

GridEd REPORT SUMMARY

1. Project Title / Sub-program: Leveraging Industry Research to Educate a Future Electric Grid Workforce / Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) & Leveraging Industry Research to Educate a Future Electric Grid Workforce in the Western U.S. / Solar Training and Education of Professionals (STEP)

2. FOA / Award#: DE-FOA-0000856/DE-EE0006338 & DE-FOA-0001329/DE-EE0007328

3. Principal investigator: Tom Reddoch, Electric Power Research Institute, 942 Corridor Park Blvd. Knoxville, TN 37932, 1 (865) 218-8120 [w], 1 (865) 218-8001 [f], reddoch@epri.com

4. Other Participating Organizations & (PIs): University of North Carolina, Charlotte (Badrul Chowdhury); Clarkson University (Tom Ortmeyer); University of Puerto Rico, Mayaguez ; (Agustin Irizarry-Rivera); Georgia Institute of Technology (Sakis Meliopoulos); Arizona State University (Vijay Vital); University of California, Riverside (Nanpeng (Eric) Yu); Portland State University (Robert Bass)

5. Project Schedule:

1. Initiation Date: 9/30/2013 (GEARED) & 2/15/2016 (STEP)
2. Dates of Intermediate Phase Completions or Go/No-Go Points:
 - 9/30/2014; 3/31/2015; 3/31/2016; 3/31/2017 (GEARED)
 - 6/30/2017 (STEP)
3. Expected Completion Date (Original and Current Plan, if different): (9/30/2018 – original GEARED) – both GEARED & STEP to be completed by 2/14/2019

6. Project Scope: Over the last 100 years, electric utilities have focused on meeting customer demand for electricity while maintaining a reliable power generation and delivery infrastructure. In the future, renewable and other distributed resources and more price sensitive and responsive loads will change old operating norms and present new requirements and challenges in the quest to achieve an efficient and reliable delivery of electricity. However, trends in the nation's power engineering workforce have not kept pace with the increasing complexity and significant changes expected in the electric power distribution grid. Recent studies have shown that at least 50% of the design and operations personnel (both engineers and line crews) are past the midpoint in their careers and there are diminishing requirements for power systems courses in electrical engineering programs. An aging workforces and lack of skilled replacement workers puts the future reliability of the grid at risk. In response to this rising need, the project team aspires to leverage electric industry research and address the deficiency in power systems education by educating a future electric grid workforce and empowering new and continuing education students to become not only competent and well-informed engineers, but also participate and influence major technological, social, and policy decisions that address critical global challenges. The government plays a key role in this endeavor as science and engineering education and curriculum development has traditionally been addressed by government. Further, the government can play a key role in jump starting the professional development training efforts which heretofore have not been addressed by the industry.

7. Project Goals: GridEd has a threefold mission under this project:

1. Educate new engineers at the graduate and undergraduate level where each university partner is committed to curricula changes to add, expand, and update current offerings.
2. Create professional development opportunities for career professionals who want to expand their knowledge base for professional development and career advancement.
3. Stimulate student interest in the field of electric power and energy engineering.

Our goal, our approach, and our team is dedicated to this mission. GridEd translates recent R&D results

Solar Energy Technology Office Portfolio Review

on DER into training and educational products. The robust training program includes two main channels of expert knowledge. First, the results of decades of research on integrating DER into the grid informs the training consortium. Second, the expert knowledge that would normally be lost by attrition (such as through retirement) is captured by experts in the teaching and development of material. Simply put, GridEd educates power engineers in the entire workforce pipeline, giving them the necessary skills and knowledge to effectively design, plan, operate, and protect the electric grid of the future.

GridEd defines and develops educational offerings focused on power systems engineering for all levels: from high school students, the beneficiaries of outreach, through undergraduate and graduate students, practicing engineers pursuing professional development, to mature and experienced engineers who are keen on understanding and developing skills to design, plan, operate, and protect evolving energy systems, especially distributed generation and its integration into the traditional electricity grid. Stated objectives include:

- Identify and incorporate high-level power systems/grid related research already being performed within the partnering institutions of GridEd into GEARED educational products.
- Project implementation will include new and revised courses in regular undergraduate and graduate programs, as well as in a variety of custom tailored short courses, tutorials, workshops, symposia and other methods of instructional and experiential delivery.
- Set priorities in consultation with utility members for the benefit and development of all aspects of their diverse workforce and also with the GEARED NNA for coordination.
- Stimulate student interest in the field of electric power engineering through connection with student organizations in the power and energy field as well as establish activities at participating universities in support of power engineering.
- Facilitate student internships, rotations and fellowships at utility and industry partnering organizations, and promote regular employment opportunities with utility and industry.

8. Project Objectives: The project work plan follows a series of tasks as prescribed below. Each task has one or metrics to assess the success of meeting the requirements of the task. Courses and outreach are performed in a variety of environments including live in-person, live-online, and recorded trainings.

Task 1: Development of Training Dissemination and Evaluation Strategic Plan – Quarterly metrics collection on student enrollments in educational offerings and annual updates to the strategic plan.

Task 2: Identification of Electric Industry Needs and Gaps Related to Distributed Technology – Bi-annual advisory meetings with utility advisors and an annual topic prioritization survey.

Task 3: Development of Curriculum & Course Materials for Academic & Professional Courses – Bi-annual updates w/ new and revised material to undergraduate and graduate courses. Original plan:

Course Type	Year 1	Year 2	Year 3	Year 4	Year 5	Total
New			4	2	2	8
Revised		4		2	2	8

Task 4: Deliver Short-Courses on Selected Critical RE-Related Topics – Periodic short courses on topics prioritized by utility advisors. Original plan:

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Short Courses	4	4	3	3	1	15

Task 5: Develop E-Learning Modules for Open-Access Subscription – four free eLearning modules originally to be completed by the end of year 3.

Task 6: Develop Strategy for Consortium Self-Sustainability – establish strategic plan to increase paid participation in the collaborative by year 3. Revise plan in year 5 for a self-sustaining consortium.

Task 7: Community Engagement and Outreach Programs – outreach materials targeting high school students and 4 community engagement events by year four. Annual tech transfer workshops to train instructors starting in year 3. Periodic human resource committee meetings starting in year 4.

Task 8: Develop and Maintain Communication Structures and a GridEd Website – <http://grided.epri.com>

Task 9: Create and Maintain GridEd Student Scholars at each GridEd Partner University – Starting in year 1, hold periodic meetings for a Student Innovation Board composed of student leaders at each GridEd university. Link to existing student organizations and allocate funding to support student

Solar Energy Technology Office Portfolio Review

activities and design projects.

Task 10: Plan and Host Regional Student-Centered Research Conferences – in coordination with the GEC, support student activities at annual conferences and promote student engagement.

Task 11: Project Management and Reporting – Monthly coordination meetings with GridEd and GEARED stakeholders.

Note that experimental design and data analysis were not major components in the scope of this project.

- 9. Project Organization and Responsibilities:** EPRI leads all seven partner universities and manages their work product through subcontracts. EPRI and its partner universities are advised by twenty-one utility advisors (see Table 1 below) through monthly webinars and bi-annual advisory meetings. Additionally, utility advisors nominate Affiliate universities (see Table 2 below) which also provide feedback to the consortia via periodic webinars and an annual tech transfer workshop. Collectively EPRI, its partner universities, utility advisors, and affiliate universities comprise the GridEd-East and GridEd-West consortia.

Table 1. Committed Utility Advisors as of January 5, 2018

GridEd-East	GridEd-West
Central Hudson	Arizona Public Service (APS)
Consolidated Edison, Inc.	Bonneville Power Administration (BPA)
CPS Energy	Pacific Gas & Electric
Duke Energy	Portland General Electric (PGE)
Entergy	Salt River Project (SRP)
First Energy	Snohomish County Public Utilities
LG&E and KU Energy	Southern California Edison (SCE)
Lincoln Electric System	Tri-State G&T
National Grid	Western Area Power Authority (WAPA)
New York Power Authority	Xcel Energy
Southern Company	

Table 2. Committed Affiliate Universities as of January 5, 2018

GridEd-East Affiliate Universities	GridEd-West Affiliate Universities
University of Texas - SA	California Polytechnic State University
University of the Incarnate Word	Sacramento State University
State University of NY (SUNY) New Paltz	Washington State University, Vancouver
North Carolina State University	Oregon State University
Clemson University	Oregon Institute of Technology
Louisiana State University	New Mexico State University
University of New Orleans	University of California – Los Angeles
Akron University	University of California – Irvine
Case Western Reserve University	Washington State University, Pullman
University of Louisville	Western Washington University
University of Nebraska	University of Colorado, Denver
Buffalo State	Colorado School of Mines
Rensselaer Polytechnic Institute	West Texas A&M University
University of Alabama Birmingham (UAB)	
Syracuse University	
Worcester Polytechnic Institute	

GridEd also has monthly coordination meetings with other GEARED consortia lead by the National Network Administrator (Interstate Renewable Energy Council). The principal investigators for each GEARED consortium also meet three times a year through the GEARED Executive Committee (GEC) Meeting and meet periodically with a GEARED Advisory Board. The overall GEARED coordination and advisory meetings are led by IREC while GridEd advisory meetings are led by EPRI.

- 10. The Challenges:** The electric power system is changing fundamentally and profoundly—rapidly in some geographical areas, inevitable in all—with the rise of distributed energy resources (DER), such as small natural-gas-fueled generators, combined heat and power plants, electricity storage, and solar

Solar Energy Technology Office Portfolio Review

photovoltaics (PV) on rooftops and in larger arrays connected to the distribution system. To fully realize the value of DER and to serve all consumers at standards of service quality and reliability they demand, the distribution grid needs to be designed to expand its capability to integrate and benefit from DER operation. Realizing a fully integrated grid requires utility technical staff that can plan and operate such a system. Engineers and planners that are tasked with developing and operating the future grid will require new and innovative knowledge. GridEd's charge is to support and inform a growing knowledge base of new technologies and is dedicated to fulfilling this training role. GridEd is not setup to resolve the technical barriers and conduct research on unknown and unanswered questions. Rather, GridEd is addressing the workforce development issues of the industry by taking the most recent industry research findings and translating them into educational and training materials.

11. Milestone Status: All major milestones have been achieved and exceeded with the exception of the e-Learning deliverable. The original scope was expanded from 4 modules into a two-semester course sequence on basic power system analysis per feedback from utility advisors which extended the time required for completion. Additionally, the passing of the lead professor at Georgia Tech and hurricane Maria in Puerto Rico have further delayed completion of this milestone. The current plan is to complete the 2-semester basic power systems course by Q2, 2018. Other adjustments from the original schedule have included a revision of scheduled phases to align with university recruiting of graduate teaching assistants and the additional of a human resources committee to incorporate feedback regarding hiring and retention needs from that part of utility organizations. Further, EPRI expanding its training agenda beyond what was originally conceived at the beginning of the project and as a broader institution is more directly addressing professional training beyond just R&D.

12. Scalability / Replicability / Impact: GridEd has been assessing a strategy for sustainability beyond GEARED funding from the beginning of the project. Several key elements that provide long-term stability are centered around GridEd's management by EPRI and EPRI's mission of addressing the challenges in electricity. These include:

- EPRI's collaborative strength to build strong ties between utilities and universities;
- EPRI providing ongoing access to Short Course programs for the electric industry;
- EPRI actively expanding relationships with universities;
- EPRI seeking electric industry executive commitment to the value of education and training for its professional staff;
- EPRI seeking out and using modern technology to more easily access the industry as a whole. EPRI has created new projects to facilitate utility access to education and training opportunities. Our goal is to build upon the 19 utilities that are part of GridEd and to broaden access to the industry. EPRI is exploring its role in education and training well beyond GridEd, but as a potential corporate commitment. Historically, EPRI has focused on the R&D aspects and left most training to other entities except in unique circumstances.

13. Project Results:

University Curricula - A curriculum review of GridEd partner universities has been conducted to identify gaps. Fifteen (15) new courses and sixteen (16) modified courses have been developed to date. This exceeds the milestone of four (4) new and four (4) modified courses originally set in the project plan. There have also been 9,634 enrollments in power courses at GridEd partner universities. To expand the curriculum to more universities, GridEd has hosted Tech Transfer workshops which typically bring ~25 professors together to discuss curriculum developed.

Professional Development and Training - To date, 715 attendees have participated in 31 short courses and workshops covering 14 topics through the GridEd short course program and one utility workshop. Course topics were chosen based on annual surveys of the advisory body and feedback from bi-annual advisory meetings. Further, a free and open access e-Learning course which will cover two semester's worth of basic power systems is being developed based on direction from utility advisors. A syllabus has been developed, modules have been assigned to each of the four GridEd-East Partner universities, and modules are in development.

Student Engagement and Outreach – GridEd's Student Innovation Board (SIB) consists 12 student

Solar Energy Technology Office Portfolio Review

leaders for GridEd-East, and 10 student leaders for GridEd-West to date and is continuing to grow. GridEd has participated in the planning and execution of several conferences where GEARED has had a presence including the North American Power Symposium (NAPS) at UNCC in 2015, DistribuTECH in 2016, 2017 & 2018, the IEEE Power & Energy Society's General Meeting in 2016, and Solar Power International in 2016. Multiple outreach activities have been conducted including an energy pathway curriculum for high school students from Georgia Tech, Discover Engineers Day at UNCC, seminars for high schools at UPRM, in addition to educational materials for middle-school students and outreach through microgrid research at Clarkson. A webcast was held for Affiliate universities to share best practices for internships and co-ops; and, links to internships and co-ops have been posted to the GridEd website and are being shared with the SIB and other students. Tentative results from a survey of students taking power courses reveal that ~80% did an internship, coop, or were employed over the summer. Further, ~50% of students taking power system courses were applying to companies predominantly known for power engineering, ~40% were applying to electric utilities, and ~30% were applying to GEARED utility participants and/or EPRI.

Note: publications in professional or scientific literature and developing intellectual property are not within the scope of this project.

14. Budget Tables: The budget tables below indicate EPRI's cumulative budget and for the GEARED and STEP awards and reflect spending through September 30, 2017. Contractual spending is slightly behind schedule due to university reporting delays, slow down at UPRM due to hurricane Maria, and PI transitions at Georgia Tech. EPRI cost share is ahead of schedule due to an expanded short course agenda.

Cumulative Budget (GEARED & STEP) and Spend through Sept. 30, 2017			
	Budget Plan	Cumulative Actual Expended	% Expended
Personnel	\$527,085	\$ 460,887	87%
Fringe	\$526,535	\$ 444,861	84%
Travel	\$104,950	\$ 111,283	106%
Equipment	\$0	\$ -	
Supplies	\$0	\$ 235	
Contractual	\$5,236,630	\$3,495,929	67%
Construction	\$0	\$ -	
Other	\$20,000	\$ 21,336	107%
Indirect Charges	\$1,301,223	\$ 982,824	76%
Grand Total	\$7,716,421	\$5,517,354	72%
Federal Share	\$5,200,001	\$3,213,166	62%
Cost Share	\$2,516,420	\$2,304,188	92%

Project Participants	Cost Share Planned (\$)	Cost Share Actual (\$)	% Expended
Electric Power Research Institute	\$1,325,128	\$1,390,644	105%
Georgia Tech Research Corporation	\$258,190	\$194,016	75%
University of North Carolina at Charlotte	\$248,079	\$208,863	84%
Clarkson University	\$224,148	\$229,957	103%
University of Puerto Rico - Mayaguez	\$271,406	\$185,257	68%
Arizona State University	\$62,500	\$45,118	72%
University of California, Riverside	\$63,623	\$20,737	33%
Portland State University	\$63,346	\$29,597	47%