Developing a Sustainable Business Model for Training and Education in Electric Power: A GridEd Report

Abstract

This report summarizes five years of market testing for electric industry interest in training and education (T&E) in electric power through EPRI's GridEd program. This report also provides high-level results of a survey of electric utility and industry partners. The survey sought to identify high value workforce development initiatives which are suited to EPRI's collaborative funding model to ensure the long-term viability of the GridEd model. In addition, this report reflects on elements of sustainability in key activities of the GridEd consortium including: professional training, enhancing utility-university relationships, university course curriculum, student engagement and human resources. It concludes by assessing the GridEd business model, funding sources, marketing efforts, metrics for success, and adding value through additional federal funding; and provides examples and learnings from the program, which allows it to serve as an actionable, strategic document for sustaining GridEd.

Executive Summary

The GridEd team envisions sustaining a training and education (T&E) activity through EPRI's collaborative business model whereby high-value propositions related to T&E can be financially supported. This report draws from experience of the GridEd program and describes the business cases and marketing plans to provide T&E products and services out into the marketplace. A summary of key takeaways includes:

Professional Training

- Professional training short courses and particularly eLearning is a high priority that is likely to attract fiscal support going forward.
- The mass market for professional training of power engineers in the T&D sector of the electric industry is typically driven by the need to acquire PDHs for licenses.
- There is a growing interest in human resources organizations to use T&E as a recruiting and retention tool to show professional growth potential for attracting engineers to companies.
- There is ample opportunity to expand audiences for professional training to executives, managers and technicians.

Student Engagement

- Advisors prioritize student activities which focus on design projects and competitions.
- Supporting students to attend conferences through activities such as poster presentations is a great way to engage students. However, without public funding, it may be difficult to secure broad collaborative utility funding for this type of activity.

University Curriculum Development

- There is no consensus on how to best support the development and delivery of new and revised university courses. Some utilities ranked this activity as high value with high likelihood of fiscal support while others saw little value with low likelihood of support.
- While professors tend to shape course content to fit their preferences, there is a need for photos, example case studies, and other educational materials that could enhance the quality of teaching products. The electric industry could be great sources of these materials.

Other Activities

- There were mixed responses for other workforce development activities such as support for K-12 outreach and the HR committee. Some utilities ranked these as high value activities with high likelihood of fiscal support while others saw little value with low likelihood of support.

Business Model

- The multi-funder supplemental project business model provides forward funding which reduces cost recovery risk and leverages pooled funds which reduce per-unit course costs.
- Significant leverage (>30 utilities or through additional DOE or NSF funding) may provide support beyond professional training and help support student activities and/or university course development.

Metrics for Success - Experience from GridEd has led to the development of the following key performance indicators (metrics) across three activity areas.

Area	Metric	Threshold	Target	Distinguished
Utility Advisors	# of utility advisor organizations	15	20	30
	Utility advisor satisfaction	85%	90%	95%
	% of participation	35%	50%	75%
Professional Training	Cost per short course	$25k	$20k	$15k
	Avg. short course enrollment	10	15	20
	Student satisfaction	85%	90%	95%
University Curriculum	Cost per NEW university course[1]	$80k	$55k	$45k
	Avg. student enrollment(undergrad/grad)	10/5	20/10	25/15
	% of Affiliate university participation	20%	40%	60%
	Affiliate university satisfaction	85%	90%	95%

Background

In 2013, the U.S. Department of Energy (DOE) Solar Energy Technologies Office, awarded EPRI with funding for the Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) program. In response EPRI created what is known as “GridEd” —The Center for Grid Engineering Education. In 2016 the DOE granted EPRI an expansion for a formal program in the western U.S. called Solar Training and Education for Professionals, or “STEP”. The two grants resulted in GridEd-East and GridEd-West, and separate efforts continue to reflect the regional differences in the philosophies of the eastern and western U.S. The GridEd collaboration includes EPRI, seven Partner universities (Arizona State University, Clarkson University, Georgia Institute of Technology, Portland State University, University of

[1] Will significantly vary depending on course length, whether labs are involved, and how much existing material can be leveraged.

California—Riverside, University North Carolina—Charlotte, and University of Puerto Rico Mayaguez), and participating electric utility sponsors.

Launched with a five-year, $5.2 million investment from DOE, along with a cost-share commitment from the 25 sponsoring utilities and seven university collaborators, GridEd will have invested an estimated $8.9 million dollars into power engineering education and workforce development through the end of 2018.

GridEd leverages electric industry research through EPRI and university engagement to educate a future electric grid workforce. The GridEd approach to expanding the knowledge base through a university network is to provide ready access to state-of-the-art training and education (T&E) materials to a wide university audience. As such, the GridEd Affiliate university program was established through our utility sponsors to extend the university network. Affiliate universities have many opportunities to engage the GridEd program through shared course materials, Student Innovation Boards, discounts to GridEd short courses (sometimes at no cost), annual GridEd tech transfer workshops, GEARED student conferences, and professional meetings like DistribuTECH.

Report Objectives

From the beginning of the GridEd project, the team has focused on creating a sustainability plan for GridEd or a GridEd-like entity supported and financed through EPRI in a post-DOE-funded era. To achieve that goal, positive business cases have been identified where participants obtain value for T&E products and services. The GridEd team envisions sustaining a T&E activity through EPRI's collaborative business model whereby high-value propositions related to T&E can be financially supported. This report draws from experience of the GridEd program and describes these business cases and marketing plans to provide T&E products and services out into the marketplace.

GridEd Activities

GridEd has been focused on four primary activities as described below. A primary goal of this effort has been to build relationships between electric utilities and universities, believing that these relationships are the long-term, sustainable outcome that is required. This report focuses on principles of sustainability for each of these four efforts, which have been identified by the GridEd project team.

University Curriculum

GridEd partner universities conducted a curriculum review and inventory to assess desired modifications to each university's curriculum. This review, along with institutional education goals, led to the development of new and/or revised courses at each institution. GridEd also established a national university network and course sharing program for electric power systems knowledge through its Affiliate university program. A key aspect of this program is the sharing of academic curricula and materials developed by the Partner universities with the Affiliate universities. Materials such as PowerPoint slides, lecture notes, and problem sets have been uploaded to an internal GridEd SharePoint site which serves as the main repository within the GridEd initiative. This allows Affiliate universities to access course materials that may help in the development and revision of their own courses. Further engagement with Affiliate universities are conducted through technology transfer workshops where university professors are assembled to review GridEd products, discuss curriculum development, and share laboratory experiences.

Professional Training

A key element of the GridEd strategy is to address training and education needs for active professionals in the electric industry. In 2014, GridEd launched a four-course tutorial short course series as a first step in addressing the educational needs of practicing engineers. The tutorial series represented an effort to link multiple courses as a complete package directed at the effects of DER devices and systems on the electric distribution system. Most participants failed to enroll in the entire series and instead elected to take the various courses separately. The concept of a linked series was dropped, and subsequently only individual courses are now offered. A library of courses has been developed covering 14 short course topics. These courses focus on fundamentals and help participants understand analytical procedures, industry practices, and emerging technologies for electric power system planning, design, and operation of present and future electric grids. A companion report[2] identifies primary gaps in T&E needs which served as a basis for the chosen short courses.

Student Engagement and Outreach

To help address both technological and workforce challenges that are associated with the exponential growth in distributed energy resources (DERs), GridEd, with the guidance of DOE and the GEARED Executive Committee, assembled a Student Innovation Board (SIB). Students selected to join the SIB act as advisors to GridEd and advocate for student participation in design competitions, multidisciplinary engineering projects, and paper or poster presentations at technical and professional society meetings. GridEd also offers financial support (up to $5,000-per-project) for undergraduate design projects which are related to engineering challenges associated with the generation, transmission, distribution, or end use of electric power. These awards are eligible for Affiliate universities of GridEd to help stimulate additional focus on power engineering at the undergraduate level.

The GridEd university network has participated in a wide variety of activities in a range of industry conferences such as a poster competition at the North American Power Symposium, panel sessions at IEEE PES conferences, and student power exhibits at DistribuTECH. Venues such as these provide students valuable experience to learn about the latest trends, technologies, and issues emerging in the industry. They also help enrich a network of students, experts, and leaders involved in the GridEd initiative by providing a venue to convene in-person.

Beyond engaging university students, GridEd also has engaged in K-12 outreach initiatives including a variety of innovative methods for piquing student interest. GridEd's impact in its outreach initiatives have been evident through activities such as:

- Development of classroom curriculum and training materials for high schools,
- Solar PV demonstrations,
- Special programs devoted to hands-on engineering activities, and
- Community outreach using engineering expertise, systems and technology in poor and impoverished areas by creating a lasting impression on the lives of the youth who live there.

Human Resources Committee

In pursuit of understanding T&E needs through industry engagement, the GridEd team identified another gap related to T&E. Electric utilities have been struggling to recruit qualified electric power engineers for some time. Often, utilities hire good electrical engineers, but they are inadequate as power engineers, thus requiring additional training before they can contribute to valued company needs in electric power. Further, retention of engineering staff has become an issue. Most electric utility

[2] *Identifying Training and Education Gaps in the Electric Industry: A GridEd Report*. EPRI, Palo Alto, CA: 2018. 3002014732.

human resource (HR) departments have recognized that T&E is key to both recruiting and retaining engineers.

Today's engineer is seeking professional growth in a world where company mobility is a growing trend. As a part of working with electric utilities, maintaining a relationship with HR departments is essential as this part of the organization often provides a source of funding for developing engineers. Recognizing that a utility's HR strategy is key to developing and sustaining a workforce, GridEd established an HR Committee composed of representatives from utility partners with the purpose of examining workforce development needs for electric power engineers for the electric utility industry.[3]

GridEd Sustainability Survey Results

GridEd conducted a survey of its utility advisors to assess the value of ten different activities offered through GridEd as described below.

- **New/Modified University Course Materials** – Creation of new course materials (ppts, problem sets, assignments, projects, etc.) to be included in university curriculum. This includes "train the trainer" or Affiliate University Tech Transfer workshops to support networking and transfer of knowledge.
- **Support Industry Advisory Boards** – EPRI support and participation in Industry Advisory Boards for Affiliate Universities.
- **Professional Short Courses** – All aspects of developing and delivering short courses to industry professionals.
- **eLearning Courses** – Collaboratively developed eLearning courses such as the Basic Power Course.
- **Student Conferences** – Support student engagement at industry conferences. This could include activities such as organizing poster sessions, student networking events, etc.
- **Student Innovation Boards** – Support cross university student innovation boards with the goal of connecting student organizations related to power engineering across multiple universities.
- **K-12 Outreach** – Develop materials and support events targeted towards STEM outreach to K-12 students.
- **Undergraduate Design Projects** – Provide fiscal support and/or some formal program to support undergraduate design projects in power at Affiliate universities.
- **Student Design Competitions** – Organize student design competitions or "hackathons" to engage students in electric power engineering concepts.
- **Human Resource Committee** – Organize and run an HR Committee to support discussion of best practices in hiring, training, and retaining the workforce of the future.

There were two main questions for each of these ten topics and a free response section to gather formal feedback from each survey participant. Table 1 summarizes the question and response categories.

[3] A separate report summarizing findings of the HR committee is expected to be issued in the first quarter of 2019.

Table 1. GridEd Sustainability Survey Questions

Question	**Response Options** [Weight given response]
Please indicate the level of value for each of the following activities of GridEd. (Figure 1)	Very High Value [5], High Value [4], Some Value [3], Little Value [2], No Value [1], I have limited visibility/knowledge of this activity [N/A]
Please indicate your organizations likeliness to fund the following activities as an EPRI organized project assuming it was reasonably priced. (Figure 2)	Highly Likely [3], Maybe [2], Probably Not [1]
Please provide any additional comments you have about what you would like to see in a sustaining workforce development initiative at EPRI? - specifically, how could a workforce development project at EPRI help your organization achieve its workforce development goals.	Free Response

As illustrated in Figure 1 below, eLearning and short courses were the two activities that received average responses between "Very High" and "High" value. The HR Committee activity received an average response of "High" value, while all other activities received average responses between "High" and "Some" value. Except for student design competitions, there was at least one utility respondent who indicated a very high value for each of the ten activities.

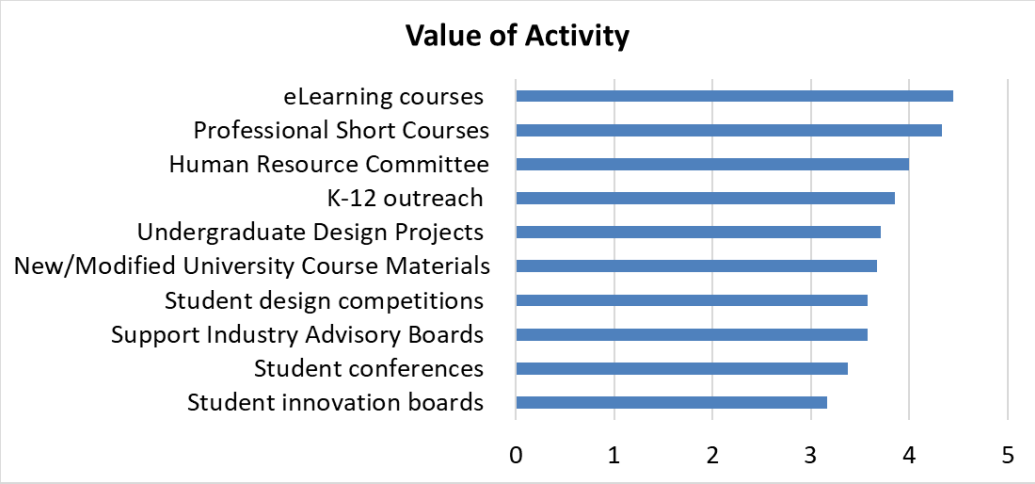

Figure 1. Average Response to Value of GridEd Activities

As illustrated in Figure 2 below, eLearning and short courses were the two activities that received average responses for likelihood of fiscal support. At least one utility respondent indicated a high likelihood of fiscal support for each activity. Support for student conferences and student innovation boards were the only two activities that received an average response in likelihood of fiscal support between "Probably Not" and "Maybe".

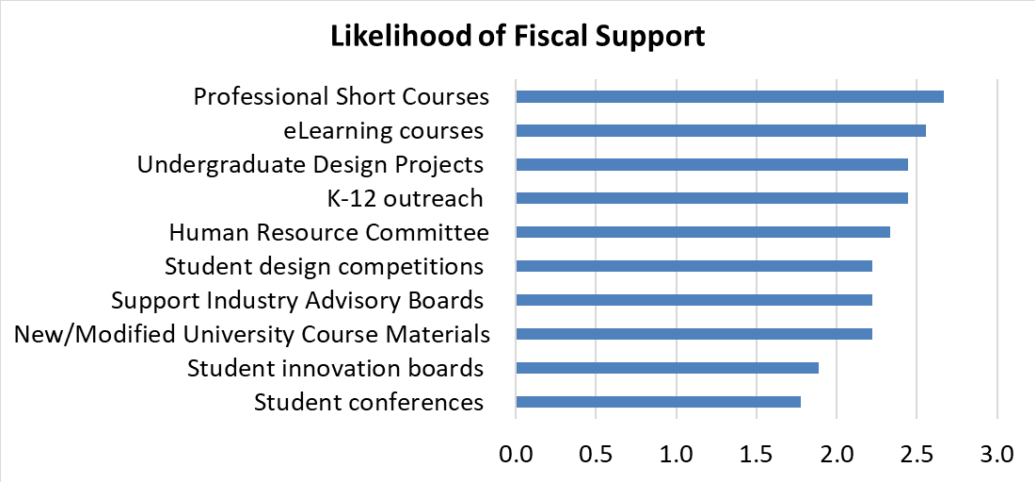

Figure 2. Average Response to Likelihood of Fiscal Support for GridEd Activities

Several observations can be made from the survey results and accompanying comments provided to the free response question as summarized below:

Professional training is a high priority – eLearning and professional short courses were deemed to be the most valuable activities and those that were most likely to attract fiscal support going forward. Ideas provided from comments include:

- Focus on eLearning which is more viable.
- Include courses focused on multiple audiences and topics such as:
    - Engineers seeking to pass the fundamentals of engineering exam and the professional engineering exam.
    - Supervisors, managers and executives needing management and leadership training. Too many courses currently available are 4 and 5-day courses or focus too much on human personality traits, instead of how to deal with real world day to day employee supervisory tasks.
    - Training activities for technicians that come from the lineman/wireman trades.
- Develop training plans similar to a qualification card system that indicates knowledge needed by objective. Develop a "common knowledge" system that would fit any utility and provide guidance on how utilities can develop their utility specific knowledge requirements. This could help guide the training and gauge specific training needs of the next generation of engineers – given large number of retirements, high attrition rates, and a mobile workforce.

Focus university student support efforts on design projects – Of the four student engagement activities in the survey, the two activities which garnered the highest prioritizations were those that focused on design projects and design competitions. Fiscal support for student networking or for students to attend conferences was a lower priority.

There are different philosophies on how to best support curriculum development at universities – There was no consistency on how to best support new and revised university courses. Some utilities ranked this activity as high value with high likelihood of fiscal support while others saw little value with low likelihood of support. Comments related to university engagement included:

- Maintain university connections within EPRI to foster growth of the workforce.
- Work to develop "course sharing" among universities.
- Help engage more undergraduates in power systems (which could include):
    - Develop a specialized power engineering degree that is approved by the Accreditation Board for Engineering and Technology, Inc. (ABET)
    - Promote power curriculum early in students' education
    - Increase number of power courses offered

There were mixed responses for other workforce development activities such as support for K-12 outreach and the HR committee. Some utilities ranked these as high-value activities with high likelihood of fiscal support, while others saw little value with low likelihood of support. Survey participants were technical, not from HR or corporate parts of utility organizations. Comments about these activities included:

- Continue HR activities to support our organization
- Increase the pipeline of local college bound students through STEM outreach in K-12 to increase the number of U.S .citizens that are in or near our service territory entering engineering departments.
    - Develop metrics of effectiveness for this outreach at each level

Professional Training

Drivers

Professional training is rapidly emerging as a very important topic for the electric industry. These training activities are focused primarily on technology innovation that is rapidly changing the character and content of the electric system. Seasoned engineering staff are being presented with alternative engineered solutions such as DERs, grid modernization strategies, and new end-use technologies such as electric vehicles, process electrification methods, and power electronic interface devices. This inrush of new technologies leaves many well-trained professionals unfamiliar with these newer options. Also, T&E is emerging as an HR recruiting and retention asset. Many professionals today want job opportunities where they can grow professionally – which can be achieved through T&E.

As participants take courses, they seek some type of credit to recognize their professional advancement. These professional advancements generally do not lead toward a degree, rather they focus on acquired knowledge in a particular field. Three types of measures are used:

- **Professional Development Hours (PDHs)** – The use of PDHs is recognition for having training hours in a field of study, but such courses are not necessarily certified.
- **Continuing Education Units (CEUs)** – Generally, recognition of CEUs comes from courses that have been certified by some entity perhaps as in an ANSI Standard. A formal process is used by the ANSI organization to establish a training program as certified per the appropriate standard.[4] Often times, some type of exam is used to measure comprehension.

[4] For example, the International Association for Continuing Education and Training (IACET) standards for lifelong learning (www.iacet.org)

- **Certificates of Achievement** – A Certificate of Achievement is recognition that a series of courses have been taken in a given field application creating a specialized expertise. These can be either certified or not.

GridEd has observed that the mass market for professional training of power engineers in the transmission and distribution sector of the electric industry is typically driven by the need to acquire PDHs which is a requirement to maintain professional engineering licenses in many states.

Audience

Most GridEd courses to date have been directed as introductory for a first experience in a new technology or business assessments. Courses are largely directed at engineers seeking professional enhancement. The audiences generally consist of a wide range of ages suggesting participants at all levels of seniority within a company. As revealed by the sustainability survey results and through discussions with utility advisors, there is ample opportunity to expand audiences for professional training. Future courses will be designed for non-technical, technical, and executive audiences.

Modes

There are a variety of formats for presenting professional training. The classic ***live, in-person*** is the most familiar; however, its popularity is diminishing. There are costs to travel to a common site which potentially makes it a cost prohibitive experience. However, some participants prefer this style of presentation given the face-to-face engagement. In some cases, live, in-person courses are offered at company's facility to simplify logistics for participants. Distance learning options that are becoming more popular included ***live-online*** or ***prerecorded*** lectures***.*** Prerecorded sessions provide maximum flexibility while the live-online format helps to avoid travel costs, but still allows for live engagement with the instructor. A robust program will provide all options as each learner has his or her own preference.

Length

GridEd has chosen the twelve-hour unit as a standard unit of course duration. The 1.5-day format helps with logistical constraints for live in-person courses so that participants can avoid a three-night trip for a two-day course. In the live-online format, these courses are frequently offered in one-and-a-half hour periods, two days-a-week, over a four-week period. This provides flexibility for course participants by distributing time for engagement. Each session is recorded thus allowing continuity should a class session be missed.

There are occasions where special courses are developed for select audiences. Typically, these are eight hours in duration. These courses are provided at conferences and at company locations where large audience participation is involved. Other formats could include courses of several days through a couple weeks. These longer formats either involve a wide range of topics or single topic in greater depth. Creating course lengths that match student/company needs could be a key factor in attracting audiences for courses.

GridEd has developed a special course which is comprehensive on the basics of electric power. It is approximately 85, one-hour lectures covering what most audiences would classify as a two-semester course. These materials are publicly available and have been adopted as a basis by the Center for Advanced Power Engineering Research (CAPER) [5] organization, based in Clemson, South Carolina, to

[5] http://caper-usa.com/

deliver a compact, basic power systems course in a live in-person two-week format. The CAPER course is presently under development and represents a great example of how materials under the GridEd program can be sustained.

Enhancing Utility-University Relationships

From the beginning, GridEd has been focused on building long term relationship between electric utilities and universities. This relationship is very important as university products must support a workforce development strategy that meets the needs of both the electric industry and the electric utility industry. Electric utilities are a key resource in providing guidance on requirements for the types and bandwidth of future electric power engineers. Further, electric utilities follow a hiring pattern established years ago where they hire "locally." Historically, utilities find that the best employee retention is achieved through a regional hire.

Companies prefer to obtain the best employees at all levels, including students from the university system. The process of recruiting is an everyday action – not just those few days on campus at recruiting time. Establishing recognition of the company begins by being connected. Supporting campus laboratories, donating equipment, and other fiscal contributions such as internships, scholarships, and sponsoring student competitions are excellent steps for building that identity. Also, serving on industrial advisory boards are very strong statements and affiliations. This ongoing presence helps to build for recruiting day. Connecting with professors is also important. Building relationships with professors through seminar presentations, tours, or a highly recommended "take a power professor to lunch" program are best practices. Establishing theses connections will provide an excellent pathway to the top students.

There are several great examples of connectivity. Duke Energy has established the Center for Advanced Power Engineering Research (CAPER) which is a membership driven consortium among several universities and industry partners in the Southeast region of the U.S. The primary mission of the center is to develop and demonstrate grid modernization technologies and enhance the educational experience for students in electric power engineering. As a collaborative effort, CAPER will develop research and demonstrate advanced technologies to meet the operational and expansion needs under uncertainties with an increased penetration of distributed renewable generation. Its Industry Advisory Board (IAB), composed of numerous industry partners, meets twice per year with CAPER researchers and students to conduct business and to engage in discussions about the Center's research and education activities.

Portland General Electric (PGE) and Portland State University have established close connections as institutions. PGE funded and established a power system laboratory which is a hub of student engagement. Through its community relations group, PGE is supporting various activities on campus to support community engagement with a rally point around electric transportation.

Southern California Edison works closely with three Los Angeles-area universities including the University of California-Riverside (UCR), the University of California-Irvine, and UCLA. This includes engaging in all types of research projects with both undergraduate and graduate students.

The GridEd program has strived to connect electric utilities and universities. This connection has been enhanced through its affiliated university program where each electric utility that joins GridEd can

nominate two universities as Affiliates. The Affiliate university program is a collaboration of universities that share materials, experiences, and student activities in electric power systems for the expressed purpose of improving educational opportunities and better access to electric utilities. Annually, a tech transfer workshop is held to share knowledge gathered through the GridEd program to enhance power system programs at participating universities.

University Course Curriculum

Keeping university curriculum up to date is an important aspect of developing a competent and qualified electric industry workforce of the future. If program content is not up to date and relevant, this increases professional training requirements for the electric industry itself to build-up the required skill sets of new hires in the workforce. While universities have the self-incentive to stay tuned to industry educational needs and update their respective programs, consistent power industry involvement in university-, college-, and department-level industry advisory boards is needed to ensure curriculum continues to meet hiring needs.

It has been observed through discussions with GridEd Partner and Affiliate universities that each professor prefers to develop and shape the content of the materials that he or she uses as instructional material. Each has his or her own style, preference, and experience from which to draw. However, as indicated from feedback received from the 2018 GridEd tech transfer workshop, several university professors indicated that they need photos, example case studies, and other educational materials for enhancing their course content. To this end, continued support for developing university curriculum is warranted.

There are two general philosophies for supporting continued course development, each with its own advantages and disadvantages as shown in Table 2. Both activities are needed to ensure credibility and usefulness of course materials. Developing source materials is best suited for collaborative or public funding, and should be made publicly available to ensure broad applicability and maximize usefulness. This type of activity should target leading experts in relevant fields of study that also have strengths in developing educational content, not just research. Support for individual universities to develop courses is better suited for regional collaboration or individual utility/university funding where utilities may have strong relationships and active recruiting pipelines.

Table 2. Activities which support university course development

Activity	Description	Advantages	Disadvantages
Develop Source Materials	Materials developed from leading experts to be shared and used by others	•Broad availability •Credibility	•Risk for not be used •Still needs additional support to be broadly used (training, funding to incorporate into flow of other courses, etc.).
Support Individual University Course Development	Funding for individual professors to develop their own course materials.	•High likelihood of materials will be used •Support individual professor preferences	•Risk that materials lack most up to date content •May not be broadly used if materials lack credibility

EPRI has an internal program called Technology Innovation (TI) that addresses issues with a forward look up to a decade in time. Often, universities are made a part of these efforts. The TI program is fiscally

supported by all EPRI members across all research sectors. EPRI's TI program is uniquely suited to provide broad collaborative funding to support the development of source university materials for undergraduate and particularly graduate level courses. The long-time horizon and broad industry applicability associated with the development and implementation of enhanced educational materials could be great addition to the EPRI TI program suite of activities.

The GridEd program also can be used to develop source materials and even support individual university's course development efforts. Funding university curriculum development at local universities through a collaborative model like GridEd may be more ideal than direct university funding as it could help ensure alignment with broader industry direction in terms of course content.

Student Engagement

There are two main target audiences to engage students which can be differentiated as "K-12 students" and "university students". Consistent engagement with both audiences is important for long-term sustainability of any workforce development program. The experience at GridEd has shown that each activity type is likely best-suited for different engagement and funding models.

K-12 Engagement

There are many public and private programs dedicated to increasing student engagement in science, technology, engineering, and mathematics (STEM) which is needed to grow the foundation of the future workforce pipeline. The power industry should tap into these programs and help provide content and "real world" examples of power and energy applications that help students engage at the local level. An emphasis is placed on engaging at the local level considering there is evidence of better employee retention from a local workforce. Successful models may include public funding for development of seed material in power and energy such as that accomplished by Georgia Tech for the Atlanta Public School District. Other models may include developing power systems games or general course materials that could be used by professionals in the power industry as a guest speaker in K-12 science classes.

University Student Engagement

Students in the university environment need a different type of engagement which is more specific to power engineering. Connectivity and support of existing student organizations such as IEEE PES student chapters is an easier path to success compared to developing new organizations or activities. Students have many distractions once they reach the independence of the university environment and have limited time to commit to new activities. GridEd survey results showed that it may be difficult to secure broad support for these new activities.

GridEd's experience has shown that supporting students to attend conferences through activities such as poster presentations is a great way to get students engaged in the broader industry. However, GridEd's sustainability survey results showed that it may be difficult to secure broad funding for this type of activity as utility's showed weak interest in funding it. Given the noticeable interest by student engagement in these activities, public funding or support from individual conferences may be needed.

As mentioned earlier, perhaps the most successful method of engaging university students is through design projects. These opportunities provide students with interesting and relevant topics, where they gain experience working in teams on real world problems, and engage with local employers. Providing some form of competitive structure around these design projects could help increase engagement

whether it is through some form of competitive bid for funding or post-funding competition with awards.

Business Model

GridEd has always pursued a business model strategy that would allow for standalone operation of a T&E program. During the GEARED project, an existing EPRI business model has been used to support the short course program and other project activities. This model, as described below, provides for forward funding which reduces cost recover risk and leveraging multi-funder arrangements to reduce per-unit course costs.

Multi-Funder, Forward-Funding Arrangements

An EPRI "multi-funder supplemental project" that is advertised through a "Supplemental Program Notice" (SPN). This form of funding instrument allows for funds to be collected in a forward manner. The availability of forward funding reduces risk of failure by avoiding by relying on gathering funding as activities rollout.

EPRI's supplemental business form is a collaborative agreement among a group of entities (during the GEARED/STEP period it was all electric utilities) that agree to share costs and risks on a project. All participants contribute monetarily on a prescriptive basis that typically discriminates by size of entity to allow smaller entities to get equal access to results and voting authority where they otherwise, due to budget, would be unable the participate at a full cost of a large enterprises. This process allows diversity in participants making it a richer experience.

Using a forward funding model also allows the costs to produce a short course to be separated from those of actual execution. The forward funding can be used to provide other services to those funders such as adding Affiliate universities, qualifying for discounts on short courses, obtaining prepaid seats, and hosting short courses. With significant leverage, on the order of 30 utilities involved as funders, other activities like university and student activities can be supported. GridEd has secured several utilities that have been very strong supporters. Our plan is to build our GridEd constituency around these champions for a sustainable program.

Although joining multi-funder supplemental projects can be done annually, typically the offerings are made as multi-year awards. Our objective is to pool multi-year funders to establish a base of working capital to develop long term program content and continuity. EPRI has been successful with this type of business structure for more than 30 years. There is confidence that such a structure can be made routine part of supporting the GridEd T&E program.

EPRI is also planning to pursue more traditional sources of university funding such as in the National Science Foundation (NSF) for curriculum development. The basis for our approach is to leverage electric utility funding to advance T&E in energy fields. This will include teaming with universities.

EPRI also has had some success with seeking General Foundation funding. These efforts will be directed along the lines of advancing university capability through grant applications – again leveraging core monies from electric utilities in the program.

Marketing Efforts

Any type of sustainable activity needs to include an effective marketing strategy to reach target audiences. Collaborative engagements require long lead times with extensive relationship building. However, other types of engagements, such as a professional short course program, can realize short term success using impactful marketing campaigns.

Brand Recognition

It took several years for GridEd and GEARED to get broad exposure for target audiences to recognize the GridEd brand and associate it with T&E. Still, today, after nearly five years of effort, the GridEd brand is not as strong as the EPRI brand. The move of EPRI into formal T&E with the development of EPRI U[6] will increase awareness of T&E activities due to the existing value of the EPRI brand – known worldwide for excellence in research for the electric power industry. Including GridEd training within the umbrella of EPRI U activities will broaden market exposure. However, separating GridEd – a specific multi-funder collaborative project within power delivery and utilization – will help reach specific target markets. When reaching new audiences, it is important to have easily-digestible content readily available. Single-page program fliers, a succinct PowerPoint slide, and a website with readily accessible information for inquiries are all important aspects of outreach.

Target Marketing

Targeted marketing efforts should leverage established relationships and existing engagements with audiences of interest.

Leverage Established Relationships – EPRI's Member and Technical Services (M&TS) team as well as its Strategic Account Executive (SAE) team have long standing relationships with EPRI's utility members. Introducing readily available T&E courses to target audiences through the M&TS and SAE teams will be an effective way at marketing to individuals within utilities, as is linking with those utilities that are empowered with budget authority. Further, EPRI research programs have established relationships with utilities in specific topical areas. Advertising available courses through applicable programmatic outreach where EPRI has established relationships with target audiences will increase exposure, awareness, and credibility of course offerings.

Leverage Existing Engagements – Existing conferences, symposia, and other collaborative engagements that physically bring together many people can be a great avenue to hold in-person courses. This minimizes travel time and can be an effective way at reaching audiences that are unware of course offerings or collaborative T&E activities. Therefore, connecting through assemblies of program offerings is both convenient and pertinent.

Metrics for Success

Excellence in performance is ensured through a well-constructed evaluation process with three area foci: 1) metrics, 2) formative assessment for continual improvement, and 3) summative assessment to determine success and impact.

[6] https://www.epri.com/#/epri-u?lang=en-US

Metrics

Metrics serve as benchmarks to evaluate the successful execution of project objectives. Assigning levels for each metric indicate "measures of success" for the project at reaching its objectives. "Threshold" markers indicate baseline levels needed to move ahead. If threshold is not achieved, this indicates the project needs to change direction. "Target" markers indicate expected achievements, while "Distinguished" markers indicate exceeding expectations. Experience from GridEd has led to the development of the following key performance indicators (metrics) across three activity areas.

Utility Advisory Engagement

Fiscal support and participation from utility advisors is a key metric for ongoing sustainability. GridEd has sustained a consistent advisory group of 20 utilities across the U.S. While this number has produced a successful program, there is still room to grow. By comparison, some of EPRI's largest research programs have more than 50 utility members. Engaging with collaborative advisory bodies is always a challenge. It is a-typical that only about 50% of the members in the advisory body attends any single webcast or in-person meeting. While GridEd did not formally survey its advisors to evaluate program satisfaction, metrics have been adapted from EPRI program advisory member satisfaction surveys.

Metric	Threshold	Target	Distinguished
# of utility advisors	15	20	30
Utility advisor satisfaction	85%	90%	95%
% of participation	35%	50%	75%

Professional Training Program

The professional short courses offered by GridEd have helped establish cost goals for a sustainable effort. Market prices for 1.5 – two-day short courses range from $1,500/person to $3,000/person. GridEd has an established, nominal price of $1,200/person or priced at $100/delivered-hr. While we do continue to get participation at this price, we receive clear messages from our advisory body that a lower price point is needed for broader participation. While the most cost-effective way to execute a short course is to place an instructor on site to teach many people simultaneously, experience has shown that having more than ~twenty-five (25) people in any given course significantly reduces engagement. While large cost-effective workshops may be sufficient for obtaining professional development hours, more engaging training is typically more expensive. The five years of GridEd experience has shown that a price point of $600/person ($50/delivered-hr.) may be achievable and sustainable subject to the following:

1. Registrations remain high (25 people = total revenue of $15,000),
2. Courses are taught more than ~5 times to recover development costs (which can be as high $20,000), and,
3. Variable costs remain low:
    a. Provision of room and food costs by a host site, booking instructor's travel well in advance, and instructor(s) labor costs of less than ~$250/hr., and
    b. Live-online offerings with no instructor travel and minimal meeting expenses.

Metric	Threshold	Target	Distinguished
Cost per short course	$25k	$20k	$15k
Avg. short course enrollment	10	15	20
Student satisfaction	85%	90%	95%

University Curriculum

Fiscal support for professors and their graduate students at our Partner universities to develop and deliver new or revised course materials has been one of the core activities of GridEd. The costs to develop a university course will vary greatly depending on several factors such as: 1) course content – all new to revised, 2) how much lab activity is involved, and 3) how much of the development that is delegated to graduate students. Estimating curriculum development costs under GridEd was difficult given the number of activities in each university subcontract and the fact that there is a range in quantity of course materials developed. Given this uncertainty, the following metrics have been devised to guide future course development costs.

The GridEd model did not provide a direct source of funding to Affiliate universities other than resources for travel costs to Tech Transfer workshops. Each Affiliate university had to cover its own manpower costs. Obtaining attendance from more than 30% of Affiliate universities at any tech transfer workshop was a challenge. The tech transfer workshops are a primary method of sharing curriculum developed by the collaborating universities.

Metric	Threshold	Target	Distinguished
Cost per NEW university course[7]	$80k	$55k	$45k
Avg. student enrollment (undergrad/grad)	10/5	20/10	25/15
% of Affiliate university participation	20%	40%	60%
Affiliate university satisfaction	85%	90%	95%

Performance Assessment Methods

A performance assessment process is needed to measure success and effectiveness of course delivery. Our plan is to measure both for continual improvement and for success and impact.

Formative Assessment Methods for Continual Improvement - Feedback gathered during courses, training events and workshops, with timely reports delivered to stakeholders, will help make improvements while these events are still in session. Representative results that are shared with those who provide the feedback ("closing the loop") will encourage future participation in the evaluation process. This practice has been demonstrated to improve learning, increase learner satisfaction, and increase participation.

Summative Assessment to Determine Success and Impact - A strategic, summative evaluation plan should be conducted to demonstrate the efficacy of all courses. Evaluation surveys should be collected at the end of each learning event with resulting outcomes shared at least quarterly with all stakeholders. Also, there needs to be balance in determining success. For example, using "hot topic" terminology may boost attendance but may reduce learning effectiveness and lead to poor course evaluations if courses are too broad or are targeted for a different audience than those who attend.

Risk Exposure for Sustainability

The principles of sustainability for a collaborative T&E program as portrayed in this report helps to reduce the risk for failure. Following these principles will help keep future T&E program risks low because they are based on several years of very strong participation from electric utilities in the GridEd program and enrollment in professional training courses. While garnering support and establishing

[7] Will significantly vary depending on course length, whether labs are involved, and how much existing material can be leveraged.

audience recognition for T&E activities was a struggle in the first several years of GridEd operation, steady campaigning has developed a strong electric utility support for such activities. Our short course enrollments have increased significantly as we have developed an understanding of the buying audience, and in turn, what the buyers have recognized about value in the offerings. It has been a mutual development. Electric utilities have bought R&D product from EPRI for years. However, they don't immediately recognize EPRI as a source for T&E products and services. Confidence is very high that the five-year GEARED/STEP program has built a constituency that can be extended and expanded.

EPRI does see significant barriers to successfully continuing university curriculum development at the same scale that was accomplished under the DOE GEARED/STEP effort. One of our key objectives has been enhancing the electric utility/university relationship. Through those efforts, EPRI will establish value for utilities to support future GridEd efforts through a multi-funder supplemental project where a strong subscription service will produce marginal revenues to leverage with entities like NSF, General Foundations, and internal EPRI programs like TI.

The largest risk area is student engagement. It is vital to connect with universities to maintain that steady student outreach. Finding revenue streams to support universities, and hence connect with students is the largest challenge. While continued funding of student design projects may be feasible, garnering support for student organizations and engagement at conferences may struggle. The IEEE has strong student chapters for power and they become a key linkage to reduce risks.

Adding Value through Additional Federal Support

While EPRI has organized efforts to operate a program independent of DOE, additional funding from DOE can absolutely enrich and enlarge the ongoing efforts to accelerate the adoption of renewable energy and other technologies by providing additional funding. There are several unique opportunities for the DOE to establish the principles that underpin the electric grid of the future and how it can be foundational for mass adoption of DER assets. By supporting efforts in this sustainability plan, DOE can:

- Stimulate national awareness on the electric grid requirements,
- Accelerate the T&E process of developing the next generation workforce for the future grid, and,
- Provide a foundation for universities to develop and educate the new electric workforce.

Federal funding will accelerate the process of training the next-generation workforce by producing large quantities of open-source training materials and software which is challenging to secure through private investment. Credentials and standards for professional specialists are needed for a competent and qualified workforce. Further they will facilitate recruitment of employees in critical roles and expand participation beyond existing efforts by guiding other universities, venders, and third parties to provide the necessary T&E.

DOE funding also will enable the university community to expand course offerings through the creative commons format. This will help educate undergraduates (the primary hiring demographic by electric utilities) on foundational concepts through a cross-listed course in engineering, computer science, and other disciplines. Supporting the GridEd Affiliate university model will help grow and strengthen bonds between universities and utilities.

The Electric Power Research Institute, Inc. (EPRI, www.epri.com) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, affordability, health, safety and the environment. EPRI members represent 90% of the electric utility revenue in the United States with international participation in 35 countries. EPRI's principal offices and laboratories are located in Palo Alto, Calif.; Charlotte, N.C.; Knoxville, Tenn.; and Lenox, Mass.

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