ research and development
- ✓ technology deployment
- ✓ workforce development.

Each area is briefly described below.

#### **Policy and Business Model Development**

The ongoing collaboration between Illinois and Korea has helped to refine policy makers' understanding of the smart grid and what is required to advance its potential. Senior leaders in both governments have begun the process of considering how best to accommodate this paradigm-changing technology. The experiences and results of already initiated demonstration and pilot programs in Illinois and Korea will guide future policy decisions.

Our adoption and integration of new smart grid technologies and capabilities will enable new, innovative business models. For these models to succeed we must support economic policies and industry structures that allow manufacturers of smart grid enabled technologies, providers of new smart grid-enabled services, and electricity consumers themselves to become active participants in expanded markets. Illinois and Korea are collab-

orating in evaluations of market participation strategies for demand response, load control, load shifting, and integration of distributed and renewable resources to expand market participation and markets.

#### **Research and Development**

The continual assessment of changing technology and market needs and application of our intellectual capital to meeting those needs is a central strategy in optimizing the economic benefits of smart grid deployment. Illinois is home to a number of outstanding public and private universities, federal laboratories, and corporations. This expertise, particularly in the areas of electric power systems and cybersecurity, must be leveraged. Advanced research and close industry-academia-government collaboration are areas in which Illinois and Korea can be driving forces in the development and deployment of the smart grid. Illinois and Korea are working collaboratively to establish timely and effective technology transition pathways for commercializing validated innovative technologies.

#### **Technology Deployment**

To date, this Illinois-Korea collaboration has focused its joint efforts on three areas that promise immediate market impact: smart buildings, smart communities, and smart transportation.

##### **Smart Buildings**

Because metropolitan areas like Chicago cannot accommodate significant new local generation, they may see less electricity price stability as peak demand increases over the long term. Driven both by new smart grid capabilities and governmental directives, the need for additional generation resources will likely increasingly be met by integrating intermittent renewable generation resources like wind and solar, resulting in added difficulties for maintaining system balance moment

to moment. Using the smart grid's real-time data and communications, the vulnerability of concentrated metropolitan loads can become an economic opportunity. Smart building technology can be used to reduce one's own consumption when prices spike. That same capability, coupled with smart grid communications, can provide valuable peak-load reduction to balance demand and capacity at times of system stress. These capabilities represent a significant opportunity for buildings to reduce the payback period for energy-efficiency improvements and to capture the market value of real-time load management in the demand- and supply-side markets.

#### Smart Communities

Illinois communities are interested in sustainable economic development that promises lasting benefits to the local environment and improved quality of life in the community. Tailored community-wide initiatives that focus on resource conservation and energy usage awareness can help local governments and their citizens manage energy costs, strengthening the local economy and creating local jobs, and they can help reduce the production of emissions harmful to the community and to society in general.

Our contemplated smart community efforts seek to identify and test models that deliver technology and knowledge to end users in a way that effectively engages energy consumers in leveraging the technology (to manage energy consumption) and reduce the economic burdens of inefficient usage on communities and the grid. These technologies and knowledge delivery techniques are still developing and emerging. A smart community test will be useful in identifying new business models and financing options for larger scale future initiatives. These community goals suggest that local microgrids can be a model that is more efficient, sustainable, and environmentally sound. Electricity usage and

delivery optimized at the microgrid level can enable greater consumer participation in energy management and result in the more robust and sustainable generation, delivery, and consumption of electricity.

#### Smart Transportation

As electric vehicles enter the automobile market, Illinois must position itself to be an early adopter and test site for these vehicles. This will require market-making efforts. Utility infrastructure, rate structures, and regulation should facilitate the necessary financial transactions between electricity distributors and these mobile consumers. A major concern of potential electric vehicle users is "range anxiety." To advance the region-wide deployment of needed charging facilities, the State of Illinois and City of Chicago have recently joined together to fund a north-east Illinois regional electric vehicle infrastructure pilot. The objective of that effort is to establish Illinois as a welcoming location for electric vehicle deployment and to improve the region's standing as a target location for manufacturers seeking early market success and consumer adoption.

#### Workforce Development

Current and future market opportunities will pass us by without the necessary trained workforce to manage and support the smart grid. Producing and maintaining a highly skilled workforce that can keep pace with the evolving demands of the smart grid and related businesses/technologies will be challenging as large numbers of power industry workers are expected to retire in the next five years. Fostering the next generation of entrepreneurs and technicians must be a focus of any comprehensive smart grid plan.

A well-trained and highly skilled smart grid workforce also is vital to maintaining our leading edge position in the research, development, and implementation of a smart grid, the value-added innovations using that

platform, and the integration of renewable energy resources that will feed into it. A successful workforce deployment and development program must engage all stakeholders in Illinois education and career training—from utilities, corporations, and labor unions to educators, community colleges, and universities to the national laboratories, legislators, and policy makers. The objective should be a collaborative initiative to establish the strongest smart grid workforce in the world. This will require enhancing existing science, technology, engineering, and mathematics (STEM) curricula to build a pipeline of students and workers beginning with early childhood education and continuing through elementary, high school, and post-secondary education or trade training. Only with such a combined effort will Illinois be able to meet the global challenges in the smart grid, energy independence, clean environment, and sustainable energy.

### The Smart Grid as an Economic Development Tool

The smart grid is a transformative set of technologies and business models. With mutually supportive private and public investment and with governmental policies that accommodate entrepreneurial smart grid innovations, we can grow our economy, create new high-paying jobs, and help protect our environment. The convergence of these diverse benefits represents an unparalleled opportunity for policy makers to advance an agenda based on research and development, on innovation, and on economic development. Through continued advancement of the Illinois Smart Grid Regional Innovation Cluster, the state is positioned to be a leader in the development and deployment of smart grid enabling strategies, services and technologies. Additional information is available at [www.adica.com](http://www.adica.com) and [www.istcoalition.org](http://www.istcoalition.org).

