THE POWER ENGINEERING WORKFORCE IN WASHINGTON AND THE PACIFIC NORTHWEST:

OPPORTUNITIES AND CHALLENGES

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2013

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WSUEEP13-036 • September 2013

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Project Funding

Financial support for this project was provided by the Washington State Legislature through the Strategically-Aligned Academic Research (STARS) program.

Permission to Cite

About the WSU Energy Program

The WSU Energy Program is a recognized leader in energy research, development and technology transfer. The WSU Energy Program works with government agencies, power marketers, utility consortiums, educational institutions, private businesses and industries on projects that promote energy conservation, research, development of renewable energy sources, and economic and workforce development.

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The Social and Economic Sciences Research Center (SESRC) at WSU is a recognized leader in developing and conducting survey research. The SESRC–Puget Sound Division specializes in research design, data collection, and analysis using qualitative and quantitative methods. The Division also provides interpretive reports, policy studies, presentations and consulting services directly to individual clients, organizations and consortia.

Acknowledgements

The authors would like to thank the many industry participants and supporters of this project. Special thanks go to the employers and respondents who provided data and were interviewed for this study. Their many contributions to this research are greatly appreciated. The authors are grateful to Chen-Ching Liu and Jody Opheim of the WSU-ESIC for their sponsorship, and to Sally Zeiger Hanson and Melinda Spencer (WSU Energy Program) for content contributions, draft reviews, and editing support. Thanks also to Barbara Hins-Turner and the Pacific Northwest Center of Excellence for Clean Energy (Centralia College) for supporting the replication of selected project data presented in the report.

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Executive Summary

In 2008, the Washington State University (WSU) Energy Program completed a regional labor market and workforce study of electric power employers. The study collected data regarding new hiring, anticipated retirements and replacements, hiring challenges, and workforce education needs. The study mirrored national predictions about the aging utility workforce, looming retirements, challenging population trends, and other factors that were predicted to create considerable labor and skill gaps in the electric power industry. It primarily focused on technical craft occupations: operators, mechanics, electricians, technicians and line workers. The engineering workforce was not a focus of the original study.

Since that time, the electric power industry has continued to transform how it generates, transmits and distributes electric power through the application of advanced technologies and processes, and other Smart Grid innovations. At the same time, the deepest recession since the Great Depression contributed to delayed departures by retirement-eligible employees. Yet, how those two factors affected the power engineering industry and its workforce has not been well understood. The intent of this study, therefore, was to investigate power engineering specifically.

To address these issues, the WSU Energy Program supplemented the 2008 research specifically for electrical power engineers. The project reviewed existing research and collected new data directly from a sample of Northwest employers. The combined quantitative and interview data were used to generate near- and longer-term forecasts for new employment, replacing retirees, and filling key skill gaps.

To balance information from employers at multiple levels, the study gathered information by survey and by direct interviews with employers at 18 Pacific Northwest energy companies. These companies, from Washington, Oregon, Idaho, Montana and Utah, represented a mix of public and private utilities and energy service companies of different types, sizes and geographic locations.

The selection of the organizations was not based on statistical sampling procedures and the results cannot be reliably generalized to the electric power industry as a whole. The companies represented were concentrated in Washington, but many of these organizations provided employment in nearby states, reflecting the regional nature of the labor market. They included both utility and consulting engineers, and those engaged in power system design, generation, transmission and distribution.

The power industry has continued to grow more complex since 2008. Some of the most critical workforce problems noted then, particularly retirements, abated during the recession, but did not go away. Other problems grew worse as engineering departments faced the same economic cutbacks that undermined much of higher education, which were compounded by retirements among engineering faculty.

As a result, the industry still faces critical workforce challenges. Although enrollment in electrical engineering college programs appear to be up nationwide, new industries increasingly compete with

traditional power generation for graduates. Employers report that only a small number of graduates have any experience with the power industry, particularly traditional hydropower generation and distribution. And many engineering students are foreign nationals who cannot meet security clearances required by some industry employers.

Yet the industry needs workers. Although retirements abated during the recession, the senior workers did not get younger in the meantime, and the potential for substantial loss of experience in the industry workforce remains. The data collected for this study shows that while employers project a modest number of new hires in the near future, at the time data was collected 85 power engineering vacancies existed, most at the mid-levels of experience. *Perhaps more important is that employers expect 210 retirements to occur among current power engineers by 2018, which is more than 20 percent of the current power engineering workforce. It is worth noting that the study sample of 18 firms does not account for retirements at other organizations; thus, the results likely understate the actual number of retirements in Washington and across the region.*

Further, jobs continue to grow more multifaceted, reflecting substantive changes created by smart grid installation and increases in regulatory requirements. These changes affect the sheer volume of knowledge and skills required of new power engineers, and continue to increase skill demands among mid-career engineers. In particular, employers uniformly reported that new engineers lacked exposure to the industry and, thus, basic understanding of its requirements. They were deficient in many basic workplace skills, including teamwork skills, basic workplace etiquette, and business basics. Most new engineers are very familiar with computers and software, but not the elements of smart grid operation. Too few know how to generate and use data, and fewer still can present data to a general audience. Yet these are considered core skills by every employer.

Mid-career power engineers, who will be needed to step into senior positions as retirements occur, have too often developed specialized skills but not the more well-rounded proficiencies required for senior leadership. In particular, these engineers frequently have underdeveloped computer and data skills, and not all welcome opportunities to broaden their range of skills.

Employers report following a variety of approaches to address the issue:

- Retaining senior staff through retire/rehire and emeritus options.
- Relying on contractors to fill temporary workforce needs.
- Utilizing college internships to attract engineering students and expose them to the industry.
- Using mentors and rotating assignments to initiate new engineers to the industry workplace and culture.
- Working with the K-12 system to attract younger students to the industry.

Recommendations

Washington State University, as well as other regional institutions, should continue to develop, enhance and expand power engineering program capacity so that the supply of trained engineers is adequate to meet current and future demand in the power industry and in affiliated industry sectors in Washington

and across the region. Periodic surveys of regional employers should be conducted to help confirm hiring trends and match labor market supply and demand. There is strong current demand for qualified power engineers, and although employers do not anticipate adding a large number of new power engineer positions over the next few years, a sizable number of current engineers are predicted to retire, and employers plan to replace all of those openings. Because this study did not include all power industry employers, and because trained power engineers are also in demand by many other industry sectors and companies, it is likely that the true future demand for power engineers in Washington and across the region will exceed the totals identified in this study.

A second recommendation is that existing power engineering programs should be reviewed to ensure that students are engaged in learning experiences that impart the knowledge, skills and abilities that employers require, including the technical and non-technical workforce skills that students will need to succeed in the workplace. The review process should include discussion and content review with industry staff, many of whom expressed strong opinions about what current programs lack.

A third recommendation is that students should be encouraged—or even required—to participate in internships and other industry-based experiences that allow them to apply their academic learning in a work setting, and which will help to equip students with an understanding of the industry culture and employer expectations that is essential for career success. These opportunities provide myriad benefits to students, employers and institutions alike.

Finally, regional universities should consider how future technology enhancements and power engineering workforce retirements could generate new or expanded partnerships with industry. Growing demand for skill upgrades, graduate-level training, continuing education and professional certification, leadership development and research services to the power industry could offer new opportunities for regional universities to provide direct support to employers.

Background

In 2008, the Washington State University (WSU) Energy Program completed a regional labor market and workforce study of electric power employers. The study collected data regarding new hiring, anticipated retirements and replacements, hiring challenges, and workforce education needs.[1] The study mirrored national predictions about the aging utility workforce, looming retirements, population trends and other factors that were predicted to create considerable labor and skill gaps in the electric power industry.

That initial study focused primarily on technical craft occupations: operators, mechanics, electricians, technicians and line workers. The engineering workforce was not a focus of the original study.

Since that time, the electric power industry has continued to transform how it generates, transmits and distributes electric power through the application of advanced technologies and processes, and other smart grid innovations. At the same time, the deepest recession since the Great Depression contributed to weaker short-term demand for electric power and delayed departures by retirement-eligible employees due to economic uncertainty and weakened retirement portfolios. How those two factors affect the power engineering industry and workforce were not well understood.

Purpose

This project was launched to provide current, systematic data on engineering employment to identify the labor market and workforce challenges in the Northwest, and particularly in Washington State. This study sought to find answers to the following questions:

- Have industry restructuring, new technology and the recession reduced the need for new hires or expanded demand in specific occupations and sectors?
- What are employers' estimates of the need to replace experienced power engineers due to retirements?
- What gaps do employers' anticipate, and what new succession plans or strategies do they have for filling these gaps?

Employer responses to these questions were collected to provide useful information for power engineering programs, faculty and students.

Methodology

To address these issues, the WSU Energy Program supplemented the 2008 research specifically for electrical power engineers, leveraging a portion of the research data collected for an expanded regional update of the 2008 study.[2] The project reviewed existing research and collected new data directly from a sample of Northwest employers. The combined quantitative and interview data were used to generate near- and longer-term forecasts for new employment and replacement of retirees, and strategies for filling key skill gaps.

To balance information from employers at multiple levels, the study gathered information by survey and by direct interview. As shown in Table 1, 18 Northwest energy companies from Washington, Oregon,

Idaho, Montana and Utah – representing a mix of utilities and energy service companies of different types, sizes and geographic locations – were included. All participants were assured confidentiality.

The selection of the organizations was not based on statistical sampling procedures and the results cannot be reliably generalized to the electric power industry as a whole. The organizations represented the concentration of the industry in Washington, but many provide employment in nearby states, reflecting the regional nature of the labor market. The organizations include utility and consulting engineers, and those engaged in power system design, generation, transmission and distribution.

Table 1. Participating Employers and Total Employment

Employer	Total Regional Employment
Avista	1,672
Bonneville Power Administration	3,089
Chelan County PUD	643
Grant County PUD	721
Grays Harbor County PUD	152
Idaho Power	2,081
Incremental Systems	7
Northwestern Energy	1,428
PacifiCorp	6,251
Pacific Northwest National Labs	4,500
Portland General Electric	2,547
Puget Sound Energy	2,981
Schweitzer Engineering Labs	2,030
Seattle City Light	1,801
Snohomish County PUD	1,044
Tacoma Power	843
Transalta	296
U.S. Bureau of Reclamation	1,093
Total Employment	**33,179**

Survey topic areas included:

- Total employment and current employment for power engineers.
- Current job vacancies, employment forecasts for new hires, and retirement replacements for power engineers.
- Succession planning and related strategies.
- Current and future training needs for power engineers.

The next section of the report includes:

- A brief summary of the major changes in the industry since 2008, and
- Associated workforce and education-related trends, and
- The reactions of representatives of the Northwest electric power industry.

General Changes: 2008 – 2013

Two key factors have driven change in the Northwest electric power industry since 2008: the continuation of earlier changes and unforeseen circumstances.

The first consists of the continued modernization of the electric power infrastructure, particularly the implementation of technological innovations such as those included in smart grid installation. These include the technical and procedural changes driven by regulation and those created by continuing advances in technology. Technological changes are altering the industry in terms of power production and delivery, and changing the tools and procedures employed in all modern business. Customer expectations, customer skills and access to home technologies are changing the way that utilities do business just as deeply as they are changing businesses like banking and retail trade.

The second set of changes results from the economic recession that began in 2008. Despite official recovery, the recession's effects continue to reverberate in varying degrees around the nation. In parts of the Northwest, it may seem that the recession is well behind us, but the recovery has been deeply erratic, varying widely among communities and industries, as evidenced by power consumption and employment patterns.

For power engineers, then, changes come from two directions: from the change in the science of the power industry and from change in its business environment.

Regulation and Technology Changes

Much of the regulatory change still affecting Northwest utilities arises from the massive blackout in the Northeast in 2003. The bi-national, three-month investigation that followed concluded that the blackout had been caused by a combination of human error and equipment failures. The final report recommended far-reaching changes to reduce the chance of repeating such a widespread event. These included replacing the voluntary standards for industry reliability that were established by the North American Electric Reliability Council with standards that were mandatory and enforceable. When Congress passed the Energy Policy Act of 2005, it expanded the authority of the Federal Energy Regulatory Commission (FERC) and required it to request, approve and enforce new reliability standards for the new North American Electric Reliability Corporation (NERC).[3]

Since that time, the federal government has invested $4.5 billion in federal stimulus money toward the construction of a smart grid, enabling utilities to add hundreds of advanced grid sensors and millions of smart electric meters, which help power companies keep near real-time tabs on the state of the grid.

In fact, the increased demand of escalating regulation was a consistent refrain from those interviewed for this report. These regulatory responsibilities had a big impact on utility staffing and personnel. One common result of complying with these requirements is to combine the traditional core activities of an electrical engineer with those of computer engineers (see further discussion below).

Additionally, some of the technological changes arising from modernizing the grid required current workers to be retrained to ensure accurate installation, maintenance and support. Adding new forms of

electricity generation while utilities also investigate alternative energy sources can increase the need for additional training, as do the enhanced information and safety components of smart grid technologies.

Workforce Issues

Modernizing an infrastructure as widespread as the nation's electrical power system – which is critical to the nation's economy, national defense, and the general population's sense of well-being – is fraught with political and economic difficulty. Workforce issues are only one aspect of this complex undertaking, but these issues are critical because human error played a significant role in the power failure of 2003.

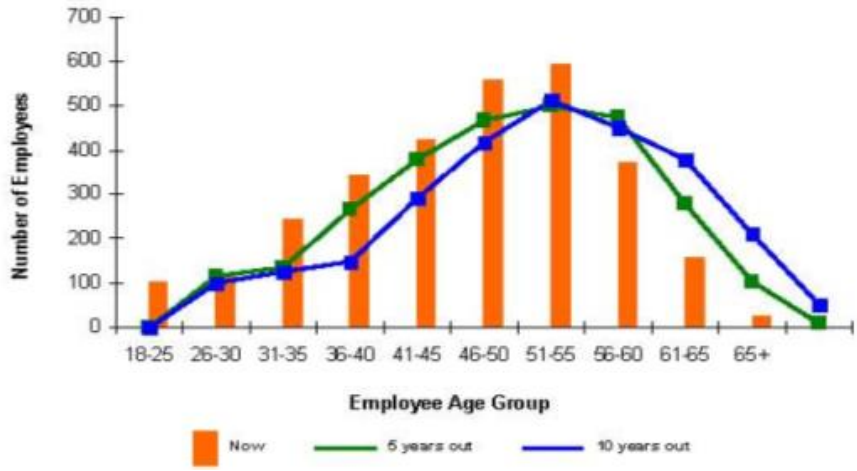
The Aging Workforce

Compounding the need for employees who are adept at managing new technologies is the imminent threat of widespread retirements.

In fact, retirements have been a critical issue ever since the blackout, impelled by a National Science Foundation workshop in 2007, when the Power & Energy Society of the Institute of Electrical and Electronics Engineers (IEEE) founded the U.S. Power and Energy Engineering Workforce Collaborative (PWC).[4] Its charge was to strengthen the U.S. power and energy workforce. In a 2009 report, the PWC noted that approximately 45 percent of U.S. electric power engineers would be eligible for retirement or could leave engineering for other reasons in the subsequent five years (see

Figure 1).[5] A corroborating survey conducted by an industry consortium, the Center for Energy Workforce Development (CEWD), in 2008 found that this decline could reach 40 to 50 percent by 2013.[6] A more recent survey by CEWD found that while the percentage of potential engineering replacements had declined to around 38 percent, due in part to the recession, this nonetheless represents the potential replacement of 10,600 engineers between 2010 and 2015.[7]

These general concerns about the age of the utility workforce are not lost to employers in Washington State and across the Pacific Northwest.[8] Figure 2 shows that among the age cohorts for all industries in the Pacific Northwest states combined, 37 percent of the workforce is made up of employees under age 35 and just 20 percent of the workforce in all industries is age 55 or older. In contrast, for each state's utility sector, just 20 percent or fewer of employees are under 35, while 30 percent or more are 55 and older. More broadly, over 60 percent of regional utility workers are now 45 years of age or older.



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

Figure 1. The Aging Utility Workforce

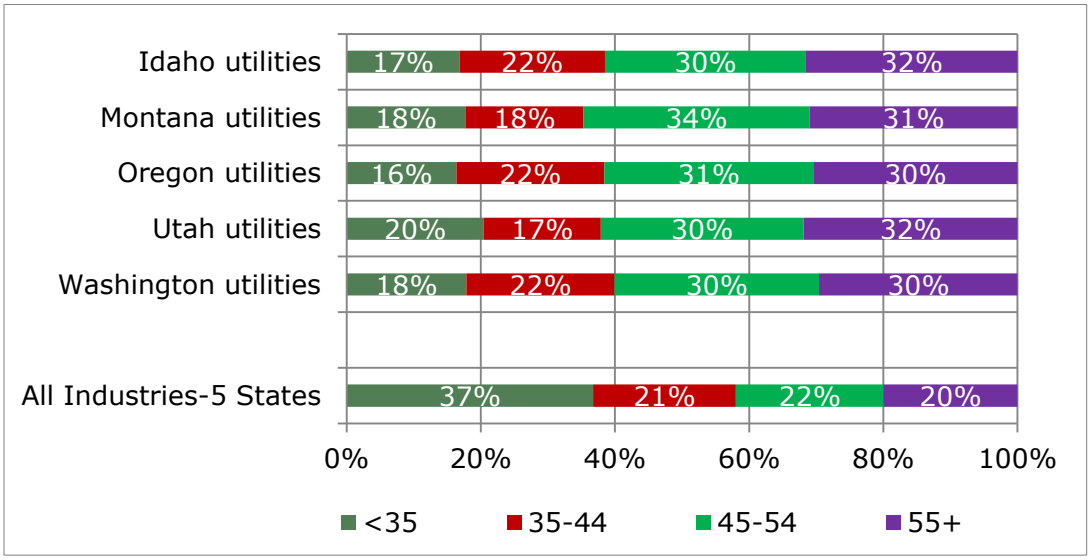


Figure 2. Age Cohorts and Percentages by State: Utilities versus All Industries (five states combined)

University Programs

Unhappily, while the need to prepare new workers was increasing, many university power engineering programs were weakening. This is largely due to the increasing popularity of other electrical engineering specialties, a decline in research funding to support graduate students, and low student interest in science, technology, engineering and mathematics in general.

Additionally, the 2009 PWC report indicated that approximately 40 percent of power engineering faculty at U.S. universities would become eligible for retirement within the next five years, and 27 percent were expected to retire.[9] The gap in the number of engineers available for hire cannot be filled without faculty in place to train them.

This concern is echoed by many industry analysts concerned that the pipeline to replace experienced engineers is not as dynamic as needed, largely because so many professors in university power programs face retirements and many programs have severely limited faculty replacement allotments.

The PWC report noted that overall enrollment of university students in power and energy engineering courses was increasing. The report speculated that the increase resulted from a growing interest among young people in renewable energy systems and green technologies. Yet, the report also pointed to survey results showing that the overall number of students interested in electrical engineering was declining, and that the number of students completing power engineering degrees would need to double over the next five to eight years to meet future employment demand from utilities and other industry sectors. A shrinking pool of electrical engineering students limits the future supply of new power engineers.

All of the industry representatives who were interviewed for this study indicated some level of interaction with the universities where they most frequently recruit new employees. The industry representatives generally understood the need to have good working relationships with engineering programs and their students. How closely they were engaged with campuses varied widely, from those who went only for recruiting and informational opportunities, to those with on-going curriculum discussions with faculty. Most had what they considered a good relationship with between three and six universities where they routinely hired graduates.

Describing the specific challenges they faced when recruiting power engineers, many industry representatives replied that engineers with experience in power planning and operations were the most difficult to find. Industry needs engineers who understand the nature of compliance with new and ever-changing regulations, including planning for upcoming changes. Too many applicants had too little experience, particularly in power generation, and no experience in a large power plant. Others found that the applicants had too little understanding of the challenges of providing urban power service.

Nearly all industry representatives found few applicants with experience that extended beyond the classroom. As one group of engineering managers noted, "We can find HVAC-experienced engineers, but not engineers with large energy plant, power generation experience."

Some utilities have benefitted over the past few years from a stable workforce, as retirement-eligible employees chose to defer their departures due to the recession. Now, as recovery gains traction, employers are finding that they have acute hiring needs but a shortage of qualified applicants and few recruiting experiences to guide them.

Employers also need supervisors for mechanical and electrical engineers across the electrical grid, but cannot find applicants with relevant experience. Some utilities that are now using recruiters are finding that advertisements are attracting entry-level applicants, but not experienced applicants.

Employers also report compensation to be a substantial issue through the entire salary range, although there are industry variations. Federal employers found themselves at a disadvantage for the first few years of an engineer's employment due to very low starting salaries, but their attractiveness increased after a few years with the steady "step" increases of public personnel systems. Other employers seemed able to set starting salaries at a competitive level, but were not able to advance salaries at the same rate as industry partners, contributing to the churn of mid-level engineers.

Effects of Recession

For a while, the economic recession stalled many retirements and made employees less likely to change jobs. Both factors reduced the number of potential replacements required in the short term. The CEWD survey in 2011 illustrated the change:

- **More engineers overall**
  Even during the recession, utilities continued to hire engineers – a 3.6 percent increase nationally – even while the size of the industry workforce decreased overall by 11,000 jobs in the two years from 2009-2011.
- **Fewer employees leaving for reasons other than retirement**
  "Forecasts for annual attrition for reasons other than retirement decreased over previous years from an average of 5 percent to 2.2 percent, most certainly a result of the (recession)."
- **Fewer retirements, which move the looming retirements forward, but increasing the potential abruptness of their loss**
  "The workforce continues to mature – the average age of the Electric and Natural Gas Utility workforce has increased from age 45.7 in 2006 to 46.1 in 2010. Comparisons by age groupings show that the number of employees between the ages of 18-27 has decreased while the number of employees age 53 and above has increased, reflecting both the number of mid-career hires and the number of employees who are waiting to retire."

Other Issues

In addition to the effects of recession, many parts of the energy industry remain affected by the federal budget cuts and sequestration. This is particularly true of federal organizations in the Northwest, such as the Bureau of Reclamation, part of the Department of the Interior that runs Coulee Dam. These cuts appear particularly damaging to internships, which are commonly used as a way for the power industry

to attract, initiate and select potential employees from among engineering students. Federal internship programs, such as the one at Coulee Dam, have been heavily restricted by sequestration.

These conditions form a backdrop to the information gleaned in this study from representatives of the Northwest power industry. The next section presents analyses of employment-related data, future forecasts, and commentary on the workforce conditions these employers face.

Results

This study inquired specifically about employment and workforce issues that affect electric power employers and engineers across the Pacific Northwest. These include:

- Current demand and vacancies;
- The aging workforce, retirement forecasts and industry responses to it;
- Recruiting new workers and future demand;
- Supplementing the skills of new workers;
- Supplementing the skills of experienced workers; and
- Attracting youth to the industry.

It is important to note that this study is based on a limited employer sample, and the data do not account for vacancies, retirements or hiring estimates at other organizations. Thus, the data reported by employers likely understates the actual number of current and future employment opportunities available to power engineers across the region.

Overall Demand

The primary method for measuring overall demand in the industry is what employers report as their current "demand," based on their current openings and anticipated needs. To learn this, we surveyed employers in the electrical power industry in the Pacific Northwest. These employers reported their demand in a critical core of occupations; their responses highlight the need for power engineers.

As shown in Table 2, employers reported 85 current vacancies for power engineers, accounting for 28 percent of total vacancies among the nine occupations studied. The 11 employers who had engineering vacancies also reported that, despite the many challenges of recruiting and hiring qualified power engineers, they expect to eventually fill all but one of the openings they have available. Although it was not a focus of this study, it is worth noting that the electric power industry provides very high-wage employment and compensation for power engineers is among the highest across all occupations.[10]

The Aging Workforce

All the industry representatives interviewed for this study were asked about the retirements they anticipate and how they were planning for those retirements. In most cases, employers were well aware of the issue; most knew how many of their current engineers were or would soon be eligible to retire and they knew the imminent plans of those engineers. Table 3 illustrates employers' five-year retirement projections across several occupations, including power engineers. Over 20 percent of current power engineering workforce is expected to retire over the next five years. Further, the 15 employers who estimated future retirements and indicated replacement values for power engineers indicated that they expect to replace all openings.

Table 2. Current Vacancies and Hiring Expectations by Occupational Group, 2013

Occupational Group	Number of Vacancies	Number of Vacancies Employers Expect to Fill	Number of Vacancies Expected to Remain Unfilled
Operator	28	28	0
Mechanic	15	15	0
Electrician	39	25	14
Technician	24	22	2
Line Worker	60	47	13
Power System Operator	18	18	0
Power Engineer	**85**	**84**	**1**
Customer Service Representative	51	50	1
Energy Efficiency Program Manager	3	3	0
***Total* in these occupations**	**305**	**275**	**30**

Table 3. Anticipated Retirements in FTEs per Occupational Group, 2013-2018

Occupational Group	Number of Retirees Projected	Percent of Current Workforce Expected to Retire
Operator	152	14.6%
Mechanic	150	16.4%
Electrician	251	26.0%
Technician	158.5	18.6%
Line Worker	386	18.2%
Power System Operator	66	17.0%
Power Engineer	**210**	**20.5%**
Customer Service Representative	144	8.8%
Energy Efficiency Program Manager	38	22.9%
Total	***1,555.5***	***17.0%***

Naturally, employers realize the potential damage caused by losing so many senior staff in a short period. In fact, *no employer reported being unaware of the looming problem.* Many have developed strategic plans for replacing their veteran staff as they retire. How much planning – and how well it has been absorbed at the operational level – varies, as evident in the comments of industry representatives with whom we spoke.

At one company, for example, a unit manager stressed, "We have a succession planning culture. We have had for about 10 or, really, 15 years. We always try not to get caught with retirements or people leaving and us not knowing how to backfill those positions."

Another employer, for whom senior staff members are particularly crucial, reported, "We have a hiring plan approximately five years in advance of need. It's updated annually, and it's fairly seamless. And for senior staff we have a succession plan. We target those, but of course everyone will be replaced at some point."

More often, however, while employers were thinking about the issue and most were aware of their employees' ages, their approaches to the problem varied in different units or were largely *ad hoc*. Describing a common condition, one representative said, "It's really up to department managers. We do have a system for filling critical needs, but it's mostly up to department managers to determine how to do this. It's up to them."

Employers frequently referred to the importance of their internship programs. A representative response was, "A few years ago, we started a program of hiring seven interns each summer to evaluate and expose them to the industry. The number had fluctuated before with the budget, but for three to four years it was seven consistently. We followed that with a plan to hire young engineers, even creating positions for them to backfill potential retirees. We prefer to hire to a specific position."

Many employers rely on grooming interns as a way to fill openings, although filling entry-level positions does not address the retirement of a senior engineer unless, as many noted, the entire spectrum of staff is also prepared so they can be promoted to fill senior positions.

A few managers, primarily with larger employers, also mentioned that their succession policies have evolved since the issue of retirements arose. One manager noted, "Our succession planning has changed and evolved, of course, as staffs have changed and different people have been involved. And it is driven by the needs of different sectors (of the utility), as some parts have more needs than others." These variations may be practical, but they make it more difficult to observe and report a singular approach to addressing retirements.

At several utilities, section managers admitted that while their human resources staff might have plans on file, operational reality could be different and usually varied with each retirement. When faced with openings and no applicants, what did they do? Some changed the work so it could be done by less experienced engineers. Some hired new graduates and trained them. While these employers have investigated hiring from other industries, only a few have done so successfully. Most reported that the work was too dissimilar. "It works for other trades, such as electricians, but not for engineers."

A Recycled Asset: Retire/Rehire

One obvious way to address retirement is to hold on to the employee who is eligible to retire for as long as possible, providing incentives for deferring departure. Another strategy is to utilize the employee after retirement to help address the longer-term challenges associated with the transition of skilled employees. Among the targets are retirees who can be rehired on a part-time and/or project basis or consulting organizations that have hired retirees.

Because retirees offer the benefit of institutional knowledge, many employers report using them to offset the lack of experienced engineers for mid-career positions. None of the respondents reported using retirees as a substantial part of their workforce; rather, many seemed only to utilize particularly skilled or unusually experienced retirees. A common example: "We use retirees just a little bit. Two examples are a former employee who is a mechanical engineer and one who was always a consultant to fill vacancies on an as-needed basis."

A few employers described the relationship between consultants and retirees. When senior engineers retired, skilled mid-level people were not always available to fill those positions. As one employer explained, "You hope to have somebody you've been working with who can step into the role. But if not, then we recruit – advertise in the larger engineering community first. But if that expertise is just not out there, then we look for temporary solutions until we can train up an internal employee. Sometimes we can use a retiree on a temporary basis."

At least one employer appreciated the contributions of retired employees so substantially that they were given emeritus status and a workspace was maintained for them. As a result, said this employer, "…Many stay around half days. They are not rehired, but also not doing regular work. They add credibility to what we do."

Hiring Contractors

Many employers reported utilizing consultants to help address staffing needs. "We use contractors quite a bit. We have contractors with whom we work regularly and they send us engineers from all over: Florida, Chicago, Denver. We use them for engineering, as project managers, for support positions."

Frequently, contractors were relied on to meet temporary needs for which permanent staffing was not required. A common example was the need to make changes in workplace processes to comply with regulations. Once these changes were made by consultants, the on-going duties were absorbed by regular staff. "We have a lot of work right now with license implementation. There's just no way we can do all the design work for the floating surface collectors, for the hatcheries, for that type of work, so we are trying to stay involved and managing (the contractors) with our own in-house engineers and doing as much design as we can, but there is just a level we cannot accomplish. So, yes, we are hiring consulting engineers. And they are having similar (staffing) problems!"

In other cases, costs motivated the hiring of consultants. Many employers reported that consultants were hired more cheaply than permanent staff. One employer spoke specifically of hiring a consultant in order to use one of their staff, who was later hired directly when the budget permitted. Others mentioned similar examples of hiring staff from consultant companies. "I hire the best I can find, I don’t compromise. If you do, you pay for it later. The consulting firm appreciated having the work we gave them, but they didn’t appreciate me taking most of their best people!”

One reason cited for the "poaching" of experienced staff was the cost of mentorship and training, which had suffered budget cuts in recent years.

> “We used to hire a bunch of new engineers, rotate them around the company, but then hiring leveled off. We may get back to that model because we have to – we can’t seem to find (experienced engineers) on the market – but for now, the financial realities just don’t allow for us doubling-up on hiring (meaning, hire and put with mentor for three to six months, for example, to train and do knowledge transfer). We just can’t double up on hiring to do student-mentoring anymore.”

Attracting and Preparing New Power Engineers

Extending relationships with retirees is not a permanent solution to a personnel shortfall, and the situation is likely to worsen soon. As CEWD noted in 2011, the current prolonged employment of senior workers is likely temporary because the economic recovery may make retirement feasible once again. That may, in turn, cause employers to begin attracting mid-career engineers away from each other. No matter how much churn occurs, new engineers are needed and the supply of power engineers in the pipeline becomes more critical.

As part of this study, employers were asked about their anticipated hiring in the next few years in nine occupational groups. The results appear in Table 4. Although projected new hiring among these employers is very modest, the anticipated hiring is highest for power engineers.[11] When combined with current vacancies and especially employers' estimates for retirement replacements, the data further emphasizes how critical the availability of new power engineers will be.

Recruiting New Engineers

In the study interviews, employers were asked specifically about how they recruited power engineers and the difficulties they faced doing so. Table 5 summarizes their responses.

Overall, employers reported that power engineers were the most difficult employees to recruit and hire. Several noted that the competition for experienced power engineers (mid-levels and above) was especially intense, and that younger engineers – especially electrical engineers with power experience – were frequently lured to other companies by higher compensation, better work conditions, or other factors. Employers noted that these young professionals tended to be very mobile, and that high demand for this occupation meant that qualified candidates had many employment options both within and outside of the energy industry.

Cultivating Relationships with Universities

Given these reported challenges, employers were also asked how they found their new, entry-level hires. Most immediately cited a small number of engineering programs they worked with regularly and recruited from most often. The University of Washington and Washington State University were frequently mentioned as the regional public universities producing the most engineers. Others named Seattle University, Gonzaga University, Idaho State, Portland State, and a small number of schools outside the region (Howard University, for example). And one employer, with a particular need for employees who would need to relocate to a very rural environment, preferred to recruit from Eastern Washington University and focus on students from rural backgrounds.

Table 4. Projected Staffing Change in FTEs per Occupational Group, 2013-2016

Occupational Group	Net Growth in FTEs	Total Current Employment in Occupation	Percentage Change Next 3 Years
Operator	2	1,039	0.2%
Mechanic	18	912	2.0%
Electrician	6	964	0.6%
Technician	1	854	0.1%
Line Worker	1	2,120	< 0.1%
Power Systems Operator	0	388	0.0%
Power Engineer	**21**	**1,027**	**2.1%**
Customer Service Representative	0	1,635	0.0%
Energy Efficiency Program Manager	1	166	0.6%
Total New Employment	***50 FTEs***	***9,105***	***0.5%***

Table 5. Recruiting and Hiring Challenges

Position	Challenges
Power Engineers	Requires four-year engineering degree, usually electrical engineering
	Hardest to find
	Prefer power generation experience
	For smart grid work, need IT and computer science/software and automation knowledge and related skills
	Requires multi-state recruitments to secure qualified engineers
	Experience high turnover; many newer graduates, in particular, stay for only 3-5 years
	Lack of preparation requires lengthy in-house training progression

Two employers expressed related concerns about the intensely technical focus of engineering programs.

- One was concerned that there is no effort to address a key characteristic of Generation Y, which is the desire to find their work meaningful and to contribute to change. The employer argued that this case could be made more strongly by faculty and through engineering programs. However, these programs are usually so heavily focused on the technical aspects of engineering that the personal values and societal benefits associated with engineering education are not adequately emphasized for the millennial generation. This deficit in engineering education is likely leading potential engineers to turn elsewhere for that satisfaction.
- The other employer was concerned that over-emphasizing technical skills may push out candidates who could do the work required and might, in fact, bring more well-rounded characteristics to their jobs. These are characteristics the industry is actually looking for, such as having a team-based approach, interdisciplinary skills, project management skills, and broad knowledge of computer, IT, and communication software and applications.

The Role of Internships in Recruitment and Pre-Training

Nearly all the industry organizations engaged actively in internships to attract engineers to the field, provide practical experience in the industry, and provide a first look at potential future hires. Those employers that did not hire interns were restricted by budget constraints.

Despite the important role that internships play, especially in light of the potential shortfall of workers, the number of engineering students for whom internships are available seems small. Typical responses included:

- "We will have two or three per year."
- "Typically we hire four interns. We screen an application, check GPA, etc. Then we interview, introduce eight applicants to staff, and we will hire four."

A few employers were able to do more:

> "We hire 20 summer interns. They are work assignments and the interns apply like they would for a job, but we expect less of their qualifications. We provide a mentor, but nothing more formal than that, except that they should participate in our summer lecture series, as all staff do, which are one-hour lectures on a variety of topics. Any of us can sponsor an intern, so the focus is on what the project needs. And we also have graduate program internships of three to six months."

As might be expected, budget allocations determined the final number of interns. At least one employer found that pre-planning helped them identify how many interns they were likely to support. If they were planning to assign work from an on-going project, then the funds already assigned to that project would cover the internship.

Those who mentioned recruiting from specific schools reported that, in their opinion, the strength of interns from the programs they targeted reflected the quality of the engineering program there. Many reported recruiting nationally, particularly those employers who expressed concern about recruiting minorities. Still, several also expressed dismay that successful recruitment of interns or new graduates did not necessarily correlate with successful retention, particularly for those employers with lower pay scales and challenging community environments.

One employer also reported working specifically with the Multiple Engineering Cooperative Program (MECP), typically sponsoring three MECP engineers per year. [12] "And we do that in generation, as well as substation design areas."

Interns were usually placed throughout the company. Most, in fact, were "brought into specific departments" and matched to specific projects. "We hire interns every year – across the company, in many disciplines." The assignments varied, but all interns were required to get at least some field experience. In a few cases, interns were intentionally rotated through a variety of departments to extend their exposure, but most were "exposed" to different work areas rather than formally rotated. "They must also be exposed to other units, at least one, and take tours and participate in detailed project discussions."

In a few cases, the internship was a structured program, utilized across the company. In more cases, however, interns were hired as needed and used where projects could utilize them. "Historically these have been project driven, so we look for projects during the year that would suit an intern well. (We) might be looking at efficiency unit data, it might be inventorying asset management related, it varies, and if we have a solid project we bring an intern in. Usually one per year, two maybe last summer." For a few employers, that meant planning throughout the year to identify which projects could utilize an intern. But for most it meant a commitment to using interns who, once hired, were matched with available work.

According to the employers who were interviewed for this study, internships were not usually structured and depended on matching interns with appropriate projects after they had been selected. As one employer noted, "To my knowledge, we don't have a written plan that would describe what we hope the intern goes away with. We should, but we don't." Some utilities had specifically defined programs, focusing on corporate business practices, for example, but most engineering interns were simply assigned to do current project work. And most firms found the internships fruitful: "We have only ever once had an intern who clearly wouldn't fit in our culture. All our other interns, we've had no difficulty and have hired several."

Lack of formal program definition did not necessarily mean lack of forethought, however. Several employers described the intern hiring process as the midpoint in a planning/hiring/supervising continuum. "Interns are planned for ahead of time so the unit that will be getting one is part of the interviewing, takes responsibility for the intern, and takes ownership of delivering at least as much value to the intern as the intern might deliver to us."

While most organizations may be committed to recruiting and employing interns, the experience of each intern could vary widely, even when with a single employer.

Many engineering units plan for their summer interns throughout the year, examining projects for opportunities that might suit a student, and then requesting an intern for the work. Other worksites recruit interns, and then as they interview the applicants, determine where they might be most useful and most successful.

> “We use interns in specific areas: substation engineering, protection and control, and planning/operations. We are targeting more juniors, and depending on the coursework they have taken – and if they have some power-related courses – we assign them. But we tell them where they are to be placed, who would be the mentor, and ask if that is what they want to do. We get their input into the assignments. The internship typically lasts 13 weeks. We do two batches: normally WSU students start early, in the middle of May; later, UW students come on as school ends.”

So important are internships to students that some seek to repeat the experience. When employers were asked if interns were allowed to repeat, responses varied. One employer told us, "We've had a couple return. We don't have a formal policy to try to hire different people and spread the wealth (of opportunity) around, but there is some consideration of not hiring interns too early or too late in their

studies, so there is probably one good year or maybe two when this is most valuable." And sometimes interns were not only extended, but were hired directly: "In two cases, we extended longer than summer and finally just hired them. I have a case like that now."

And the interns are right about the importance of the experience. Almost all employers who used interns reported a high likelihood of hiring those who proved themselves. As one noted, "Our internship is very successful. We have hired about 25 percent of them, usually two out of every summer's seven."

Every industry representative with whom we spoke reported at least some difficulty hiring engineers. The most common difficulty was finding experienced engineers, and particularly those with 15 or more years of experience. Many employers found salaries a hindrance, particularly among public entities that did not feel competitive with private industry. This was particularly true when competing for PhDs or even engineers with master's degrees. Entry-level hiring seemed comparatively easier.

> "Yes, we mostly hire younger and train. We prefer to find PhDs and industry experience, but it is rare. And only for three or four years are our salaries really competitive. So, we hire out of college, with all the experience on paper, no field experience. It doesn't cause any real problems, except that we have to provide that knowledge and make careful benchmarks for developing experience."

Supplementing the Skills of New Workers

Many employers have created specific processes for adding to the skill base of newly hired engineers. Most were not formal training programs; rather, they were typically unstructured training experiences, relying on current workers to provide varying degrees of oversight and mentorship. A few employers remarked that they found this requirement acceptable. They seemed particularly understanding of the breadth of material that a baccalaureate-level program must cover and sympathized with the need to make the bachelor's-level instruction generic enough to serve a diverse industry. They were not dissatisfied with the need to seek master's-level candidates for power engineering specializations, even accepting that graduates with master's degrees still required additional training in the specifics of their organization. As one employer noted, "Even with a PhD or master's, we find more expertise, but not experience."

Most new hires are young engineers. Although internship experiences were described as an asset for entry-level applicants, they were not prerequisites for hiring. Given the small number of internships apparently available, that would be untenable. Thus, most new hires arrive without much – if any – background in the industry. In fact, many industry representatives lamented the lack of industry exposure among new hires.

Therefore, in our interviews we inquired specifically about the preparation of new engineers. We asked about the technical preparation of graduates, but also about their general preparation for working in the electric power industry.

Employers indicated strong agreement that the graduates hired from Pacific Northwest universities and a select number of out-of-region schools were well prepared in basic engineering.[13] Some employers

commented that the new engineers recruited from schools where they had cultivated relationships were well prepared. There was equally strong agreement, however, that new graduates were far less well prepared for work *in the power industry*. "Power system engineering under electrical engineering is not taught at enough schools," said one employer. It was generally observed, too, that this largely resulted from student choice. "EEs want (courses in) microelectronics, not power."

A few employers noted specific issues about internships that others did not mention.

- One observer noted that the issue of hiring, both for engineers and interns, is particularly American. "We have a great shortage of U.S. citizens available in the industry. It's not sexy. We look at the students of 11 different nations, countries paying them to come here to train and then return home. Two-thirds of my staff are foreign nationals, and it might be more except that security clearances require citizenship, at least in our setting, for which cybersecurity, federal and state security clearances are required. But recently we had posting with 16 mid-career applicants, and only one was a U.S. citizen."
- A related issue was candidate diversity. "We make specific recruiting efforts for women and minorities. It's just that the pool's not that deep, so when someone appears, they often leave here relatively quickly. The real problem is the general supply. They get multiple offers."

Most of the concerns about preparation for the electric power industry fell into two categories:

- Technical skills, including those particular to utilities and those likely required by many employers; and
- Social skills, likely affecting any employment, but a strong shortcoming for the energy industry work.

Technical Skills Lacking Among Young Engineers

Employers described technical skills they saw as lacking among young engineers.

Power Industry Specificity

The most common complaint among the employers who were interviewed was the lack of exposure to and experience with power industry equipment, processes and requirements. Many employers observed that "fundamental power system engineering principles" had shifted out of undergraduate programs and now resided in graduate-level studies. Most acknowledged that the electrical engineering undergraduate program was demanding in order to include all the core requirements, but the most senior interview participants felt that was acceptable. "When I was there, EE was way more credit hours than other programs, because you really needed the time (to cover those essentials). Things like basic power flow and sequence components training seem to be lacking at undergraduate levels. We're getting MSEEs now with that background, but I did most of that in undergrad courses."

Many noted that some graduates lacked a "broad, complete foundation in power system basics." One noted, "System protection and power flow are big, important topics to (cover)."

In related comments, employers observed that new graduates were "unfamiliar with the equipment. They haven't seen it before except in textbooks. They have textbook skills, but it takes them awhile to distinguish between bushings, insulators, and other equipment pieces." Other practical applications were also too rare. "Reading drawings; making drawings. They are taught theory, but not how to put together a contract preparation or how to put a design on paper for a bid."

Computer-Related Knowledge

Several employers considered the division between computer and electrical engineering too rigid. "Our electrical engineers need more computer-related knowledge and skills. That's where the industry is going. The electrical engineering core is not functioning unless the engineer has enough computer skill to know how an electrical control device is going to work. Otherwise, you are reliant on someone else."

They also found that while younger engineers were comfortable using computers and electronic devices, they tended "to trust computer tools too much. They assume the result is correct without doing a common-sense check."

Although these observations might seem contradictory at first, the uncritical reliance on computer-generated results may indicate a critical lack of expertise.

General Business Practices

For many, the most critical problem was the lack of basic understanding of the business world. On one level, the problem was lack of any kind of workplace experience, with the result that new hires had no idea how to behave in an office environment (see below). But even more critical was the failure to understand how engineering and the business of the organization intersected, and what responsibilities that entailed for them. Several strongly conveyed that their new hires knew nothing of the business and legal processes that are critical to the industry, and had no appreciation that those principles were "at least as important as their engineering products."

> "We have a really strong interest in not becoming extinct. (That means) producing power for attractive rates and with high reliability and, therefore, we have a need to talk at least as much in business principles as we do in engineering principles."
>
> Pacific Northwest employer

Others noted that, while some students had taken courses in engineering economics, somehow it did not prepare them for how decisions were made in a business environment. New engineers did not commonly deliberate questions such as "Is this cost effective?" or "Is it too radical for this customer?" according to the employers. As one employer reported, "Most of what we have to teach is in terms of contract research: "Who are our customers? What difference does that make?" Many of the employers we interviewed wondered why new power engineers lacked the ability to answer practical, useful questions such as these, which should be included among the skills they learn as part of their college degree.

Use of Data, Statistical Analysis and Presentation Skills

In a somewhat related observation, employers found that new engineers were not prepared to use data to explain their recommendations, particularly in a manner understandable to the general public. They felt that "data analytics, that's getting to be a big and important function, big for our industry." And that

"data management skills, pulling the data and presenting the data to non-technical people" was essential. "We have 825,000 customers, each one has a smart meter on their house and we're getting tons of data from them. We're getting tons and tons of data, and we need to make sense of it. Both data organization and management, and the analysis process" were deemed critical skills.

Respondents carefully distinguished this from computer skills, noting that what they needed from their power engineers was not what IT staff were accustomed to doing. ""IT likes to think its function is data organization, data management, but they don't get the operational side of our business well enough to do it so that it is functional for us. We need to partner with them, but a lot of that will rest on our staff people: we need to extract (our own data), put it into usable format. IT should manage the data warehouse and big files, but we have to be able to manipulate and make sense of the data. (A generic IT person) doesn't know what to look for."

Other Communication Skills

Power engineers need to know how to "translate" technical data for consumption by the general public consumption, and for the trades and crafts employees with whom they work.

Communication skills were commonly cited as an issue, although they are for most employers of every kind of employee. Several referred to the introverted nature of many engineers, who would prefer to work alone or only with other engineers. Few new hires were accustomed to making presentations or even participating in group discussions. "Engineers (who) can talk and communicate seem to be few and far between."

The most important communication skills mentioned by these employers were related to communicating technical information to the public and to trades workers. Communicating with the general public was often about explaining new products and processes; communicating with other workers was related to providing instruction and persuading the other workers that the engineer had the right answer to a problem. For some employers, this was a vital issue: "Engineers have to convince workers of the solutions they've decided to implement."

The lack of communication skills hindered new engineers' career progression. Mid-level positions are often characterized by more shared responsibility and management duties. Without communication skills, engineers were less likely to rise in positions of leadership. "Here, we have mostly business leadership because it is hard to find engineers who are as socially aware as they are technically skilled."

Project Management

Other general workplace and career preparation skills that new engineers seem to lack involve project management. Even without personnel management responsibilities, power engineers were commonly assigned to run projects, yet many managers found their project management skills weak. "Budgeting, scheduling, and organizational skills generally" were often cited.

Basic Workplace Skills

A large number of employers pointed to even more basic skills that new engineers lack: very basic social skills and common workplace skills, often termed "soft skills." The employers talked about the nature

and culture of the power energy workplace. "Utilities are conservative institutions, staid. . . . Some new hires are surprisingly rude, self-absorbed, and lacking in social skills. I think interdisciplinary studies would help them consider other points of view, other ways of being. They would go further professionally and have more career opportunities with (better) social skills."

Teamwork and Work Habits

Some employers reported personal knowledge that engineering programs were trying to increase students' exposure to teamwork through projects, but they wondered if the commitment was serious enough. They still found too many graduates who did not expect or want to work with others. "They are reluctant to work on team projects that involve other trades and engineering disciplines."

Many employers believed this lack of preparation for the realities of the workplace was a disservice to students and recommended including a basic workplace readiness component to engineering coursework. "(Some kind of) organizational behavior course (is needed. Preparation for) Engineers as part of a larger company is especially important for graduates without any significant working experience. Just a little primer would be an asset."

While few critics considered these work habits more important than basic engineering skills, many reflected on the demand placed on employers to develop these skills in new hires and the enormous advantage of job candidates who could demonstrate these workplace skills.

Teaching Industry-Specific Skills to New Engineers

Most employers had grappled with the best way to impart industry-specific skills in new engineers and arrived at the same conclusions:

- Provide mentoring by experienced employees, and
- Assign new engineers to diverse projects.

Provide Mentorships

Faced with a common array of shortcomings in new engineers, most employers reported relying on more senior staff to help initiate new employees. Most referred to the system as "mentorships." Although the term "mentor" was most frequently used to describe the relationship between staff and interns, much of the initiation of new hires paralleled that strategy. Most employers reported assigning newly hired engineers to a lead staff or manager. "When a new engineer comes on, we assign (them to) a senior engineer or principal engineer and they work together so the senior can review their work and teach the process."

Some also provided in-house training, mostly focused on company procedures, but relied on mentors to explain and supervise technical expectations. "All technical products prepared by people who have not yet been licensed are reviewed, so that reviewer is responsible for mentoring. It's part of their duties to make that investment in our future. *And we evaluate senior employees on their mentoring."*

Diversify Assignments

New hires are often deliberately assigned to diverse projects to provide cross-training in multiple departments and functions. They commonly rotate among experienced engineers, directly paired or as a team, for active mentoring and guidance. This critical instruction is provided as on-the-job training. For many employers, the approach is not entirely new, but has become more deliberate and strategic than in the past. Many senior engineers reported doing assignment rotation early in their careers, but remembered their experiences as involving a smaller number of people. Now firms are trying to increase the exposure of new engineers to projects across the organization, both to expand the scope of the recruit's experience but also to utilize the best mentors and instructors, regardless of their specialty.

Only a few of these programs were formally defined. Most were impromptu assignments. In addition to providing a mentor and exposure to a variety of assignments, some move the new hire gradually from simple to more complex projects. "Typically, we try to put new engineers in new service area groups so they can start with residential and small commercial buildings. Then, once they have more experience, they move to where they can get more experience. (It's) not a program, though, just do it on an individual basis."

In some cases, this stair-stepping approach to increasing responsibility is done instead of mentoring, with the supervisor of each unit responsible for the new engineer's work. "We tend to give them smaller projects to start with. Don't directly assign them a mentor, although they are typically mentored with senior engineers since they usually don't have a license so the senior engineer has to sign off on their designs. Designs are reviewed as they go through a project with more senior engineers who are going to stamp the design and sign off, and then many of our sites are dual purpose so we generally train by doing small projects that develop into larger ones."

Retention and Retraining Issues

The retention of new hires through mid-career engineers has been a consistent issue for the industry, although it waned somewhat during the recession. Indications are that the industry may lose 10 to 15 percent of its engineers per year for non-retirement reasons. Reasons for this include difficulty keeping salaries competitive and challenges due to work location.

While a few utilities have found themselves able to "sell" the advantages of small town and rural life as benefits, others have found that engineers recruited from urban areas often wish to return to them. Even utilities in cities such as Tacoma reported that younger engineers often left after only a few years, preferring urban Seattle or returning to the East Coast.

Interestingly, several employers noted that former interns were more likely to stay, reflecting the substantial benefit that resulted from candidates who knew more about the organizations – and the lifestyles – to which they were committing.

Supplementing the Skills of Experienced Workers

Finding the most effective way to nurture and sustain mid-career engineers will continue to be critical retention and development issues as senior engineers retire.

The challenge of replacing mid-career engineers was mentioned by many of the employers we interviewed. Cost was one issue, but so was simply the length of time it takes to gain relevant experience. Many of these employees have specialized experience in a critical aspect of the industry, but lack well-rounded, mid-level skills and experience. One employer noted: "(These positions) can be very hard to fill because people with those skills aren't readily available. They're highly-skilled specialists."

> "We can't hire all newbies just out of college. What we really need is more in the middle, experienced people, but we just can't find them. We're already stretched. We can't bring a bunch of new people on board and train them up. It's especially hard in key technical positions to hire for experience."
>
> Pacific Northwest employer

Upgrades and Mid-Career Training

Mid-career training is important to retain experienced power engineers and also to compensate for the loss of institutional memory due to the retirement of senior engineers.

Employers acknowledged that mid-career engineers were often lacking computer skills – from programming to basic computer user skills—that were sometimes were more common among younger, less experienced engineers. One employer noted, "Advanced software skills, database and programming skills; pulling data into Excel, presenting the data to non-technical audiences, report writing and technical documentation – (this is often) harder for senior engineers than juniors."

This may seem contradictory at first, but while employers often found new engineers lacking in some technical skills, particularly those related to explaining and presenting technical materials to a general audience, they found mid-level staff had not kept up with computer-related developments. Their skills too often were underdeveloped or outdated.

Another critical aspect of upgrade training is compensating for the loss of institutional memory due to the departure of senior engineers. As one employer noted:

> "Employees may have experience at another utility, but we are lacking someone with 20-30 years of experience with *us*. We had an early-out package in the 1990s and lost some of our most senior engineers. Institutional knowledge went with them. That was worsened by turnover in some groups, like protection and control, and low tenure resulted."

These losses have caused employers to redouble efforts to retain mid-level staff, even while "poaching" by other employers—and sometimes even among their own departments—increases.

In-House Training Programs

As a result of these conditions and because some larger firms have managed to retain formal training programs, a few employers reported providing structured in-house training to address common employee development needs. These internal trainings were frequently described in terms of generic skills, such as communication and planning skills. "(We) also have an (internal) offering 6-12 times per year, sponsored by the civil side of the house, to talk about project management areas (open for all)."

But even these companies noted the current budget constraints made training difficult to achieve. Some noted that training was hampered not by a lack of a training budget, but because they were too short-staffed to allow time for training. One manager noted, "What drives engineers to learn is having a problem to solve, so you do that from experience and with mentoring. If there are skills they are lacking, then we will look for that, for a specific technical skill (to provide)." However, those specific skills were generally gained on the job.

The lingering effects of budget constraints meant employers were looking to minimize training costs, even while many recognized a need for continuous growth by this valuable group of employees. A few tried to give employees time to learn, rather than providing training. "Essentially we provide on-the-job training…We don't invest a lot in long-term training, but sometimes in short-term, on a case-by-case basis. It's not so much skills development as exploring a new knowledge area. We'll often allocate "thinking time," a three- to six-month period to try out a new idea." As may be expected, these practices were most common among employers who conduct the most research and development.

All employers also reported relying on external training providers, such as vendors providing support for new equipment. A few reported supporting employees to attend external courses, including a few who sponsored employees to attend power system courses outside the region. Most often, this practice was mentioned as part of the pursuit of employee promotion and project requirements. "For example, we had a very knowledgeable engineer on the generation side, who needed better modeling skills, so that employee attended training on power software and built those skills. That was our need, driven by compliance."

Employers also mentioned the specific skills most needed by mid-career and senior staff, as compared to those needed by new hires.

> "Change management, which seems hard on older engineers, learning to accept doing things differently."
>
> "Technical writing seems to be a bigger problem for experienced engineers than new hires."

Attracting Youth to the Industry

All of the employers interviewed for this study had some form of internship and working relationships with the engineering departments at the state's four largest public and private engineering schools. Discussion of internships naturally led to discussion of the longer pipeline and the exposure of younger students, including high school students, to the industry. One employer noted:

> "One of the reasons we sponsor internships is students often think the power industry is a dying industry. Juniors (college interns) often say 'a project I worked on was beneficial to changing my mind about the industry.' I know the line sections (line workers) demonstrate to high schools what the power industry is about, but I'm not sure how we do. Need to think about it more."

Several employers commented on the power of internships and student outreach to change the image of the industry. The former persona of the industry as being staid and uninteresting is being replaced by one that promises new learning experiences and the satisfaction of working in a challenging, high-tech environment in a specialty that also "makes a difference" to society. One employer added:

> "From a generation side, if we could somehow convey the diversity of the work. They really do get a lot of job satisfaction because you may work on fish rearing one day, hydro units the next day, the sites are all beautiful to go to, you have the potential to do automation with computer programming and cyber security – there's always something to learn, a lot of job satisfaction, and there's just a lot of things you can do, you never get bored, and trying to convey that to students – I'm not sure how to do it other than bringing them here to see what they get to work with."

Student outreach to local secondary schools also provides opportunities for employers to target engineering as well as the full range of careers available in the electric power industry. Field trips and projects connect students with employees in the workplace, and also serve as a vehicle for emphasizing the importance of academic preparation in science, engineering, technology and math (STEM) for energy careers. One employer noted:

> "In (our area) there is a STEM high school that requires students, as part of their process, to find a role in an organization and do work assignments. We have had two for a full year. They worked with computer technicians because that was their interest, but we would do it again. We also do career fairs. Staff rotate responsibility with the local middle and high schools, usually twice a year."

Yet, for some organizations, budget constraints have limited how much outreach they are able to do. The impact of limited funding on student hiring for one large public employer was especially pronounced:

> "We work to help high schools by talking about engineering as well as trade and craft occupations. We had also planned to hire local students for summer employment again this year, but the federal hiring freeze ended that. We have done it before. There used to just be three or four, but last summer I think we had 12. This year we were going to have 13."

Conclusions and Recommendations

The power industry has changed since the 2008 workforce study of electric power employers, and it continues to grow more complex. Some of the most critical workforce problems noted then, including looming retirements, stalled during the recession but did not go away. Other problems grew worse, as engineering departments faced the same economic cutbacks that undermined much of higher education, compounded by retirements among engineering faculty.

As a result, the industry still faces critical workforce challenges. Although electrical engineering enrollments appear to be up nationwide, new industries increasingly compete with traditional power generation for graduates. Employers report that only a small number of graduates have any experience with the power industry, perhaps least of all with traditional hydropower generation and distribution. And many engineering students are foreign nationals, who cannot meet security clearances required by some industry employers.

Yet the industry needs workers now and in the future. While retirements abated during the recession, the senior workers did not get younger while waiting for the economy to recover, and the potential for substantial loss of experience in the industry workforce remains. The data collected for this study shows that while employers project a modest number of new hires in the near future, at the time data was collected 85 power engineering vacancies were reported, most at the mid-levels of experience. Perhaps more important is that employers expect 210 retirements to occur among current power engineers by 2018, which is more than 20 percent of the current power engineering workforce. It is worth noting that the study sample of 18 firms did not account for retirements at other organizations; thus, the results likely understate the actual number of retirements in Washington and across the region.

Further, jobs continue to grow more multi-faceted, reflecting substantive change from smart grid installation and regulatory increases. These changes affect the sheer quantity of knowledge and skills required of new power engineers, and continue to increase skill demands among mid-career engineers. In particular, employers uniformly reported that new power engineers lack exposure to the industry and, thus, basic understanding of its requirements. They lack many basic workplace skills, including teamwork skills, basic workplace etiquette and business basics. Most are very familiar with computers and software, but not the elements of smart grid operation. Too few know how to generate and use data, and fewer can present data to a general audience. Yet, these are considered core skills by every employer.

Mid-career power engineers, who are needed to step into senior positions as retirements occur, have too often developed specialized skills but not the more well-rounded proficiencies required for senior leadership. Frequently they have underdeveloped computer and data skills, and not all welcome opportunities to broaden their range of skills.

Employers report utilizing a variety of methods to address these issues:

- Retaining senior staff through retire/rehire and emeritus options.
- Relying on contractors to fill temporary workforce needs.
- Utilizing college internships to attract engineering students and expose them to the industry.

- Using mentors and rotating assignments to initiate new engineers to the industry workplace and culture.
- Working with the K-12 system to attract younger students to the industry.

Recommendations

The employer data collected for this study shows that there is strong current demand for qualified power engineers, and that employers are also hiring at the entry-levels to fill current openings due to labor shortages. Although employers do not anticipate adding a large number of new power engineer positions over the next few years, a sizable number of current engineers are predicted to retire, and employers plan to replace all of those openings.

Because this study did not include all power industry employers, and because trained power engineers are also in demand by consulting organizations, technology companies, manufacturers, suppliers and other industry sectors, it is likely that the true future demand for power engineers in Washington and across the region will exceed the totals identified in this study. Therefore, one recommendation is that Washington State University, as well as other regional institutions, should continue to develop, enhance and expand power engineering program capacity so that the supply of trained engineers is adequate to meet current and future demand in the power industry and in affiliated industry sectors in Washington and across the region. Periodic surveys of regional employers should be conducted to help confirm hiring trends and match labor market supply and demand.

A second recommendation is that existing power engineering programs should be reviewed to ensure that students are engaged in learning experiences that impart the knowledge, skills and abilities that employers require, including the technical and non-technical workforce skills that students will need to succeed in the workplace. The review process should include discussion and content review with industry staff, many of whom expressed strong opinions about what current programs lack; many employers agreed to participate in these interviews because they wanted their views to reach educators, which signals a willingness to also participate more formally in work to update curricula.

A third recommendation is that students should be encouraged—or even required—to participate in internships and other industry-based experiences that allow them to apply their academic learning in a work setting, and which help to equip students with an understanding of the industry culture and employer expectations that is essential for career success. Many employers already offer work-based learning experiences to power engineering students, and more employers are likely willing to provide these opportunities, which offer myriad, mutual benefits to students, employers and institutions alike.

Finally, regional universities should consider the implications of future technology enhancements and power engineering workforce retirements for the opportunities these transitions may present. Mid-career professionals will require skill upgrades as they design, implement and adapt to new technologies, and as they prepare to replace senior engineers who retire. This could present new opportunities for regional universities to provide graduate-level training, continuing education and professional certification, leadership development and research services to the power industry.

Footnotes

[1] See: Hardcastle, A. (2008). *Workforce Challenges of Electric Sector Employers in Washington and Oregon*. Prepared by the Washington State University Energy Program for the Center of Excellence in Energy Technology (now Pacific Northwest Center of Excellence for Clean Energy-Centralia College): http://www.energy.wsu.edu/Documents/WSU_Workforce_Challenges_Final_Report_090311.pdf

[2] Hardcastle, A., Jull, P. & Zeiger Hanson, S. (2013). *Workforce Challenges of Electric Power Employers in the Pacific Northwest*. Washington State University Energy Program, for the Pacific Northwest Center of Excellence in Clean Energy. See: http://cleanenergyexcellence.org/resources/

[3] Hinkel, J.R. (2008). "The 2003 Northeast Blackout – Five Years Later," *Scientific American*, 8/13/2008.

[4] National Science Foundation. *Workshop on the Future Power and Energy Workforce.* November 29-30, 2007, Arlington, VA. September 8, 2008. http://ecpe.ece.iastate.edu/nsfws/

[5] See: *Preparing the U.S. Foundation for Future Electric Energy Systems: A Strong Power and Energy Engineering Workforce*, U.S. Power and Energy Engineering Workforce Collaborative, Power & Energy Society, the Institute of Electrical and Electronics Engineers, 2009. See: http://www.ieee-pes.org/images/pdf/US_Power_&_Energy_Collaborative_Action_Plan_April_2009_Adobe72.pdf

[6] *Gaps in the Energy Workforce Pipeline: 2008 CEWD Survey Results.* Center for Energy Workforce Development, http://www.cewd.org/documents/ CEWD_08Results.pdf. The study investigated a wide range of power industry technical job categories, including lineworkers, pipefitters, pipelayers, engineers, plant operators, and technicians.

[7] Gaps in the Energy Workforce Pipeline, 2011 CEWD Survey Results. Center for Energy Workforce Development: http://www.cewd.org/surveyreport/CEWD-2011surveyreport-021512.pdf

[8] See: Hardcastle, A., Jull, P. & Zeiger Hanson, S. (2013). *Workforce Challenges of Electric Power Employers in the Pacific Northwest*. Washington State University Energy Program, for the Pacific Northwest Center of Excellence in Clean Energy. See: http://cleanenergyexcellence.org/resources/

[9] *Preparing the U.S. Foundation for Future Electric Energy Systems: A Strong Power and Energy Engineering Workforce,* IEEE-Power & Energy Society, U.S. Power and Energy Engineering Workforce Collaborative, 2009. See: http://www.ieee-pes.org/images/pdf/US_Power_&_Energy_Collaborative_Action_Plan_April_2009_Adobe72.pdf

[10] See: Hardcastle, A., Jull, P. & Zeiger Hanson, S. (2013). *Workforce Challenges of Electric Power Employers in the Pacific Northwest*. In 2011 the average annual wage for utilities (all employees) in Washington State was over $79,000. State labor market data shows that the average annual wage for electrical engineers (March 2012) was $93,967; however, these data do not report specifically for power engineers. See: https://fortress.wa.gov/esd/employmentdata/reports-publications/occupational-reports/occupations-in-demand

[11] This finding is reasonably consistent with the existing state labor market forecast for Washington, which shows electrical engineers as an in-demand occupation with an annual growth rate of 1.9 percent between 2010 and 2020. However, these data do not report specifically for power engineers. See: https://fortress.wa.gov/esd/employmentdata/reports-publications/occupational-reports/occupations-in-demand

[12] Multiple Engineering Cooperative of Oregon universities, an exclusive program, sponsors three, six-month internships in the industry. Students require five years to graduate due to the internship, which is paid ($17/hour) Interns are given simple to advanced projects to do, and are given guidance. Interns include electrical, civil and mechanical engineering students.

[13] One employer disagreed strongly, alleging that engineering programs generally were not preparing electrical engineers adequately. This employer hired nationally and reflected on the engineering graduates broadly. The reference was also made, generally, about older engineers rather than recent graduates. "We have seen EEs with degrees who don't know the basics of electrical engineering. This was (among) the older group, who studied certain aspects of EE but didn't know others." Their solution was to determine which universities had the strongest programs and recruit only there.