Grid Engineering for Accelerated Renewable Energy Deployment (GEARED)

Topic Area 2: National Network Administrator

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The Interstate Renewable Energy Council, Inc. (IREC)

Final Report

Project Name:

Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) – National Network Administrator

Key Takeaways:

1) Length of the Project

The GEARED Initiative had a five-year window to complete the goals and objectives envisioned by DOE. One of the overarching goals of GEARED was to create a nationwide network. To be successful, participants had to establish meaningful professional relationships. Four consortiums were chosen, and each had multiple partners from universities, education institutions, and the utility industry. Many of these partners had never worked together before. Because of the size and scope of this project it took nearly 18-months, after modifications to SOPOs at the end of budget-period one, before the three remaining DTTCs and IREC could come together and function in a wholistic way. IREC applauds DOE for recognizing the challenges inherent in the project and demonstrating the willingness to adjust goals and expectations. It should also be noted that in budget-periods three, four, and five the GEARED Executive Committee (GEC) was operating at a high-level of efficacy. In fact, all representatives expressed sadness and dismay that the project was ending; there was strong desire to keep the positive momentum going. The GEC discussed how GEARED could have benefited from the National Science Foundation award format where initiatives can continue to receive funding. In the end, the five-years of working together produced long-term professional relationships that will foster opportunities to work together again as part of a nationwide network.

2) Challenges Associated with the GEARED Project

a) **Unique students not identifiable:** DOE sought to capture the *true* number of students taking GEARED-related courses. Universities routinely share student IDs with most third-party vendors (e.g., Learning Management Systems, course evaluation platforms, homework tools) so the vendor can provide their service. However, due to the Family Educational Rights and Privacy Act (FERPA) the DTTCs were unable to get university Registrars offices or other departments to share student IDs for the purpose of identifying unique students. This could be the role of a future national administrator – to ensure gathering of critical metrics by securing the same access allowed to any SaaS provider who requires limited access to critical student IDs.

b) **Industry vs. Academic Conferences**: Utility industry conferences have immense value for power engineering students and faculty. Students have an opportunity to observe how power engineering technology researched and discussed in the classroom is currently being utilized by industry and in a real-world environment. Moreover, there isn't another power technology venue in the country that offers students' networking opportunities with 500+

companies. Students also received excellent feedback from industry professionals regarding their design projects, which were displayed on the exhibitors' floor, and most students obtained multiple business cards from companies seeking to offer internships, jobs, or a chance to further discuss their design projects with companies working on the same issue. Faculty have the chance to see first-hand how technology taught in the classroom was being utilized, broadening their experiences and bringing real-world examples to their courses. Faculty networking also leads to creating partnerships with industry that improves the overall quality of education and training through shared knowledge and equipment.

Despite all the benefits to attending industry conferences, early in the GEARED project, it became evident that most engineering faculty do ***not*** participate in these events. When faculty have resources to travel, they prefer to participate with their peers at academic conferences such as the Institute of Electrical and Electronics Engineers – Power & Engineering Society (IEEE-PES) and the North American Power Symposium (NAPS). There are many important reasons for this choice, but one of the biggest is that academic conferences allow faculty to present papers for peer review. University faculty in search of tenure need to demonstrate they are well-published. Industry conferences have a completely different focus and audience. IREC spent considerable time trying to convince faculty of the value of attending industry-focused conferences and it was an uphill battle. Those faculty that did attend the DistribuTECH and TechAdvantage industry conferences instantly saw the value for students and themselves; many continued to come each year GEARED was showcased.

As DOE seeks to further link students to industry, understanding this challenge is critical. Faculty are the gateway to students, and as IREC sought to disseminate information about participation in industry conferences, the information either wasn't getting to the students, or it wasn't presented in a fashion that invoked excitement. Adding to the challenge was senior faculty advising newer faculty to focus on academic conferences because of personal advancement. This is endemic of higher education and that culture is not easily changed. DOE should consider mandating, through incentives or otherwise, that universities participating in GEARED-type projects must also participate in industry conferences. The positive outcomes will inspire faculty and motivate students to participate as well.

For additional key takeaways see section: 6, Page 15

Open Questions:

Q1: Would the number of power students wanting to work for a utility company increase over time as they took more GEARED courses and participated in more GEARED activities?

Q2: Would a project the size and length of GEARED been better served by choosing a National Network Administrator prior to negotiating final Statements of Project Objectives with the Distributed Technology Training Consortia?

Q3: Knowing the success of the midterm evaluations on improving the quality training, would the GEARED initiative have been better served if participation in midterm evaluations was mandatory instead of voluntary?

Q4: Would an increase in participation of power engineering faculty and students at utility-sector sponsored conferences like DistribuTECH improve (1) quality of instruction; (2) industry engagement with power engineering programs; (3) student interest in working within the utility industry?

COMPLETED TASKS AND MILESTONES

See Appendix A

CUMULATIVE SPENDING	BUDGET REMAINING
Fed Share $ $1,100,000.00	**Fed Share $** $0.00
Cost Share$ $0.00	**Cost Share$** $0.00

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Executive Summary

Grid Engineering for Accelerated Renewable Energy Deployment (GEARED)

In 2013, one objective of the Energy Efficiency and Renewable Energy division of the U.S. Department of Energy (DOE) was to support the increase in power systems research, development, and analytical capacity while simultaneously growing the expertise and preparedness of current and incoming electric utility sector professionals for high penetrations of solar and other distributed energy technologies. DOE felt strongly that power systems expertise was needed to meet the unique challenges and opportunities posed by increasing penetration of renewable power technologies – specifically for distribution systems. Integrating distributed PV, small wind, transactive controls, demand response, electric vehicles, distributed storage and other variable and distributed power technologies into the grid would require new skills and power systems expertise.

In order to achieve its joint power systems research and human capacity goals, DOE developed the five-year, Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) initiative and provided funding to create four Distributed Technology Training Consortia (DTTC) made up of universities, utilities, and organizations. These DTTCs supported the inclusion of power systems analysis, research and development, into training activities such as curriculum and short course development, internships & coops, and continuing education. Additionally, DOE aimed to build a national framework for power systems training and curriculum that accelerates the growth of power systems programs and human capacity. To that end, the GEARED initiative utilized a National Network Administrator (NNA) to manage and leverage the activities of the four DTTCs as well as that of others participating in distributed technology and engineering through research or practice. DOE chose the Interstate Renewable Energy Council (IREC) as the NNA.

IREC partnered with the Smart Electric Power Alliance (SEPA) and developed a well-conceived plan around what the partnership called the four-Cs: coordination, connections, consistency, and accountability. The approach was to provide a range of complementary activities:

- Coordination was monthly conference calls, an annual in-person meeting of the GEARED consortia, a national steering committee, and other sharing of technical and instructional expertise.
- Connections was a web site and social media, yearly, student-centered conferences held at a major utility event, and an online directory of power engineering courses.
- Consistency was driven by best practices, shared metrics, industry workforce standards, and national credentialing pathways.
- Accountability was measured by network-wide evaluation and assessment metrics.

IREC and SEPA would effectively coordinate multiple activities, connect diverse stakeholders, and present accountability of efforts. The concept was well-received by DOE, and in budget-period one, IREC hit the ground running as National Network Administrator.

IREC demonstrated its leadership and deep understanding of the challenges, breadth of knowledge, and subject matter expertise needed to build a nationally coordinated network. Based on feedback from DOE and industry stakeholders, the GEARED initiative was a highly successful endeavor, which paved the way for a follow-up DOE initiative to continue much of the work accomplished under GEARED. In year-one alone IREC convened an in-person kick-off meeting of representatives from the four DTTCs, DOE, and IREC/SEPA; launched a national website that provided links to each DTTC website; convened a very successful student-centered conference in conjunction with SEPA's Utility Solar Conference; laid the groundwork for DOE's vision of a National Student Innovation Board; established standardized metric collection priorities and embedded assessment opportunities; and *began* establishing the "network" through scheduled monthly conference calls.

In budget-period one, IREC struggled with two main objectives: (1) fully establish a nationwide "network," and (2) coordinate activities that were common throughout the DTTCs. It is noteworthy that IREC was the National Administrator of the highly successful Solar Instructor Training Network (SITN) and utilized the same management team for GEARED. Many of the lessons-learned from the SITN initiative proved invaluable, especially during the first-year challenges faced by the GEARED initiative.

Each DTTC had its own approach and methodology towards fulfilling the goals and objectives of the GEARED initiative. Meeting their own contractual obligations was each DTTCs highest priority and this resulted in a silo effect where each DTTC began working independently. Exacerbating the situation was the underperformance of one DTTC, making IREC's coordination efforts even more difficult. The NNA was becoming marginalized and changes needed to be made.

Meetings with DOE led to a significant rewrite of IREC's Statement of Project Objectives (SOPO) and partial rewrites of the DTTCs' SOPOs for budget periods 2-5. The GEARED project was in a transitional phase the first two quarters of budget-period two, and communication substantially increased with the three DTTCs chosen to continue their projects. IREC's leadership, guidance, and expertise played a significant role in the rewrite process to ensure GEARED would be a successful endeavor.

The GEARED project thrived under the new SOPO. IREC proposed the formation of the GEARED Executive Committee (GEC) which included representatives from each consortium, IREC, and DOE. Additionally, IREC created operating guidelines for GEARED that were approved and accepted by the GEC, allowing IREC to play a more active role in coordinating the common activities among the three remaining consortia.

Under the newly created guidelines, the GEC met in-person, three times per budget period, and the outcomes of those meetings dramatically helped to minimize the silo-

effect that was apparent in budget-period one and the early phase of budget-period two. As the GEARED initiative moved into budget-period three, the improved collaboration spawned ongoing communication between the DTTCs and IREC as well as better coordination and communication between DTTCs. The in-person meetings and ongoing coordination fostered stronger relationships between and amongst the DTTCs and IREC. There was a sense of trust, leading to frank conversations about what could be accomplished and what was unrealistic regarding coordination of common activities. IREC's leadership played a critical role at this juncture of the project, and while DTTC's had their own individual deliverables, it was abundantly clear that collaboration would only increase as the initiative moved forward. Strong collaboration allowed IREC to more effectively implement its four-C's plan. GEARED was finally becoming the nationwide network envisioned by DOE.

IREC continued to demonstrate its leadership and guidance during budget-period four by encouraging greater DTTC collaboration with industry, promoting student engagement and activities at national utility conferences, gathering student feedback on standardized questions, and fostering long-lasting industry/education relationships through in-person meetings and monthly conference calls. The GEARED Executive Committee and its structured approach proved to be an efficient and effective modality for communication and collaboration with the consortia and IREC considers the creation of the GEC to be one of the cornerstones of IREC's contributions to the success of GEARED.

After initial connections were made through DTTC partners, IREC began to forge close ties with national conferences around the country. These conferences provided unparalleled opportunities for GEARED students to gain employment and internships, while significantly increasing industry awareness of the GEARED initiative. IREC played a leadership role in coordinating GEARED-related activities at the North American Power Symposium and the DistribuTECH and TechAdvantage conferences with tremendous success and is equally proud of this deliverable. In fact, efforts are ongoing to find a sustainable path for students and faculty to participate in future DistribuTECH conferences well beyond the sunset of the GEARED initiative.

Throughout the five-year project, IREC collected quantitative and qualitative metrics on the GEARED project and the data reinforced DOE's originally stated objective for GEARED. The data collection process would not have been successful without the coordination of the GEC and each DTTC ensuring their universities were responsive to IREC's requests. The metrics numbers identified throughout this report are impressive; the impact on the utility-sector measurable. By December 2018, a total of 1,258 GEARED-related courses had enrolled 37,341 academic and professional students.

Lastly, IREC's role as network administrator ensured this project was a national success. It was IREC's leadership, determination, and influence that pulled-together three strong, independent consortiums and projects, into a national powerhouse of training and education for the power systems field. The nationwide network envisioned by DOE came to fruition and will last long beyond the GEARED initiative.

Project Objectives

In collaboration with the U.S. Department of Energy, National Network Administrator (NNA) helped to facilitate and support efforts of the Distributed Technology Training Consortia (DTTC) to build a national framework for power systems training and curriculum that will accelerate the growth of power systems programs and human capacity. Specific Project Objectives included:

1) Providing effective coordination of consortia activities through clear communication channels that promoted an increase in power systems research, development, and analytic capacity (within and among GEARED consortia partners);
2) Promoting DTTC connectivity through a national website, social media, participation in annual regional and a national student-centered conference, an online directory of PE courses, and GEARED branding.
3) Growing the expertise and preparedness of current and incoming electric utility sector professionals for high penetrations of solar and other distributed energy technologies through updated and enriched education and training programs. The National Administrator supported coordinated educational innovation and also helped increase interaction among GEARED consortia through the adoption of best practices.
4) Providing nationally coordinated accountability of consortia activities through standardized, network-wide evaluation and assessment metrics.

Motivation for Project

Intelligent controls of power flow into and out of the utility grid are required to ensure grid reliability, stability, and power quality. Alternative protection strategies are also required to accommodate large numbers of distributed energy sources. Time-of-use and peak-demand rate structures require more sophisticated system designs that integrate energy management and/or energy storage into the system architecture.

This increasing complexity leads to the continued and growing need for more training and support for power systems analysis, research, and development in order to facilitate the integration of distributed technologies like photovoltaics, both within utilities and at institutions that support the workforce pipeline to the power and energy sectors. Unfortunately, electric utilities have few mechanisms by which they can partner with researchers to support power systems analysis, research and development.

At the time the GEARED project was beginning, a number of reports, including those from the President's Council of Advisors on Science and Technology (PCAST)[1] and

[1] President's Council of Advisors on Science and Technology. Report to the President on Accelerating the Pace of Change in Energy Technologies through an Integrated Federal Energy Policy. November 2010. < http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-energy-tech-report.pdf >

MIT's Energy Initiative[2], indicated there was a shortage in power systems personnel and a lack of programs to grow the skilled workforce needed to operate power systems across the United States. According to 2009 estimates from the U.S. Power and Engineering Collaborative, approximately 45 percent of power system engineers would be eligible for retirement within five years.[3] Utilities would need to hire more than 7,000 new power engineers to replace retiring engineers and two or three times this amount would be needed to satisfy the needs of the entire country. Furthermore, approximately 40 percent of key power engineering faculty at U.S. universities would be eligible for retirement in the next five years. This knowledge and workforce gap was inhibiting the U.S. from efficiently updating, improving, and integrating new technologies such as photovoltaics, other distributed technologies, and advanced grid infrastructure.

Power systems expertise is needed to meet the unique challenges and opportunities posed by increasing penetration of renewable power technologies – specifically for distribution systems. Integrating distributed photovoltaics, small wind, transactive controls, demand response, electric vehicles, distributed storage and other variable and distributed power technologies into the grid will require new skills and power systems expertise.

Project Team

Interstate Renewable Energy Council, Inc. (IREC): The Interstate Renewable Energy Council is a 36-year-old not-for-profit organization with a talented team of professionals dedicated to working toward the goal of 100% renewable energy. Millions more Americans in nearly every state are able to enjoy the benefits of clean and efficient energy as a result of IREC's thought-leading, fact-based regulatory policy engagement and best practice resources. Working state by state, IREC's unique work helps make affordable, reliable, sustainable clean and efficient energy possible, including for low-to moderate-income renters and multi-family dwellers, and in underserved communities.

More important than ever is IREC's work building a quality-trained workforce, both within and outside clean energy industries. This includes incorporating clean energy training for allied professionals, like solar training for fire fighters and local building code officials.

IREC established a strong team to fulfill its role as the GEARED Initiative's National Network Administrator. Team Members included:

[2] Massachusetts Institute of Technology. MIT Study on the Future of the Electric Grid. < http://mitei.mit.edu/system/files/Electric_Grid_Full_Report.pdf >

[3] The U.S. Power and Engineering Workforce Collaborative. Preparing the U.S. Foundation for Future Electric Energy Systems: A Strong Power and Energy Engineering Workforce. April 2009. < http://www.ieee-pes.org/images/pdf/US_Power_&_Energy_Collaborative_Action_Plan_April_2009_Adobe72.pdf >

- **Joe Sarubbi, Principal Investigator and Project Manager:** As manager of the GEARED Project, Joe provided leadership and was the driving force that directed the project's vision, goals and objectives. Joe is a consultant, who also served as Project Manager for the Solar Instructor Training Network, another U.S. Department of Energy SunShot Initiative, where IREC acted as the National Administrator. Previous to his work with IREC, Joe spent 32 years at Hudson Valley Community College as a college Professor and Executive Director; and was the Department Chair of the Plant Utilities, Electrical Construction & Maintenance, Civil Engineering, Heating Ventilation, Air Conditioning & Refrigeration, and Construction Technologies programs.

  Joe was the main architect for the college's TEC-SMART facility, the country's first totally integrated Training and Education Center for Semi-Conductor Manufacturing and Alternative and Renewable Technologies, and in 2009 was honored by the visit of President Barak Obama in which the President recognized his work in developing model programs for other institutions to emulate. Joe has garnered a national reputation for the design and delivery of renewable energy and other industry training programs.

- **Mary Lawrence, Project Coordinator:** Mary Lawrence played a critical role in the day-to-day activities of the GEARED initiative, providing administrative support for all aspects of the GEARED Project. Mary acted as the communication and information hub for IREC, communicating with the GEARED Network and industry stakeholders, arranging meetings and webinars, taking meeting notes, and overseeing the GEARED website. Mary held a similar position from 2011 to 2016, working as IREC's Project Coordinator for the U.S. Department of Energy's Solar Instructor Training Network.

  Mary came to IREC with strong organizational, project administration, and computer skills. Prior to joining IREC's team, Mary worked for another federally funded grant program, AmeriCorps Cape Cod (ACC). ACC is a full-time, residential, service program that focuses its efforts on the natural resource management and disaster preparedness needs of the Cape Cod community. For her final three years with the program Mary acted as Program Coordinator, handling the day-to-day activities of the program and overseeing five staff and 26 AmeriCorps members.

- **Dr. Matthew Champagne, Evaluator:** Dr. Matt Champagne was responsible for metrics collection and the system of evaluation that helped determine the impact of the GEARED Initiative. Matt worked closely with the Project Manager and Project Coordinator ensuring the goals and objectives of the project were met. Matt's research and practice in developing and assessing large-scale online training programs has influenced the field of assessment in Higher Education for 22 years. Matt and his colleagues have generated 45 articles and how-to guides that have been heavily cited by practitioners and were amassed by collecting data from over 6,000,000 students and instructors at 440 colleges and learning

organizations since 1997. Matt has been a Senior Evaluator for the U.S. Department of Education, the National Science Foundation, and the Sloan Foundation. He was Senior Research Fellow for the Army Research Institute and was Principal Investigator or Evaluator for a dozen federally-funded projects of national impact.

- **Jane Pulaski**, **IREC Communications**: As one of IREC's Communications staff, Jane Pulaski was responsible for GEARED's presence on social media, developing, maintaining, and writing content for national GEARED website. Jane has been with IREC since 1999 supporting the organizations communication and outreach efforts. She has extensive knowledge of the IREC stakeholder network, serves as the editor of IREC's newsletters, and coordinates IREC's media placement with Renewable Energy World and other trade outlets. Before joining IREC, Jane spent 17 years in working for the State of Texas in a variety of communications positions including the State Energy Conservation Office, The Texas Department of Agriculture, the Texas House of Representatives and the Texas Senate.

Smart Electric Power Alliance (SEPA): The Smart Electric Power Alliance is a nonprofit organization that envisions a carbon-free world by 2050. They are one of many entities globally working to make this vision a reality. SEPA's specific role is to facilitate the electric power industry's smart transition to a clean and modern energy future through education, research, standards, and collaboration. SEPA engaged Bob Gibson to work with IREC on the GEARED Initiative.

- **Bob Gibson:** Now retired from full-time work, Bob was Vice President of Education and Outreach at SEPA. Bob led SEPA's outreach activities as part of the GEARED team and was co-chair the GEARED National Advisory Board. Bob came to SEPA from the National Rural Electric Cooperative Association, where he was a senior manager in the Cooperative Research Network for seven years, leading NRECA's analysis of renewable energy and energy efficiency technologies and business models. Bob also worked at an alternative energy services company, marketing fuel cells, microturbines, photovoltaics and other technologies to electric utilities. One of his key responsibilities while with the Technology Transition Corporation was program management and outreach for the Utility Photovoltaic Group. Bob's diverse background includes work on projects to bring electricity to rural communities in developing countries in Asia and Latin America, as an award-winning magazine and newspaper editor, writer and photographer, and service as a U.S. Peace Corps Volunteer.

National Advisory Board Team: In addition to representatives from each DTTC as well as IREC, a select group of industry experts were invited to join the GEARED National Advisory Board. This group met quarterly via tele-conference to provide the GEARED Initiative with industry guidance and support. 17 individuals made up the Board:

- Frank Peverly, Orange and Rockland Utilities
- Peter Muhoro Pedernales Electric Cooperative

- Steve Whisenant, Duke Energy Carolinas, LLC
- Carmine Tilghman, Tucson Electric Power
- Jon Eric Thalman, PG&E
- Steve Collier, Milsoft
- Michael Coddington, NREL
- Ann Randazzo, Center for Energy Workforce Development
- Tom Reddoch, EPRI (GridEd)
- Mariesa Crow, University of Missouri Science and Technology (MARMET)
- Kurt Yeager, Galvin Electricity Initiative (MARMET)
- Zhihua Qu, University of Central Florida (FEEDER)
- Jennifer Szaro, Orlando Utilities Commission (FEEDER)
- Joe Sarubbi, Co-Chair, IREC (NNA)
- Bob Gibson, Co-Chair, SEPA (NNA)
- Jane Weissman, IREC (NNA)
- Jerry Ventre, IREC (NNA)

Significant Results

1) Creation of the GEARED Executive Committee and Adoption of the Supporting Guidelines

IREC created and managed a structured approach to ensure the GEARED consortia operated as an effective network; one that actively fostered collaboration, coordination, and communication among all DTTC and stakeholder partners. To accomplish this, IREC created a GEARED Executive Committee (GEC) that:

- Coordinated and leveraged complementary capabilities and activities in research, education, training, and workforce development among DTTC partners.
- Identified, prioritized, and continually updated key issues and challenges facing the electric power industry in research, development, analytic capacity, and workforce development.
- Assigned inter-DTTC resources and working groups to address identified issues and challenges.
- Provided a representative body for key decision making on project direction, working group assignments, process facilitation, and resource allocation.

IREC created a set of guidelines that was adopted by the GEC (See Appendix B.) The guidelines were discussed at each in-person, GEC meeting and any modifications were approved and adopted. IREC created the agenda for each GEC meeting by seeking input from DOE and the DTTCs and IREC facilitated the meeting discussions. This structured approach helped IREC to act in a leadership capacity and improved DTTC accountability throughout the project. As relationships grew, trust was built, allowing for more frank discussions about what was, or wasn't possible to accomplish regarding specific deliverables. IREC's leadership proved

invaluable as DTTC confidence in the process soared and the GEARED project being the net beneficiary.

One of DOE's goals, to build a national framework for power systems training and curriculum, would not have been possible without the collaboration of the GEC. In-person meetings lead to DTTCs openly sharing curriculum, best practices and lessons learned and ultimately lead to the pursuit of a national repository of all curriculum developed under GEARED.

2) Forging Close Relationships with National Utility Conference Event Companies

It was important for IREC to hit-the-ground-running with a plan to connect students with utility-sector professionals and the IREC/SEPA Team agreed that SEPA's Utility Solar Conference was a good place to start. In budget-period one, IREC worked closely with the SEPA conference planners, ensuring student-planned activities were assimilated directly into the utility conference agenda. Student participation in this first GEARED student-centered conference included one student per GEARED university for a total of 17. Student activities included poster presentations, networking opportunities, and participation in the conference sessions. Follow-up evaluations with students affirmed the value of attending the conference. The Utility Solar Conference was IREC's opportunity to see, first-hand, the value of the poster sessions regarding student and industry professional engagement, and networking for jobs and internships. Moreover, it was an opportunity to showcase the GEARED Initiative and engage utility industry professionals in the project. Conference attendees were excited to have students participating in the conference, and equally excited to learn the type of projects students were investigating that aligned with industry needs. While the DTTCs were conducting activities with utility companies at a local and regional level, SEPA's Utility Solar Conference was the beginning of the GEARED Initiative's introduction to the utility industry at a nationwide level.

While the Utility Solar Conference was a great venue for the GEARED Initiative and SEPA was a perfect partner, the fixed future dates of the conference were at a time inconvenient to students. The FEEDER DTTC suggested another national utility industry conference – DistribuTECH – as an alternative venue. FEEDER has a strong partnership with Siemens Corporation, a significant sponsor of DistribuTECH, and this relationship provided the catalyst for GEARED activities at DistribuTECH. This began a multi-year partnership between GEARED, IREC, and Clarion Events (formerly PennWell Corporation). As the organizers of the DistribuTECH Conference, Clarion Events saw meaning and value to engaging university students and faculty in their conference activities. Over time, GEARED activities at the conference became significant enough that the GEARED Initiative's presence at the conference was highlighted in the opening plenary session, as well as on signs, on the conference website, and in the conference program. This recognition provided wonderful exposure to GEARED and its purpose.

IREC played a leadership role in coordinating GEARED-related activities at the DistribuTECH conference, including student and faculty registration, coordination of poster sessions, panel discussions with industry representatives, field trips, networking opportunities, and navigating the exhibitor's floor, which typically supported 500+ utility sector exhibitors. From exit surveys with students, IREC learned that the poster session was an important justification for students to travel to the conference, but once in attendance, the exhibitor's floor generated the greatest excitement. For many students, it was the first time they had participated in such a large event, and one that drew 15-18,000 utility sector professionals in one location. Students could see first-hand how the technology they were learning about in the classroom was being utilized in the real world.

Clarion has been thoroughly impressed with the outcomes of student activities at the DistribuTECH conferences over the last four years. IREC is currently in discussions with Clarion Event staff to determine the best way to engage students at the conference in the future. All involved feel confident activities will continue, and it will be a wonderful legacy to the GEARED Initiative.

In addition to the DistribuTECH conference, IREC worked closely with the National Rural Electric Cooperative Association (NRECA) coordinating additional student activities at its TechAdvantage Conference & Expo. The NRECA was a partner of a DTTC but needed a liaison to coordinate and manage logistics with students. The TechAdvantage Conference was a much smaller event compared to DistribuTECH but it provided students with a more intimate environment to engage with utility professionals. The TechAdvantage Conference also introduced students to rural electric cooperatives and possible job opportunities and internships available on that side of the industry. Like DistribuTECH, students presented posters, networked, and experienced interacting with industry representatives on the exhibitor's floor. Unique to TechAdvantage, students had a chance to make presentations about the design projects to industry representatives to round-out their conference experience.

While not initially identified as an important goal of the GEARED initiative, DOE recognized the value of the utility-sector conference activities and wholeheartedly supported the GEC's efforts, such that it became a major task of IREC to provide a leadership role in helping students engage utility professionals. IREC is proud of its work to connect students with the utility industry and considers this task another major accomplishment.

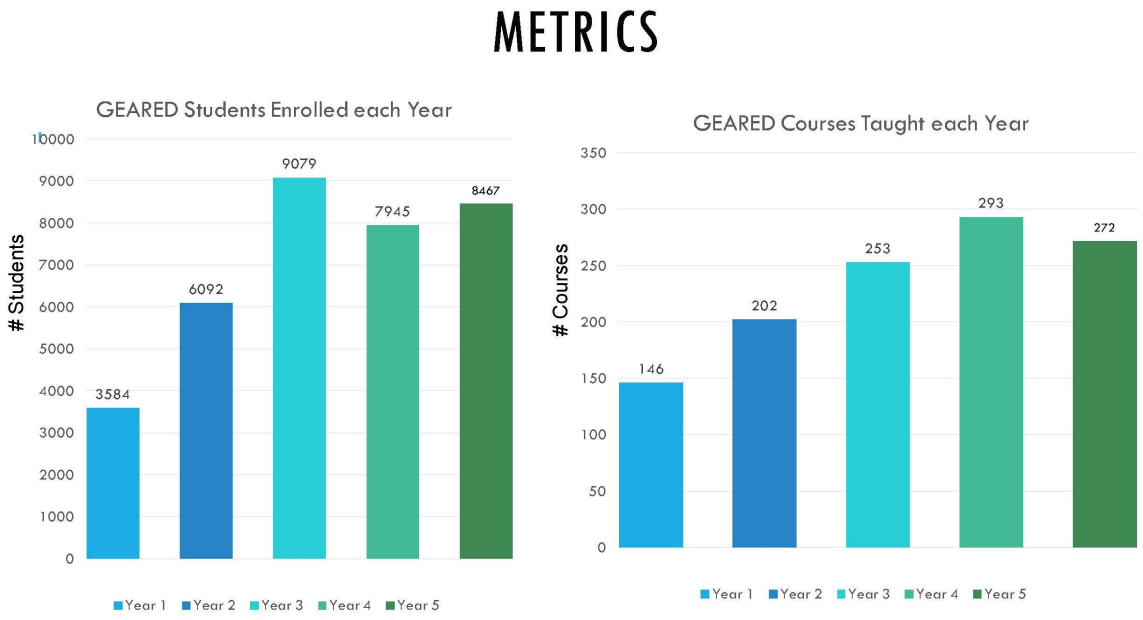
3) Overall Metrics Collection and Impact

a) Quantitative Metrics

Through coordination and accountability, the NNA obtained and verified course-level and instructor-level data from 26 universities and partners, critical for accurate metrics. At the start of the GEARED project (Fall 2013), 59 existing power-based courses were identified that enrolled 1,431 students. In the final year of the GEARED project, 272 power-based courses

were delivered to 8,467 students – a 361% increase in courses and 492% increase in students over the grant period. By December 2018, the cumulative totals were 1,258 GEARED-related courses enrolling 37,341 academic and professional students.

Of these 1,258 courses, 153 were newly created by faculty and industry partners and an additional 75 courses were substantially revised to serve GEARED students (e.g., converted to online, jointly taught across multiple institutions).



In the outgoing Fall 2018 term, an additional 2,174 students were enrolled in 92 GEARED courses. These figures and all metrics are reported in the Appendix (but not represented in the figure above since not all DTTCs reported metrics beyond Year 5 ending Summer 2018).

See Appendix C for a full summary of metrics data collected from the GEARED Project.

b) Impact/Jobs

Beyond the sheer magnitude of the GEARED Initiative in terms of numbers of courses created and students served, was the success of students getting jobs. A series of four surveys were conducted from Fall 2017 through Fall 2018 to monitor the post-graduation plans for GEARED students. A surprisingly high, 45% of GEARED students voluntarily responded to the survey, demonstrating their eagerness to share their stories. A total of 1,296 unique students from 24 universities shared their insights, identifying the 488 utilities, laboratories and other organizations to which they applied for jobs.

A critical question was whether GEARED students wanted to work in the power industry after graduation. The answer was a consistent YES by a 3-to-1 margin over all 3 terms.

Do you want to work in the Power Industry after graduation?

	Fall 2018	Spring 2018	Fall 2017
Definitely Yes	30.7	33.7%	35.0%
Probably Yes	41.4	41.6	39.5
Probably No	23.4	19.0	21.3
Definitely No	4.4	5.7	4.2
YES vs. No	72% v. 28%	75% v. 25%	75% v. 25%

Other interesting findings included:

- 29% of students planned to work at a utility, 27% planned to work at other (non-utility) organizations, 13% of students planned to continue their studies in graduate school, and 9% were going to work full time at their existing job
- Although geography played a dominant role in utility hiring, there were several interesting outlier companies that hired multiple students from universities that were geographically distant (e.g., students at U Hawaii, USC and UC San Diego accepting positions at Duke Energy).
- From Fall 2017 to Fall 2018, there appeared to be a shift in priorities towards students working in utilities. The percentage of students' undecided about their careers decreased from 20.1% to 17.6% while the percentage of students' planning to take a utility-based job increased from 26.4% to 29.2% over the same period. Numbers of students planning to attend graduate school also ticked upward but other career options remained consistent over time.

Regarding this last finding, since different cohorts of students answered the questions each term (and because other assumptions of statistical testing were not met), further data collection with more control over the participants would be needed to establish this trend and determine if this is a statistically significant increase.

The results of each survey were compiled into a "Jobs Report" made available to all GEARED students, a valuable resource from which they could learn of the job and internship opportunities available to other students across the nation. See Appendices D and E for additional material related to the student employment and internship surveys.

c) Qualitative/Student Input

The quality of GEARED teaching was clearly demonstrated through ongoing "midterm" student feedback measures conducted from Fall 2015 through Fall 2018. This standardized measure not only provided a consistent set of outcomes across all instructors and courses, but it helped faculty to make immediate and ongoing improvements to course content and delivery while the classes were still in session and while it still mattered to students.

More than 4,800 students participated in these midterm evaluations, administered by 134 faculty across 18 universities. Although not mandatory, an amazing 55% of students responded and contributed more than 160,000 words of comments – enough to fill a 300-page book with text alone! This feedback, carefully interpreted and reported to individual faculty, was then used by each instructor to create a better learning environment. And it paid off: 90% of students said they would recommend their GEARED instructor to their friends and 88% of students would recommend their GEARED course to their friends.

This high satisfaction rate encouraged more faculty to participate in the midterm evaluation process and by Spring 2018 the number of faculty, courses and students participating in the midterm evaluations tripled, while maintaining the high level of response rates and satisfaction with courses and instructors.

Quantitative and qualitative metrics were not originally identified as a goal of the GEARED project. After discussions with IREC metrics collection and overall impact of GEARED was added as a major task of IREC, and limited additional resources were added to IRECs award. The length of the GEARED project allowed IREC to shift its focus towards quantitative analysis and overall impact of GEARED.

See Appendix F for a full summary of the midterm evaluation process used during the GEARED project.

Key Takeaways

1) Length of the Project

The GEARED Initiative had a five-year window to complete the goals and objectives envisioned by DOE. One of the overarching goals of GEARED was to create a nationwide network. To be successful, participants had to establish meaningful professional relationships. Four consortiums were chosen, and each had multiple partners from universities, education institutions and organizations, and the utility industry. Many of these partners had never worked together before. Because of the size and scope of this project it took nearly 18-months, after modifications to SOPOs at the end of budget-period one, before the three remaining DTTCs and IREC could

come together and function in a wholistic way. IREC applauds DOE for recognizing the challenges inherent of the project and demonstrating the willingness to adjust goals and expectations. It should also be noted that in budget-periods three, four, and five the GEARED Executive Committee (GEC) was operating at a high-level of efficacy. In fact, all representatives expressed sadness and dismay that the project was ending; there was strong desire to keep the positive momentum going. The GEC discussed how GEARED could have benefited from the National Science Foundation award format where initiatives can continue to receive funding. In the end, the five-years of working together produced long-term professional relationships that will foster opportunities to work together again as part of a nationwide network.

2) **Statement of Project Objectives (SOPO) Negotiations**
The GEARED initiative sought to have four consortiums work together under the guidance and leadership of a national administer, yet all five SOPOs and final contract negotiations were conducted separately. DOE should consider a different approach when developing SOPOs and negotiating contracts under this type of arrangement. At the onset of the project IREC, as national administrator, had little, if any leverage to motivate the DTTCs to support the development of a national network as each DTTC was contractually responsible to ensure its own deliverables were being met. DTTCs had little motivation to work with each other for the same reason. It wasn't until budget-period two when SOPOs for the DTTCs and IREC were adjusted with new, consistent, language did the project take-off as envisioned by DOE. It is noteworthy that IREC was the national administrator of the Solar Instructor Training Network (SITN) and had similar challenges with nine Regional Training Providers (RTPs). In budget-period three of SITN project, the RTPs underwent similar SOPO modifications that allowed the SITN Initiative to become a success. To further reinforce the importance of better SOPO alignment at the onset of the project, the national administrator for the SITN was not chosen until the RTPs were operating for a full year. Many of the RTPs questioned whether a national administrator was even needed. They couldn't see that each RTP was working in isolation preventing the development of synergies that could take projects to the next level. When the RTPs came together with IREC as the national administrator, the SITN started operating as a team and amazing metrics were produced.

3) **Challenges Associated with the GEARED Project** Since metrics collection became a large and important task, IREC shares the following information to help improve future projects that require copious amounts of data to be collected and analyzed for project impact.

    a) **Appropriate Resources:** The original GEARED Funding Opportunity Announcement (FOA) did not require metrics to be collected. After lengthy discussions with IREC, DOE agreed to add an additional 10% to the award for metrics collection and program evaluation. This added $100,000 to the total award. Over a five-year period, it amounted to $20,000/year, not nearly enough to conduct thorough metrics collection, evaluation, and reporting on results. To complicate matters, the DTTCs did not have metrics collection

built into their respective budgets, making collection even more difficult. It's important to remember that collecting important metrics means dealing with humans. There must be incentives and motivation for people to spend time gathering data. In all cases, IREC relied on certain champions within each DTTC or at certain universities to rally others to provide this data through their relationships, relying on favors and pleading to get the job done. Since those providing the data were not paid from the grant, when key personnel left, the data dried up. In the future there needs to be more resources and authority given to the NNA to incentivize those responsible for gathering and reporting metrics. DOE should consider allocating a certain percentage of each budget for metrics collections that align with National Science Foundation standards.

b) **Unique Students Not Identifiable:** DOE sought to capture the ***true*** number of students taking GEARED-related courses. Universities routinely share student IDs with most third-party vendors (e.g., Learning Management Systems, course evaluation platforms, homework tools) so the vendor can provide their service. However, due to the Family Educational Rights and Privacy Act (FERPA) the DTTCs were unable to get university Registrars offices or other departments to share student IDs for the purpose of identifying unique students. This could be the role of a future national administrator – to ensure gathering of critical metrics by securing the same access allowed to any SaaS provider who requires limited access to critical student IDs.

c) **Demonstrations of Achievemen**t: The GEC identified and agreed to collect data on nine common, or shared metrics across the consortia. However, once IREC began collecting "demonstrations of achievement" in Year 3 (e.g., # of degrees and certificates), there was no agreement or consistency as to what should ***count*** towards identifying an individual as a "GEARED Student." Some DTTCs counted PhDs earned by students who took just a single GEARED-related course while others thought there should be some agreed minimum of courses taken so as to count as a "GEARED student". Because of these problems, the "demonstrations of achievement" metric was discarded and replaced by "student impact," which all parties agreed was a more meaningful outcome.

d) **Inconsistent Metrics Collection Methods:** IREC crafted a common metrics collection plan that all DTTCs agreed to and IREC created a template for the purposes of collecting all data in a similar way across the DTTCs. One DTTC chose to create their own metrics tracking template and gained permission from DOE to use their template instead of following the process established by IREC. This inconsistency led to massive inefficiencies, lost data, and time wasted on all sides as the metrics from the exempt DTTC did not translate easily to the templates used by the other two DTTCs. As an example, the exempt DTTC template did not track "new courses" or "modified courses." This meant that each reporting period required additional work for IREC to

track down which courses might be classified as new or modified. In the future, DOE should support and mandate consistent collection methods for metrics and evaluations.

e) **Inconsistent Metrics Collection Personnel:** Each DTTC tasked particular individuals to gather key metrics for their project. However, due to the 5-year time frame of the project, individuals changed roles or left their university all together. This inconsistency caused gaps in coverage and necessitated additional training by IREC to keep data consistent. In the future, the NNA should have the sole and unchanging role to gather critical metrics directly from each source.

f) **Voluntary Participation in Course Evaluations:** There was a remarkably high participation from the university faculty in the GEARED mid-course evaluation process. However, the decision to participate was often left up to individual faculty who might have declined without understanding the importance of the project. This resulted in missing or incomplete data. The NNA should have more access to faculty and resources to adequately incentivize participation.

g) **No Internal Evaluation Requirements:** The GEARED Initiative did not require internal evaluations to determine whether students ***learned*** as much or more with new and modified GEARED courses compared to traditional courses. More important than sheer number of GEARED courses should be whether these new courses are higher quality or more effective at teaching the new skills needed to work with the new needs of the grid. “were these courses ***better*** than traditional courses in terms of student learning, engagement, and satisfaction?” It is quite possible that DOE wasn’t seeking this level of course evaluation, or maybe DOE did not think of this evaluation strategy when the FOA was generated. Either way, it was a missed opportunity to show additional GEARED impact.

h) **Loss of Student Participation**. Although the DTTCs had agreed to include “student participation in events” as one of the original “shared metrics”, tracking of this outcome was haphazardly conducted, resulting in increasingly inaccurate metrics as the project progressed. In the future, the NNA should have the authority and access to gather important data.

4) Industry vs. Academic Conferences

Utility industry conferences have immense value for power engineering students and faculty. Students have an opportunity to observe how power engineering technology researched and discussed in the classroom is currently being utilized by industry and in a real-world environment. Moreover, there isn’t another power technology venue in the country that offers students’ networking opportunities with 500+ companies. Students also received excellent feedback from industry professionals regarding their design projects, which were displayed on the exhibitors’ floor, and

most students obtained multiple business cards from companies seeking to offer internships, jobs, or a chance to further discuss their design projects with companies working on the same issue. Faculty have the chance to see first-hand how technology taught in the classroom was being utilized, broadening their experiences and bringing real-world examples to their courses. Faculty networking also leads to creating partnerships with industry that improves the overall quality of education and training through shared knowledge and equipment.

Despite all the benefits to attending industry conferences, early in the GEARED project, it became evident that most engineering faculty do ***not*** participate in these events. When faculty have resources to travel, they prefer to participate with their peers at academic conferences such as the Institute of Electrical and Electronics Engineers – Power & Engineering Society (IEEE-PES) and the North American Power Symposium (NAPS). There are many important reasons for this choice, but one of the biggest is that academic conferences allow faculty to present papers for peer review. University faculty in search of tenure need to demonstrate they are well-published. Industry conferences have a completely different focus and audience. IREC spent considerable time trying to convince faculty of the value of attending industry-focused conferences and it was an uphill battle. Those faculty that did attend the DistribuTECH and TechAdvantage industry conferences instantly saw the value for students and themselves; many continued to come each year GEARED was showcased.

As DOE seeks to further link students to industry, understanding this challenge is critical. Faculty are the gateway to students, and as IREC sought to disseminate information about participation in industry conferences, the information either wasn't getting to the students, or it wasn't presented in a fashion that invoked excitement. Adding to the challenge was senior faculty advising newer faculty to focus on academic conferences because of personal advancement. This is endemic of higher education and that culture is not easily changed. DOE should consider mandating, through incentives or otherwise, that universities participating in GEARED-type projects must also participate in industry conferences. The positive outcomes will inspire faculty and motivate students to participate as well.

5) The Challenges of Standardization

Since it was not easy to get engineering faculty to industry conferences, IREC also participated in the aforementioned academic conferences, IEEE-PES and NAPS. It was an opportunity to engage faculty from all over the country who were connected with the GEARED Initiative. IREC used these events to facilitate discussions relevant to the GEARED common activities and gain consensus on certain topics. For example: "what constitutes a power engineering student?" or "how many power courses would a student need to take to place 'power engineer major' on their resume?" or "how would industry recognized that a student has the requisite power background?" or "what are the core power engineering courses students need to take?". The faculty were quite passionate with their opinions and the conversations were very spirited, yet IREC could not bring about a consensus on these topics as

there was such varied opinions. In the future, DOE should consider doing more events that bring faculty together like this at academic conferences. IREC believes that the diverse opinions expressed in meetings like these eventually bring those people closer together in mind and thought.

6) **The Case for a National Advisory Board**
In IREC's original proposal, the task of organizing a National Advisory Board was included. This group would provide guidance throughout the GEARED Initiative. Early in the project IREC invited a wide range of utility industry experts to participate on this Board and offer their expertise to support the GEARED Initiative. Throughout the first three years of the project, IREC found it difficult to engage this group and get them to participate in meetings. In hindsight, IREC believes that a National Advisory Board was too-far removed from the activities associated with the DTTCs to provide any meaningful insight. Each DTTC had its own Advisory Board that met more regularly and were made-up of individuals with a national understanding of utility sector and the challenges it faces. The DTTC Advisory Boards were more connected to the projects and could offer valuable advice. The National Advisory Board was hearing about activities at a 50,000-foot level making it harder to offer realistic guidance. By the fourth year for the project, IREC and DOE agreed this National Advisory Board was no longer needed. IREC believes if DOE were to create a national administrator position again for pulling together multiple projects that the creation of a National Advisory Board is superfluous when regional-level advisory boards are involved.

Outreach

1) IREC produced several posters, banners, and flyers to promote the GEARED Initiative. See Appendix G to view these materials.

2) IREC represented the GEARED Initiative and its goals at power and energy focused industry and academic conferences. IREC used these events to plan GEARED-specific activities for students and faculty. See Appendix H and I to view materials related to the conference events listed below.

    - April 2014, Utility Solar Conference – IREC organized student-centered activities including a student poster session and student presentations.

    - July 2015, IEEE PES General Meeting – IREC participated in a panel discussion and presented, "Addressing the Workforce Challenges of Distributed Technologies and the Evolving Smart Grid".

    - September 2015, Solar Power International Conference – IREC attended and represented GEARED Initiative.

- October 2015, North American Power Symposium – IREC organized student-centered activities including a student poster session and a student break-out session.

- February 2016, DistribuTECH Conference – IREC organized student-centered activities including a student-poster session; the GEARED Initiative was highlighted in a conference video project https://www.youtube.com/watch?v=s8QxcVIDGSs

- April 2016, Utility Solar Conference – IREC partnered with SEPA to hold a panel session titled "How Utilities are Meeting the Workforce Challenge Triggered by Solar"

- July 2016, IEEE PES General Meeting – IREC coordinated a GEARED panel session titled "Multiple-Institutional Power System Education Collaboration: On-going Efforts, Lessons Learned, and Future Plans."

- September 2016, Solar Power International Conference – IREC produced two GEARED Initiative posters which were displayed in the education corridor during the conference; IREC conducted a 30-minute presentation on the Expo Floor titled "What Keeps Electric Utility Industry HR Managers Awake at Night?", discussing the challenges HR managers face when recruiting, hiring, and retaining employees.

- September 2016, North American Power Symposium – IREC organized student-centered activities including a student professional development workshop.

- January 2017, DistribuTECH Conference – IREC organized a GEARED Booth on the Exhibition Show floor; student-centered activities including a student poster session and an off-site tour of the UC San Diego microgrid; Conference Mega Session titled, "Educating, Hiring and Developing the Next Generation of Electric Power Engineers"

- February 2017, TechAdvantage Conference – IREC supported student-centered activities including a student poster session with presentations.

- January 2018, DistribuTECH Conference – IREC organized a GEARED Booth on the Exhibition Show floor; student-centered activities including a student poster session, an off-site tour at CPS Energy's Mission Solar Energy site, and a young professionals panel discussion and networking session.

- February 2018, TechAdvantage Conference – IREC supported student participation at the conference.

- February 2019, DistribuTECH Conference – IREC organized a GEARED Booth on the Exhibition Show floor; student-centered activities including a student poster session and an off-site tour at Entergy.

Job Creation

Beyond the sheer magnitude of the GEARED Initiative in terms of numbers of courses created and students served, was the success of students getting jobs. A series of 4 surveys were conducted from Fall 2017 through Fall 2018 to monitor the post-graduation plans for GEARED students. A surprisingly high, 45% of GEARED students voluntarily responded to the survey, demonstrating their eagerness to share their stories. A total of 1,296 unique students from 24 universities shared their insights, identifying the 488 utilities, laboratories and other organizations to which they applied for jobs. Among the many interesting findings were:

- GEARED students consistently wanted to work in the power industry after graduation by a 3-to-1 margin.
- 29% of students planned to work at a utility, 27% planned to work at other (non-utility) organizations, 13% of students planned to continue their studies in graduate school, and 9% were going to work full time at their existing job
- Although geography played a dominant role in utility hiring, there were several interesting outlier companies that hired multiple students from universities that were geographically distant (e.g., students at U Hawaii, USC and UC San Diego accepting positions at Duke Energy).
- From Fall 2017 to Fall 2018, there appeared to be a shift in priorities towards students working in utilities. The percentage of students' undecided about their careers decreased from 20.1% to 17.6% while the percentage of students' planning to take a utility-based job increased from 26.4% to 29.2% over the same period. Numbers of students planning to attend graduate school also ticked upward but other career options remained consistent over time.

Regarding this last finding, since different cohorts of students answered the questions each term (and because other assumptions of statistical testing were not met), further data collection with more control over the participants would be needed to establish this trend and determine if this is a statistically significant increase.

The results of each survey were compiled into a "Jobs Report" made available to all GEARED students, a valuable resource from which they could learn of the job and internship opportunities available to other students across the nation.

See Appendices D and E for additional material related to the student employment and internship surveys.

Project Spending

The original National Network Administrator five-year award was for $1,000,000. During the negotiation phase an additional $100,000, or 10% of the total award, was added to cover metrics collection and evaluation, which was inadvertently left out of the FOA. The additional 10% did not come close to covering the costs associated with the type of metrics and evaluations DOE sought, leaving IREC to manage expectations of what was possible. In hindsight, IREC believes the NNA award as a whole was underfunded. IREC's success as NNA of GEARED was helped by having the same project team as the Solar Instructor Training Network, another five-year award as national administrator, and was able to take advantage of lessons-learned from that experience.

Path Forward

The success of GEARED provided the impetus for DOE to already release an additional Funding Opportunity Announcement (FOA) that would continue much of the work GEARED accomplished. Moreover, the focus under the new FOA will be more utility-centric where the GEARED initiative was more university-centric.

As part of sustainability efforts, IREC was working closely with Clarion Corporation, investigating different ideas and pathways that would allow students to continue to engage utility-sector employers at the DistribuTECH conference. The focus would be on attempting to attract engineering students from universities that are geographically close to the location of the DistribuTECH conference, which chooses different locations across the country each year.

The long-term relationships established within and amongst the DTTCs and NNA will flourish well beyond the GEARED initiative. The university/utility partnerships will help inform future research to support Distributed Energy Resources (DER) integration into the GRID. Employers will have a better talent pipeline for hiring needs, and the current utility workforce will benefit from professional development courses that will buttress evolving power systems technology.

Lastly, the jobs survey and shared metrics process were time-sensitive successful tools that demonstrated the impact of the GEARED initiative and DOE should take full advantage of the process and lessons-learned for future projects.

Acknowledgement

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Appendix A - Completed Tasks and Milestones

Milestone	Description	Status Notes
BUDGET PERIOD 1		
Task 1: Convene monthly conference calls of the consortia and DOE and quarterly online conferencing webinars *Task 1.1: Convene kick-off conference call meeting upon reception of award.* *Task 1.2: Establish a calendar for regularly scheduled conference calls.* *Task 1.3: Establish a calendar for quarterly webinars.*		
M1.1	Provide agenda and minutes to the kick-off meeting.	IREC held the GEARED project kick-off meeting on December 11 & 12, 2013, in Orlando, Florida and shared an agenda prior to the meeting; meeting minutes where shared with the GEARED Network and DOE post-meeting.
M1.2	Provide agenda and minutes to the monthly meetings.	IREC maintained a monthly GEARED Network conference call schedule beginning in the first quarter of 2014 and running through the end of the DTTC's performance period in September 2018. Agendas were shared prior to the meetings and meeting minutes where shared after the meetings.
M1.3	Provide topics and speakers of quarterly webinars.	
Task 2: Convene an annual in-person meeting of the consortia and DOE		
M2.1	Provide agenda and minutes to the in-person meeting.	GEARED Network annual meetings were held in conjunction with other industry meetings and conferences where GEARED faculty and staff were present; IREC shared agendas prior to the meetings and sent out meetings minutes post-meeting.
Task 3: Create and convene a National Steering Committee *Task 3.1: Create charter for the National Steering Committee, describing the purpose and mission of the Committee, roles and responsibilities of its members.* *Task 3.2: National Steering Committee will provide advice on the themes and content of the annual student-centered research conference.* *Task 3.3: Schedule quarterly meetings via conference calls.*		
M3.1	Provide agenda and minutes to the Steering Committee quarterly meetings.	The first National Steering Committee teleconference meeting took place on October 14, 2014 with subsequent meetings taking place quarterly thereafter. Agendas and meeting minutes were sent out pre- and post-meeting.

Appendix A: Completed Tasks and Milestones

Task 4: Create and maintain a national website for communication and information sharing		
M4.1	Wireframe, outline, sitemap, and content pages are developed.	IREC launched a national website for the GEARED initiative at www.gearedusa.org where news and highlights were shared as well as information on each of the DTTCs.
M4.2	Website launched and maintained.	
M4.3	Provide website maintenance and hosting.	
Task 5: Establish and maintain a social media presence		
M5.1	Social media content pages are developed.	IREC maintained a social media presence on Facebook, Twitter, and LinkedIn throughout the duration of the project.
M5.2	Social media accounts launched and maintained.	
M5.3	Social media accounts maintained.	
Task 6: Organize and convene a yearly student-centered research conference *Task 6.1: Organize and lead a conference planning committee with representatives from each consortium.* *Task 6.2: Build the agenda and annually facilitate the GEARED student conference co- located with the Utility Solar Conference.* *Task 6.4: Seek to task each consortium to manage a session at the conference.*		
M6.1	Planning committee is established, and list of members provided.	The first annual GEARED student-centered conference was held on April 28-29, 2014, in conjunction with the Utility Solar Conference in Newport Beach, California; 17 students (1 from each GEARED university) participated, displaying a research poster at the conference and also giving a 5-mimute oral presentation describing their projects.
M6.2	Agenda created and GEARED student conference launched.	IREC worked very closely with SEPA to allow students to participate in one day of the Utility Solar Conference and provided networking opportunities for students and conference attendees.
M6.3	Specific sessions were managed by each consortium.	IREC and the DTTCs worked very closely together to plan activities at each student-centered conference throughout the project.
Task 7: Build and maintain an online national directory of Power Engineering programs organized by state		
M7.1	Directory wireframes and content pages are developed.	This task and associated milestones were put on hold initially as the GEARED Network was ramping up in BP1; the task was ultimately removed from IREC's
M7.2	Identify existing course offerings.	

Appendix A: Completed Tasks and Milestones

M7.3	Determine how submittals will be reviewed and updated.	SOPO for BP2-BP5.
M7.4	Develop the criteria for inclusion.	
M7.5	Program the database and launch website.	
M7.6	Maintain website and add new course listings.	
Task 8: Investigate industry credentialing paths, workforce standards, and professional licensing, and make recommendations *Task 8.1: Create and update an inventory of industry workforce standards* *Task 8.2: Examine the value of existing certifications and professional licensing and identify where new credentials are needed.*		
M8.1	Identify industry credentialing paths.	This task and associated milestones were put on hold initially as the GEARED Network was ramping up in BP1; the task was ultimately removed from IREC's SOPO for BP2-BP5.
M8.2	Provide an inventory of existing certifications, professional licenses, and industry workforce standards.	
M8.3	Make recommendations based on industry gaps.	
Task 9: Coordinate the sharing of DTTC developed best practices that meet NNA established criteria		
M9.1	NNA criteria established and shared with DTTC.	After discussion with the DTTCs, it was determined that the resources and best practices developed through GEARED would be housed on consortia platforms to be shared with the GEARED Network as a whole.
M9.2	Posting of DTTC's best practices.	
Task 10: Establish criteria, develop standardized instruments, coordinate, collect, and aggregate DTTC metrics		
M10.1	Metrics criteria established and shared with DTTCs.	IREC established a list of common metrics to be collected by each of the DTTCs throughout the duration of the GEARED initiative.
M10.2	Standardized instruments shared with DTTCs to be administered at the midterm of each course and end-of-course.	IREC developed metrics collection templates in order to standardize the collection process.
M10.3	Collect and aggregate metrics.	Throughout the project, IREC created reports on the common metrics collected by the DTTCs as well as reports on the success of the mid-term course evaluations.
Task 11: Coordinate the connection of expert analysis and guidance on course and program evaluation and		

Appendix A: Completed Tasks and Milestones

assessment *Task 11.1: Continuously gather and evaluate feedback.* *Task 11.2: Document evidence of project success.* *Task 11.3: Provide DTTCs with expert advice regarding internet-based technology, proven strategies to improve courses, and offer tried-and-true feedback tools and methods to students and faculty.* *Task 11.4: Assist in generating useful resources, conference papers, and scholarly articles that would serve other schools looking to the GEARED project for guidance.*		
M11.1	Convene meetings of DTTCs and program and evaluation expert.	IREC worked closely with the evaluation contact at each DTTC; meetings covered the common metrics, collection templates, as well as the individual nuances of each projects' metrics collection needs.
M11.2	Provide minutes of meetings.	IREC shared meeting minutes and action items as necessary.
M11.3	The evaluation of actionable data and submittal of customized reports.	IREC developed a mid-term course evaluation process that was utilized voluntarily by GEARED faculty; use of this mid-term evaluation grew from 4 faculty covering 5 courses and receiving feedback from 91 students in the first year of the project to a total of 134 faculty across 18 universities giving mid-term course evaluations to over 4,8000 students.
M11.4	Feedback tools are provided.	IREC provided detailed feedback to faculty who participated in each mid-term course evaluation. Suggestions were provided on how to circle back with students and address their comments and concerns.
Task 12: Provide a central repository of project metrics through the national website		
M12.1	Content pages on website developed	IREC established an online portal through the GEARED national website where metrics reports and data collection summaries were kept along with meeting notes and other resources.
M12.2	Metrics uploaded to website	
Task 13: Support the creation and coordination of a Student Innovation Board Task 13.1: Work closely with the DTTCs to create the criteria for the selection of students to the SIB, including the size of the Board. Task 13.2: Seek industry support for procuring valued recognition awards for the yearly student conference.		

Appendix A: Completed Tasks and Milestones

M13.1	Student Innovation Board established.	IREC developed a 5-year plan for the GEARED Student Innovation Boards and shared this with each DTTC.
M13.2	Provide agenda and minutes to the SIB meetings.	
M13.3	Convened a yearly student competition starting in year two.	This milestone was cut from IREC's SOPO for BP2-BP5.
Task 14: Yearly site visits will be conducted by the NNA Project Manager		
M14.1	Site visits conducted; and agenda and general minutes added to the quarterly report.	The Project Manager conducted a site visit at each of the DTTCs in 2014 and continued to engage with the DTTCs later in the project through attendance at the GEARED Executive Committee meetings and Consortium Advisory Board Meetings.
Task 15: Project Management and Reporting Task 15.1: Evaluate and restructurer IREC/SEPA staff as needed to successfully manage the tasks outlined in each budget period of the SOPO. Task 15.2: Complete reporting as required by GEARED National Network Administrator and US DOE.		
M15.1	Reports submitted in a timely fashion in accordance with the Federal Reporting Checklist.	IREC completed all reporting requirements and maintained ongoing communication with DOE Project Managers throughout the duration of the project via phone, email, and in-person meetings.
At the end of BP1, IREC and DOE took time to evaluate the success of the GEARED Project and it was determined some reworking was necessary. IREC and DOE went through a SOPO renegotiation process to establish new tasks and milestones for the remaining 4 years of the project. The table below reflects tasks and milestones associated with IREC's renegotiated SOPO.		
BUDGET PERIOD 2-5		
Task 1: Create operating guidelines for the GEARED Network and its Consortia. Drafts of the documents created, reviewed at the GEC meeting, sent back out for review. *Subtask 1.1 – Draft guidelines for Review by the DTTC* *Subtask 1.2 – Reach agreement on the GEARED draft operating guidelines from the GEC, DTTC Principal Investigators, and Original DTTC Institutional Partner Members for each DTTC.*		
M1.1	IREC drafts the GEARED guidelines document.	IREC drafted documents to provide guidelines on how the GEARED Network would collaborate on common activities. The documents were reviewed at the GEARED Executive Committee meeting on 1/29/2015
M1.2	The draft guidelines document is reviewed and refined with input from the GEARED Executive Committee (GEC).	

Appendix A: Completed Tasks and Milestones

M1.3	The operating guidelines document is approved by the GEC and circulated to the appropriate DTTC representatives for comment and suggested modifications.	and edits were made based on comments and feedback from committee members. The "GEARED Coordination Guidance Document" was finalized and distributed to all three DTTCs. The document included three appendices: • Appendix A: Student Innovation Board • Appendix B: Common Metrics • Appendix C: Working Groups
M1.4	The operating guidelines document is approved by all appropriate DTTC representatives.	
M1.5	The operating guidelines document will be modified and approved as needed through the duration of the project	During each GEC meeting the GEARED Coordination Guidance Document was reviewed and necessary edits were made. An updated version of the document was distributed to all three DTTCs.
Task 2: Establish the GEARED Executive Committee (GEC) and facilitate its structure and operation. *Subtask 2.1 - Create draft guidelines document that describes the structure and operation of the GEC.*		
M2.1	IREC drafts the GEC Program Operations guidelines document.	IREC drafted documents outlining the structure and role of the GEC as well as collaborative efforts on common GEARED activities.
M2.2	A draft GEC operating guidelines document is established, GEC representatives are identified, and a schedule for meeting is set for remainder of BP2.	IREC worked with each DTTC to determine who would participate in the GEC; representatives were identified, and the first GEC meeting was scheduled.
M2.3	Meet as GEC, review, revise, and agree to follow the GEARED Executive Committee operating guidelines.	The GEARED Executive Committee (GEC) was formed and held its first meeting on January 29, 2015; the meeting was hosted by the University of Central Florida in Orlando, Florida and
M2.4	Meet as GEC at a selected DTTC activity, review and revise Guide for Members of the Student Innovation Board; set meeting and events calendar for BP3	The GEC held a meeting on June 22-23, 2015; the meeting was hosted by the University of Missouri Science & Technology, in Rolla, Missouri and
M2.5	NNA will meet with students and DTTCs at the annual student-centered conference (hosted regionally). The NNA will seek to convene a meeting of DTTCs to: Review progress and identify areas of collaboration such as: curriculum development, course sharing, industry training programs (courses and schedule); faculty development, research, and metrics;	IREC planned and facilitated a GEARED Network Meeting and student breakout session on October 6, 2015 during the North American Power Symposium. Discussion topics included curriculum development, common activities, course sharing, student involvement, ways to support student, and what makes a student a power systems engineering student.
M2.6	Meet as GEC, review, update, and agree to follow the	The GEC met on October 4, 2015, in conjunction with

Appendix A: Completed Tasks and Milestones

	revised GEARED Executive Committee operating guidelines.	the North American Power Symposium in Charlotte, North Carolina and hosted at the University of North Carolina, Charlotte.
M2.7	Review progress on curriculum and course development and sharing (50% review of curriculum design targets set by GEC). The NNA will work with the working group lead to produce a report identifying gaps and prioritizing action items; disseminate to the GEARED Network stakeholders.	The GEC met on February 8, 2016, in conjunction with the DistribuTECH Conference in Orlando, Florida; this meeting included discussions on the status of curriculum development by the DTTCs.
M2.8	NNA will request to meet with students and DTTCs at the DTTCs regional student-centered conferences as scheduled, and seek to convene a meeting of DTTCs to: review progress and identify areas of collaboration in curriculum development, course sharing, industry training programs (courses and schedule), faculty development, research, and metrics; or the GEC will meet at a mutually agreeable location	The GEC met on July 17, 2016, in conjunction with the IEEE Power & Energy Society General Meeting in Boston, MA; this meeting included discussion of common areas of collaboration.
M2.9	Meet as GEC at a selected DTTC activity, review and revise Guide for Members of the Student Innovation Board; set meeting and events calendar for BP4.	The GEC met on October 23, 2016 in Arlington, VA, in conjunction with the GEARED External Peer Review.
M2.10	There is no Milestone 2.10.	The milestones were mis-numbered in the SOPO so there is no milestone 2.10
M2.11 .	Review progress on curriculum and course development and sharing (75% review of curriculum design targets set by GEC.) Identify gaps and prioritize action items.	The GEC met on February 2, 2017, in conjunction with the DistribuTECH Conference in San Diego, CA; this meeting included discussions on the status of curriculum development by the DTTCs.
M2.12	GEC will request to meet with students and DTTCs at annual student-centered conference and seek to convene a meeting of DTTCs to: review progress and identify areas of collaboration in curriculum development, course sharing, industry training programs (courses and schedule), faculty development, research, and metrics.	IREC coordinated GEARED student and faculty activities at the DistribuTECH Conference in San Diego, CA.

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M2.13	Meet as GEC at a selected DTTC activity, review and revise Guide for Members of the Student Innovation Board; set meeting and events calendar for BP5.	The GEC met on July 21, 2017 in Chicago, Illinois, in conjunction with the IEEE PES General Meeting.
M2.14	Review progress on curriculum and course development and sharing (100% review of curriculum design targets set by GEC). Identify gaps and prioritize action items.	The GEC met on October 4, 2017 in Denver, Colorado and was hosted by the GridEd Consortium and their industry partner Xcel Energy; this meeting included discussions on the status of curriculum development by the DTTCs.
M2.15	NNA will request to meet with students and DTTCs at the BP 5 national annual student-centered conference, and seek to convene a meeting of DTTCs to: review progress and identify areas of collaboration in curriculum development, course sharing, industry training programs (courses and schedule), faculty development, research, and metrics; or the GEC will meet at a mutually agreeable location	The GEC met on March 1, 2018, in conjunction with the TechAdvantage Conference in Nashville, Tennessee and was hosted by the NRECA; this meeting included discussion of common areas of collaboration as well as DTTC sustainability plans.
M2.16	Meet as GEC at a selected DTTC activity; summarize success in collaborative activities; provide summary assessment of overall progress and achievements of the GEARED project.	The GEC met for a final time on June 18, 2018 in Orlando, Florida. The meeting was hosted by the FEEDER consortium and their industry partner, the Orlando Utility Commission. This meeting included discussions of DTTC sustainability plans and GEARED achievements.
Task 3: Support the creation of DTTC Student Innovation Boards. *Subtask 3.1 - Provide the DTTCs with suggested guidelines that articulate the SIB structure.*		
M3.1	Establish a first edition of a member guide for the Student Innovation Board.	IREC drafted a document outlining the structure of the Student Innovation Boards and the GEC reviewed the document at the January 29, 2015, GEC meeting. A final copy of the outline and guidance document was included in the GEARED Coordination Guidance Document – Appendix A.

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M3.2	Request DTTCs to complete the selection of SIB members for the 2014-2015 academic year; including multiple engineering disciplines; SIB members at each DTTC requested to meet at least once with their faculty representative and with selected student organization(s) during the semester.	IREC communicated with DTTCs regularly regarding their SIB activities. At the beginning of each academic year, IREC updated the national GEARED website with newly added and graduated SIB students.
M3.3	Populate the GEARED website with SIB member information and an events calendar; attend and participate in the student conference; request the names and information for students to serve on the SIB for the 2015-16 academic year; working with the GEC, request senior design and graduate research project ideas from the engineering and planning staffs of the GEARED National Advisory Board members, SEPA Board members, EPRI, NRECA, and DTTC advisory boards.	IREC communicated with DTTCs regularly regarding their SIB activities. At the beginning of each academic year, IREC updated the national GEARED website with newly added and graduated SIB students.
M3.4	Working with the GEC, review and suggest revisions to the Guide for Members of the Student Innovation Board; working with the DTTCs, help plan electronic meetings of SIB members at each DTTC for early Fall semester if needed.	The Student Innovation Board Guide was reviewed and updated as part of the June 2015 GEARED Executive Committee Meeting.
M3.5	Distribute the latest revised Guide for Members of the Student Innovation Board, which goes into effect during the Fall academic semester 2015.	IREC updated the Student Innovation Board Guide based on GEC feedback and included a copy in the GEARED Coordination Guidance Document – Appendix A. All documents were distributed to GEARED Network.
M3.6	Request that the DTTCs identify multiple engineering and non-engineering disciplines to be considered for service on the SIB.	The GEC met on July 17, 2016, and discussed ways to involve students from a variety of disciplines in the Student Innovation Boards.
M3.7	Populate the GEARED website with SIB member information and an events calendar; attend and participate in student conferences; request the names and information for students to serve on the SIB for the 2016-17 academic year; working with the GEC, request senior design and graduate research project	IREC communicated with DTTCs regularly regarding their SIB activities. At the beginning of each academic year, IREC updated the national GEARED website with newly added and graduated SIB students.

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	ideas from the engineering and planning staffs of the GEARED National Advisory Board members, SEPA Board members, EPRI, NRECA, and DTTC advisory boards.	
M3.8	Working with the GEC, review and suggest revisions to the Guide for Members of the Student Innovation Board; continue to request the names and information for students to serve on the SIB for the 2016-17 academic year; working with the DTTCs, help plan electronic meetings of SIB members at each DTTC for early Fall semester.	The Student Innovation Board Guide was reviewed and updated as part of the October 2016 GEARED Executive Committee Meeting.
M3.9	The latest revised Guide for Members of the Student Innovation Board goes into effect during the Fall semester 2016.	IREC updated the Student Innovation Board Guide based on GEC feedback and included a copy in the GEARED Coordination Guidance Document – Appendix A. All documents were distributed to GEARED Network.
M3.10	Request that DTTCs identify multiple engineering and non-engineering disciplines to be considered for service on the SIB; SIB members at each DTTC requested to meet at least once with their faculty representative and with selected student organization(s) during the semester.	The GEC met on February 2, 2017 and discussed ways to involve students from a variety of disciplines in the Student Innovation Boards.
M3.11	Populate the GEARED website with SIB member information and an events calendar; attend and participate in the student conference; request the DTTCs to supply the names and information for students to serve on the SIB for the 2017-18 academic year; working with the GEC, request senior design and graduate research project ideas from the engineering and planning staffs of the GEARED National Advisory Board members, SEPA Board members, EPRI, NRECA, and DTTC advisory boards.	IREC communicated with DTTCs regularly regarding their SIB activities. At the beginning of each academic year, IREC updated the national GEARED website with newly added and graduated SIB students.
M3.12	Working with the GEC, review and suggest revisions to the Guide for Members for the Student Innovation Board; working with the DTTCs, help plan	The Student Innovation Board Guide was reviewed and updated as part of the July 2017 GEARED Executive Committee Meeting.

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	electronic meetings of SIB members at each DTTC for early Fall semester.	
M3.13	The NNA's latest revised Guide for Members of the Student Innovation Board will be ratified by the GEC and if ratified will go into effect during the Fall semester 2018.	IREC updated the Student Innovation Board Guide based on GEC feedback and included a copy in the GEARED Coordination Guidance Document – Appendix A. All documents were distributed to GEARED Network.
M3.14	Request the DTTCs to identify multiple engineering and non- engineering disciplines to be considered for service on the SIB; SIB members at each DTTC requested to meet at least once with their faculty representative and with selected student organization(s) during the semester. NNA will review which GEARED universities do not have an IEEE PES student chapter currently and encourage those institutions to start one with the help of the SIB students. The goal will be at least one new chapter for each DTTC.	IREC communicated with DTTCs regularly regarding their SIB activities. At the beginning of each academic year, IREC updated the national GEARED website with newly added and graduated SIB students. Through online searches and communicating with GEARED faculty, IREC conducted an assessment of IEEE PES Chapters at GEARED universities. IREC shared this information with the GEC and with the GEARED Network as a whole. Discussions were held as to how best to encourage more chapters to start up.
M3.15	Populate the GEARED website with SIB member information and an events calendar; attend and participate in the student conference.	IREC communicated with DTTCs regularly regarding their SIB activities. At the beginning of each academic year, IREC updated the national GEARED website with newly added and graduated SIB students.
M3.16	Working with the GEC, provide input into the preparation of an assessment report on the operation, evolvement, and performance of the GEARED Student Innovation Board.	IREC submitted a final report on the GEARED initiative and in the report included thoughts on what made the GEARED Student Innovation Boards a success and what made them a challenge.
Task 4: Create a communication network among the consortia and increase stakeholder outreach. *Subtask 4.1 – Establish a content management system and network functionality for the GEARED web site.* *Subtask 4.2 - Submit proposals to speak about GEARED initiatives at utility related conferences.* *Subtask 4.3 - IREC will attend utility-related conferences with an emphasis on networking with stakeholder organizations.*		
M4.1	NNA completes the content management software basic training.	IREC finalized a contract for a content management system with aXs Info. **IREC did cancel this contract and later in BP2, created a microsite associated with the national GEARED website. The microsite acted as a*

Appendix A: Completed Tasks and Milestones

		document repository for the IREC.
M4.2	The content management system is activated (launched) and agendas, minutes, and documents are shared among the consortia. Representatives from the DTTCs complete basic software training.	IREC held individual meetings with DTTC metrics leads to show them the content management system and explain its purpose.
M4.3	IREC will submit an application to speak at SEPA's Utility Solar Conference in 2015.	IREC submitted a proposal to speak at the SEPA 2015 Utility Solar Conference; after a long discussion with Bob Gibson at SEPA, it was determined that the timing was not right for the session – and it would be better to wait until more activity was occurring.
M4.4	New and enhanced GEARED website continues to add features and functions as required by DTTCs. A calendar of events, SIB initiatives, and student-centered conference activities are highlighted.	IREC maintained, made improvements to, and added content to the www.gearedusa.org website throughout the duration of the GEARED project.
M4.5	If application is accepted, IREC will present the GEARED project at the SEPA Utility Solar Conference in April 2015.	IREC's application was not accepted.
M4.6	A social media GEARED network is established for faculty, students, and stakeholders.	IREC maintained a social media presence on Facebook, Twitter, and LinkedIn throughout the duration of the project.
M4.7	IREC participates in 1-2 utility-related conferences and meets with industry stakeholders to provide the latest information on GEARED-related initiatives.	IREC attended the Solar Power International Conference in Anaheim, CA, September 14-17, 2015 and the IEEE PES General Meeting in Denver, CO, July 30, 2015
M4.8	The main GEARED web site will be populated with basic information regarding each DTTC, including contact information for individual DTTC institutional members, links to GEARED-created course descriptions that are offered by DTTC university members, and a GEARED events list. It will also contain a list of Student Innovation Board members and contact information for the SIB, segmented for GEARED member-only access.	IREC maintained, made improvements to, and added content to the www.gearedusa.org website throughout the duration of the GEARED project.
	Milestones identified in Q6, Q7, and Q8 will be	IREC continued activities within Task 5 throughout the

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	ongoing through the duration of this project.	duration of the GEARED project. IREC maintained the GEARED website and continually added new content; maintained a social media presence for the GEARRED Network; participated and facilitate activities annually at national utility industry conferences; and maintained ongoing communication with a variety of stakeholders for the project.
Task 5: Establish criteria, develop standardized instruments, coordinate, collect, and aggregate DTTC metrics. Subtask 5.1 - Collect metrics to measure progress and determine success and maintain those metrics in a central repository. Subtask 5.2 - Continually improve course content and instruction via formative evaluation. Subtask 5.3 - Monitor program and gather feedback from all stakeholders		
M5.1	Gather, analyze, and evaluate current university course evaluation forms.	IREC communicated with each GEARED university regarding their standard course evaluation methods and questions.
M5.2	Create templates for the 9 common metrics to be used by each DTTC	With feedback from each DTTC, IREC created a template for the DTTCs to use to collect data on the nine common metrics.
M5.3	Initial collection of data for the 9 common metrics	Using the newly created metrics collection template, the DTTC evaluators retroactively gathered data through the first quarter of the project.
M5.4	Construct “ideal” evaluation instrument with input from DTTC evaluators	With feedback from each DTTC, IREC created paper-based and web-based mid-term evaluation forms for each participating course/instructor.
M5.5	Create paper-based and web-based forms of ideal instrument	
M5.6	Administer mid-term evaluation in available GEARED-related courses & report results to all instructors to improve courses while still in session	IREC administered mid-term course evaluations each fall, spring, and summer semester for GEARED courses from BP2 through BP5; faculty participation was voluntary. IREC provided results to each faculty after their evaluations closed.
M5.7	Provide tutorials and instructions to all GEARED instructors	IREC spent significant time working with DTTC evaluators to make sure data collection and mid-course evaluations were efficient and consistent. The data
M5.8	Train DTTC evaluators to upload and share metrics	

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	within data repository	repository was transitioned to a microsite within the national GEARED website. This area was password protected and allowed IREC to post agendas, meeting minutes, metrics reports, etc.
M5.9	Train all stakeholders how to access common metrics in data repository	
M5.10	Revisions to 9 Common metrics core following feedback from DTTC evaluators	IREC's Metrics and Evaluation SME led eight discussions by phone/web-conference with individual DTTCs to explain and modify the metrics collection template based on input from the university leads.
M5.11	Summary report to all stakeholders	IREC shared metrics reports at each of the GEC meetings and reports were also shared during monthly conference calls with the full GEARED Network.
M5.12	Administer comprehensive mid-term evaluations & report results to instructors	IREC administered mid-term course evaluations each fall, spring, and summer semester for GEARED courses from BP2 through BP5; faculty participation was voluntary. IREC provided results to each faculty after their evaluations closed.
M5.13	Provide year-end report on Metrics	IREC shared metrics reports at each of the GEC meetings and reports were also shared during monthly conference calls with the full GEARED Network.
M5.14	Administer comprehensive mid-term evaluations & report results to instructors	IREC administered mid-term course evaluations each fall, spring, and summer semester for GEARED courses from BP2 through BP5; faculty participation was voluntary. IREC provided results to each faculty after their evaluations closed.
M5.15	Administer comprehensive mid-term evaluations & report results to instructors	IREC administered mid-term course evaluations each fall, spring, and summer semester for GEARED courses from BP2 through BP5; faculty participation was voluntary. IREC provided results to each faculty after their evaluations closed.
M5.16	Provide year-end report on Metrics	IREC shared metrics reports at each of the GEC meetings and reports were also shared during monthly conference calls with the full GEARED Network.
M5.17	Administer comprehensive mid-term evaluations & report results to instructors	IREC administered mid-term course evaluations each fall, spring, and summer semester for GEARED courses from BP2 through BP5; faculty participation was

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		voluntary. IREC provided results to each faculty after their evaluations closed.
M5.18	Provide updated common metrics report to include latest semester data.	IREC shared metrics reports at each of the GEC meetings and reports were also shared during monthly conference calls with the full GEARED Network.
M5.19	Develop a process and necessary tools to collect data on student employment and internships from DTTC universities with GEC input; Present final process and tools to the GEC for review and get final approval from DOE.	IREC developed a process and the corresponding tools necessary to collect information about student employment and internships from DTTC universities and GEARED students. The final plan for these surveys was presented to and approved by the GEC and DOE at the GEC meeting in October 2017.
M5.20	Develop a How-To Guide on Mid-Term Evaluations; share with the GEC for review. Provide the final How-To Guide to DTTCs and GEARED faculty.	Beginning in the Fall of 2017, IREC was no longer the central administrator for GEARED Course mid-term evaluations. IREC developed a guide on how to run the mid-term course evaluations and provided this information to the DTTCs and the GEARED faculty.
M5.21	Administer the process outlined in Milestone M5.19 to collect data on student employment and internships.	IREC administered a total of three GEARED student employment and internship surveys across three separate semesters. The data collected from these surveys was shared with the DTTCs, GEC, and DOE.
M5.22	Provide updated common metrics report to include latest semester data.	IREC shared metrics reports at each of the GEC meetings and reports were also shared during monthly conference calls with the full GEARED Network.
M5.23	Compile a report that includes a final summary of the GEARED common metrics broken out by DTTC, a summary of the employment and internship data with descriptive stats and verbatim comments, and other data collection efforts over the course of the award (e.g. event evaluations, mid-term course evaluations). Describe data collection methods, a summary of trends and highlight lessons learned. Share report with DOE, the GEC and other GEARED stakeholders.	IREC submitted a final report on the GEARED initiative and the report included a specific section on the GEARED metrics data, mid-course evaluation data, and student employment and internship survey data.
M5.24	Ongoing upload of metrics into data repository	On an ongoing basis IREC uploaded metrics reports, mid-course evaluation reports, monthly conference call meeting notes, and other resources to the GEARED

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		microsite and was accessible to all within the GEARED Network.
M5.25	Ongoing viewing, sharing, and downloading of metrics among all stakeholders	IREC shared metrics reports at each of the GEC meetings and reports were also shared during monthly conference calls with the full GEARED Network. Reports and resources were also available on the GEARED microsite.
M5.26	Solicit feedback from stakeholders on project communication/calls/meetings	IREC utilized several methods for soliciting feedback from relevant stakeholders including student surveys, National Advisory Board meetings, in-person and tele-conference meetings, and GEC meetings. These methods were used throughout the GEARED project.
Task 6: Participate in yearly, DTTC coordinated and convened student-centered conferences. *Subtask 6.1 - Provide the DTTCs with suggested guidelines that articulate the objectives and desired outcomes of the student-centered conference.*		
M6.1	IREC begins drafting the student-centered conference guidelines document.	IREC drafted student-centered conference guidelines and shared with the GEC members for review.
M6.2	GEARED student-centered conference guidelines are created, approved by DOE and the GEC and circulated to appropriate DTTC representatives.	The GEC members offered comments and feedback and the final guidelines for coordinating and convening student-centered conferences was included in the GEARED Coordination Guidance Document – Section II.
M6.3	GEARED student-centered conference guidelines document is agreed-to by all appropriate DTTC representatives.	
M6.4	DTTC Regional Student-centered conferences convened with NNA participation and support	IREC attended the North American Power Symposium at the University of North Carolina, Charlotte, October 4-6, 2015; IREC facilitated the first GEARED student poster session at this event.
M6.6	DTTC Regional Student-centered conferences convened with NNA participation and support, following revised student-centered conference guidelines	IREC supported GEARED activities during the DistribuTECH Conference, February 9-11, 2016.
M6.7	Student-centered conference planning, coordination and implementation continue throughout the year. Conference guidelines are reviewed and revised as necessary.	IREC continually planned, coordinated, and implemented activities at industry conferences throughout 2016.

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M6.8	DTTC Regional Student-centered conferences were convened with NNA participation and support, following revised student-centered conference guidelines.	IREC coordinated activities for faculty and students at several conferences: a GEARED Network Meeting and student professional development workshop at the 2016 North American Power Symposium hosted by the University of Denver 9/18/2016-9/20/2016; and a GEARED Workforce Panel Session at the IEEE PES General Meeting in Boston, MA 7/17/2016-7/21/2016.
M6.9	Student-centered conference planning, coordination and implementation continue throughout the year. Conference guidelines are reviewed and revised as necessary.	IREC continually planned, coordinated, and implemented activities at industry conferences throughout 2016.
M6.10	Administer a post-event questionnaire to students that participate in NNA-coordinated national events including questions on the value of event and the value and success of networking. Share data with DOE and GEC.	IREC use post-event surveys for two DistribuTECH conferences to assess the value of the GEARED student activities at these events. Feedback was used to better understand student motivations in attending industry conferences and what activities were most worthwhile for students.
M6.11	Summarize available data about the GEARED program from DistribuTECH and TechAdvantage conference organizers and GEARED social media outlets.	IREC submitted a final report on the GEARED initiative and in the report included information specific to the value of industry conferences to students and faculty.
M6.12	The NNA will coordinate activities for the GEARED Network at two national industry conferences – DistribuTECH and TechAdvantage.	IREC continually planned, coordinated, and implemented activities at industry conferences throughout 2017 most specifically for the DistribuTECH and TechAdvantage industry conferences.
Task 7: Create and convene a National Advisory Board.		
M7.1	National Advisory Board meeting convened; undergraduate engineering student design and graduate engineering student project ideas were identified. Board member participation in student-centered conferences.	The first national GEARED Advisory Board Meeting was held on October 14, 2014; meeting notes were distributed to members after the meeting.
M7.2	National Advisory Board meeting convened	A National Advisory Board Meeting was held on May 27, 2015; meeting notes were distributed to members after the meeting.

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M7.3	National Advisory Board meeting convened; undergraduate engineering student design and graduate engineering student project ideas were identified. Board member participation in student-centered conferences.	A National Advisory Board Meeting was held on November 10 ,2015; meeting notes were distributed to members after the meeting.
M7.4	National Advisory Board meeting convened.	A National Advisory Board Meeting was held on June 7, 2016; meeting notes were distributed to members after the meeting.
M7.5	National Advisory Board meeting convened; undergraduate engineering student design and graduate engineering student project ideas were identified. Board member participation in student-centered conferences.	A National Advisory Board Meeting was held on January 19, 2017; meeting notes were distributed to members after the meeting.
M7.6	Final National Advisory Board meeting convened, with intention of using Board input to guide the final Budget Period of activities.	A National Advisory Board Meeting was held on June 20, 2017; meeting notes were distributed to members after the meeting.
Task 8: Project Management and Reporting.		
	This task did not have any associated milestones	IREC maintained ongoing correspondence with DTTCs through emails, individual phone calls, and conference calls. IREC submitted all quarterly reports as stipulated in the DOE Terms & Conditions of this award. Other information about grant activities has bee provided to DOE upon request.

GEARED PROJECT COORDINATION GUIDANCE DOCUMENT

Section I: Structure and Operation of the GEARED Executive Committee

GEARED Objectives as Defined by U.S. DOE in the FOA

- Support the increase in power systems research, development, and analytic capacity
- Grow the expertise and preparedness of current and incoming electric utility sector professionals for high penetrations of solar and other distributed energy technologies

Purpose of the Executive Committee

- Establish a GEARED network that actively fosters collaboration, coordination, and communication among all DTTC and stakeholder partners.
- Coordinate and leverage complementary capabilities and activities in research, education, training, and workforce development among DTTC partners.
- Identify, prioritize, and continually update key issues and challenges facing the electric power industry in research, development, analytic capacity, and workforce development.
- Assign inter-DTTC resources and working groups or sub-committees to address identified issues and challenges.
- Provide a representative body for key decision making on project direction, working group assignments, process facilitation, and resource allocation.

Structure and Operation of the GEARED Executive Committee (GEC)

- Members of the GEC will include a project lead from each DTTC, a representative from the NNA, and one at-large member.
    - Members:
        - Project Leads - Tom Reddoch, Zhihua Qu, and Suzanne Long (replaced Mariesa Crow)
        - NNA - Joe Sarubbi
        - At-Large Members
            - Diane Rhodes-Michaely, Mike Casper, Patti Metro NRECA (July/October 2016, January/July/October 2017, March 2018)
            - Steven Coley (June/October 2015, Feb 2016)
            - Jerry Ventre (Jan 2015)
- Project leads will serve as permanent GEC members as long as they hold lead responsibility. The at-large representative will be selected by the permanent members on an annual basis.
- A representative from DOE will be invited to participate in each GEC meeting.

- The GEC will meet three times per year, once each during the Fall and Spring semesters, and once in the summer, with the location decided by and rotated among the DTTCs.
    - 2018 Meetings: 3/1/2018, Nashville, TV
    - 2017 Meetings: 2/2/2017, San Diego, CA; 7/21/2017, Chicago, IL; 10/4/2017, Denver, CO
    - 2016 Meetings: 2/8/2016, Orlando, FL; 7/17/2016, Boston, MA; 10/23/2016, Arlington, VA
    - 2015 Meetings: 1/29/2015, Orlando, FL; 6/22-23/2015, Rolla, MO; 10/4/2015, Charlotte, NC
- The NNA will be responsible for setting up the meetings, handling meeting logistics and covering the cost of the meetings.
- The NNA will be responsible for setting the GEC meeting agendas. GEC members can make recommendations for the meeting agendas at any time.
- During the first in-person GEC meeting (1/29/2015), Members will review and agree upon the structure and operating the plan of the GEARED Executive Committee. This content will be outlined in Section I of the GEARED Project Coordination Guidance Document.
- During the first in-person GEC meeting (1/29/2015), Members will draft an outline detailing common tasks and the coordination efforts that will take place among all GEARED Project participants. This content will be outlined in Section II of the GEARED Project Coordination Guidance Document.
- At each subsequent GEC meeting, Members will review and update the GEARED Project Coordination Guidance Document.

Section II: GEARED Project Common Objectives

At the first meeting of the GEC (1/29/2015), Members discussed each topic below and agreed to these common GEARED project objectives. The GEC agreed to work together and collaborate on these common objectives as described below. These common objectives will be updated over time as decided by the GEC Members.

Student Innovation Board

- DTTCs will operate their individual SIBs in a way that best suits their partnering universities, faculty, and students while continuing to meet the goal of connecting and engaging students in power systems engineering locally, regionally, and nationally. See **Appendix A** for a more detailed outline of the objectives of the Student Innovation Boards. A shortened version of the outline was created July 2016 and this version is included in Appendix A.
- DTTCs can leverage existing student organizations/groups.
- During BP5, IREC will work with SIBs to establish which GEARED Universities currently have IEEE Student Chapters. Those universities who do not currently have IEEE Student Chapters will be encouraged to establish one.
- SIB activities do not always have to be formal meetings or events – they can be informal gatherings and social activities.
- Students respond very well to face-to-face events but are also very adept at connecting across the virtual landscape.
- The SIBs should promote senior design projects consistent with the GEARED project's goals
    - DTTCs and the NNA will query the project Advisory Board members for design project topics.
- There is a lot of possibility for utility engagement in the SIBs and this can be explored over time.
- The NNA will maintain SIB student profiles on the GEARED website, including a list of SIB student alumni.
    - Shortly after the start of each fall semester, roughly October 1, the DTTCs will provide the NNA with information regarding students that have graduated as well as new students joining the SIBs.
    - The SIB Student Information Survey and profile template are included as the last two pages of **Appendix A**.

GEARED Participation in Regional/National Conferences with a Focus on Student Engagement

- GEC members agreed that student participation in regional events is more economical and practical than a large national event.
- GEC members agreed that student participation in events might be more heavily influenced by location rather than Consortia.

- GEC members agreed (and DOE supported) the idea that there can be some experimentation over time to see what events work best for GEARED students – for example, event timing will have an impact on the participation of undergraduate versus graduate students.
- Figuring out a way to engage undergraduate students deserves more conversation – timing is a challenge for them.
- The NNA will concentrate its event planning efforts on the 2018 DistribuTECH and TechAdvantage conferences.
    - The DTTCs will provide financial support to plan and participate in these two conferences.
- GEC members agreed that while a design competition has value, the time and resources required to set up one (or more) competitions across universities and Consortia is a challenge. Design competitions will remain a consideration for the future, however; at this point, the DTTCs will more heavily promote senior design projects that align with GEARED project goals.
    - DTTCs will also continue to seek opportunities for students to share their research and design project results.

***** Note: Individual DTTCs participate in regional and local events based on their own activities. Events listed here are collaborative and involve NNA coordination and planning.

Metrics Collection

- DTTCs will continue to support one metrics lead for the NNA to communicate with directly.
    - Each DTTC metrics lead will be responsible for collecting metrics from their partner university faculty and reporting it to the NNA on designated templates.
    - Metrics Leads:
        - GridEd – Frank Lambert
        - MARMET – Diane Rhodes-Michaely and Suzie Long
        - FEEDER – Damla Turgut
    - The DTTC Primes should be CC'd on communications with Metrics Leads
- GEC members agreed to use a common system to collect and report on GEARED metrics coordinated by the NNA.
- GEC members agreed to a list of common metrics. See **Appendix C.**
- The NNA will work with DTTC Primes and Metrics Leads to set up a process for collecting raw metrics data.
- The NNA will provide guidance and support through the metrics data collection and reporting process.
- The NNA will create a report detailing metrics data for the GEARED Network as a whole. This report will be posted on the GEARED microsite for internal viewing including DOE.
- The NNA will support the creation of DTTC-specific metrics data reports upon request.

- GEC members agreed to use a time schedule for reporting metrics data that follows quarterly reports requirements:
    - Quarter Ending March 30 (report due in April) – no metrics updated
    - Quarter Ending June 30 (report due in July) – Update metrics for previous spring semester.
    - Quarter Ending September 30 (report due in October) – Update metrics for previous summer semester.
    - Quarter Ending December 31 (report due in January) – Update metrics for previous fall semester.

Course Evaluation

- Due to changes in its SOPO for the final budget period, IREC will no longer provide centralized support for mid-term evaluations.
- IREC will create and disseminate a How-To Guide on the mid-term evaluations and it will be the responsibility of the faculty and the DTTCs to administer them.
- The DTTCs will report what information they collect on faculty participation to IREC for continued metrics collection.

Project Advisory Boards

- Due to changes in its SOPO for the final budget period, IREC will no longer maintain a National Advisory Board for the Network.
- The DTTCs will maintain their Consortium based Advisory Boards for the final phases of the grant.

Promotion of and Communication about GEARED Project

- The DTTCs will continue to maintain their individual project websites.
- A national GEARED website is hosted at www.gearedusa.org.
    - Each DTTC is profiled on the national website and a link to each individual DTTC website is included.
    - The NNA will post information about each SIB student on the national GEARED website and will maintain a list of SIB alumni.
    - The centerpiece of the website will be DTTC and student activities; the NNA will work very closely with DTTC teams to keep the website content current.
    - The GEARED website includes a password protected microsite: www.gearedusa.org/share. The content on the microsite is for internal project participants only (it is not for public viewing). IREC will use the microsite as a repository for meeting notes, coordination documents, National Advisory Board information, and metrics summaries.
        - Additional microsites can be created in the future if more uses are presented.

- The NNA will use its social media presence to showcase and promote GEARED Network activities.

Collaboration Groups

- The GEC will assign appropriate partners to serve on inter-DTTC collaboration groups to address and discuss key issues and common activities.
    - The GEC had a specific discussion regarding the term "working group" and decided to call these groups "collaboration groups". The GEC felt "working groups" indicates a specific and detailed outcome is being delivered.
    - The goal of the GEARED collaboration groups will not always involve a specific deliverable but might be more focused on sharing strategies and best practices between the DTTCs.
- Active Collaboration Groups include:
    - DistribuTECH 2018 Planning
    - TechAdvantage 2018 Planning
    - Training Programs for Practicing Engineers in the Utility Industry
- **Appendix E** gives additional detail on active and inactive Collaboration Groups.
- Any collaboration groups created by the GEC will have a DTTC Lead to act as the convener and facilitator; the other two DTTCs will designate individuals to participate.
    - Collaboration group members can come from a variety of GEARED stakeholder groups – university faculty, utility advisors, the NNA, etc.
- Updates on collaboration group progress will be shared during monthly conference calls.
- For start-up, in-person meetings among collaboration group members will be encouraged.

APPENDIX A

GEARED Student Innovation Board

To help address both technological and workforce challenges associated with the exponential growth in distributed resources, the U.S. Department of Energy (DOE) has funded three Distributed Technology Training Consortiums (DTTCs) and a National Network Administrator as a part of the Grid Engineering for Accelerated Renewable Energy Deployment (GEARED). To better engage students in the GEARED Network, Consortium university partners have created Student Innovation Boards. DOE believes that applying fresh approaches and unfettered creating thinking by students to power engineering problem solutions will prove immensely beneficial to utilities, support industry, and consumers. Additional background information is outlined at the end of this document.

Student Innovation Board Members Roles:

- Act as liaison and communicate directly with students and student organizations at your university regarding DTTC and GEARED projects and activities.
- Provide leadership and encouragement for student participation in GEARED projects and activities.
- Along with your fellow SIB member(s), meet periodically to review the status and update progress on GEARED-related student projects and activities; plan for upcoming events; and make recommendations to increase the value of the GEARED project to students.
- Participate in an advisory role with utility, industry and other members of your DTTC Advisory Board.
- Attend and participate in the GEARED annual student conferences when funding time and funding allows.
- A national network website is maintained at: **www.gearedusa.org**. SIB member profiles are listed on this website along with other network activities. SIB members should use the template provided at the end of this document to submit profile information for posting.

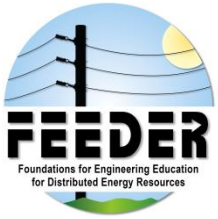
Example GEARED projects and activities for students:

- Graduate and undergraduate engineering research projects; Senior Design Projects
- Paper and/or poster presentations at technical and professional society meetings
- Industry and utility-sponsored design competitions
- Campus-based renewable energy demonstration projects (such as smart buildings, energy efficiency, electric vehicles, etc.)
- Preparation/dissemination of papers related to energy, environment, and economic policy issues
- Research clusters to advance distributed technologies (generation, storage), smart grid technologies, and workforce development for the electric power industry
- Market analysis and business model development based on products, processes, and services related to distributed technologies and the smart grid

Structure of the GEARED Network

The GEARED network consists of three Distributed Technology Training Consortiums (DTTCs) and one National Network Administrator (NNA), all of whom report to the U.S. Department of Energy SunShot Initiative. In addition to the listed university partners, many utilities and supporting industries are part of GEARED.

The Center for Grid Engineering Education (GridEd)
Website: http://grided.epri.com/
Lead Organization: Electric Power Research Institute
Eastern Partnering Universities: Clarkson University, Georgia Institute of Technology, University of North Carolina-Charlotte, and University of Puerto Rico, Mayaguez
Western Partnering Universities: University of Arizona, Portland State University, University of California-Riverside



Foundations for Engineering Education for Distributed Energy Resources (FEEDER)
Website: http://www.feeder-center.org/
Lead Organization: University of Central Florida
Partnering Universities: University of Arkansas, Auburn University, University of California-San Diego, University of Central Florida, University of Florida, Florida State University, University of Hawaii, University of Kentucky, University of Pittsburgh, University of South Carolina, San Diego State University, University of Texas-Dallas

Mid-America Microgrid Education and Training Consortium (MARMET)
Website: http://marmet-center.org
Lead Organization: Missouri University of Science and Technology
Partnering Universities: University of Illinois-Urbana Champagne, Iowa State University, Missouri University of Science and Technology, University of Wisconsin

National Network Administrator (NNA)
Website: http://www.irecusa.org/
Lead Organization: Interstate Renewable Energy Council (IREC)

Student Innovation Board:
Student Profile Template

We would like to highlight your participation in the GEARED Project, please fill in the information below. This information will be posted on GEARED Project websites. See the second page for an example of what your information will look like online.

In addition to your Consortium Contact please send completed surveys to the Mary Lawrence with the GEARED National Network Administrator at mary@ireusa.org.

PLEASE INCLUDE A CLEAR PICTURE to include with your profile. We are happy to crop the picture to just your headshot.

First Name: Click here to enter text.

Last Name: Click here to enter text.

University: Click here to enter text.

Year: Click here to enter text.

Program: Click here to enter text.

Title or Objective of Research/Design Project (if applicable): Click here to enter text.

Hometown City: Click here to enter text.

Hometown State: Click here to enter text.

Academic Goals: Click here to enter text.

Career Goals: Click here to enter text.

Student Organizations: Click here to enter text.

Email: Click here to enter text.

EXAMPLE PROFILE LISTED ON GEARED WEBSITE

JENNY LAWRENCE
University of South Carolina
Senior, Electrical Engineering
Hometown: Ann Arbor, Michigan

Your Profile Picture Here

Academic Goals

- Graduate with a B.S. in Electrical Engineering in May 2015
- Focus in power and energy and on business management
- Successfully design and upscale a previously tested DC protection circuit with my senior design project team

Career Goals

- Apply the knowledge and skills gained at the University of South Carolina to address the challenges facing utilities with the evolving grid network

Student Organizations

- Member of the GEARED Student Innovation Board representing USC and the FEEDER Distributed Technology Training Consortium
- Electrical Engineering Student Advisory Board president
- Society of Women Engineers Recruitment Chair
- IEEE Student Chapter Member

Email: jenny-lawrence@xyz.com

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Background Information on GEARED, Distributed Technologies, and the Smart Grid

The National Academy of Engineering had described the U.S. electrical network as "the supreme engineering achievement of the 20th century." More recently, however, technological developments, environmental concerns, and government policies have changed and are changing the landscape of the traditional electrical grid network. Technological developments include a variety of different types of electric generators – distributed generators – that are creating challenges and opportunities for both providers and consumers. Examples of distributed generators include: reciprocating engines, combustion turbines, microturbines, fuel cells, wind turbines, and solar electric systems. For this project, emphasis will be on distributed solar electric systems, especially photovoltaic (PV) systems, and their integration into the grid.

In addition to distributed generators, various types of energy storage systems are being researched and developed to mitigate the effects of power intermittency that occur with solar and wind resources. Distributed energy storage options include battery and uninterruptible power supply systems designed to improve power quality and reliability, thermal storage, flywheels, compressed air, and pumped hydro storage, among others. In addition, the growing use of electric vehicles, most notably plug-in hybrid electric vehicles (PHEVs), present opportunities to make the grid both cleaner and more efficient. They extract electric energy from the grid when it is most available, use some of it to displace fossil fuels for transportation, and have the capability to return some of it to the grid during peak demand using vehicle-to-grid (V2G) technology.

Government policies, including deregulation, renewable portfolio standards, and various incentive programs, have produced an exponential increase in the number of distributed generators on the electric grid network. The electric power industry fully recognizes the technological challenges posed by these developments and the need to significantly upgrade and modernize the grid. The "smart grid" will help facilitate and accelerate the integration of distributed generators and energy storage systems with the electrical grid network.

In the past, despite aging grid hardware, utilities had a relatively small number of generators to control in making sure that generation (minus losses) was equal to load demand at all times. However, with tens of thousands of distributed generators being integrated into the electrical grid network, operation and control becomes much more complicated. In addition, with the traditional grid, wind-generated electricity does not contribute effectively to either base load or peak load demand as will be possible with a smarter grid. And, because of resource variability, photovoltaic (PV) systems have relatively low capacity factors. Solar thermal electric systems (e.g., concentrating solar power) do have thermal storage, but need water (to produce steam) that is often in short supply in areas with the most sunlight. In short, high penetration of distributed solar and wind electric systems is a huge issue for utilities.

To effectively handle large penetration of distributed power systems, the electric grid must be a highly interconnected and interactive network of power systems, monitoring systems, computer systems, communication systems, and control systems. In addition to many different types of distributed

resources, it will be made up of advanced metering, smart end-use equipment and appliances, smart switchgear, smart sensors, advanced protection and security systems, wireless communications, and sophisticated energy management and control systems. More simply, it will consist of a modernized electrical infrastructure married to a highly intelligent communications infrastructure. Not only will the smart grid help mitigate the effects of power fluctuations from distributed generators, but also the distributed power systems will provide utilities with multiple pathways for the flow of electricity.

Currently the ability to move electricity throughout the country is limited, and the grid needs to be significantly improved to make best use of solar and wind power. Development of the smart grid is a work in progress. It is important to note that communications and control technologies are at the heart of the smart grid. Rapid communication of generation capacity and user demand will result in more efficient management of the transfer of power from generation to load.

GEARED Metrics – Summary of all DTTCs

COURSES/CURRICULUM	MARMET	Electricore	EPRI	FEEDER
1. # new courses developed (e.g., non/credit, online, short, modules)	X	X	X	X
2. # courses modified/revised/archived/converted to online	X	X	X	X
3. Training courses or e-learning modules revised/produced offered to utilities and industry	X	X	X	X
PROGRAMS/DEGREES				
4. # degrees, certificates, theses, dissertations, other demonstrations of achievement	X	X	X	X
5. Programs developed: certificates, grad/UG, other	X	X	X	X
STUDENTS				
6. # UNIQUE students enrolled (full/short courses, online, other)	X	X	X	X
7. Student perceptions (course/instructor evaluations or equivalent)	X	X	X	X
8. Student participation (# students attending conferences/SIB/other events)	X	X	X	X
LEARNING OUTCOMES				
9. Student learning outcomes via existing or updated means	X	X	X	X
FORMATIVE ASSESSMENT / Professional Development				
Faculty input: questionnaire, anecdotes				
Student input: midterm evaluation/pulse survey				

SAMPLE of Unique Metrics

- Content capture, extraction, and development from industry experts facing imminent retirement
- Optimization of teaching assignments
- Course and program throughput of students
- Overall efficiency and effectiveness of shared course delivery options
- # courses shared among universities & course enrollments
- Research videos and mini-conferences for graduate and undergraduate (REU) students
- STEM recruitment programs and efforts
- Student representation from universities sharing courses
- Outreach material targeting middle/HS students
- Number of instructional person-hours
- Host for training activities
- Develop Smart Grid Lab
- Develop simulation lab
- Develop CMS
- Compilation of written material into textbooks

APPENDIX E

GEARED PROJECT COLLABORATION GROUPS

Participants and Activities as of 3/1/2018

ACTIVE GROUPS

DistribuTECH 2019 Planning (formed August 2017)

- This group will discuss and coordinate activities for GEARED faculty and students at the DistribuTECH conference, February 5-7, 2019
- Planning updates will be shared monthly on the GEARED Network conference calls.

FEEDER: Zhihua Qu	UCF	qu@ucf.edu
FEEDER: Bob Reedy	UCF	bob.reedy@ucf.edu
GridEd: Tom Reddoch	EPRI	treddoch@epri.com
GridEd: Steven Coley	EPRI	scoley@epri.com
GridEd: Amy Feser	EPRI	afeser@epri.com
MARMET: Suzie Long	MARMET	longsuz@mst.edu
NNA: Mary Lawrence	IREC	mary@irecusa.org
NNA: Joe Sarubbi	IREC	joesarubbi@gmail.com

TechAdvantage 2019 Planning (formed August 2017)

- This group will discuss and coordinate activities for GEARED faculty and students at the TechAdvantage conference, March 10-13, 2019.
- Representatives currently consist of MARMET Team members. It will be determined as planning continues whether or not other DTTCs need representation.
- Planning updates will be shared monthly on the GEARED Network conference calls.

MARMET: Suzie Long	MS&T	longsuz@mst.edu
MARMET: Pete Sauer	Uof Illinois Urbana Champaign	psauer@illinois.edu
MARMET: Bulent Sarlioglu	Uof Wisconsin	sarlioglu@wisc.edu
MARMET: Jim McCalley	Iowa State University	jdm@iastate.edu
MARMET Industry Partner: Diane Rhodes-Michaely	NRECA	diane.rhodes-michaely@nreca.coop
MARMET Industry Partner: Patti Metro	NRECA	patti.metro@nreca.coop
NNA: Mary Lawrence	IREC	mary@irecusa.org
NNA: Joe Sarubbi	IREC	joesarubbi@gmail.com

Training Programs for Practicing Engineers in the Utility Industry (formed

- This group will act as a forum for the DTTCs to discuss professional training activities within GEARED including best practices, needs and trends in the industry, training topics, etc.

MARMET: Bulent Sarlioglu	University of Wisconsin	Bulent@engr.wisc.edu
FEEDER: Bob Reedy	UCF-Florida Solar Energy Center	reedy@fsec.ucf.edu
GridEd: Tom Reddoch	EPRI	treddoch@epri.com
MARMET Industry Partner: Diane Rhodes-Michaely	NRECA	diane.rhodes-michaely@nreca.coop

INACTIVE GROUPS

Curriculum and Program Development

- Group Goal/Purpose: Better prepared graduates to meet the present and future challenges of distributed technologies and the smart grid.
- Specific Outcomes:
  - A suggested model undergraduate curriculum in power systems engineering that is consistent with current and imminent developments in grid modernization
  - A suggested list of required core courses, including prerequisites, credit and contact hours, delivery options and recommendations (e.g., classroom, online, hybrid, lab, etc.)

MARMET: Pete Sauer (LEAD)	University of Illinois	psauer@illinois.edu
FEEDER: Larry Holloway	University of Kentucky	holloway@engr.uky.edu
GridEd: Tom Ortmeyer	Clarkson University	ortmeyer@clarkson.edu
GridEd: Badrul Chowdhury	UNC-Charlotte	b.chowdhury@uncc.edu

Professional Development of University Faculty

- Group Goal/Purpose: Upgraded capabilities of university faculty in teaching and performing research related to distributed technologies and the smart grid.
- Specific Outcomes:
  - Implementation of professional development programs for DTTC faculty to upgrade and broaden their capabilities to enhance existing courses, develop and/or teach new courses related to distributed technologies and the smart grid
    - Proposed Professional Development Session at the IEEE PES General Meeting, July 2016, Boston, MA.
  - Document the use of existing e-learning and newly developed modules to be shared among multiple courses and universities (e.g., the modules developed for CUSP by the University of Minnesota and others) that are relevant to the GEARED objectives.

MARMET: Jim McCalley	Iowa State University	jdm@iastate.edu
FEEDER: Zhihua Qu (LEAD)	University of Central Florida	qu@ucf.edu
GridEd: Agustin Irizarry	University of Puerto Rico	agustin@ece.uprm.edu
GridEd: Ron Harley	Georgia Institute of Technology	rharley@ece.gatech.edu

Microgrid Textbook Development (formed July 2016)

- This group will investigate the feasibility of developing a Microgrid textbook through the GEARED Project.
- It was decided that due to a change in roles for Mariesa Crow at MARMET and the closing out of the GEARED grant in a year, that there is not time to complete a textbook.

Final METRICS

Fall 2013 – Fall 2018

Total Impact

Fall 2013 – Fall 2018

DTTC	Students	Courses	New	Modified
MARMET	11,326	283	74	14
GridEd	12,292	412	44	52
FEEDER	*13,723*	*563*	*35*	*9*
Totals	***37,341***	***1,258***	***153***	***75***

Trends

Fall 2013 – Spring 2018

Term	Students Enrolled	Courses Taught
Fall 2013 – Summer 2014	3,584	146
Fall 2014 – Summer 2015	6,092	202
Fall 2015 – Summer 2016	9,079	253
Fall 2016 – Summer 2017	7,945	293
Fall 2017 – Summer 2018	8,467	272
*Fall 2018 only***	*2,174*	*92*

** Excludes MARMET

Cumulative Metrics

Fall 2013 – Fall 2018

Cumulative Terms	Students	Courses
thru Fall 2013	1,431	59
thru Fall 2014	6,263	235
thru Fall 2015	13,991	516
thru Fall 2016	21,470	781
thru Fall 2017	31,827	1,062
thru Fall 2018	**37,341**	**1,258**

GridEd

GridEd University Courses

TERM	Students	Courses	New	Modified
Fall 2013	339	8	0	0
Sp/Su 2014	846	26	1	1
Fall 2014	876	31	2	2
Sp/Su 2015	951	35	2	2
Fall 2015	1,427	31	3	6
Sp/Su 2016	1,471	41	4	9
Fall 2016	1,487	48	3	4
Sp/Su 2017	1,188	49	10	8
Fall 2017	1,910	47	4	6
Sp/Su 2018	1,020	64	13	10
Fall 2018	777	32	2	4
Totals	**12,292**	**412**	**44**	**52**

GridEd Training Courses

Students	#	Courses	New	Modified
Academic	11,426	374	32	48
Professional	866	38	12	4
Totals	**12,292**	**412**	**44**	**52**

MARMET

MARMET University Courses

University Courses / Short Courses / Senior Design Courses					Seminars / Workshops	
TERM	**Courses***	**Students**	**New**	**Modified**	**Events***	**Students**
Spring 2014	7	204	3	0	0	0
Fall 2014	13	550	5	1	0	0
Spring/Summer 2015	23	1099	19	2	5	190
Fall 2015	28	1251	2	1	11	844
Spring /Summer 2016	29	996	9	2	*14*	*593*
Fall 2016	18	350	5	1	*2*	*190*
Spring/Summer 2017	35	1,015	3	4	*25*	*729*
Fall 2017	28	902	8	2	4	120
Spring 2018	24	1,600	4	1	17	593
TOTALS	**205**	**7,967**	**58**	**14**	**78**	**3,259**

*** Only GEARED-funded courses and events are included**

MARMET University Courses

TERM	University Courses / Short Courses / Senior Design Courses		Seminars / Workshops	
	Content Hours*	Contact Hours*	Content Hours	Contact Hours
Spring 2014	192	4560	0	0
Fall 2014	477	9823	0	0
Spring/Summer 2015	814.5	10,127	5	190
Fall 2015	512.5	15,278	21.5	1488.5
Spring/Summer 2016	511	13,497	26	783
Fall 2016	641	9,258	2	190
Spring/Summer 2017	450	5,178	13	520
Fall 2017	882	28,607	4	120
Spring/Summer 2018	891	32,540	37	1012
TOTALS	**5,371**	**128,868**	**109**	**4,304**

*** Only GEARED-funded contact and content hours within each course are included**

MARMET Training Courses

Students	#	Courses	New	Modified
Academic	7,967	205	58	14
Professional	3,259	78	16	0
Totals	**11,326**	**283**	**74**	**14**

FEEDER

FEEDER University Courses

TERM	Students	Courses
Fall 2013	1092	51
Sp/Su 2014	1103	54
Fall 2014	1249	45
Sp/Su 2015	1177	50
Fall 2015	876	35
Sp/Su 2016	1621	64
Fall 2016	1413	49
Sp/Su 2017	1473	67
Fall 2017	1,731	60
Sp/Su 2018	591	28
Fall 2018	1,397	60
Totals	**13,723**	**563**

FEEDER Training Courses

Students	#	Courses/Events
Academic	13,159	534
Professional	*564*	*29*
Totals	**13,723**	**563**

Appendix D: National Jobs Survey Insights

National Jobs Survey Insights

An example of the "jobs report" shared with students at the conclusion of each survey administration (as seen at https://gearedusa.org/jobs2019)

In the Fall of 2018, 430 students from 19 universities shared insights on what companies hired them for jobs and internships and what organizations they applied to. 86% of students who responded were earning Bachelor's degree, 10% were earning Master's degree, and 4% were earning their Ph.D.

Highlights from the survey:

1. When students were asked "what work-related activities do you plan after graduation?" Here was the percentage responding YES to each answer:

- Work at a utility company (29%)
- Get a job, somewhere that is not a utility company (29%)
- Not sure or still considering options (18%)
- Go to graduate school full time (14%)
- Continue working full time where I work now (9%)
- Volunteer with an organization (1%)

2. 72% of students said they want to work in the power industry

3. Of the 67 companies where students have accepted offers to work in 2019, here are the 9 companies that hired the most students:

- Burns & McDonnell
- Northrop Grumman
- Boeing
- Duke Energy
- SPAWAR
- International Paper
- Lockheed Martin
- NextEra Energy
- Savannah River

4. Here are the 8 most popular companies where students have already applied for jobs:

1. Duke Energy
2. Burns & McDonnell
3. Northrop Grumman
4. Raytheon
5. Black & Veatch
6. Boeing
7. National Grid
8. SDG&E

We hope this helps in your future job search!

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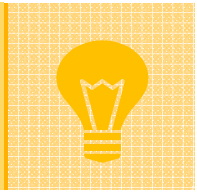
Appendix E - Top 10 Employers Graphic

TOP 10 COMPANIES FALL 2018



FEEDER	GridEd	MARMET
Duke Energy**	Duke Energy**	Burns & McDonnell**
SDG&E**	National Grid**	Black & Veatch**
Siemens	General Motors	Boeing**
Eaton	NAVSEA	Ameren
NextEra Energy	NYPA	Emerson Electric
General Electric	Central Hudson G&E	Northrop Grumman
Florida Power & Light	Burns & McDonnell	Sandia
Mitsubishi	ISO	NASA
Northrop Grumman	Lockheed Martin	Raytheon
Southern Company	Raytheon	Texas Instruments

**These companies also Top-10 in Spring 2018

4 companies in red font occurred across DTTCs

REGION 2

FALL 1 2017

- Eaton Corporation
- Westinghouse Electric Company
- Norfolk Southern Railroad
- Duquesne Light
- Exelon Corporation

FALL 2 2017

- Eaton Corporation
- Lockheed Martin
- Boeing
- Exelon
- Tesla

Spring 2018

- AEP Electric Utility
- J&J
- Dominion Energy
- Georgia Power
- Medtronic
- Abbot
- Stryker
- Boeing
- REU Lab at Univ of TN

Fall 2018

- Dominion Energy
- Raytheon
- General Motors
- Harris Corp
- Duke Energy
- FPL
- Georgia Power
- Honeywell
- Tesla
- Southern Company

OVERALL TOP COMPANIES

- **Eaton Corp**
- **AEP Electric**
- **Dominion Energy**
- **Exelon**
- **Norfolk Southern Railroad**
- **Westinghouse**
- **Duquesne Light**
- **Raytheon**
- **GM**
- **Lockheed Martin**

REGION 3

FALL 1 2017

- Eaton Corp
- Portland General Electric
- Norfolk Southern Railroad
- Westinghouse Electric Co
- Central Hudson Gas & Electric
- Duquesne Light
- Eversource Energy
- Exelon Corp
- Lee County Electric Co-op (LCEC)
- Lockheed Martin

FALL 2 2017

- Eaton Corp
- Lockheed Martin
- Pacific Gas & Electric
- Glumac Engineering
- Pacific Architects & Engineers
- PacificCorp
- Portland General Electric
- Eversource Energy
- Lee County Electric Co-op (LCEC)
- National Grid

Spring 2018

- Portland General Electric
- MECOP
- Pacific Power
- Bonneville Power
- FirstEnergy Service Company
- Eaton Corp
- Sigma Design
- Air Force
- Daimler
- Rhodes Group

Fall 2018

- NYPA
- Mitsubishi
- National Grid
- Duquesne Light
- Eaton
- Power Engineering
- ISONE
- NYISO
- Siemens
- Westinghouse

OVERALL TOP COMPANIES

- Portland General Electric
- Eaton
- Lockheed Martin
- MECOP
- Duquesne Light
- National Grid
- Pacific Power
- NYPA
- Westinghouse
- Mitsubishi

REGION 4

FALL 1 2017

- Duke Energy
- Florida Power & Light
- Kentucky Utilities
- Lockheed Martin
- GE
- TN Valley Authority (TVA)
- Caterpillar (CAT)
- Eaton Corp
- LG&E
- Texas Instruments (TI)

FALL 2 2017

- Duke Energy
- Florida Power & Light
- Kentucky Utilities
- Lockheed Martin
- Black & Veatch
- LG&E
- OUC
- Exelon
- Georgia Power
- National Grid

Spring 2018

- Duke Energy
- Siemens Energy
- LG&E
- Tesla
- Lockheed Martin
- Jacksonville Electric Authority
- Dominion Energy
- ABB
- Schweitzer Engineering Lab
- Sandia National Labs

Fall 2018

- Duke Energy
- Siemens
- NextEra
- Lockheed Martin
- KU
- Southern Company
- LG&E
- Burns & McDonnell
- FP&L
- GE

OVERALL TOP COMPANIES

- Duke Energy
- Lockheed Martin
- Siemens
- FP&L
- KU
- LG&E
- NextEra
- GE
- Southern Company
- Tesla

AUBURN UNIVERSITY

FLORIDA STATE UNIVERSITY 1851

UF UNIVERSITY of FLORIDA

UCF

Georgia Tech

UNC CHARLOTTE

REGION 5

FALL 1 2017

- Commonwealth Edison
- G&W
- GE
- Madison Gas & Electric
- Molex
- ETC Company
- Nat Renewable Energy Lab
- Hutchinson Technology
- John Deere
- Xcel Energy

FALL 2 2017

- Ameren
- ComEd
- Eaton Corp
- Schneider Electric
- Siemens
- Faith Technologies
- Sun Run

Spring 2018

- Sandia National Lab
- SESE
- Micron Technology Inc
- Microsoft
- Intel
- ComEd
- Continental Automotive
- Ball Aerospace
- CAT
- Tesla

Fall 2018

- Burns & McDonnell
- NASA
- ComEd
- Intel
- Ameren
- Abbott Labs
- Google
- IBM
- Microsoft
- Northrup Grumman

OVERALL TOP COMPANIES

- ComEd
- Edison
- Ameren
- Burns & McDonnell
- Intel
- Microsoft
- Madison Gas & Electric
- NASA
- Micron Technology
- GE

ILLINOIS

University of Wisconsin COLLEGES

REGION 6

FALL 1 2017

- REVT Lab
- AT&T
- Florida Power & Light
- MISA
- Raytheon
- Tesla
- Toyota

FALL 2 2017

- REVT Lab
- ABB
- Ford Motor
- Siemens
- Tesla

Spring 2018

- REVT Lab
- Texas Instruments (TI)
- Tesla
- GE
- Google
- Honeywell
- Siemens
- Volvo
- BMW Group
- BOSCH

Fall 2018

- Tesla
- Texas Instruments
- GE
- SpaceX
- Black & Veatch
- Burns & McDonnell
- GM
- Google
- Siemens
- Silicon Labs

OVERALL TOP COMPANIES

- REVT Lab
- Tesla
- Texas Instruments
- GE
- Siemens
- ABB Group
- AT&T
- Google
- SpaceX
- FP&L

UNIVERSITY OF ARKANSAS

UT DALLAS

REGION 7

FALL 1 2017

- Alliant Energy
- MidAmerican Energy
- 3M
- Black & Veatch
- Burns & McDonnell
- Baker Group
- Hunter Engineering Company
- Ameren
- Kiewit

FALL 2 2017

- Black & Veatch
- MISO
- Alliant Energy
- Ameren
- MidAmerican Energy
- Texas Instruments (TI)
- Kiewit
- Melton Machine & Control
- Burns & McDonnell

Spring 2018

- MidAmerican Energy
- Alliant Energy
- Burns & McDonnell
- Black & Veatch
- Boeing Company
- Dashiell Corporation
- Exelon
- ITC Holdings
- John Deere
- Intel

Fall 2018

- Boeing
- Burns & McDonnell
- Ameren
- Emerson Electric
- Sandia
- Black & Veatch
- Dynetics
- Lab Los Alamos
- AT&T
- Blatnner Energy

OVERALL TOP COMPANIES

- Alliant Energy
- Black & Veatch
- MidAmerican Energy
- Burns & McDonnell
- Ameren
- Boeing
- MISO
- 3M
- Kiewit
- Texas Instruments

IOWA STATE

MISSOURI S&T

REGION 9

FALL 1 2017

- On Semiconductor
- Santee Cooper
- NuCOR
- Boeing
- Intel
- Microsoft
- EPC Power Corp
- Google
- Hatch Ltd
- Textron Systems

FALL 2 2017

- Duke Energy
- San Diego Gas & Light
- Santee Cooper
- Southern California Edison
- General Atomics
- Intel
- SCE&G
- SPAWAR
- Texas Instruments (TI)
- Burns & McDonnell

Spring 2018

- San Diego Gas & Electric
- Tesla
- Boeing
- Southern California Edison
- HECO
- Helix Electric
- NREL
- Northrop Grumman
- NAVFAC
- Pearl Harbor Naval Shipyard

Fall 2018

- SDG&E
- LADWP
- Eaton
- Duke Energy
- PG&E
- Power Engineers
- SPAWAR
- General Atomic
- Northrop Grumman
- Savannah River Site

OVERALL TOP COMPANIES

- SDG&E
- Duke Energy
- Santee Cooper
- LADWP
- SPAWAR
- Eaton
- General Atomic
- Intel
- On Semiconductor
- Southern California Edison

Appendix F - Mid-Term Course Evaluation Summary for GEARED Network

The Impact of "Midstream Evaluation" on GEARED Courses

OVERVIEW

Gathering student feedback and acting on that feedback while courses are still in session offers the best opportunity for students *and* instructors to succeed. However the National Survey of Course Evaluation in Higher Education (2013) found only 7.3% of colleges administered any formal "midstream evaluation" process. This was a lower figure than the 10% reported a year earlier (Champagne, 2012) but relatively unchanged since the first National Survey was administered in 1999. That is, although students are more satisfied with course delivery and course content when allowed to give feedback and experience modifications to course delivery while the course is still in session, the vast majority of colleges have consistently ignored this successful practice.

GEARED faculty are leading the way by administering midstream evaluations in solar courses, while training is still in session and while it still matters to students. The result has been more relevant course content, fewer obstacles to learning, and a learning environment where instructors and students are more engaged.

From Fall 2015 to Fall 2018, GEARED faculty at 20 universities supplemented their existing end-of-term evaluations with a midstream evaluation form, administered several weeks into each term to the 5,887 students across 177 courses. Faculty chose either the paper format or an online version of a uniquely designed 15-item measure. The items were crafted to accurately gauge student perceptions on the 13 criteria most often addressed in course evaluations. There were also two comment boxes designed to solicit specific and relevant answers that would help improve the course content and instruction. In addition, faculty could add their own course-specific questions to the midstream form.

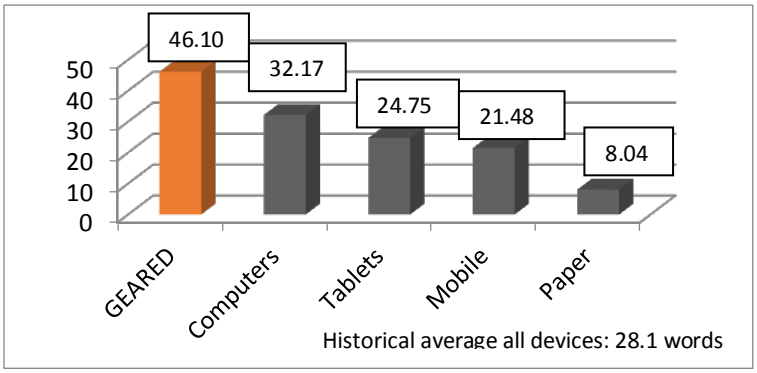
Table 1. Aggregated Numbers across all DTTCS (2015-2018).

	Faculty	Courses	Students	Response Rate	Avg words per comment
2018	**56**	66	2,152	55%	34.5
2017	50	50	1,526	55%	33.5
2016	36	39	1,429	63%	29.3
2015	20	22	780	42%	46.1
TOTAL	**162**	**177**	**5,887**	**55.2%**	**34.1 words**

Response Rates. In the Fall 2015 term, the mean student response rate was 42%, consistent with the national average response rate of 48.6% for end-of-term course evaluations conducted online (based on reports from 55 colleges in the 2012 National Survey). However, response rates increased significantly in the Spring 2016 term (63%) and continued to remain high for subsequent terms as the faculty experienced the benefits of this approach and encouraged students to respond.

Amount of Student Feedback. More important than response rate was the amount of valuable student feedback in the form of comments. In Fall 2015, students wrote an average of 46.1 words of comments in the two comment boxes provided on the online forms. This is remarkable when put in context as to the average number of comments provided by students via an online evaluation form as shown in Figure 1. Although the vehicle for responding (computer, tablet, phone) was not captured in this study, 46.1 words is nearly 50% more comments than typically typed by students on a computer and twice the amount typically typed by students on a mobile device.

Figure 1. Number of student comments for GEARED courses in Fall 2015 far exceeded historical values* for any mode of response.



(*Historical values based on 410,437 student responses on 95 campuses gathered January 2011 – August 2012)

The amount of comments provided by students in subsequent terms was lower than the initial term, but remained higher than the typical final course evaluation averaged across all devices (34.1 vs. 28.1 words).

Quality of Feedback. Participating faculty overwhelmingly felt that student feedback was not only abundant but also useful and relevant in making modifications to their courses. Typical quotes from faculty were:

- "My students appreciated the opportunity to communicate with me about their needs."
- "Students were happy to see I was very serious about their feedback."
- "I distributed the results to the students - they thought it was interesting to see what each other had to say."
- "This was indeed helpful in finding out what the students actually think."

Timely Feedback. An important factor to achieving positive outcomes was the ability for faculty to "close-the-loop" and share results with students in a timely manner, usually by the following class period. Within 24 hours of the close of the evaluation, faculty received results and instructions on how to best share specific (but anonymous) comments and ratings. A 5-step training guide was developed in Fall 2015 and modified for Spring 2016 based on faculty feedback.

Table 2. The 5-step Faculty Training Guide.

1. Illustrate Commonalities. Based on the at-a-glance results provided, faculty pointed out the most popular answers and interesting suggestions given by students. Real examples were:

- *"The note packets are very helpful."*
- *"The micro quizzes help me remember the material."*
- *"I like the idea of meeting in a larger class on Monday, and then meeting in smaller classes on Wednesdays. This adds to the personal feel of the class."*

2. Illustrate Differences. Faculty shared student comments to illustrate the difficulty of navigating the best path to teach students who have different opinions, for example:

- One student wrote: *"I appreciate that he (the Professor) calls us out with a name card, just because it makes me feel that the class is more connected and responsive as a whole."*
- Another student wrote: *"I do not like being singled out in front of a group to test my intelligence*."

3. Changes that CAN be made. Faculty demonstrated that the students' voices were heard by agreeing to make certain changes to the course delivery, for example:

- "A few students said they would prefer to *go over the homework on Mondays,* so let's do that from now on."
- "Several students preferred that I *use the whiteboard while teaching rather than read the slides,* and I will consider this".

4. Changes that CANNOT be made. Faculty could still acknowledge student feedback while explaining why certain suggestions could not be implemented, for example:

- "I see that a couple people said they *wanted more advanced notice of when homework assignments are due,* but in reality I can't give more than 2 days notice due to the nature of this course."
- "Some of you don't *like the how I call out names to answer questions* but it's my experience that this increases student learning."

5. Kudos. And, of course, faculty shared positive comments given by students, for example:

- *"The professor is actively putting forth a tremendous amount of effort to teach this course. That's uncommon and I appreciate it."*
- *"I think our instructor is very kind."*

The Midstream Evaluation Instrument. The foundation for the success of the midstream evaluations was the 15-item measure used by faculty, designed to be the most accurate and informative instrument possible. It is a "meta-evaluation" tool constructed by synthesizing the actual course evaluation measures used at 78 U.S. colleges into distinct criteria. Six instructor-based criteria and seven course-based criteria were selected from the larger pool of criteria, and clearly worded items were created to represent those 13 criteria. In addition, one comment box about the instructor and one comment box about the course were uniquely worded to

generate the most actionable and relevant feedback possible. This meta-evaluation instrument has continually outperformed any other course evaluation instrument in terms of quantity of student feedback and interpretability of results.

Other Positive Outcomes. Although the midstream evaluation was intended only to supplement the end-of-term evaluation instruments used by individual universities, two of the participating faculty asked to use the same meta-evaluation tool and process as their end-of-term class evaluation as well. This has been a successful practice used by dozens of other universities prior to GEARED (e.g., Pace, NCSU, Quinnipiac) and we would encourage GEARED universities to do the same as a means to address the shortcomings of the typical end-of-term evaluation process.

Building upon Success. To generate the same positive outcomes at other colleges, faculty and administrators can simply implement the three tools developed by GEARED for the midstream evaluation process:

1. **Faculty Communication Plan** to boost response rates and quickly gather student feedback
2. **The 5-step Faculty Training Guide** to help faculty efficiently "close-the-loop" and demonstrate that student voices were heard
3. **The 15-item midstream meta-evaluation instrument** to gather the most accurate data possible

Summary. Gathering timely and accurate student feedback and acting on that feedback while it still matters helps both students and instructors to succeed. Students become more enthusiastic and engaged in solar courses, recognize the importance of feedback to the learning process, and are more satisfied with course delivery. Instructors are able to remove obstacles to learning once they are revealed, create a superior course environment, and better nurture students in their solar courses.

Appendix G - GEARED Outreach and Promotional Material

GEARED

Grid Engineering for Accelerated Renewable Energy Deployment

Reimagining the 21st Century Power Engineering and Power Systems Workforce for a Modern Grid

Government, academia and industry working together:

- Increasing power system research, development and analytical capacity.
- Educating professionals for distributed generation and smart grid technologies.
- Hiring power systems workers with new skills.

3 Consortiums represent universities, utilities and other industry partners:

FEEDER Foundations for Engineering Education for Distributed Energy Resources
Led by University of Central Florida

MARMET Mid-America Regional Microgrid Education Training Consortium
Led by University of Missouri Science and Technology

GridEd The Center for Grid Engineering Education
Led by Electric Power Research Institute

The Interstate Renewable Energy Council (IREC) is National Network Administrator for GEARED.
For more information, visit **www.gearedusa.org** or contact joesarubbi@irecusa.org.
Follow us on Twitter @IRECUSA. Like us on Facebook www.facebook.com/irecusa.

FEEDER Foundations for Engineering Education for Distributed Energy Resources

MidAmerica Regional Microgrid Education and Training Consortium

GRIDED The Center for Grid Engineering Education

IREC Interstate Renewable Energy Council

Powered by SunShot U.S. Department of Energy

www.gearedusa.org

Building a Skilled Power Generation Workforce
FOR THE 21ST CENTURY GRID

GEARED

Michael Carlson, Siemens President of Digital Grid NA, in the GEARED booth at DistribuTECH 2016.

GEARED fills an urgent need for increased Education and Training that aligns with power system research, development and analytical capacity around Distributed Generation and Smart Grid technologies.

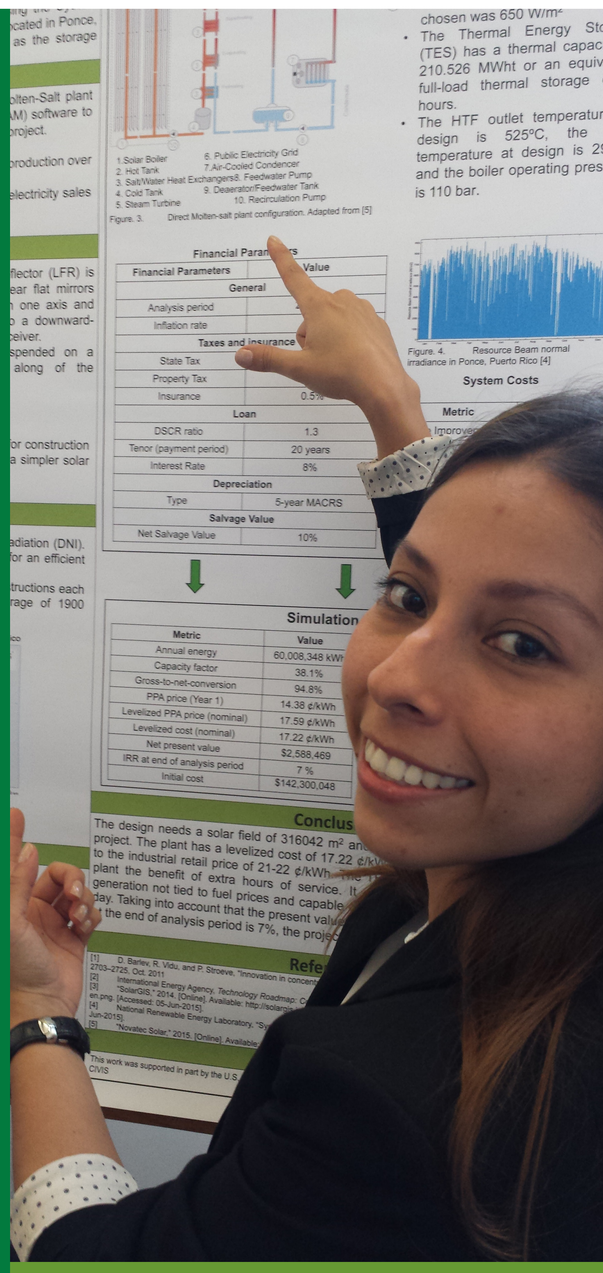
- 15,590 students enrolled in GEARED-supported courses
- 511 GEARED-supported courses taught
- 64 new courses developed through GEARED support
- 13 existing courses modified through GEARED support

Government, Academia and Industry Working Together

- Building and inspiring the next generation of Power System Engineers
- Educating current utility industry professionals for distributed generation and smart grid technologies
- Ensuring the utility industry has a skilled workforce to meet future employment needs

3 Consortiums Represent Universities, Utilities and Other Industry Partners

- FEEDER Foundations for Engineering Education for Distributed Energy Resources led by University of Central Florida
- MARMET Mid-America Regional Microgrid Education Training Consortium led by University of Missouri Science and Technology
- GridEd The Center for Grid Engineering Education led by Electric Power Research Institute (EPRI)



Student poster session at NAPS (North American Power Symposium) 2015 showing off power system engineering research.

www.gearedusa.org

FEEDER — Foundations for Engineering Education for Distributed Energy Resources

MidAmerica Regional Microgrid Education and Training Consortium

GRIDED — The Center for Grid Engineering Education

IREC — Interstate Renewable Energy Council

Powered by SunShot U.S. Department of Energy

THE FUTURE IS NOW

INVEST In Human Capital: Inspire, Challenge and Support the Next Generation Workforce for the Modern Grid

GEARED

Opportunities for STUDENT Engagement

- Student Innovation Boards – Regional student collaborations that inspire **IDEAS** and **RELATIONSHIPS** across universities.
- Senior Design Projects and Competitions – **STUDENT RESEARCH** focused on the challenges and solutions related to distribution generation and smart grid technologies.
- Student-Centered Conferences and Workshops – Opportunities to **ENGAGE WITH THE UTILITY INDUSTRY** and connect with utility professionals.

A program of the U.S. Department of Energy SunShot Initiative

"I see myself in an industry that works to integrate renewable energy into the grid in order to keep the world environmentally friendly, cleaner and safer for everyone."

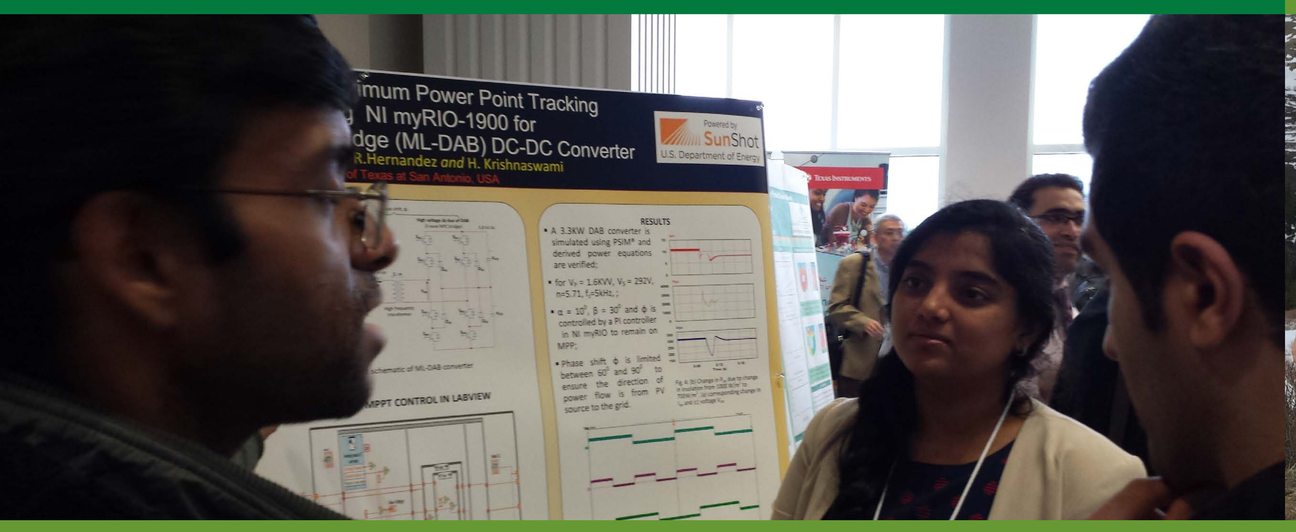
George Vellaringattu, Georgia Tech, electrical engineering student, member GridED Student Innovation Board

"There is something exciting and challenging about power systems – about all the different energy sources and how this knowledge can lead to a better world for all of us."

Monica Mercado-Oliveras, University of Puerto Rico, Mayaguez

"I feel right at home studying and working in the renewable energy industry. This is absolutely where I want to spend my career."

Matt Aberman, University of Central Florida, electrical engineering student



Student poster session at NAPS (North American Power Symposium) 2015 showing off power system engineering research.

FEEDER students at summer renewable energy workshop at NREL.

www.gearedusa.org

FEEDER – Foundations for Engineering Education for Distributed Energy Resources

MidAmerica Regional Microgrid Education and Training Consortium

GridED – The Center for Grid Engineering Education

IREC – Interstate Renewable Energy Council

Powered by SunShot U.S. Department of Energy

GEARED Project Summary:

What is GEARED and what are its objectives?

The acronym GEARED stands for: Grid Engineering for Accelerated Renewable Energy Deployment. The objectives of this U.S. Department of Energy (DOE) SunShot initiative are to:

- Support the increase in power systems research, development, and analytical capability.
- Grow the expertise and preparedness of current and incoming electric utility sector professionals for high penetrations of solar and other distributed energy technologies.

To develop both the needed technological capability and human capital, GEARED currently supports two activities:

- Four Distributed Technology Training Consortiums (DTTCs) that focus on quickly integrating research, development, and analytical findings into education and training programs
- A National Network Administrator (NNA) that links these consortia together through communications and coordination activities.

Current Structure of the GEARED Network

Currently, the GEARED network consists of four Distributed Technology Training Consortiums (DTTCs) and one National Network Administrator (NNA), all of whom report to the U.S. Department of Energy SunShot Initiative. These organizations, together with their websites links and participating universities, are shown below. In addition to the listed university partners, many utilities and supporting industries are part of GEARED. All SIB members are strongly encouraged to visit the DTTC websites to learn more about their DTTC and partnering organizations, along with associated objectives, research, development, education, and training activities.

The Center for Grid Engineering Education
(GridEd)

Website: http://grided.epri.com/
Lead Organization and Individual: Electric Power Research Institute, Dr. Thomas Reddoch
Partnering Universities (4): Clarkson University, Georgia Institute of Technology, University of North Carolina, Charlotte, and University of Puerto Rico, Mayaguez

Foundations for Engineering Education for Distributed Energy Resources
(FEEDER)

Website: http://www.feeder-center.org/
Lead Organization and Individual: University of Central Florida, Dr. Zhihua Qu
Partnering Universities (8): University of Arkansas, Auburn University, University of Central Florida, University of Florida, Florida State University, University of Kentucky, University of Pittsburgh, University of South Carolina

Mid America Microgrid Education and Training Consortium
(MARMET)

Website: http://marmet-center.org
Lead Organization and Individual: Missouri University of Science and Technology, Dr. Mariesa Crow
Partnering Universities (4): University of Illinois, Iowa State University, Missouri University of Science and Technology, University of Wisconsin

Southwest United States of America – Distributed Technology Training Consortium
(SWUSA-DTTC)

Website: http://www.electricore.org/swusa_dttc
Lead Organization and Individual: Electricore, Inc., Kodie Arnold
Partnering Universities (4): Arizona State University, University of California, San Diego, University of Hawaii, Manoa, San Diego State University

National Network Administrator
(NNA)

Website: www.gearedusa.org
Lead Organization and Individual: Interstate Renewable Energy Council, Inc. (IREC), Joe Sarubbi
NNA Partner: Solar Electric Power Association (SEPA), Bob Gibson

Appendix H - Conference Presentations

Addressing the Workforce Challenges of Distributed Technologies and the Evolving Smart Grid

Jerry Ventre

Interstate Renewable Energy Council

IEEE PES General Meeting

July 30, 2015

April 2016

Utility Solar Conference
Speaker Proposal

Track: Adapting the Utility Business Model

Topic Area: Recruiting the Utility Workforce of the Future

Topic: Bridging the Skills Gap: How utilities, institutions, and the Department of Energy are collaborating to help build the 21st century utility workforce of Power System Engineers.

Session: Panel Discussion

Abstract: Integrating distributed PV, small wind, transactive controls, demand response, electric vehicles, distributed storage and other variable and distributed power technologies into the grid is requiring new skills and power systems expertise. Intelligent controls of power flow into and out of the utility grid are needed to ensure grid reliability, stability, and power quality. Alternative protection strategies will also be required to accommodate large numbers of distributed energy sources. Time-of-use and peak-demand rate structures require more sophisticated system designs that integrate energy management and/or energy storage into the system architecture. The goal of this panel session is to hear from utility experts about the types of skills needed to help build the 21st century utility workforce of Power System Engineers, and what the DoE SunShot GEARED program is doing to support the growth of expertise and preparedness of current and incoming electric utility sector professionals. Panelist will be from the utility and workforce sectors.

Speakers: Frank Doherty, Project Manager, Consolidated Edison; Gary Freeman, General Manager, Renewable Compliance and Origination, Duke Energy; Joe Sarubbi, Technical Education & Training Consultant, Interstate Renewable Energy Council; Talin Sokugawa, Renewable Energy Engineer, Hawaiian Electric Company

July 2016

2016 IEEE PES General Meeting

Panel Session Information Request - PEEC

SUBCOMMITTE (SC) NAME
n/a
WORKING GROUP (WG) NAME
n/a
Session Length
Panel session, 3-4 hours
Expected Attendance
40
Preferred Time Slot
n/a

Panel Session Title
Multi-Institutional Power System Education Collaboration: On-going Efforts, Lessons Learned, and Future Plans
Sponsored (Co-sponsored) By
PEEC

Chair(s) *(detail information: name, titles, contact, affiliation, etc.)*		
Zhihua Qu	SAIC Endowed Professor & Chair of ECE	University of Central Florida <qu@ucf.edu>
Mariesa Crow	Fred Finley Distinguished Professor of Electrical Engineering	Missouri University of Science and Technology <crow@mst.edu>
Tom Reddoch	Executive Director	EPRI <treddoch@epri.com>

Panel Abstract

(max. 150 words)

Innovations in curriculum development, course delivery and multi-institutional collaborations are much desired to meet increasing demands in smart grid education and to better align academic research with utility efforts in renewable deployment. The DoE SunShot GEARED program aims to increase power system research, development, and analytical capacity, and it supports three consortia to engage collaborations among universities, electric utilities and industry. As a result, multi-institutional course sharing agreements have been developed, and collaborative course offerings have been undertaken. The goal of this panel session is to understand benefits and obstacles of these multi-institutional efforts, share pedagogical innovations and best practices, and enhance future endeavors. In particular, the topics include: overview of DoE GEARED program, on-going activities at three GEARED consortia, key components of multi-university course sharing agreements, curriculum trends, distance and mixed learning/delivery modes, roles of DoE/utility supports, and impacts. Panelists are from DoE, academia, national laboratories, and utility.

Lead, Topics and Panelists
8:00-8:30am Dr. Elaine Ulrich, Department of Energy, "DoE SunShot GEARED Program"
8:30-9:00am Dr. Mariesa Crow, Missouri S&T, "Overview of GEARED DTTCs"
Panelists: Mariesa Crow, Tom Reddock, and Zhihua Qu
9:00-10:00am Dr. Larry Holloway, Univ of Kentucky, "GEARED University Curricula on Renewable Energy, Power Engineering and Smart Grid"
Panelists: Larry Holloway, James McCalley, and Ronald Harley
10:00-11:00am, Mr. Steve Whisenant, Duke Energy, "Workforce Development for Utility Industry"
Panelists: Steve Whisenant, Peter Sauer, Roger Dougal, Badrul Chowdhury
11:00-11:30am Dr. Zhihua Qu, UCF, "Multi-Institutional Course Sharing Agreement"
Panelists: Zhihua Qu, Mariesa Crow, Steven Coley
11:30-noon Mr. Tom Reddoch, EPRI, "Professional Training Programs"
Panelists: Tom Reddock, Bulent Sarlioglu, Bob Reedy

September 2016

What Keeps Electric Utility Industry HR Managers Awake at Night?

Grid Engineering for Accelerated Renewable Energy Deployment (GEARED), a U.S. Department of Energy SunShot Initiative
Joe Sarubbi, Interstate Renewable Energy Council, Inc.
Tom Reddoch, EPRI
Phil Mathews, Talent Acquistion, Southern California Edison

Session Description:
Identifying future leadership in a company has always been a challenge. Electric utility industry HR Managers are under new pressures as the current hiring environment is very different from years past. Gone are the days of lifetime-employees. Employees, in general, are far more mobile in today's society for a variety of reasons and millennials have new priorities as they search for jobs. Strategies used for employee recruitment, hiring, and retention must evolve if the utility industry has any hope of meeting its future workforce demands. Attend this session and learn more about these topics as well as other needs when recruiting and retaining the next generation of power engineers.

Target Audience:
Anyone looking at hiring new engineers, interested in developing new talent for the future grid, and/or creating human resource infrastructure for retaining existing professional staff should attend. This includes those tasked with the hiring needs of their respective company -- both the technical operation & planning, as well as Human Resources staff should participate.

January 2017

Mega Session Title: Educating, Hiring and Developing the Next Generation of Electric Power Engineers

Tentative List of Panelists:

- Stephen Collins, Distribution Engineer, Advanced Technology, Southern California Edison (SCE)
- Kimberly Howard, Education Initiatives, Education Initiatives – Corporate Social Responsibility, Portland General Electric (PGE)
- Taka Isshiki, Planning & Strategy, Pacific Gas & Electric (PG&E)
- Susan Kidd, General Manager T&D, Arizona Public Services Co. (APS)

Moderators: Scott Bordenkircher, Director Innovation, APS

Point of Contact: Mary Lawrence, Interstate Renewable Energy Council, Inc. (IREC), mary@irecusa.org

Session Purpose and Content:

Electric utility industry Human Resource (HR) Managers are under new pressures as the current hiring environment for electric power engineers is very different from years past. Gone are the days of lifetime-employees. Instead, employees (in general) are far more mobile in today's society and millennials have different priorities as they search for jobs. A complete infrastructure is needed for companies to successfully provide a high quality supply of next generation power engineers and to address the current need for replacing a retiring workforce. There are many aspects to consider when creating a hiring strategy including access to universities with a top power system curriculum, creating corporate recruiting structures, attracting and retaining young talent to the electric industry, attracting students into university engineering programs, and developing partnerships between universities and electric utilities. In this session, the audience will hear about initiatives that utilities are using to develop a competent workforce and address hiring challenges. We will also discuss the role of HR in developing robust programs that promote the electric utility industry as a desirable place of employment.

Appendix I - Student Guide to Navigating Industry Conferences

DistribuTECH Conference 2018

January 23-25, 2018
Henry B. Gonzalez Convention Center
San Antonio, Texas
www.distributech.com

Engaging Conference Attendees at the Poster Session

The DistribuTECH conference poster session is a great opportunity to hone your networking skills while simultaneously promoting yourself and your design project. The following list includes suggestions to help make your networking opportunity rewarding and productive:

- It is a real challenge to walk that "fine line" between being too aggressive or being too shy. Eye contact is everything up front. An attendee coming out of a session might be quite interested in what you are displaying, or might have casual interest. When making eye contact, use your instincts to determine if that person wants to engage you or is just browsing.
- Fear is the number one reason people struggle with networking, and your body language is a dead give-away to the person you seek to engage. At least half of the way we communicate is through body language. When you speak, your facial and body clues need to match what you're saying. It's important to maintain eye contact throughout the engagement.
- Keep a warm-genuine smile! People are more likely to want to engage people who seem happy. Smiling sets a tone. You don't want to seem stand-offish.
- If you get to introductions during the engagement, be sure to give a good handshake while making eye contact. It will make you look more professional.
- Prepare a 30-second elevator speech describing your project. Practice it!! If people are interested, they will ask additional questions. You don't know the person's motive for stopping at your poster. If they are not that interested, then you also wasted a lot of time that could have been allotted for others to engage you. When someone says: "tell me about your research," you don't want the person's eyes to gloss-over!
- You need to exude enthusiasm and passion about your work. It could go a long way towards someone wanting to follow-up with you about a job opportunity.

Follow-up with Companies Post DistribuTECH

If you were fortunate enough to exchange business cards with conference attendees from companies of interest, then your follow-up becomes critical if you seek to gain employment in the near or present future. Following-up with an email within 24 to 48 hours after the conference demonstrates your interest in that company and could go a long way towards an interview opportunity.

There are numerous "follow-up" email templates online. Choose a template that best fits your style.

Your goal is to continue the dialog that could lead to an interview, so make sure your follow-up email leaves the door open for further engagement. Additionally, even if a company expresses interest in you, but you are not necessarily interested in them, you should continue the dialog all the way to an interview for the following reasons:

1) The company might surprise you! Remember, *"nothing ventured, nothing gained!"*

2) If you have not been on many job interviews, this gives you a chance to hone your interviewing skills. You NEVER want to put "all your eggs in one basket!" If you wait until you land an interview with that perfect company, and it's the only interview you have taken, your inexperience might be obvious. Practice makes perfect!
3) It gives you an opportunity to do a better comparison of offers. One company might have better starting pay, but another company might have better opportunities for advancement. You become a more informed candidate and know what questions to ask when you conduct multiple interviews.

Networking on the Exhibitor's Floor

Many of the suggestions outlined above under the Poster Session hold true for walking the exhibitors floor. Body language is critical, and keep in mind, that many of those company employees are skilled to read your body language.

Timing is EVERYTHING! Remember, the exhibitors are there to sell product. They will give you time, but YOU need to be conscientious of their time. If you approach them and they are willing to speak with you, great! But be mindful if other interested people stop at their booth as the salesperson might want to engage them. Politely offer to step aside, and take the salesperson's lead at that point. Most likely, they will re-engage you once they are finished.

If it's a large company with a significant display and many employees "working" the booth, you can ask if there is an HR representative present. Many of the larger companies are now bringing HR representatives to DistribuTECH. If not, ask them if there is someone available to talk about opportunities. If not, ask if they are willing to take a resume. They might direct you to their website. That's fine, but do your best to get a business card from one of the salespeople. It will give you a reference for your cover letter. You can say you were speaking with (XXXXX) at the DistribuTECH and he/she suggested that you should send a resume.

Your 30-second elevator speech about your research will really come in handy here too. Brevity is key, but it could help you relax and have a simulating conversation that could lead to something big.

Do your best to get as many business cards as possible. Make a note on the back of the card that will trigger the conversation you had while it is fresh in your mind. If you wait until later you will not remember all the conversations. That "note" could help immensely in your cover letter.