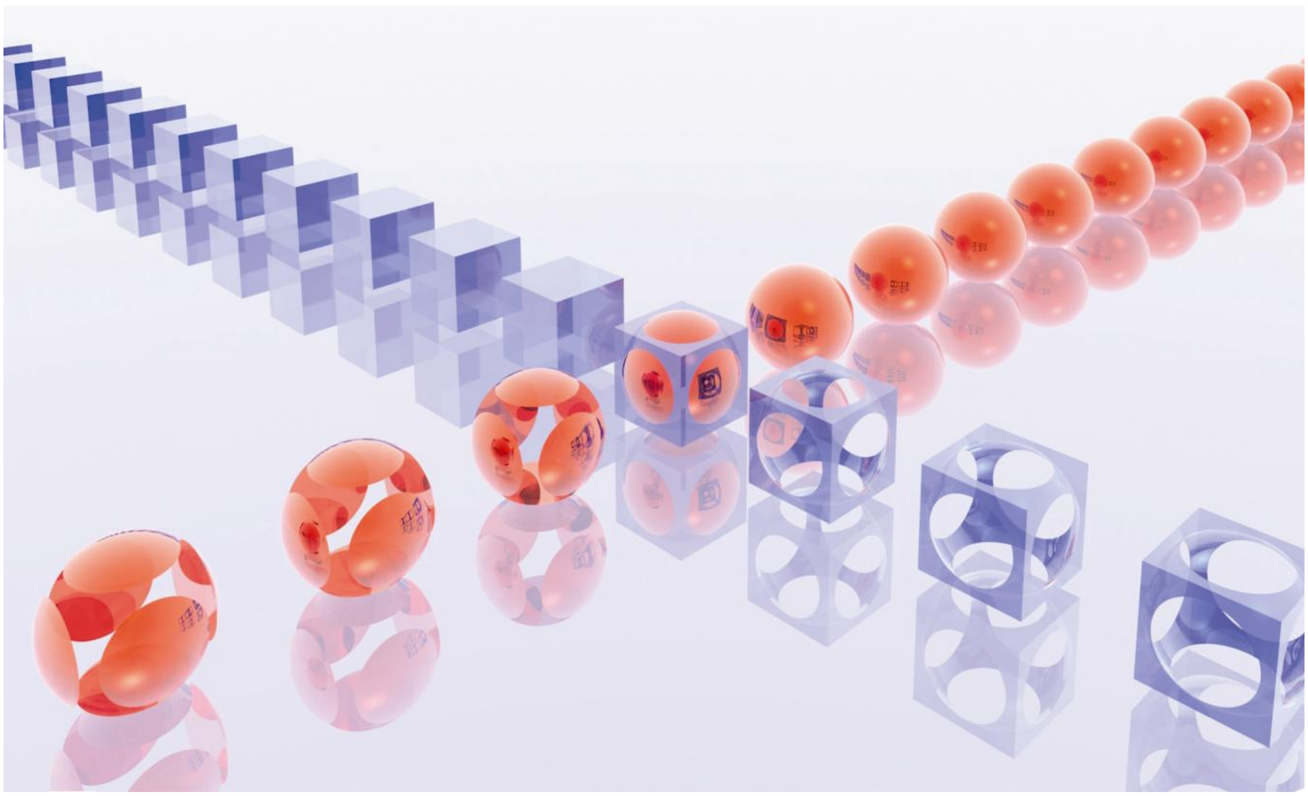
The U.S. Smart Grid Revolution

Smart Grid Workforce Trends 2011



Prepared by KEMA for
The GridWise Alliance
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1. Executive Summary

The future of smart grid continues to be very strong. Investment continues to flow into businesses active in the smart grid sector, driving innovation, job creation and significant change. Utilities are moving from the planning to the deployment stage of smart grid and budgets to support those efforts are on the rise. (Microsoft - Industry Survey 2011)

In the utilities sector, shifting requirements of existing jobs makes retraining efforts of the existing workforce a primary priority, particularly in those utilities that are in the process of deploying smart grid solutions. While new jobs are being created, this retraining effort to enable current employees within the utility smart grid workforce to adapt and take on new roles related to smart grid technology and processes is particularly active.

Utilities, contractors, suppliers, integrators, and manufacturers continue to take an active interest in the smart grid. Skill sets related to communications technology and software development and management will be particularly valuable for companies throughout the electric energy industry. Developing sufficient skill strength in the labor market to address this demand is critical.

Education and training for the existing and future smart grid workforce is of paramount concern and priority. It is vital to design retraining programs that speak directly to the training gaps of existing utility workers and to design engineering and technical curricula for future employees that resonate with the needs of the smart grid workforce, such as broad analytical skills, strong engineering fundamentals and strong business acumen. The success of organizational transitions within utilities relies upon successful retraining efforts for all companies in the electric energy industry to familiarize workers with smart grid technology and systems. The future success of the electric energy industry depends on the education of current students who will be the smart grid workforce.

Pursuant to the development of a strong, capable, dynamic, educated and skilled smart grid workforce, the GridWise Alliance believes the following:

- Smart grid will expand opportunities in the electric industry as a whole. It presents an opportunity for the United States to develop a strong native industry around development, deployment, maintenance, and servicing smart grid infrastructure and technology

- Preparing a new workforce that can make smart grid work well from the moment it is deployed will be the electric industry's central challenge in the next decade
- Smart grid will require higher level and more diverse skills for sustainable electric energy industry positions
- To develop a strong smart grid workforce, it is essential to instill excitement in students from an early age about satisfying careers in engineering, especially power engineering and related sciences and technology education platforms essential to the support of smart grid
- Training teachers to know more about engineering, and power engineering specifically, makes them more likely to recommend that students pursue engineering as a discipline
- For engineering job candidates, employers emphasize basic power-system principles as a priority; followed closely by understanding power system operating principles, smart grid applications, communications systems and cybersecurity issues; and understanding renewable generation
- Collaboration between industry, governments, and schools to create effective curricula that meet the broadest possible base of smart grid skills is critical to training employees effectively
- Electric energy industry efforts to bolster training programs with affiliated educational institutions and within their own companies is critically important and should be supported to the greatest extent possible
- The movement toward a nationally developed retraining framework for electric energy industry employees would be a productive step to harness best practices and ensure high standards of smart grid education
- Members of the smart grid workforce need a well-rounded education to facilitate the necessary breakdown of functional silos within utilities that impede the fully developed function of smart grid
- The millennial generation, by virtue of its lifelong familiarity with communications technology and affinity for dynamic and creative work environments, will bring significant

positive change to the electric energy industry and help the deployment and effectiveness of smart grid

2. Background

2.1 Methodology

In this report we examine how the continued development and deployment of smart grid has impacted the existing electric energy industry workforce and identify relevant skill and training gaps. The electric energy industry workforce includes direct utility workers and those who work for contractors, Tier 1 utility suppliers such as meter manufacturers and communications providers, software suppliers and integrators, indirect utility supply chain members who would supply the Tier 1 suppliers, energy service companies (ESCOs), renewable energy companies, distributed generation companies, and electric vehicle (EV)-related products and services.

We have used primary research, such as industry survey results, to gain understanding about the particular skills that utilities are looking for in the new smart grid workforce. Interviews of industry experts – both within and external to utilities – have informed our analysis of utility, academic and technology-related perspectives.

We have consulted secondary sources to find the latest thinking about smart grid workforce trends and have harnessed KEMA's knowledge from consulting engagements within a variety of clients, including electric utilities, contractors, utility suppliers, software suppliers and integrators, energy service companies, and renewable energy-related companies within the electric power industry.

2.2 Context of Research of Smart Grid Workforce

Section 1301 of the Energy Independence and Security Act of 2007 (EISA) "establishes a federal policy to modernize the transmission and distribution system to maintain reliability and infrastructure protection," and section 1303 calls for a smart grid advisory committee within the Department of Energy. (Congressional Research Service (by Fred Sissine) 2007) These actions, among other provisions of EISA, have the effect of codifying a national policy of the United States to pursue smart grid development, deployment and implementation. The smart grid market has evolved and developed in the last two years. The American Recovery and Reinvestment Act of 2009 (ARRA) smart grid investment grant and demonstration project opportunities have injected significant federal government funding into the market, deployment strategies have shifted, and new technologies and applications have emerged. Utilities are moving consistently from the planning stage to the deployment stage of smart grid.

In October 2009, the U.S. Department of Energy awarded $3.4 billion in Smart Grid Investment Grants to 96 organizations in 43 states and another $685 million for Smart Grid Regional and Energy Storage Demonstration Projects. (US Department of Energy 2011) These awards were matched and exceeded by industry funding, creating a total smart grid investment of $8.1 billion in the U.S. driven by ARRA. Private equity and venture capital involvement in smart grid-related product development is an important element of this funding, indicating investor interest and confidence in the sector. Increased merger and acquisition activity in the sector further points to the market's interest to leverage opportunities and change in the sector. Many niche technology players have been launched and even acquired as a hedge by larger firms for the potential of smart grid. (Business Wire - Research and Markets 2011)

While smart grid activity to this point has focused on applications within the electric energy industry, we recognize that the communications and information technology systems and processes that enable a smart grid will likely be adopted by gas and water industry operations as well.

2.3 The GridWise Alliance

The GridWise Alliance seeks to transform the electric grid to achieve a sustainable energy future. It represents a broad range of participants from the energy supply chain and its membership includes utilities, technology companies, academic institutions and venture capital firms. The GridWise Alliance believes that the electricity industry must capture the synergies created from the explosion of innovations related to smart grid creation and implementation

This report seeks to align with the GridWise Alliance's broad perspective about relevant smart grid stakeholders by considering industry, academic, and government challenges to developing the smart grid workforce.

2.4 The Education and Workforce Working Group

The GridWise Alliance's Education and Workforce Working Group (EWWG) explores issues and advocates positions that inform the development of a smart grid workforce and the next generation of electric industry employees. The EWWG recognizes the importance of a collaborative approach between government, industry, and academia to design, create, implement, and fund relevant, successful training programs that give organizations the opportunity to hire workers with skills relevant to a smart grid future. EWWG members actively contributed to the content and perspective of this report.

3. Drivers of Electric Energy Industry Workforce Change

Technology evolution and worker retirements are two primary drivers of change in the electric industry workforce. It is well documented that large numbers of individuals in the electric industry workforce are nearing retirement in the next 5-15 years. At the same time, new technologies and smart grid innovations are hitting the market in force. New employees, who will have to replace the current workforce, will bring a generationally different perspective on technology and human resource development. Not only will they need to have different, and perhaps additional, skills than those workers they replace, but they will also have different expectations and requirements for their working lives. We will explore young worker expectations and requirements further in Section 4.5. The interaction between employee retirements, new hires, and evolving smart grid technology will affect the transition to and development of the smart grid workforce.

3.1 Aging Utility Workforce

Since the previous GridWise/KEMA report on smart grid jobs in 2009, the forecast for utility workforce retirements has changed. The economic downturn of 2008-2009, and the related wealth destruction in the markets, made some workers postpone retirement. However, those retirements will come and the need for new entrants into the electric energy industry workforce remains. This represents an opportunity for the electric energy industry to leverage smart grid with new services and solutions.

As of 2008, approximately 53 percent of the electric industry workforce employed by utilities is aged 45 years or older. More recent survey results suggest that utilities will need to replace 46 percent of skilled technician positions by 2015 because of retirement or attrition. Approximately fifty percent of the engineering workforce will be eligible to retire by 2015. (Center for Energy Workforce Development 2009) and (IEEE Power and Energy Society 2009) and (U.S. Bureau of Labor Statistics 2010)

The statistics in Table 3.1 outline utility retirements as a percentage of current workers and show the estimated number of new workers needed to replace those retirees at a 1:1 ratio.

Table 3.1

Utilities Workforce Transition 2009-2015		
Job Category	**Potential Attrition and Retirement %**	**Estimated Number of Replacements**
Technicians	50.7	27,800
Non-Nuclear Plant Operators	49.2	12,300
Pipefitters/Pipelayers	46.1	8,900
Lineworkers	42.1	30,800
Engineers	51.1	16,400

(Center for Energy Workforce Development 2009)

Table 3.1 portrays the number of legacy utility workers who will retire and implicitly assumes that each will be replaced by one new worker. Full smart grid deployments have not yet been completed, so empirical data will not be available for some time to confirm the number of positions that are preserved or created under an actual smart grid. However, we do not believe that each retiring utility worker will be replaced with one new worker. First, it is unlikely, in the world of a smart grid, that utilities will structure new hiring by using legacy position openings as the only guidepost. New positions to deal with the new reality and technological change of smart grid will emerge. Some legacy positions, such as meter readers, will no longer be needed and will remain unfilled. In short, smart grid is likely to change the job mix within a utility, reduce the overall number of utility jobs, change the skill requirements of utility jobs, and, at the same time, create significant numbers of jobs in the electric energy industry overall.

3.2 Technology Innovation: Creating Opportunity and Change

A second primary driver of changing workforce requirements is the pace of technical innovation within electric energy delivery systems. Smart meter pilots, extra-high-voltage sensors and new and emerging smart grid applications require new skills—and new training programs that speak to those skills.

For example, dozens of utilities have recently deployed advanced metering infrastructure (AMI) pilots; some even have full-scale AMI system deployments. While using vendors for meter replacement projects is not new, the level of dependency on vendors from within the smart grid value chain for AMI systems is higher. In many cases, meter technicians must have proprietary diagnostic tools and training to perform even the most basic AMI installation and monitoring.

Meter technicians have a much higher skill level than have meter readers. To avoid outsourcing those jobs, a utility must aggressively retrain meter readers. The meter technician position is one position that meter readers – most of whom will be displaced by the new functionality inherent in AMI (except for those who will continue to read large commercial and industrial account meters) – can be retrained to fill. Meter readers could also be retrained to fill positions in customer service, scheduling and administration. Meter electricians can be similarly retrained to a higher level of skill to fill positions such as line technician, meter lab repair, or meter support.

The requirement-skills gap becomes even greater with AMI communications needs. In the past, the utility workforce had only to support communication between a few key energy-delivery assets and potentially a land mobile radio network for field workers. Implementation of smart grid assets increases the requirements to support two-way communication with every customer premise and to a host of new intelligent electronic devices throughout the transmission and distribution network. Network and radio frequency (RF) engineers are not new to a utility workforce, but these internal resources are being stretched thin as smart grid communication requirements increase. Now, tasks such as RF propagation studies and trouble-shooting also apply to home and access network layers rather than just a few point-to-point backhaul links.

The electric energy industry workforce will be faced with another challenge of collecting, processing, storing, and protecting the data produced by AMI and other applications once smart grid communication networks are in place and operational. Meter data management, network management, and cybersecurity are some of the top concerns for many utility IT executives, who have been tasked with designing, procuring, and operating higher-layer system functions. Solutions to cyber security risks are only in the early stages of implementation. Smart grid database management and automation demands exceed those of existing customer service and operations systems.

Even traditional heavy assets, such as high-voltage transmission lines and substations, demand a new set of technical competencies from the utility and system operator workforce. Renewable integration and other smart grid considerations require new transmission protection schemes and communication techniques. Innovations in sensor and control technology give operators more information and control over this part of energy delivery system. However, the technology is often unfamiliar to existing field personnel and supervisors, who ensure the safety and reliability of these critical bulk power systems. The transmission and distribution workforce must bridge the gap between keeping the system reliable and technological innovations that threaten to outpace workforce skill set development.

Table 3.2 below lists additional electric energy industry workforce classifications that will be impacted immediately upon deployment of a smart grid system.

Table 3.2

Electric Industry Workforce Classifications Affected by Smart Grid Deployment	
• Line Technicians	• Management/Supervision
• Meter Readers	• Customer Service Reps
• Meter Electricians	• Supply Chain
• Engineers (New Construction)	• Meter Lab Repair
• System Operation/Dispatch	• New Hires
• Administrative Support	• Communications Technicians
• Substation Operations	• Contract Construction/Engineering Labor
• Engineering Support (planning/reliability)	• Other Support (IT, Staffing)

Though many job classifications will be impacted, there is a positive economic impact to retraining workers for higher skill smart grid jobs. New jobs within the industry that require a higher skill level also pay significantly higher wages, thereby generating the economic benefit both to the retrained employee and to the economy at large. For example, a large investor-owned utility pursuing smart grid initiatives has forecasted a local economic benefit of $9 million annually through retraining over 200 potentially displaced workers for smart grid-related positions that pay, on average, between 50-67 percent more than the annual salary of existing positions. Utilities will need to adjust the number of positions within these classifications to suit individual deployment plans to maintain overall performance efficiency as the legacy electrical network is upgraded.

There are many different areas within the electric energy industry where investment and activity will create additional jobs directly related to smart grid, described in the following Table 3.2.2.

Table 3.2.2

Non-Utility Smart Grid Job Areas	
Sector	**Description**
Contractors	Will accelerate installation and deployment of smart grid
Tier 1 Utility Suppliers	Will supply smart grid equipment to utilities: • Meter manufacturers • Intelligent Transmission and Distribution automation device companies • Communications systems products and services
Software Suppliers and Integrators	Will supply applications and software products to run the grid and/or provide customer-facing applications and other behind-the-meter software applications
Indirect Utility Supply Chain	Will supply raw materials and finished components to the Tier 1 suppliers of meters, DA & DG infrastructure, and for other related systems
New Utility / Energy Service Companies (ESCOs)	Will be a developing market built upon the broad adoption of automation and communications technologies within the utility industry
Renewable Energy	
Distributed Generation	Will be accelerated by smart grid deployment of enabling technologies
Electric Vehicles (including Plug-in hybrids, full electric)	

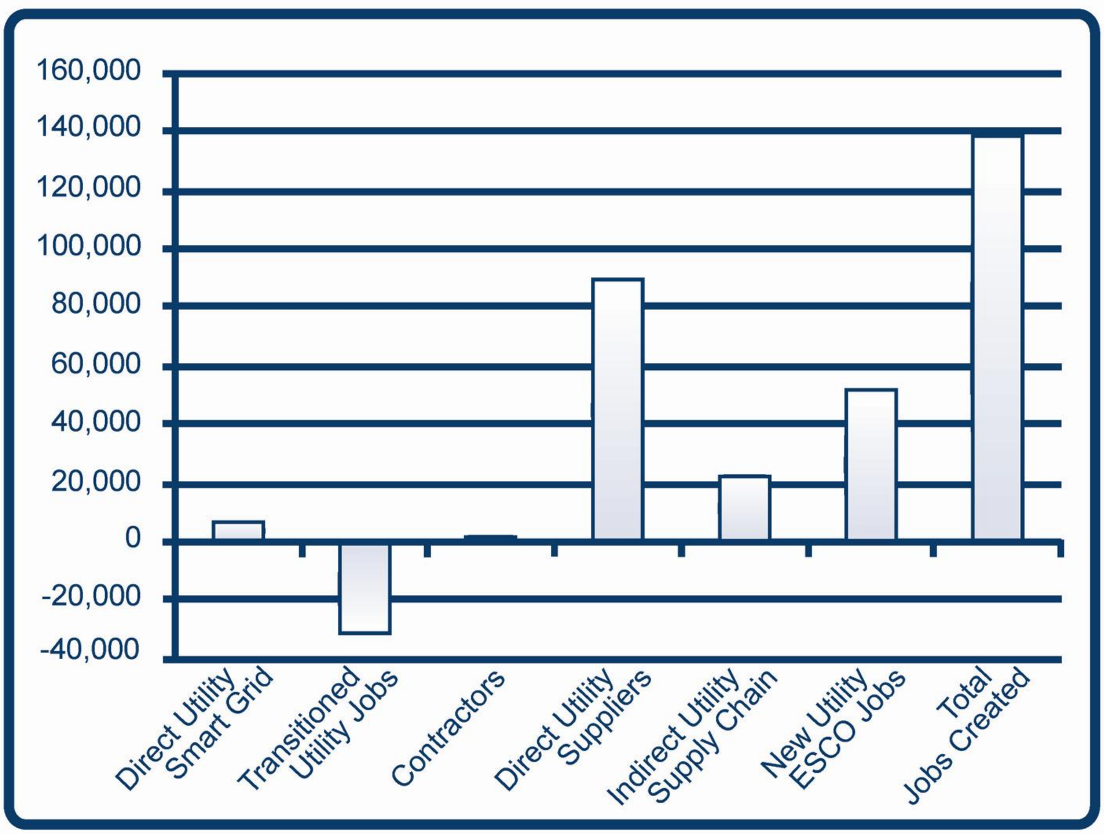
4. State of the Smart Grid Workforce

4.1 Research and Forecast update

In its 2009 report to the GridWise Alliance, KEMA outlined job projections for six categories for smart grid deployment as shown in table 4.1 below.

Table 4.1

Total Smart Grid Jobs Created and Transitioned: 2009-2018



(KEMA, Inc. 2009)

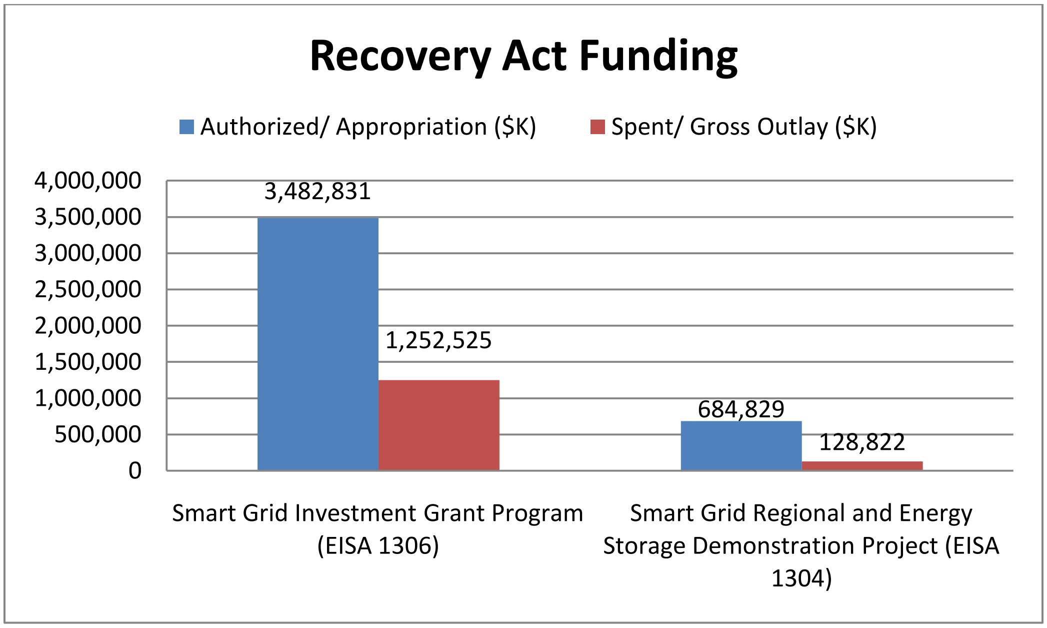
In the 2009 report, KEMA stated:

> During the next four years, KEMA's projection anticipates that a potential disbursement of $16 billion in smart grid incentives would act as a catalyst in driving associated smart grid projects that are worth $64 billion. The impact of these projects would result in the direct creation of approximately 280,000 new positions across various categories, of which more than 150,000 will be created by the end of 2009. Furthermore, we estimate that nearly 140,000 new direct jobs would persist beyond the smart grid deployment as permanent, on-going high-value positions.

Table 4.1 above highlights the sustainable job creating power of the secondary and tertiary industries that will enable and assist utilities to deploy and maintain the smart grid.

As of July 1, 2011, the U.S. Department of Energy has disbursed $1.252 billion of smart grid funding through its ARRA account by way of the Smart Grid Investment Grant Program and $128.8 million through the Smart Grid Regional and Energy Storage Demonstration Program as shown in table 4.1.2 below.

Table 4.1.2 – Federal Outlays from Stimulus Allocation (As of July 1, 2011)



(US Department of Energy 2011)

Earlier in this report, we noted that the Department of Energy has allocated $4.1 billion for smart grid through ARRA. Industry matching funds increase the total projected investment to $8.1billion. The Department of Energy will continue to outlay this funding, and grant and demonstration recipients are required to spend it within three years of award.

4.2 Emerging Smart Grid Jobs Skill Requirements

The emergence of smart grid changes the necessary electric energy industry workforce skill sets. Managing new communications infrastructure, data management, customer service, and strategy development initiatives and processes are areas where the new smart grid workforce will have to be especially proficient. New and future employees must be well rounded in power-system engineering, telecommunications, and business acumen.

Employees who interface with smart grid will need to possess fundamental engineering, planning, analysis, and management skills that have long been the mainstay of the electric energy industry. However, in the smart grid world, these skills may need to be applied differently. With a fully connected grid providing two-way communications through a bevy of new technologies the electric energy industry workforce will need to have an increasingly broad knowledge of every aspect of the electric power system and its related functions. Real-time enterprise-wide collaboration will be even more important. To the extent that operations continue to be hamstrung by corporate silos, they will have to change.

In the near term, it is likely that smart grid-related skill requirements will manifest as additional responsibilities for existing positions within utilities rather than in new smart grid-specific positions. The Center for Energy Workforce Development reports in a recent survey that most of the smart grid positions within utilities occur in management and engineering. There were very few job titles reported in the survey, however, that indicated a smart grid-only role. Rather, smart grid roles were incorporated into existing positions with familiar titles such as project manager or distribution engineer. (Center for Energy Workforce Development 2009)

The Microsoft Worldwide Utility Industry Survey 2011 reports the following findings:

- 72 percent of utility professionals and executives perceive distribution management as the most important solution needed for successful smart grid implementation
- More than 50 percent of respondents see their customer information systems changing dramatically because of smart grid. (Microsoft - Industry Survey 2011)

These findings are relevant both to all participants in the electric energy industry. With the deployment and management of smart grid, utilities will look to outsource functionality previously held in-house. There are aspects of distribution management, such as sensor design and production, telecommunications infrastructure and applications, and renewable generation management that are fertile ground for suppliers and energy service companies (ESCOs) because of the specialized nature of the products and applications. Customer information systems as well could be outsourced by a utility. With such outsourcing, suppliers and ESCOs, and other external players in the smart grid market will demand a smart grid workforce with enhanced skills. Workers will need a solid foundation in power system engineering and an understanding of the nuances and details of the grid. Telecommunications skills, analytical skills, and the ability to understand a utility's business case needs and how a vendor or supplier technology can fulfill those needs are all skills that are critical for suppliers and ESCO smart grid employees. The customer information systems challenge could present an additional opportunity for individuals and firms with specific capabilities around customer care, customer management, customer relations and marketing. Smart grid will allow companies many new gateways through which to relate to the customer, demanding a set of skills that has not been a traditional electric energy industry strength.

KEMA survey results on curriculum development from utility executives support the assertion that future members of the electric energy industry workforce need a strong foundation of fundamental engineering and power system skills, which should be supplemented with specific smart grid training either through school courses or hands on training. For engineering candidates, employers list understanding basic power-system principles as a priority; followed closely by understanding power system operating principles, smart grid applications, communications systems and cybersecurity issues; and understanding renewable generation. Comments from survey respondents about engineering candidate skill requirements were diverse and include:

- Understand energy supply and the relationship with smart loads / demand
- Have an understanding of IT and technological development
- Understand integration of AMI system into distribution system
- Have the ability to conduct new technology assessment: how to evaluate new technologies and develop requirements and specifications
- Know computer science
- Understand the way in which individual devices work and how they work on the electric T&D

For non-engineering employee candidates, utility priorities included having analytical, written communications, oral communications, project-management, presentation skills, and engineering economics knowledge. More utility key priorities included understanding the utility business model and how to build business cases that justify smart grid investments and understanding government and regulatory processes. Customer-relations skills represented an additional priority, especially when linked to smart grid technology. Customer metering, demand-side management, and managing customer interactions, along with new behind-the-meter technologies, all require skills sets that take on additional importance as smart grid becomes more ubiquitous. These skill sets will be critical for all electric energy industry companies, not only utilities.

With smart grid, utilities will be able to collect data from a variety of sources in ways that are completely new. AMI, substation automation, and distributed generation are a few of the new data-collection points on a smart grid-enabled power system. A utility will have more data at its disposal than ever before, which raises questions about how an organization will harness, process, aggregate, and use the data. Data can be used for power pricing strategy, outage management-related operations, and marketing operations, such as customer support and customer care. Integrating all sources of data and using those data to generate positive business outcomes in these categories will be a central challenge for the electric energy industry. The overall demand for data-management and analysis skills will increase in the electric power industry.

4.3 Skill Gaps

Identifying skills gaps in the current and future electric energy industry workforce can help drive utility human resource strategy as well as inform analysis of training requirements for the entire electric energy industry. The current electric industry workforce within utilities is highly skilled in traditional processes that have been used for decades. Namely, they are quite good at planning, designing, and operating the power system as it exists, without fully deployed smart grid capability.

At the management level, it will be critical for utilities to bolster their strategic capabilities. The explosion of smart grid technology and the market competition that will arise in light of significantly increasing investments will force utilities to understand their strengths and weaknesses. Conducting fundamental SWOT analyses (strengths-weaknesses-opportunities-threats) are not a strong suit of utilities. Such analysis will become critical as utilities determine on what level to compete for new smart grid-related business. Determining which services and skills to develop internally and which capabilities it makes sense to outsource in such a competitive environment will become an important strategy function within utilities and will drive development of and demand for skills throughout the electric energy industry.

The following tables 5.1 and 5.2 show various smart grid workforce job categories and show a broad account of potential skill gaps that exist under several skill categories related to each job.

Table 4.3 – Smart Grid Jobs and Skill Gaps

	Skill Category	**Safety**	**Telecommunications**	**Protection and Control**	**Computer-related**	**Distributed Resources**
Job Category	***Job Roles***	**Skill Gaps**				
Line Workers and Technicians	Build and maintain the grid	Learning smart grid general safety issues and procedures; developing awareness of risk in the field	Connecting, initiating, troubleshooting and replacing telecom devices and circuits; developing awareness of privacy issues related to customer information	Connecting, initiating, troubleshooting and replacing protection and control devices	Identifying device/equipment problems and confirming that problem is with microprocessors in individual devices	Connecting and isolating distributed resources owned by the utility or customer
Contract Construction and Engineering	Build, maintain and repair electrical lines					
Distribution Dispatchers	Analyze outages and send field personnel to investigate/validate/repair	Developing control procedures for new risks	Initiating troubleshooting/repairs on telecom devices and infrastructure	Understanding protection and control scheme operations	Knowing what type of employee to dispatch when computer problems are suspected	Understanding protection schemes and how to isolate devices
Distribution Work Center (Sched&Admin)	Schedule work and work order management	Developing awareness of risks in the field	Initiating service work	Understanding of skill level required to install / maintain smart grid equipment and devices	Knowing what type of employee to dispatch when computer problems are suspected	
Telecom O&M Schedulers	Management of radio, cell, and cable comms networks	Developing awareness of risks in the field	Initiating troubleshooting/repairs on telecom devices and infrastructure	Understanding protection and control scheme operations		Understanding protection schemes and how to isolate devices
Substation Operations	Repair, maintain, and build electric substations	Developing awareness of risks in the field	Connecting, initiating, troubleshooting and replacing telecom devices and circuits; developing awareness of privacy issues related to customer information	Connecting, initiating, troubleshooting and replacing protection and control devices	Identifying device/equipment problems; confirming that problem is with microprocessors in individual devices	Connecting and isolating distributed resource devices owned by the utility or customer
Meter Technicians	Install and remove smart meters and utility-owned connected devices	Learning smart grid general safety issues and procedures; developing awareness of risk in the field	Connecting, initiating, and troubleshooting telecom devices at meters and into homes and customer buildings; developing awareness of privacy issues related to customer information	Connecting, initiating and troubleshooting protection and control devices associated with meters and customer facing networks		

Meter Lab/Shop Electricians / Technicians	Test, repair and maintain smart meters and utility-owned connected devices				Identifying device/equipment problems; confirming that problem is with microprocessors in individual devices	
Meter Reader	Read meters	Most will be retrained and redeployed to other jobs within smart grid				
Engineering Technicians, Designers	Plan and design lines, service connections, and stations	Designing to mitigate risk	Specifying telecom devices and infrastructure from standards	Specifying protection and control devices from standards	Specifying individual devices with microprocessors from standards; knowledge of interoperability standards and how to specify tests that confirm / certify interoperability on the utility's smart grid	Knowing impact on designs of distributed resource devices and how to connect them according to standards
Engineers	Plan for capacity/protection of the system and standards for contstruction	Planning for and specifying equipment to mitigate risk	Understanding of complex telecom device operations; interfacing w/ protection and control to set standards; knowing national and industry cybersecurity risks and standards	Understanding complex operations/interactions of protection, sensing and control devices to set standards and specify complex individual installations; knowing national and industry cybersecurity risks and standards	Setting standards for individual devices and design the hierarchy of control for system master processor; knowing national and industry cybersecurity risks and standards	Knowing national and state standards for connecting distributed resource devices and developing consistent internal standards and protection schemes; knowing national and industry cybersecurity risks and standards

Table 4.3.2 – Smart Grid Jobs and Skill Gaps

	Skill Categories	Physical and Cybersecurity	Real Time Infrastructure Control and Operations Systems	Supply Chain	Customer Service
Job Category	*Job Role*	Skill Gaps			
Information Technology	PMO; Enterprise architecture; systems integration; project management; business process design; use case development; system testing and implementation; user testing and deployment; system administration	Understanding of systems' cybersecurity risks and infrastructure physical security risks and related mitigation standards; implementing system protocols that support security standards; understanding of NERC CIP (Critical Infrastructure Protection) standards	In-depth understanding of real-time infrastructure control systems (AGC, EMS, Substation and Distribution Automation/DMS, AMI) and operational systems that support SG functionality (DMS/OMS, work and asset mgmt, mobile workforce management, CIS); expertise in meter data management, integrating operations support and back office information systems with real-time control systems, development of real time decision systems	Understanding how the vendor QA lifecycle methodology and criteria mitigate supplier risks; developing and implementing project management procedures that support the methodology	Understanding meter data management, pricing/rate, and billing requirements for new or enhanced CIS and related customer service systems; experience in designing web-based customer interaction applications
Supply Chain Management	Strategic sourcing; procurement; contract management	Understanding of cybersecurity risks and infrastructure physical security risks and related mitigation standards; implementing system protocols that support security standards; developing and implementing security criteria requirements in the vendor QA lifecycle that support those security standards	Understanding of new and enhanced systems most needed for Smart grid functionality; understanding of market landscape of vendors to meet smart grid needs	Developing and implementing Smart grid system and device supplier including QA assurance and assessments and evaluations	Basic understanding of Smart grid technology impact on customer services
Customer Service Management	Customer Service Representatives (CSRs)	Basic understanding of physical and cybersecurity risks and standards; awareness of customer data privacy issues and risks	Understanding of how to design the business process requirements to be supported by the CIS, outage restoration system, and energy management program promotions, interaction, and service tracking systems and applications	Basic understanding of the process and benefits related to vendor evaluations	Expertise in navigating customer interaction applications related to smart meters, energy use, price data, new service requests, service connects and disconnects, energy efficiency (EE) and demand response (DR) program inquiries; understanding and providing educational information on EE and DR programs; adept at promoting EE and DR programs to customers

In depth understanding of and skills to operate real time infrastructure control systems, such automatic gain control (AGC), energy management system (EMS) and distribution management system (DMS), among others, is one area where the smart grid workforce will need to improve. Another area of particular importance is to understand how to integrate operations support and back office information systems with real time load flow analysis for the distribution system. The convergence of traditional utility operating systems with internet protocol (IP)-based systems related to smart grid presents a particular challenge for integration. It is very likely that vendors will supply a significant amount of the technology applications and it will be critical for utility personnel to fully understand the product evaluation and lifecycle quality assurance process for complex communications modules, sensors, applications, and infrastructure related to smart grid.

While building out a smart grid, there is likely to be an initial flurry of outsourced contracted field work to the extent that a utility has not yet trained internal staff to complete the work. Specialty smart grid crews, to focus on installation of communications and monitoring technology, operations and troubleshooting, will be deployed in situations where a utility has yet to train its internal crews on applicable smart grid technologies. As smart grid deployment grows, a utility may need additional specialty crews to maintain and care for specific aspects of the grid or specific technologies within the grid. Training of internal utility employees would then catch up with the requirements of the new technology and the demand for specialty, contracted smart grid crews would fade in favor of a steady-state where utility crews assume the full responsibility of operating, maintaining and troubleshooting the smart grid.

Technology skills will be in particularly high demand in the electric energy industry. The renewable energy, distributed generation, and software supplier and integration sectors will all demand technologically savvy workers. To a lesser extent, contractors who accelerate installation and deployment of smart grid will also be in greatest demand, especially if they have relevant skills to immediately interface with new smart grid technologies in the deployment phase.

On the customer service side of a utility, representatives also have to understand a whole host of new technologies related to communications, and, in particular, have to understand how to explain those to the customer. Additionally, new smart grid infrastructure will further enable technologies such as distributed generation, electric vehicles, and behind-the-meter customer-facing applications. Customer service must be able to explain and, to some extent, sell benefits of smart grid-enabled technologies to customers.

There are also weaknesses in the non-engineering areas of utility employee roles such as teamwork, collaboration, and working cross functionally while breaking down traditional silo barriers. While these areas fall outside traditional engineering training, both engineers and members of the IT team will need to be able to support business case and use case development. They will have to be able to work closely and to understand how many traditionally separate functional areas, such as regulatory affairs, system control and operation, and customer services, within a utility work together to manage all the aspects of smart grid deployment. Employees in other categories, such as field technicians, also will have to broaden their scope of understanding to include subjects like cybersecurity, system control, and distributed generation resources. Since smart grid allows these systems to be linked, its implementation requires greater overall knowledge from those who work on any specific aspect of the electric power system. Vendors involved in system management of smart grid share these requirements for their employees.

Smart grid will require dynamic skill sets from many different functional areas across the electric energy industry. Utilities will have data collected from many sources and will need teams to responsively process and act upon the data and responsibly manage the devices and processes that generate that data. Smart grid will require new thinking and new ways of doing business.

4.4 Training Gaps

As noted earlier, the future smart grid workforce will need to be well rounded. Engineering skills, data-management skills, and business acumen, among other skills, will all be highly valued in smart grid-related jobs. The electric power system will become much more complex with the addition of telecommunications technology to the existing power grid. A substantial increase in engineering and design personnel will be required with advanced skills in telecommunication, protection, control, and the logic associated with getting the system to work together properly.

For current electric energy industry workers, a pressing need is to get retrained about newer smart grid-related technology. This is a relevant challenge for line workers, engineers, and managers. As technology evolves, these different worker categories will work together more than ever, and common technology knowledge will be the basis of successful collaborations.

Potential employers prefer to hire candidates who have had an internship of some kind, have knowledge and practical experience, have the ability to work in a team, and understand the business issues of the organization. This list of requirements is substantial and well-rounded. For example, a training gap exists for the future smart grid workforce to the extent that engineering programs lack required courses in business, lack team-work exercises, lack a structure that can accommodate an internship, or other ways to get practical hands-on experience.

Engineering and IT-related skills, such as those that relate to a geographic information system (GIS), supervisory control and data acquisition (SCADA) system, distribution engineering and design, conservation, energy efficiency, and AMI, must be integrated as much as possible with non-engineering skills. As noted previously, non-engineering skills of particular employer importance include oral and written communications, project management, presentation, and financial skills, which include spreadsheet analytical ability. It will be difficult to find an individual who has all these skills in abundance, but programs that focus on building well-rounded graduates, rather than those who can exist only in silos, will matriculate well-prepared graduates for the smart grid workforce.

4.5 Expectations of the Millennial Generation

The millennial generation is understood to include those born between the mid 1970s and the early 2000s. Young employees can bring an effective and modern technology perspective to the industry. They also have very different expectations of both jobs specifically and their careers in general than does the legacy electric energy industry workforce. As we consider young employees as the future of the electric energy industry, it is important to consider the way they look at work and what they expect from it.

Future smart grid workforce employees have grown up with advanced technology that often outstrips technology in an electric utility. Many have had access to technology from the beginning of their academic careers and are used to real time feedback and participation in everything from video games, to text messaging, blogging and other social media. The IEEE-PES Scholarship Plus Initiative provides scholarship and real world experience for those students who are studying or intend to study power and energy engineering. It is a prime example of an effort that is seeking to generate interest in current students for smart grid jobs and to help provide the education and real world experience, through internships, that are important for the success of the smart grid workforce.[1]

It is this background of their lives – in addition to any relevant skill sets they have – that make millennials ideally suited to work with smart grid. Many elements of smart grid are dynamic and its benefits are driven by real-time data and feedback. Dynamic pricing and outage management, for example, are real time concepts. New employees with a twenty-first century technology perspective will help successful management of these new capabilities.

The job and career priorities of millennials who will make up the smart grid workforce will help define the nature of the organizations of which they become a part. Table 4.2 below focused on the emerging workforce outlines compelling statistics across professional categories, most of which are directly applicable to utilities, and all of which are applicable to the broader smart grid workforce including utility vendors and new energy technology market entrants.

[1] See more information here: http://www.ee-scholarship.org/about-scholarship/

Table 4.2

What They Seek	
Technology Workers	**Opportunity to Learn New Skills, Bolster Resume, Work on New Technologies** *Most likely group to say employees should be required to learn new skills in order to keep job*
Manufacturing/Light Industrial Workers	**Job Security, Employers with Clear and Followed-through Mission** *64% of manufacturing workers (more than any other profession) says an employer who promises long-tern job security is much more attractive* *Least satisfied with their employer's ability to follow-through on its stated mission*
Accounting Workers	**Career Growth, Robust 401K or Retirement-building benefits** **Most likely group to say being successful at work/moving up career ladder is top priority** **74% say "saving for retirement" is top financial priority**

(Adapted from: Strategic Workforce Solutions (SFN Group) 2010)

According to a recent study by Strategic Workforce Solutions focused on younger workers:

- The percent of employees who "prefer a job that allows them to think creatively"— 95 percent
- The percent of employees who "prefer a job that allows them to think of better ways to do things"— 88 percent
- The percent of employees who "are satisfied with their potential for growth and extra earnings at their current company"— 24 percent

These preferences represent a challenge for traditional companies within the electric energy industry. However, young, future employees seem well suited to the environment that will evolve with greater smart grid technology deployment and integration, because smart grid characteristics require a dynamism that is less prevalent in the legacy workforce.

Young employees are more likely than their legacy counterparts to demand well-defined career ladders, training opportunities, and leadership roles. A key strategy for appealing to younger workers is to communicate an accurate image of a power engineer and how he or she can improve others' quality of life. Jobs that make a difference in the world are attractive to the millennial generation. (IEEE Power and Energy Society 2009)

A challenge for utilities is to ensure that they have the appropriate personnel in leadership and strategic roles, people who understand that these human-resource dynamics of the new workforce can be integrated with smart grid innovation, deployment, and management demands. Smart grid will require a workforce with a broader-based skill set, a strong ability to work cross functionally, and willingness to process information on a real-time basis. These qualities are well represented in the younger emerging workforce.

4.6 Costs and Consequences of Skill and Training Gaps

The electric industry's evolution to smart grid technologies and processes will proceed more slowly as long as skill gaps exist in the workforce. Technology will not be adopted because smart grid investments will not realize their full operating potential without an effective workforce to integrate the technology, infrastructure, and processes. The central challenge for the electric energy industry is to obtain personnel with relevant skill sets that make technology work well from the moment of deployment. A workforce with strong relevant skills is the key to a enterprise harnessing the full benefits of smart grid.

4.6.1 Financial and Operational

The training gap can affect a company's financial and operational performance. Recently, utilities reported that 30-50 percent of applicants were unable to pass required pre-employment aptitude tests. On average, utilities conduct 30 interviews for every successful hire. This type of process is highly inefficient, cumbersome, and expensive.

Companies that work with academic institutions report a far higher success rate with interviews and employee aptitude tests: “Those companies that work with secondary and post-secondary institutions to develop programs tailored to the industry, such as energy career academies at the high school level, ‘boot camps’ prior to apprenticeships, and community college programs aligned to the specific skill requirements report significant increases in the pass rate for pre-employment tests” (Center for Energy Workforce Development 2009) This collaboration between industry and academia is directly relevant to the industry’s bottom line both because of reduced overhead costs associated with the hiring process and because of the reduced need for on-the-job training programs.

4.6.2 Safety and Security

Matching skill levels and competencies to the capabilities of new smart grid systems are key safety and security issues as well. Craft and technical workers must understand the communications technology inherent in the grid to preserve cybersecurity strength throughout the system and to prevent malfunctions within the more traditional infrastructure that can affect physical safety of personnel and infrastructure. Cybersecurity breaches can directly impact power-system safety for both workers and customers, particularly when the power system is replete with distributed generation and distribution automation. Line workers will have to think of the power system as a machine they have to operate and keep in top running condition with power and communications elements operating in parallel harmony. (Harrison 2011)

4.6.3 Cybersecurity

Managing system-protection risks have been a long-time central operational goal for utilities. In the age of a smart grid, system control and communications are becoming more complicated and more vulnerable. As utility communication systems become more complex, the number of cyber access points to critical networks, such as SCADA, EMS, and certainly AMI, increases as does the potential for a cybersecurity breach. A wide variety of operations, including voltage control, health monitoring, and distribution automation, can be affected by a cybersecurity breach. If there is a breach in one place, a fully linked system will be vulnerable to invasion, which potentially could affect operations’ controls and processes.

A significant security concern for a power system is the number of data-collection access points. Since the smart grid generates large volumes of data, such as customer meter, substation control, distribution automation, recloser, and voltage information, it is very susceptible to error given its large number of access points. One goal of smart grid is to enable two-way communications. Remote system controls create additional weaknesses and opportunities for invasion as much as for monitoring system status. A breach could involve not just information distortion but hijacked control of live systems. Safety and reliability concerns around such scenarios are vital, significant, and large.

At an enterprise level, many of the security concerns appear as operational and asset management issues. Cyber risk threatens reliability and security. It is important to consider too that individuals—company personnel— are part of the system. First, they are assets to the company. As the legacy industry workforce retires and is replaced by a new, younger workforce, more employees will be able and inclined to use smart systems. They will have access to points of entry for the entire communications and control system. While unlikely, they will potentially become a cybersecurity risk. As more outsourcing occurs, the umbrella of individuals with access to the system widens even further. The larger that umbrella becomes, the larger the opportunity for security breaches.

Small utilities will likely want to outsource more smart grid-related technological processes because of financial and managerial constraints. Outsourcing creates cybersecurity risk, but that risk, in some cases, might be better managed by a large vendor with the resources and knowledge to offer more security, rather than by a small utility. Outsourcing helps isolate technology users from the actual hardware and the ability to cause problems. (Berry 2011)

5. Moving Forward

Align Stakeholders to a Common Goal

To address future smart grid workforce needs, industry, academia, and government must collaborate to create and sustain degree and training programs that meet the broadest possible base of emerging smart grid-related skills.

Academia

While individual electric energy industry businesses are different, much of the training required for smart grid-related jobs will be similar and should address new technologies and new potential customer interactions, as well as evolve engineering, maintenance, and outage processes related to adoption of new technology. Technical programs that are non-vendor specific are important, so line workers are familiar with a wide variety of equipment and techniques. Training programs will need to address both hands-on technical field work and advanced engineering training to support the complex technological and analytical environment that smart grid will create.

Universities must increase emphasis on cross-disciplinary work, such as requiring engineering students to take business classes. Smart grid jobs will require leaders who can think about several aspects of a utility or other smart grid-related organization, such as accounting, operations, and technology departments at the same time. The central challenge is to maintain high quality engineering educational programs while augmenting and modifying them to fit this cross-disciplinary need.

Community colleges are uniquely positioned to respond directly to local and regional workforce needs and often have direct relationships with individual businesses and industries. Community colleges excel at developing training programs, and even full courses, quickly to respond to a particular short-term workforce demand. For the most part, they also offer comprehensive online courses, which are particularly useful and convenient for workers who need to retrain while maintaining full-time work. Unemployment continues to be a pressing issue in the U.S. economy, and community colleges offer individuals looking to redirect their careers an accessible resource.

According to the Government Accountability Office (GAO), the number of students earning degrees in engineering in the United States decreased during the decade ending in 2004. The quality of teachers during grades K-12 and the levels of mathematics and science courses completed during high school are primary drivers of students' decisions to choose to pursue STEM fields in college. (Government Accountability Office 2006) The IEEE reports that most high school students know little about engineering and have little confidence in their math and science skills. (IEEE Power and Energy Society 2009) It is important to emphasize in the strongest possible terms the importance of elevating grade and high school educators' knowledge and skill level of science, technology, engineering and mathematics (STEM), particularly engineering, disciplines. Teachers, guidance counselors, and other advisers to students are far less likely to recommend to a student a future in engineering if they themselves do not understand what such a future entails. Without such knowledge, they are unable to mentor students effectively and are unable to recognize and cultivate potential as effectively as they would be with targeted training to increase their awareness and competence in of STEM disciplines.

The GAO reports that 40 percent of students who left college science fields reference inadequate high school preparation as the primary reason. Efforts are underway, in part through the Department of Energy's $100 million commitment to high-school and college smart grid training, to generate interest in younger students about the electric energy industry. The successful transformation of a smart grid workforce requires having bright, enthusiastic students choose the industry as a career path. This goal is critical too all members of the electric energy industry.

Private institutions are providing funding that enables the development of training opportunities as well. The Bill and Melinda Gates Foundation recently granted $1.37 million to the Center for Energy Workforce Development to train low-income adults for careers in the energy industry. The 'Get-Into-Energy' career pathways program is an example of efforts to lure young people into the utility industry. (CEWD - Press Release 2010) Such a program's existence points toward the importance of influencing students early in their acdademic careers and instilling interest in engineering fields. It is then critical, for reasons outlined above, to follow through and provide good academic instruction and opportunities for interested students.

Government

Government has funded workforce re-training programs with effective targeted use of resources for a smart grid-centered industry. These government-funded programs allow students to earn valuable smart grid-related knowledge, which is directly pertinent to the electric energy industry. Such programs recognize that transitioning companies to a smart grid workforce will be driven by people. Smart grid-related positions will require an increased level of basic computer, math, electronics, reading comprehension, and analysis skills. Employees with two-year technical degrees, who can fill technician and electrician positions, will be in high demand.

Industry

The pace of new market entrants participating in the electric energy industry is faster now than during any recent period. Consultants, software vendors, and IT manufacturers are expanding their offerings and bringing competencies from parallel industries, such as telecommunications, financial service, IT, and other commercial database businesses to the electric energy industry. As companies deploy smart grid, these related industries will create products and solutions to help make smart grid a reality. It will be important for utilities to have strong internal capability to understand and evaluate the many vendor-sourced solutions from other industries that will be available to bolster smart grid efforts.

Utilities must develop roadmaps to fully integrate smart grid as a system, rather than implementing it in an ad-hoc manner. Generating system efficiencies sufficient to justify smart grid investment relies on a comprehensive plan.

The electric energy industry must communicate consistently with academic institutions to inform curricula development. The most effective educational programs are driven by market forces, by way of industry activity and input. Therefore, it is also critical for industry to communicate effectively with purveyors of government funding streams that support workforce training. Misdirection of funding for training will slow the development of necessary skills, which makes the development and deployment of smart grid less efficient and lengthens the timeframe to realize smart grid system potential. Industry must be a mainstay participant in consortia of state governments, the federal government, standards groups, boards of education, community colleges, universities, technology and green jobs associations and, when possible, the military and labor unions.

6. Summary and Recommendations

Job creation and development of industry native to the United States is a national priority and Smart grid continues to be a primary example of a technological area that is ripe with opportunity and ready for continued innovation and creativity.

The evolution of smart grid continues to redefine the electric energy industry. Utilities will begin, and in some cases already have begun, to reorganize and redefine themselves around smart grid technology, processes, procedures, requirements, and products. Strong investment continues to flow into the smart grid sector, creating change and strong opportunity. New job opportunities are opening because of this investment and redefined job requirements are opening opportunities for current employees and those will replace them in the future. Smart grid presents a significant opportunity for the United States to continue to develop a native knowledge, service and employment base related to smart grid and to develop an even more dynamic electric energy industry that also seeks to export new services and solutions.

The importance of education initiatives for training and retraining the smart grid workforce cannot be overstated. Existing and future employees alike, and therefore the smart grid effort itself, benefits from active, direct and productive engagement of the industry at every level of education. The evolution and effectiveness of the smart grid workforce depends on matching the needs of the industry and the curricula that support students throughout their academic career and into their working life with retraining and continuing education programs. The development of new technology and the implementation of effective organizational processes and change related to smart grid rest on this foundation of strong education.

Exhibit A – Bibliography

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