

**AC 2007-636: BRINGING POWER BACK TO THE POWER INDUSTRY
THROUGH INDUSTRY-ACADEMIA PARTNERSHIP**

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Bringing Power Back to the Power Industry through Industry-Academia Partnership

Introduction

Within the last months of 2006, two reports have been issued – one by the US Department of Energy (DOE), the other by the North American Electric Reliability Council (NERC) that warn about potential reliability problems of the North American electric power grid. For the first time, these reports address critical interrelations between reliability of the power grid and the engineering and technical expertise of the power industry workforce^{1,2}. It is clear that not only the physical infrastructure of the power grid is aging but so is its workforce. Lack of adequate supply of its replacement requires coordinated effort by both, the power industry and the academia to address this dual edged problem.

This paper concentrates on some of the steps that are being taken in Western New York.

Although it does not address long-term strategic issues, we feel that even small steps in the right direction could help solve both immediate and long-term needs of the industrial and academic sides of power industry.

Historical Perspective

The factors of economic production are capital and labor, materials and technology, management skills, and energy. Without the large amounts of energy consumed by the production system, the modern economy, and the high standard of living it provides, cannot be sustained. One of the major sources of energy for the economy is electricity. Therefore, its production, transmission and distribution constitute a critical infrastructure of a modern economy. Taking New York State as an example, energy delivered in the form of electricity accounts for approximately 24% of energy consumed, not counting the transportation sector³. Note that transportation sector accounts for 35% of total energy use. With electricity being the most versatile form of energy, developing the technical talent to address the issues of its generation, transmission and delivery are the focus of this paper.

Electric energy has been used since the 1890's when the world entered the Age of Electricity.

Since then the world has moved through a series of these ages:

1890's – The "Age of Electricity" begins with the lighting of the Chicago World's Fair in 1893, and completion of the first long distance transmission line moving hydro-electric power from the mighty Niagara Falls to Buffalo in November of 1896.

1930's – The "Industrial Age" begins with electricity, power tools, and automation in factories, at the end of the Depression. Industrial productivity, measured in terms of output per unit of labor, makes major gains during this period. This results in economic prosperity in the Western world, creating a large middle class of consumers.

1940's – The "Atomic age" begins after the Second World War, giving us the technology to build elaborate nuclear power plants for the production of cheap electricity during the fifties and sixties; necessary to keep the wheels of the economy turning.

1960's – The "Space Age" begins with the challenge to land man on the moon and bring him back safely. This sudden increase in research and development accelerates

developments in semi-conductor electronics from transistors and thyristors to integrated circuits and microprocessors.

1980's – The “Information Age” begins, fueled by advancements in microelectronics, computers, and the creation of the World Wide Web. This brought productivity gains to the white-collar workers of industry, and the “dotcom” revolution during the 1990's.

2000's – The “Energy Age” begins as we enter a new millennium and witness the growth and industrialization of new economies in China and India, soon to be followed by Africa. This growth coupled with people's desire for a better standard of living would create intense pressures on the world energy supply. We are facing a daunting challenge to minimize the amount of energy consumed per unit of function performed by every piece of equipment we use. The global nations and specifically the United States, the world leader in energy use, must pursue efficient use of energy and reduce stress on the environment from wasted heat and pollutants such as CO₂, SO₂, and NO_x.

We are entering the “Energy Age” at a time when the United States is not producing engineers and technicians at the rate of other countries⁴. Of particular concern, we are not producing engineers and technicians in the Energy field at a time when the use of energy in industry is experiencing significant growth and new challenges; and the current pool of energy engineers is rapidly approaching retirement stage.

What is happening in the Power Industry?

In its Executive Summary¹, the DOE report states: “Today, the power engineering education system in the United States is at a critical decision point. Without strong support for strategic research in power systems engineering and without qualified replacements for retiring faculty, the strength of our Nation's university-based power engineering programs will wane, and along with them the foundation for innovation in the power sector to meet our energy challenges in the 21st century.”

The energy industry will see a significant turnover in personnel at all levels: Engineers, Technologists, Technicians, and Craftsmen. This turnover follows an extended period of reduced hiring activity as utilities downsized their workforce because of economic pressures to reduce costs. The reduced demand for power engineering graduates in turn resulted in a reduced supply of graduates from technical and engineering schools and colleges. In addition, apprentice level programs, historically run internally at utilities, are also in decline as the need for the programs diminished and the cost to operate them increased. The result is an industry that has age stratified itself. The energy industry will require personnel with a higher level of technical training and education at a time when the educational institutions are not supporting this at the high school, two year, four year, and advanced degree college levels. This comes just as the current pool of skilled and talented workforce approaches retirement en mass.

One of the impacts on the power industry workforce, often overlooked, is deregulation. Being driven by market forces, it puts an important component of the system's lifecycle – education and training – on the side burner in the eyes of industry executives, government officials and general public. According to Reder² “market incentives often are short-term, whereas the time horizons for critical human infrastructure education and training are very long. Market dynamics will do what they will, but we need greater awareness of how markets are not just affecting investments in physical infrastructure but in education and research.”

What is happening in Academia?

The number of students entering engineering and technology fields is declining⁵. Most two-year associate programs are seeing a decline in enrollment across the country because parents and high school guidance instructors push high school students into four-year schools to major in either non-technical areas or innovative technology disciplines such as bioinformatics and nanotechnology.

In response to declining enrollment, most schools are not supporting their electric power programs. Four-year programs are diminishing; most power professors are at or near retirement age and few are being replaced. The number of course offerings are declining and obtaining a good foundation in the electric power field is becoming increasingly difficult. Graduate students that are interested in pursuing an advanced degree find that they have great difficulty obtaining necessary courses at their local university; and must take whatever is offered from the course catalog until they accumulate enough credits for graduation.

What are we doing to address this problem?

National Grid partnered with the University at Buffalo Electrical Engineering Department to develop a Master of Engineering Program to fill its education and professional development needs for their engineers. Engineers from other utilities were also invited to participate. The classes were selected and developed for a professional education program (similar to an MBA program) resulting in a Master of Engineering degree with an emphasis on obtaining application-oriented knowledge relevant to students' employment as well as work-related projects in cooperation with companies involved⁶. The first group of twenty engineers started the program in March of 2004, out of which 16 have graduated in February of 2007, and the other four are scheduled to graduate in June 2007.

It was decided that Internet based web casting to deliver the class to any student that had Internet access is a better option. A combination of Microsoft Live Meeting ® for visuals, and teleconferencing for audio, was selected for real-time interactive lectures. University at Buffalo has the latest equipment for setting up the phone link and to transmit streaming video of the class, to record the class, and to make it available for digital download for later viewing at course web site.. Videotaping the class and making it available for download the next day allows students, all working full time, to access the class at convenient time when they are unable to attend interactive sessions or participate "on line".

This results in multiple options for taking the class:

1. Students are able to come to UB and take the class in person
2. Students are able to take the class from anywhere with telephone service and Internet access. Some attended class from their office; others with high-speed internet access took the class from their home. If traveling, a student can even attend the class from a hotel room.
3. Students that could not take a class because of a time conflict are able to download the class the next day (200 to 300 MB video file) and watch the lesson at their convenience.

Over the course of the program, few enhancements to the classes were tested and implemented:

1. Reaching out to guest speakers during some courses to get industry experts to present on different topics. Two speakers for FACTS technology and one for digital relays presented to the class. One of the speakers came to the campus to deliver his message, the other two presented from their offices using the Web cast and their telephone.
2. An instructor from outside UB faculty was invited to present a course on Relay Protection. This was the first attempt to pool instructor talent from other colleges and universities to present a course and it went very well. It also allowed the inclusion of a broader selection of topic material.
3. A guest speaker from Villanova University was invited to give two lectures on Solar Energy to the class, which allowed sharing his broad research and teaching expertise in this area.

Due to the success of these methods, steps like these would be continued in the future.

List of courses in Masters of Engineering program

EE 582 Z Power Systems Engineering I.

Review of fundamentals of three-phase power systems, power circuit analysis, characterization and modeling of power system components, such as transformers and transmission lines, for study of power flow and system operation with extension to advanced power system components. This course, although it seem like a basic undergraduate level course, was selected because number of students did not have prior power engineering education.

EE 587 Z Special Topics in Electrical Power Distribution.

System planning and design, surge protection, system protection, system power factor, power system pollution, and system interfaces.

EE 583 Z Power Systems Engineering II.

Investigate transmission line characteristics of aerial and underground lines including development of their symmetrical component sequence impedances. Steady-state performance of systems including methods of network solutions. The course was selected for the same reasons as EE 582 Z.

EAS 521 Z Principles of Engineering Management I.

Basic engineering management functions of planning, organizing, leading, and controlling as applied to project, team, knowledge, group/department and global settings, including discussion of the strengths and weaknesses of engineers as managers, and the engineering management challenges in the new economy. Emphasis is placed on the integration of engineering technologies and management. Students are to understand/practice the basic functions in engineering management, the roles and perspectives of engineering managers, and selected skills required to become effective engineering managers in the new millennium.

EE 540 Y Static Power Conversion for Power Systems.

Principles of operation of static compensators and basic configurations; series, shunt and shunt-series; flexible ac transmission systems (FACTS); line and self commutated controllers,

configurations and control aspects; applications to power distribution systems; performance evaluation and practical applications of static compensators.

EE 641Y Special Topics in Power System Protection.

Principles of relay techniques (classical and solid state), current and potential transformers and their application in relaying technique, over-current, differential, impedance, frequency, overvoltage and undervoltage relays, relay protection of overhead and underground power lines, generators, transformers, motors, and buses.

EAS 606 Distributed Generation.

Wind energy systems; PV-Solar systems; fuel cell systems; emerging new technologies in power conversion; grid interface and power system protection.

EE 598 Contemporary Issues in Electrical Power Industry.

Energy management issues – supply/demand/conservation; electrical power system quality and reliability; industry restructuring – pains and gains; electrical power generation and global warming; cost effectiveness issues.

This program provides a venue for new engineers, without a strong power background, to take power-oriented programs. It gives existing engineers an opportunity to continue their education on a Masters Degree level and in the process gain knowledge in current technologies. It also provides a method to obtain Professional Development Hours required to sustain their Professional Engineers license. Classes are tailored to adult learners, one class per week, from 3:30 PM to 7:15 PM using a 10-week Quarter system instead of the usual 15-week Semester system. Each course is rated at 3 semester credit hours (although the scheduling is done using quarter system, the course content and contact hours are based on semester system). It totals 30 credit hours (8 courses of 3 credit hours and a project of 6 credit hours).

Improvements to the Current Program

After the initial program offering, which began in March 2004 and will matriculate in the fall of 2006, possible improvements were considered. Based on students' feedback, more management classes are considered for addition to the program.

EAS 522 Principles of Engineering Management II.

This course covers the basics in engineering economics, managerial accounting, financial management and marketing management in order to prepare future engineering managers to fulfill these corporate functions. To further broaden students' perspectives, discussions on web-enabled engineering applications, globalization, and the impact of emerging market forces are introduced.

CIE 593 Project Management.

Life cycle planning of projects; project delivery strategies, contract types; preconstruction and mobilization; bid packaging; value engineering; use of scheduling techniques; management of general conditions; quality control; risk management; safety on job site; work site coordination; public and labor relations; project acceptance and closeout.

These additions are consistent with recent discussions on adding technology management aspect to engineering education⁷.

Programs for technicians and apprentices

National Grid and other utilities and generation companies are seeing a shortage of qualified technicians and crafts persons that may be more dire than the shortage of qualified engineers. In particular, the company experiences a shortage of line mechanics, relay and instrument and control technicians.

Taking a cue from various community college programs around the nation, National Grid is partnering with local two-year community college to develop a one-year certificate program directed at line workers with an emphasis on distribution systems construction. National Grid plans to provide instructors, expertise, material and equipment to support the program and insure its success.

This one-year certificate program is appended to a portion of the college's existing two-year technology program and has two special classes directed at line work. Students obtaining the certificate can seek employment as a line mechanic at a sponsoring utility and have the option of continuing on to complete a two-year associates degree at night. They also can stay on full time, finish the Associate degree, and seek technical employment upon graduation. Graduates of the Associate program can then continue to pursue a Bachelors level degree at Buffalo State College or University at Buffalo.

Power engineering education consortium

Having a major research university (University at Buffalo), a large comprehensive 4-year college with Engineering Technology program (Buffalo State College), a community college (Erie Community College), and traditions reach utility company (National Grid) within less than 30-minutes driving distance from each other, just calls for better and more coordination in their efforts to improve power engineering education. It is time for creation of Power Engineering Education Consortium. Advantages of such close cooperation are:

1. Mutual use of facilities (laboratory and others) for more efficient allocation of funds for equipment.
2. Coordination of curriculum development at different levels, identification of talented students for possible recruitment by educational and industrial partners.
3. Cooperation on undergraduate and graduate research, both basic and applied.
4. International cooperation with partnering institutions.

It is obvious that utilizing combined resources would allow addressing industry and academia needs more efficiently, both in terms of educating workforce and research and development efforts.

Conclusions

It is not enough to complain about the lack of technical workers. Energy companies and universities must take an active role to insure that an adequate supply exists.

Some suggestions are:

1. Become actively involved with local universities and colleges that offer technical programs.
2. Actively recruit and hire their graduates.
3. Use those recent hires to identify the high potential future hires from their program.
4. Encourage professional development and graduate level programs for engineering as well as technical areas.
5. Encourage and reward employees for becoming involved with the education system at all levels: technical high schools, community colleges, four year colleges, and graduate level.
6. Encourage the colleges to offer distance learning programs and courses via the Internet.
7. Support programs with research dollars, scholarships, internships, and aid to education programs.
8. Market forces under new power industry structure are not adequate to address this problem. Therefore, a three way partnership of industry-academia-government is needed. Government resources are needed as a catalyst to support development of industry-university programs and laboratories for hands-on training and research.

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