AC 2008-487: POWER ENGINEERING TECHNOLOGY: A NEW PROGRAM TARGETED AT THE NUCLEAR POWER INDUSTRY

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Power Engineering Technology: A New Program Targeted at the Nuclear Power Industry

Abstract

Recent studies indicate that over the next five years, there will be significant increases in the demand for utility workers. These studies also show that the present supply of these workers will not keep pace with this anticipated growth. This is especially true in the nuclear power industry, where the aging workforce and expected increase in the number of operational nuclear power plants are early indicators of a severe shortage of skilled utility workers. In Texas alone, NRG (South Texas Power Nuclear Operating Company), Luminant, and Exelon have all announced their intentions to license and build six new nuclear power plants. These plants will require approximately two thousand qualified personnel to operate and maintain them. Traditionally, the nuclear power industry has relied on a strong nuclear navy and nuclear construction work force to supply their human resource needs. However, these resources have dwindled leaving the nuclear power industry looking for new sources to fill their staffing requirements. It is in this context that engineers from the South Texas Project Nuclear Power Plant approached the Engineering Technology and Nuclear Engineering Departments at Texas A&M University in April 2007 with a proposal to create a four-year Power Engineering Technology degree. After four months of effort, a proposal was submitted to the Texas Workforce Commission for the resources necessary to fund this and other related initiatives.

This proposal has been funded and work on the new Power Engineering Technology program has begun. As a starting point, a faculty member spent the Summer of 2007 onsite at the South Texas Project Nuclear Plant to learn about their workforce needs. Using this knowledge, a new curriculum is being designed that includes a strong emphasis in three technical areas:

- Electronic Engineering Technology, with a focus in the areas of power, instrumentation, and control.
- Mechanical Engineering Technology, with a focus in the areas of materials, thermal systems, and mechanics.
- Nuclear Engineering, with focus in nuclear reactor physics/operation and radiological safety.

This paper will present the new Power Engineering Technology curriculum, progress to date, ongoing academia/industry interactions, and success stories that have resulted from this new program.

Introduction

It has been recognized that the United States' power requirements are rapidly approaching its generation capacity[1] and the need for new generation capacity and power infrastructure has come to the forefront of issues to be addressed by the power industry. One sector of this industry that has the potential for rapid growth is nuclear power generation ad public awareness of global warming and the potential impact of greenhouse gases have limited the choices of generation methods[1]. Not only does nuclear power have no carbon costs, but its monetary costs are well aligned with current generation alternatives[2]. The results of a Department of Energy sponsored study by the University of Chicago in 2004 as shown in Table 1 estimated that the cost of nuclear

power for new plants built over the next decade was approximately 4.4 cents/kWh, comparable with both coal and gas power generation costs.

Table 1 – Cost comparison of power generation alternatives[2]

Generation Method	Cost (cents/kWh)
Coal	3.5-4.1
Nuclear	4.2-4.6
Gas	5.5-7.0

Due to this potential for growth, the Nuclear Regulatory Commission (NRC) is currently expecting twenty-one applications for new nuclear power plants and thirty-two new units across the United States through 2009. In Texas alone, NRG Company has applied for two units in 2007 and it is expected that Amarillo Power, Luminant, and Exelon will file for six more units in 2008[3]. The build-out and maintenance of this new capacity will create the need for over two thousand qualified employees in the near future.

Equally as important as the expansion of the nuclear power industry, the power industry as a whole is expecting a shortage of workers over the next decade. Due to retirement and the move of engineers and engineering technologists from the power industry into other areas, as much as thirty percent of the technical workforce could need to be replaced over the next five years[4]. This problem has been exacerbated by the decline of power-focused technology degrees and faculty. With the exception of a few programs in the State of Texas such as the University of North Texas's Nuclear Power Engineering Technology[6] and the University of Houston's Power Engineering Technology[7], there is little focus on delivering a robust education in power engineering technology and committed to fostering a renewed interest in careers related to the power industry.

With this in mind, the South Texas Project Nuclear Operating Company (STPNOC) created a consortium of Texas-based schools to address their immediate, short term, and long term workforce needs. In an effort to respond to these needs, Texas A&M University has created the Nuclear Power Institute and through collaboration with several community/junior college partners, new programs and curricula are being developed as an early response to the anticipated workforce shortage. Two year degrees are being put in place to educate technicians and maintenance workers. A Nuclear Power Certificate is being developed on Texas A&M University's main campus to augment the education of the typical engineering undergraduate. Finally, as an integral part of this initiative, the Department of Engineering Technology and Industrial Distribution (ETID) has created a new Power Engineering Technology Program. This program is being designed to respond not only to the STPNOC's immediate need, but also to expected needs of the regional, state, and national power industry in general. This paper will present the new Power Engineering Technology (PET) curriculum, progress to date, ongoing academia/industry interactions, and success stories that have resulted from this new program thus far.

New Power Engineering Technology Curriculum

As a result of ongoing talks with the Department of Nuclear Engineering concerning an anticipated workforce shortage, STPNOC approached the Department of Engineering Technology and Industrial Distribution in April 2007 about the creation of a new program. Their

need was for a multidisciplinary program that could supply future maintenance and operation engineers. Their choice of working with Texas A&M was based on STPNOC's previous success with engineering technology graduates, the proximity of a major university to their facilities, and the department's mix of electrical and mechanical disciplines. At the same time, the Electronics Engineering Technology (EET) program had already been considering an emphasis in power as a response to increasing requests from the power companies such as American Electric Power and Oncor for graduates. Thus, the department chose to respond very quickly to this new request. In order to help STPNOC prepare a proposal to solicit funding for their initiatives, the department quickly created the draft curriculum in Table 2.

Table 2 – New Power Engineering Technology Curriculum

FRESHMAN FALL		
CHEM 107	General Chemistry	4
ENGL 104	Composition	3
MATH 151	Calculus I	4
HIST I	History	3
KINE 198	Health	1
Total Hours		15

FRESHMAN SPRING		
MATH 152	Calculus II	4
PHYS 218	Physics I	4
HIST II	History II	3
GOVT I	Government I	3
KINE 199	PE	1
Total Hours		15

SOPHOMORE FALL		
ENTC 210	Circuits I	4
ENTC 219	Digital Electronics	4
ENTC 207	Materials	3
PHYS 208	Physics II	4
STAT 211	Statistics	3
Total Hours		18

SOPHOMORE SPRING		
ENTC 211	Power Systems	4
ENTC 349	Microcontrollers	4
ENTC 303	Fluid Mechanics	4
ENTC 275	Mechanics	4
Total Hours		16

JUNIOR FALL		
ENTC 350	Electronics	4
NUEN xxx	Plant Systems and Ops	3
ENTC 370	Thermodynamics	4
ENTC 376	Strength of Materials	4
ENGR 482	Eng. Ethics	3
Total Hours		18

JUNIOR SPRING		
ENGL 210	Tech Writing	3
ENTC 359	Instrumentation	4
ENTC 402	Inspection Methods	3
NUEN xxx	Reactor Theory	3
ENTC 371	Thermal Systems	3
Total Hours		16

SENIOR FALL		
ENTC 419	Project Management	3
NUEN xxx	PRA/Nuclear Safety	3
COM 203	Speech	3
GOVT II	Government II	3
INEN 302	Eng. Economy	2
ENDG xxx	Technical Drawings	2
Total Hours		16

SENIOR SPRING		
ENTC 420	Senior Project	3
ENTC 462	Control Systems	4
NUEN xxx	Reactor Experiments	3
Soci/ICD	Social Science	3
VPA/ICD	Visual/Perf Arts	3
Total Hours		16

COLOR CODE

General Technical Courses

Electrical, Electronics, I&C

Mechanical, Thermal, Materials

Nuclear Engineering (Tech Electives)

Core Curriculum

With the department having two very strong programs in the electronics and the mechanical/manufacturing areas, it was a straightforward process to create a well-rounded interdisciplinary curriculum. STP indicated that future engineers and technologists needed a background in several topic areas including:

- Electronics
- Power Systems and Rotating
- Digital Instrumentation
- Process Control Systems
- Nuclear Power Generation Topics
- Materials
- Fluid Mechanics
- Thermodynamics and Thermal Systems
- System Design and Test

Based on these needs, current courses from the Electronics and Mechanical/Manufacturing Programs were chosen for the new program. By using existing courses to the extent possible, the department was able to control the cost associated with creating a new program. Through this selection process, most of the requested topics were covered with the exception of Power Systems, Thermal Systems and Nuclear Power Topics. To address these missing elements, the new curriculum proposed that:

- the circuits sequence be modified to include power,
- a new thermal systems course be added, the inspection methods class be modified to include power generation plant topics,
- four technical electives with a nuclear power focus be added,
- and the capstone design sequence feature projects related to power generation, transmission and distribution.

In addition, the courses would be modified to include relevant topics and projects as needed. For example, it was proposed that the instrumentation course, traditionally a sensor and signal conditioning course, include topics on distributed digital instrumentation and a project related to the instrumentation of a continuous process. The technical electives that were added were left general so that other focus areas could be addressed in the future, if necessary. The final draft curriculum aligned well with STPNOC's requests, while retaining the ability to be ABET accredited and generally accepted by others in the power industry.

Current Progress

Identifying Customer Needs

As a first step in creating this new program, the department has participated in several meetings with STPNOC over the past eight months, both on the campus and at their facilities. To this end, specific faculty members were targeted to participate and act as leaders within the department; Dr. Wei Zhan to focus on electrical/power/instrumentation curriculum, Dr. Jorge Alvarado to focus on mechanical/thermal curriculum, Dr. Joseph Morgan to manage the capstone design sequence, and Dr. Jay Porter to manage the new program creation process and the incoming students. The primary goal of these meetings was to identify the customer's needs and develop a short term plan for successfully creating a new program. Multiple meetings focused on the educational topics relevant to a power plant engineer. It was quickly determined that the most efficient way to transfer the essential knowledge from STPNOC was to embed a faculty member on site for a summer and have him work directly with plant engineers. Through this process, information could be culled and fed into the curriculum development process.

Summer Faculty Fellowship

The summer faculty fellowship was offered at STPNOC for Summer 2007 and Dr. Wei Zhan from the EET Program worked on site for twelve weeks. The faculty member was imbedded in the instrumentation and control group to learn the basics of nuclear power generation and to work on the specific research topic of assessing the communication protocols for Distributed Control System (DCS) and field devices to be used in the new nuclear power plants.

The summer faculty fellowship turned out to be a very successful collaboration between academia and nuclear power industry. It allowed the faculty member to learn first hand what knowledge in electrical circuit, instrumentation and control is needed by the nuclear power industry. The research project was successfully completed and a technical report was generated to provide recommendations for the communication protocols for the DCS and field devices used in the new nuclear power plants.

As a result of the summer faculty fellowship, Dr. Zhan made several changes to the proposed curriculum including modification of two EET courses. First, material on motors and power generation with nuclear power plant should be added to the circuit analysis sequence. Second, process control and Fieldbus material should be introduced to the students in the instrumentation course. Also, the new Power Engineering Technology Program and STPNOC should work together on potential senior design projects, summer/spring student internship, research laboratory development, and research topics related to nuclear power generation.

Funding Sources

As with the development of any major initiative, funding is necessary to support items such as faculty and staff time. In April, STPNOC committed to supporting the onsite meetings necessary for continued discussions with Texas A&M and the costs of preparing a proposal for long-term support of a regional nuclear power initiative. To this end, they funded two summer faculty fellowships including the fellowship mentioned previously for Dr. Zhan.

The result of this initial work was a $2M proposal to the Texas Workforce Commission (TWC) to support short and long-term efforts to grow the nuclear power workforce in the State. The proposal included support for a Nuclear Power Institute based at Texas A&M that could focus efforts across the State, support for two year schools to educate technicians and maintenance personnel, support for a certificate program in Nuclear Power targeted at engineering students, and finally, $200k in support of the new Power Engineering Technology Program. This proposal was submitted in August of 2007 and funding was announced in November. With this in place, efforts in curriculum development and student recruiting have begun.

Course Development

One of the topic areas identified during Dr. Zhan's faculty fellowship was the need for coursework in power generation, power systems, and rotating machines. Currently the ENTC 210, Circuits I and ENTC 211, Circuits II course sequence are focused on DC circuit analysis and AC circuit analysis respectively. These courses are currently being modified to move all of the circuit analysis material into the first course and then use the second course to introduce students to three phase power, power generation and transmission systems, and rotating machines. Even with this change, the second circuits course will still fulfill its original goal of ensuring that students can apply phasors to real world problems.

Also underway is the modification of ENTC 359, Electronic Interfacing. The original course focused on teaching students about sensors, signal conditioning, and computer/microcontroller interfacing. The course also had a six week project where students worked in teams to develop and complete "instrument" for a designated application by choosing appropriate sensors, implementing the necessary signal conditioning for each sensor, and interfacing the signal to a LabVIEW based system for signal processing and display. To complement the Power Engineering Technology curriculum, this project will now focus on a continuous process control system. The project will also entail the added element of using a microcontroller to interface their sensor to a standard instrumentation bus architecture such as Foundation Fieldbus. As a class, they will design a system to monitor and control the specified process.

Next, the leadership in ETID is currently working with the Department of Nuclear Engineering and the University of North Texas' Nuclear Power Engineering Technology Program to find appropriate technical electives. These courses will be offered to the new PET students either on campus or via the web. Also, discussions with STPNOC are still being held to ensure that topics important to their industry such as project management, troubleshooting skills, and root cause analysis are addressed adequately throughout the curriculum.

Recruiting

Finally, recruiting for the first Power Engineering Technology class has begun. A cap of ten students has been placed on the first class to minimize impact on the other programs. Several avenues for recruiting are being pursued including:

- High school and Junior College Recruiting – In April 2007, ETID faculty participated in the Bay City Career Fair to introduce the new program to graduating seniors. In addition, faculty members are working with regional junior colleges to develop 2+2 agreements. Also, the Department of Nuclear Engineering has an aggressive recruiting program and has volunteered to help promote Power Engineering Technology at their functions.
- Internal Recruiting – Faculty members are presenting the new PET program to all incoming freshman engineering students twice a year through the entry-level engineering courses across the College.

Though recruiting just started this year, as of January 15th two students have already enrolled in Power Engineering Technology and six additional students are currently considering the program.

Future Work

Student Internship Program

To augment student learning, the EET program has a long history of promoting student internships. Most students in the program graduate having completed at least one internship with a company in the electronics sector. These internships not only provide valuable real world experience, but often result in job offers at graduation. Similarly, the Power Engineering Technology program will promote summer internships with relevant companies. STPNOC is one obvious employer, but internships in other areas of the power industry would be equally beneficial to students. With the program officially starting in the Fall of 2008, the faculty will work over the summer to find internship prospects that start in the Summer of 2009.

Onsite Summer Course

Another initiative that is being pursued is the development of a summer course that would be delivered onsite at STPNOC. This course would be offered jointly by ETID and the Department of Nuclear Engineering and would last two weeks. The format of the course would consist of morning lectures by faculty and STPNOC employees that would introduce the basics of nuclear power plants and their operating principles. In the afternoon, the students would shadow workers to learn about the different functions within the facility. It is anticipated that this course would by offered to both engineering and engineering technology students, and would draw prospective students in either the certificate program or the Power Engineering Technology Program. It will be offered for the first time either in Summer 2008 or 2009.

Identifying Additional Partners

While the new Power Engineering Technology Program originated by focusing on the needs of STPNOC, it must become a resource to other companies in the power sector in order to grow and survive. The Summer 2008 will be used to recruit new industry partners. Luminant, Amarillo Power, and Exelon are obvious potential partners based on their intention to file applications for new nuclear units this year. Second, several companies from the power transmission and distribution industry have approached ETID in the past two years to look for recruits including Oncor and American Electric Power.

Conclusions

As of today, the development of new Power Engineering Technology at Texas A&M University is funded by the Texas Workforce Commission and has begun. A draft curriculum has been created that leverages existing courses in engineering technology while addressing new topics through course development and technical electives. The program has strived to develop an interdisciplinary flavor to ensure that students receive a well-rounded education.

Currently, the required new courses are being developed and the new curriculum will be in place by the Fall of 2008. Recruiting for the program has begun with a target class size of ten students. Of these ten, two new students have already committed to the new program. Future work includes formalizing the new program, finding long term funding sources to support the program, developing relationships with other power generation, transmission and distribution companies, and creating new laboratory facilities in the areas of power, process control, and thermal systems.

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