The Smart Grid Workforce of the Future

Job Impacts, Skill Needs, and Training Opportunities

Developed With:

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1 Executive Summary

The aging U.S. electric grid is subject to significant challenges from increased growth in power needs, decreased investment in transmission connectivity, remote deployment of renewable generation resources, consumer digital reliability expectations, and more recent concerns about physical and cyber security threats to critical infrastructure. Recognizing these challenges, the industry has begun to invest significant resources in modernizing the electric grid, stimulated by more than $4 billion in federal grant funds distributed to utilities as smart grid demonstration projects and infrastructure grants.

This transformational level of capital investment is occurring in an industry already suffering from shortages of key engineering and technical skills; a shortage that will continue to increase through attrition over the next five to ten years. The technologies and systems introduced through smart grid initiatives will require a new highly-trained and flexible workforce to fully realize the smart grid promise. This future workforce will be vital to deploying and maintaining a national clean-energy smart grid infrastructure. Growing and training this smart grid workforce will only be possible if the industry commits to intensive, sophisticated, and integrated workforce-development initiatives.

West Monroe Partners and the Illinois Institute of Technology commissioned this report to take an initial step toward addressing this national workforce challenge. Key results of this research include:

- Identifying the jobs impacted by the smart grid
- Capturing the level of smart grid impact on these jobs
- Defining critical smart grid skills requirements
- Evaluating current training opportunities available to address smart grid workforce skill requirements

Our research team developed and employed a comprehensive methodological approach to acquire and analyze a significant level of current knowledge about this topic in order to formulate the findings presented in this report. These activities included review of industry-leading and academic literature; development and administration of two national surveys; qualitative individual interviews; and expert validation with industry leading experts, educators, and federal and local government representatives.

Smart Grid Job Impacts

Our team evaluated hundreds of Standard Occupational Classifications (SOCs) across numerous smart grid related organizations captured in the North American Industry Classification System (NAICS) and documented and forecast by the Bureau of Labor Statistics (BLS). We identified more than 100 jobs specifically impacted by the smart grid and grouped these under seven organizational/departmental categories and three functional expert categories to facilitate survey, analysis, and interview techniques. Finally, we validated the preliminary list further through interviews with industry thought leaders and experts.

Our research found that smart grid technologies and processes will impact these jobs to varying degrees, requiring different levels of education and training. A summary of our findings in Table 1 of this report lists the jobs with a major impact resulting from the introduction of smart grid solutions.

Smart Grid Skill Requirements

Smart grid technologies, standards, and systems are still evolving, and specific future skills required by the smart grid workforce will change continually. Our research presents a current snapshot of almost 100 specific sets of smart grid knowledge and skills that future workforces will need to possess , grouped into 12 major skill categories that encompass current and future training needs. These 12 areas are arranged in specific skill quadrants in Figure 2:

- Technology
    - Advanced Components
    - Advanced Control Technologies
    - Sensing & Measuring Elements

- System Integration & Communications
    - IT System, Networks and Architecture
    - Integrated Communications Protocols and Technologies
    - Cyber Security & Interoperability Standards

- Organizational Management
    - Business Transformation Challenges
    - Legal & Regulatory Issues
    - Utility Decision Support Applications

- Customer Management
    - Customer Communication & Relationships
    - Energy Supply Side Management
    - Customer Energy Management Systems

To develop these skills requirements, our research team relied upon industry-leading trade organization reports and published data; national electric system, interoperability, and technology standards and initiatives; equipment manufacturer and vendor specifications; and key smart grid evaluation models such as:

- Department of Energy National Energy Technology Laboratory (NETL), especially the results from the five-year smart grid Implementation Strategy research
- GridWise Architecture Council research, publications, and proceedings
- Institute of Electrical and Electronics Engineers (IEEE) Smart Grid Conceptual Model, Grid Operations and Planning, and IntelliGrid standards, research, and reports
- Electric Power Research Institute (EPRI) smart grid research, demonstration projects, and resources;
- Carnegie Mellon Software Engineering Institute's Smart Grid Maturity Model

Additionally, our team collected survey responses and conducted qualitative interviews with a diverse panel of industry professionals. Finally, we validated and reviewed a preliminary draft of smart grid skill areas and deficiencies further through individual discussions with a sampling of cross-industry experts.

Smart Grid Skill Competencies

By combining the defined smart grid job impacts with the smart grid skill requirements, our team created the Smart Grid Job Classifications and Skills Deficiencies Matrix (Figure 3). We then administered a national survey to allow utilities, educators, and other experts to define the level of competence (awareness, knowledge, and expert) required for each point of intersection on the matrix.

The resulting competency combinations led to the development of the Smart Grid Job Classification and Skills Heat Map (Figure 4). These are among the key themes from this competency assessment:

- Engineers require the highest level of competencies across all smart grid skill areas
- Specialists in IT, Telecom, Cyber Security, Interoperability and Field Crew resources require high levels of competencies for smart grid technology skills
- Officers/Executives and Managers/Supervisors require high levels of smart grid organizational management and customer management skills
- Competency in Customer Communications & Relationships skills are required across all job classifications

Further analysis of this information-rich matrix will guide future curriculum and delivery channel options.

Smart Grid Training Market Opportunities

After identifying the impacted jobs, skill requirements, and competency levels, our team evaluated current gaps in smart grid training. This task included assessing the capacity and the accessibility of current smart grid training practices available for the specified job classifications and skill deficiencies. The gaps identified in smart grid training led to the development of the Smart Grid Training Opportunities Web (Figure 5), which displays a snapshot of the current training opportunity available for a given smart grid job function for each of the previously defined smart grid skill areas.

To properly assess the current availability of smart grid training programs, we utilized responses from a second international survey; conducted interviews with a sampling of national associations, vendors, educators, labor unions, and other agencies; and thoroughly reviewed previously published research, reports, and other articles on the topics of smart grid training and education.

The current opportunities for training, coupled with job classifications that require a high degree of skill area competence, led to the identification of Smart Grid Hot Jobs (Table 2). This report presents a summary of the smart grid "hot jobs"— jobs currently underserved with training offerings and that represent the greatest need for training given the level of competence required for the smart grid skill area.

Key Findings

The research provided insight to the specific job impacts, skill competencies, and current training landscape associated with the introduction of smart grid technologies. This effort revealed several findings that are summarized below and further discussed in the report, including:

1. The smart grid will bring new job duties, titles, and roles
2. Introduction of smart grid technologies into a utility will result in significant business transformation activities
3. Smart grid development requires significantly heightened communication skills to effectively reach and impact stakeholders; an opportunity to capture lessons learned and best practices exists through early-stage programs
4. Currently, smart grid training within organizations is minimal
5. No specific curriculum plans or courses have evolved, and most programs remain in the smart grid “awareness” stage of education
6. Labor union legacy workforce approaches will be challenged
7. There is no unified approach to frontline skills development; the industry attitude contends that smart grid technologies are just another set of new technologies to master incrementally
8. Smart grid solutions will increase demand for knowledge of multiple telecommunication systems, while skill training is minimally available and limited to vendor-specific solutions, mostly in the existing SCADA (supervisory control and data acquisition) and telecom space
9. The most developed smart grid system integration and communication training programs lie in the cyber security arena
10. Large-scale equipment vendors do not have integrated smart grid training programs beyond specific vendor solutions but expressed a desire to collaborate, build, and use these programs
11. Smart grid professional certifications have not yet been developed nor delivered

Conclusion

This comprehensive research approach produced useful insights and tools to evaluate the current availability and content of ncessary smart grid education and training.

The lack of training in the smart grid sector is not surprising and is one of the predominant reasons the government is investing heavily in the current round of smart grid education grants. Aggressive development of smart grid training is being hampered, however, by barriers that are only slowly being addressed, such as the immaturity and continued ambiguity of the smart grid concept itself, the industry’s inability to take on the short-term risk for the long-term reward, significant resistance to change, and the need for a more efficient workforce to operate a smarter grid while replacing key skills and knowledge lost through high attrition rates.

While utilities are investing significant resources in AMI programs, smart grid roadmaps and business plans, and demand response activities, the evolution of the smart grid workforce needs time to grow and “catch up” to the significant levels of infrastructure investment. This growth will be hampered by the sizeable attrition rate occurring in the industry over the next five to ten years. But there may be enough time for the education industry to develop, align, and deliver industry-endorsed degree programs, certificates, and applied training programs. The reward for swift and integrated actions will be a well-prepared workforce able to leverage the newly transformed electric utility industry.

2 Background

2.1 Smart Grid Workforce Training

The aging U.S. electric grid is subject to significant challenges from increased growth in power needs, decreased investment in transmission connectivity, remote deployment of renewable generation resources, consumer digital reliability expectations, and more recent concerns about physical and cyber security threats to critical infrastructure. These challenges have compelled industry and government stakeholder investment to modernize the electric grid and turn it into a 21st Century network that provides numerous benefits, including resiliency and flexibility, and enables new products, services, and markets. This shift to a "smart grid" that can heal itself, engage active participation by consumers, accommodate all generation and storage options, and provide energy independence and security has been described as a "transformational" event; an event perhaps as significant as the creation of the Internet.

The Energy Independence and Security Act of 2007 catalyzed the industry and promoted the federal government into a leadership position in this arena. Smart grid activities are becoming well documented and discussed on main streets as the federal government, electric utilities, and industry vendors have invested over $8 billion dollars annually in the past three years in smart grid technologies, systems, and processes. A recent report by the Electric Power Research Institute (EPRI) estimates the United States will spend $17 billion to $24 billion annually for the next 20 years to realize the full smart grid vision[1].

This transformational level of capital investment is occurring in an industry already suffering from shortages of key engineering and technical skills. In addition, as the aging baby boomer generation reaches retirement age, the utility industry could lose 40 to 50 percent[2] of its current workforce, taking with it irreplaceable knowledge and experience. The addition of new smart grid technologies; the conversion of legacy planning, operations, and decision-making; and the transformation of traditional utility stakeholder relationships require a new highly-trained and flexible workforce to realize the full smart grid promise. This new workforce will be vital to deploying and maintaining a national clean-energy smart grid infrastructure.

While many organizations, institutions, companies, and government sectors are focused on training workers for the green economy, there is a critical shortfall in key knowledge and skills required by the future smart grid workforce. The nation's capability to manufacture new electrical equipment for smart grid implementation and to enhance research and development needed to launch a national clean-energy mandate hinges on successful establishment of a highly trained workforce that can support the changing U.S. electric industry. This can only be addressed through an increased commitment to an intensive, sophisticated set of workforce development initiatives.

2.2 Research Purpose & Objectives

In April 2010, the Illinois Institute of Technology (IIT) received $5 million in funding from the Department of Energy (DOE), for a total project dollar value of more than $12.5 million, to establish the IIT Smart Grid Education and Workforce Training Center and develop and deploy training programs focused on smart grid technology.

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[1] Sticker Shock: EPRI Says Smart Grid Will Cost $165 Billion Over 20 Years. Feb 15, 2010. SmartGridNews.com
[2] 2007 Workforce Survey Report from the Center for Energy Workforce Development (CEWD)

As part of the funding, IIT partnered with West Monroe Partners (WMP) to conduct a national assessment of needs for smart grid workforce training, supported by stakeholder surveys, extensive interviews, and reviews of existing published data reported by educational institutions, interest groups, labor organizations, and government agencies. The research team identified the specific job classifications to be targeted for training and skill deficiencies impacted by the smart grid and that should be addressed through the workforce improvement efforts. Further, the team identified gaps in current smart grid training by assessing the capacity and the accessibility of current training opportunities in the United States. Our research team conducted a comprehensive review of available training practices in use for the specified job classifications and skill deficiencies identified.

2.3 Approach Overview

The diagram below provides an overview of the approach our team used to conduct a comprehensive assessment, define the future jobs and skills most impacted by the introduction of smart grid technology, and review available training practices in use for the specified smart grid job classifications and skill deficiencies.

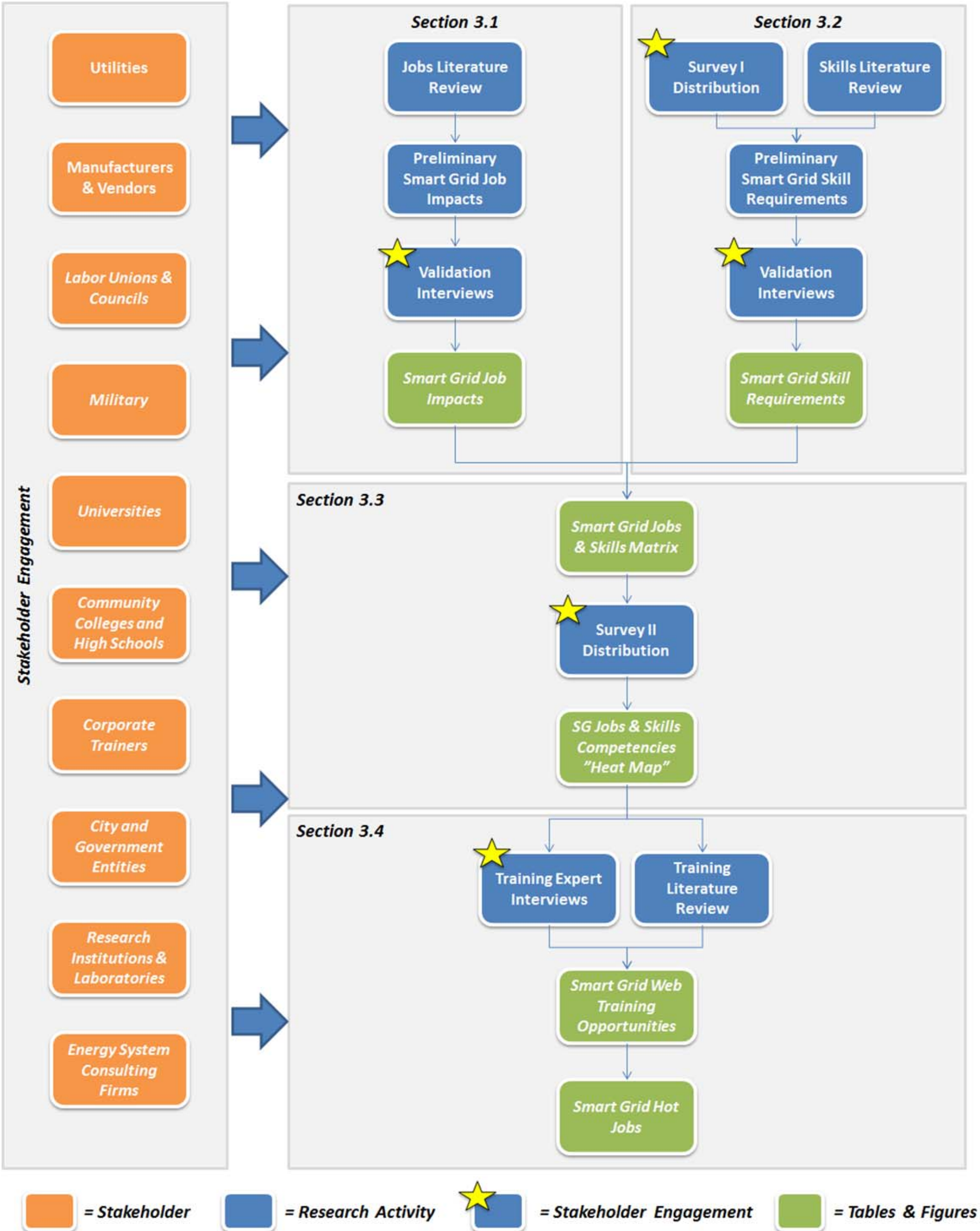

Figure 1: Workforce of the Future Research Approach Overview

3 Methods & Results

3.1 Smart Grid Job Impacts

3.1.1 Overview

The purpose of this commissioned research study is to identify the jobs impacted by the smart grid and the level of impact the smart grid has on these jobs. Jobs identified as being impacted by the smart grid include 104 of the Bureau of Labor Standards Standard Occupational Classifications (SOC). Our team grouped these 104 jobs under seven organizational/department categories and three functional expert categories.

3.1.2 Methodology

To appropriately define the industries, jobs, and specific occupation skills that will be impacted by smart grid, our team conducted an extensive review of existing secondary research and data. The literature review included identifying the specific job categories most impacted by smart grid technologies and processes The research included review of the DOE smart grid job classifications, the Occupational Information Network (O*Net), the Bureau of Labor Statistics of the U.S. Department of Labor (BLS), and the DOE Smart Grid Department of Labor SOC List.

This effort produced a hypothesis of the defined jobs classifications most impacted by the introduction of smart grid technologies and processes. We then vetted and validated the smart grid job classifications and hypothesized degree of impact by interviewing a diverse sampling of utilities, academics, laborers, and engineers, all from a variety of U.S. geographic regions.

3.1.3 Results

The smart grid job categories fall into seven organizational/department classifications and three functional/expert classifications. The smart grid job categorization is listed below:

<u>Organizational / Department Classifications</u>

1) Officer/Executive
2) Manager/Supervisor
3) Field & Line Crew
4) Customer Service/Marketing
5) Business & Support Specialist
6) Legal & Regulatory
7) Communication & Public Relations

<u>Functional / Expert Classifications</u>

1) Engineering
2) IT/Telecom/Cyber Security/Interoperability
3) Architecture/Manufacturing/Building Design

Our team further classified each of these identified 104 SOC jobs with respect to the severity of impact—major, moderate, or minor—that smart grid activities and technologies will have on the typical daily job functions. For example, our research revealed 35 jobs facing major impact from smart grid implementation (23 organizational/department and 12 functional). These "major-impact" positions will experience more than 50 percent redefinition or elimination of their job duties or responsibilities. The following tables display the jobs most significantly impacted by the introduction of smart grid technology.

Table 1: Smart Grid Jobs with Major Impact

SOC	Organizational/Department Job Classifications w/Major Impact (23)
	Managers/Supervisors
11-1021	*General and operations managers (includes facility managers)*
11-2020	*Marketing and sales managers*
11-3021	*Computer and information systems managers*
11-9041	*Engineering managers*
11-3031	*Financial managers*
	Field Employees
47-1011	*First-line supervisors/managers of construction trades and extraction workers*
33-1000	*First-line supervisors/managers, protective service workers*
43-5041	*Meter readers, utilities*
47-2111	*Electricians*
47-4011	*Construction and building inspectors*
49-2094	*Electrical and electronics repairers, commercial and industrial equipment*
49-2095	*Electrical and electronics repairers, powerhouse, substation, and relay*
49-9051	*Electrical power-line installers and repairers*
49-9052	*Telecommunications line installers and repairers*
49-9099	*Installation, maintenance, and repair workers, all other*
51-8012	*Power distributors and dispatchers (include system dispatchers)*
	Customer Service/Marketing
41-4011	*Sales representatives, wholesale and manufacturing, technical and scientific products*
43-4051	*Customer Sales Representatives*
	Business & Support Specialists
13-1111	*Management analysts*
15-2031	*Operations research analysts*
	Legal & Regulatory
11-9199.01	*Regulatory Affairs managers*
13-1041.07	*Regulatory Affairs specialists*
	Communication & PR
27-3031	*Public relations specialists*

SOC	Functional Expert Classifications Job Classifications w/ Major Impact (12)
	Engineers
17-2070	*Electrical and electronics engineers*
17-2071	*Electrical engineers*
17-2072	*Electronics engineers, except computer (includes telecommunications engineer)*
	IT/Telecom/Cyber security/Interoperability
15-1061	*Database administrators*
15-1071	*Network and computer systems administrators*
15-1081	*Network systems and data communications analysts*
15-1099.02	*IT systems architecture (Computer Systems Engineers/Architects)*
15-1030	*Computer software engineers*
15-1031	*Computer software engineers, applications*
15-1032	*Computer software engineers, systems software*
	Architects/Manufacturing/Building Design
17-1011	*Architects*
17-3011.01	*Architectural drafters (include GIS mappers)*

3.2 Smart Grid Skill Requirements

3.2.1 Overview

Our research reveals broad and diverse opportunities for developing the future smart grid workforce. The skill requirements arising from implementation of the smart grid will include opportunities to update and integrate current knowledge and areas in line with new roles and responsibilities. Skill deficiencies relate to the technologies and operations of smart grid elements, as well as to the business and management issues triggered by smart grid evolution. Since the smart grid is still evolving, the current skill requirements represent a snapshot of current known and predicted knowledge and skills gaps and will be subject to modification and update over the next few years; however, our research offers a starting point to design and deliver needed training.

3.2.2 Methodology

Our team conducted an extensive review of existing published data, research, and literature. For example, we relied upon industry-leading trade organization reports and published data; national electric system, interoperability, and technology standards and initiatives; equipment manufacturer and vendor specifications; and key smart grid evaluation models such as:

- Department of Energy National Energy Technology Laboratory (NETL), especially the results from the five-year smart grid Implementation Strategy research;
- GridWise Architecture Council research, publications, and proceedings;
- Institute of Electrical and Electronics Engineers (IEEE) Smart Grid Conceptual Model, Grid Operations and Planning, and IntelliGrid standards, research, and reports;
- Electric Power Research Institute (EPRI) smart grid research, demonstration projects, and resources;
- Carnegie Mellon Software Engineering Institute's Smart Grid Maturity Model.

The complete listing of resources is included in this report's Appendix.

Additionally, our team collected survey responses and conducted qualitative interviews with a diverse sampling of industry professionals. This allowed the team to formulate a preliminary draft of smart grid skill areas and skill deficiencies. Our team then validated and reviewed the preliminary draft of smart grid skill areas and deficiencies with a sampling of cross-industry experts through individual validation interviews. This validation exercise led to the conclusive definition of the specific smart grid skills to be addressed through workforce improvement efforts.

3.2.3 Results

Our research revealed 98 specific skills related to smart grid technologies and processes, grouped under 12 major categories. These skills and categories represent knowledge and training gaps based on current smart grid visions and are not intended to be exhaustive or explicitly detailed. These skill categories do offer, however, a context and framework for delivering necessary skill sets and knowledge upgrades and can be tailored and adopted by individual organizations and companies as the smart grid network develops. These smart grid skills fall into four primary quadrants:

- Smart Grid Technology
- Smart Grid Systems Integration & Communications
- Smart Grid Organizational Management
- Smart Grid Customer Management

The smart grid skills are shown in the figure below.

Figure 2: Smart Grid Skills Requirements

Smart Grid Technology includes the skills and knowledge necessary to design, build, operate, and maintain components, controls, and key elements of the electrical system.

Skills deficiencies in this quadrant are grouped under the following three areas: Advanced Components, Advanced Control Technologies, and Sensing & Measuring Elements.

Advanced Components – Skills associated with installing, operating, and maintaining smart grid devices are included in this area. Typically, device vendors provide training, but when selecting and specifying devices there should be a basic understanding of when and where to utilize such devices on the network. Additionally, users should understand economic considerations, including costs and benefits derived from installation of such devices.

Advanced Control Technologies – Control methods associated with smart grid operations include both advances of current technologies and development of new applications as the smart grid grows more intelligent. These systems and technologies allow for remote feedback and control of devices and deliver decision support information for operator action.

Sensing & Measurement Elements – Smart grid intelligent devices provide status information to decision makers and include equipment sensors and monitoring systems. This area also includes applications that notify operators and allow them to assess events properly. An outage management system (OMS) would fall into this category.

Smart Grid System Integration & Communications includes the skills and knowledge necessary to design, integrate, and operate the information systems and telecommunications systems necessary for safe, reliable, and continuous grid functionality. This quadrant embraces a wide range of current and emerging telecommunications platforms and technologies, software and information systems, and the critical standards necessary to protect and integrate new smart grid developments. Information regarding smart grid system integration, communication, and architecture was derived from a number of standards development, software design, and infrastructure pilot programs and initiatives.

Skills deficiencies in this quadrant are grouped under the following three areas: IT System, Networks & Architecture; Integrated Communications Protocols & Technologies; and Cyber Security & Interoperability Standards.

IT System, Networks & Architecture – The smart grid requires more extensive data flow and data manipulation than legacy systems. Integrating the data flow from discrete interfaces requires broader and more flexible approaches. For example, utilities are installing enterprise service buses rather than creating point-to-point interfaces between applications. The output from these new systems and networks will increase database management issues and create new jobs that require new skills.

Integrated Communications Protocols & Technologies – Smart grid components and systems will use a wide array of existing and new telecommunications approaches. People working in this sector of the smart grid economy will need to master both the technologies and the standards that allow for interoperability among the various devices on the smart grid system. This relates to standards associated both on the utility side and the customer side.

Cyber Security & Interoperability Standards – A critical aspect of the smart grid is protecting the information that passes through various and sundry communication systems. Additionally, with the implementation of new applications, moving data effectively between these applications provides significant value to utilities.

Smart Grid Organizational Management includes the skills and knowledge required to address business and organizational opportunities and risks that develop from smart grid initiatives. The skills required to transform utility industry companies, organizations, and suppliers are critical to successful smart grid implementation and integration. Information regarding organizational management in this new environment was derived from numerous academic, industry, and subject matter expert sources.

Skills deficiencies in this quadrant are grouped under the following three areas: Business Transformation Challenges, Legal & Regulatory Issues, and Utility Decision Support Applications.

Business Transformation Challenges – Implementation of smart grid technology within a utility will impact many areas of the organizational structure. Organizational change management techniques and business transformation strategies will need to be developed to manage these cultural and structural challenges.

Legal & Regulatory Issues – Utilities and their regulators face many new challenges as smart grid investments are large and the systems are complex. New and alternative rate structures require design regulatory approvals. In addition, as new smart grid devices and systems are marketed, there will be patent, manufacturing, and reliability issues that develop new devices also bring with them safety and health concerns. Additionally, data privacy issues continue to surface.

Utility Decision Support Applications – Smart grid information passes between and through various devices and systems. This information is used to control the network and individual devices. The information is also used for maintenance planning, workforce management, outage restoration, and planning future smart grid expansion or upgrades.

<u>Smart Grid Customer Management</u> includes the skills and knowledge applicable to a wide range of stakeholder management, customer technologies, and alternative generation resources that occur when the smart grid is fully deployed and operating. These issues are occurring today in many areas across the country and the world as utilities plan for new customer relationships, new customer choices, and new customer control over their energy consumption in the smart grid economy. The skills include application of existing outreach and communications techniques, as well as the management and integration of new technologies beyond the meter and beyond the localized grid.

Skills deficiencies in this quadrant are grouped under the following three areas: Customer Communications & Relationships, Supply Side Management, and Customer Energy Management Systems.

Customer Communication & Relationships – The smart grid will create more customer information and choices, requiring additional systems and skills to facilitate and manage new relationships. Utilities will need to develop strategies and channels to communicate essential information effectively to customers regarding program offerings, event occurrences, and other energy conservation initiatives. In addition, utilities will need more skilled customer and marketing resources to maximize the value of the new smart grid.

Energy Supply Side Management – The smart grid standardizes and enables the integration of alternative and renewable energy resources added beyond the grid by customers. The planning, integration, dispatch, safety, and billing for these resources will require new systems and skills. In fact, there are entire new industries that have developed around these "green energy" opportunities. This research did not try to capture nor distill the dynamic growth in this market sector. Rather, these elements are included to provide a platform for skills development in managing their integration to the smart grid.

Customer Energy Management Systems – Beyond the utility meter, customers also seek control of their energy costs. This includes the ability to install and control renewable energy effectively on the grid as well as to control their energy consumption, timing of use, and choices of services. This area has attracted numerous entrants, including utilities that desire to offer competitive services beyond the meter in regulated and deregulated service territories.

3.3 Smart Grid Skill Competencies

3.3.1 Overview

Previously, our team identified the specific job classifications to be targeted for training and defined the skill deficiencies to be addressed through the workforce improvement efforts. To fully define the gaps in smart grid training needs, we needed to compare the competency level required for each point of intersection between the smart grid job classifications and each of the 12 smart grid skill areas. We achieved this competency definition by administering a second survey wherein respondents identified the level of skill competency required for each intersection of job classification and specific smart grid skill (see figure below).

IIT Smart Grid Jobs & Skills Matrix

Smart Grid Job Classifications	Smart Grid Skill Areas: Advanced Components	Advanced Control Technologies	Sensing and Measurement Elements	IT System, Networks and Architecture	Integrated Communications Protocols & Technologies	Cyber Security and Interoperability Standards	Business Transformation Challenges	Legal and Regulatory Issues	Utility Decision Support Applications	Customer Communication and Relationships	Supply Side Management	Customer Energy Management Systems
Organizational/Department Classifications												
1. Officers/Executives												
2. Managers/Supervisors												
3. Field Employees												
4. Customer Service/Marketing												
5. Business & Support Specialists												
6. Legal & Regulatory												
7. Communication & PR												
Functional Expert Classifications												
1. Engineers												
2. IT/Telecom/Cyber security/Interoperability												
3. Architects/Manufacturing/Building Design												

Figure 3: Smart Grid Jobs & Skills Matrix

3.3.2 Methodology

To obtain applicable cross-industry data that defines smart grid skill competencies, the research team designed and deployed a second research survey. The survey included 30 questions and asked the respondents to define the level of competency required for each smart grid skill per job classification. The survey yielded responses from a diverse sampling by organization size, geographic presence, and organization type, including utilities, educational institutions, consultants and vendors, and manufacturers.

3.3.3 Results

From survey data, our project team identified the level of competency required of each job classification for each smart grid skill and then created the Job Classification & Skills Heat Map, displayed in the figure below.

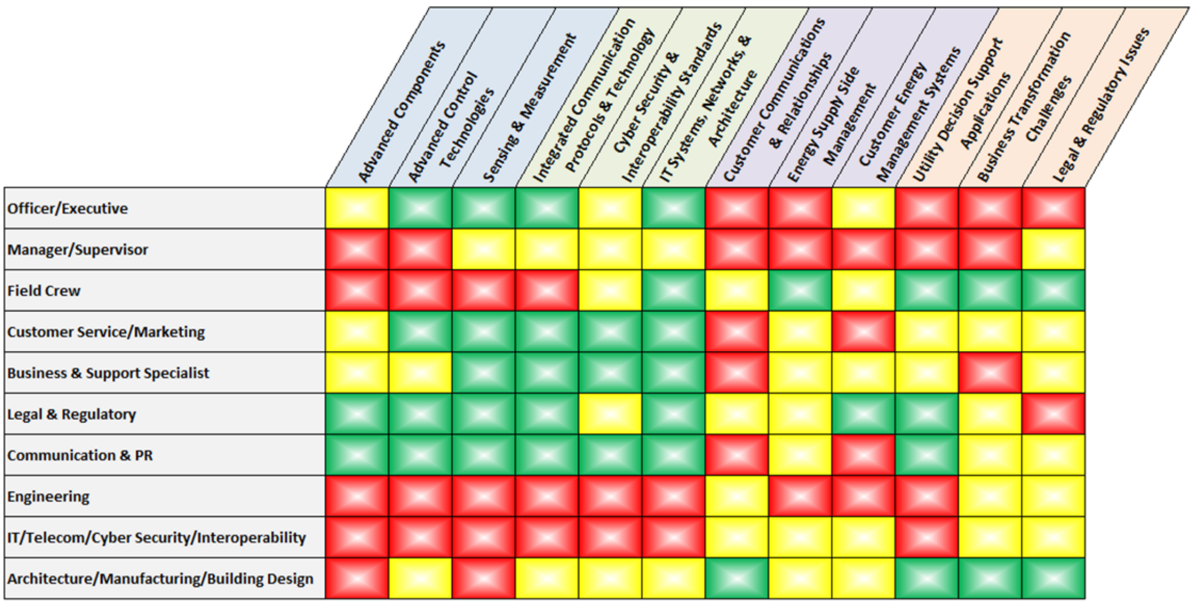

Figure 4: Smart Grid Job & Skills Competency Heat Map

The heat map represents the level of competency[3] required for each job classification (on the left) for the smart grid skill area (on the top). These competency numbers were tallied on a three-point Likert Scale:

- Aware (green): Awareness of topics and solutions being taught and an understanding of their relevance to the learner's job and industry.
- Knowledgeable (yellow): Knowledgeable of topics and solutions at a level where competency of concepts will be directly required for roughly half of the learner's job responsibilities.
- Expert (red): Mastery of topics and solutions at a level where competency of concepts will be directly required for nearly all of the learner's job responsibilities.

Below are key themes emerging from development of the Job Classification/Skills Heat Map:

1. Engineers require the highest level of competencies for smart grid skill areas across the board, specifically in smart grid Technology, Integration and Communication, and Customer Management skill areas.
2. IT/Telecom/Cyber Security/Interoperability and Field Crew resources require high levels of competencies for smart grid technology skills (IT/Telecom/Cyber Security/Interoperability resources require high levels of competencies in smart grid integration and communication skills, as well).

[3] *Levels of Learning: A Framework for Organizing Inservice Traning*, Institute for Human Services, 2001

3. Officers/Executives and Managers/Supervisors require high levels of smart grid Organizational Management and Customer Management skills.

4. Customer Communications & Relationships skills require highest level of competence across all job classifications.

3.4 Smart Grid Training Market Opportunities

3.4.1 Overview

Having defined the smart grid jobs, skill needs, and level of skill competence for each smart grid job function, the team turned its attention to identifying gaps in smart grid training needs with respect to any combination of curricula. This included assessing the capacity and the accessibility of current smart grid training opportunities in the United States. Our team employed a thorough literature review, interviews, and expert validation to ensure a comprehensive understanding of the current gaps in smart grid training needs.

3.4.2 Methodology

To assess the current availability of training programs, we approached the market analysis through the lens of IIT's previously adopted multi-level approach to providing smart grid training for employment in various industries. Specifically, the three levels of training include fundamental training, applied training, and advanced training[4].

Our approach included conducting interviews with a sampling of national associations, vendors, educators, labor unions, and other agencies and thoroughly reviewing previously published research, reports, and other articles on the topics of smart grid training and education.

The research interviews allowed us to review and benchmark several current training offerings and course curricula focused on smart grid topics through various entities, including the following leading organizations:

- National Association of Workforce Investment Boards (NAWIB)
- National Science Foundation (NSF)
- Association of Energy Engineers (AEE)
- Center for Energy Workforce Development (CEWD)
- American Association of Community Colleges (AACC)
- Pacific Northwest Center of Excellence for Clean Energy Technology
- Society for Manufacturing Engineers (SME)
- S&C Electric
- Institute of Electrical and Electronic Engineers – Power and Energy Society (IEEE-PES)
- International Brotherhood of Electrical Workers (IBEW)
- National Electrical Contractors Association (NECA)
- Power Systems Engineering Research Center – University of Wisconsin – Madison

[4] A World-Class Smart Grid Education and Workforce Training Center, Power and Energy Society General Meeting, 2010 IEEE, 25-29 July 2010

Additionally, our team conducted a thorough literature review to summarize and synthesize the leading resources on smart grid training. The resources include industry-leading trade organization reports, published survey data, academic reports, published education curriculum models, and smart grid related competency models (see Appendix for a detail listing of references). This comprehensive repository of current knowledge on this subject area has been considered and incorporated into the results of this report.

3.4.3 Results

The environmental scan of the availability and accessibility of smart grid training has revealed gaps in both content and delivery. Our team combined the smart grid job competency assessment derived from our survey results and incorporated the analysis from our research of training availability. The result is a current snapshot of training opportunities available for each job function and skill competency level.

To fully determine the training opportunities available for a given smart grid job function, it was necessary to relate the significance of the smart grid occupation to the level of job competency required for the smart grid related skill area. Our analysis led to the development of the "Smart Grid Training Opportunities Web," which displays a snapshot of the current training opportunity available for a given smart grid job function for each of the previously defined smart grid skill areas. The figure (below) provides a sample of training opportunity available for three skill areas.

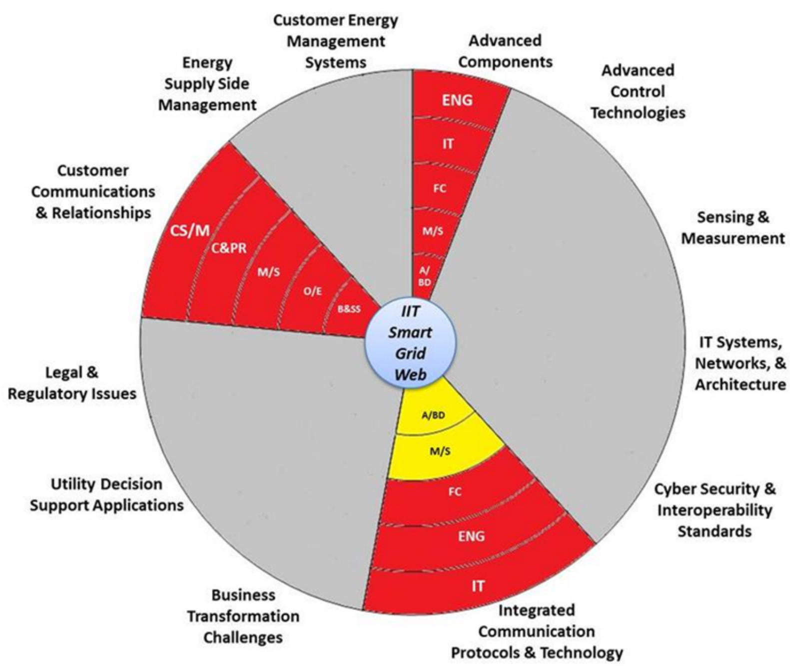

Figure 5: Smart Grid Training Opportunities Web

Smart Grid Web Job Classification Key

O/E – Officer/Executive	C&PR – Communication & PR
M/S – Manager/Supervisor	ENG – Engineering
FC – Field Crew	IT – IT/Telecom/Cyber Security/Interoperability
CS/M – Customer Service/Marketing	A/BD – Architecture/Manufacturing/Building Design
B&SS – Business & Support Specialist	

Each specific smart grid skills surface area represented in the Smart Grid Training Opportunities Web reflects the total available training opportunity (the larger the surface area, the larger the available training opportunity). Each job function is listed from highest competency to lowest competency level for each of the smart grid skills areas as shown in the figure above.

In this web diagram, the size of each "slice" of the circle for each of the 12 skills categories represents the size of the gap in currently available training. For instance, there is less training available for skilled technological and networking activities, producing a larger opportunity slice. Conversely, more training exists currently for business operations and transformations; thus, the opportunity slice is smaller. Additionally, each individual slice can be further segmented into competency levels ranging from the highest competency level on the outside ring, to a lower competency level in the inside ring. There are three examples of this competency segmentation highlighted in the web diagram above: Advanced Components, Customer Communications & Relationships, and Integrated Communication Protocols and Technologies.

Examining the Customer Communications & Relationships "slice" demonstrates the power of this mapping. For instance, in our education and training model, jobs that relate to customer service and marketing duties have the highest need for competency in this category (estimated to require an "expert" level of competence) and appear in the outside ring of this category. Conversely, Business & Support Specialists are estimated to need a lower level of competency in this category and appear in the inner ring. The overall level of training opportunity (or need) in this category is greater than in other areas, and therefore, the total surface area of the slice is larger. Compare this to the Advanced Components category where the slice is smaller, and thus, the training opportunity is smaller due to numerous organizations already providing training within this skill area.

Although this diagram only provides a sampling of our results, this approach can be applied for every job classification and skill area. This approach provides a framework for developing training and can prioritize smart grid "hot jobs"—or those jobs that are currently underserved with training offerings and also represent the greatest need for training, given the level of competence required for that skill area. Some of the identified "hot jobs" from our research are detailed in the table below, including the list of skill competencies for each smart grid job.

Table 2: Smart Grid "Hot Jobs" Per Skill Area

Manager / Supervisor
- Advanced Control Technologies
- Customer Communications & Relationships
- Customer Energy Management Systems

IT/Telecom/ Cyber Security/ Interoperability
- Integrated Communication Protocols & Technology
- Cyber Security & Interoperability Standards
- Advanced Control Technologies
- Sensing & Measurement

Engineering
- Advanced Control Technologies
- Integrated Communication Protocols & Technology
- Sensing & Measurement
- Cyber Security & Interoperability Standards
- Customer Energy Management Systems

Customer Service/ Marketing
- Customer Communications & Relationships
- Customer Energy Management Systems

Field Crew
- Advanced Control Technologies (2.4)
- Sensing & Measurement
- Integrated Communication Protocols & Technology

4 Key Findings & Conclusions

4.1 Key Findings

Our research provided insight to the specific job impacts, skill competencies, and current training landscape associated with the introduction of smart grid technologies. Our effort revealed several findings that are discussed below.

Finding #1: The smart grid will bring new job duties, titles, and roles.

The convergence of telecommunications systems, information technology, and electrical system operations will demand combined and blended skill sets for front-line employees, technicians, operators, and engineers. The integration and blending of these skill sets will create new field and operations roles and responsibilities.

The entire strategic transition of the electric utility industry as a result of the transformational impact of smart grid solutions will create new job titles and combination skills and duties such as Grid Administrator versus the existing System Dispatcher, System Operations Manager versus Distribution Manager, or Digital/Network Supervisors and Technicians. These jobs will also blend cyber security and risk management skills into real-time decision support and operational decision making.

The addition of two-way communications from the customer usage perspective will create new job duties and responsibilities for the frontline customer service representatives. Utilities need to add knowledge and job skills in managing customer options and relationships. This retraining effort requires integrating traditional customer account manager responsibilities, new knowledge of smart grid information flow, home area network (HAN) integration, and improved customer marketing and consulting skills.

As the industry continues to expand smart grid technologies and components throughout the next five to ten years, the presence of contract labor will expand and become an integrated component of ongoing utility operations. The rapid expansion of new technologies, operations, and relationships virtually assures the critical need for more contract management and project management skills in the utility of the future.

Beyond the meter, the smart grid will also open up new job roles and responsibilities that will expand from current energy management and conservation roles to trusted energy advisors, distributed generation integrators, and home energy specialists. Industrial, commercial, and residential providers of service will also need to be trained and educated about smart grid technologies and processes to leverage the new consumer partnership fully.

Finding #2: Introduction of smart grid technologies into a utility will result in significant business transformation activities.

Smart grid technologies and processes will transform our electric industry and our society. For example, the integration of distributed and renewable energy resources will require unique system planning and operational strategies, especially when combined with demand response, storage, and customer energy control options.

Integration and automation of the distribution system will migrate control and design of the system from operations to the IT department. Legacy operations groups may not accept these changes readily, requiring use of significant change management techniques. Such a strategic re-focus will also require re-educating the IT department about true customer service needs and interfaces, or even creating a new operations management expert with elements from each of these disciplines.

Customer relationships and energy partnering will become valued and tangible resources to develop and manage. Utility managers, regulators, and investors will have to deal with new risks and risk management techniques as well as the dynamics of competition and growth. Smart grid technology choices, integration, management, and operations will require new decision-making platforms and data analysis techniques. The entire range of interaction between the utility and the customer will mimic the real-time generation and utilization of electricity and will create new and challenging choices.

Finding #3: Smart grid development requires significantly heightened communication skills to effectively impact stakeholders; an opportunity to capture lessons learned and best practices exists through early-stage programs.

Implementing a smart grid program includes changing the entire utility corporate mindset relative to customer relationships and involvement in the energy business. Integrated knowledge of alternative resources, new sources of data, and new choices for the customers must be blended into a myriad of educational resources (on-line customer education, digital media, community outreach, and education). The outreach, marketing, and education activities also need to embrace regulatory and employee stakeholder management. As AMI is rolled out, the customer will become more involved in the energy procurement process. Successful customer adoption will be reliant on tailored and flexible pricing schemes, the quality and usefulness of information provided to the customer, and customer appetites for control, security, and comfort.

Traditional utility customer outreach and information sharing will be challenged in dealing with an increasing customer expectation for useful decision-making information. Third-party access and utilization of legacy proprietary customer information will affect the nature of customer data security and control.

Customer choices, options, and responses will expand geometrically, and a static "one-size-fits-all" approach to customer relationship management will evolve into a multi-channel, mixed-media, real-time portfolio for every utility. Creating alliances and partnerships with large commercial and industrial customers, off-system generators, and key home area network vendors will extend the utility's communication needs beyond the meter and into an environment rich with competition, choices, and distractions. Additionally, regulatory, legislative, and governance communications will become highly charged and focused on leveraging these new investments and increasing customer satisfaction.

Lastly, smart grid customer management training is evolving at both the utility and private training levels, where strong customer relationship management training and skills development already exist. Some community colleges will also expand communications programs to target technology communication and customer education in addition to customer service. With numerous AMI programs underway, however, the landscape for customer communications and relationship management is evolving. There is an opportunity to capture lessons learned and best practices in these early programs to help develop smart grid specific skills training and longer-term combined skills jobs.

Key Finding #4: Currently, smart grid training within organizations is minimal.

Interviews revealed that while companies and organizations have initiated new smart grid employee training and development, it consists of a basic awareness and exposure to the smart grid. Very few utilities have initiated comprehensive and integrated training platforms for future smart grid skill development. Participants of our survey gleaned their own knowledge from individual internet "surfing" of favored sites. Some industry seminars are attended, but no one has yet to develop an integrated and sustainable employee development plan.

The interviews revealed that a useful tiered learning framework could offer initial and ongoing opportunities to create and expand organizational smart grid skills tied to the timing and expansion of a utility's own smart grid plans. For instance a Tier One exposure to AMI, for current and future employees would provide knowledge and skills mastery over the HAN, AMI, and communication systems as well as the required service, support, and education of customers. Tier 2 might include maintenance and operations of the digital system integration, including MDM and cyber security as AMI becomes more widespread and coverage is completed. Tier 3 might address DA and SA applications, skills, and integration into legacy systems, including new grid control and dispatch skills, information management skills, and component and technology mastery. This approach would use internal and external training programs, self-paced instruction, on-site or off-site certification, continuing education, and new learning technologies, and does not yet exist as an integrated, bundled, and delivered product set.

Key Finding #5: No specific curriculum plans or courses have evolved, and most programs remain in the smart grid "awareness" stage of education.

The electric industry has initiated smart grid program scoping and development, and several of the primary industry organizations—including the IEEE, Center for Energy Workforce Development (CEWD), and Electric Power Research Institute (EPRI)—have proposed curriculum elements and suggested focus. But, again, there are few "delivered" programs, and no integrated approach or active leadership exists. In addition, the United States government has funded numerous educational efforts through the DOE, Department of Labor, and other federal departments, focused on creating jobs in the green sector. These programs have yet to yield explicit smart grid technology or integration programs but have developed strong foundations in distributed generation, alternative energy sources, and energy conservation and usage—all components of smart grid beyond the meter.

Much of this investment in job training has been focused at the community college level, a market that exists nationally but delivers at a local level. One of the more prevalent sets of training is for Energy Technicians, which is almost ubiquitous in the community college and professional certification industry (e.g. Association of Energy Engineers, Society for Manufacturing Engineers, etc.). There is opportunity to expand these programs and add tailored modules for specific smart grid solutions, but there are no current plans at a national level to guide or move this curriculum forward. In most cases, professionals in these industries cited a lack of demand for smart grid courses and noted their continued operations are dependent on providing needed and valued programs.

Finding #6: Labor union legacy workforce approaches will be challenged.

Training a new workforce with blended telecommunications, IT, and power system electrical skill sets will require new learning methods, incremental expansion of current basic skill sets, and challenges for organized labor legacy approaches to jurisdictional classifications and contract job duties. In addition, front-line employees will also be expected to interact regularly with the customer in a new information sharing and partnership relationship, requiring major upgrades to their communications and relationship-management skills.

Real-time decision making, customer communications, and flexibility in work duties will require labor unions to redesign current approaches to building employee/member value and receiving fair and equitable reimbursement in return. Management of this new workforce will also require changes in approach, expectations, and collaboration. Multiple blended job classifications shared among multiple labor unions will be necessary to effectively create a new smart grid workforce.

Currently, this sector of the industry is gathering information and designing new classes, but this work is occurring in separated and disparate clusters across the country. For instance, the 750,000 members of the International Brotherhood of Electrical Workers (IBEW) are organized and trained at more than 940 local chapters. The National Electrical Contractors' Association (NECA) is similarly structured with more than 115 local chapters. Absent national leadership, guidance, and direction, the impact of smart grid systems on this workforce will move forward in an independent and reactive basis and could jeopardize labor/management relationships in the future.

Key Finding #7: There is no unified approach to frontline skills development; the industry attitude contends that smart grid technologies are just another set of new technologies to master incrementally.

There is no unified approach to frontline skills development, although existing pre-apprentice, apprenticeship, and journeyman programs have been elevated in importance as the industry is forecasted to lose significant levels of experience through attrition. This replacement effort is occupying more attention than developing smart grid specific skills or combined classifications based on the convergence of telecom, information, and electricity. The industry attitude, top to bottom, is that smart grid technologies are just another set of new technologies to master incrementally. Experts refer to "upskilling" and "re-skilling" versus new training material or approaches.

The industry is depending on legacy approaches to incremental education and skills versus developing new integrated skill sets. This prevailing opinion lacks urgency, may not consider the massive financial and political investment in smart grid technologies and programs, and has not considered issues of cross-classification skills and job duties. Experts admit that the impact of smart grid programs and policies will change the historical nature of the utility, but they have not yet become interested in designing new integrated job classifications or roles or re-visiting current approaches to learning. There are opportunities to elevate local and state-wide skills-based programs to a coordinated national level.

Key Finding #8: Smart grid solutions will increase demand for knowledge of multiple telecommunication systems, while skill training is minimally available and limited to vendor-specific solutions, mostly in the existing SCADA and telecom space.

One of the more significant changes created by smart grid solutions is the transformation of a legacy electric utility into a modern telecommunications provider. Electric utilities have traditionally hired telecommunication technicians and engineers to manage their SCADA, telecommunication, and radio systems. AMI developments will require broad and significant expansion of telecommunication systems, including wireless and cell technologies, not currently mastered by electrical utility workers. In addition, current telecommunication workers are not familiar with, nor trained in, maintenance, installation, and repair of integrated electric/telecommunication networks. These legacy workers are typically restricted to working in the telecommunication "safe zone" residing below the distribution lines.

The future smart grid electric utility will resemble a telecommunication company in every aspect, including the planning and operational requirements for an integrated network operations center (NOC). Customer portals, substation gateways, and distributed automation (DA) device intelligence will be linked through multiple media options and technologies, each with their own life-cycles and maintenance cycles. Additionally, utilities are using multiple communication protocols that must be understood and maintained by utility personnel.

Training on smart grid system integration and communication is minimally available and limited to vendor specific solutions, mostly in the existing SCADA and telecom space. Advanced smart grid college curricula and craft skills development courses have yet to be developed, although a number of IBEW local offices and vendors are beginning to discuss joint program development. The national level of both utility and labor organizations is only at the awareness stage of this training gap issue, and no specific curriculum plans or courses have evolved. Moreover, a recognized national or even regional leader does not exist in this space. This is a major contributing factor to the lack of complete interoperability standards.

Key Finding #9: The most developed smart grid system integration and communication training programs lie in the cyber security arena.

The most developed training programs of smart grid system integration and communication lie in the cyber security arena. This activity has been spurred by federal legislation and Federal Energy Regulatory Commission (FERC), North American Electric Reliability Corporation (NERC), and National Institute of Standards and Technology (NIST) cyber security and reliability initiatives focused on protecting critical infrastructure in the industry. There is a natural evolution and application of these standards and techniques to smart grid communication and software integration technologies. Many of these early standards are in use in numerous smart grid deployments, and training is available through vendors, universities, and community colleges.

As further interoperability and security standards are developed and approved over the next five years, there will be a growing need to educate and train industry engineers, technicians, and managers in these requirements. Since security is at the core of smart grid solutions, the current level of training and development will increase signficantly.

Key Finding #10: Large-scale equipment vendors do not have integrated smart grid training programs beyond specific vendor solutions but expressed a desire to collaborate, build, and use these programs.

Conversations with large scale equipment vendors reveal a lack of integrated smart grid training programs beyond specific vendor solutions. The rush to market, driven by industry investment, replaces long-term smart grid system education with short-term equipment installation, operation, and maintenance guidance. The larger vendors with which we spoke are interested in developing internal education for their own world-wide workforces and participating in development of broader skills-based and applied training.

Key Finding #11: Smart grid professional certifications have not yet been developed nor delivered.

Smart grid professional certifications have not yet been developed nor delivered. Leading vendors in this space are interested but not yet committed, since they have yet to see the demand. This represents possible opportunities alignment and partnership.

4.2 Conclusion

Through an exhaustive literature review, personal interviews, broad surveys, and expert validation, our research team has produced useful insights and tools to evaluate the current availability and content of needed smart grid education and training. While there are numerous ongoing activities that could develop into valued skills training and knowledge advancement, these efforts are fragmented and narrowly focused. The range of smart grid competencies is great and the available smart grid training to deliver these competencies is small. This gap needs to be filled through aggressive and integrated education and training initiatives over the next few years.

The lack of training in this sector is not surprising and one of the reasons the government is investing heavily in the current round of smart grid education grants. Aggressive development of smart grid training is being hampered, however, by barriers that are only slowly being addressed. These barriers include the immaturity and continued ambiguity of the smart grid concept itself, the industry's inability to take on the short-term risk for the long-term reward, significant resistance to change, and the need for a more efficient workforce to operate a smarter grid.

While utilities are investing significant resources in AMI programs, smart grid roadmaps and business plans, and demand response activities, the evolution of the smart grid workforce needs time to grow and "catch up" to the significant levels of infrastructure investment. This growth will be hampered by the sizeable attrition rate occurring in the industry over the next five to ten years, but there may be enough time for the education industry to develop, align, and deliver industry-endorsed degree programs, certificates, and applied training programs. The reward for swift and integrated actions will be a well-prepared workforce able to leverage the newly transformed electric utility industry.

5 Appendices

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5.2 Resources

To appropriately define the industries, jobs, and specific occupation skills that will be impacted by a smart grid, our project team conducted an extensive review of existing secondary research and data. We reviewed and synthesized these resources for the purposes of incorporating all relevant smart grid related research and knowledge into this report. The following summary of smart grid related research and resources serves as a comprehensive repository of current smart grid thought leadership resources.

Smart Grid Job Classifications, Skills, and Competencies

- ***Department of Energy Smart Grid SOC codes (See Appendix B) –*** *Within the Guidebook for ARRA Smart Grid Program Metrics and Benefits, the DOE published the group names for the specific smart grid related Department of Labor Job Categories. This initial listing of occupational categories was used to define the initial listing of smart grid related occupations.*

- ***Occupational Information Network (O*Net) –*** *The Occupational Information Network (O*Net) was used to review the descriptions and further define the listing of the DOE smart grid SOC occupations. Additionally, the listing of DOE smart grid SOC codes was comparatively analyzed against the O*Net Green Occupations database sector from the report "Greening of the World of Work: Implications for O*NET®-SOC and New and Emerging Occupations." The O*Net database helped provide the preliminary input for job description and job related tasks for the occupation.*

- ***Banner Center for Energy*** *– A statewide, industry-driven resource for energy workforce education and training. The website and resources were reviewed to incorporate smart grid technologies and processes into this report.*

- ***Better Power Lines (BPL) Global*** *– A smart grid technology company dedicated to leading the transformation of energy efficiency and reliability. The website and resources were reviewed to incorporate smart grid technologies and resources into the research findings.*

- ***Cambridge Energy Research Associates (CERA)*** *– Leading advisor to international energy companies, governments, financial institutions, and technology providers. The website and resources were reviewed to incorporate smart grid technologies and resources into the research findings.*

- ***Carnegie-Mellon Software Engineering Institute (SEI)*** *– The Smart Grid Maturity Model (SGMM) is a management tool that helps utilities plan smart grid implementation, prioritize options, and measure progress. SGMM was used to identify skill categories and training deficiencies.*

- ***Department of Energy (DOE), Smart Grid*** *– Established to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions. The list of DOE grants (SGIG awards and Smart Grid Workforce Selections) programs, technologies, and standards were reviewed and incorporated into the research.*

- ***Edison Electric Institute (EEI)*** *– An association of shareholder-owned electric companies. Provides information about EEI products, services, and meetings; and electric utility industry* *restructuring. The website and resources were reviewed to incorporate smart grid technologies, policies, standards, and activities into the research findings.*

- ***Edison Foundation** – **Institute for Electric Efficiency** – Promotes advanced energy-efficiency practices and demand response among electric utilities; the sharing of information, ideas, and experiences in energy efficiency and demand response in the power sector; and development of a resource base of effective business models, practices, and processes. The website and resources were reviewed to for research, developments, and technologies related to the smart grid.*

- ***Electric Power Research Institute (EPRI)** – An independent, non-profit company performing research, development, and demonstration in the electricity sector for the benefit of the public. The website and resources were reviewed for smart grid technologies, standards, research, papers, activities, etc.*

- ***Electric Utility Consultants Inc. (EUCI)** – A leading provider of in-person and online conferences, seminars, workshops, and courses designed exclusively for the energy industry. The website and resources were reviewed for industry technologies, issues, conferences, and report findings.*

- ***Federal Energy Regulatory Commission (FERC)** - Provides notices, major orders, and energy information for the electric, gas, oil, and hydro industries. The website and resources were used to review policies, programs, initiatives, technologies, developments, and research related to smart grid.*

- ***Galvin Electricity Initiative** – The organization is leading a campaign to transform the way communities generate, deliver, and use electricity across the nation. Promotes a new smart grid paradigm that is consumer-focused and based on microgrids. The website and resources were reviewed to consider smart grid technologies, services, and developments.*

- ***Global Smart Grid Federation** – Committed to creating smarter, cleaner electricity systems around the world. The federation will share best practices, identify barriers and solutions, foster innovation, and address key technical and policy issues. The website and resources were used to review smart grid technologies, world market developments, and other smart grid activities.*

- ***Greentech Media (GTM) Research** – Provides critical and timely market analysis in the form of concise and long-form market research reports, monthly newsletters and strategic consulting services. The website and published reports were used to research smart grid developments, links, technologies, and studies.*

- ***GridWise Alliance** – The GridWise Alliance developed into an organization that represents a broad range of the energy supply chain from utilities to large tech companies to academia to venture capitalists to emerging tech companies. The website and resources were used to understand smart grid developments, technologies, and industry activities.*

- ***GridWise Architecture Council (GWAC)** – A team of industry leaders who are shaping the guiding principles, or architecture, of a highly intelligent and interactive electric system. The website and resources were used to define the underlying smart grid technologies, designs, and systems.*

- ***IBM** – Develops innovative smart grid technologies for utilities, helping to reduce energy usage, costs, and greenhouse gasses. The website and resources were used to define technologies, processes, activities, industry information, Global Intelligent Utility Network Coalition, and the Smart Grid Maturity Model.*

- ***Illinois Smart Grid Collaborative (ISGC)** – The Illinois Statewide Smart Grid Collaborative was established by the Illinois Commerce Commission (ICC) in September 2008, by its Order in Docket No. 07-0566. The website and on-line resource documents were referenced and used to understand Illinois smart grid developments, smart grid definitions, smart grid applications, technical components, current strategies, challenges, policies, and consumer engagement models.*

- ***Illinois Smart Grid Initiative (ISGI)** – The ISGI is a public-private working group formed in 2008 to engage Illinoisans in examining 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 website and resources were used to review the Illinois state smart grid strategy, developments, and key stakeholders.*

- ***Information Technology and Innovation Foundation (ITIF)** – A think tank organization at the cutting edge of designing innovation policies and exploring how advances in information technology will create new economic opportunities to improve the quality of life. The website and resources were used to review smart grid technologies and developments.*

- ***Institute of Electrical and Electronics Engineers (IEEE)** – The largest professional engineering association for advancing technological innovation and excellence for the benefit of humanity. The website and resources were used to review smart grid technologies, standards, developments, and research.*

- ***KEMA** – A global, leading authority in energy consulting and testing and certification, active throughout the entire energy value-chain. The website and resources were used to review smart grid technologies, processes, and services.*

- ***National Association of Regulatory Utility Commissioners (NARUC)** – A non-profit organization dedicated to representing the state public service commissions that regulate utilities providing essential services such as energy, telecommunications, water, and transportation. The website and resources were used to understand state regulatory smart grid policies, testimony, developments, reports, and various resource links.*

- ***National Energy Technology Laboratory (NETL)** – Part of DOE's national laboratory system, is owned and operated by the DOE. NETL supports DOE's mission to advance the national, economic, and energy security of the United States. The website and resources were used to review of smart grid technologies and processes.*

- ***National Institute of Standards (NIS)** – An agency of the U.S. Department of Commerce was founded in 1901 as the nation's first federal physical science research laboratory. The National Institute of Standard provides resources used for standards for the smart grid, energy efficient* *lighting, photovoltaic, net-zero-energy buildings, and software for "smart" building. The website and resources were used for standards, guidelines for regulators, general smart grid information.*

- ***National Electrical Manufacturers Association (NEMA), Smart Grid*** *– The trade association of choice for the electrical manufacturing industry with 450 member companies manufacturing products used in the generation, transmission and distribution, control, and end-use of electricity. The website and resources were used to understand emerging smart grid technologies, systems, and applications.*

- ***North American Electricity Reliability Corporation (NERC)*** *– Organization of U.S. electrical grid operators with published research papers on grid reliability standards, self-assessments, and research reports. The website and resources were used to define smart grid standards, technologies, security, and risks.*

- ***PEW Environment Group*** *– A charitable trust driven by the power of knowledge to solve today's most challenging problems. Pew applies a rigorous, analytical approach to improve public policy, inform the public and stimulate civic life. The website and resources were used to define smart grid solutions, technologies, and benefits.*

- ***Smartgrid.gov*** *–A resource for information about the smart grid and government-sponsored smart grid projects. The website and resources were used to understand overall smart grid activities, technologies, standards, reports, developments, and links to DOE, FERC activities, details on ARRA grants, and research.*

- ***Smart Energy Alliance (SEA)*** *– An alliance of organizations that combines deep industry strengths of Cap Gemini, Cisco Systems, GE Energy, Hewlett-Packard, Intel, and Oracle to help utilities transform their transmission and distribution operations. The website and resources were used to define smart grid technologies, resources, services, and research.*

- ***Smart Grid Collaborative*** *– Primary goal is to accelerate revolutionary change by encouraging replication of smart grid solutions of one country in others. The website and resources were used to define FERC/NARUC collaborative dialogue on smart grid transition issues, policies, and technologies.*

- ***Smart Grid Interoperability Panel (SGIP)*** *– Support NIST in fulfilling its responsibilities under the 2007 Energy Independence and Security Act. The SGIP will identify, prioritize, and address new and emerging requirements for smart grid standards. The website and resources were used to review specific smart grid technical developments under NIST sponsorship.*

- ***Smart Grid Information Clearing House (SGIC)*** *– The objective of the clearinghouse is to populate, manage, and maintain a public Smart Grid Information Clearinghouse (SGIC) portal. Contents in the SGIC portal will include demonstration projects, use cases, standards, legislation, policy and regulation, lessons learned and best practices, and advanced topics dealing with research and development. The website and resources were used to review the smart grid industry technologies and developments.*

- ***SmartGridNews.com*** *– The largest and highest-ranked specialty site. It produces daily news analysis, a weekly e-mail summary, the sector's only hands-on product reviews, and the Web's largest collection of smart grid-specific resources, including research papers, case studies, and stimulus tools.*

- ***Smart Grid Today*** *– The worldwide daily news journal of the modern electric utility industry. The website and resources were reviewed for smart grid technologies, links, and activities.*

- ***SmartMeters.com*** *– Established as a comprehensive online source for news and views surrounding the smart energy industry. The website was used to review smart grid technologies and processes.*

- ***Technology Marketing Corporation (TMC) Smart Grid*** *– The world's leading business to business and integrated marketing media company, servicing niche markets within the communications and technology industries. The website and specific smart grid resources were used to understand current developments, technologies, telecommunications, and smart grid systems.*

- ***Transmission and Distribution World*** *– A magazine targeted for engineers and operations professionals in the electric power transmission and distribution industry. The website and resources were used to review smart grid developments, technologies, and systems.*

- ***Utility Smart Network Access Port (USNAP) Alliance*** *–The alliance is established to create a protocol independent serial interface standard that enables any HAN (home area network) standard, present and future, to use any vendor's smart meter as a gateway into the home, without adding additional hardware in the smart meter. The website and resources were used to define smart grid technologies, HANs, portals, gateways, and further industry research.*

- ***Utilimetrics*** *– The world's premier utility technology association, providing advocacy for utilities and information about innovative technologies that lead to improved operations, customer service, and resource utilization. The website and resources were used to review smart grid technologies and processes.*

Smart Grid Training & Education Literature Review

- *Electric Power Engineering Education Resources 2005-2006, IEEE Power Engineering Society Committee Report*

- *Educating the Workforce for the Modern Electric Power System University–Industry Collaboration, The Bridge, Spring 2010*

- *2010 IEEE Power and Energy Society General Meeting, Minneapolis, MN, July 28, 2010*
    - *Educational Needs for the "Smart Grid" Workforce, University of Illinois at Urbana-Champaign*
    - *Focus on Education – "Smart" Electric Power Systems 101 an Employer's Perspective, OATI*

  - *Fundamentals of Analysis and Computation for the Smart Grid, Center for Energy Systems and Control (CESaC)*
  - *A World-Class Smart Grid Education and Workforce Training Center, Illinois Institute of Technology*
  - *Smart Grid Education Models for Modern Electric Power System Engineering Curriculum, University of Pittsburgh, Swanson School of Engineering Electrical & Computer Engineering Department*

- *Energy Industry Competency Model : Generation, Transmission and Distribution, Center for Energy Workforce Development (CEWD)*

- *Professional Master in Electric Power Systems Engineering Curriculum Report, North Carolina State University*

- *Professional Resources to Implement the "Smart Grid", North American Power Symposium Report, October 2009*

- *Illinois Green Economy Network (IGEN) Presentation & Report, 2011*

- *Industry Moving Forward with Smart Grid, Academia Stuck in 20th Century, IEEE Today's Engineer, October 2008*

- *U.S. Smart Grid Finding New Ways to Cut Carbon and Create Jobs, Center on Globalization, Governance & Competitiveness Duke University, April 2011*

- *National Science Foundation's Workshop and Executive Summit on the Future Power Engineering Workforce held November 29-30, 2007:*
  - *Overview of the Status of U.S. University Power Programs, Power Systems Engineering Research Center*
  - *National Science Foundation Workshop on the Future Power Engineering Workforce, U.S. Department of Energy Perspective*
  - *Power Engineers and the Electric Utility Industry, Edison Electric Institute*

- *Preparing the U.S. Foundation for Future Electric Energy Systems: A Strong Power and Energy Engineering Workforce, U.S. Power and Energy Engineering Workforce Collaborative*