WISE
Washington Internships for Students of Engineering

Help Wanted:
The Power Engineering Pipeline and its Role in the American Nuclear Industry

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Executive Summary

The search for alternative, environmentally conscious fuel sources has caused nuclear power to take center stage as an option worthy of serious consideration. As a source of safe, cost-effective electricity with low carbon emissions, nuclear power has caught the recent attention of engineers and policymakers alike. Republican presidential nominee John McCain has promised the American people that, if elected, he will set the U.S. on the course of 45 new nuclear power plants by 2030.

As the Nuclear Regulatory Commission receives applications for new nuclear plants and the expansion of nuclear power gains public and political support, the existing weaknesses of the American nuclear industry must be considered. Among others, primary concerns for an aging workforce, an aging national infrastructure, and a weakened student pipeline threaten the possibility of a "nuclear renaissance." Nearly half of the existing nuclear workforce is expected to retire in the next decade, requiring replacement from new engineers and technicians. Yet, for every worker that retires, a potential mentor is lost. In addition to an aging workforce, numerous existing nuclear power plants are over 30 years old, and the national power infrastructure is, arguably, not ready for new power plants. However, the issue of greatest concern is a weakened power engineering student pipeline. Student enrollments continue to lag, as power engineering faculty have decreased or disappeared from most American universities.

Solving each of these issues requires the efforts of the government, universities, and the nuclear industry. The nuclear industry must establish workforce recruitment programs and support local schools through scholarships, internships, and mentor programs. American universities must make a conscious effort to recruit engineering faculty with power engineering experience and interests, and accordingly develop power engineering electives. The government, first and foremost, must add this issue to the America Competes Act, and begin to give serious thought to developing solutions. This includes providing tax incentives to nuclear plants with active workforce programs, providing increased grant opportunities for power engineering faculty members, and also encouraging the improvement of the nation's STEM education.

Foreward

About the Author

Brooke Buikema is a fourth-year undergraduate student at Calvin College in Grand Rapids, Michigan. She will graduate in 2009 with a Bachelor of Science in Engineering with a chemical concentration. Brooke's interest in nuclear engineering began in the summer of 2007, during an internship at Donald C. Cook Nuclear Plant, located in Bridgman, Michigan. She is a student member of the American Nuclear Society and U.S. Women in Nuclear, and plans to pursue a career in the nuclear industry after graduation.

About WISE

The Washington Internships for Students of Engineering (WISE) program was founded in 1980. This collaborative effort among several engineering societies has become one of the premier Washington internship programs, rated as one of the top 100 internship opportunities in the country. Its goal is to groom future leaders in the engineering profession who are aware of and can contribute to the important intersections of technology and public policy. This multi-society program is supported by the American Association of Engineering Societies. Please see http://www.wise-intern.org for more information.

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1.0 Introduction

There is no question as to whether or not energy is a major concern in the United States today. Newspaper and television headlines are continually dedicated to the growing need for independence from foreign oil suppliers. As a nation, we have begun to search for and further develop alternative energy sources that are environmentally friendly and economic. However, industry experts have also begun to turn their attention to what is being called "the perfect storm" of issues arising in the American power industry—an aging infrastructure that is nearing its capacity, an aging workforce, and, most importantly, a weakened student pipeline[1].

This paper will discuss each of the primary issues concerning the future of power engineering, and the combined overall impact they may have on the nation's economy. While the current scope of alternative energy options also includes solar, wind, and hydro sources, further discussion within this paper will focus primarily on the role and importance of power engineers within the American nuclear power industry. Small steps have been taken by the nuclear power industry to improve the power engineering student pipeline, but these efforts must be acknowledged, enhanced, and supported on a national level if measurable progress is to be made in the immediate future. The recommendations to be made at the conclusion of this paper are relatable and beneficial to the entire power engineering community, and the programs and partnerships currently under consideration and use in the nuclear industry may also translate for use among other power industries.

2.0 Background

2.1 The Definition of Power Engineering

Since the commercialization of electricity in the late 19th century, the role of power engineering has been vital to the quality of life for citizens worldwide.[2] Power engineers are responsible for the generation, transmission, and distribution of electric power, and they are generally employed in power generation plants, industrial facilities, and residential or commerical buildings. The power industry requires the efforts of engineers from all concentrations. The design of pumps, turbines, and heat exchangers requires the expertise of a mechanical engineer, while civil engineers contribute to structural designs and environmental engineering. Electrical engineers assist in designing power networks as well as the electrical systems used within power plants. For high pressure and high temperature conditions, such as those in nuclear and coal plants, materials science engineers are vital for the design process and choice of materials. Chemical engineers ensure the proper water chemistry and additive choice for water streams used in power plants.

2.2 Great Expectations for Nuclear Power

Improving the national power infrastructure is a constant effort for power engineers of all concentrations. The efforts of today's and tomorrow's power engineers will be essential in discovering, developing, and implementing alternative power sources. One source under serious consideration is nuclear power.

Nuclear power generation is not a new concept. Commerical nuclear power plants have existed in the U.S. for over 30 years. Yet, concerns for the safety of nuclear power plant workers and the citizens in the areas surrounding the plant have always been impossible to ignore. These fears were further reinforced through the historical events at Chernobyl and Three Mile Island. News of these events spread quickly, forever changing the opinions of the public concerning nuclear power.

Since the event at Three Mile Island, no new reactors have been built on U.S. soil. Nuclear sources presently account for approximately 20% of the power generation in the U.S. Despite the lack of nuclear power growth in the U.S., much of the international community has embraced and advanced nuclear power generation. France, for example, produces approximately 80% of its power using nuclear generation methods. In the past, the U.S. has been able to rely heavily on coal and natural gas sources for power generation. However, concern over global warming has begun to change the outlook of the American power industry as well as the outlook of nuclear power.

The U.S. government recognizes the need for alternative energy sources. Many members of congress, both democratic and republican, consider the expansion of nuclear power crucial to establishing America's independence from foreign oil. In a speech given on June 19, 2008, republican presidential nominee John McCain stated, "If I am elected president, I will set this nation on a course to building 45 new reactors by the year 2030, with the ultimate goal of 100 new plants to power the homes and factories and cities of America."

Recent polls have shown that the American public has also begun to change their opinion of oil and coal sources and of the nuclear industry. In a 2007 survey sponsored

by the Nuclear Energy Institute[3], respondents were asked to rank seven energy sources in order of their expected use in the future. Oil and coal were ranked lowest among the options given, while solar, nuclear, and wind energy ranked first, second, and third, respectively. Solar energy was also ranked first among respondents in a 2008 survey conducted by Bisconti Research Inc. and GfK, with wind energy ranked second. However, this survey also included discouraging government projections for solar and wind energy. The U.S. Energy Information Administration[4] projected that, despite strong support from U.S. citizens, wind and solar energy will provide only an approximate two percent of U.S. electricity in 2020. Two strong conclusions can be drawn from these surveys—the American public would like to diverge from oil and coal energy sources, but the U.S. government does not project solar and wind sources to be the alternatives of choice. It is precisely these conclusions that ultimately support the advancement and growth of nuclear energy.

3.0 Issues

With a presidential candidiate strongly supporting nuclear power and applications for proposed nuclear facilities currently being reviewed by the Nuclear Regulatory Commission[5], the expansion of the American nuclear industry seems to be growing more inevitable. Yet, industry experts and casual observers alike are questioning the feasibility of these new developments. In addition to an aging infrastructure, the aging popultion of power engineers and the weak student pipeline must be seriously considered.

3.1 An Aging Infrastructure

As power companies prepare to expand their nuclear power facilities, it is essential that the stability and overall health of the existing U.S. power grid be considered. This is an issue that is all too familiar to millions of Americans, due to an event which is now known as the Northeast Blackout of 2003. On the afternoon of August 14th, 2003, a large power surge spread across the northeastern portion of the U.S. and the Canadian province of Ontario, creating the largest blackout in North American history. The cause of the blackout, though highly debated, was traced back to a chain event of failures across the nation's power grid. It began with the failure of three power lines in Ohio, causing a significant power load to be redirected onto other portions of the grid. However, the computerized warning system which would have notified other power plants of the incoming load was broken, and the power surge compounded from state to state.[6] Nearly 50 million people were directly affected by the blackout's power outages, and the cost to the American economy was estimated at $6 billion in losses. Ensuring a reliable power grid for the future transmission of power from renewable sources will require evaluation efforts from power engineers countrywide, as well as recommendations for improvement and plans for implementation. In 2000, executive Mark Mills made this statement at a nuclear energy assembly in Chicago:

> "We are at 'the end of the beginning' of the new era in which pervasive information technology can tolerate power outages of no more than 30 seconds per year. Existing levels of service reliability—though astounding at 99.9%—equate to outages of only eight hours per year, but are inadequate to meet the continuous electricity needs of the new silicon economy."

One challenge to be addressed in the construction of new nuclear facilities will be fighting the "not in my backyard" stigma while choosing a building site. Due to the misunderstanding of a nuclear facility's safety and unreasonably heightened fear of

health issues related to radioactive materials, many individuals would strongly oppose having a nuclear plant built in their hometown. For example, Michigan's citizens would prefer a new power plant to be constructed further north along the coastline, away from larger populations. For some states and regions, the only available land may also be further away from the more densely populated regions. This presents a new challenge, though, as the transmission of the electricity produced would require significant additions to the northern Michigan power grid and the grids of other regions, and the integration of newly developed technologies, such as high voltage direct current.[7]

In addition to implementing necessary repairs and innovative upgrades, an increasing demand for electricity is also of concern to power engineers. According to the Census Bureau's decennial census, the United States is growing at a rate of approximately 3.3 million people per year. The U.S. Department of Energy's Energy Information Administration has also projected that overall electricity demand will increase by 40 percent by 2030. In order to accommodate this constant increase of demand on the country's power sources and transmission lines, power and energy engineers must stay one step ahead of capacity and reliability.

The need for well-trained power engineering professionals is compounded when the capacity of the U.S. power system is also considered. Currently, the capacity of the U.S. bulk power system for electricity generation is nearing its limit, requiring the role of power and energy engineers to begin transitioning to a state of growth and innovation in addition to current maintenance responsibilities. This growth alone is expected bring a 25 percent increase in the demand for power and energy workers by 2015[8]. Any hope of

integrating innovative new technologies will require balance and collaboration between young, freshly trained engineers and engineering professionals with acquired experience.

3.2 An Aging Workforce

The North American Electric Reliability Corporation[9] (NERC) serves as an independent, self-regulatory organization, acting in the best interest of electricity reliability. One responsibility of NERC is to assess future and current reliability of the North American bulk power system. The NERC 2007 long-term reliability assessment included concerns related to transmission, capacity, and power source options. However, it also stressed a growing concern of an aging workforce. This concern represents an ongoing issue that has begun to reach a critical state.

In research conducted by the Hay Group, approximately 40 percent of senior electical engineers and supervisors were estimated to be eligible for retirement in 2009. In a further survey of the country's electric utility companies conducted by the Center for Energy Workforce Development, approximately 46 percent of all electric and gas utility engineering jobs could be vacated by 2012. As stated in the NERC long-term reliability assessment of 2007,

> "The loss of industry workers and their years of accumulated expertise due to the retirements is a serious threat to the bulk power system reliability, exacerbated by the lack of new recruits entering the field."

Projections for the nuclear industry's workforce are very similar to those of power engineering in general. Within the next decade, nearly half of the nuclear workforce—both engineers as well as skilled labor—is expected to retire.[3] The loss of experienced

engineers and skilled trade workers carries a far heavier consequence in the nuclear industry, though, compared to other power plants. The process of educating and training replacement workers for a nuclear plant requires a significant amount of time. With each individual that retires, a potential mentor is also lost. Many nuclear power plants require new employees, specifically engineering graduates, to spend one to two years under the guidance of a senior employee. This one-on-one mentorship allows the new employee to first follow their mentor and observe their daily responsibilities, and, eventually, to complete those same tasks with observation and guidance from their mentor. It is this training process that has created the safety record and excellence of today's nuclear power facilities. Once retired, the knowledge and experience of senior employees is lost, unable to be transferred to a new employee.

3.3 A Weakened Student Pipeline

Outside of the U.S., the number of students pursuing power engineering is increasing steadily. New professors are being hired faster than retirements are occurring to accommodate increased classroom sizes.[8] Students and faculty alike see opportunities to expand their national power infrastructure, as well as potential opportunities to provide energy to nations such as the U.S.

Within the U.S., the number of power engineering faculty currently outnumbers new professor hires. Because of this, once-successful programs are either slowing to or already at a halt, with power engineering electives no longer being available. Students are being attracted to other areas of study, both in other engineering concentrations as well as other majors. A significant number of international students make up the small

power engineering student population within the U.S. After receiving their degrees, many of these international students then return home to serve their respective nations as power engineers.

Ultimately, university administrators must decide whether or not to seek and hire new faculty for specific departments at their universities. These men and women must be educated and encouraged to see the value in hiring new engineering faculty with power and energy background and experience. For example, in 1975, the Carnegie Mellon University and the University of Missouri-Columbia engineering departments each included eight power engineering faculty members. In 2007, Carnegie Mellon University had one power engineering faculty member and the University of Missouri-Columbia had no faculty members with power engineering interests or experience. This trend is present throughout many American universities, and the implications are clearly shown in the decreased number of power engineering electives offered at the undergraduate level. Without qualified faculty members, potential power engineering students are not able to take elective courses to receive an introduction to the field. Their interests are diverted elsewhere and their talent is then lost. Thus, it is essential for university administrators to recognize the need for rejuvinated power engineering programs and to seek and hire faculty members with this interest.

4.0 Solutions

Finding an all-inclusive solution to the current issues facing U.S. bulk power system is no easy task. Professionals and government officials alike realize that finding a solution will require vast time and investment. However, the Power and Energy Engineering Workforce

Collaborative[8] (PEEWC), a subgroup of IEEE-PES, believes that solving the nation's power issues begins with improving the pipeline of students entering this specific field. Although K-12 education is essential in this effort and addressed by it, college students and young professionals are the primary focus of PEEWC initiatives. Presently, PEEWC is a relatively new group and is still in the process of establishing a national leadership board. However, each of the following existing solutions are receiving their attention.

4.1 K-12 Initiatives

Several partnerships have been established to aid in recruiting K-12 students to careers in science and engineering. One such program is the Future for Kids Partnership, which is aimed at high school students who are contemplating which career to pursue and how to succeed in college and beyond. Using online interest surveys, students are presented with a variety of recommended career opportunities and materials to further research the education and preparation for those specific careers. Career research surveys such as this are the perfect opportunity to solicit careers in power engineering and provide the necessary educational materials to spark further interest. When surveyed, 91 percent of students involved in the partnership said they now understood what was needed to get the type of jobs they were interested in pursuing.

A similar partnership exists in some cities between local industries and the Boys and Girls Club. Students complete interest surveys and are given a similar listing of career possibilities, as is used for the Future for Kids Partnership. Unlike the Future for Kids Partnership, the Boys and Girls Club also seeks job shadow opportunities for their students, allowing students to make a connection with a local company and its employees. Programs such as this also allow students to receive advice from local

professionals, such as which high school programs would be best and what local college programs would be appropriate. Students also create a "foot in the door" for future internship, co-op, and entry level job opportunities. For the PEEWC and power plants with local programs such as these, it's important to ensure that engineering is provided as an option, and that sufficient mentors are available.

For the K-12 years of a student's education, science, technology, engineering, and mathematics (STEM) courses are the essential introduction and preparation for a career in power engineering. While advocates of power engineering may not be able to directly influence the amount of power engineering topics included in the K-12 curriculum, but STEM education initiatives are certainly the best way to promote power engineering pipeline improvements. The need to improve STEM education in the U.S. educational system has begun to gain attention on a national level, and numerous partnerships are making these initiatives the focus of their efforts.

4.2 Community College and University Initiatives

Industry executives play an important role in the strengthening of university programs and the power engineering workforce. At the Donald C. Cook Nuclear Plant in Bridgman, Michigan, seeking new talent has become a priority for plant leadership. In the spring of 2008, Lake Michigan College announced its new energy production technology degree program.[10] This two-year technical degree was created with help from DC Cook leadership as well as leadership from Palisades Nuclear Plant, another local facility. The degree will offer students scholarship opportunities for courses at Lake Michigan College, including evening classes, as well as potential co-op positions within

the DC Cook and Palisades plants. For adult students, the program allows for a steady salary while working toward their degree. Both local power plants will benefit greatly, as program graduates will have been well-educated and also mentored within the plant for nearly two years.

Through summer internships and entry-level positions, university students are able to get hands on experience in the power engineering field, exposing them to the vast array of opportunities and rewarding, satisfying careers to be had at this time. Internships and job experiences also allow students to interact with and be mentored by current engineering professionals. However, industry executives decide the priority of issues that their companies are faced with, allocating resources according to these priorities. Internships require investment, and entry-level engineering jobs to replace retirees require pay for both the retiree and the replacement during a period of mentorship or apprenticeship. Companies must look to the future of their workforce to justify such costs.

Internships and co-op employement are especially important for nuclear power plants. Unfortunately, a stigma still exists in the minds of citizens concerning the safety of nuclear power plant employees. The best way to conquer and dimish that stigma is by exposing students first-hand to the safety of today's nuclear facilities. Additionally, the heightened security measures currently enforced at U.S. nuclear power plants make field trips and tours nearly impossible. Internships and co-op employment are often the only way for students to gain access to the plant.

5.0 Recommendations

5.1 Recommendations for the U.S. Governement

A primary recommendation for the U.S. government is to amend the America Competes Act. Although this act seeks to increase federal funding of research programs and improve the STEM education of K-12 students, it does not include any language concerning the present pipeline issues being experienced for power engineering students. Should nuclear power continue to gain strength and more nuclear facilities be proposed, the language of the America Competes Act should also include specific action to be taken to improve the nuclear power engineering pipeline. Securing a reliable national power grid is essential to the American economy, and the strength of U.S. factories and companies depends upon it. Without qualified talent, the futures of the national grid and U.S. power sources are in jeopardy.

In addition to ammending the America Competes Act, increased grants for power engineering students and faculty members are necessary. Grants allow for cutting-edge research to occur in an educational setting, creating innovative new technologies as well as passionate college gradutes ready to enter their respective fields. However, grants for power engineering faculty are especially important, as the decline in faculty members is perhaps the greatest issue mentioned in the scope of this paper. Grants provide faculty members with opportunities to research topics within their own set of interests, perhaps providing a more fulfilling experience and increasing the rate of rentention.

Last, tax incentives should be offered for companies with active workforce development programs. The efforts of power engineering leadership provide immense opporunities and benefits to local economies, with many benefits translating to other industries beyond their own.

5.2 Recommendations for Community Colleges and Universities

As mentioned, experienced power engineering faculty members are the foundation of today's university power engineering programs. It is for this reason that universities must be focused on hiring new faculty members with backgrounds, experience, or interests in power engineering topics. If faculty members are available, power engineering elective courses should be made available not only to electrical engineering students, but students from all engineering concentrations. Retaining these valuable faculty members is an issue yet to be addressed, requiring more exploration and facilitation. This initiative begins with university administrators.

5.3 Recommendations for the Industry

Internships, co-op employment, and two-year degree offerings are invaluable assets to the power engineering industy as well as local communities. Partnering with local community colleges to train necessary skilled trade workers is essential for the strength of the power engineering workforce. It is recommended that these programs be integrated for use at power plants nation wide, in addition to providing four-year college scholarships for local high school students.

6.0 Conclusions

Preparing for a possible “nuclear renaissance” and solving workforce and infrastructure issues in the exising American nuclear industry is no easy task. Strengthening the nuclear workforce begins, ultimately, with the strengthening of power engineering programs within colleges and universities. Without power engineering faculty, it is impossible to spark the interest of students or prepare them for a career in the nuclear engineering workforce. Very little attention has been given to the process of recruiting and retaining qualified power engineering faculty members. Future efforts toward resolving this issue could include a dicussion of existing university faculty tenuring processes. Additional attention should be given toward discussing measures to provide more satisfying experiences for faculty members, including increased salaries and increased grants for research opporuntities.

The benefits of an improved power engineering and nuclear workforce will provide vast benefits to the American people in the future. The U.S. will have the talent necessary to staff new nuclear power plants, providing clean, safe electricity and supporting local factories and businesses. The future of the power engineering workforce is more than an isolated industrial issue—it is an issue of American competitiveness.

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