nearly half the nation's undergraduate students.[62] Specifically, they "provide open access to postsecondary education, preparing students for transfer to four-year institutions, providing workforce development and skills training, and offering noncredit programs ranging from English as a second language to skills retraining to community enrichment programs or cultural activities."[63]

Many of the workers needed to fill electric industry jobs in the future will utilize the community college system as they prepare to enter the workforce. Community colleges are well-positioned to provide the kind of training and re-training programs that will be needed as the United States transitions to a low-carbon economy. Not only will some electric industry jobs require new and different skills, but there will likely be mid-career workers in other industries who seek re-training in the electric industry for continued employment or career advancement. [64]

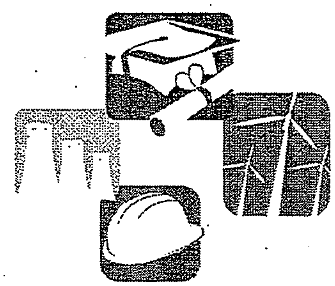
Community colleges are also positioned to partner with local industry and labor stakeholders to develop courses and curricula that serve the needs of stakeholders and benefit the local population. Through these partnerships, community colleges are able to offer pre-apprenticeship courses that prepare students to enter formal apprenticeship programs and offer training programs that prepare students to fill specific needs identified by industry. For example, a community college might work with an electric industry partner to develop a course that provides the training needed to conduct energy efficiency audits at customer homes.

The first case study described in Appendix C highlights the Washington State Center of Excellence for Energy Technology, Centralia College which is part of a network of Centers of Excellence developed by Washington State. As a Center of Excellence, Centralia College serves as a point of contact and resource hub for industry trends, best practices, innovative curricula, and professional development opportunities. The objective is to maximize resources by bringing together workforce education and industry partners in order to develop highly-skilled employees for targeted industries.

Community-Based Organizations

CBOs and Workforce Investment Boards (WIBs) serve an important function in the U.S. workforce development system by connecting people to jobs and to the skills necessary to secure a job. WIBs were created as part of an effort to overhaul federal support for workforce development under the 1998 Workforce Investment Act (WIA). WIBs consist of public- and private-sector members who provide strategic leadership on workforce development issues in their communities. WIBs plan and oversee state and local workforce development and job training programs, while CBOs, community colleges, and other organizations carry out the on-the-ground training.

At the local level, CBOs provide or play an integral role in providing many workforce development services. For example, the Massachusetts Workforce Alliance estimates that CBOs provide 53 percent of workforce training



Community colleges are well-positioned to provide the kind of training and re-training programs that will be needed as the United States transitions to a low-carbon economy.

[62] Stacy Teicher Khadaroo. "Community colleges play key role in tough economic times: Many schools have to turn away those seeking new job skills. Proposed federal funds could help." Christian Science Monitor, April 11, 2009. Available http://www.csmonitor.com/2009/0411/p99s01-usgn.html.
[63] American Association of Community Colleges: http://webadmin.aacc.nche.edu/Pages/default.aspx.
[64] Green for All. "Going Green: The Vital Role of Community Colleges in Building a Sustainable Future and a Green Workforce." 2009. Available http://www.greenforall.org/resources/going-green-the-vital-role-of-community-colleges-in-building-a-sustainable-future-and-a-green-workforce/download.

Los Alamos National Laboratory Math and Science Academy[65]

The Math and Science Academy (MSA) of the Los Alamos National Laboratory (LANL) is a three-year intensive professional development program for math and science teachers in northern New Mexico. LANL recognized a need to improve math and science education within northern New Mexico to serve the needs of students, many of whom are low-income or minorities, as well as the lab, which requires a highly skilled staff.

The MSA is considered a best practice example of a K-12 teacher professional development program as outlined by the America COMPETES Act of 2007, building on educational principles that are well-understood and supported by extensive research on effective math and science curricula. The MSA strives to improve teacher knowledge of math and science content and instructional skills. The program consists of a summer institute, regular online collaboration, and classroom observation. Teachers participate in a three-week summer intensive program to refocus their understanding of standards-based education, classroom management, professional collaboration, effectively using technology as a tool, and math and science content. Participants interact online and in-person during weekly collaboration sessions. MSA staff also observes classroom sessions in order to provide customized, informal coaching and hands-on feedback. Additionally, teachers have an opportunity to simultaneously enroll in a Masters of Arts in Teaching Math and Science degree program administered online by New Mexico State University.

The program requires a three-year commitment from the participating teachers' school district. Three-year implementation costs for 10 teachers are estimated to be around $500,000, the majority of which is covered by the LANL through grants and fundraising efforts. School districts have begun to cover some costs, including the stipends paid to participating teachers. MSA, in its tenth year, has provided this specialized training for 300 teachers from five northern New Mexico school districts, ultimately affecting more than 5,000 students to date.

The program provides sustained, long-term support for teacher participants and tailored monitoring and metrics for students and school districts. The results have been measurable – students taught by MSA-trained teachers have significantly improved math proficiency scores. For example, in one New Mexico school district, students in MSA classrooms outperformed non-MSA classrooms on the math subtest of the 2007-2008 state assessment. MSA student performance was 37 percent higher in the third grade, 10 percent higher in the fourth grade, 5 percent higher in the fifth grade, and 25 percent higher in the sixth grade. MSA coordinators attribute the success of the program to the intensive nature of the three-year engagement.

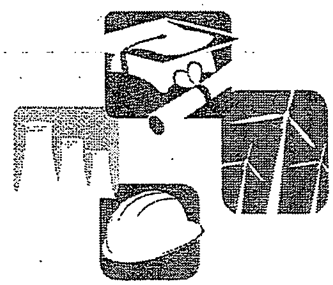
[65] Program information and materials provided by Dr. Kurt A. Steinhaus (Director of Community Programs Office at Los Alamos National Laboratory) to Sen. Pete Domenici (Retired), April 2009.

in Massachusetts. CBOs generally target certain groups, such as un- or underemployed adults, and they often include workforce training as a component of a broader set of community development efforts. In many cases they also provide complementary or "wrap-around" services, such as housing or meal vouchers. CBOs deliver comprehensive education and training services to diverse populations that may lack access to traditional opportunities such as community college or on-the-job training programs. According to the Massachusetts Workforce Alliance, a typical community-based education and training program may provide:

- Classes in reading, writing, math, and computer skills, and English language learning;
- Job readiness preparation and assistance with career identification, job search, and resume development; and
- Training in specific job skill areas, internships, job shadowing, work experience, and mentoring connections.

CBOs also help to fill the training gap for workers outside traditional pipelines, such as returning students or those in need of mid-career retraining. Because of their community-based structure, CBOs are able to reach potential workers through existing programs, such as language classes, and direct them to training opportunities. Unlike other pipeline entry points, CBOs have existing relationships with communities and individuals that pre-date—and later continue beyond—the decision to seek retraining or to pursue a particular training pathway. As a result, CBOs play an important role in connecting employers and workforce training programs to local communities and otherwise-untapped sources of un- or underemployed workers.

Van Jones, Special Advisor for Green Jobs, Enterprise and Innovation at the White House Council on Environmental Quality, and founder of the Oakland, California-based CBO Green For All, has underscored the important role that CBOs can play in transforming our energy economy. Green For All was founded on the concept that clean energy jobs are needed not only to achieve federal energy policy objectives, but also to provide "pathways out of poverty" for low-income workers. In recent Congressional testimony, Jones explained that "[w]e have an opportunity to connect the people who most need work with the work that most needs to be done, and fight pollution and poverty at the same time, and be one country about it."[66]

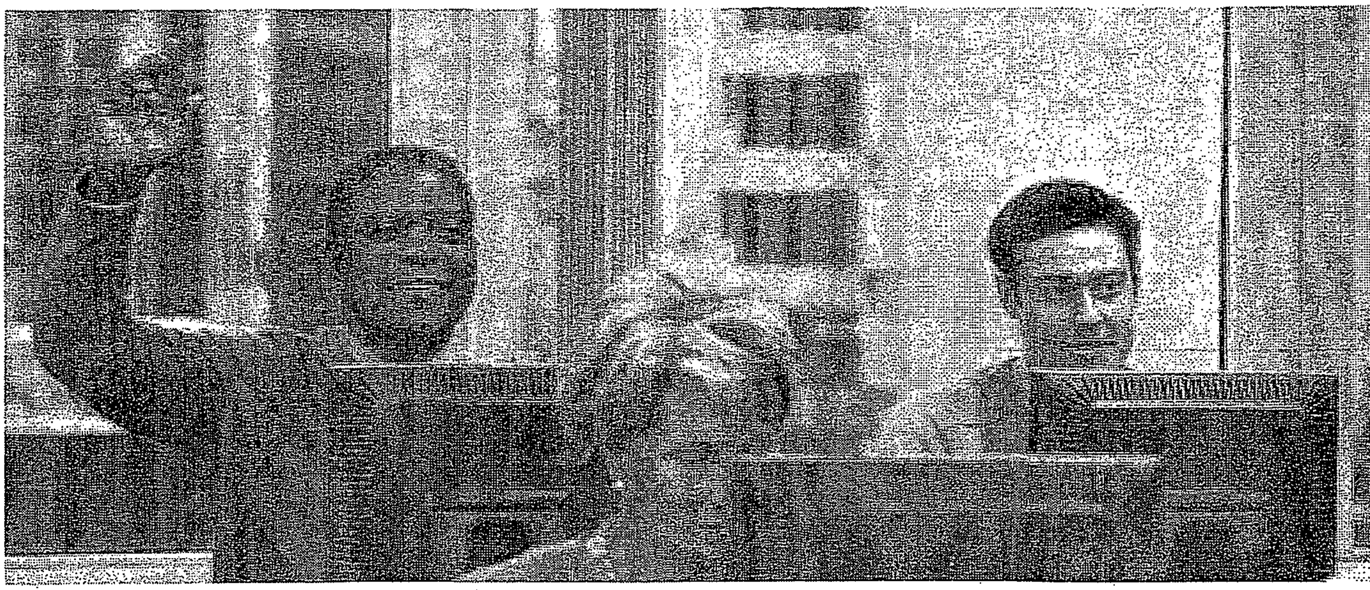


CBOs play an important role in connecting employers and workforce training programs to local communities and otherwise-untapped sources of un- or under-employed workers.

Apprenticeship Programs

By offering supervised on-the-job training in addition to formal classroom instruction, apprenticeship programs serve as a key training resource for the industry. Apprenticeship programs frequently involve a joint partnership between an employer and a labor organization. Through these joint labor-management apprenticeship programs, workers learn skilled trades through on-the-job training and related classroom instruction. Apprentices progressively earn more responsibility and earn wages while learning skills. Apprenticeship programs generally last three to five years. After completing such a program, an apprentice becomes a journeyperson, which means he or she is fully qualified to perform the work of the trade, and earns full pay.[67]

[66] Statement before the U.S. House of Representatives, Select Committee on Energy Independence and Global Warming. January 15, 2009. Available http://www.greenforall.org/resources/recovery-package-1/transcript-of-testimony.
[67] Jefferson County Public Schools (KY). "Apprenticeship Programs." Available http://www.jefferson.k12.ky.us/Departments/SchooltoCareer/apprenticeship2.html.



The Construction Labor Research Council lists average annual active apprentices in the United States by craft as shown in Table 12. The electric power industry will compete with other sectors for these skilled workers.

Table 12. Average Expected Annual New Entrants in Selected Crafts 2005-2015[68]

Occupational Title	New Entrants
Boilermakers	1,000
Bricklayers	4,000
Carpenters	22,000
Cement Masons	8,400
Electricians	22,400
Equipment Operators	15,300
Insulators	2,700
Ironworkers	4,500
Laborers	20,100
Painters	8,000
Pipefitters/Plumbers	17,500
Sheet Metal Workers	6,200

Under uncertain economic or policy circumstances, many employers, including those in the electric power sector, will hesitate to recruit relatively unskilled new hires for long-term apprenticeship programs in which the employer will invest years of training. In response, unions, electric power companies, community colleges, and other stakeholders have begun developing multi-employer and labor-sponsored programs designed to share the benefits and training costs of apprenticeship programs. While these programs do not replace or supplant traditional apprenticeship programs, they allow students to effectively try out skills and careers before competing for, or completing, a full apprenticeship. Similarly, electric power companies and labor unions gain additional confidence in potential hires and may select new employees from a more skilled pool of workers, increasing the likelihood that apprenticeships will be completed.

As highlighted in the review of multi-stakeholder collaborations in Appendix C, the International Brotherhood of Electrical Workers (IBEW) signed an agreement in January 2009 with several electric companies to develop a trust that would support multiple IBEW regional training centers across the United States. The goal of the program is to partner with utilities to offer hands-on training for a new generation of electric power employees. The IBEW is currently working to identify sites for additional centers in the southeast, the northeast, the northwest, and Texas. Once centers are established, IBEW envisions them as offering regional resources that a range of stakeholders may want to utilize.

[68] Construction Labor Research Council. "Craft Labor Supply Outlook 2005-2015." Available http://www.buildri.org/stuff/contentmgr/files/b80e3403e6c7cb9532d7645598cf3e85/misc/2005.craft_labor_supply_report.pdf.

In-House Training Programs

Electric power companies have traditionally hired technically-proficient employees and put them through their own intensive, customized internal training programs to create a workforce with the specific skills and knowledge required by each company. While there has been some coordination, this training has largely been conducted in-house on a company-by-company basis. Companies frequently require that employees go through company-specific training, or test out of such training, even if they have previous industry experience.

As discussed elsewhere, a movement to competitive electric markets in some states led to an overall decline in workforce levels through the end of the 1990s. As the industry's demand for new workers slowed during this period, some training activities were outsourced for the first time in the history of the industry.

As a part of this trend, some electric power companies have begun partnering with local community colleges and unions to develop creative, flexible training programs to supplement the programs they previously conducted in-house. These multi-stakeholder training partnerships have allowed companies to successfully partner with community colleges to establish curricula and establish hiring consortia. PG&E's innovative training program, PG&E PowerPathway™, is featured as the third case study in Appendix C.

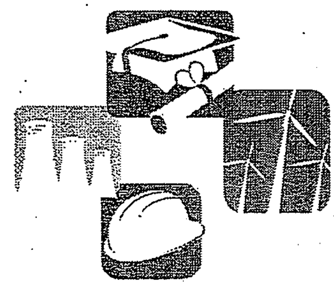
Re-Training Programs

Additionally, workers in other technically-proficient fields may retrain for the electric power industry. For example, Helmets to Hardhats is a national program that connects National Guard, Reserve, and transitioning active-duty military members with career training and employment opportunities within the construction and other skilled industries.[69] The program is designed to provide career transition support for returning veterans while also providing employers with technically-proficient workers who possess many soft workplace skills. Helmets to Hardhats helps address the unique challenges that confront individuals transitioning from military service to civilian employment. At the same time, it helps those individuals accentuate qualifications, such as general technical proficiency and specific training gained while in the military, that are unlikely to be formally certified in a way that is recognized by industry.

Skilled Craft Worker Training Challenges

The diversity of training programs for skilled craft workers creates some unique challenges for the electric power sector. Some of these challenges are specific to preparing skilled craft workers for work in the electric power sector while other challenges apply more generally to skilled craft workers in both the electric power and construction sectors.

Understanding Electric Power Sector Demand for Skilled Workers. A key challenge is aligning training programs with the demand for workers. Chapters 1 and 2 review estimates of potential future demand for skilled craft workers in the electric power industry. While such order-of-magnitude estimates are useful, developing specific training programs within each of the institutions and programs highlighted above requires a much more detailed understanding of workforce needs and opportunities. As discussed in Chapters 1 and 2, the pace and



A KEY CHALLENGE IS ALIGNING TRAINING PROGRAMS WITH THE DEMAND FOR WORKERS.

[69] Helmets to Hardhats: http://helmetstohardhats.org/.

direction of technology deployment will have important impacts on future demand for workers and types of skills. In addition, workforce demand will likely vary by region of the country, further complicating nationwide estimates.

These assessment challenges are compounded by the current system used by BLS to estimate future industry demand. BLS relies on historical trends to project future industry growth and does not include estimates for replacing positions lost through retirements or other attrition. This methodology ignores important demographic and technological shifts in the electric power sector as well as the need for skilled labor to design, build, and operate new generating assets.

Lack of Communication among Stakeholder Groups. A lack of communication among stakeholders leads to a number of challenges. Without effective communication, education and training systems may duplicate efforts, resulting in an inefficient use of limited resources. Such gaps in communication can leave students behind as one institution assumes that another institution provided training in critical subjects like math and science or basic technical skills. Additionally, a lack of communication between employers and educators can result in the training system producing potential employees without the proper skill sets. Educational institutions need time to develop quality training programs and hire faculty. By encouraging the sharing of data on workforce needs, employers can give educational institutions valuable lead time to develop quality training programs tailored to current and future industry needs.

Lack of Credential Portability. The lack of standardized skill sets and curricula for some skilled crafts within the electric power sector presents a significant challenge for students, community colleges, and employers. From the perspective of skilled craft workers within the electric power sector, one of the challenges to getting a job or moving through a career—particularly where this involves changing companies or re-entering the workforce after spending time in another industry—is providing documentation of relevant skills. In part to address this issue, the nuclear power industry, through NEI, recently announced the development of a set of core curricula intended to help develop a widely recognized training system for workers in that industry.[70]

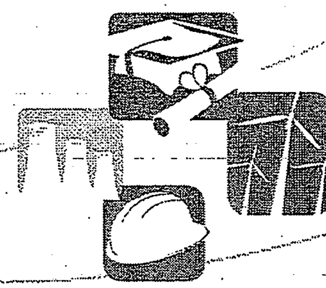
As discussed above, the construction sector has addressed credential portability by developing national standards to guide its apprenticeship system. Skilled craft construction workers are accustomed to moving as workforce needs shift from region to region and sector to sector.

[70] NEI is currently working with 46-plus community colleges to develop the Nuclear Uniform Curriculum Program. Curriculum requirements are laid out in ACAD 08-006, the Uniform Curriculum Guide for Nuclear Power Plant Technician, Maintenance, and Nonlicensed Operations Personnel Associate Degree Programs as well as NEI 09-04 Nuclear Uniform Curriculum Toolkit. Full program information is available only to members, but the NEI homepage will include basic information once the program is finalized.

Collecting and Tracking Skilled Workforce Data. Information on the number of people that pass through training systems is currently not well captured.[71] These data are needed to establish a clear picture of the electric power workforce pipeline. For example, knowing how many students with an electrician's degree are working in the electricity sector versus in the residential heating ventilation and air conditioning (HVAC) industry would enable electric power companies to better assess their workforce needs. The lack of clear and complete data complicates efforts to understand workforce needs and can lead to over- or under-estimates of the number of trained workers likely to be employed by the industry in the future.

Costs of Education. Students who receive adequate education in technical skills and who would be prime candidates for electric sector employment may have trouble paying for post-secondary education. These students may not complete degrees or take additional courses that could provide long-term benefits. Scholarships or grants that focus on the electric power sector could help to address this challenge.

Improving the Image of Electricity Industry Careers. As labor groups and companies look to expand the pool of technically skilled workers, many Task Force members are concerned that students and their parents are focused on attainment of four-year college degrees and fail to view apprenticeship or other programs outside four-year colleges as providing similar or better opportunities for long-term career and salary potential.



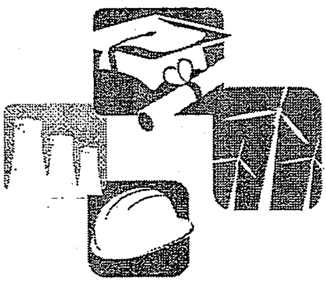
SOME ELECTRIC POWER COMPANIES HAVE BEGUN PARTNERING WITH LOCAL COMMUNITY COLLEGES AND UNIONS TO DEVELOP CREATIVE, FLEXIBLE TRAINING PROGRAMS TO SUPPLEMENT THE PROGRAMS THEY PREVIOUSLY CONDUCTED IN-HOUSE.

Lack of Career Preparatory Skills within the Workforce. A lack of math and science skills among many high school students represents a major challenge in terms of training a new generation of skilled craft workers. Because of this lack of preparatory skills, introductory courses have become more prevalent at the community college level. To better prepare students and reduce the need for introductory classes, some institutions are now partnering with K–12 educators to ensure that students receive instruction in basic math and science skills early in their academic careers.

[71] U.S. Department of Labor, National Center for Education Statistics: http://nces.ed.gov/IPEDS/. Some data are available on fields in which community college degrees are awarded. However, these data are reported on a voluntary basis with the U.S. Department of Education's Integrated Post Secondary Education Data System and are incomplete.

Training and Educating Engineers

Many of the skilled positions essential to design, build, operate, and maintain the low-carbon economy will require four-year college degrees, usually in science, engineering, or a related technical field.[72] The United States has an extensive system of colleges and universities that excel in the training of students in engineering and technology. These schools have established programs and draw students from around the world to undergraduate and graduate programs.



IT IS IMPORTANT TO FOSTER MECHANISMS FOR PULLING BOTH RESEARCH AND STUDENTS INTO THE ELECTRIC SECTOR.

Engineers will be among the most important of the professionals needed. A number of the leading engineering schools have research centers that attract faculty and expose students to the skills and thinking required for technically-rigorous professions. Beyond providing educational experiences for students, colleges and universities that emphasize research help drive technology innovation. Innovation in energy technologies like nuclear energy, renewable energy, and CCS will be critical to meeting the challenges of transitioning to a low-carbon economy.

Professional Engineer Challenges

As discussed in previous sections, a challenge for developing engineers to work in the electric power sector is ensuring that high school graduates are properly equipped to pursue a technical career. Once students are appropriately prepared for a four-year college or university, students must be encouraged to enroll in engineering programs related to the electric sector. The text box on Electric Power and Transmission Engineers highlights some of the challenges by looking at the example of electric power engineers. Elements of the challenges are expanded below.

Mobilizing the Research Community. Professional engineers are needed to develop, design, and implement new, low-carbon technologies that produce electricity. This requires graduates with Bachelor of Science, Master of Science, and doctoral degrees in engineering and related disciplines. While some of the technologies already exist, some have not yet been developed. There is a need for active and invigorated research programs in power engineering and related areas. To appropriately engage students, faculty need to be engaged through the development of research programs, including programs that are multidisciplinary in their approach and thinking.

Encouraging Students to Work in the Electric Industry. In addition to stimulating research, it is important to foster mechanisms for pulling both research and students into the electric sector. One way to do this is through partnerships with industry. Industrial partners can expose students to the application of technologies in the business world through involvement in research initiatives and through internships to students.

Costs of Education. The cost of post-secondary education in the United States is daunting and can be a barrier to entry. Scholarships or grants that focus on the electric power sector could help address this challenge.

[72] Idaho National Engineering and Environmental Laboratory and Bechtel Power Corporation. "U.S. Job Creation Due to Nuclear Power Resurgence in the United States: Volumes 1 and 2" (Prepared for the U.S. Department of Energy, Office of Nuclear Energy, Science, and Technology). November 2004. Available http://www.inl.gov/technicalpublications/Documents/3772069.pdf.

Electric Power and Transmission Engineers[73]

It is important to identify trends within the subset of engineers who undertake training in electric sector-related fields. These engineers focus on the generation of electricity, construction of delivery systems, and management of electricity usage.[74] A recent DOE analysis of workforce trends noted that "[i]n the 1970s, power concentration represented approximately 10.5% of undergraduate electrical engineering students in the United States. Over time, enrollments dropped, and by 2001, that percentage dropped almost in half to 6%."[75] Additionally, DOE concluded that "the number of power engineering programs at universities has declined over the past twenty years."[76] A recent report by the U.S. Power and Energy Engineering Workforce Collaborative found that "there are less than five very strong university power engineering programs in the U.S."[77] The report defined such programs as having:

- four or more full-time power engineering faculty;
- research funding per faculty member that supports a large but workable number of graduate students;
- a broad set of undergraduate and graduate course offerings in electric power systems, power electronics, and electric machines; and
- sizable class enrollments of undergraduates and graduate students in those courses.

Without strong support for strategic research in power systems and without qualified replacements for retiring faculty, the strength of existing power engineering degree programs at U.S. universities could begin to erode.[78] And, without such programs, the United States is likely to lose its leadership position in technology innovation. As one industry commentator notes, "the application of [the fundamental principles of electric power engineering], as well as our understanding of the electric system, continues to evolve. This enables technology enhancements that significantly improve the capability, performance, and reliability of the entire electricity system. The electric power engineer is critical to this process."[79]

Many expert groups have recommended focused attention and investment to maintain the quality and productivity of engineering programs in the United States. The Gathering Storm report, DOE's Workforce Trends report, the U.S. Power and Energy Engineering Workforce Collaborative report, and the National Science Foundation's Power Engineering Workshop 2008 report, among others, recommend focusing on faculty retention and research and development opportunities for engineering programs.[80]

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73 U.S. Department of Energy. "Workforce Trends In The Electric Utility Industry: A Report To The United States Congress Pursuant To Section 1101 Of The Energy Policy Act Of 2005." August 2006. Available http://www.oe.energy.gov/DocumentsandMedia/Workforce_Trends_Report_090706_FINAL.pdf.

74 Ibid

75 Ibid

76 Ibid

77 U.S. Power and Energy Engineering Workforce Collaborative, "Preparing the U.S. Foundation for Future Electric Energy Systems: A Strong Power and Energy Engineering Workforce," IEEE Power & Energy Society. April 2009. Available http://www.ieee.org/portal/cms_docs_pes/pes/subpages/pescareers-folder/workforce/US_Power-Energy_Collaborative_Action_Plan_April_2009_Adobe7.pdf.

78 U.S. Department of Energy. "Workforce Trends In The Electric Utility Industry: A Report To The United States Congress Pursuant To Section 1101 Of The Energy Policy Act Of 2005." August 2006.

79 Badhul Chowdhury. "Power Education at the Crossroads." IEEE Spectrum, October 2000.

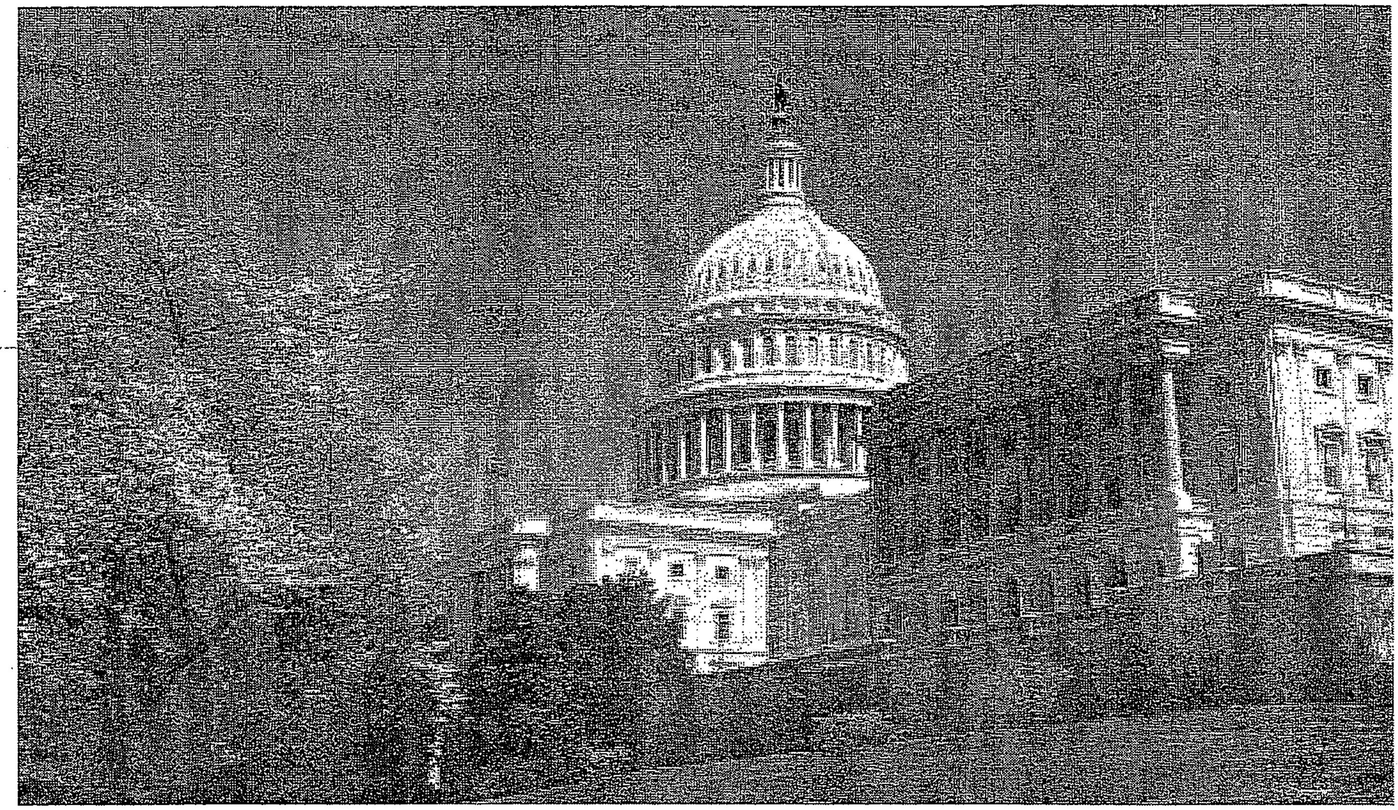
80 National Science Foundation. "Report of the National Science Foundation Workshop on the Future Power Engineering Workforce (Held November 29-30, 2007)." September 2008. Available http://ecpe.ece.iastate.edu/nsfws/Report%20of%20NSF%20Workshop.pdf.

CHAPTER 4.

CONCLUSION

The Task Force on America's Future Energy Jobs strongly believes that addressing the need for a well-qualified electric power sector workforce must be a major national priority.

Building the workforce needed to enable a transition to low-carbon energy systems is essential to realizing important national policy objectives, including maintaining economic competitiveness, reducing greenhouse gas emissions, and improving energy security. Without near-term investment in the next generation of electric power and construction workers, we could find ourselves constrained in our ability to make necessary infrastructure changes.

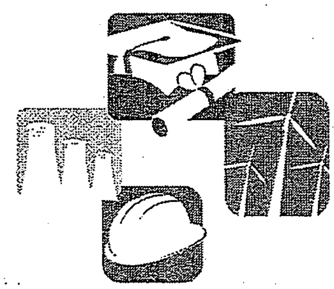


While the need for different types of specialized workers will vary depending on the deployment trajectory of different generation technologies, it is clear that there will be substantial overall demand for technically educated students; skilled craft electric power and construction workers; and math, science, and engineering professionals. Investments in training infrastructure are beneficial to our broader socioeconomic well-being and economic recovery efforts. If well-placed, such investments can also play a critical role in rebuilding our long-term ability to innovate and lead in technical fields.

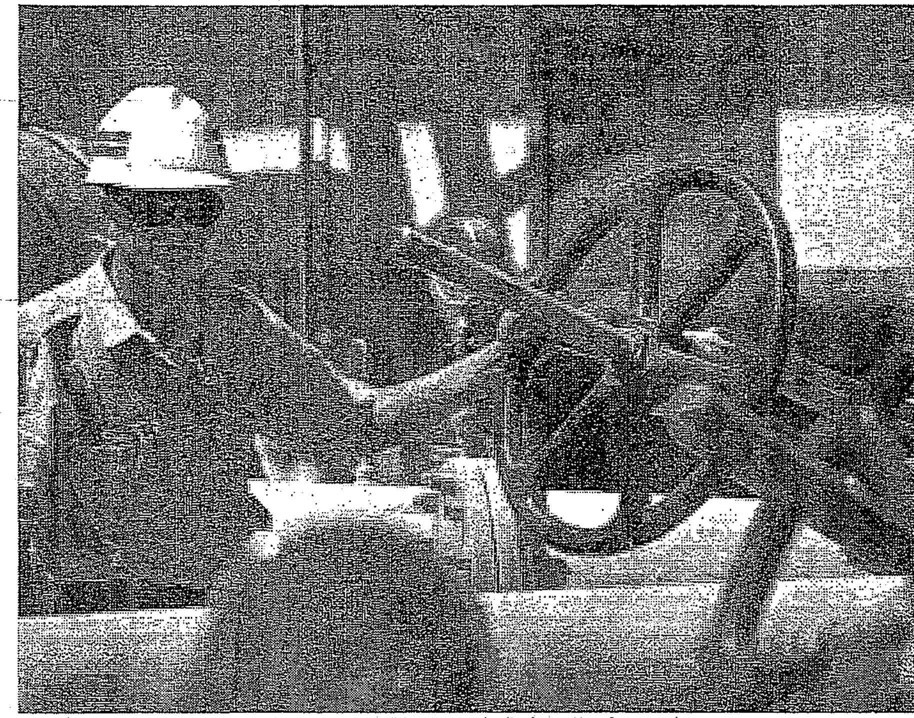
In exploring the workforce challenges specific to the electric sector, the Task Force has evaluated the potential demand for and supply of workers in three broad categories: skilled craft electric power workers, skilled craft construction workers, and engineers. A closer look at these categories suggests that the current training pipeline will be insufficient to meet anticipated demand. Task Force members agree that this critical workforce gap must be addressed in an urgent and deliberate way so that near-term measures create maximum long-term economic benefits.

Skilled Craft Electric Power and Construction Workforce

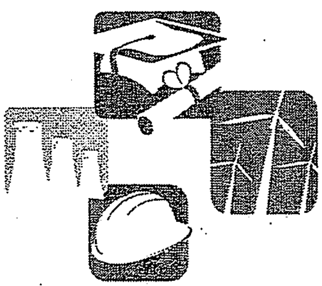
The Task Force sought to develop order-of-magnitude estimates of the potential need for skilled crafts workers in the fields of electricity infrastructure design, construction, operations and maintenance. Due to policy and other uncertainties, it was not our aim to generate precise forecasts of workforce demand and supply. Based only on the age distribution of current workers in the industry and on historical retirement patterns, there will be a large need for qualified candidates to replace existing workers. Filling that need, by itself, is not likely to be an easy task. Moreover, the situation is likely to be exacerbated by competition for skilled craft workers from other sectors of the economy as



IT IS CLEAR THAT THERE WILL BE SUBSTANTIAL OVERALL DEMAND FOR TECHNICALLY EDUCATED STUDENTS; SKILLED CRAFT ELECTRIC POWER AND CONSTRUCTION WORKERS; AND MATH, SCIENCE, AND ENGINEERING PROFESSIONALS.



anticipated large-scale infrastructure projects are undertaken over the next ten years. Additional workforce needs as the nation transforms to a low-carbon economy will further strain the potential workforce.



Focused national policy support and investment is needed to address workforce challenges in the electrical sector in a timely way.

Professional Workforce for Electric Power Industry

As with the skilled craft trades generally, estimating the potential shortage of professionals in the electric power sector is complicated by a lack of specificity in the data concerning qualifications for many professional categories. The data that are available point to a trend of declining interest in electrical and power engineering, just as we are experiencing an increased need for research, development, and innovation in these areas. With the flow of students into four-year colleges and universities increasingly ill-prepared for math, science, and engineering studies, it is important to connect all the pieces and maintain a consistent focus on all the elements of the workforce pipeline, starting with K–12 education.

In keeping with the Gathering Storm report, the Task Force believes efforts to ensure that the nation is producing significant numbers of Masters- and PhD-level scientists and engineers provide a dual benefit. First, having these professionals available in the workforce is crucial to enabling a low-carbon energy transition. Second, these same professionals can contribute to the electrical technology innovations that the U.S. and world economy will need to secure long-term energy and environmental security.

The Task Force concludes that focused national policy support and investment is needed to address workforce challenges in the electrical sector in a timely way. Investments in improving and enlarging the training pipeline for future energy-sector workers will also provide a foundation for long term economic health and global competitiveness.

The workforce challenges identified by the Task Force are significant and addressing them will take a concerted and sustained effort by many stakeholders. To advance that process, the Task Force developed a set of five primary recommendations for federal policy. While these recommendations are specifically focused on the development of direct future energy jobs associated with design, construction, and operation of assets in the energy sector, many of the insights could be applied to job training associated with deploying energy efficiency and manufacturing the materials and equipment needed to build and operate the future energy system.

The Task Force's recommendations follow.

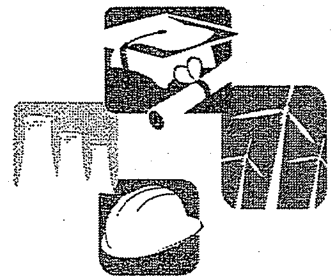
Task Force Recommendations

Recommendation 1: Evaluate regional training needs and facilitate multi-stakeholder energy sector training programs across the country

In addition to the work currently underway at DOL and DOE to address the workforce gaps associated with projected retirements and the initiatives in the American Recovery and Reinvestment Act of 2009, Congress should appropriate funds through existing funding mechanisms that allow DOL and DOE to work with existing state or regional energy workforce consortia or establish new state or regional energy workforce consortia, as appropriate. These consortia should be tasked with evaluating near- and long-term needs for a skilled workforce, including:

- Workforce gaps at existing facilities over the next ten years associated with workforce retirements;
- Workforce gaps over the next twenty years associated with;
  - constructing new low-carbon generating assets and retrofiting existing generating assets,
  - constructing the additional electric infrastructure needed to effectively use new and retrofitted generating assets (e.g. transmission lines, CO_2 pipelines, local distribution systems),
  - operating and maintaining new and retrofitted generating assets and the accompanying infrastructure, and
  - deploying energy efficiency in the retrofitting of the nation's building stock and in Smart Grid technologies.

As a part of this evaluation, DOL, DOE, and each state or regional energy workforce consortium should highlight any policy uncertainties that are currently delaying or have the potential to delay the deployment of new generating assets, retrofit technologies, and infrastructure that are essential to the transition to a low-carbon economy.



In regions of the country where workforce gaps are identified, Congress should provide financial resources and coordination assistance to support the development of targeted local or regional training programs for energy sector workers.

In regions of the country where workforce gaps are identified, Congress should provide financial resources and coordination assistance to support the development of targeted local or regional training programs for energy sector workers. DOL should award funding on a competitive basis through the Green Jobs Act, or other appropriate federal funding mechanisms, to training programs that meet the following criteria:

- Involve a wide range of stakeholders from industry, education, labor, professional organizations, and workforce development agencies or non-profit community groups that focus on workforce development in all stages of program development.

- Coordinate the use of resources at a regional level while recruiting and matching skills to jobs at a local level. For example,
    - Recruit prospective employees from local populations using local groups, such as community-based organizations or workforce investment boards, that have a deep knowledge of the community and a capacity to prepare prospective employees through education and training; and
    - Integrate regional employer needs into the curriculum development process.
- Build upon existing programs and infrastructure, including training and education programs run by community-based organizations, technical or community colleges, and stakeholder companies, and joint labor-management apprenticeship programs.
- Include curricula and course content that utilize industry skill standards and lead to industry-recognized credentials.
- Use best practices (identified under Recommendation 3) in developing training and education programs.
- Encourage development of accredited, credential-focused programs that put individuals on a long-term career track. Programs should allow transferability of credits throughout the industry and should develop skills that translate from one program to the next. Programs should issue 'stackable' credentials that allow individuals to develop the building blocks of a career in the energy sector.
- Develop innovative strategies to engage populations that have traditionally been underrepresented in the energy sector workforce,

in particular communities of color, and to address the needs of lower-skilled, low-income workers to enable them to access career pathways into the energy sector workforce.

- Include a strategy for sustaining the program over the long term.

Recommendation 2: Improve energy sector data collection and performance measurement metrics and tools

Improve the collection, management, and availability of workforce data for the energy sector to facilitate the measurement of progress in addressing identified needs and to enable more effective identification of future needs.

Workforce data should include people entering energy sector-specific training programs and/or the energy workforce; these data should be measured against the workforce targets identified by the state energy workforce consortia in Recommendation 1.

BLS should be provided with the resources to accurately assess workforce needs in the energy industry and to incorporate industry input on growth and staffing patterns. This will allow for improved forecasts of future demand for different types of skills, including emerging skills associated with the build out of low-carbon energy infrastructure.

Recommendation 3: Identify training standards and best practices for energy sector jobs

DOL in consultation with industry, labor, and education stakeholders, including ED and DOE, should develop a repository of best practices for electric power sector job training that is widely accessible, transparently managed, and maintained by a public entity. This repository should include existing skill standards and registered apprenticeship programs for electric power sector jobs. Examples of best practices can be found at energy career academies at the secondary level, and at pre-apprenticeship, certificate, associate degree, apprenticeship, and community-based training programs at the post-secondary level.

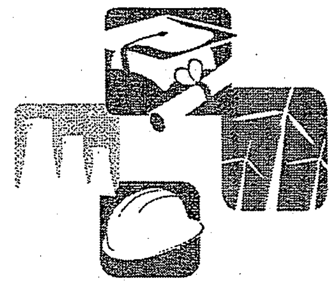
The purpose of the repository should be threefold: (1) it should be a resource for employers to evaluate training programs and potential employees, (2) it should be a resource for individuals to evaluate training options as they move through a career, and (3) it should be a resource for educators as they develop courses and curricula.

As a part of this initiative, DOL, in consultation with industry, labor, community, and education stakeholders, including ED and DOE, should identify skill areas where best practices or training standards do not exist or should be expanded, and work to fill such gaps.

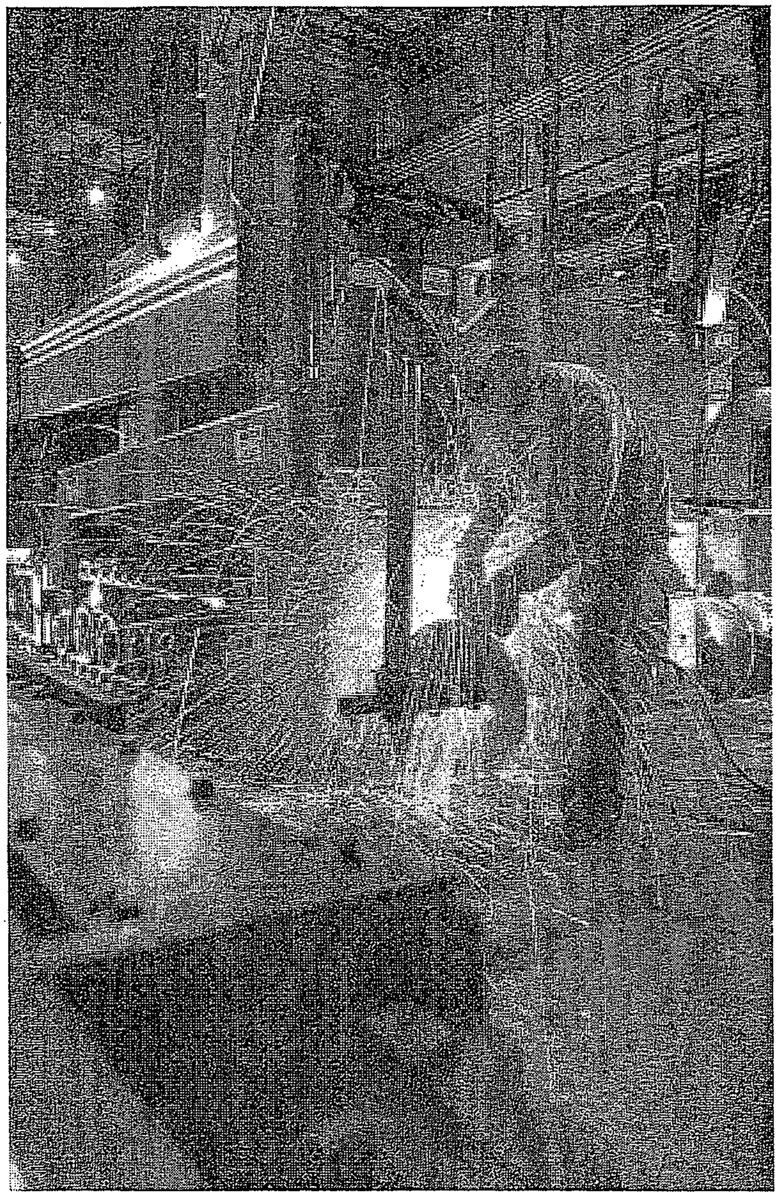
Recommendation 4: Provide funding support for individuals seeking energy sector-related training and education

The Task Force recommends that financial support, targeted to those most in need, be provided to individuals pursuing energy-related technical and professional training (or retraining) and to students pursuing post-secondary degrees in engineering and other energy-related technical fields. Using existing funding mechanism as appropriate, Congress should consider:

- Developing a program that provides financial support through educational scholarships or grants to individuals,



The Bureau of Labor Statistics should be provided with the resources to accurately assess workforce needs in the energy industry and to incorporate industry input on growth and staffing patterns.



- Providing worker training tax credits to energy companies who support apprenticeships and internships, and
- Clarifying and streamlining support for apprenticeships, technical certifications, and on-the-job training for veterans by combining the benefits of the Post-9/11 GI Bill and the Montgomery GI Bill into one program.

Recommendation 5: Aggressively focus on revitalizing the math and science skills, education, and career counseling of individuals who have the interest and skills to work in the energy sector

Enhance preparatory skill training for technically rigorous careers by:

- Improving and expanding contextual education in science, technology, engineering, math, and environmental literacy for students in all grades from kindergarten through 12th grade,
- Expanding the use of instructional technology at all levels to provide access to computerized and on-line educational resources and information about science, technology, engineering and math,
- Integrating lessons in applied math and science into the foundational curriculum for all students, with a particular emphasis on early (K–4) education,
- Expanding educational opportunities that include reading, writing, and applied math and science for adults who wish to enter the energy workforce,
- Providing opportunities for teachers and instructors to learn about the energy sector and greenhouse gas emissions through off-site programs organized by local colleges, universities, and industry partners,
- Ensuring that students are at or above grade level in math,
- Developing energy-related, contextual modules for math and science teacher training carried out at colleges and universities,

including historically black colleges and universities or other minority institutions,

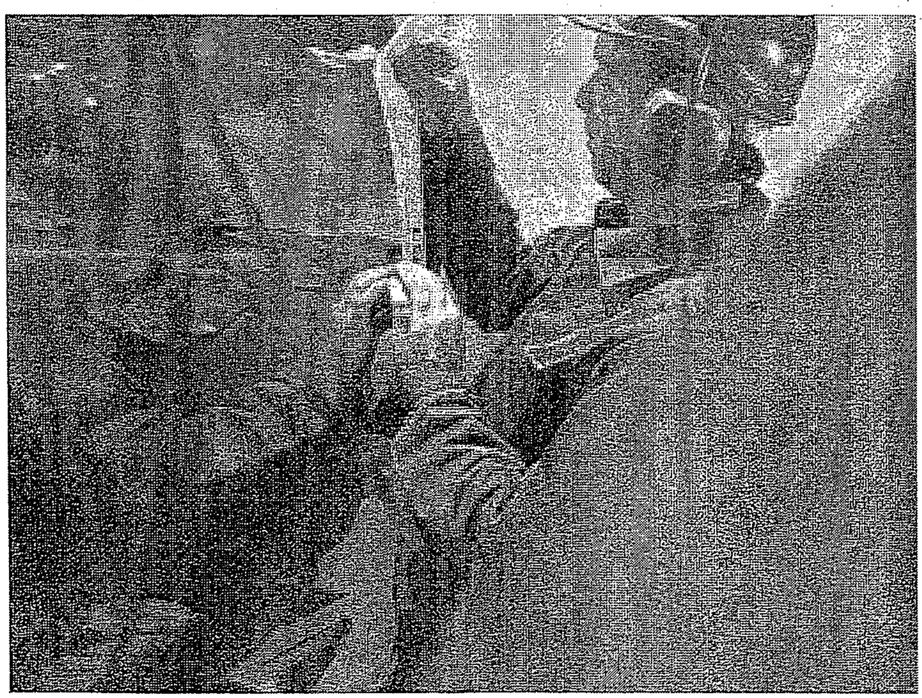
- Developing robust programs to train and retrain our teachers in math and science,
- Engaging retired professionals and helping them transition from a career in energy to the education system, and
- Creating seamless pathways from K–12 through post-secondary education.

Engage the next generation of energy scientists and engineers by following through on and expanding commitments to U.S.-based research and development efforts. This should include:

- Finishing the ten-year doubling[81] of the budgets for the National Science Foundation, DOE Office of Science, and the National Institutes of Standards and Technology, with a special emphasis on (1) encouraging high-risk, high-return research; (2) supporting researchers at the beginning of their careers; and (3) research focused on low-carbon energy sources and technologies.
- Investing in sustained research programs and academic tracks that support advanced energy systems.

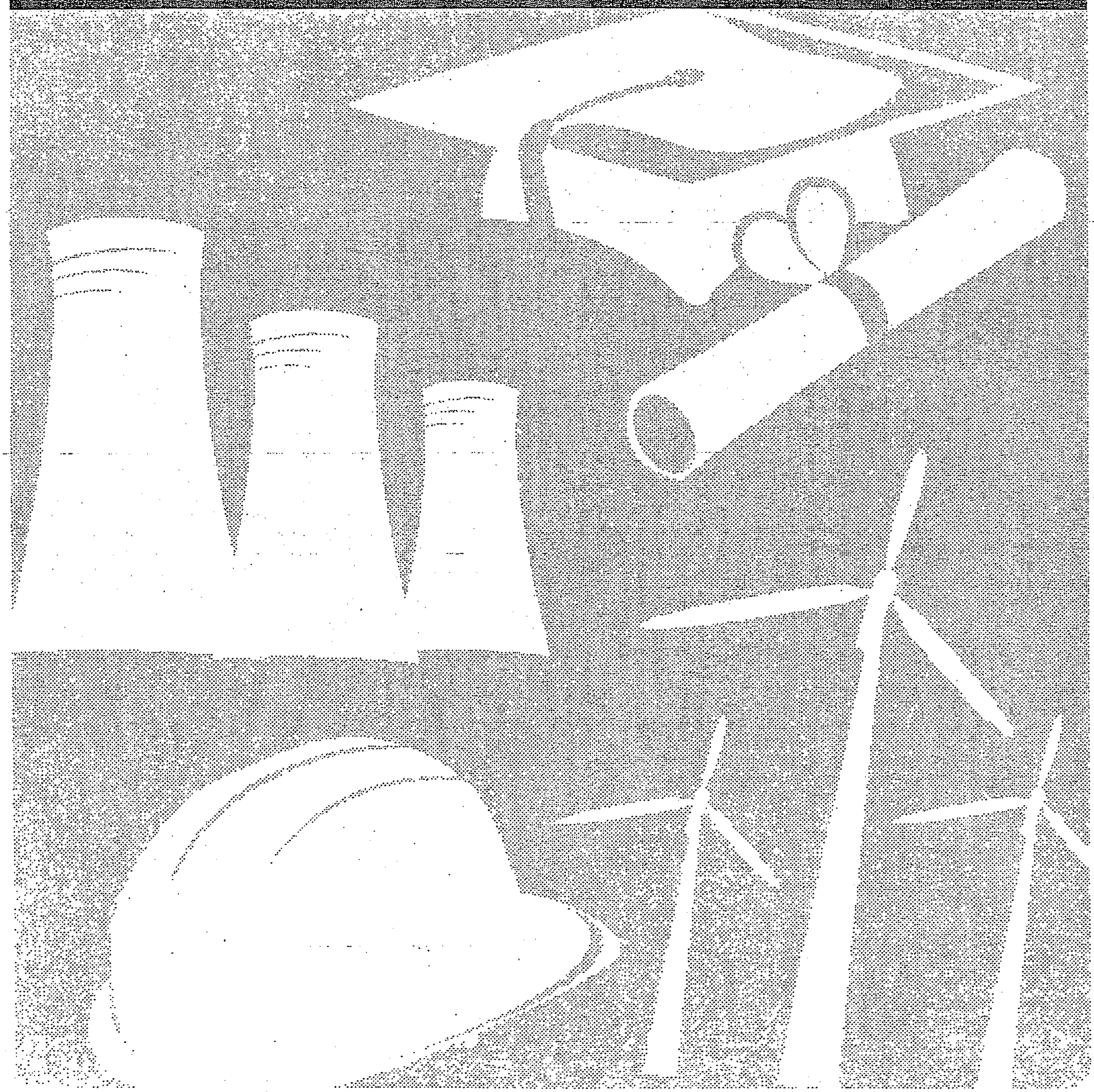
Increase awareness of opportunities in the energy sector by:

- Creating targeted career awareness material that addresses specific audiences including youth, adults, minority populations, veterans, government officials, and educators,
- Developing messaging materials that (1) highlight how critically important technically-educated individuals are for addressing our long-term energy and environmental challenges and (2) address a lack of public awareness about the security, pay, and job satisfaction associated with careers in the electric sector,
- Supporting community-based organizations that help to match potential job seekers and employers,
- Informing career counselors and educators about job opportunities and experiences in the energy sector, and
- Communicating that skilled trades are a vital component of the American economy and should be viewed as desirable options for individuals seeking career training.



[81] White House Office of Management and Budget. "A New Era of Responsibility: Renewing America's Promise (FY2010 Budget). February 26, 2009. Available at www.whitehouse.gov/omb/assets/fy2010_new_era/a_new_era_of_responsibility2.pdf

APPENDICES



Appendix A: Bechtel Report on Design and Construction

A Report to the Bipartisan Policy Center
National Commission on Energy Policy's
Task Force on America's Future Energy Jobs

Prepared by
Bechtel Power Corporation

May 2009
Bechtel Confidential

Bipartisan Policy Center
National Commission on Energy Policy
Task Force on America's Future Energy Jobs

Scope of Study

The National Commission on Energy Policy (NCEP) requested that Bechtel Power Corporation (Bechtel) provide an approximate quantification of workforce demand requirements associated with the addition of new power generation for a number of technologies. The study's primary task was to approximate the number of people (jobs) required for the engineering, procurement, and construction (EPC) services to deploy 1 gigawatt (GW, which equals 1,000 megawatts (MW)) of generation for each identified technology, with the following detail:

- differentiate between project development and project engineering/construction phases
- differentiate between domestic and offshore jobs
- differentiate between hourly and salaried jobs
- for hourly jobs, provide further details with respect to certain "critical crafts"

NCEP requested that Bechtel perform the above analyses with respect to building new power generating assets for each of the following technologies:

1. Nuclear
2. Conventional coal (super-critical, pulverized coal, or SCPC)
3. Conventional coal including carbon capture and storage (SCPC w/CCS)
4. Integrated gasification combined cycle (IGCC)
5. IGCC including carbon capture and storage (IGCC w/CCS)
6. Natural gas combined cycle (NGCC)
7. Onshore wind
8. Solar thermal
9. Solar photovoltaic (PV)

Upon completion of the workforce demand ranges per GW of new generation for each technology above, NCEP requested that Bechtel calculate total long-term workforce demands associated with three separate, approximately 20-year, generation deployment scenarios provided by NCEP, summarized as follows:[82]

1. "EPRI PRISM" Scenario: this scenario forecasts the addition of approximately 210 GW of new generation between 2007 and 2030

2. "EPRI Nuclear/Renewables" Scenario: this scenario forecasts the addition of approximately 235 GW of new generation between 2007 and 2030

3. "EPRI Coal + CCS" Scenario: this scenario forecasts the addition of approximately 221 GW of new generation between 2007 and 2030

[82] Although Bechtel has performed and attached the requested calculations, we have not reviewed any of the deployment scenarios provided by NCEP for reasonableness or feasibility (technical, commercial, or otherwise). The scenarios and their resulting data, including the long-term workforce demands reflected in this study, should be viewed as solely reflecting the opinions of NCEP.

Study Limitations

Bechtel analyzed data readily available from our direct experience (actuals or projections) or from industry sources considered reliable for the intended purpose of this task. The study's scope was limited to approximate quantifications of the direct jobs required to develop, design, procure material for, and construct the power generating facility itself. The study specifically did not attempt to quantify the indirect jobs associated with implementing new generation capacity, such as those related to the manufacture of the power generation and other equipment and materials that are integral to the facility. However, we are providing an approximate dollar spend range for the power generation and other equipment and materials associated with the engineering and construction of 1 GW of each technology for NCEP's further use (e.g., others working with NCEP may be able to utilize this data to quantify a range of indirect workforce requirements attributed to such spend).[83]

The study also did not attempt to quantify indirect jobs associated with the design and construction of supporting infrastructure such as transmission lines, natural gas pipelines, roads, or CO_2 pipelines and sequestration sites that may be required for the facility to operate.[84]

Average quantifications of workforce demands and construction schedules are inherently uncertain and highly variable. Site conditions can greatly influence the scope of work within each specific power generation technology and local conditions can affect workforce demands and construction schedules based on factors such as weather and labor productivity. Also, specific (e.g., proprietary) designs within any given technology can lead to differences in project scope and workforce requirements, as can design advancements that occur over time which lead to improvements in areas such as technology efficiency, project cost, emissions, safety, and other characteristics. As a result, the workforce quantifications provided in this study are expressed as a range, reflecting the study's expected general +/- 25 percent level of accuracy.

Construction schedules can similarly vary based on major equipment lead-time assumptions, the project's ability to commit to certain purchases prior to full Notice to Proceed, and other factors. Although for simplicity in presentation we have not depicted a time-axis range to address such variabilities in construction schedules, it should be recognized that the base construction period used for each technology is also inherently uncertain and highly variable, and therefore, should also be considered to have a similar +/- 25 percent general level of accuracy.

While estimates of workforce demand and dollar spend range information is provided for each technology, the cumulative effects of the inherent uncertainties must be considered when reviewing the individual results for each specific technology. Because of these variances, we believe that relative comparisons across the technologies provide the most revealing insights and therefore suggest they be given the most weight when utilizing the results of this study.

[83] Bechtel estimates pertaining to CCS do not consider the transportation or storage of carbon.
[84] The study also did not attempt to quantify the tertiary jobs associated with implementing new generating capacity, such as those in the transportation, restaurant, hospitality, and other sectors that would result from the power generation facilities.

Study Methodology

1. Development Phase

The development phases for the projects considered in this study create salaried workforce requirements related to tasks such as project conceptual design, plant permitting, and project financing activities. However, except for nuclear power generation, the numbers of jobs required during this phase are small when compared to the requirements created during the construction phase. The primary reason for addressing the development phase in this study is to illustrate the inherent lag between the time a project is approved for development and the beginning of project engineering and construction.

Bechtel has relevant experience with the development of projects across each of the technologies covered in this study, as an EPC contractor supporting the efforts of project developers, and as a project developer through its affiliated company, Bechtel Enterprises. To estimate the workforce requirements associated with the development phase, we drew upon this collective experience to establish, for each technology, the following:

- An expected development time in months for a typically-sized plant based on recent experience. Technology-specific development time periods used in this study may lengthen or contract as a result of incentives included in the economic stimulus bill, passage of legislation pertaining to carbon emissions, experience and comfort level of permitting agencies as they become more familiar with applications for plants based on new nuclear and emerging technologies, or other similar factors.
- Approximate job-hours required for all entities supporting the typical project development effort. This includes both the developer and its consultants, who typically include siting, environmental and permitting, legal, engineering, fuel, and other specialists.
- To normalize our results to a per GW basis, we assumed that multiple units of the typical plant would be developed to achieve 1 GW of generation (i.e., if an 800 MW plant could be developed over 30 months, we assumed that 1.25 such plants would be developed in the same 30 month period to achieve the standard 1 GW of generation, as opposed to scaling up the 800 MW typical plant to a 1,000MW plant).

Once the above information was finalized, we converted the resulting salaried job-hours per GW of development into equivalent man-months using a 154 job-hour per man-month conversion factor, a standard industry factor that accounts for holiday and vacation time off. We then converted the total man-months into equivalent development phase staffing curves for each technology by spreading the total man-months over the development period duration in a manner consistent with actual industry experience. All curves in this study are presented as equivalent staffing since the aforementioned conversion factor assumes a standard 40-hour work week. The use of regularly scheduled overtime, six-day work weeks, or other incentives would result in actual staffing levels being somewhat lower than those reflected on each curve (the use of such incentives is currently common practice with respect to attracting hourly workers (and, to a lesser extent, salaried workers) during the construction phase).

Finally, the resulting staffing curves are presented in a generalized range of +/- 25 percent in recognition of the uncertainty factors discussed earlier.

2. Construction Phase

For each technology listed above, Bechtel reviewed its database of historical and ongoing projects and selected a cross section of representative projects based on plant size, location, date of construction, and other factors. For those technologies that we had a large number of datapoints (i.e., nuclear, coal, NGCC, and IGCC), we were able to cull from our analyses any projects determined to be "outliers" (e.g., a project that experienced a suspension during construction) that might skew the resulting per GW ranges substantially and make them less relevant to the study purposes. For those technologies that are still evolving (i.e., CCS, solar (PV and thermal), and wind), there are fewer datapoints available, and as such the study results for these technologies have a somewhat lower degree of confidence. Not all individual projects are expected to conform to the ranges shown, but in general it is expected that the ranges cover the majority of outcomes and are relevant to the purposes of the study.

Once Bechtel formulated a working list of projects for each given technology, we populated an analysis template at the individual project level as follows:

- For salaried (professional) services, which include engineering, project management, construction oversight, and other support services, we identified hours for the entire project, and also noted the subtotals at the project site, at corporate offices, and at any offshore design facility.

- For hourly (craft) services, we identified hours at the project site for all such workers, whether direct employees or subcontractors (where actual subcontractor job-hour data was not available, estimated hours were derived from subcontractor dollars using historical metrics).

- Subtotals within the hourly (craft) services for certain critical crafts were also identified. For the purposes of this study, critical crafts include pipefitters, electricians, boilermakers, millwrights, and ironworkers.

- Each specific project's size (net MW), start and end date, and overall schedule duration in months was noted.

- Costs for the power generation and other plant equipment and materials required to construct the project were identified. For this data to be useful to the study, we escalated the identified dollars to current day. This was done by noting the midpoint of the construction schedule for that project and applying the CPI US city average escalation factor to the base dollars for each year from the midpoint to current day. Although there are inherent inaccuracies within this methodology that compound with the age of the data, we believe the results obtained are generally consistent with the level of accuracy represented for all other study results.

Once the above data w as assembled for each project within the given technology, we established a base case plant for that technology by averaging the job-hour data, escalated equipment and material costs, plant size, and schedule duration across each project. These resulting, base case plants were the building blocks for further analysis across each technology, although they clearly do not and should not be interpreted to reflect or be applicable to any one specific project. As with the development phase, to normalize the results to a per GW basis, we again assumed that multiple units of the resultant base case plant would be installed to achieve 1 GW of generation (i.e., if the base case plant reflected an average size of 800 MW and an average construction duration of 48 months, we assumed that 1.25 plants would be built in the same 48 months to achieve the standard 1 GW of generation, as opposed to scaling up the 800 MW base case plant to a longer duration, 1,000 MW plant).

Job-hour information was translated into staffing curves as follows:

- Each labor category of the 1 GW standard capacity block was converted into equivalent man-months using the standard 154 job-hour per man-month conversion factor discussed earlier.
- The total man-months for each labor category, including the hourly services subsets of critical crafts, were converted into equivalent staffing curves over the capacity block's duration, using historical staffing curves from specific projects for each technology as guidance.

The individual curves for the hourly services subsets of critical crafts were developed using the overall shape of the total hourly curve as a template. This approach does not address the time phasing of the critical craft activities that normally occurs as construction progresses; however, we expect that this approach yields results consistent with the level of accuracy represented for all other study results.

Bechtel then analyzed the resulting staffing curves for each labor category for reasonableness and addressed any inconsistencies via minor modifications based on engineering and estimating judgment. Finally, these staffing curves are presented with the same 25 percent margin of error discussed above.

The curves depicting salaried (professional) services are inclusive of all positions associated with this scope of work. However, it is common practice for engineering firms to utilize global execution centers when performing certain aspects of the design and procurement activities for the power generating facilities addressed in this study. As a result, the construction phase staffing levels for salaried personnel as depicted on the attached staffing curves include a small percentage of offshore positions. The percentage of work done offshore varies in accordance with each individual contractor's (or consortium's) execution strategy and can also vary across technologies. For this study, it can be assumed that a general range of 5 percent to 15 percent of the salaried personnel staffing levels reflected during the construction phase are actually workforce requirements that will be fulfilled offshore.

Overview by Technology

Below is a summary of the analysis performed for each technology included in this study. Tables at the end of this section reflect the following results of the study:

- Base salaried and hourly man-years associated with adding 1 GW of each technology; and
- The range of equipment and material spend developed (as discussed herein) associated with the construction of 1 GW of each technology.

1. **Nuclear:** The study's analysis of nuclear technology considered ten units at four sites. Nine of the units are completed (dating back to the 1970s and 1980s), and one is a current working projection for a project we are currently supporting in its early development phase based on a new generation plant design. Unit sizes range from approximately 800 MW to 1,600 MW. The projected staffing plans assume a development period of three years and a construction period of six and a half years for an approximately 1,600MW new nuclear generation unit.

2. **Conventional coal:** The study's analysis of conventional coal technology considered 11 units utilizing various technologies at nine sites. Five of the units are completed (1990s and newer), and six are currently under construction. Unit sizes range from approximately 200 MW to 800 MW. The projected staffing plans assume a development period of two and a half years and a construction period of four years for an approximately 600 MW new super-critical, pulverized coal generation unit.

3. **Conventional coal including carbon capture and storage:** The study's analysis of CCS technology was done on a stand-alone basis and draws from work we either are performing or have reviewed at three separate sites with respect to the separation and capture of CO_2. These data points include sites adding this capability either on a retrofit basis or as part of initial construction, which is inherently more efficient. Although the blended results of this analysis likely yield higher workforce requirements than would be expected going forward (where CCS will be implemented with initial construction), it is expected that the results presented for the CCS analyses are consistent with the level of accuracy represented for all other study results. Each of these applications is targeting CO_2 capture efficiencies in the 85-90 percent range, which is the basis for the CCS technologies included in this study.

   This approach resulted in a "CO_2 Capture Adder" (i.e., the hourly and salaried job-hours, and the equipment and material dollars spend, associated with the implementation of CCS technology) that we normalized to a per GW of plant treated basis and then applied to both the SCPC and IGCC options. To apply this adder to SCPC, we took the base data from item 2 above and increased all parameters by 33 percent to offset the approximately 25 percent parasitic loads that will be imposed by adding CCS technology to a SCPC power plant. In other words, a starting SCPC generating capacity of 1,333 MW without CCS is needed to end up with a SCPC generating capacity of 1,000 MW with CCS, assuming a 25 percent loss of output associated with powering the CCS equipment. The CO_2 Capture Adder staffing curves and spend dollars were then added to these revised results. We have not attempted to analyze the staffing requirements associated with transportation and sequestration of CO_2.

4. **IGCC:** The study's analysis of IGCC technology considered six units at four sites. Two of the units are completed (dating back to the 1980s and 1990s), two are currently in execution, and two are current projections for projects we are familiar with. Unit sizes range from approximately 100 MW to 300 MW. The projected staffing plans assume a

development period of two years and a construction period of four years for an approximately 600 MW new multi-unit IGCC plant.

5. **IGCC including carbon capture and storage:** The study's analysis of IGCC with CCS is similar to item 3 above, but with an adjustment factor of 25 percent to the item 4 results to offset the approximately 20 percent parasitic loads that will be imposed by adding CCS technology to an IGCC power plant. In other words, a starting IGCC generating capacity of 1,250 MW without CCS is needed to achieve an IGCC generating capacity of 1,000 MW with CCS, assuming a 20 percent loss of output associated with powering the CCS equipment.

6. **Natural gas combined cycle:** The study's analysis of NGCC technology considered 21 units at seven sites. Fifteen of the units are completed (within the past 10 years), and six are current projections for projects we are familiar with. Unit sizes range from approximately 250 MW to 350 MW. The projected staffing plans assume a development period of two years and a construction period of two and a half years for an approximately 800 MW new multi-unit NGCC plant.

7. **Onshore wind:** The study's analysis of wind technology considered wind farms at three separate sites that we have reviewed within the past several years. The wind farm sizes ranged from 20 MW to 150 MW. The projected staffing plans assume a development period of two years and a construction period of one year for approximately 100MW of wind generation.

8. **Solar thermal:** The study's analysis of solar thermal technology is based on our analysis of a limited number of projects we are familiar with, as well as from industry sources considered reliable for this technology. The projected staffing plans assume a development period of two years and a construction period of two years for an approximately 100 MW solar thermal plant.

9. **Solar PV:** The study's analysis of solar PV technology is based upon current projections for two projects we are familiar with, as well as from industry sources considered reliable for this technology. The projected staffing plans assume a development period of two years and a construction period of two years for an approximately 100 MW solar PV plant.

Development Plus Construction Phases: Man-Years per GW of Generation*

Technology	Salaried	Hourly
1. Nuclear	4,785	9,575
2. Conventional coal (super-critical, pulverized coal)	1,390	4,980
3. Conventional coal including CCS	2,140	8,435
4. IGCC	2,130	5,150
5. IGCC including CCS	2,795	8,145
6. Natural gas combined cycle	495	1,270
7. Onshore wind	305	1,180
8. Solar thermal	3,345	5,185
9. Solar PV	2,560	8,720

* Man-years per GW block of generation reflect base data for both development and construction phases; a +/- 25 percent level of accuracy applies to all workforce requirements and associated data presented in this report.

Equipment and Material Dollar Spend Ranges per GW of Generation Capacity ($ in millions) *

Technology	75 percent	Base Case	125 percent
1. Nuclear	$1,000	$1,325	$1,650
2. Conventional coal (super-critical, pulverized coal)	$725	$975	$1,225
3. Conventional coal including CCS	$1,275	$1,700	$2,125
4. IGCC	$925	$1,225	$1,550
5. IGCC including CCS	$1,450	$1,925	$2,400
6. Natural gas combined cycle	$285	$380	$475
7. Onshore wind	$935	$1,250	$1,550
8. Solar thermal	$915	$1,220	$1,525
9. Solar PV	$1,550	$2,050	$2,555

* Data in table above are intended to provide an approximate dollar spend range for the equipment and materials needed to construct 1 GW of each technology. These estimates do not address specific plant operational characteristics, nor do they include the cost of supporting infrastructure, such as transmission lines, natural gas pipelines, roads, or CO_2 pipelines and sequestration sites that may be required for the facility to operate. All of these factors, in addition to the capital costs shown in the table above, can affect the cost of electricity to the consumer.

Appendix: Bechtel Qualifications

- Bechtel, headquartered in Frederick, MD, is one of the preeminent EPC contractors in the world. With power experience dating back more than seventy years, Bechtel has been ranked by Engineering News-Record magazine as the #1 EPC contractor in the industry in each of the past eleven years. Its corporate resume includes over 200,000 MW of completed power projects, with the following highlights:
  - 118,000 MW (500 units) of fossil power
  - 76,000 MW (80 units) of nuclear power
  - 26,000 MW (180 units) of hydro power
  - 20 years of gasification/IGCC experience (6 major projects, over 60 studies)
  - Significant renewables experience with completed projects utilizing waste-to-energy, biomass, solar, geothermal, and wind technologies

- Bechtel Enterprises Holdings, Inc. (BEn), also headquartered in Frederick, MD, is the Bechtel Group's project finance and development arm. With close to forty years of experience, BEn has been involved in the development of seventy seven projects representing $32 billion in project costs. Included in this are fifty power projects totaling more than 28,000 MW of generation across a variety of technologies.

Attachments

Attachment 1 - Staffing curves, by technology, for a standard 1 GW of generation

- Part 1: curves are provided for each technology assessed, which identify the range of hourly and salaried workforce requirements, with the vertical line on each curve denoting the transition from the development phase to the construction phase.
- Part 2: separate curves are also provided for each technology reflecting the critical crafts component of the hourly workforce requirements.

The information provided in these curves was not prepared for the purposes of being representative of any past, current or future project utilizing the identified technology. As such, this information should not in any way be deemed to be representative of or applicable to any particular project utilizing the identified technology and should not in any way be utilized for the purposes of any commercial discussions, analyses or determinations in respect of any particular project.

Attachment 2 - Details of generating capacity additions for the NCEP-provided scenarios

This table shows the total GW additions by technology and by year for each of the scenarios provided by NCEP. Results of the workforce requirements analyses associated with each of these scenarios are provided in Attachment 3.

Attachment 3 - Staffing curves for the NCEP-provided scenarios

- Base curves for each scenario (Each curve tails down to zero workforce requirement by the year 2030 since there are no capacity additions beyond that point in any of the deployment scenarios)
- Hourly workforce requirements curve across all scenarios
- Salaried workforce requirements curve across all scenarios
- Critical craft components for each scenario