Energy Research and Development Division
FINAL PROJECT REPORT

CALIFORNIA SMART GRID WORKFORCE DEVELOPMENT NETWORK

Strategic Plan

Prepared for:  California Energy Commission
Prepared by:    The California Smart Grid Center at the California State University, Sacramento

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Collaborators

Led by the California Smart Grid Center at Sacramento State University, the following organizations have contributed to development of this strategic plan:

- The California Energy and Utility Workforce Consortium (aligned with the Center for Energy Workforce Development – CEWD)
- Pacific Gas and Electric
- San Diego Gas & Electric
- Sacramento Municipal Utilities District
- The Bay Area Consortium of Community Colleges
- The San Diego Consortium of Community Colleges
- California State University – East Bay

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PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The Energy Research and Development Division conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

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California Smart Grid Workforce Development Network – Strategic Plan is the final report for the Recovery Act - California Smart Grid Workforce Development Network project (contract number 500-11-011) conducted by University Enterprises, Inc. The information from this project contributes to Energy Research and Development Division’s Energy Systems Integration Program.

For more information about the Energy Research and Development Division, please visit the Energy Commission’s website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.
ABSTRACT

The California Smart Grid Workforce Development Network supports the development of California’s Smart Grid workforce, engaging electric utilities, California State University campuses, California Community Colleges, labor unions, and smart grid manufacturers. The network accelerates the workforce development initiatives among stakeholders involved in smart grid activities through a strategic road map and statewide leverage of programs, resources, and best practices. Its objectives are: (1) connect smart grid technology advances and roll-out timing to workforce needs; (2) create, execute, and evolve a statewide workforce development strategy; (3) enhance economic benefits of individual initiatives by leveraging programs, resources, and best practices statewide; and (4) build a strategic model to be shared with interested parties across the United States. The California Smart Grid Workforce Network is led by the California Smart Grid Center at Sacramento State in collaboration with all other partners mentioned above.

Keywords: California Energy Commission, California Smart Grid Center, Smart Grid, workforce development, best practices, strategic model

Please use the following citation for this report:

# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>i</td>
</tr>
<tr>
<td>PREFACE</td>
<td>ii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>iv</td>
</tr>
<tr>
<td>EXECUTIVE SUMMARY</td>
<td>1</td>
</tr>
<tr>
<td>Background</td>
<td>1</td>
</tr>
<tr>
<td>Strategic Approach</td>
<td>2</td>
</tr>
<tr>
<td><strong>CHAPTER 1: Strategic Framework</strong></td>
<td>4</td>
</tr>
<tr>
<td>1.1 The Need for a Strategic Framework</td>
<td>4</td>
</tr>
<tr>
<td>1.2 A New Ecosystem</td>
<td>4</td>
</tr>
<tr>
<td>1.2.1 Holistic Approach</td>
<td>5</td>
</tr>
<tr>
<td>1.2.2 Accessibility</td>
<td>5</td>
</tr>
<tr>
<td>1.2.3 Incumbent Training</td>
<td>5</td>
</tr>
<tr>
<td>1.2.4 Student Pipeline</td>
<td>5</td>
</tr>
<tr>
<td>1.2.5 Governance</td>
<td>6</td>
</tr>
<tr>
<td><strong>CHAPTER 2: Strategic Elements</strong></td>
<td>8</td>
</tr>
<tr>
<td>2.1 Incumbent Workers</td>
<td>8</td>
</tr>
<tr>
<td>2.1.1 Workforce Definition</td>
<td>8</td>
</tr>
<tr>
<td>2.1.2 Curriculum Development</td>
<td>8</td>
</tr>
<tr>
<td>2.1.3 Training Delivery</td>
<td>8</td>
</tr>
<tr>
<td>2.1.4 Scaling</td>
<td>8</td>
</tr>
<tr>
<td>2.1.5 Credentials</td>
<td>9</td>
</tr>
<tr>
<td>2.2 Pipeline of New Employees</td>
<td>9</td>
</tr>
<tr>
<td>2.2.1 Certificate and Degree Programs</td>
<td>9</td>
</tr>
<tr>
<td>2.2.2 Selection of Education Partners</td>
<td>9</td>
</tr>
<tr>
<td>2.2.3 Accessibility</td>
<td>9</td>
</tr>
<tr>
<td>2.2.4 Integration with Supplier Programs</td>
<td>9</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

Background

The Smart Grid is expected to help California avoid redundant capital investment in an aging grid infrastructure, reduce costs of electrical disturbances and outages, help achieve the state’s goals for greenhouse gas reductions, and drive new economic growth across multiple industry sectors. The California utility vision for the smart grid will link electricity with communications and automated control systems to create a highly automated, responsive, and resilient power delivery system that will both improve service and empower customers to make informed energy decisions. Integrated communications will enable this smart power grid to continuously send, receive, and process data on system conditions, component health and power flows, as well as pass information among intelligent electronic devices, generators, independent system operators, marketers, and consumers. A smart grid with these characteristics will also allow for the integration of increased levels of renewable generation resources, accommodate increased loads associated with electric vehicle transportation, and provide increased protection from cyber security attacks and customer privacy concerns.

Smart Grid is a strategy that is being implemented throughout the United States and the world to promote more efficient use of energy and the integration of renewable energy into the existing electric grid. The Smart Grid aims to revolutionize the electric grid by combining its robustness and reliability with the great advances from telecommunications, sensors, controls, and optimization schemes. Realizing these benefits will depend heavily on the workforce developed by the California Smart Grid Workforce Development Network (Network). Particularly important is a workforce that can leverage technology investments by the state’s utilities and ratepayer-funded initiatives through the California Public Utilities Commission and the California Energy Commission. The California Smart Grid Center at California State University, Sacramento, has undertaken this project in collaboration with many of the major stakeholders in California’s smart grid initiatives.

Substantial growth and change of the electric power grid with significant technological investments, coupled with utility worker retirements, will require workforce skills development and continual upgrading for California’s electric utilities through this decade. Over time, virtually all of California’s engineering, technician, program delivery, and customer service utility workers will be affected by technologies and business systems associated with the smart grid. About 40 percent of the electric utility workforce will be eligible for retirement in the next five years, which will drive the need for training large numbers of new workers. According to KEMA, suppliers to the utilities and energy service companies, a factor emphasized in the Network’s strategic plan, will create most new jobs in the smart grid space.

The Network offers many benefits to its utilities and education stakeholders. Through this Network, the California Smart Grid Center has a powerful platform for creating linkages between technology advances by private industry, smart grid deployment by the utilities, and a workforce whose ongoing development is synchronized with the evolution of the grid.
**Strategic Approach**

The Network is committed to the development and implementation of a clear strategy for enhancing the state’s capacity to build the smart grid workforce via a three-prong approach:

- Training incumbent workers through a just-in-time process that is synchronized with the utilities’ smart grid technology roll-out plans
- Creating a pipeline of new workers through collaborative programs with the state’s public postsecondary system
- Developing relationships with selected institutions (universities and national laboratories) to embed workforce considerations into research and development

The Network is positioned to contribute to national strategies promulgated by the U.S. Departments of Energy, Labor, Education, and Commerce. Such contributions are expected to include:

- Building a strategy that engages utilities and others in workforce development.
- Demonstration of methods to link workforce development to technology deployment.
- Advancement of collaborative workforce development methods.
- Innovation in education structures like certifications and credentialing.
- Efficiency in leveraging professional development and best practices in education.
- Aligning education and training for smart grid with demand-side energy management to become more customer-oriented and empower the ratepayers to better manage their own energy consumption.

In June 2011, California’s investor-owned utilities (IOUs) filed plans with the California Public Utilities Commission outlining their smart grid technology rollout plans. These plans will result in evaluations of potential benefits to be expected from utility-wide deployment of new technologies and systems. Demonstration projects provide the experience necessary to make this evaluation. Workforce development is identified as a cross-cutting strategy that supports demonstration pilot projects in the near term and builds a pool of qualified workers over the next decade. This strategic plan is responsive to the IOUs’ smart grid technology rollout plans as documented separately by the Network.
CHAPTER 1: Strategic Framework

During the initial convening of stakeholders, a shared vision unfolded that will drive activities of the California Smart Grid Workforce Development Network (Network) through the grant performance period and beyond. This resulted in the following Strategic Plan framework.

1.1 The Need for a Strategic Framework

Universities and community colleges currently offer certificate and degree programs that in many cases do not evolve with the needs of the utility workforce. The educational system throughout California remains fragmented and lacking in capacity. Workers find it difficult to upgrade their skills over the long term because: (1) clear pathways do not exist that support career advancement, (2) availability of programs varies widely across the state, (3) courses are offered at times that conflict with work schedules, and (4) discontinuities in credentialing between institutions limit ongoing education for workers who relocate.

Education and training programs often are not linked to economic realities – job creation and new skills requirements, for example – and often lack sufficient input from industry partners. The result is a system poorly suited for delivering the right workers for the right jobs at the right time. Nimbleness to meet workforce needs can be challenging, as new courses can take a year or more for development and approval, a problem exacerbated by lack of funding for adding curricula.

A notable exception is the National Joint Apprenticeship and Training Committee (JATC) training programs for union workers are directly linked to the industry through employer sponsored training and workforce development. The JATC programs are demand-driven by design and reflect the workforce needs of the employers. Course curricula are developed on the local, state, and national level to respond to training required by emerging technologies.

California’s workforce education and training system for the modern grid needs to begin with a clear understanding of the challenges faced by the utilities. Because the utilities’ requirements evolve over time, this calls for a statewide approach for continuous definition of “the right workers for the right jobs at the right time”.

1.2 A New Ecosystem

A new system is proposed that will assure ongoing connectivity between the modern grid’s workforce requirements and the state’s system of training and education, producing the right mix of skilled workers.

The primary characteristics of this system are:

- Building a strategy that engages utilities and their vendors in workforce development
• Demonstration of methods to link workforce development to technology deployment
• Advancement of collaborative workforce development methods
• Innovation in education structures such as certifications and continuing education
• Efficiency in leveraging professional development and best practices in education
• Aligning education and training for Smart Grid with demand-side energy management

1.2.1 Holistic Approach
The nature of education in California tends toward silos among institutions of higher learning and a fragmentation of educational pathways from high school through post-secondary. While industry advises educators in many cases, workforce needs often are not well integrated into curricula or practical work experience. Acting as the hub through which a shared vision is implemented, the Network forms a single entity in the state that unifies and coordinates activities that, over time, will develop a holistic approach to building a Smart Grid workforce responsive to industry needs. The Network is industry-led, conducting ongoing research that translates technological and economic developments into education and training programs that serve students, career-changers, labor unions, and incumbent workers.

1.2.2 Accessibility
For the Network to be effective, its deliverables need to be accessible and shared among a wide range of entities. All Network materials will be open source, with no intellectual property rights applied to educational materials. Further, Electronic Learning Systems will be needed to transcend geographic limitations on access, including widespread use of media-based labs and video technology. A Wiki-style approach will be applied to assure continuous thought leadership advances to match the pace of technological and economic developments.

1.2.3 Incumbent Training
Many of the current professionals from trades to engineers to customer service staff will need new skills and knowledge that will enable the Smart Grid. Existing skilled workers may be the focus of programs for initial activities, and the primary target for credentials and continuing education programs. The Network will respond to the utilities’ need for up-dating the skills of workers, using the stackable credentials framework to enable the workforce to quickly transition into new roles, earning credits toward advanced degrees in the process.

1.2.4 Student Pipeline
Smart Grid is expected to be identified as a desirable career field. In the short term, however, the state’s utilities see declining numbers of qualified candidates. Major elements of the Network’s charter include attracting students into Power Engineering and Smart Grid programs and building educational capacity to meet the workforce need. Success in this area will involve outreach, program funding for labs and program-related functions, and applied research opportunities that link students to industry challenges. Perhaps the most urgent need
is for faculty and graduate students who can assume the teaching roles needed by the
Network’s colleges. There needs to be a clear matriculation path from high school programs to
the wide range of programs the Network will develop.

1.2.5 Governance
The Network creates and maintains a focus on innovative practices through linkages among the
stakeholders, development of unified regional programs, and strategic direction from an
Advisory Council. Cost effective means such as online courses, distance learning, virtual
laboratories, and project-based learning will be employed to match speed of delivery with the
practicalities of serving a broad and geographically diverse audience. As proven in the
manufacturing sector, continuous improvement drives innovation. The breadth and richness of
California’s Smart Grid Workforce Development Network amplifies the effectiveness of
regional initiatives, and its strategy of continuous improvement provides a fertile field for
ongoing innovation. Figure 1 highlights the Network’s governance structure.

**Figure 1. Governance Structure**

Key stakeholders in the California Smart Grid Workforce Development Network are organized into a Statewide
Advisory Council.

Staff and management for the Network are part of the California Smart Grid Center at
Sacramento State University. It drives the Network’s contributions to the state’s smart grid
workforce educations and training systems in accordance with the strategic plan created
through the funding provided by the Department of Energy. Implementation of the strategy
will occur on a regional basis based on the priorities of the utilities located in those regions.

An Advisory Council comprised of the above stakeholders also include members of the
California Energy Commission, the state’s Workforce Investment System, the Independent
System Operator, IBEW-NECA and other involved labor organizations, and suppliers and value chain partners serving the state’s electric utilities industry.
CHAPTER 2: Strategic Elements

2.1 Incumbent Workers

This plan will engage small groups of utility employees in defining the workforce knowledge, skills, and abilities expected from Smart Grid technology deployment. It employs a just-in-time training model that accompanies relatively small-scale business validation projects and provides the basis for broader deployment.

2.1.1 Workforce Definition

Tied to a specific business validation project, a small employee work group would outline how the work would change in the environment created by that particular technology (e.g. Volt/VAR). The team would represent a vertical slice of the full workforce spectrum – from engineers to customer service representatives. The Network team would structure these meetings and then facilitate a focus session to outline the knowledge, skills, and abilities that would be needed for this work group.

2.1.2 Curriculum Development

Using focus groups, the Network team has been developing specifications for educators to follow in developing curriculum. This specification emphasizes practical student learning outcomes such as application of Volt/VAR, or other similar major challenges, in various circuit configurations. When the utilities’ Smart Grid implementation teams approve this specification, the Network team would work with educators to develop programs that can be delivered to incumbent workers. It is proposed that curriculum developers be embedded within each project team, as appropriate, to develop training that supports the IOUs’ eventual requirements for full deployment. Several outcomes would result from this approach:

- Training packages that integrate standard industry curriculum with Smart Grid vendors’ training and experience gained from demonstration pilot projects.
- Recognition by the utilities that completion of a training package represents a level of proficiency that can be certified as readiness to perform the work.
- A cadre of curriculum developers that can train cohorts of trainers to deliver the curriculum.

2.1.3 Training Delivery

The Network team will work with the utilities’ preferred education partners to offer Smart Grid courses. Delivery within the utility will be the initial approach, with these courses evolving into the academic mainstream over time.

2.1.4 Scaling

Training delivery based on standard curriculum will be localized across each utility’s regions. For example, employees of the utilities’ local operations center would receive training at a preferred community college nearby, with assistance from a state university and/or IBEW as
required. Because Smart Grid deployment will involve many facets over a long period, each region within a utility would develop a strategic relationship with its local education partners as a delivery channel for all Smart Grid training programs. These relationships could expand to include other initiatives beyond Smart Grid. The Network team, in collaboration with the Community College System, will help form these relationships and arrange training delivery as appropriate.

2.1.5 Credentials
A system of “Badges” or micro-credentials will be developed to record employees’ training in these programs. As this system matures, utilities can use it to track the technical competencies of its employees.

Each utility in the Network would apply these same processes as new technologies are rolled out and in accordance with their specific strategic directions. The Network would consolidate requirements in collaboration with the public postsecondary system as outlined in the Integrated Program Design section.

2.2 Pipeline of New Employees

2.2.1 Certificate and Degree Programs
The Network team will work with colleges and universities to embed Smart Grid student learning outcomes in mainstream academic courses. The objective is certificates in Smart Grid disciplines at the AA, AS, BS, and MS levels, with course content derived from the utilities’ incumbent worker training. This is detailed in the Integrated Program Design section. In addition, the utilities’ employment application processes are capable of capturing a job candidate’s micro-credentials to aid in recruiting efforts.

2.2.2 Selection of Education Partners
The first priority is the network of colleges and universities from which utilities’ recruit. New education partners may be selected through the Network team’s work with the public postsecondary system as well as with private colleges and universities as appropriate.

2.2.3 Accessibility
Smart Grid education programs may exist in technology-focused pockets throughout California, limiting availability of programs in other parts of the state. Students statewide need online access, a key priority for the Network team. Technology-enabled learning systems such as virtualization, simulation, and digital game-based learning are also priorities for the Network.

2.2.4 Integration with Supplier Programs
Smart Grid vendors are projected to be the largest employers of Smart Grid professionals. The Network team will work with the utilities’ supply chain organizations to collaborate on joint education program development with key vendors. This approach assures enrollment that will be attractive to educators.
2.2.5 Statewide Uniformity
Through the California Energy and Utility Workforce Consortium, the Network team will work with their organizations to create a uniform or compatible system of credentials across the state. Although curriculum may vary from college to college, standard statewide credentials will assure a common set of competencies for identification by recruiters.

2.3 Strategic Education Partnerships

2.3.1 Workforce Sector Strategy
The Network team will collaborate with qualified colleges and universities to address specific workforce segments involving the utilities and the vendor community.

2.3.2 Research and Simulation Focus
New research centers are offering capabilities that can be used by the utilities and its education partners to prepare the workforce for Smart Grid. Examples are the IOUs’ joint filing for Grid Modernization work with the Lawrence Livermore National Laboratory High Performance Computing Center and the Sandia National Laboratories’ Cyber security Technologies Research Center. The Network team can play a role in creating mainstream education programs based on these initiatives.
CHAPTER 3: Integrated Program Design

3.1 Curriculum Developers

The utilities will approve selection of curriculum developers to be on specific demonstration pilot project teams. Curriculum developers will be assigned to a project team based on the combination of skills represented in the project. For example, a selected university would assign a developer to capture functions such as engineering and commissioning, and an assigned community college developer would capture technician/customer care functions. The design result would be training that generally reflects the way the project team functions.

3.2 Standardization

Each training package – engineering, technician, customer care, etc. - that results from the demonstration pilot project will be submitted to the utilities for certification as meeting the criteria for knowledge, skills, and abilities for functional proficiency.

3.3 Credentialing

The public postsecondary system will create specific credentials based on certification of training packages by the utilities. Students completing the training will be tested to assure proficiency in the subject matter, with passing scores yielding an industry-recognized credential.

3.4 Recruiting

A set of utility-approved credentials create a means by which the utilities can make hiring and placement decisions. Job applicants can be identified as having earned the appropriate credential(s).

3.5 Portability

Once certified by the utilities, the curricula can be offered by any public postsecondary institution as a credentialed training package. With the support of the public postsecondary System Offices, students at any participating college or university can apply these credentials to a certificate or degree program.

3.6 Flexibility

Comprised of relatively small, discrete modules, training and credentialing programs can evolve with technology and workforce needs over time.
CHAPTER 4: Implementation

The Network team, led by the California Smart Grid Center at the California State University, Sacramento (Sacramento State), will continue to facilitate implementation of this Strategic Plan with utilities. Concept approval and program design will be on an individual utility basis, reflecting their unique palettes of demonstration pilot projects. The California Energy and Utility Workforce Consortium will continue to provide the platform, with statewide standards as the eventual goal.
APPENDIX A:
Smart Grid Engineering Curriculum Requirements

California’s utilities place a high priority on engineering education and training for Smart Grid. Two major drivers influenced this priority: (1) engineering is the leading edge that other organizations follow in Smart Grid implementation, and (2) a significant number of engineers have reached or are reaching retirement age over the next five years.

During the first quarter of 2011, the Network conducted interviews and focus groups with Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, and Sacramento Municipal Utilities District to determine core requirements for engineers with Smart Grid responsibilities. The following student learning outcomes were defined through this process as utility industry-driven parameters to guide Smart Grid education and training curricula. A proposed set of topics was also developed as input to curriculum developers.

Proposed Student Learning Outcomes

Distribution

1. Demonstrate the ability to accurately communicate the system-level changes enabled by Smart Grid technologies and how they are projected to benefit customers
2. Demonstrate the ability to design a viable distribution circuit to serve demand side loads that are expected to be typical in a Smart Grid environment
3. Demonstrate competency in engineering economics applied to distribution circuits from a utility perspective. Demonstrate an understanding of the principles of integrating utility-based renewables into the grid

Transmission

1. Demonstrate basic competencies in Smart Grid transmission infrastructure design
2. Demonstrate a range of abilities in applying engineering economics to the integration of renewables into transmission system design

Operations and Economics

1. Demonstrate basic competencies in applying Smart Grid design standards and analytical methods
2. Demonstrate ability to optimize system infrastructure and investment based on regulatory, business, technical performance, and customer-driven factors
3. Demonstrate a working knowledge of ICT networking, SCADA, and Cyber Security as these systems intersect with power engineering practices

Applications and Design
1. Demonstrate a working knowledge of power electronics and grounding
2. Demonstrate basic competencies in designing a residential neighborhood substation
3. Demonstrate basic competencies in designing an industrial zone substation
4. Demonstrate basic competencies for integrating a solar farm into the grid, complete
   with stability control, sensing, fault detection, and protection
5. Demonstrate a working knowledge of engineering design across multiple Smart
   Grid domains
APPENDIX B:
Smart Grid Engineering Courses at Sacramento State University

Based on the student learning outcomes described in Appendix A, Sacramento State University has developed the following courses. Course offerings began in the spring of 2012 and will be available online in the fall of 2013.

Course Descriptions

Introduction to Power Systems:
This is a 2-module course designed to familiarize and certify Electrical Technicians and Electrical Engineers with the basics of Power System elements and the standards for governing safe and reliable system operations. Students will gain a general understanding of the different components of electrical power and energy systems, such as generation, transmission, substations, and distribution. They will also learn the regulatory requirements and general standards for safe and reliable practices. The course reviews the major elements of the Power System and a variety of fuels and/or prime movers used in generation systems.

Future Power System and Smart Grids:
This course focuses on future Power Systems from component and system perspectives. It reviews smart grids, microgrids, and interactive power systems using renewable resources and energy storage elements. Students will learn the national standards for certification of distributed generation involving machine-based and inverter-based technologies. They will also discover the essential elements of advanced sensing, communications and information technology and their roles in adaptive automation, control, protection, and security.

Smart Grid Data Telecommunication:
This course consists of four modules: Software Engineering, Data Communication and Computer Networking, Database Management Systems, and System Security and Quality Assurance. The Software Engineering Module covers the software development life cycle, project management and documentation, and the development of written and oral communication skills. The Database Management Module reviews the principle of database theory and practical applications of database systems including the use of existing database systems in smart grid software and applications. The Data Communication and Computer Networking Module provides a broad view of the fundamental concepts of data communications and computer networks including a survey of major protocols, standards and architectures. The System Security and Quality Assurance Module focuses on the principles and applications of Verification and Validation during all phases of the lifecycle process as well as security issues in smart grid technology and applications.
Power Electronics:

This course reviews thyristors, silicon controlled rectifiers, DC choppers and inverters and pulse width modulation methods including the space vector method. It also examines the control of DC drives and methods of control for induction synchronous motors such as flux-vector methods and computer simulations.
APPENDIX C:
DOE_CDFA 81-122 Final Report
California Smart Grid Workforce Development Network

Recovery Act-Workforce Training for the Electric Power Sector

Funding Opportunity Number: DE-FOA-0000152
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Submitted By: Emir Macari, Principal Investigator

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National Energy Technology Laboratory
Table of Contents

Executive Summary ........................................................................................................................ 1
Goals and Objectives ...................................................................................................................... 1
Accomplishments ............................................................................................................................ 2
Schedule Summary ......................................................................................................................... 4
Cost and Financial Summary .......................................................................................................... 5
Continuity of the Project Objectives into the Future ...................................................................... 6
Lessons Learned and Recommendations ......................................................................................... 8
Acknowledgements ........................................................................................................................ 9
Appendix I. CEC Report Requirements ....................................................................................... 11
Appendix II. Table of Deliverable Reports ................................................................................... 12
Executive Summary

The California Smart Grid Center at California State University, Sacramento has engaged a wide array of stakeholders from electric utilities, California State University campuses, California Community Colleges, labor unions, Smart Grid industry representatives, and state regulatory agencies to address workforce needs and training resources in order to better support the development of California’s Smart Grid workforce. This California Smart Grid Workforce Development Network (CSGWDN) has identified industry workforce requirements through numerous interviews, focus groups, and regional forums. It has also researched demand projections for key occupations, inventoried and classified program intensity of college and university training programs applicable to Smart Grid.

As a result of this work, educators and workforce trainers have a clearer understanding of California’s Smart Grid workforce needs and training and education gaps, with which they can improve curricula and course offerings relating to Smart Grid in order to meet these needs. This document describes the findings and conclusions regarding California’s Smart Grid workforce requirements and training and education gaps that must be addressed to meet these needs. It also describes the components of this research, which led to these findings and conclusions.

Goals and Objectives

The California Smart Grid Workforce Development Network (CSGWDN) supported the development of California’s Smart Grid workforce, and engaged electric utilities, California State University campuses, California Community Colleges, labor unions, and Smart Grid manufacturers. CSGWDN accelerated the workforce development initiatives among stakeholders involved in Smart Grid activities through a strategic road map and statewide leverage of programs, resources, and best practices.

The project’s objectives were to:
1. Connect Smart Grid technology advances and roll-out timing to workforce needs;
2. Create, execute, and evolve a statewide workforce development strategy;
3. Enhance economic benefits of individual initiatives by leveraging programs, resources, and best practices statewide;
4. Build a strategic model to be shared with interested parties across the United States.

Led by the California Smart Grid Center, which is funded by the California Energy Commission, and others, and operated by California State University, Sacramento (CSUS), CSGWDN created leverage among Smart Grid education and training programs at CSUS, California State University East Bay, California State Polytechnic University, Pomona, the community colleges of Los Angeles Trade Tech, San Jose Evergreen, and American River, plus statewide facilities of industry and labor provided by the International Brotherhood of Electrical Workers and the National Electrical Contractors of America IBEW-NECA, to
serve each of the state's major geographic regions. The array of degree and certificate programs outlined is in direct response to workforce needs identified by the project's electric utility partners – Pacific Gas and Electric (PG&E), Southern California Edison, and Sacramento Municipal Utility District (SMUD) - with additional data from Southern California Edison. These utilities deliver approximately 75% of the electricity consumed in California. CSGWDN research will further define workforce needs.

Projected economic impact was more than $2.4 million over the grant performance period (July 2010 to September 2013) using the FOA's guidelines of per capital salary increases and career ladder benefits. An even greater impact was projected from achieving the state’s goals for rolling out Smart Grid infrastructure. Based on Electric Power Research Institute estimates of Smart Grid savings in kilowatt hours, potential economic impact of Smart Grid deployment can be expected to range from $14 million to $56 million in 2015. Fully realizing this economic potential is directly dependent on the workforce skills and capacity for transitioning to a statewide Smart Grid.

Detailed data from the partner utilities along with numerous publications show that industries that depend on power engineering related employees will experience a 40-50% workforce retirement over the next 10 years. The same references estimate that the total new workforce demands may reach 40,000 workers. This estimate includes a significant number of present workers who will need retraining in the advanced technologies and ecology concepts. Providing the education to enable the fulfillment of these job requirements will also provide the base for a wide range of complimentary job opportunities predicated on new technologies and green energy concepts. This will support an extensive stimulus to our economic growth and help allow us to maintain national leadership in a global marketplace. The combined consortium universities presently provide 1,068 newly graduated engineers in the State of California as well as the only Master’s program in Electrical Power Engineering. It also includes the only Smart Grid Center in the California university system. Because of this extensive capability the resources exist to expeditiously initiate and maximize the benefits of the proposed project.

Accomplishments

The first goal of the project was to connect Smart Grid technology advances and rollout timing to workforce needs. This was fully accomplished by three major efforts. The primary activity was an on-going discussion with as wide a range of utility, industry and academic partners as possible. The results of the dialog are encapsulated in the Phase II deliverables which are Task 2.1 Structure Partnerships in the CSGWDN and Task 2.2 Create a five-year strategy. The second activity in this goal was the creation of a workforce training clearinghouse in the form of a website under Phase III. The website gathers information from hundreds of California educational institutions and disseminates that information is ways approachable by various stakeholders. The third activity was also in Phase III and was the development of various smart grid related courses by faculty at CSU Sacramento. These courses are in an online accessible format and will receive continued work to make this and future courses as widely available as possible.
The second goal of the project was to create, execute, and evolve a statewide workforce development strategy. Phase III of the project successfully completed six tasks that surveyed utility workforce needs, technology roll-out plans, training gap analyses, online education development. Some of the tasks overlapped the third goal of the project which was to enhance economic benefits of individual initiatives by leveraging programs, resources, and best practices statewide. The project members helped define educational pathways, delivering several webinars and actively engaged in statewide discussions again and again over the course of the project.

The fourth goal of the project was to build a strategic model to be shared with interested parties across the United States. The culminating report is the CSGWDN model for Smart Grid workforce development (Task 4.1). The model is a comprehensive discussion of best practices which can be followed to encourage and enhance effective workforce training in order to support accelerated adoption of smart grid efforts.

These four major goals were completed by the culminating reports of Task 1.1 through Task 4.1. The list of projects deliverables includes (See Appendix II):

<table>
<thead>
<tr>
<th>Task</th>
<th>Deliverables for this project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Project Management Plan</td>
</tr>
<tr>
<td>1.2</td>
<td>Metrics and Benefits Reporting Plan</td>
</tr>
<tr>
<td>2.1</td>
<td>Business Case (aka Charter Document)</td>
</tr>
<tr>
<td>2.2</td>
<td>Workforce Development Strategic Plan</td>
</tr>
<tr>
<td>3.1</td>
<td>Survey of California Utility Smart Grid Technology Plans and Programs</td>
</tr>
<tr>
<td>3.2</td>
<td>Needs and Gap Analyses of Existing Regional Training Programs</td>
</tr>
<tr>
<td>3.3</td>
<td>Power Laboratory Online Learning Alternatives</td>
</tr>
<tr>
<td>3.4</td>
<td>Deliver Smart Grid Technical Material and Practical Application of Advanced Technologies</td>
</tr>
<tr>
<td>3.5</td>
<td>Continuous Improvement of Smart Grid Programs and Courses</td>
</tr>
<tr>
<td>3.6</td>
<td>Smart Grid Educational Pathways</td>
</tr>
<tr>
<td>4.1</td>
<td>Model for Smart Grid Workforce Development</td>
</tr>
</tbody>
</table>

The formation of the CSGWDN and its “network of networks” provides a model for other regions of the U.S. to consider emulating when needing to advance workforce skills development to meet the needs of the nation’s deployment of new Smart Grid technologies for modernizing the power grid. These affiliated networks are employing various models, or tools, to address different needs and situations arising from the generating plant to the wall socket. Together they represent a toolbox of comprehensive solutions that can be applied to prepare workers to meet the many varied requirements that Smart Grid will present over time.

This work has effectively forged long-term partnerships among utilities and the energy industry, colleges and universities, workforce developers, labor apprenticeship programs, and economic development corporations that have begun to bear fruit in terms of advancing a sector strategy approach for smart grid that is driven by current and projected industry workforce needs. Thanks to funding support from DOE and CEC, the California Smart Grid workforce development network of networks has developed into an effective multi-disciplinary partnership focused on the common goal of preparing workers to meet the evolving technology challenges and opportunities that are enabling a smarter grid.

3
The work in Task 3.4, Deliver Smart Grid Technical Material and Practical Application of Advanced Technologies, led to the development the following course offerings which targeted needs identified in the gaps analyses.

### Summary of smart grid related courses

<table>
<thead>
<tr>
<th>Smart Grid Related Curriculum</th>
<th>Number of Enrollees</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Planned</td>
<td>Actual</td>
<td></td>
</tr>
<tr>
<td>Introduction to Power</td>
<td>70</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Electronics CSUS course num:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EEE 146.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Electronics Laboratory</td>
<td>40</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>CSUS course num: EEE 148</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Energy Electric</td>
<td>40</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Conversion Systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSUS course num: EEE 257</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction to Power</td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systems</td>
<td></td>
<td>Planned offering</td>
<td></td>
</tr>
<tr>
<td>Introduction to Databases,</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communications and Cyber</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Security Issues in Smart Grid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>245</td>
<td>111 (so far)</td>
<td></td>
</tr>
</tbody>
</table>

### Schedule Summary

a. Discuss all major project milestones (and list in table below), deliverables, decision points and success criteria relative to the approved schedule. Include a discussion of rationale if a milestone(s), deliverable(s) and/or remaining schedule was not met /or was exceeded.

<table>
<thead>
<tr>
<th>Major Milestone</th>
<th>Planned Completion Date</th>
<th>Actual Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I Project Definition</td>
<td>9/21/2010</td>
<td>9/21/2010</td>
</tr>
<tr>
<td>Phase II Establish the California Smart Grid</td>
<td>8/31/2011</td>
<td>4/30/2013</td>
</tr>
<tr>
<td>Grid Workforce Development Network (CSGWDN)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase III Create Positive Impacts on</td>
<td>6/30/2013</td>
<td>9/30/2013</td>
</tr>
<tr>
<td>Statewide Smart Grid Workforce Development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiatives</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
There was a significant delay in Phase II, Establish the California Smart Grid Workforce Development Network (CSGWDN) due to the ability of industry to formulate a response to training needs. There was a healthy and significant interaction with the major utilities in California from the earliest stages of this project in 2010 and 2011. But the investor owned utilities (IOUs) in California needed time to absorb the California Public Utilities Commission rulings rolling out in late 2011 in particular. In late 2012, the pathways were much clearer to the IOUs and workforce development as envisioned by the IOUs moved swiftly forward in early 2013. Phase II concluded with the completion of Task 2.2 (Five year strategy) in April 2013.

b. Discuss all significant schedule changes from the original project award (i.e., extensions, schedule changes, etc.).

In order to give the California IOUs more time to develop more refined workforce development plans, the project requested and received a two month no-cost extension of the project. The revised project ending date moved to 9/19/2013. The approach proved very useful and a revised Task 2.1 (Structure partnerships) was completed on 6/30/2013. The remaining tasks in the project in Phase III were then quickly wrapped up by September 2013.

Cost and Financial Summary

a. Provide the final financial status of the project in the Project Financial Summary table below.

<table>
<thead>
<tr>
<th>Project Financial Summary</th>
<th>Planned</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOE Share</td>
<td>749,992.00</td>
<td>749,992.00</td>
</tr>
<tr>
<td>Recipient Cost Share</td>
<td>83,355.00</td>
<td>83,351.35</td>
</tr>
<tr>
<td>Total Project</td>
<td>833,347.00</td>
<td>833,343.35</td>
</tr>
</tbody>
</table>

b. Discuss in detail the Recipient (claimed) cost share, compared with what was stated in the approved budget in the Assistance Agreement. Discuss any major changes or other issues relating to financial status.

The Recipient cost share total was the “as planned” at 10% of the entire project cost. The cost share did not incur any major changes with cost share details shown below.
Match Funds Cost Status:
Total grant expenditures to September 30, 2013 is $83,351.35 with a grant balance of $3.65 (under budget).

<table>
<thead>
<tr>
<th>Recipient CSUS UEI</th>
<th>CEC Funds</th>
<th>Grant Ending</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Budget</td>
<td>Actual</td>
</tr>
<tr>
<td>Education Specialists Salary</td>
<td>56,999</td>
<td>58,318.69</td>
</tr>
<tr>
<td>Fringe Benefits</td>
<td>7,085</td>
<td>5,763.16</td>
</tr>
<tr>
<td>Supplies &amp; Materials</td>
<td>2,600</td>
<td>2,599.29</td>
</tr>
<tr>
<td>Indirect</td>
<td>16,671.00</td>
<td>16,670.27</td>
</tr>
<tr>
<td>Total</td>
<td>83,355.00</td>
<td>83,351.35</td>
</tr>
</tbody>
</table>

The California Energy Commission (CEC) provided matching funds have been (nearly) fully expensed as of September 19, 2013. Required DOE match has been fully met. All DOE required reports and deliverables will be also sent to the CEC under the terms of the matching grant. The matching funds were provided under the State Energy Resources Conservation and Development Commission (Energy Commission) agreement number 500-11-011 with contract performance dates of March 26, 2012 to May 26, 2014.

Continuity of the Project Objectives into the Future

a. Provide a brief discussion of the project’s next steps and/or plans of going forward.

The completion of this grant-funded project comes at a critical time. Just as the state’s utilities are rolling out deployments of new technologies and awaiting CPUC direction on continued deployment plans, there is no readily apparent source of funding to continue this organization and management function among the many stakeholder organizations in order to realize the value that these various workforce models represent. Without funding of a lead organization to continue managing this network it is likely that informal connections among network participants will continue, but with a diminished focus and lack of coordinated execution. This may result in a return to a more fragmented and less effective approach to addressing workforce needs, which may have negative implications that reach beyond California to impede the nation’s Smart Grid workforce development efforts.
The workforce development clearinghouse website is fully functional and will be maintained periodically for the foreseeable future.

Smart Grid related courses will be under continuous improvement and revision with more online aspects anticipated.

Continue discussions stakeholders in the state of California.

The study team therefore, recommends that DOE consider follow-on funding to enable the organizing function of the CSGWDN to continue during this critical phase in Smart Grid deployment in order to realize the full value of its original investment to create the network. If such funding is not forthcoming from DOE, alternative funding from the CPUC, the California Energy Commission, and the California IOUs will become absolutely essential for realizing the promise that the California Smart Grid Workforce Development Network has demonstrated thus far.

b. Did you collaborate or share your materials with other organizations?

The California Smart Grid Center at California State University, Sacramento engaged a wide array of stakeholders from electric utilities, California State University campuses, California Community Colleges, labor unions, Smart Grid industry representatives, and state regulatory agencies to address workforce needs and training resources in order to better support the development of California’s Smart Grid workforce. This California Smart Grid Workforce Development Network (CSGWDN) has identified industry workforce requirements through numerous interviews, focus groups, and regional forums. It has also researched demand projections for key occupations, inventoried and classified program intensity of college and university training programs applicable to Smart Grid.

Information Dissemination included:
1. Webinars – over four webinars offered in venues including CSU, Sacramento, UC Berkeley, UC Davis, and in conferences state and nation-wide.
2. Visiting Scholar – CSUS provided a faculty member to San Deigo Gas & Electric (SDG&E) as part of their onsite education program. Content included power system analysis, upgrading relay protection, and other smart grid related topics.
3. Ongoing meetings and discussions with industry stakeholders such as the California Community College Engineering Liaison Council. Membership includes community colleges and universities in California – both public and private institutions.
4. Ongoing meetings with the California Energy Commission’s Technical Advisory Committee.
5. Seminars and professional meetings in the California Smart Grid Lecture series.
6. Energy education training of over thirty K-12 teachers (June 2013) on methods and best practices to introduce energy related topics and projects into the linked learning environment.
Lessons Learned and Recommendations

Our development of courses included stages. In Spring 2012, three of the developed courses (Introduction to Power Electronics, Power Electronics Laboratory, and Wind Energy Electric Conversion Systems) were offered in a traditional face to face approach. Prior to the start of Spring 2013, the lecture notes were revised (PowerPoint presentations) and video lectures based these revised lecture notes were recorded. During Spring 2013, the course was offered in a hybrid format, through which students were provided with video lectures and presentations before each class, and the class was dedicated to complementary discussions on the topics, problem solving and conducting simulations.

For the Wind Energy Electric Conversion Systems course in Spring 2013, students were divided in 5 groups and each group was given a different subject to explore. The results of these projects have been added to the materials of the course which will be used in the following semesters. Comparing the experiences during these two semesters and student evaluations, it was learned that providing the course materials to the students before each class can potentially help the students in deep learning. However, since this practice necessitates active participation of the students in reviewing the course materials before each class, they feel that they need to spend extra time on the course, compared to other courses. Since many of our graduate students work full-time jobs, such dedication seems to be hard for them. This matter has been reflected through course evaluations in the second semester, which show a reduction of 0.44 points. For the most part, this reduction is due to the extra effort of the students. In following semesters, the instructor intends to assign simple, yet conceptual quizzes to the students accompanied by the course materials before each class. Grades of these assignments will be counted towards part of the overall assessment of the class. The instructor believes that the reward gained through these assignments will potentially boost the level of satisfaction of the students and will encourage them to review the pre-class lectures more seriously.

<table>
<thead>
<tr>
<th>Things That Worked Well</th>
<th>Things That Were a Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engaging all stakeholders in a comprehensive discussion across a California-wide platform.</td>
<td>Gathering existing workforce training courses and professional development avenues was a very challenging activity.</td>
</tr>
<tr>
<td>Looking at smart grid training from an outside-the-academic viewpoint that included utilities, support industry, and practicing engineers.</td>
<td>The current training is divided among a large variety of training providers from universities, community colleges, so-called “trade schools” and other educational venues.</td>
</tr>
</tbody>
</table>

a. Provide a brief discussion of the project’s outcomes relative to the stated project goals and objectives.

The California Smart Grid Workforce Development Network created a culminating model of smart grid related workforce development applicable to all regions of the nation. The model laid out interrelationships across a spectrum of certification, technical training and professional education through all levels of the workforce. The only surprise was the time necessary for the
full discussion by the stakeholders who viewed the technology as still somewhat in flux and thus the training goals also in flux.

b. Discuss any observations, benefits or opportunities for improvement resulting from the project. (Please limit to no more than two paragraphs).

The CSUS California Smart Grid Center, its FOA-152 study team, and numerous partner organizations from industry, education, and government have come together in a spirit of collaboration to understand the workforce needs relating to the deployment of Smart Grid technologies “from the power plant to the wall socket”. This California Smart Grid Workforce Development Network (CSGWDN) has been engaged in complimentary efforts to address these workforce requirements through improved alignment of education and training resources and development of new curricula. This network of organizations continues to work together and intends to carry on this important cooperative workforce development initiative for years to come as the modernization of the power grid unfolds over many years to come.

The two-pronged investigative approach utilized grid side and demand side management, combined with leveraging of partnering organizations’ complimentary workforce development efforts. This has facilitated a much deeper dive into industry workforce needs and educational resources than had originally been proposed for this project, thus yielding more comprehensive results. The FOA-152 study team has conducted numerous interviews and focus group meetings with California utilities to determine their workforce training requirements for Smart Grid. This input, which has been invaluable in guiding education planning efforts. This industry input has already resulted in the development of new power engineering courses at CSU, Sacramento. Other education partners, from community colleges to four-year universities, are taking note as well and are planning curriculum enhancements to better prepare incumbent workers and new entrants to the industry to work with new Smart Grid technologies. The project team has worked in close collaboration with the Energy Workforce Sector Strategy (EWSS) project, which is focusing on demand side Management (DSM) and energy efficiency workforce requirements that relate closely with grid side technology deployments. This complimentary effort, which includes many of the CSGWDN partner organizations, is providing considerable leveraging of DOE’s grant resources. This has enabled a much deeper dive into investigating needs, education resources, gaps, and developing new linkages and solutions. The EWSS project implementation will continue well beyond the DOE grant period, as will the ongoing collaborative efforts of the CSGWDN.

Acknowledgements

The California Smart Grid Center at California State University, Sacramento wishes to recognize the financial support of the U.S. Department of Energy and its National Energy Technology Laboratory, without which this project would not have been possible. We also thank
our many partner organizations including Pacific Gas & Electric, Southern California Edison, San Diego Gas and Electric, Sacramento Municipal Utility District, other utilities in the California Energy and Utility Workforce Consortium, the California State University, the California Community Colleges, UC Berkeley Don Vial Center on Employment in the Green Economy, various workforce development programs, California Public Utility Commission, California Energy Commission, IBEW-NECA, and a wide array of businesses too numerous to list.
Appendix I. CEC Report Requirements

California Smart Grid Workforce Development Network (CSGWDN)
Final Report Attachment for the California Energy Commission
CEC Agreement Number 500-11-011

CEC Subtask 1.5 Final Report
The goal of the Final Report is to assess the project’s success in achieving its goals and objectives, advancing science and technology, and providing energy-related and other benefits to California.

In addition to any DOE final report requirements are that the final report shall describe the following at a minimum:

a) Original purpose, approach, activities performed, results, and conclusions of the work performed under this (CEC match) Agreement.
b) How the project advanced science and technology to the benefit of California’s ratepayers and the barriers that were overcome.
c) Assessment of the projects success as measured by the degree to which the goals and objectives were achieved.
d) How the project supported California’s economic recovery in the near term and number of jobs created or sustained.
e) How the project results will be used by California industry, markets, and others.
f) Project cost reduction impact and other benefits resulting from the project.
g) Discuss the project budget, including the total project cost and all the funding partners with their associate cost share.
h) Discuss how the Energy Commission funding was spent on the project, including any unique products and benefits.
i) Observations, conclusions, and recommendations for further research, development, and demonstration projects.

The author’s believe that the DOE Final Report has met all the above requirements of the CEC and that the DOE final report meets the full completion of the CEC match grant.

The deliverables under the CEC match funds agreement for the final report are:
Provide a copy of the Final Report submitted to the DOE. The Final Report shall be completed on or before the end of the Agreement Term.

Written correspondence from the DOE regarding acceptance of the final report. The completion of the CEC match grant thus includes this attachment, a copy of the CSGWDN DOE FOA 152 Final Report, and DOE confirmation of acceptance of the Final Report.
Appendix II. Table of Deliverable Reports

The following list of project deliverables is included as attachments in the full submission package to both the Department of Energy and the California Energy Commission.

<table>
<thead>
<tr>
<th>Task</th>
<th>Deliverable Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Project Management Plan</td>
</tr>
<tr>
<td>1.2</td>
<td>Metrics and Benefits Reporting Plan</td>
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