The Technical Talent Challenge

by Wanda K. Reder

And Implications of Our Maturing Workforce

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THE ELECTRIC SYSTEM IS THE LARGEST, MOST COMPLEX MACHINE EVER created. It requires a long-term perspective to develop and maintain a complex system designed to last 50 years or more in an always-on state. In recent years, industry leaders have taken a short-term approach, reacting to regulatory pressures, financial targets, and system performance, placing relatively little emphasis on workforce development. For example, in the United States, California led the way, passing a bill in 1996 that radically restructured the state's power industry. That deregulation effort was declared a failure in 2001. Shortly thereafter, Enron unraveled, resulting in a bankruptcy that caused market skepticism and a tarnished industry image. The U.S. federal government responded by introducing Sarbanes-Oxley legislation to ensure financial control compliance and by August 2003, a blackout occurred in the Midwest and northeastern United States and Ontario, Canada, affecting an estimated 50 million people. With so much emphasis on financial performance and emergency response, intellectual capital has been overlooked.

This short-term financial focus has resulted in staff reductions, hiring curtailment, and the early retirement of experienced personnel. While the trends in hiring and infrastructure investment may be turning, many who have been in the power delivery industry are quickly approaching retirement. Because of past hiring practices, there are relatively few in the midcareer phase to assume the responsibilities and replace the expertise of those exiting the workforce. The industry faces a technical talent challenge, due in part to short-term thinking.

The Maturing Technical Workforce

As experienced in August 2003, a lapse in the supply of electricity is devastating. Due to the decline in technical expertise, the viability of the electrical infrastructure and ultimately the economic outlook of the power industry as a whole could be in jeopardy. The IEEE Power Engineering Society (PES) sponsored a survey of electric utilities in the United States and Canada in spring 2005. With the assistance of the Edison Electric Institute (EEI) and Western Energy Institute, U.S. and Canadian utilities contributed to the survey to identify average age, retirement, succession planning, and five-year availability trends. The survey results estimated 20% of the employees will be eligible for retirement within the next five years; in some extreme cases, as many as 40% of the workforce will be eligible for retirement. Some noted that their company's stock price is the biggest driver for retirement activity; if the stock is up, employees will exit as forecasted, and if it is depressed, they tend to work longer. The study also revealed many utilities will experience a drain in the leadership base within the same time frame. Some power engineers will likely be promoted into these vacated leadership positions, creating even more of a technical gap than that caused by retirement attrition alone.

There is also the risk that power engineers will be recruited into other industries due to an across-the-board high demand for midcareer talent. U.S. government statistics indicate the median age of the U.S. labor force has been steadily rising since 1988. By 2010, one in three U.S. workers will be age 50 or older. The U.S. Bureau of Labor Statistics forecasts there will be a 15% decline of those at age 35–44 by 2015, yet the demand for those in this age group will increase by 25%. Other countries face similar trends.

It is unclear how the availability of technical knowledge may affect the reliability of electric service, but the potential link is strong. A shortage of experienced technical talent can delay infrastructure projects and negatively impact reliability, cost, safety, and productivity since new hires, by definition, have less experience than seasoned personnel. Figure 1 shows a typical age distribution for the power industry. For many power industry employers, less than 10% of their workforce is 35 years old or younger. According to the IEEE PES survey, the average age is well over 45 years and is increasing each year. In addition, the *Aging Workforce Report* recently conducted by UTC Research indicates the median age for workers in the utility sector (including telecom) is 3.3 years higher than the national average, with nearly half of the utility workforce currently over the age of 45.

Given this age distribution, many companies will field a rapidly maturing workforce for the foreseeable future. Without replacing the retirees—and their expertise—how can companies avoid a crisis? With large numbers slated to retire and relatively minimal hiring in recent years due to cost cutting, will the talent and experience to do basic utility work be available to support a reliable power infrastructure in the future? Will there be adequate infrastructure to attract and train the talent needed?

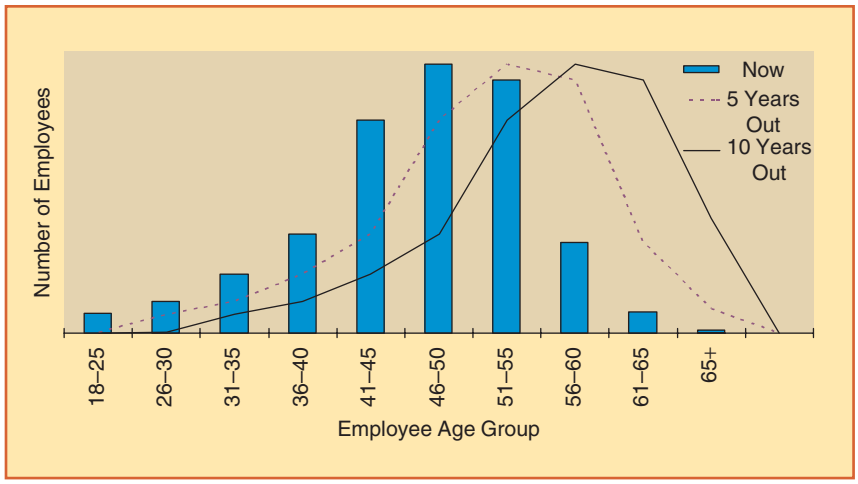

figure 1. Typical power industry employee age distribution.

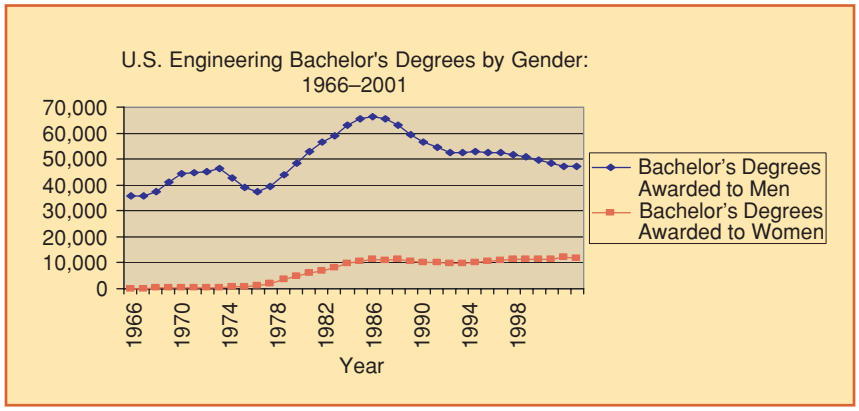

figure 2. U.S. engineering bachelor's degrees by gender (1966–2001).

Succession Planning and Knowledge Retention

According to the IEEE PES survey of U.S. and Canadian utilities, succession plans are in place and extensive for senior management. For middle management, approximately two-thirds of utilities now have succession plans in place. However, survey results indicated that succession plans for technical positions were limited, with only isolated activity to date. In some cases, critical skills are being identified to target technical succession planning efforts, typically including skills associated with dispatching, operating, relaying, planning, and design engineering. Other broad-based business skills were also identified as critical, particularly those relating to finance, interpersonal skills, strategic thinking, communications, decision making, curiosity, emotional IQ, and learning agility.

Like many other employers, Tennessee Valley Authority (TVA) is facing the imminent retirement of an estimated 30–40% of its workforce in the next five years. They have determined that it is critical to respond to impending knowledge loss. But, given limited resources, TVA recognizes it is equally important to focus on the most critical positions and types of knowledge. Since 1999, they have been utilizing a critical skill analysis, coupled with retirement forecasts, to create targeted plans for hiring and knowledge transfer. In developing knowledge retention plans, several possible responses are considered:

- ✔ codification and documentation to create procedures and checklists
- ✔ reengineering processes to eliminate tasks, taking advantage of updating equipment, and using smarter tools
- ✔ training through classroom, simulator, on-the-job, and one-on-one training
- ✔ establishment of alternative resources like contractors or retirees to assume responsibility.

The Availability of Technical Talent and Power Curricula

The industry's cost-cutting effort did indeed save money in the short term, but it also had a serious unintended consequence. The lack of hiring and reduction in employment precipitated a decline in the availability of power curricula at a time when engineering enrollment in the United States is on the decline across the board. According to a presentation made by S.S. Venkata of Clarkson University, the United States graduated about 65,000 engineers in 2004, down from 77,000 engineering graduates in 2001. Engineering enrollment has been on the decline for the last 15 years. It is estimated that the country currently needs 100,000 engineers per year to fill the demand. As shown in Figure 2, since the mid-1980s, the number of women getting bachelor's degrees has been relatively constant; meanwhile there are nearly 20,000 fewer men receiving engineering bachelor's degrees annually than just 15 years ago. Given the increase in demand and the decline in engineering supply, the technical talent gap that will be created in the next five years is significant.

table 1. 2010 labor demand by skill type.

Skill Type	2003 Employment	2010 Demand	Percent Change
Civil engineers	211,280	256,000	21%
Electrical engineers	149,540	175,000	17%
Mechanical engineers	214,070	251,000	17%
Lineman	99,290	108,000	9%
Electricians	575,980	819,000	42%
Boilermakers	17,970	28,000	56%
Construction laborers	845,890	926,000	9%
Total	2,114,020	2,563,000	21%

Source: U.S. Bureau of Labor Statistics

While the availability of engineering graduates is a challenge, the availability of power-educated engineering graduates is even more discouraging. Currently in the United States, approximately 1.5% of engineering students are selecting power engineering as their focus. In a survey conducted by the IEEE PES Power Engineering Education Committee (PEEC), the state of electric power engineering education throughout the world was identified through responses from 67 universities worldwide. This survey and previously collected data revealed that the number of viable power programs in the United States is down over the last 20 years. In the United States, power faculties tend to have few practicing professors—in the three to four range—and retirements generally outpace new hires in the field. Outside the United States, power faculties are often considerably larger, in the 10–11 range, and new hires outpace retirements. Previously collected data indicate that the average age of U.S. professors in power is creeping up and the number of useful years remaining in the professional lives of power faculty is dropping. Therefore, one long-term concern, especially for U.S. universities, is the difficulty of maintaining faculty numbers and student interest as new technologies emerge and draw attention away from electric power engineering. Apparently, the lack of jobs in recent years and a less-than-glamorous image of power careers have caused universities to shift focus into other curricula, placing the power education foundation at risk. As a result, the universities offering power education is decreasing as is the number of students who enroll in them.

Technical Talent Demand Is Increasing

While both power curricula and the number of students entering engineering are dropping, industry demands for technical talent and the required competencies are increasing. There is a crucial need to maintain aging and highly loaded infrastructure. The technical complexities of integrating new, electronic-based technology into existing infrastructure are growing and require different skills. Adding infrastructure, especially in densely populated areas, is increasingly difficult, yet load is added every day and must be served while the pressures to perform reliably continue. The technical workload is also increasing to accommodate capital reinvestment following years of cost reduction. Sophisticated information, modeling, control, and data-acquisition systems significantly add to the technical skill set requirement of yesteryear. In addition, it is increasingly important for engineers to participate in growing regulatory, policy, and environmental discussions. Participation requires expertise that integrates business, social, and technical fundamentals, adding even more to the necessary competencies and workload. In *Electric Perspectives* published in September 2005 and as shown in Table 1, it was noted that the 2003 workforce will need to be expanded over 20%, to accommodate skills needed to support the construction of new infrastructure anticipated by 2010.

Respondents to the IEEE PES survey projected an increasing demand for entry, midcareer, and senior technical positions in the next five years. Simultaneously, there was a predicted shortage in the supply of middle and senior-career technical talent, as shown in Figure 3.

Technical Talent Moves on to Other Positions

There is another attrition phenomenon that may not even have been considered in the utility responses. The Nuclear Energy Institute (NEI), in its 2003 Workforce Survey, compiled a detailed assessment of a maturing workforce, indicating 18% will be lost to nonretirement attrition, largely resulting from the portability of engineering skills. Projecting that in five

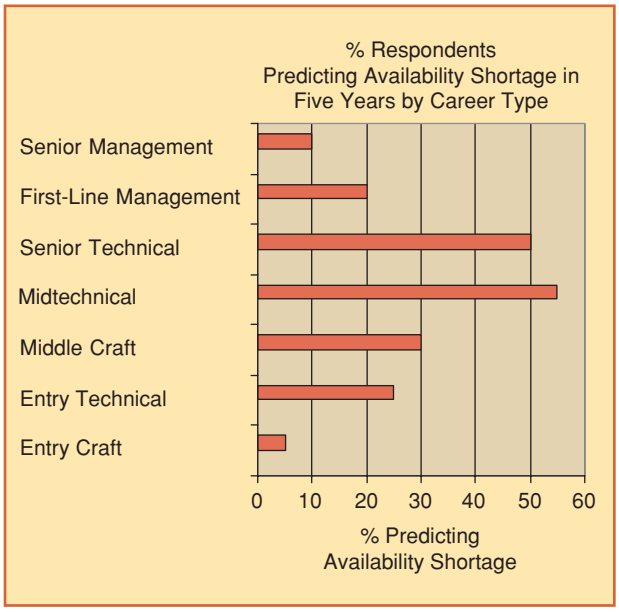

figure 3. Percent of respondents predicting availability shortage in five years by career type.

years, the demand for midcareer technical talent will exceed supply, the call for those with portable skills will cause engineers to flee to other industries or cause them to exit from technical disciplines. NEI also forecasts that 15% of the engineers currently occupying technical roles could be promoted to fill other positions in five years. These attrition risks are certainly applicable to power engineers. While the nuclear industry may represent an extreme case, it is certainly a plausible, and perhaps conservative, estimate that 10% of the technical talent in the power industry will choose to move into management positions or into other industries in the next five years.

Workforce Profile

The demographic dynamics of those entering the workforce show an increase in the number of women; however, women have been underrepresented in the electric power sector. Recruiting for diverse ethnic and female candidates continues to be a significant challenge. In the United States, women make up 11% of the engineering workforce and are earning 20% of the engineering undergraduate degrees. According to the Washington, D.C.-based Commission on Professionals in Science and Technology, engineering has the lowest percentage of female graduates among all the professions—lower than medicine, law, economics, dentistry, architecture, and pharmacy. Yet, this year, women will make up 50% of the workforce in the United States. The power industry is perceived to be male dominated and has relatively few role models for women and minorities, which negatively impacts the attractiveness for these groups to pursue a career in power. Because 85% of all new entrants into the U.S. workforce in 2005 are forecasted to be either women or ethnic minorities, it is critical for the power industry to successfully recruit and retain these groups.

Engineering, especially in the United States, suffers from an image problem. Furthermore, layoffs, scandals, the power crisis, and environmental lawsuits reported in the general news media add up to a poor reputation specifically for the power industry. Visibility and image need to improve to attract ethnically diverse and female candidates into power engineering careers. Adequate representation of women and ethnically diverse candidates will likely improve if the power engineering profession is perceived to be highly valued by society. Employers, academics, and technical societies must work together to boost the image and promote the value of the profession.

Fulfilling the Technical Talent Requirement

It is difficult to precisely estimate the actual technical talent requirement. Depending on the increase in workload, the power industry in some countries, like the United States, may need to replace up to 30% of the existing technical workforce in the next five years. Since it is very unlikely that graduating engineers alone can fill this requirement, a

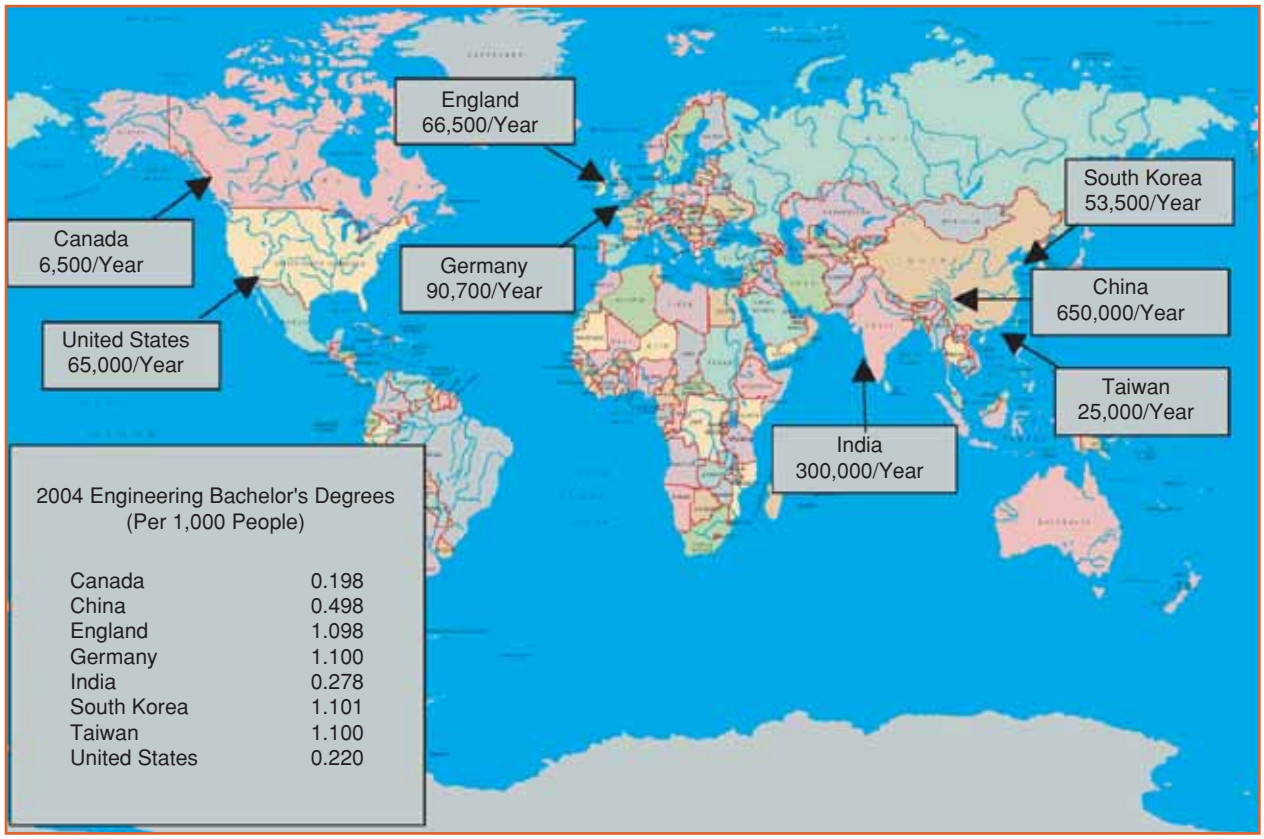

figure 4. Engineering bachelor's degrees vary considerably by country.

The industry faces a technical talent challenge, due in part to short-term thinking.

projected supply-and-demand gap is created between industry needs and graduate availability.

A forecast published in 2004 by the Canadian Electricity Association summarizes that country's situation well. A growth scenario assumed that electricity demand in Canada will grow at 1.8% per year, needed infrastructure replacement will drive an increase in the required workforce by 2010, retirements will account for 17% attrition, and the electric sector will attract 5% of the engineering graduates. At the time of the study, there were 11,525 in the Canadian power industry. Demand for engineers from 2005–2009 would be 3,510 (30.5%), and the supply of engineers would be 325 (2.8%) over the same period, leaving a gap of 3,185 (27.7%) engineering positions.

The Canadian engineering results as summarized in Table 2 are believed to represent trends occurring in the United States and in many other parts of the world. However, the forecasted shortage of technical talent is not a universal problem. As shown in Figure 4, some nations are graduating great numbers of engineers. In 2004, China, for example, graduated approximately 650,000 engineers, and India graduated approximately 300,000 engineers. Relative to their populations, Asian nations such as Taiwan and South Korea are graduating five times as many undergraduate engineering students as the United States.

Addressing the Technical Workforce Gap

Proactive steps are needed to ensure the availability of expertise to replace a rapidly maturing workforce and avoid a crisis, especially given the dependence of society on the power system. With the technical workforce demand increasing while talent is depleting, the strategies below can be implemented to begin proactively managing the current situation.

Implement Technology to Reduce Engineering Workload

In recent years, new technology has been implemented to automate meter reading and control systems and to digitize mapping, to name just a few functions. The next evolution of technology deployment could focus on technologies to increase workforce efficiency through standardization, process streamlining, and training simulations. Productivity gains can be achieved that should reduce the number of engineers required to complete tasks by an estimated 10% of the current base level. In some cases, the necessary competency-level requirements may also decrease through technology utilization.

Utilize Chiefs and Retirees

Employers should designate selected individuals as seasoned chiefs and remove day-to-day management duties so they have time to provide technical expertise, transfer knowledge, and mentor junior staff. Retention efforts should be focused where skill supply is at risk. Many retirees welcome part-time project work and can be a useful, trained resource. This strategy may require the development of retirement packages that provide opportunities to ease into full retirement.

Concerns have been raised in recent surveys indicating that retirees' willingness to work is dwindling. That being noted, retirees may be able to accommodate 5% of the technical workforce gap.

table 2. Canadian electric power engineering five-year gap.

Canadian engineers in power	11,525	
Demand		
• Retirement attrition	1,960	17.0%
• Workload growth	1,550	13.5%
	3,510	30.5%
Supply	325	2.8%
Gap	3,185	27.7%

Consider Outsourcing and Talent Trained Elsewhere

Another strategy is to augment staffing deficiencies and complement missing competencies by outsourcing to third-party firms and utilizing suppliers for technical services. Outsourcing can be a more efficient and cost-effective alternative because of scale and the ability to level workload. As the technical component is outsourced and core expertise is released, typically the importance of long-term relationships increases dramatically to ensure that organizational technical needs are fulfilled.

The growing pool of international talent makes engineering a sector that's ripe to move overseas. Wall Street investment banks and large U.S. accounting firms already have shifted many routine jobs abroad. Engineering could follow. There is evidence that global suppliers for the power industry are already starting to shift high-end engineering research from Germany, Sweden, and the United States to India and China. While this potentially decreases costs and ensures a supply of talent, it introduces challenges involving language,

technical support, and practical system understanding, to name a few. By easing the process for attaining work visas and creating recognized educational standards, international talent can be a meaningful element in solving the technical workforce gap. Outsourcing and utilization of international talent can make up at least 5% of the technical workforce gap and potentially much more. Utilizing international talent will require assimilation efforts, standard recognition of educational status, and security clearance process improvements.

Invest in Technical Workforce Pipeline Development and Target Image Enhancement

Depending on the impacts of the prior strategies, as shown in Figure 5, the industry could be faced with replacing 30% of the existing technical workforce in the next five years. Four strategies must be pursued to adequately develop the engineering pipeline.

- ✔ To reverse the power engineering enrollment trend, or at least rebalance the proportion of power engineers as a percentage of all engineers, employers can build relationships with universities to convey hiring needs, develop research initiatives, influence curricula, sponsor interns, and continuously hire graduates. With these practices supported for the long term, student will become more attracted to careers in power engineering.
- ✔ Remaking the image will attract more power engineering students. If image enhancement is done well, engineers from other disciplines will transfer into power. Power engineers can visit schools to explain their careers, emphasizing the creativity, social importance, and challenge. Opportunities can be created to make role models visible, promoting engineering, especially in middle school when career images are being formed and decisions are made regarding the pursuit of math in high school. Promotional efforts like National Engineers Week need to be supported and further enhanced with job shadowing, assigned mentors, and visible science fair awards. Finally, nonprofit organizations like Future for Kids Partnership (http://www.f4k.org) that provide Web portals explaining power careers and assessment tools for students need to be supported.

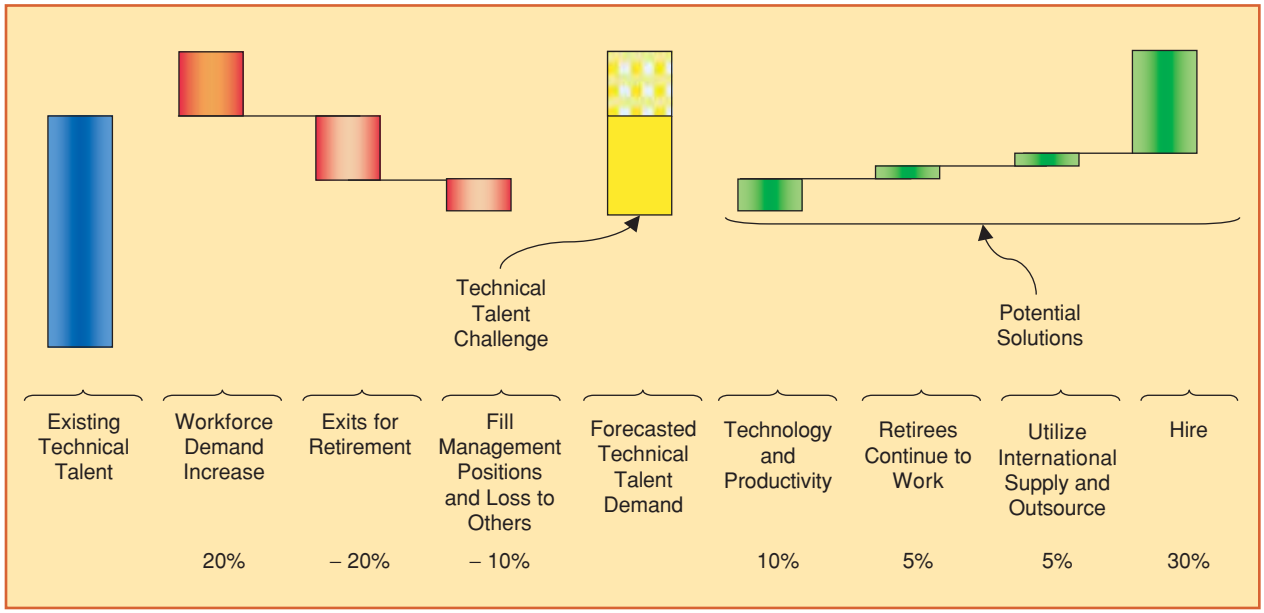

figure 5. The technical workforce gap analysis.

table 3. Students' participation in math and science.

	7th Grade	12th Grade	College Entry	College Graduation	College Doctorates
2,000 male	1,000 male	280 male	140 male	45 male	5 male
2,000 female	1,000 female	220 female	45 female	20 female	1 female
Study group	Understand math well enough to take advanced high school math classes	Take enough math for a quantitative college major	Enter college with plans to major in science	Number emerging from college with baccalaureate degree	Number emerging with Ph.D. in quantitative field

- ✔ Recognize the labor pool has changed; ethnic diversity and greater participation by women will provide the long-term solution to power engineering workforce needs. The current barriers limiting the involvement of women and minorities tie into socioeconomic realities, early educational choices, and workforce stereotypes. Ensuring an adequate supply of technical candidates requires focus to increase women and minority participation in the field. Table 3 provides a summary of boys' and girls' participation in math and related studies from junior high school through college graduation. The declining participation, especially in females throughout the scholastic journey, emphasizes the importance of establishing role models to connect with students by promoting the power industry image and exciting benefits of engineering careers.
- ✔ Expertise can be developed with existing employees. Through participation in technical standards groups like the IEEE PES, employees will acquire practical skills and build industry relationships. E-learning can also be utilized to speed the rate of development and share knowledge that has historically been conveyed through "tribal learning." Development of e-learning and Web-based training provides an opportunity for senior employees to formally document critical information into a medium that is readily adopted by the incoming workforce generation, a group that readily learns from computers. Once this information is available online, it is in a format that can be used for ongoing training.

Conclusions

Figure 5 provides a summary of the technical talent gap analysis. While the impacts in the next five years from workload, retirement and nonretirement attrition, technology, working retirees, and nontraditional workforce sources are not known with certainty, the forecast is believed to be reasonable. Approximately 30% of the existing technical workforce could be in need of replacement in the next five years. With relatively few power engineers in their midcareer and few students selecting power engineering, the power industry is facing a major shortfall in technical skills.

Organizations like the IEEE PES can facilitate solutions by sharing technical workforce information between educators and employers, pursuing activities to improve the power-career image, and alerting decision makers of development and recruiting needs. Within the IEEE PES, an ad hoc Long-Range Planning Committee has been created to identify and explore problems and solutions. Practical application-based educational tracks are being offered at PES meetings to augment the knowledge of newly minted engineers in power-related fields. This program will be supplemented by offering the material through Web-based communications. Additionally, PES officers continue to communicate with power industry executives on a regular basis to ensure their technical talent needs are being met as well as to explore other mutually beneficial areas.

Long-term planning and collaborative actions must be taken to mitigate the affect of attrition in order to maintain the viability of the electrical infrastructure. The concern of an adequate incoming engineering supply is shared throughout many countries in the world. Employers, organizations, and educators need to team up to monitor, measure, understand, communicate, and resolve these technical workforce needs. By working together to attract and retain entry talent, opportunities can be created to highlight power-related careers, showcase role models, introduce technology, and keep curricula current. With collective focus, the industry can shift to longer-term thinking that includes the development and availability of expertise to ensure the most complex machine ever created will flourish reliably and benefit society for many years to come.

For Further Reading

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Biography

Wanda K. Reder received a B.S.A.E. from South Dakota State University and an M.B.A. (New Ventures) from the College of St. Thomas. She is the vice president of S&C Electric Company's Power Systems Services. Previously, she served as vice president, engineering and system planning, and vice president of asset management for Exelon Energy Delivery.