THE CHALLENGES AND OPPORTUNITIES TO MEET THE WORKFORCE DEMAND IN THE ELECTRIC POWER AND ENERGY PROFESSION

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ABSTRACT

There is a tremendous imbalance between engineering workforce demand and supply in the world in general, and in the US, in particular. The electric power and energy industry is no exception and the problem is beginning to reach crisis level. The primary objective of this paper is to review and describe some of the various proactive strategies being undertaken by various stakeholders to meet the workforce shortages. The paper will first summarize the dimensions of the problem: shortages of engineers, technicians and educators worldwide. Secondly, the paper will review successful programs that are being undertaken jointly by various stakeholders of this profession that will decide the future economic health of the global society. Two specific aggressive efforts undertaken by the stakeholders will be described in detail as examples of the serious attention given to the problem: a road map for purposeful future action topics that will include the details of the IEEE/PES/LRP strategies, and the MSU/SJSU/PG&E plans that will address the creation of an advanced degree. Other global initiatives are also briefly mentioned.

1. The Challenge:

Electric energy has not only become a basic necessity for human existence, but also has become the backbone for our economic development. The world has witnessed electric power systems becoming larger and more complex in the last sixty years due to the unprecedented population growth and higher standards of living demanded by society. The continuation of the technology explosion of the second half of the 20th century requires the availability of a diverse and highly capable technical workforce. Unfortunately, the education of engineers has not kept pace with the global demand. As a result there is a tremendous shortage of technical personnel all around the world. In the context of globalization this is a complex challenge and the cooperative efforts among stakeholders are required.

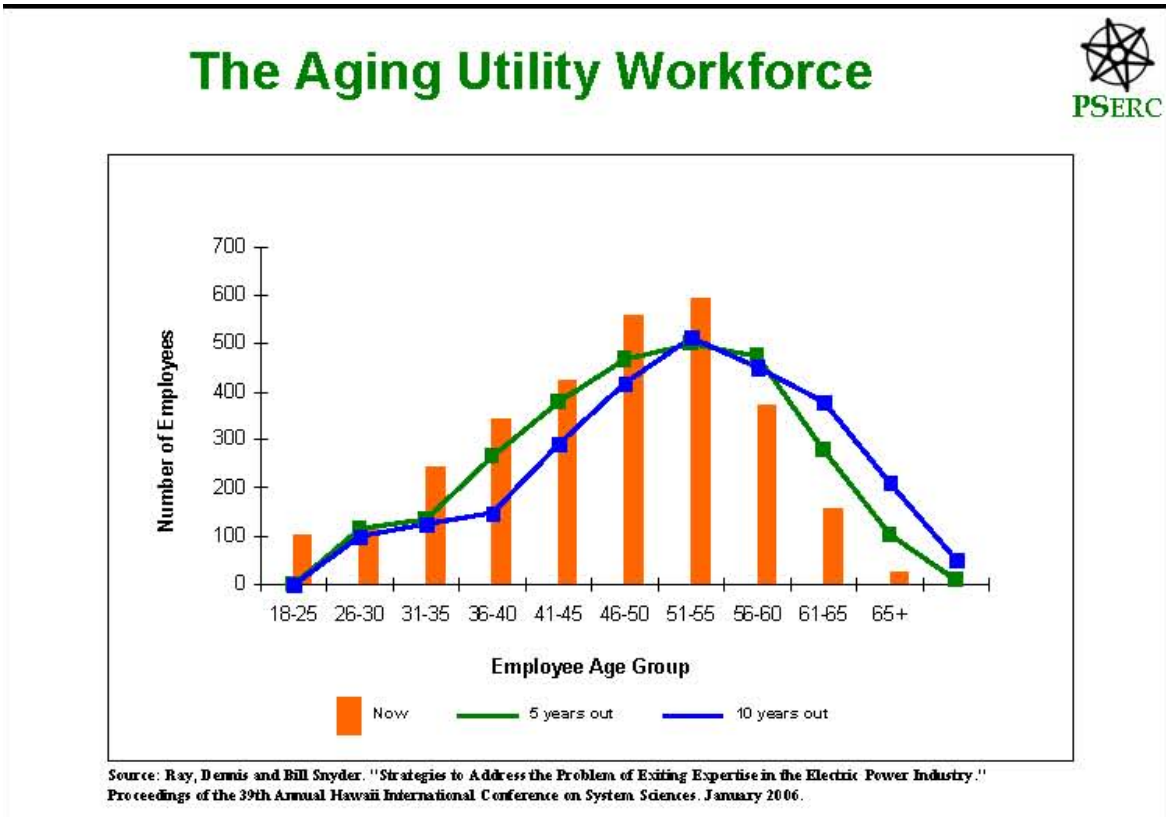
1.1 The Global Situation:

The shortage problem is real worldwide which can be exemplified by the following reports: Alberta will need thousands of energy workers in the next decade [1]. Australia and India will have significant shortage of qualified engineering faculty in the near future [2-3]. Similar trends are observed all over the world.

1.2 The North American Situation:

To illustrate the critical nature of this situation, President Bush in his recent speech on September 28, 2007, stressed the need for new engineering curriculum, skilled university staff, and a more focused partnership between power companies, manufacturing sectors, and the power industry professional to build a robust global economy.

The Workers are getting older in the U. S. By 2010, one in three U.S. workers will be age 50 or older as depicted in the figure below [4]. Utility executives estimate one half of the technical workforce will reach retirement age in 5 to 10 years. At 50 plus, utility craft workers have highest average age of any industry. The demand for workers is increasing. In 2015, with a 15% decline of the 35 to 44 age group, the demand increase is anticipated to be about 25%. The demand for U.S. electrical engineers in construction will be up from 150,000 today to 175,000 by 2010. On the flip side, the supply of workforce is decreasing. There is reduction in graduating engineers during the past 15 years. A similar reduction occurred for power engineering graduates [5].



Source: Ray, Dennis and Bill Snyder. "Strategies to Address the Problem of Exiting Expertise in the Electric Power Industry." Proceedings of the 39th Annual Hawaii International Conference on System Sciences. January 2006.

In addition, as quoted below, the U.S. Department of Energy (DOE) [6] and North American Electric Reliability Corp. (NERC) [7] identified the aging workforce as a critical challenge facing the electric power industry and the educational system that supports it. If not managed properly, the loss of experience and expertise will affect reliability, safety, productivity, innovation, and the capability to solve pressing issues, such as grid modernization and climate change.

"The aging of the American workforce has emerged as a critical issue facing American productivity in the 21st century. As the so-called "Baby Boomer Generation" reaches retirement eligibility, the impact will be felt across both the public and private sectors. These 78 million individuals born between 1946 and 1964 have accumulated a wealth of experience and knowledge, and represent 44% of America's workforce. For electric utilities, whose service quality and reliability depends on maintaining an adequate, knowledgeable workforce, managing the upcoming retirement transition is a particular challenge." [6].

"The reliability of the North American electric utility grid is dependent on the accumulated experience and technical expertise of those who design and operate the system. As the rapidly aging workforce leaves the industry over the next five to ten years, the challenge to the electric utility industry will be to fill this void…"[7]

The aging workforce is seen throughout the industry, such as management, skilled workers and engineers, and in the educational infrastructure; however, the electric power industry is not alone. It is a society-wide concern. The goal is to ensure there is an educated, skilled and energized workforce to meet the challenges of the 21st century by creating and sustaining an appropriate educational infrastructure supporting the development of engineers for the power industry.

1.3 The Main Contributions of the Paper:

Two significant efforts undertaken by stakeholders are described in this paper: (1) The IEEE Power Engineering Society (PES) as part of its Long-Range Planning (LRP) mission has undertaken a four-pronged approach that will alleviate the impending workforce shortages in the global scene, and (2) a joint effort undertaken by Mississippi State University (MSU), San Jose State University (SJSU) and Pacific Gas & Electric (PG&E) in creating an advanced degree for part-time industry students that does not require relocation or compromise full-time employment. The program takes advantage of distance learning and other collaborative tools. This allows the students to take classes and participate in the core curriculum. However, they have the ability to conduct research at their work place.

2. The Opportunities:

2. 1 IEEE/PES Initiatives

Moving beyond the DOE and NERC reports requires action to attract students into power careers and to build a sustainable educational infrastructure that can produce enough highly trained engineers into the future. The IEEE Power Engineering Society (PES) as part of its Long-Range Planning (LRP) mission has undertaken a four-pronged approach that will alleviate the impending workforce shortages in the global scene. The PES is working collaboratively with industry, government, and universities to define what those

next steps should be. In that regard, a number of initiatives, including image building, on-line career services customized to student needs, and collaborative efforts to create an action plan for technical workforce development have been launched.

2.1.1 Image Building:

Worldwide, the average age of PES members is approaching 50, about eight years older than the average age of IEEE members, so we need to actively recruit and retain new members. To attract crucial new talent to both the industry and PES, the visibility and image of power engineering and PES need to improve. In addition to increasing membership, other aspects of this strategic initiative include boosting the involvement of GOLD members, improving the public image of power engineering, and seeking collaborative efforts and opportunities to communicate the value of the power industry profession.

PES began addressing the Society's image by implementing on-line surveys to gain understanding and perspective for a branding campaign. On-line surveys were sent to IEEE PES members, non-members active in the power industry, and students planning to pursue careers in power. The responses and the rate of response for these three groups included:

- Members: 2708 responses (16%)
- Non-members: 1435 responses (1.1%)
- Students: 464 responses (11.4%)

The survey resulted from valued feedback which future Society initiative and direction will be derived. Fundamentally the themes that evolved from the survey response were for PES to:

- Assist students into employment; retain their membership
- Provide practical information and education
- Readily embrace emerging technologies
- Expand education offerings to including webinars
- Make offerings relevant worldwide
- Recruit members by asking them to join
- Support / involve students and GOLD members
- Enhanced on-line tools and web communications
- Emphasize "criticality to society" to build image

PES must move forward on these fronts while clarifying our purpose and mission in the emerging context of energy reliability and the environmental impact of growing energy use. To this end, the notion enhancing the PES and power engineering image with a Society name change to *Power & Energy Society* was tested. Respondents were generally in favor or indifferent with notable increased interest in Society participation from students and respondents from non-US countries. The PES Board has approved the name change. Efforts are underway for approval within IEEE and anticipated to be completed in 2008. Pending approval, the new Society name:

- Better reflects the Society's existing mission, scope, field of interest
- Is more relevant to current interests and aligns with global needs
- Aligns with the "*Power & Energy"* Magazine title
- Positions for increased interaction and external collaboration
- Improves external image
- Provides framework for embracing emerging technologies
- Maintains the IEEE PES acronym and identity
- Appeals to "Societal" interest of potential members

There are numerous other image building initiatives within the Society. Some of them include:

- Updating the web site to make it easier and more exciting to navigate
- Encouraging technical committees to keep web-sites current
- Providing tools for K-12 outreach on the web site (http://tinyurl.com/32ar3k and www.tryengineering.org)
- Providing links for mentoring (www.mentornet.net)
- Developing on-line tutorials
- Offering stand-alone, practical training that will be supported by Chapters
- Creating membership brochures and posters advocating the importance to "Get into Energy"
- Creating two additional vice president positions within the IEEE PES board that can focus on membership and new initiatives and outreach efforts

2. 1. 2 On-line Career Services:

In the United States, retirements of experienced engineers are estimated at 40% or so over the next 5 years. Other developed countries are experiencing similar trends. Meanwhile, the retention of new hires through mid-career engineers is a challenge since the industry may be losing 10-15% per year for non-retirement reasons. Many are concerned that the pipeline to replenish these experienced engineers is not as robust as needed given university power programs (faculty retiring, too, and new faculty are not being hired at the same rate) are declining as is student interest in science, technology, engineering and mathematics in general.

Better understanding of the challenges and the response options is needed and will require collaboration among industry, government and academia to provide a quality education for the next generation of power engineers. Meanwhile, a tangible action that has been taken is to create an IEEE PES on-line career service

- To help address emerging engineering workforce challenges
- As a service to students and their future employers
- To facilitate collaboration among industry, government and academia to provide a quality education for the next generation of power engineers

The web site is running at http://www.PES-Careers.org. It was developed in cooperation with Power Systems Engineering Research Center (http://www.PSERC.org). The initial

prototype targets students and potential employers in US and Canada to assist them in connecting with regards full-time, part-time and internship power engineering positions. Geographic expansion outside of the US and Canada will be evaluated after a trail period. The functions of the site include:

- Organization profiles for students
- Job openings
- On-line job applications (if desired)
- Student profiles search capability for needed career interests and skills
- Students search capability for geographic preferences
- Screen function based on identified criteria (e.g., GPA, degree, etc.)
- Mechanism to communicate with potential job candidates
- Vehicle to announce of web-based information sessions to students
- Shared calendar for tutorials, conferences and other Society events
- Ability to capture forecasted engineering need from employers which is seeded to inform discussions about how to meet the need for new power engineers

While it is free for employers to use this service, they are asked to encourage new power engineering employees to receive IEEE PES services by becoming regular members. All students need to do is provide a resume and profile with career interests, courses taken, skills, states/provinces where they will consider employment, and more. Faculty members are urged to encourage their students to use the service and to join IEEE as student members. Faculty can view employers and jobs (not student information) to understand market trends.

2.1.3 Action Plan:

IEEE PES is being proactive in response to the DOE and NERC reports by developing a recommended industry action plan that proposes possible next steps for the electric power industry, its regulators, and the supporting educational system in addressing the aging workforce challenge. The objectives of the proposed action plan are:

1. Analysis: Increase understanding of aging workforce challenges and facilitate planning of effective collaborative responses to those challenges.
2. Students: Increase the number of well-trained engineering graduates prepared to meet the need for the next generation of power engineers
3. Infrastructure: Create a sufficient and sustainable power engineering education system.

Since the workforce challenge is so diverse and multi-faceted, the breadth of the possible responses is quite large. Here are some possible responses [14]:

- Preparing youth for careers involving science, technology, engineering and math
- Getting more youth aware of and interested in power careers, providing tools and games that simulate the various aspects of running the business
- Building and sustaining the post-high school educational system
- Improving workforce planning, recruiting and management

- Redesigning jobs and the work environment to attract and retain the new workforce
- Retaining existing employees, particularly senior employees
- Including workforce issues in strategic and financial planning efforts
- Developing sensible and balanced outsourcing practices
- Facilitating more immigration and employment of immigrants
- Reorganizing to improve efficiency in use of suppliers in the production chain
- Rehiring the retirees
- Developing knowledge retention systems
- Fostering early career education programs that expand university education
- Incorporating automation as part of the new workplace
- Re-examining public policies to insure that they support workforce solutions

To make these responses efficient and effective, there is an on-going need for a good understanding of such things as [14]:

- Current employee age profile and retirement trends
- Historical industry trends in employment of engineers
- Business strategies and their effect on employment of engineers
- Public policies affecting employment of engineers and support of the education infrastructure
- Technology and policy drivers of the future need for engineers
- Retention rates in the power industry
- Factors influencing student interest in power career choices (such as compensation, image, challenge, contribution to solving societal problems, etc.)
- Trends in K-12 student interest in science, technology, engineering and math
- Trends in university student interest in engineering, electrical engineering, and power engineering
- Programs to stimulate interest in science, technology, engineering and math
- Domestic and international trends in engineering education
- Current faculty situation and retirement trends
- Characteristics of viable power programs
- Education system practices in curriculum development
- R&D funding of university research
- Educational system graduation capacity as compared to demand for those graduates (i.e., a gap analysis)

Information, collaboration and the consensus building is needed to successfully develop and action plan. To build understanding IEEE PES is working with NSF, PSERC and NERC to host a workshop to address the national challenge on the future power engineering workforce in November, 2007. Information from the workshop will be used to complete the action plan. The specific objectives of the workshop will be:

- To assess the current state of knowledge of the future demand for and supply of university-educated power engineers, thereby reducing the extent to which there

will be a gap between the need for new engineers and the ability of universities to meet that need.
- To develop an understanding of what it takes to sustain university power programs, and the role of research infrastructure in educating undergraduate and graduate power engineers

The workshop will bring together approximately 50 industry, government and academic leaders to frame the industry action plan to bring strong, concerted efforts to sustain university power programs which is necessary to create the talent required to ensure that the nation will continue to enjoy reliable and cost-effective energy in the 21 century. [13]

2. 2 University/Industry Joint initiatives:

2.2.1 The Education Dilemma:

Specialization at the undergraduate level is becoming less prevalent due to reduced number of course hours for a four-year degree (Bachelor's Degree) and lack of domain-specific faculty for undergraduate courses. Fields of specialty are becoming narrower (as in the medical field), yet the number of faculty with diverse expertise is not available widely at every university as needed for the electric power industry. The entire profession is at a cross roads on this issue. All the stakeholders, namely, industries and universities, are facing tremendous challenges. They recognize the opportunities that will address the challenges and opportunities to alleviate the problem in the next ten to fifteen years.

The technological breakthroughs in power system require the availability of diverse and highly skilled resources. With integrated world, there is an ever increasing need to have skilled field engineers / start-up personnel knowledgeable with a variety of aspects of commissioning. Within many power companies, the vendors have been partnering with the power company teams to provide specialized type of support (ex: in the SVC, STATCOM, etc.). This example also demonstrates the need for specialized personnel that would only be possible through advanced education. Other challenges in facing the power system reliability requirements of today are, life cycle planning (asset management), compliance, and cyber security (NERC compliances).

The education of engineers has not kept pace with the technological developments. The universities cover very few classes in power systems in undergraduate programs and practical experience in signal processing and advance feedback control systems are needed to bring the practical knowledge to the universities. Though it is a science that can be covered through sound basic principles, its actual implementation permits alternatives. The alternative that is selected depends upon the power engineer's experience and the traditions of the electric utility company. Indeed, the entire power engineering education curriculum is at a crossroads and needs complete rejuvenation. Experience to date has shown that students can be attracted to and retained in power programs if they are exposed early to the joys of creation through design, discovery through research and invention through hands-on experimentation [3]**.**

In many cases, advance degrees require "Residency" which would make it more difficult for individuals on full employment to take advantage of sharing the practical knowledge

while pursuing an advanced degree. Some of the methods that have been successfully implemented are collaboration of universities offering distance courses. However, this attempt has been primarily at the Bachelor and in some cases at the Master's Degree level. More roads need to be paved to bring the universities closer to the individuals committed to pursuing advance degrees. The universities also need to recognize that fostering flexible Ph. D. programs opens the opportunity for faculty of the future with practical experience that would not only be a great financial connection for research endowments but also the opportunity to make use of the practical skills that are brought about by the future faculty. For example, due to the lack of any one university having enough students to cost-effectively offer some elective courses in agricultural, some mid-western United States universities have developed some innovative solutions. They are creating sufficient class sizes for these courses by offering them to students at multiple universities using the best qualified faculty member within the consortium for the course. This overcomes the problem of having enough faculty in specialized areas to instruct students while still enabling each university to offer the degrees. Agreements have been made to handle the tuition and faculty loading.

2.2.2. The Undergraduate Case:

Specialization at the undergraduate level is becoming less prevalent due to reduced number of course hours for a four-year degree (Bachelor's Degree) and lack of domain-specific faculty for undergraduate courses. For example, several states have mandated the maximum number of hours for a Bachelor's degree. This was predicated by parents (voters/taxpayers) who were unhappy with the fact many students (children) were taking 5 years or longer to obtain a four-year degree. In today's environment it is typical for a B.S.E.E. degree to have between 120-128 credit hours with many of these hours dictated by state core course requirements. This reduction in the number of credit hours available for electives in a Bachelor's degree has exasperated the problem of the number of students graduating with a power engineering emphasis. Coupled with the reduction in credit hours is the problem that there are not as many universities offering a power systems emphasis due to a lack of qualified faculty. And, with the lack of research funding in the electric power industry over the last decade, many of the faculty in power systems are aging and there is not an assured source of research funds for continuity in developing a research program in power systems engineering for many new faculty. Fields of specialty are also becoming narrower (as in the medical field), yet the number of faculty with diverse expertise is not available widely at every university as needed for the electric power industry. The entire profession is at a cross roads on this issue. All the stakeholders, namely, industries and universities, are facing tremendous challenges. They recognize the opportunities that will address the solutions to alleviate the problem in the next ten to fifteen years. This section of the paper will describe some programs that are on-going that may serve as exemplars for others to follow to ensure the industry continues to have access to a continual flow of qualified new employees out of the university pipeline.

2.2.3 The Graduate Case and a Solution:

One of the major shortfalls in the university system is having adequate research facilities and faculty near end users to facilitate professional development and graduate degrees. One of the authors of this paper received their Master of Science in Electrical Engineering with a power engineering emphasis while working fulltime in Pittsburgh, PA. This of course, was during the heyday of Westinghouse in the Pittsburgh community. One of the challenges to bringing graduate power engineering education to working professionals is having a nearby university which can grant doctoral degrees. Recently, the Charles W. Davidson College of Engineering at San José State University (SJSU) and the James Worth of Bagley College of Engineering at Mississippi State University (MSU) signed an agreement to facilitate the attainment of doctoral degrees by students in the "Silicon Valley" area (e.g., Pacific Gas and Electric Company employees). As a member of the *state university system* in California, SJSU is not permitted to grant doctoral degrees. This new agreement provides the option that students enrolled in either university attend classes at the Masters level at either San José State University or Mississippi State University. SJSU students can then apply to the MSU doctoral program, stand for their comprehensive exams, take any required coursework, and conduct their Ph.D. research with support from the faculty of San José State University, as well as the faculty of Mississippi State University. The Major Professor will be a MSU faculty member in all cases, however, based on the student's selected research topic, the Dissertation Director can be a faculty member from either the SJSU or MSU engineering faculty. This agreement intends to take advantage of the relative strengths of the programs at both Universities (including power systems), and to offer an opportunity for students and faculty to pursue research and academic advancement in a flexible and quality-focused environment.

Other such joint initiatives are also underway in the U. S. A couple examples involve AEP working with Michigan Tech. and National Grid with a regional consortium of universities as opportunities to solve the workforce demand.

2. 3 University/Government Initiatives*:*

2.3.1 Power Systems Engineering Research Center (PSERC):

One of the older organizations addressing this issue is the Power Systems Engineering Research Center (PSERC) (www.pserc.org) that is composed of multiple universities and industry partners in the U. S. PSERC has the mission of both research and education. This is demonstrated in the following quote from their web page:

> Under the banner of PSERC, multiple U.S. universities are working collaboratively with industry to:
>
> - engage in forward-thinking about future scenarios for the industry and the challenges that might arise from them

- conduct research for innovative solutions to these challenges using multidisciplinary research expertise in a unique multi-campus work environment
- facilitate interchange of ideas and collaboration among academia, industry and government on critical industry issues
- educate the next generation of power industry engineers.

PSERC provides:

- efficient access to experienced university researchers in an array of relevant disciplines and geographically located across the U.S.
- leading-edge research in cost-effective projects jointly developed by industry leaders and university experts
- high quality education of future power engineers.

2.3.2 The Electric Ship Research and Development Consortium (ESRDC):

The Electric Ship Research and Development Consortium (ESRDC) (http://esrdc-workshops.org/index.html) is similar to PSERC, but is not focused on the power engineering needs of the utility industry, but on the new generation of electric ships. ESRDC brings together the combined programs and resources of universities for research on near to mid-term electric ship concepts. In addition, the consortium addresses the national shortage of electric power engineers by providing educational opportunities for students in state-of-the-art experimental facilities. The Office of Naval Research manages the ESRDC.

2.4 The U. K. Initiative:

The problem being addressed in this paper is a global issue and therefore, it would not be surprising to find activities similar to those described above elsewhere in the world. In fact, in the United Kingdom is the Power Academy (www.iee.org/poweracademy). This is another organization of university and industry partners focused on dealing with the shortfall in power engineering educated students. The Power Academy's mission is to "To ensure that there is a steady stream of good power engineering graduates to address the current shortage of electrical engineers and to meet the future manpower needs of the partner Electricity Network Companies." Note that there is not an emphasis on research or doctoral education in the Power Academy. The Power Academy is actually an Engineering Scholarship Fund for students that would like to study Electrical Engineering at one of the partner universities and will offer a student support and finance for the duration of their study (either Bachelor of Engineering or Master of Engineering degree).

3. Conclusions:

It is clear that a tremendous shortage of technical personnel exits all around the world. Meeting the increased demand is a challenge and cooperative efforts among all stakeholders are required. Two significant efforts undertaken by stakeholders in North America are described in this paper: (1) The IEEE Power Engineering Society (PES) as part of its Long-Range Planning (LRP) mission has undertaken a four-pronged approach that will alleviate the impending workforce shortages in the global scene, and (2) a joint effort undertaken by Mississippi State University (MSU), San Jose State University (SJSU) and Pacific Gas & Electric (PG&E) in creating an advanced degree for part-time industry students that does not require relocation or compromise full-time employment via distance learning and other collaborative tools.

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4. Biographies:

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