National Commission on Energy Policy

NATIONAL COMMISSION ON ENERGY POLICY'S

TASK FORCE ON AMERICA'S FUTURE ENERGY JOBS

Disclaimer

This report is a product of a Task Force with participants of diverse expertise and affiliations, addressing many complex and contentious topics. It is inevitable that arriving at a consensus document in these circumstances entailed compromises. Accordingly, it should not be assumed that every member is entirely satisfied with every formulation in this document, or even that all participants would agree with any given recommendation if it were taken in isolation. Rather, this group reached consensus on these recommendations as a package, which taken as a whole offers a balanced approach to the issue.

It is also important to note that this report is a product solely of the participants from the NCEP convened Task Force on America's Future Energy Jobs. The views expressed here do not necessarily reflect those of the National Commission on Energy Policy.

Acknowledgements

The National Commission on Energy Policy would like to express its thanks for the strong support of its funders. The Commission was founded in 2002 by the William and Flora Hewlett Foundation and its partners.

Special appreciation is due to Norm Augustine and Senator Pete Domenici (ret.) for their valuable contributions to this effort. The NCEP staff gratefully acknowledges the substantial guidance, research, and support offered by M.J. Bradley & Associates, LLC throughout the course of this effort. In particular, Michael Bradley, Managing Director, Carrie Jenks, Senior Consultant, Tom Curry, Policy Analyst, and Kathleen Robertson, Policy Analyst, were essential members of the project team as was Elizabeth Ewing, of Ewing Smith Consulting, LLC. Additionally, special thanks to Ian Copeland, President, and Rick Franzese, Senior Development Manager, both of Bechtel Power Corporation, for generously lending their expertise to the Task Force. Thanks also to Todd Barker, Partner, of the Meridian Institute for his guidance during the second and third Task Force meetings, and to Revis James, Director of the Energy Technology Assessment Center at the Electric Power Research Institute for allowing the Task Force to draw on the EPRI analyses in this area.

Foreword

Jobs, energy, and climate change—these issues are not new, but they have converged with greater urgency in the political spotlight over recent months. Efforts to advance climate legislation in Congress have re-energized a long-standing debate about the jobs and competitiveness impacts of greenhouse gas constraints, even as immediate measures to stimulate the economy have emphasized the job-creating potential of clean energy investments. In this fast-changing context, one central premise is beyond dispute: Transforming our nation's energy systems represents an enormous undertaking. It will require not only new, low-carbon technologies and systems, but people with the expertise to create those technologies and to plan, design, build, operate, and maintain those technologies and systems.

In this report, the Task Force on America's Future Energy Jobs makes the compelling case that our nation's educational infrastructure must be improved and realigned to produce the next generation of professionals needed to orchestrate this critical transformation. The themes and recommendations that emerge from this assessment particularly resonate with the two of us. Our own long careers, spanning both the public and private realms, reflect a deep commitment to this nation's continued global leadership in the domains of science and technology—and a deep conviction that strength in these areas is essential to America's continued prosperity and security. Through independent paths we have, in our own ways, become students of the U.S. K–12 educational system and we have concluded it is dangerously close to failing on a number of crucial fronts. By grappling with these issues as they relate to the energy sector, the Task Force has made an important contribution. We hope it will further motivate the movement to finally reform our nation's educational systems. Indeed, we hope this report is viewed as a call to action—one that comes at a rare moment when new political will and financial resources are being directed to major investments in our nation's energy and education sectors. Implementing the recommendations in this report would represent a major step forward in dealing with some of the most difficult challenges our nation confronts in this century. We can't think of a better time than now to get started.

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CONTENTS

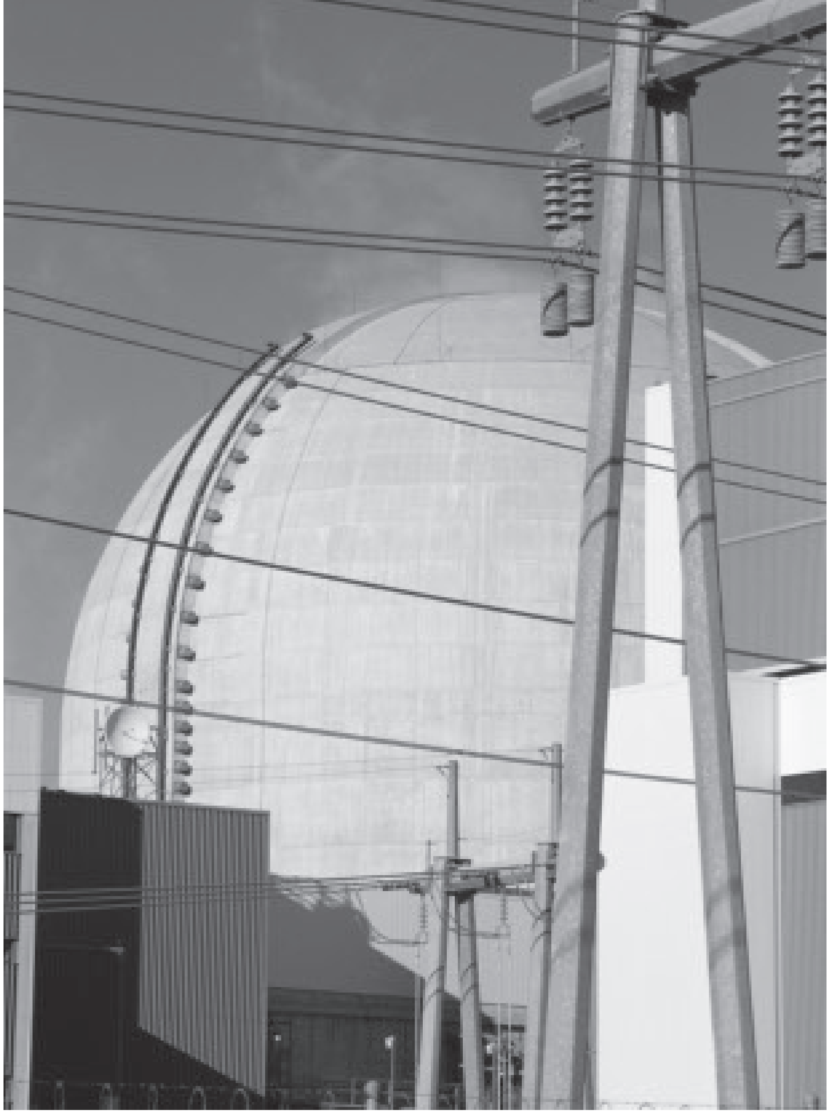
EXECUTIVE SUMMARY

In January of 2009, the National Commission on Energy Policy (NCEP) convened a group of stakeholders with expertise in the workforce of the U.S. electric power industry. The NCEP Task Force on America's Future Energy Jobs brought together representatives from labor, the electric power industry, and the training and educational sectors to explore—over a series of three meetings in six months—the existing demographic makeup and anticipated workforce needs of the electric power sector, along with the training institutions and programs that support this sector. This report summarizes the insights and conclusions resulting from this effort.

Broadly speaking, the Task Force believes the United States is facing a critical shortage of trained professionals to maintain the existing electric power system and design, build, and operate the future electric power system. The implications of this shortfall are wide-ranging and, in the view of the Task Force, of national significance. The ability to maintain a highly reliable, economically affordable electric power system while modernizing the nation's generating infrastructure to support an advanced, low-carbon technology portfolio is in serious jeopardy. This report highlights the main forces driving this situation and lays out a series of recommendations for addressing the dominant workforce challenges that will confront the electric power industry over the next several years. Ensuring the proper systems and institutions are in place to respond to these challenges is important, not only in terms of advancing critical public policy goals with respect to energy, the economy, and the environment, but because a substantial opportunity exists to create new high-skill, high-paying jobs in the energy sector at a time when growing numbers of Americans are unemployed or underemployed and face the prospect of financial insecurity.

Since the formation of this Task Force, the nation has experienced significant political and economic changes. The Obama Administration is committed to an energy policy that aims to reduce the nation's consumption of fossil fuels and contribution to global greenhouse gas emissions. At the same time, an unprecedented economic crisis has crippled global financial markets, halted global economic growth, and led to massive job losses in the United States and elsewhere. Against this backdrop, the Task Force set about examining the workforce supply and demand dynamics in the electric power industry. The recently enacted American Recovery and Reinvestment Act (ARRA) will likely provide a near-term infusion of resources that have

The United States is facing a critical shortage of trained professionals to maintain the existing electric power system and design, build, and operate the future electric power system.



the potential to facilitate many of the actions recommended in this report. To ensure that these short-term investments build the long-term capacity needed to address multi-decade challenges like climate change, policymakers should consider the actions recommended in this report when reauthorizing the Workforce Investment Act (WIA) and crafting climate and energy legislation.

Data and Definitions

NCEP conducted significant background analytical work to better assess the challenges that are often reported anecdotally by concerned parties. One of the most important conclusions from this work is that data collection and measurement systems needed to gauge the state of our nation's energy workforce are woefully inadequate. For this reason, the NCEP team endeavored to commission new work and access available information to characterize the challenges. While the data collected and presented in this report represent a significant contribution to the debate, we believe that this assessment is best used as an illustrative guide to current workforce issues. We have not attempted to develop a precise projection of future workforce needs. Additionally, our report is not intended to take the place of state and regional workforce assessments that can provide the insights needed to identify specific focus areas for individual training programs or education systems. As described further in the report, we believe that bringing together major stakeholder groups at a local or regional level is the best way to evaluate specific training needs.

A theme that seems to resonate broadly across the energy workforce debate is that "green jobs" are a positive outcome to be promoted. However, a universally accepted definition for what constitutes a green job does not exist. Organizations of all types tend to attach the "green" label when describing activities they support and promote, which highlights the ambiguity in using the term. While it is generally safe to assume that jobs directly involved in the deployment of energy efficiency and renewable energy technologies would be considered "green," a number of complexities quickly emerge as soon as one attempts to apply even this seemingly simple definition. For example, a lineworker building a transmission line that connects a wind farm to the electric grid would be viewed by most people as having a green job. If that same transmission line carries electricity generated from nearby coal-fired power plants, the "greenness" of that job may not be as clear. This example illustrates that the skills needed to perform what many think of as a green job are often the same as or very similar to traditional energy-related jobs.

The NCEP Task Force on America's Future Energy Jobs believes debating the definition of green jobs may become a distraction. In fact, we do not use this term elsewhere in this report. Rather, because our effort is focused on workforce needs associated with building and supporting energy infrastructure for a future low-carbon energy system, we believe the term "future energy job" is more appropriate for our focus. It implies that all types of jobs that support an energy system consistent with a long-term goal of reducing greenhouse gas emissions should be seen in the same light. Some of the jobs related to the transition to a carbon constrained economy will be new and will require new skill sets. But many more will use skills that are already in demand today, such as those required for sheet metal workers, transmission lineworkers, and electricians.[1] In effect, if the underlying policy framework reflects the objectives embedded in the term "green job" then future energy jobs *are* green jobs.

Overarching Challenges

As a starting point, Task Force members shared a common recognition that the electric power sector faces near- and long-term workforce challenges. Its workforce is aging and will need to be replaced. Facing a wave of retirements over the next decade, the electric power industry will need to expand hiring and training programs just to maintain the level of qualified workers required to operate existing facilities. In fact, new workers will be needed to fill as many as one-third of the nation's 400,000 current electric power jobs by 2013.[2] In the face of this surge in demand, companies are finding that applicants for open positions at electricity companies are not as prepared as they were in decades past. Companies are finding that U.S. students are not graduating at the same rates in the relevant fields and with the same qualifications as in the past. While the Task Force focused on direct electric power sector jobs, the Task Force members recognize that other economic sectors, such as the manufacturing sector, face similar demographic, education, and training challenges.

In the long-term, the deployment of new technologies and generating assets—including new energy efficiency, nuclear, renewable, advanced coal with carbon capture, and smart grid technologies—will require new design, construction, operation, and maintenance skills. This is an important opportunity for new job creation and economic growth. If too few individuals with the necessary expertise are available when they are needed, workforce bottlenecks could slow the transition to a low-carbon economy *regardless* of the commercial readiness of the underlying technologies. If the result is to delay the efficient adoption of improved low-carbon alternatives, workforce shortages would represent more than a lost opportunity—they could impose substantial costs, both in terms of economic burden and environmental damages and could damage U.S. global competitiveness.

Task Force Approach

The Task Force focused on three broad categories of jobs:

- Jobs associated with operating and maintaining the existing electric power infrastructure;

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[1] Apollo Alliance and Green For All with Center for American Progress and Center on Wisconsin Strategy, "Green-Collar Jobs in America's Cities: Building Pathways out of Poverty and Careers in the Clean Energy Economy." 2008. Available http://www.greenforall.org/resources/green-collar-jobs-in-america2019s-cities.

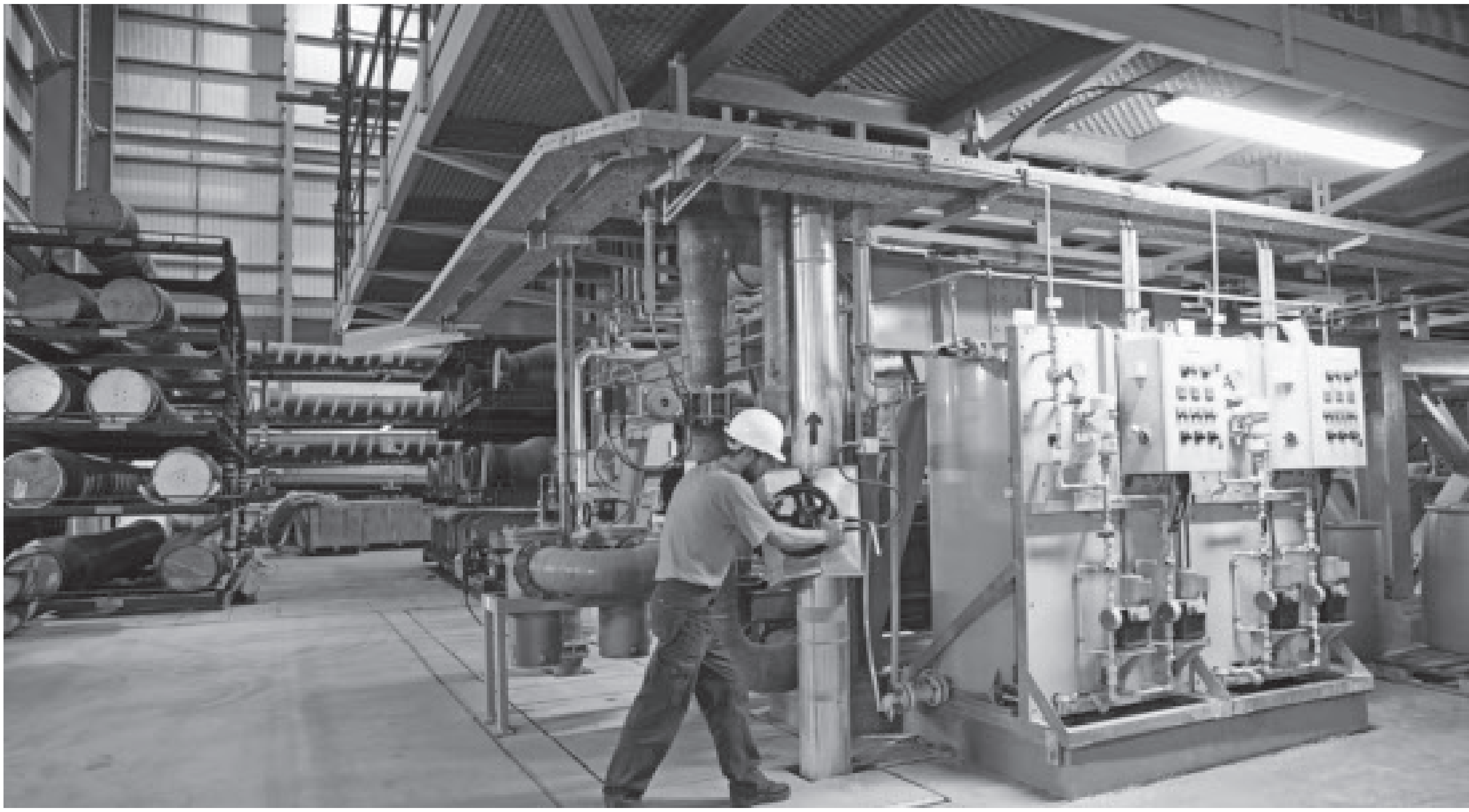
[2] While the Task Force future scenarios focus on electric power generation, transmission, and distribution, we recognize that electric utilities are frequently integrated with natural gas utilities and that natural gas utilities face similar workforce pressures. According to the Bureau of Labor Statistics, natural gas utilities employ about 106,000 people. The CEWD data referenced in this report combine natural gas utility workforce estimates with the electric utility workforce estimates.

- Jobs associated with designing and building new generation to meet future low-carbon energy needs; and
- Jobs associated with operating and maintaining the electric power industry of the future.

The first chapter summarizes the Task Force's findings on existing power industry labor markets. Rapid attrition due to retirements from an aging pool of workers is the primary concern. Chapter 2 examines what happens when an expected surge in demand for new low-carbon energy technologies is layered on top of this declining base. Comparing pending workforce requirements against the existing education and training pipeline is the focus of the third chapter. Chapter 4 presents suggested policy solutions and Task Force recommendations. We summarize key insights from each chapter along with our primary recommendations below. References for the data are included in the corresponding chapters.

Chapter 1 Critical Insights – Existing Electric Power Sector Workforce

- The electric power generation, transmission, and distribution industry employs about 400,000 people.
- A large fraction (30–40 percent) of electric power workers will be eligible for retirement or leave the industry for other reasons by 2013.
- Of the 120,000 to 160,000 electric power workers that will be eligible for retirement or leave the industry for other reasons by 2013, industry surveys suggest 58,200 will be skilled craft workers and another 11,200 will be engineers.
- While recent industry estimates anticipate that workers will delay retirement due to the current economic downturn, it is impossible to predict how long workers will extend em-



ployment. There is a concern in the industry that delayed retirement could lead to more acute worker shortages at some point in the future if many workers retire around the same time.

Chapter 2 Critical Insights – Potential Workforce Demand Surge under a Federal Climate Policy

- In addition to needing skilled workers to replace retiring workers, the industry will need skilled construction workers to design and construct new electric sector infrastructure. We estimate that in 2022, design and construction work for the electric sector will require about 150,000 professional and skilled craft workers from the construction sector. This construction workforce is about 40 percent the size of the existing electric power workforce.

- Demand for skilled workers to operate and maintain the electric generation systems of the future will increase steadily as new technologies come online. The number of additional workers that will be needed by 2030 is roughly 60,000—an increase of almost 15 percent.

- The deployment trajectory for new generation technologies directly impacts workforce demand. In scenarios with steady annual deployment of new generating assets, workforce demands will peak at a lower level and will be spread out over more years. In scenarios where construction is delayed and several generating assets are planned to come into operation in the same year, the workforce peak is higher and the demand is more concentrated around the peak year. This variability reinforces the need for local and regional assessments of workforce demand as climate policy becomes clearer.

- The industry needs to prepare to meet a long-term, sustained need for training, beyond the retirement gap.

- With respect to the design, construction, and operation and maintenance (O&M) of infrastructure and supporting technologies:
  - Demand for construction labor to build new high-voltage transmission lines and substations is expected to spike, especially in light of the transmission investments anticipated under the recent economic stimulus package. We estimate the peak demand for construction labor and skilled crafts to be about 10,000 to 15,000. However, policy and regulatory delays have affected the construction timetable of a number of proposed transmission lines. These delays increase the uncertainty around projections of future workforce demand.
  - The near-term deployment of smart grid technologies will require over 90,000 workers. However, smart grid deployment will result in about 25,000 electricity power industry workers looking to transition to new positions. This supply of workers highlights the need for training programs that

A large fraction (30–40 percent) of electric power workers will be eligible for retirement or leave the industry for other reasons by 2013.

retrain existing workers to take advantage of new opportunities within the industry.

- Construction and maintenance of CO_2 pipelines as part of a commitment to expanded carbon capture and storage (CCS) will marginally add to the demand for skilled workers. While not directly calculated as part of the NCEP Task Force estimates, additional workers will be needed to retrofit fossil fuel-fired power plants with carbon capture technologies.

- Running energy efficiency programs requires people to design and administer programs and people to promote those programs and sign up new customers. We estimate that utility or other third-party managed energy efficiency programs in the United States will require all or part of the time of approximately 11,000 employees per year through 2030. Additionally, we expect the program managers to hire contractors to implement or deploy efficiency technologies. These contractors are expected to significantly outnumber the number of direct employees required to administer and promote customer-side efficiency programs and could number in the thousands for each program. While these jobs will be an important component of future energy jobs, the Task Force decided not to seek to quantify these jobs.

Chapter 3 Challenges – Training the Future Energy Workforce

- Challenges to preparing students in grades K-12:

  - Low Graduation Rates. Of the approximately four million students who will begin high school this fall in the United States, less than three million are expected to complete high school.

  - Lack of Technical Skills. Of those who complete high school, many are ill-prepared to pursue a career that requires basic technical skills.

  - Lack of Industry-Specific Training for Educators. Teacher training and retraining is a key component of repairing our basic educational system.

- Challenges to training and educating skilled craft workers:

  - Individuals can acquire the technical skills and training to enter the skilled craft electric power or construction workforce from several types of institutions or programs, including:
    - community colleges,
    - community-based organizations (CBOs),
    - apprenticeship programs,
    - company-specific training programs, and
    - worker retraining programs.

  - Understanding the Electric Power Sector Demand for Skilled Workers. A key chal-

lenge is aligning training programs with the demand for workers. This challenge is compounded by the current system used by the Bureau of Labor Statistics (BLS) to estimate future industry demand. That system relies on historical trends to project future industry growth and does not include estimates for replacing positions lost through retirements or other attrition.

- Lack of Communication among Stakeholder Groups. Compounding the assessment challenge noted above is the fact that better communication is needed among stakeholders—particularly between training institutions and the electric power sector.

- Lack of Credential Portability. A lack of standardized skill sets and curricula for some of the skilled crafts within the electric power sector presents a significant challenge for students, community colleges, and employers. This issue is specific to a subset of skilled crafts within the electric power sector—it does not apply to skilled crafts in the construction sector.

- Collecting and Tracking Skilled Workforce Data. Information on the number of people that pass through existing training systems and their ultimate employment is currently not well captured.

- Costs of Education. Even students who have adequate education in technical skills may have trouble paying for post-secondary education.

- Improving the Image of Electricity Industry Careers. Students and parents often do not view apprenticeship programs or other programs outside the four-year degree construct as providing similar or better opportunities for career and salary potential.

- Lack of Career Preparatory Skills within the Workforce. Because of a lack of technical skills among the potential workforce, introductory courses have become more prevalent at the community college level.

- Challenges to training and educating engineers:

  - Lack of math and science skills in the population of high school graduates.

  - Mobilizing the Research Community. Professional engineers are needed to develop, design and implement new, low-carbon technologies that produce electricity. 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

A LACK OF STANDARDIZED SKILL SETS AND CURRICULA FOR SOME OF THE SKILLED CRAFTS WITHIN THE ELECTRIC POWER SECTOR PRESENTS A SIGNIFICANT CHALLENGE FOR STUDENTS, COMMUNITY COLLEGES, AND EMPLOYERS.

programs that are multidisciplinary in their approach and thinking.

- Encouraging Students to Work in the Electric Power Sector. In addition to stimulating research, it is important to foster mechanisms for pulling both research and students into the electric power sector.

- Costs of Education. The cost of education in the United States is daunting and can be a barrier to entry.

Task Force Recommendations

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. The recommendations, summarized here, are available following the conclusions in Chapter 4 of the report. 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.

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 the Department of Labor (DOL) and the Department of Energy (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. As a part of this evaluation, DOL, DOE, and each state or regional energy workforce consortium should seek to identify policy uncertainties that are currently delaying, or have the potential to delay, the deployment of new generating assets and infrastructure. In the regions of the country where the energy workforce consortia highlight workforce gaps, Congress should provide financial resources and coordination assistance for the development of locally or regionally-coordinated workforce training programs targeted to the needs of the energy sector. DOL should use the Green Jobs Act, or other appropriate federal funding mechanisms, to award funding for this purpose through a competitive process to programs that meet established criteria.

Recommendation 2: Improve energy sector workforce data collection and performance measurement metrics and tools. Improve the collection, management, and availability of workforce data for the energy sector to facilitate future efforts to measure progress and identify emerging workforce needs.

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 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 sector jobs. 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 stakeholders, 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 to individuals seeking energy sector-related training and education. Using existing funding mechanisms as appropriate, provide financial support, targeted to those most in need, to individuals that wish to pursue energy-related technical and professional training or retraining and to students interested in pursuing post-secondary degrees in engineering and other energy-related technical fields.

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 science, technology, engineering, and math training for K-12 students, adults who wish to enter the energy workforce, and teachers and instructors. Engage the next generation of scientists and engineers in the energy sector by following through on and enhancing commitments to expanding U.S. investment in research and development. Increase awareness of employment opportunities in the energy sector.

In addition to stimulating research, it is important to foster mechanisms for pulling both research and students into the electric power sector.

CHAPTER 1.

THE CURRENT ENERGY WORKFORCE

In recent years, stakeholders in the electric power labor market – electric companies; labor organizations; engineering, procurement, and construction contractors; and educators – have become concerned that the industry will face a shortage of skilled craft and professional workers over the next five to ten years due to retirement and attrition. Several reports have highlighted an impending shortage of skilled workers.[3] A 2007 Department of Labor (DOL) report reinforced these conclusions, saying, "Perhaps the most complex and pressing challenge facing the energy industry is the retirement of incumbent workers."[4]

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[3] See, e.g., NEI's November/December 2007 newsletter ("Nuclear Renaissance Presents Job Opportunities in All Sectors") available at http://www.nei.org/filefolder/insight_200711_12.pdf and M.B. Reilly's "The New Energy Crisis: Power Industry in for a Jolt as About Half of Workforce Readies for Retirement" available at http://www.uc.edu/News/NR.aspx?ID=4226.

[4] U.S. Department of Labor, Employment and Training Administration. "Identifying and Addressing Workforce Challenges in America's Energy Industry." March 2007. Available http://www.doleta.gov/BRG/pdf/Energy%20Report_final.pdf.

The U.S. Department of Labor reports the median age of American workers reached 40.7 in 2008.[5] By comparison, the median age of energy workers in 2008 was 45.[6] Estimates of the average age of the electric power workforce range from the mid-40s to 50; both *Electric Light & Power*, an industry publication, and DOL found the average age of electric power workers to be nearly 50 in 2006 and 2007, respectively.[7,8] These older demographics present a particular challenge to the industry because most electric power employees traditionally retire at age 55.[9]

Over the past five years, however, the electric power industry has made an effort to address workforce issues, with the result that the average age of the workforce appears to be declining. A 2007 survey by the Center for Energy Workforce Development (CEWD) found that the average age of utility workers declined from 45.7 in 2007 to 45.3 in 2008.[10] Surveys of pub-

Estimates of the average age of the electric power workforce range from the mid-40s to 50.

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[5] U.S. Department of Labor, Bureau of Labor Statistics: http://www.bls.gov/opub/working/page2b.htm.

[6] CEWD. "Gaps in the Energy Workforce Pipeline: 2008 CEWD Survey Results." October 2008. Available http://www.cewd.org/documents/CEWD_08Results.pdf.

[7] Electric Light & Power: http://uaelp.pennnet.com/display_article/256344/34/ARTCL/none/none/.

[8] U.S. Department of Labor, Employment and Training Administration. "Identifying and Addressing Workforce Challenges in America's Energy Industry." March 2007. Available http://www.doleta.gov/BRG/pdf/Energy%20Report_final.pdf.

[9] Ibid.

[10] CEWD. "Gaps in the Energy Workforce Pipeline: 2008 CEWD Survey Results." October 2008. Available http://www.cewd.org/documents/CEWD_08Results.pdf.

New workers will have to come from a training system that needs to be refocused and reinvigorated.

lic power companies by the American Public Power Association (APPA) show a drop in the average age of the public power workforce from 48 in 2005 to 43 in 2008.[11,12]

The declining average age of electric power workers suggests that the industry has recognized the impending shortage and has begun accelerating the hiring of younger workers. However, the same survey data suggest that a wave of employees will become eligible for retirement in the next five to ten years. As discussed in more detail below, the electric power industry estimates that 30 to 40 percent of its workforce, which numbers about 400,000 employees, will be eligible to retire in the next five years.[13] To make up for these retirements, the industry will have to hire new employees at a much higher rate.

As discussed in Chapter 3, new workers will have to come from a training system that needs to be refocused and reinvigorated. The number of people who have trained to become part of the electric power sector workforce has fluctuated over the years in response to the needs of the industry, macroeconomic conditions, the attractiveness of alternate career paths, and other factors. After a period of relatively rapid growth in the 1970s, when electricity demand grew 5 percent annually, the industry experienced much lower demand growth in the 1980s and 1990s.[14] The advent of a competitive market for electric power companies led to an increased focus on productivity, which dampened hiring trends and led to an overall decline in workforce levels through the end of the 1990s.[15] Because the industry's demand for new workers slowed significantly over this period, companies scaled back internal training programs. At the same time, the pool of qualified candidates for jobs and training programs decreased dramatically.

To address the anticipated shortfall of skilled workers, industry stakeholders formed CEWD in 2006. CEWD is a non-profit consortium of electric, natural gas, and nuclear utilities, and their associations that is tasked with addressing the industry's workforce training and education. CEWD's membership includes public, private,

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[11] APPA. "Growing Your Employees of Tomorrow." 2008. Available http://www.appanet.org/files/PDFs/2008WorkforceSurveyReport.pdf.
[12] APPA. "Work Force Planning for Public Power Utilities: Ensuring Resources to Meet Projected Needs." 2005. Available http://www.appanet.org/files/PDFs/WorkForcePlanningforPublicPowerUtilities.pdf.
[13] While the Task Force future scenarios focus on electric power generation, transmission, and distribution, we recognize that electric utilities are frequently integrated with natural gas utilities and that natural gas utilities face similar workforce pressures. According to the Bureau of Labor Statistics, natural gas utilities employ about 106,000 people. The CEWD data referenced in this report combine natural gas utility workforce estimates with the electric utility workforce estimates.
[14] Badhul Chowdhury. "Power Education at the Crossroads." IEEE Spectrum, October 2000.
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.
[15] 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.

and government-owned utilities as well as the major utility trade associations: the Edison Electric Institute (EEI), American Gas Association, Nuclear Energy Institute (NEI), and the National Rural Electric Cooperative Association.[16]

Operation and Maintenance of Existing Generating Assets and Transmission Lines

Figure 1 shows the age distribution of the electric power sector workforce as surveyed by CEWD in 2008. The CEWD survey included respondents from 56 investor owned utility and all rural electric cooperatives, representing about 46 percent of the workforce.[17] CEWD grouped survey respondents into four categories:

- Non-retirement attrition (those who leave the industry for reasons other than retirement),
- Potential retirees by 2013 (those eligible to retire, based on age and years of service),[18]
- Possible retirees by 2013 (employees eligible to retire who could possibly delay retirement due to the current economic climate),[19] and
- Retained employees.

About 30 percent of the workforce falls into the non-retirement attrition and potential retirement categories, and about 10 percent falls into the possible retirement category. That translates into a potential need to replace 30–40 percent of the total workforce by 2013. BLS estimates that about 400,000 people are employed in the electric power generation, transmission, and distribution industry and about 50 percent will retire or leave the industry for other reasons within 10 years.[20] Based on these estimates, about 120,000–160,000 workers in the electric power industry will need to be replaced by 2013 and about 200,000 will need to be replaced by 2018. Figure 2 compares these numbers.

Figure 1. Potential and Possible Employee Attrition and Retirements in the Electric and Natural Gas Industry by 2013

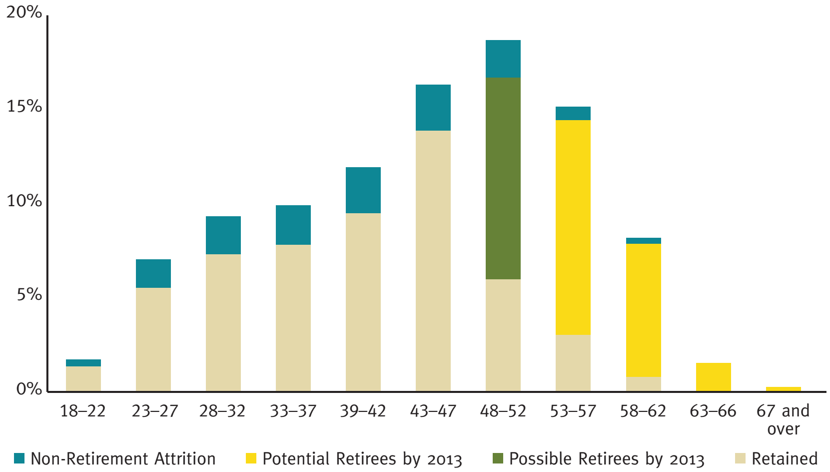
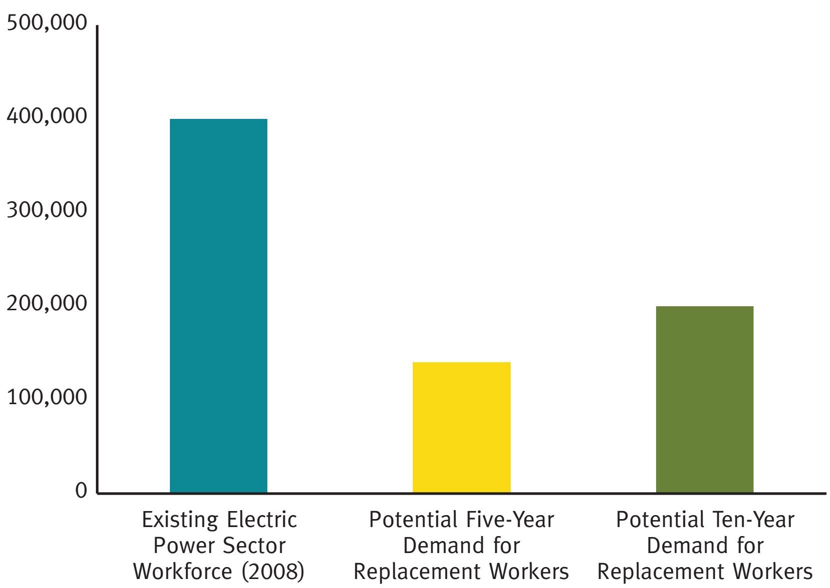


Figure 2. Comparison of the Workers Needed to Replace Workers Retiring or Leaving the Industry for Other Reasons to Existing Employment Levels



[16] CEWD, EEI, and NEI are advisors to the Task Force on America's Future Energy Jobs.

[17] CEWD. "Gaps in the Energy Workforce Pipeline: 2008 CEWD Survey Results." October 2008. Available http://www.cewd.org/documents/CEWD_08Results.pdf.

[18] CEWD defined potential retirees as employees who within the next five years will be older than 58 with more than 25 years of service, older than 63 with 20 years of service, or older than 67.

[19] CEWD defined possible retirees as employees who within the next five years will be older than 53 with more than 25 years of service.

[20] U.S. Department of Labor, Bureau of Labor Statistics. "Career Guide to Industries, 2008-09 Edition, Utilities." Available http://www.bls.gov/oco/cg/cgs018.htm.

CEWD is particularly interested in assessing the need for employees with technical skills, such as skilled craft workers and engineers. These positions require significant training, and thus are an area of great concern for the industry, including members of the Task Force. For example, according to CEWD, a pipefitter retiring with 30 years of experience would need to be replaced by a pipefitter with at least five years of experience.

In its 2008 survey, CEWD collected information on the potential for retirement in five key job categories: technicians, plant operators, pipefitters/pipelayers, lineworkers, and engineers.[21] Table 1 shows the detailed results of the CEWD survey by job category.

Table I. CEWD Survey Results by Job Category

Job Category	Estimated Number of Potential Replacements by 2013
Electric Power Skilled Craft	58,200
Technicians	20,300
Non-Nuclear Plant Operators	8,900
Pipefitters/Pipelayers	6,500
Lineworkers	22,500
Engineers	11,200

CEWD defines technicians to include a broad range of skilled crafts including electricians, boilermakers, carpenters, millwrights, machinists, and operating engineers. CEWD research suggests that individuals frequently enter the workforce as technicians and then move into more specific skilled crafts.

While CEWD has focused its efforts on the broader electric and natural gas sector, NEI has been conducting workforce surveys specific to the needs of the nuclear industry. In 2007, the U.S. nuclear industry employed about 56,000 people. Through 2012, NEI expects a need for about 6,300 workers to replace those lost through general attrition and another 19,600 to replace retiring workers. This totals about 45 percent of the current nuclear power workforce. [22]

[21] Because the CEWD assessment includes natural gas distribution, the CEWD data include a higher demand for technicians, engineers, and pipefitters/pipelayers than would have been the case if only the electric utility sector were considered.

[22] Carol L. Berrigan, Director, Industry Infrastructure, Nuclear Energy Institute. "Testimony for the Record to the U.S. Senate Committee on Energy and Natural Resources." November 6, 2007. Available http://energy.senate.gov/public/_files/CBerriganTestimony110607.pdf.

CHAPTER 2.

ESTIMATING THE WORKFORCE IMPLICATIONS OF A TRANSITION TO LOW-CARBON ELECTRICITY GENERATION

Forecasting the long-term pace and trajectory of future trends in the electric power industry is challenging in any economic and political environment. The task is even more challenging today, given the high degree of uncertainty that surrounds any prediction of future economic growth, climate policy, or technological development. These uncertainties serve, however, to reinforce the importance of understanding how policy decisions made today can affect the workforce needs of tomorrow. If the United States is going to substantially reduce its greenhouse gas emissions over the next two decades while continuing to meet the electricity demands of the economy, new low-carbon electricity generation and supporting infrastructure will need to be designed, built, and operated.

That means the electric power industry will need to do more than replace the workers who currently operate and maintain the existing infrastructure, it will need to engage workers from the construction sector to build new generating assets and it will need to expand its own workforce to operate and maintain those new assets.

Task Force members are concerned about the ability of the existing training system to handle the combined demand for technically-skilled workers to both replace retiring workers and support the rapid construction of new, low-carbon generation capacity. While the United States has yet to adopt a clear national climate policy, the Task Force sought to develop national-level estimates of the demand for labor to build and maintain low-carbon generation at the scale needed to achieve meaningful reductions in greenhouse gas emissions. After considering a number of modeled technology pathways, the Task Force decided to use an analysis developed by the Electric Power Research Institute (EPRI).[23, 24]

The EPRI Prism analysis represents one scenario for how the United States might reduce power-sector greenhouse gas emissions over the next 20 years using a mix of low-carbon generation technologies (e.g. wind, solar, nuclear, and coal with CCS) in combination with additional energy efficiency measures.[26] This scenario was attractive to Task Force members because it was technology driven, assumed a balanced mix of low-carbon options, and was not based on a particular climate policy. The decision to use the Prism analysis to develop a scenario of future workforce needs, however, does not imply an endorsement of a particular deployment pathway, nor does it mean that Task Force members agree with the technology and

THE ELECTRIC POWER INDUSTRY WILL NEED TO DO MORE THAN REPLACE THE WORKERS WHO CURRENTLY OPERATE AND MAINTAIN THE EXISTING INFRASTRUCTURE, IT WILL NEED TO ENGAGE WORKERS FROM THE CONSTRUCTION SECTOR TO BUILD NEW GENERATING ASSETS AND IT WILL NEED TO EXPAND ITS OWN WORKFORCE TO OPERATE AND MAINTAIN THOSE NEW ASSETS.

[23] Electric Power Research Institute. "The Power to Reduce CO_2 Emissions: the Full Portfolio - 2008 Economic Sensitivity Studies (EPRI Report 1018431)," December 2008.

[24] Note that the EPRI analysis consists of two distinct elements. The first is the Prism analysis, which is an estimate of electricity sector CO_2 emissions reduction potential based on a hypothetical technology scenario. The second is driven by results from the Model for Evaluating Regional and Global Effects (MERGE) energy-economic analysis, which examines the optimum portfolio of low-carbon energy technology over time under an assumed economy-wide CO_2 emissions constraint.

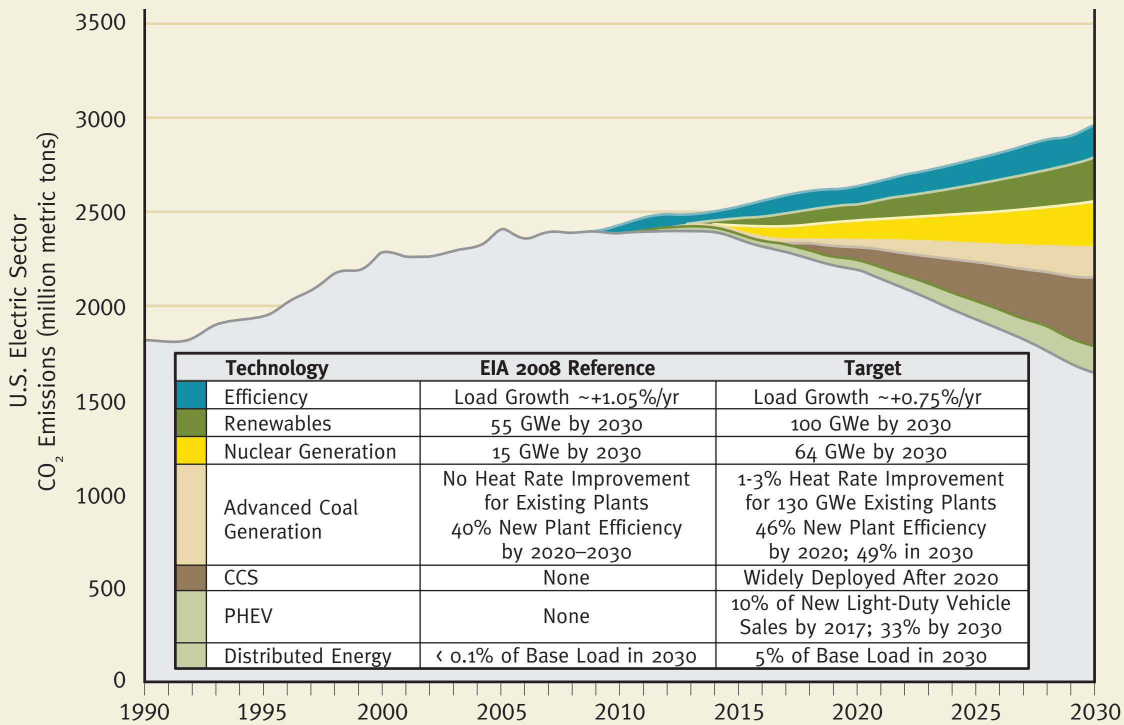
[25] Electric Power Research Institute. "The Power to Reduce CO_2 Emissions: the Full Portfolio - 2008 Economic Sensitivity Studies (EPRI Report 1018431)," December 2008.

[26] Although the EPRI Prism includes CCS on either supercritical or integrated gasification combined cycle (IGCC) plants, the Task Force modeled IGCC with CCS.

EPRI PRISM

EPRI Prism uses projections from the federal Energy Information Administration (EIA) Annual Energy Outlook 2008 and assumes an average annual electricity demand increase of approximately 1 percent. This leads to an estimated increase in total electricity demand of 20 percent above current levels by 2030, which in turn implies that approximately 210 gigawatts (GW) of new generation capacity will need to be added between 2007 and 2030. Under the Prism scenario, utilities achieve this increase in capacity by deploying roughly 80 GW of nuclear, 90 GW of coal with CCS, 40 GW of wind, 1 GW of solar thermal power, and 300 megawatts (MW) of solar photovoltaic power by 2030.[25] As a result, the industry's greenhouse gas emissions decline by 45 percent below projected business-as-usual levels by 2030. Results from the EPRI Prism analysis are illustrated in Figure 3.

Figure 3. EPRI Prism



Technology	EIA 2008 Reference	Target
Efficiency	Load Growth ~+1.05%/yr	Load Growth ~+0.75%/yr
Renewables	55 GWe by 2030	100 GWe by 2030
Nuclear Generation	15 GWe by 2030	64 GWe by 2030
Advanced Coal Generation	No Heat Rate Improvement for Existing Plants 40% New Plant Efficiency by 2020–2030	1-3% Heat Rate Improvement for 130 GWe Existing Plants 46% New Plant Efficiency by 2020; 49% in 2030
CCS	None	Widely Deployed After 2020
PHEV	None	10% of New Light-Duty Vehicle Sales by 2017; 33% by 2030
Distributed Energy	< 0.1% of Base Load in 2030	5% of Base Load in 2030

policy assumptions that were used to develop the Prism analysis. Rather, the Prism analysis simply provided a reasonable approximation to evaluate the possible future technology needs of the power sector and allowed the Task Force to impute potential workforce demands.[27]

Working from the Prism analysis, the Task Force developed national-level estimates of the numbers and the types of workers that would be necessary to implement different low-carbon technologies at the scale assumed by EPRI. These estimates are intended to outline general trends and needs rather than forecast specific

[27] The features that made the Prism scenario attractive to Task Force members as a basis for estimating workforce needs are also important for understanding the limitations of the EPRI analysis. As the Prism is based on technological feasibility, it does not include the policy interventions that would likely be necessary to bring about a low-carbon transition, such as a CO_2 price or other potential technology incentives like a renewable electricity standard. The Prism also does not consider potential constraints such as technology, materials or workforce availability.

needs by individual job type. The Task Force was particularly interested in evaluating the need for technically skilled workers. These workers fell into three broad categories:

- Skilled craft electric power workers;
- Skilled craft construction workers; and
- Engineers.

Skilled craft electric power workers include those individuals who work within the electric power sector to operate and maintain generating assets and supporting infrastructure. Skilled craft construction workers, by contrast, are generally hired by electric power companies to build generating assets and support infrastructure. Skilled craft construction workers are not specific to the energy industry. Rather, they are generally employed in industrial construction and cross over into heavy- and light-commercial construction. As considered by the Task Force, engineers work in both O&M and design and construction jobs. They perform the technical work associated with designing generating assets and supporting infrastructure and the technical work associated with running energy systems.

The Task Force identified and assessed potential workforce demands through 2030 across the following categories:

- Design and construction of new generating assets;

- O&M of existing generating assets and transmission lines (discussed in Chapter 1);

- O&M of new generating assets;

- Development and operation of the supporting infrastructure; and
  - Design, construction, and O&M of new high-voltage transmission lines;
  - Deployment and O&M of smart grid technologies; and
  - Design, construction, and O&M of CO_2 pipelines;

- Deployment of energy efficiency technologies and measures.

To generate a rough estimate of the number of workers needed in each category, the Task Force drew upon the expertise of its members and advisors. However, it is important to emphasize that the Task Force does not believe these estimates can or should take the place of state and regional workforce assessments. Greater geographic specificity is needed to identify focus areas for individual training programs or education systems. As the U.S. Congress moves forward with climate policy, the Task Force hopes that the rough estimates developed for this report can be helpful in future efforts by federal agencies and state and regional workforce boards to develop more refined workforce estimates. (Appendix D further discusses the Task Force's approach for developing the workforce estimates in this report and some areas for additional refinement.)

As the U.S. Congress moves forward with climate policy, the Task Force hopes that the rough estimates developed for this report can be helpful in future efforts by federal agencies and state and regional workforce boards to develop more refined workforce estimates.

INDIRECT JOBS

This report estimates the number of direct jobs that will need to be filled to design, build, and maintain low-carbon electric generation and associated infrastructure. The Task Force did not attempt to estimate manufacturing jobs at facilities that supply the underlying technologies, such as wind turbine blades or nuclear plant components, nor did the Task Force attempt to quantify downstream service jobs associated with demand-side management technologies or customer-owned electric vehicles. However, the Task Force anticipates that a significant number of these jobs, often referred to as indirect and induced jobs, will be created in the transition to low-carbon energy systems.

Indirect and induced jobs are often estimated to be a multiple of the direct jobs. For example:

- A DOE report on the workforce implications of a resurgence in nuclear power estimated that about four indirect and induced jobs would be created for every direct job in the nuclear industry and about five indirect and induced jobs would be created for every direct job in the broader electric industry.[28]
- A recent report on the economic benefits of advanced coal with CCS estimated that 4.8 indirect and induced jobs would be created for every direct operations and maintenance job at a coal-fired power plant with CCS.[29]

Some of the indirect or induced manufacturing jobs associated with expanded use of low-carbon technologies may be outside the United States if these technologies end up being imported rather than being produced domestically.

Design and Construction of New Generating Assets

To better understand the workforce implications of designing and constructing 210 GW of new generation as implied by the EPRI Prism scenario, NCEP commissioned a study by Bechtel Power Corporation (Bechtel). As detailed in Appendix A, experts at Bechtel drew upon data from their project experience (including actual and planned projects) and from industry sources to estimate the workforce needs associated with developing, designing, procuring materials for, and constructing new generating assets.

The Bechtel study focused solely on estimating a range of direct jobs associated with constructing new generation infrastructure. First, Bechtel staff developed 1-GW "building blocks" for each of the different types of generation assets being considered in various deployment scenarios, including nuclear, conventional coal, conventional coal with CCS, integrated gasification combined cycle (IGCC), IGCC with CCS, natural gas combined cycle, onshore wind, solar thermal power, and solar photovoltaic (PV) power. Bechtel staff then developed workforce estimates for the design and construction of each 1-GW building block of generation. This first phase resulted in a range of employment curves for each of the different generation technologies.

Figure 4 shows an example of estimated personnel requirements for the design, development, and construction of 1 GW of new nuclear generation. Bechtel's estimates include a confidence interval of 25 percent around the re-

[28] 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, Science, and Technology Under DOE Idaho Operations Office Contract DE-AC07-99ID13727). November 2004. Available http://www.inl.gov/technicalpublications/Documents/3772069.pdf.

[29] BBC Research & Consulting (Prepared for Industrial Union Council, AFL-CIO; International Brotherhood of Boilermakers; Iron Ship Builders, Blacksmiths, Forgers, and Helpers; International Brotherhood of Electrical Workers; United Mine Workers of America; and American Coalition for Clean Coal Electricity). "Employment and Other Economic Benefits from Advanced Coal Electric Generation with Carbon Capture and Storage (Preliminary Results)." February 2009. Available http:// www.americaspower.org/content/download/1459/10428/file/BBC%20FINAL%20020709.pdf.

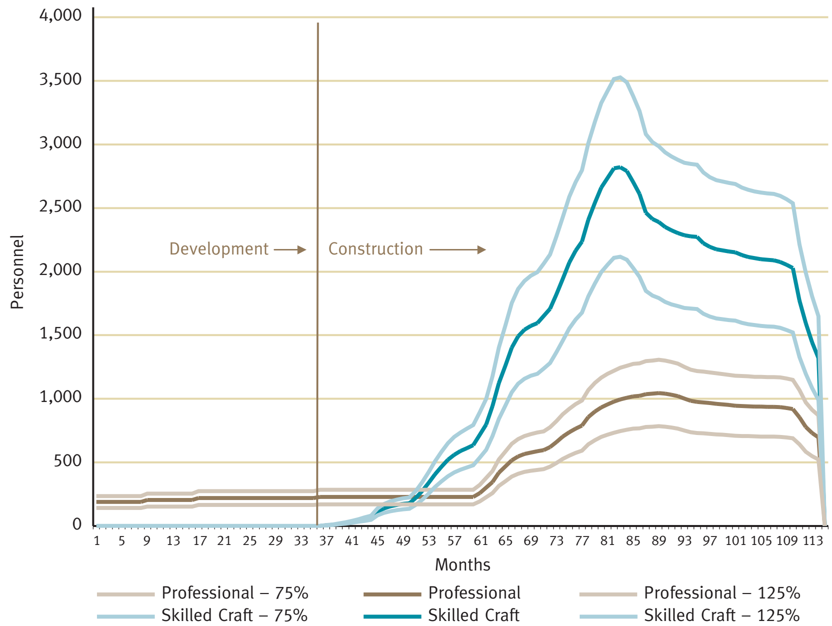
sults to reflect some of the uncertainty in these forecasts. Appendix A includes 1-GW building block personnel curves for each of the types of generation reviewed by Bechtel.

In assessing workforce needs, Bechtel considered two categories of workers: professional employees and skilled craft employees. Each designation is short-hand for a broad category of employees.

- Professional employees include individuals who provide services in engineering, procurement, project management, construction oversight, and other support services. These include employees at the project site, at corporate offices, and at offshore design facilities.

- Skilled craft employees include craft workers and craft subcontractors at a project site. As a subset of this group, Bechtel also focused on five critical crafts: pipefitters, electricians, boilermakers, millwrights, and ironworkers.

Figure 4. Average Equivalent Personnel Per Month for Design, Development, and Construction of One GW of New Nuclear Generation



Note: The information presented in this figure is not to be used independently of or without reference to the analysis in Appendix A of this report and its qualifications and assumptions, or for any commercial purposes.

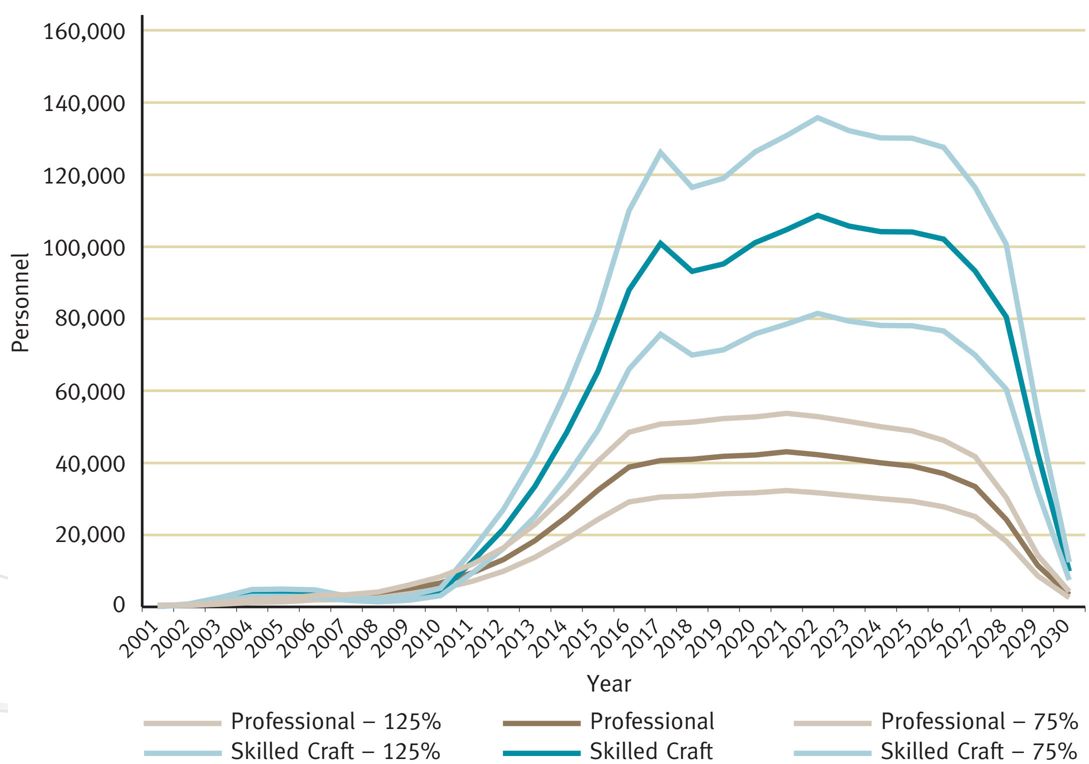
THE TASK FORCE ESTIMATES THAT ROUGHLY 113,000 TO 189,000 WORKERS WILL BE NEEDED TO DESIGN AND CONSTRUCT THE NEW GENERATING ASSETS ENVISIONED IN THE PRISM SCENARIO.

To estimate the total direct workforce demand driven by the infrastructure build in the EPRI Prism analysis, Bechtel applied these 1-GW building blocks to the 210 GW total increase in capacity.

Figure 5 shows the results of this exercise. Industry-wide, the demand for professional and skilled craft employees increases quickly over the next ten years and peaks in 2022. Note that the drop in demand as the graph approaches 2030 is a function of the EPRI Prism ending in 2030. Taking a snapshot of workforce demand in the peak year of 2022 and including both professional and skilled craft employees, the Task Force estimates that roughly 113,000 to 189,000 workers will be needed to design and construct the new generating assets envisioned in the Prism scenario. While this demand will be for construction workers as opposed to electric power workers, it is interesting to note that it is equivalent to about 30–50 percent of the existing electric sector workforce, as shown in Figure 6.

It important to clarify that this report discusses peak year demands, not cumulative jobs. This distinction is necessary due to the nature and mobility of the construction workforce. For example, the end of one construction job and the beginning of a new one does not necessarily represent an entirely new job opportunity (in the sense that it requires a newly trained professional). Rather, the new job may just be the next job for the same individual. When viewed in this manner, workforce constraints will be driven by peak demands and not by cumulative needs.

Figure 5. Average Equivalent Personnel Per Year to Design and Construct the New Generating Assets in the EPRI Prism Analysis



Note: The information presented in this figure is not to be used independently of or without reference to the analysis in Appendix A of this report and its qualifications and assumptions, or for any commercial purposes.

Bechtel identified five "critical" craft categories that comprise about sixty percent of skilled labor necessary to deploy new low-carbon generating capacity. These critical crafts include pipefitters, electricians, boilermakers, millwrights, and ironworkers. The demand for these job categories is identified in Table 2.

Table 2. Estimated Peak Demand for Construction Skilled Crafts to Design and Construct New Generation in the EPRI Prism Analysis (Peak is in 2022)

Construction Skilled Craft	Range of Expected Demand
Critical Crafts	47,800 to 79,600
Electricians	16,900 to 28,100
Pipefitters	16,800 to 28,000
Ironworkers	7,900 to 13,000
Boilermakers	5,200 to 8,700
Millwrights	1,500 to 2,500
Other Crafts	33,200 to 56,400
Total Skilled Construction Crafts	81,000 to 136,000

To evaluate the robustness of the Prism trajectories, the Task Force compared the Prism results to results from two alternate EPRI technology deployment scenarios that included economic modeling. These alternate scenarios resulted in different deployment rates of nuclear, coal with CCS, and renewable technologies. Details of the alternate scenarios are included in Appendices A and B. One important insight from the alternate scenarios is that the deployment path matters. As the United States designs and constructs new generation, the rate of deployment will drive workforce needs. At slow but steady rates of deployment, workforce needs are spread out over time; at fast, compressed rates of deployment, workforce demands build to a peak and drop off quickly. Additionally, a scenario that relies on coal with CCS may require a slightly different set of workers than a scenario that relies on nuclear power.

Figure 6. Comparison of the Workers Needed to Design and Construct the New Generating Assets in the EPRI Prism Analysis to Existing Employment Levels and Other Sources of Worker Demand

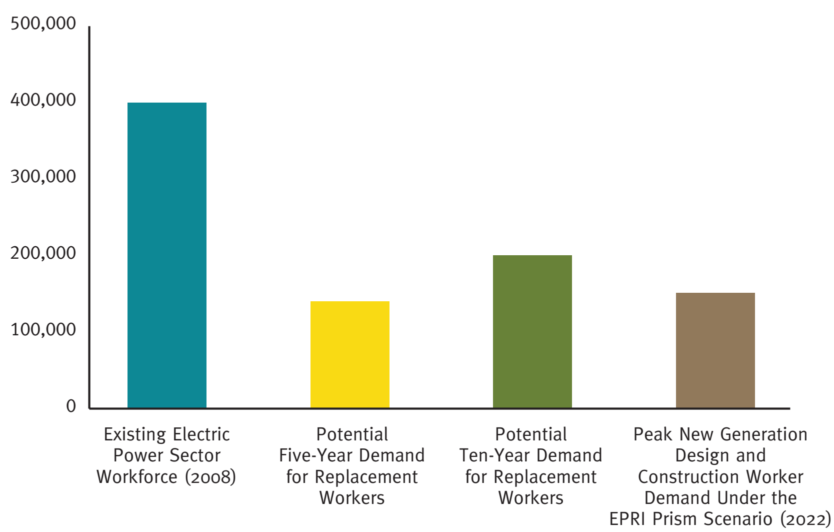
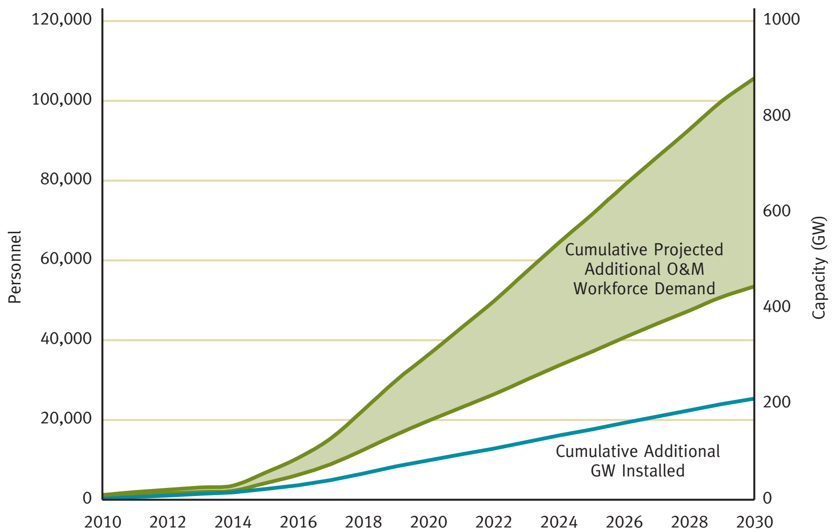


Figure 7. Estimated Cumulative O&M Workforce Requirements at Projected New Generating Assets under the EPRI Prism Analysis



Operations and Maintenance Needs for New Generating Assets

To estimate the ongoing workforce that will be required to operate and maintain new generating facilities once they are constructed, the Task Force leveraged data provided by its industry participants. Using information on industry members' O&M workforce requirements as well as publically available data, NCEP generated a range of estimates of O&M employees required per GW of generation for a range of technologies. Table 3 summarizes these findings on a per GW basis.

Table 3. Estimated Workforce Associated with Operations and Maintenance at Generating Assets

Generating Asset	Estimated Employees per GW	
	Low	High
Nuclear	400	700
Coal	100	300
NGCC	50	80
Onshore Wind	110	140
Advanced Coal w CCS	200	500

NCEP applied the data in Table 3 to the EPRI Prism results to forecast a range of estimates for O&M workforce demand. The results are shown in Figure 7. O&M-related workforce demand peaks in 2030. This peak is a function of the EPRI Prism scenario ending in 2030.

Table 4 provides a breakout of the demand for skilled craft and professional workers. Note that "professional staff" includes security personnel and administrative staff who were not included in the design and construction analysis. Figure 8 compares the projected average number of additional skilled craft and professional workers needed for O&M to the other sources of worker demand.

Table 4. Projected O&M Jobs in 2030 Given the Projected New Generation under the EPRI Prism Analysis

Job Category	Range of Expected Demand
Skilled Electric Power Craft Workers	35,000 to 70,000
Professional Staff	18,500 to 35,000
Total	53,500 to 105,000

The growth in workforce O&M demand highlights the need for training solutions that address long-term training needs. While expected retirements create demand for training over the next decade, the need to add new generating assets will propel the demand to train electric power workers into the following decade.

As with our estimates of workforce demand for design and construction, these national-level estimates of O&M needs are highly approximate and are not intended to substitute for the more detailed state and regional assessments that will be needed to identify specific training needs.

Workforce Needs for the Design, Construction, and O&M of Infrastructure and Supporting Technologies

In addition to hiring skilled workers to replace retiring workers and to build and maintain new generating assets, the electric power sector will need skilled workers to design, build, and maintain a host of infrastructure improvements and supporting technologies.

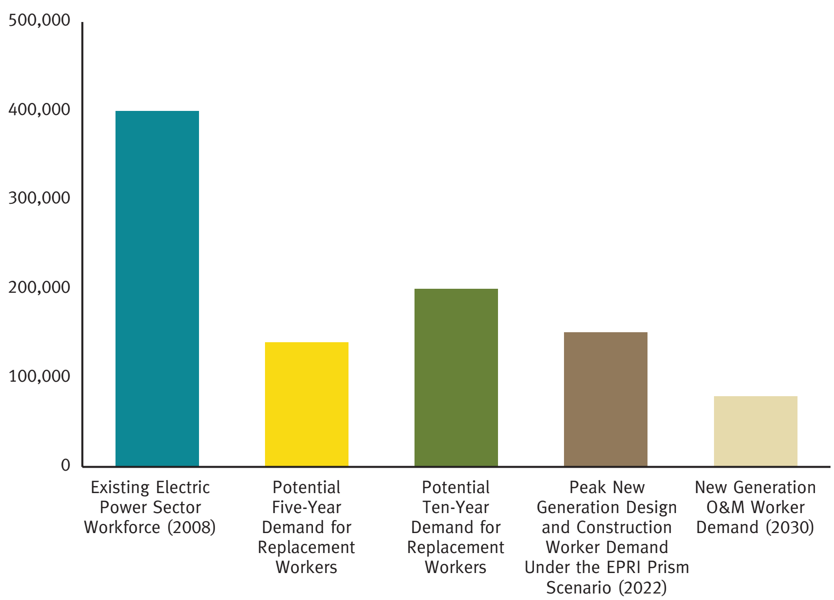
Three of the most prominent areas of infrastructure expansion are likely to include:

1. the construction of new high-voltage transmission lines;
2. the deployment of smart grid technologies to help customers use electricity more intelligently, and;
3. pipelines to move captured CO_2 from major emissions sources to geologic sequestration locations around the country.

Design, Construction, and O&M Workforce Needs for New High-Voltage Transmission Lines

The process of siting new high-voltage transmission lines in the United States has become very contentious. As a result, many projects remain in the approval process phase for years before they are approved for construction. Such uncertainty makes it difficult for a company to accurately project the commencement of construction and the timing of hiring decisions.

Figure 8. Comparison of Peak O&M Worker Demand Associated with O&M at Projected New Generating Assets under the EPRI Prism Analysis to Existing Employment Levels and Other Sources of Worker Demand



OUTAGES

In addition to the O&M staff hired by power plants, workers, especially skilled workers, will also be needed to perform maintenance on units during scheduled outages. Nuclear plants, in particular, require skilled craft workers to complement onboard electric power staff for this purpose. Indeed, in some cases as many as 1,000 additional workers may be needed over a four to eight week period, depending on the scope of the work to be performed.[30]

The types of skills that are needed for an outage depends on the scope of the work being conducted. The types of workers a utility might supplement its full time staff with includes radiation protection technicians, operator engineers, teamsters, non-manual supervisors, pipefitters, millwrights, laborers, electricians, boilermakers, carpenters, insulators, and ironworkers.

As a result, career centers and training providers lack the information they need to develop courses and direct students to the appropriate training programs.

Despite these uncertainties, NCEP compared a number of published estimates to assess the miles of new transmission infrastructure that will be needed to support the energy system of the future.

- The North American Electric Reliability Corporation (NERC) is the entity responsible for ensuring the reliability of the bulk power system in North America. NERC projects that the total number of miles of high-voltage transmission lines needed in the United States will increase by 9.5 percent (15,700 circuit-miles) over the next ten years.[31]

- Several of the nation's major power pool operators, including the Midwest Independent System Operator, the Southeast Electric Reliability Council Reliability Region, PJM Interconnection LLC, the Southwest Power Pool, the Mid-Continent Area Power Pool, and the Tennessee Valley Authority recently produced a Joint Coordinated Plan that examined the additional transmission infrastructure needed to integrate wind and other renewable resources with the existing grid network and electricity demand centers. The report estimated that the eastern portion of the United States alone would need:
  - 10,000 miles of new high-voltage transmission lines to achieve the goal of having wind supply 5 percent of total electricity needs by 2024, and
  - 15,000 miles of new high voltage transmission lines to increase the wind contribution to 20 percent of total electricity supply by 2024.[32]

- A similar national-level study by DOE that looked at increasing wind energy's contribution to 20 percent of the overall U.S. electricity supply by 2030 concluded it would be cost-effective to build more than 12,000 miles of additional high-voltage transmission capacity. Much of this new capacity would be required in later years after an initial period during which new wind generation could use the limited remaining capacity available on the existing transmission grid.[33]

- American Electric Power (AEP) has produced a conceptual transmission plan that includes 19,000 miles of new 765-kilovolt (kV) line to integrate wind as 20 percent of the overall electricity supply.[34]

[30] Carol L. Berrigan, Director, Industry Infrastructure, Nuclear Energy Institute. "Testimony for the Record to the U.S. Senate Committee on Energy and Natural Resources." November 6, 2007. Available http://energy.senate.gov/public/_files/CBerriganTestimony110607.pdf.
[31] NERC. "2008 Long-Term Reliability Assessment 2008-2017." October 2008. Available http://www.nerc.com/files/LTRA2008.pdf.
[32] Midwest Independent System Operator, et al. "Joint Coordinated System Plan 2008." 2008. Available http://www.jcspstudy.org/.
[33] U.S. Department of Energy Energy Efficiency and Renewable Energy, "20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply." July 2008. Available http://www1.eere.energy.gov/windandhydro/wind_2030.html
[34] AEP. "Interstate Transmission Vision for Wind Integration." June 2007. Available http://www.aep.com/about/i765project/docs/windtransmissionvisionwhitepaper.pdf.

NCEP also considered the new resources provided under ARRA to support transmission investments. ARRA funding is expected to accelerate the construction of approximately 3,000 miles of high-voltage transmission lines by 2012.

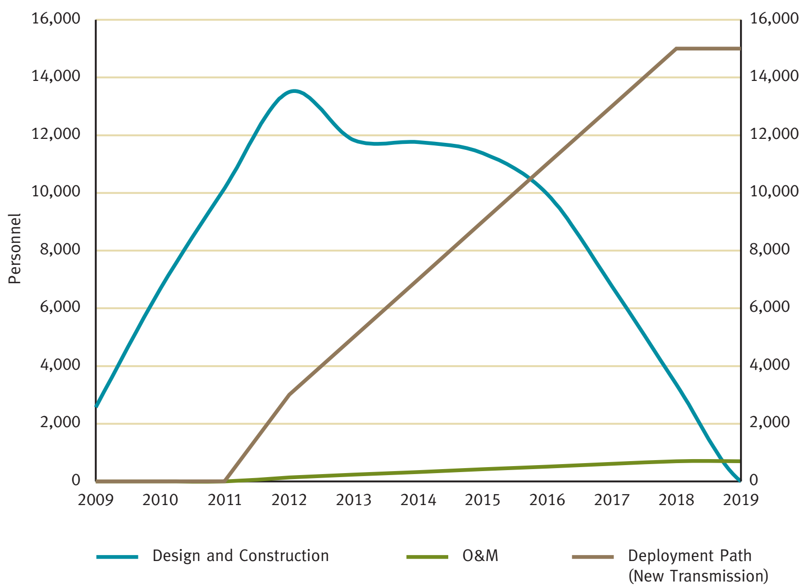
After considering these projections, NCEP modeled a deployment path that included the deployment of 3,000 miles of high-voltage transmission lines by 2012; with an additional 2,000 miles coming online each year through 2019 for a total of 15,000 miles installed by 2019 (this roughly corresponds to the 15,700 miles in ten years projected by NERC). In reality, high voltage transmission lines will be constructed as regulatory approvals and financing plans are put into place, and it is unlikely that 2,000 miles of transmission lines will be installed each year from 2013 to 2019. However, this deployment path provides a straightforward way to assess workforce implications. NCEP also accounted for workforce needs associated with the design and construction of necessary substations.

To estimate the scale of the workforce required to build and operate new high-voltage transmission lines and substations, NCEP worked with Task Force members who had experience designing, constructing, and maintaining such lines and could provide relevant data. Only workforce requirements in terms of design, engineering, and construction staff were considered. Support staff, such as security, administrative, or grounds keeping staff, were not included.

NCEP assumed a best-case scenario where all regulatory and permitting filings and approvals move smoothly and on schedule. Additionally, NCEP assumed the new high-voltage transmission lines would be constructed above ground and no severe weather or other delays would be encountered during the engineering or construction phases that would require additional staff time.

The American Recovery and Reinvestment Act of 2009 (ARRA) funding is expected to accelerate the construction of approximately 3,000 miles of high-voltage transmission lines by 2012.

Figure 9. Workforce Demand for High-Voltage Transmission Expansion for Assumed Miles Installed



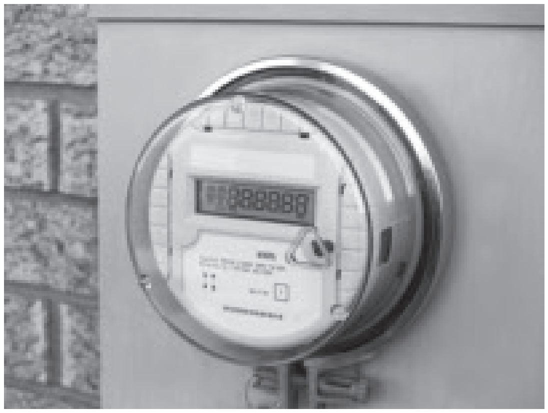
The workforce demand in annual full-time equivalents for the modeled deployment path is shown in Figure 9. Building a transmission line is a multi-year process. Even in a best-case scenario where a project moves quickly through the regulatory process, it will take more than five years from design to operation. To hit the targets set by ARRA, NCEP assumed that existing projects were already in process and that a portion of the needed workforce was already engaged.

Note that workforce demand peaks in 2012 as the 3,000 miles of high-voltage transmission associated with ARRA come online. Demand for design and construction workers declines closer to 2019 because 2018 is the last year additional transmission is added in the model. Demand for workers to operate and maintain the new transmission lines, on the other hand, grows steadily over the time period shown, reflecting the larger network there is to maintain, and reaches about 700 workers in 2019.

Table 5 shows the average estimates for the skill types and numbers of workers needed for design and construction in the peak year (2012). The largest demand is for workers on line construction crews. These crews include workers with a variety of skills including truck drivers, equipment operators, safety specialists, foremen, linemen, and tree cutters.

Table 5. Average Composition of Workforce Needed in 2012 to Design and Construct High-Voltage Transmission Lines and Substations Based on NCEP Assumptions

	Estimated Full-Time Equivalent Workers in 2012
Professional Employees	700 to 1,200
Engineers	300 to 500
Right-of-Way Agents	200 to 300
Project Managers/Coordinators	100 to 200
Consultants	<100
Designers	<100
Other	<100
Construction Labor and Skilled Craft Employees	9,400 to 15,200
Line Construction Workers	8,000 to 13,000
Below Grade Construction Workers (Groundling/Foundations)	700 to 1,100
Surveyors	500 to 800
Above Grade Construction Workers (Steel/Equipment/Setting/Bus Work/Panels)	100 to 200
Transmission Construction Representatives	100 to 200
Other	<100



A number of efforts are currently underway to model potential pathways for the development of CO_2 pipelines in the United States.

Deployment and O&M of Smart Grid Technologies

One of the key technology challenges embedded in the EPRI Prism analysis is the deployment of smart grid technologies. In December 2008, the consulting group KEMA completed a study for the GridWise Alliance that reviewed the workforce implications of rapidly deploying smart grid technologies throughout the United States.[35]

Interpretations of what is meant by a smart grid differ. In the KEMA study, the term refers to "the networked application of digital technology to the energy delivery and consumption segments of the utility industry. More specifically, it incorporates advanced applications and use of distributed energy resources, communications, information management, advanced metering infrastructure (AMI), and automated control technologies to modernize, optimize, and transform electric power and gas infrastructure."

The KEMA study assumed that there was a nationwide deployment of 128 million meters along with associated infrastructure at a cost of $64 billion. The deployment period in the study started in 2009 and lasted until 2012.[36] The study included direct utility jobs and contractor jobs as well as upstream and indirect jobs. Table 6 summarizes the direct utility and contractor job estimates reported by KEMA. In the deployment phase, KEMA projects a net increase of approximately 55,900 direct utility and contractor jobs and another 25,700 new energy service-related jobs. These projections represent an increase of approximately 6 percent relative to the current electric power sector workforce.

Once the smart grid is fully deployed, KEMA projects a reduction of 32,000 utility and contractor jobs. This reduction is more than offset by the overall addition of 54,000 "new utility or energy service company jobs" such that the net increase in workforce demand associated with smart grid deployment totals about 27,200 jobs (almost 7 percent of the current workforce). KEMA's estimate of utility and energy service company jobs is based on projections about new consumer services and workforce needs such as the installation of distributed renewable energy generators and the operating and servicing of smart grid components in the field.

Table 6. Utility and Contractor Jobs from Widespread Smart Grid Deployment Based on KEMA Estimates[37]

Job Category	Deployment Peak (2012)	O&M Level (2018)
Direct Utility Smart Grid	48,300	5,800
Transitioned Utility Jobs	-11,400	-32,000
Contractors	19,000	2,000
New Utility or Energy Service Company Jobs	25,700	51,400
Total	91,600	27,200

[35] KEMA. "The U.S. Smart Grid Revolution: KEMA's Perspectives for Job Creation (Prepared for the GridWise Alliance)." December 23, 2008. Available http://www.gridwise.org/kema.html.
[36] Ibid.
[37] Ibid.

Design and Construction of CO_2 Pipelines

Under the EPRI Prism scenario, U.S. utilities deploy 90 GW of advanced coal-fired power plants with CCS by 2030. As modeled by EPRI, the plants start to come online in 2015, with the majority—about 75 GW—constructed between 2020 and 2030. To support these plants, developers will have to construct CO_2 pipelines to transport captured CO_2 to secure geologic storage formations.

A number of efforts are currently underway to model potential pathways for the development of CO_2 pipelines in the United States. In one effort, researchers at the Pacific Northwest National Laboratory (PNNL) developed two scenarios for national CCS pipeline development based on different targets for stabilizing atmospheric concentrations of CO_2.[38] The two scenarios are summarized in Table 7. The pipeline miles shown in Table 7 are in addition to the 3,900 miles of CO_2 pipelines currently in operation in the United States.[39]

Table 7. CO_2 Pipeline Deployment Scenarios[40]

	450 **ppm Stabilization Target**	550 **ppm Stabilization Target**
Average annual number of power plants adopting CCS	~dozen per year through 2030	1-3 per year through 2030
Average growth in CO_2 pipelines 2010-2030	<900 miles per year	~300 miles per year
Additional CO_2 pipelines in operation in 2030	~18,000 miles	~6,000 miles

Using PNNL's assumption that the average power plant is approximately 50 miles from a storage location and Bechtel's assumption from the construction estimates that advanced coal-fired power plants have an average capacity of 600 MW, NCEP estimates that the CCS deployment

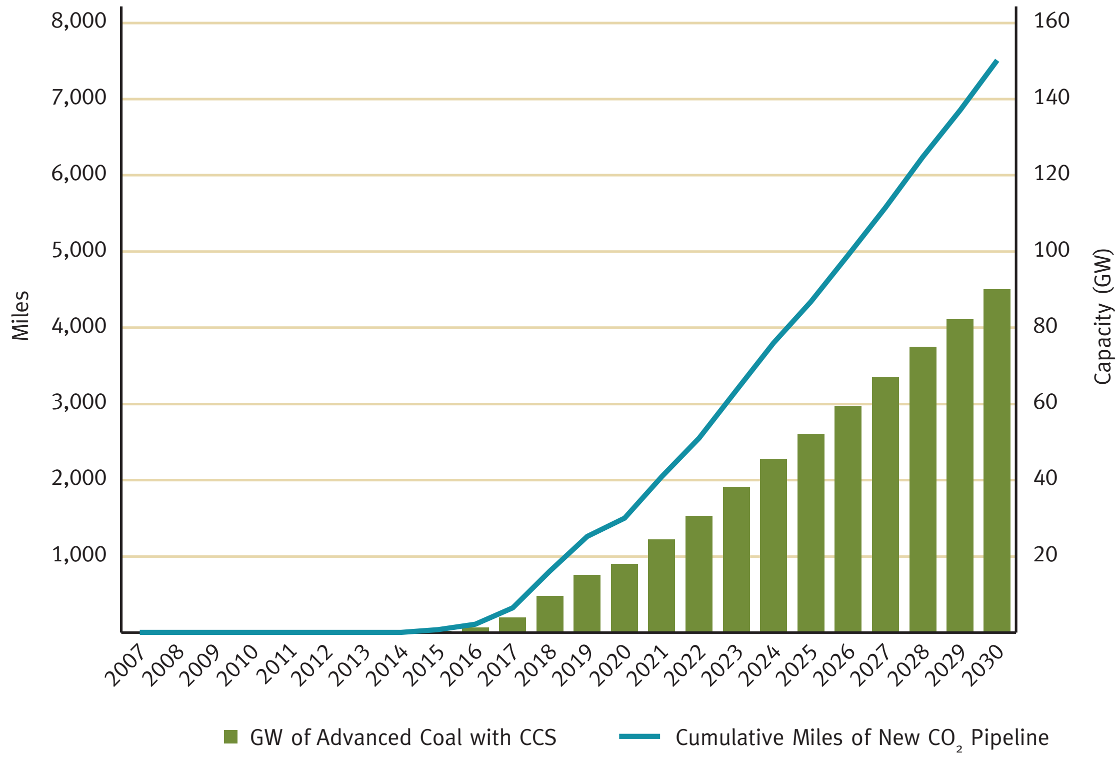
38 Dooley, JJ, R.T. Dahowski, C.L. Davidson. "Comparing Existing Pipeline Networks with the Potential Scale of Future U.S. CO_2 Pipeline Networks." (Presented at the 9th Greenhouse Gas Technologies Conference, Washington, D.C.). November 16-20, 2008. Available http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B984K-4W0SFYG-7D-1&_cdi=59073&_user=10&_orig=search&_coverDate=02%2F28%2F2009&_sk=999989998&view=c&wchp=dGLzVtb-zSkWz&md5=94d879be99ab31340ce9ffbce7eb8a64&ie=/sdarticle.pdf.

39 WRI. "CCS Guidelines: Guidelines for Carbon Dioxide Capture, Transport, and Storage." October 2008. Available http://pdf.wri.org/ccs_guidelines.pdf.

40 Dooley, JJ, R.T. Dahowski, C.L. Davidson. "Comparing Existing Pipeline Networks with the Potential Scale of Future U.S. CO_2 Pipeline Networks." (Presented at the 9th Greenhouse Gas Technologies Conference, Washington, D.C.). November 16-20, 2008. Available http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B984K-4W0SFYG-7D-1&_cdi=59073&_user=10&_orig=search&_coverDate=02%2F28%2F2009&_sk=999989998&view=c&wchp=dGLzVtb-zSkWz&md5=94d879be99ab31340ce9ffbce7eb8a64&ie=/sdarticle.pdf.

The size of the workforce needed to deploy CO_2 pipelines peaks between 830 and 1,400 workers in 2028, when approximately 660 miles of 16-inch pipeline are installed to support about 8 GW of additional advanced coal power plants with CCS.

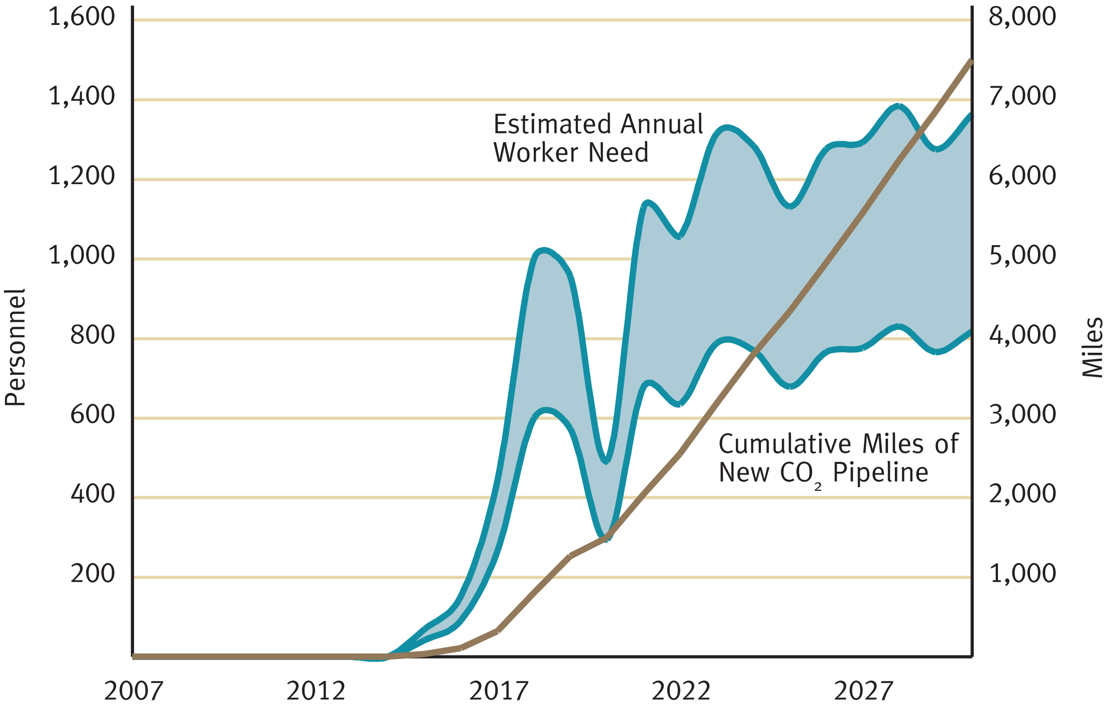
Figure 10. Miles of Additional CO_2 Pipeline Installed to Support EPRI Prism CCS Deployment



scenario in the EPRI Prism will require approximately 7,500 miles of additional CO_2 pipelines—an estimate that is closer to PNNL's 550 part per million (ppm) stabilization target scenario.[41] Figure 10 shows the modeled deployment path.

Task Force members provided NCEP with estimates of the number of workers needed to design and construct a CO_2 pipeline in the United States, assuming a pipeline diameter of 16 inches. Using those estimates, NCEP developed the worker demand curves shown in Figure 11. The variability in the curves reflects the annual deployment path of advanced coal with CCS in the EPRI Prism. The pipelines associated with each power plant are assumed to be constructed in the year the plant comes online. As in the generation design and construction estimates, the range of estimates for pipeline workers reflects a 25 percent margin of accuracy.

Figure 11. Estimated Workforce to Design and Construct CO_2 Pipelines to Support EPRI Prism CCS Deployment



[41] 90 GW of capacity divided by 600 MW plants times 50 miles of pipeline per plant equals 7,500 miles of pipeline.

The size of the workforce needed to deploy CO_2 pipelines peaks between 830 and 1,400 workers in 2028, when approximately 660 miles of 16-inch pipeline are installed to support about 8 GW of additional advanced coal power plants with CCS. A number of different skilled craft workers are needed to complete pipeline construction. Table 8 shows an approximate breakout of the types of skills required.

Table 8. Craft Skills Associated with Pipeline Construction[42]

Job Category	Percentage
Operators	30%
Welders/Helpers	25%
Laborers	20%
Vehicle Drivers (Teamsters)	10%
Inspectors	5%
Surveyors	‹5%
Salaried Foreman	‹5%
Testing Technicians	‹5%

Given the varying lengths of pipeline expected to be installed, it is difficult to estimate the number of workers who will be employed to operate and maintain the pipelines. Regulatory requirements associated with pipeline safety include the development and regular review of an operations manual with an emergency response plan. Current requirements also specify that "each operator shall, at intervals not exceeding three weeks, but at least 26 times each calendar year, inspect the surface conditions on or adjacent to each pipeline right-of-way."[43]

Deployment of Energy Efficiency Technologies and Measures

Energy efficiency technologies and measures are an essential strategy for reducing the cost of greenhouse gas abatement and are included as part of the Prism scenario. The workforce demands associated with large-scale deployment of energy efficiency technologies, however, are difficult to quantify.

In January 2009, Global Energy Partners and The Brattle Group completed a report for EPRI that assessed "the achievable potential for energy efficiency and demand response programs to reduce the growth rate in electricity consumption and peak demand through 2030."[44] While the report was not explicitly designed to estimate the energy efficiency potential represented in the EPRI Prism analysis, the range of reductions it estimates and the deployment schedule it assumes are broadly consistent with the Prism. Hence, the NCEP Task Force looked at the energy efficiency component of the Global Energy Partners and The Brattle Group

[42] Information Insights, Inc. "Stranded Gas Development Act: Municipal Impact Analysis for the application by BP Exploration (Alaska) Inc., ConocoPhillips Alaska, Inc., and ExxonMobil Alaska Production, Inc." (Prepared for the Alaska Department of Revenue Municipal Advisory Group.) November 2004. Available http://www.magalaska.com/pdf/Municipal_Impact_Analysis-Producers_Application-corrected.pdf.
[43] 49 CFR § 195.412.
[44] EPRI. "Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S." January 2009. Available http://my.epri.com/portal/server.pt?Abstract_id=000000000001016987.

analysis to estimate workforce demands associated with energy efficiency deployment.

For that analysis, researchers used a technology-driven, bottom-up approach to estimate the deployment of efficiency technologies across regions of the United States for the residential and commercial sectors and a top-down sector forecast of energy efficiency improvements for the industrial sector. The range of measures shown in Table 9 was used as the basis for the analysis—these measures are based on what is currently available in the market through utility or similar programs. The study did not review the impact of potential future policies, such as a greenhouse gas cap-and-trade program or future innovations that could increase the rate of technology diffusion or the impact of technologies on emissions.

Energy efficiency plays an important role in the EPRI Prism analysis and is an essential strategy for reducing the cost of greenhouse gas abatement.

Table 9. Summary of Energy Efficiency Measures by Sector[45]

Residential Sector Measures	Commercial Sector Measures	Industrial Sector Measures
Efficient air conditioning (central, room, heat pump)	Efficient cooling equipment (chillers, central AC)	Process improvements
Efficient space heating (heat pumps)	Efficient space heating equipment (heat pumps)	High-efficiency motors
Efficient water heating (e.g. heat pump water heaters & solar water heating)	Efficient water heating equipment	High-efficiency heating, ventilation and air conditioning (HVAC)
Efficient appliances (refrigerators, freezers, washers, dryers)	Efficient refrigeration equipment & controls	Efficient lighting
Efficient lighting (CFL, LED, linear fluorescent)	Efficient lighting (interior and exterior)	
Efficient power supplies for Information Technology and consumer electronic appliances	Lighting controls (occupancy sensors, daylighting, etc.)	
Air conditioning maintenance	Efficient power supplies for Information Technology and electronic office equipment	
Duct repair and insulation	Water temperature reset	
Infiltration control	Efficient air handling and pumps	
Whole-house and ceiling fans	Economizers and energy management systems (EMS)	
Reflective roof, storm doors, external shades	Programmable thermostats	
Roof, wall and foundation insulation	Duct insulation	
High-efficiency windows		
Faucet aerators and low-flow showerheads		
Pipe insulation		
Programmable thermostats		
In-home energy displays		

[45] Ibid.

Table 10. Cumulative Annual Efficiency Savings Under Realistic Achievable Potential Scenario (GWh)[46]

Sector	2010	2020	2030
Residential	12,127	64,374	139,637
Commercial	6,455	96,878	179,632
Industrial	2,027	45,696	78,736
Total	20,609	206,947	398,005

Table 11. Average Annual Additional Efficiency Saving Implied by Realistic Achievable Potential Scenario (GWh)[47]

	2010	2011-2020	2021-2030
Average Annual Rate of Efficiency Savings	20,609	18,634	19,106

The report focuses on what it calls "Realistic Achievable Potential Energy Efficiency", which combines technical potential with economic and other considerations. Table 10 shows the Realistic Achievable Potential by sector in annual gigawatt-hours (GWh) saved. The savings shown in Table 10 are cumulative (i.e., the savings in 2010 are carried through as part of the annual savings for 2030). Table 11 shows the implied efficiency savings added each year, assuming linear deployment of energy efficiency measures.

One way to think about the workforce needed to deploy energy efficiency measures is to focus on the people needed to support a successful energy efficiency program. The Task Force included several members from companies who were able to share their experiences deploying energy efficiency technologies and measures over the past ten years. To run energy efficiency programs, an electric company directly employs two primary groups:

- People to design and administer programs; and
- People to promote programs and sign up new customers.

While these direct employees are essential to the development and execution of energy efficiency programs, they do not perform energy efficiency audits or install energy efficient measures at customer homes or businesses. Rather, electric companies usually hire contractors who specialize in the installation of specific measures. Furthermore, businesses and homeowners also rely on non-utility based programs and services to improve the energy efficiency of their buildings. The Task Force recognized the importance of the broad range of energy efficiency jobs but only included the direct electric company employees in this study.

Based on feedback from Task Force members, a large utility-based energy efficiency program that includes residential, commercial, and industrial energy efficiency components and realizes about 1,000 GWh of annual efficiency savings would require approximately 600 employees who spend all or part of their time administering and promoting energy efficiency programs. Assuming all the programs involve an equal number of employees, this implies that about 0.6 employees would be involved in program administration and promotion for each GWh of annual savings. Using the average annual energy efficiency savings estimates in Table 11, utility or other third-party managed energy efficiency programs would require all or part of the time of approximately 11,000 employees per year through 2030. Each program managed by the utilities or similar entities would, in turn, hire contractors to implement or deploy efficiency measures. The number of workers employed by these contractors can be expected to significantly exceed the number of direct-utility employees required to administer and promote the programs—indeed these workers would likely number in the thousands for every program.

[46] Ibid.
[47] Ibid.

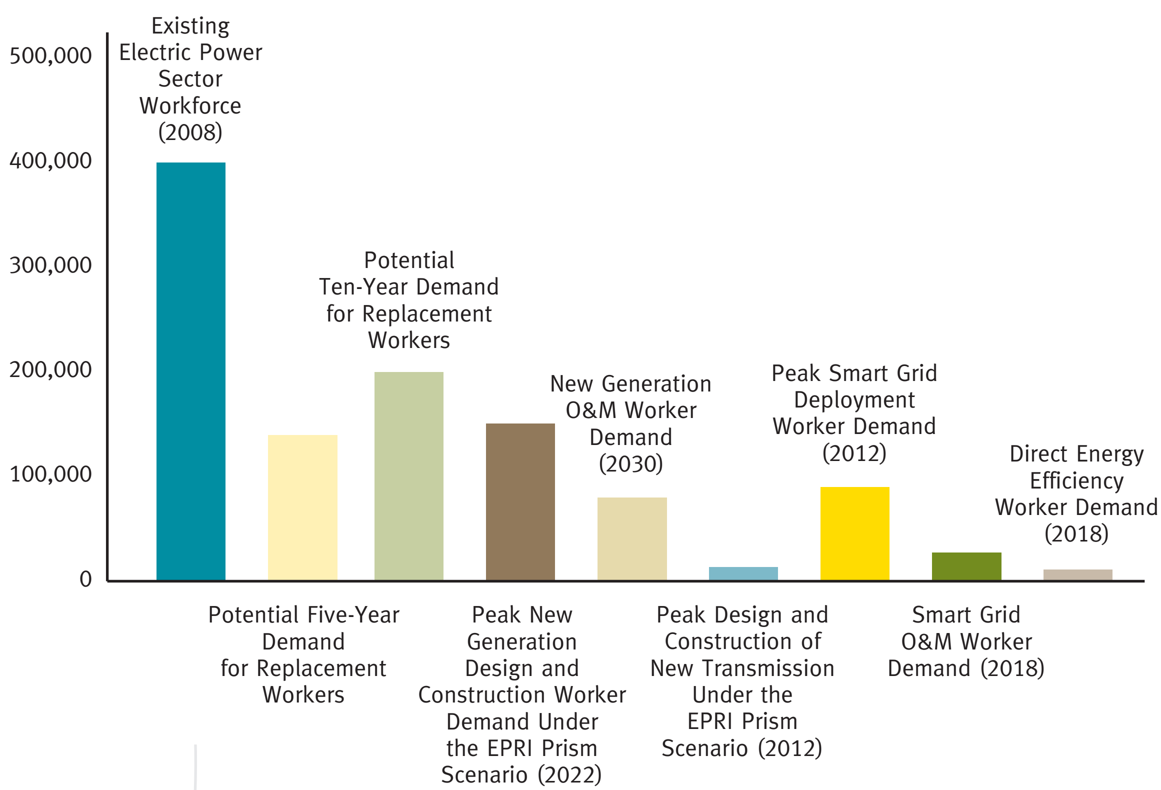
It is important to note that quite a few utilities already have established energy efficiency programs and would not need to hire a large number of additional staff. As a result, the 11,000 employee figure likely overstates the number of people who would have to be hired to deploy energy efficiency measures at the scale suggested by the Prism scenario. However, as noted above, the deployment path does not include the impact of potential future policies, such as a cap-and-trade program, or further technology innovations that could increase the rate of technology diffusion. If utilities expand their efficiency programs to comply with a mandatory greenhouse gas policy, this could increase related workforce requirements.

On the contractor side, it is important to note that the analysis conducted by Global Energy Partners and The Brattle Group suggests early deployment of residential energy efficiency measures and a movement towards commercial efficiency in the middle years. As shown in Table 10, while residential measures account for almost 60 percent of efficiency savings in 2010, they are only assumed to make up about 30 percent of savings by 2020 and then rise to about 40 percent of savings by 2030. Commercial efficiency measures account for about 30 percent of savings in 2010; 47 percent of efficiency measures by 2020; and 45 percent by 2030. This suggests that contractors will have to adapt to different technologies and customers over time as programs evolve and as different efficiency measures are deployed.

Figure 12 summarizes the major sources of worker demand and compares them to the current electric sector employment levels.

A LARGE UTILITY-BASED ENERGY EFFICIENCY PROGRAM THAT INCLUDES RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL ENERGY EFFICIENCY COMPONENTS AND REALIZES ABOUT 1,000 GWH OF ANNUAL EFFICIENCY SAVINGS WOULD REQUIRE APPROXIMATELY 600 EMPLOYEES WHO SPEND ALL OR PART OF THEIR TIME ADMINISTERING AND PROMOTING ENERGY EFFICIENCY PROGRAMS.

Figure 12. Comparison of Major Sources of Worker Demand to Existing Employment Levels



Summary: Future Workforce Needs

Job Type	Estimated Workforce Required	Year
Demand Generated by Worker Retirements Necessary to Maintain Current Electric Generation System		
Operations and Maintenance[a]	**120,000 to 160,000**	**By 2013**
Electric Power Skilled Craft[b]	58,200	By 2013
Technicians[b]	20,300	By 2013
Non-Nuclear Plant Operators[b]	8,900	By 2013
Pipefitters/Pipelayers[b]	6,500	By 2013
Lineworkers[b]	22,500	By 2013
Engineers[b]	11,200	By 2013
Demand to Build and Maintain the Future Electric Generation System		
Design and Construction[c]	**113,000 to 189,000**	**2022**
Construction Skilled Craft Workers[c]	81,000 to 136,000	2022
Electricians[c]	16,900 to 28,100	2022
Pipefitters[c]	16,800 to 28,000	2022
Ironworkers[c]	7,900 to 13,000	2022
Boilermakers[c]	5,200 to 8,700	2022
Millwrights[c]	1,500 to 2,500	2022
Professional Employees[c]	31,700 to 52,800	2022
Operations and Maintenance[d]	**53,500 to 105,000**	**2030**
Electric Power Skilled Craft[d]	35,000 to 70,000	2030
Professional Staff[d]	18,500 to 35,000	2030
Building and Maintaining New Electricity Transmission Capacity[d]		
Design and Construction	**10,100 to 16,400**	**2012**
Construction Skilled Craft Workers	9,400 to 15,200	2012
Professional Employees	700 to 1,200	2012
Operations and Maintenance	**700 to 1,200**	**2018**
Technicians	500 to 900	2018
Professional Employees	200 to 300	2018
Building and Maintaining a Smart Grid[e]		
Deployment	**91,600**	**2012**
Direct Electric Power and Contractor	55,900	2012
New Electric Power and Energy Service Company	25,700	2012
Operations and Maintenance	**27,200**	**2018**
Direct Electric Power and Contractor	-24,200	2018
New Electric Power and Energy Service Company	51,400	2018
Building and Maintaining CO_2 Pipelines for CCS[d]		
Design and Construction	**830 to 1,400**	**2028**
Deploying Energy Efficiency Technologies[d]		
Electric Power Employees[f]	**11,000**	**2010**

Table Notes

The workforce estimates are based on published sources, on projections developed by Bechtel for the Task Force, or estimated by Task Force staff. Except for the projected workforce to replace those retiring, the estimates are based on the peak number of jobs expected in one year between now and 2030. The year listed is the year of the projected peak. In the case of projected retirements, the estimate represents the total number of positions that will need to be filled between now and 2013 based on surveys developed by CEWD. All numbers are rounded. The Task Force developed these estimates as a way to understand the magnitude of future workforce demand; these estimates should not take the place of state and regional workforce assessments.

(a) Based on estimates by BLS and CEWD. U.S. Department of Labor, Bureau of Labor Statistics. "Career Guide to Industries, 2008-09 Edition, Utilities." Available http://www.bls.gov/oco/cg/cgs018.htm. Accessed May 14, 2009.
CEWD. "Gaps in the Energy Workforce Pipeline: 2008 CEWD Survey Results." 2008. Available http://www.cewd.org/documents/CEWD_08Results.pdf. Accessed May 20, 2009. This estimate includes all workers expected to retire in the next five years, including but not limited to those listed below.

(b) Based on surveys conducted by CEWD (as above).

(c) Based on estimates developed by Bechtel for the Task Force. See Appendix A.

(d) Based on estimates developed by NCEP in consultation with Task Force participants.

(e) Based on a report prepared by KEMA for the GridWise Alliance.
KEMA, "The U.S. Smart Grid Revolution KEMA's Perspectives for Job Creation, Prepared for the GridWise Alliance", December 23, 2008. Available http://www.gridwise.org/kema.html.

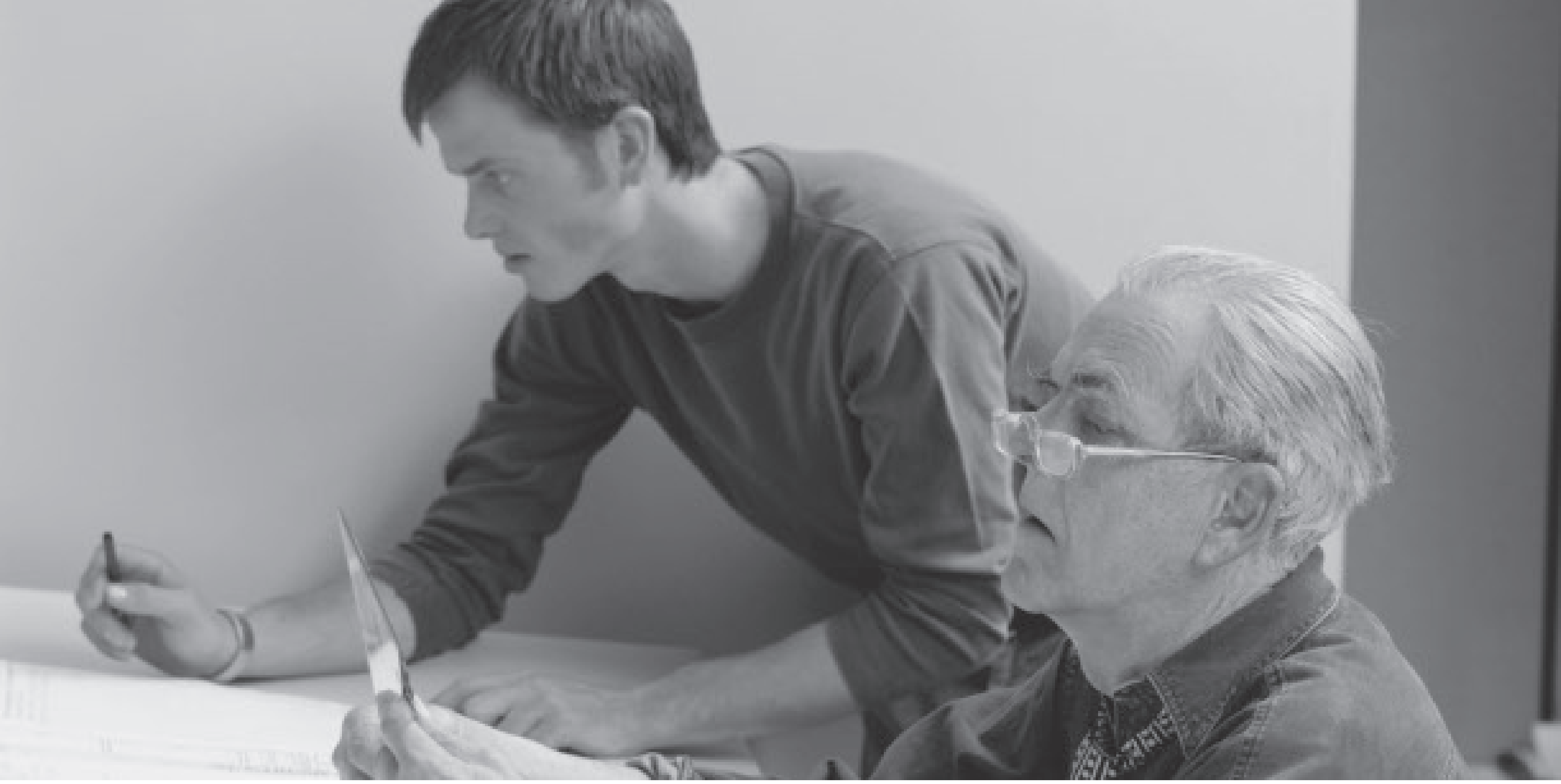
(f) This number includes employees who spend all or part of their time administering or promoting utility-run energy efficiency programs. It does not include estimates for additional programs that could be run by third parties, employees or contractors necessary to implement energy efficiency programs.

CHAPTER 3.

TRAINING THE FUTURE ENERGY WORKFORCE

As described in Chapters 1 and 2, there will be significant demand for technically-trained individuals to work in the electric power sector and to design and build the generating assets and infrastructure associated with a low-carbon economy. As discussed in Chapter 2, the Task Force focused on technically-trained individuals in three broad categories:

- **Skilled craft electric power workers,**
- **Skilled craft construction workers, and**
- **Engineers.**



As highlighted in Chapters 1 and 2, demand for skilled craft electric power workers is going to be driven, at least in the near term, mainly by retirements as well as some attrition for other reasons. Over the longer term, demand for electric sector workers will remain high as new generation comes on line and as electric power companies hire staff to operate and maintain new facilities. In addition, skilled craft electric power workers will be needed to perform field work associated with energy-system support infrastructure, including maintaining the smart grid, and to provide other services, such as installing energy efficiency measures.

Demand for skilled craft construction workers is going to be driven by the expansion of the electric power sector over the next 20 years to meet growing demand for electricity while simultaneously reducing the carbon footprint of the electric sector. In addition, skilled craft construction workers will be needed to install electricity transmission lines and CO_2 pipelines.

Demand for engineers will cut across both the electric power and construction sectors. As highlighted in Chapters 1 and 2, employee losses due to retirement and attrition will increase the demand for new engineers over the next five to ten years. Longer term—that is, over the next twenty years—the need to design and construct low-carbon energy sources and associated infrastructure will become a major driver of workforce needs in this area.

Overview of the Current Workforce Pipeline

Task Force members are concerned that the existing pipeline for skilled craft electric power workers, skilled craft construction workers, and engineers is unprepared to meet the challenges of the next two decades as the United States seeks to transition to a low-carbon economy. Several reports in recent years have examined the nature and causes of this decline in qualified potential workers.[48]

Demand for skilled craft construction workers is going to be driven by the expansion of the electric power sector over the next 20 years to meet growing demand for electricity while simultaneously reducing the carbon footprint of the electric sector.

[48] See, e.g., the National Academy of Sciences' "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future," the New Commission on the Skills of the American Workforce's "Tough Choices or Tough Times," the Department of Energy's "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," and APPA's "Growing Your Employees of Tomorrow: A Work Force Planning Model For Public Power Utilities." Badhul Chowdhury. "Power Education at the Crossroads." IEEE Spectrum, October 2000.

K–12 education is essential. Students who are lost before they complete high school or the equivalent frequently do not have the skills they need to enter the skilled craft or engineer workforce.

One of the challenges of assessing the workforce pipeline is that there are multiple entry and exit points. An effort to visualize the pipeline is presented in Figure 13. For example, an individual could leave high school or a career and technical school and move directly into an apprenticeship program or a company-sponsored training program and then to the workforce. Or, before entering an apprenticeship, an individual could enter a pre-apprenticeship program developed in coordination with labor organizations at a community college. Alternately, an individual could earn an associates degree after high school before entering a four-year college to earn a degree that provides them with the training they need to directly enter the workforce. While not shown in the figure, individuals could enter the future energy workforce from the military or as part of a second career. These individuals could enter the training system at any point or could take advantage of military-to-workforce transition programs, like Helmets to Hardhats, which are discussed later in this chapter.

Two key insights emerge from this graphic representation. First, K–12 education is essential. Students who do not complete high school or the equivalent frequently do not have the skills they need to enter the skilled craft or engineer workforce. Second, there are multiple pathways into the workforce. People can move from K–12 education to any one of a number of post-secondary education and training options including community colleges, community-based organizations, universities, pre-apprenticeship programs, or other training programs. Individuals can also enter the military or embark on a non-electric power career and then enter the workforce through retraining programs. Additionally, there can be movement back and forth between the workforce and post-secondary education as workers get additional training and education to further their career or move into a different line of work. This diversity of pathways has the advantage of improving access, but it can also make it difficult for career advisors to guide individuals and for potential employers to assess the capabilities of job applicants.

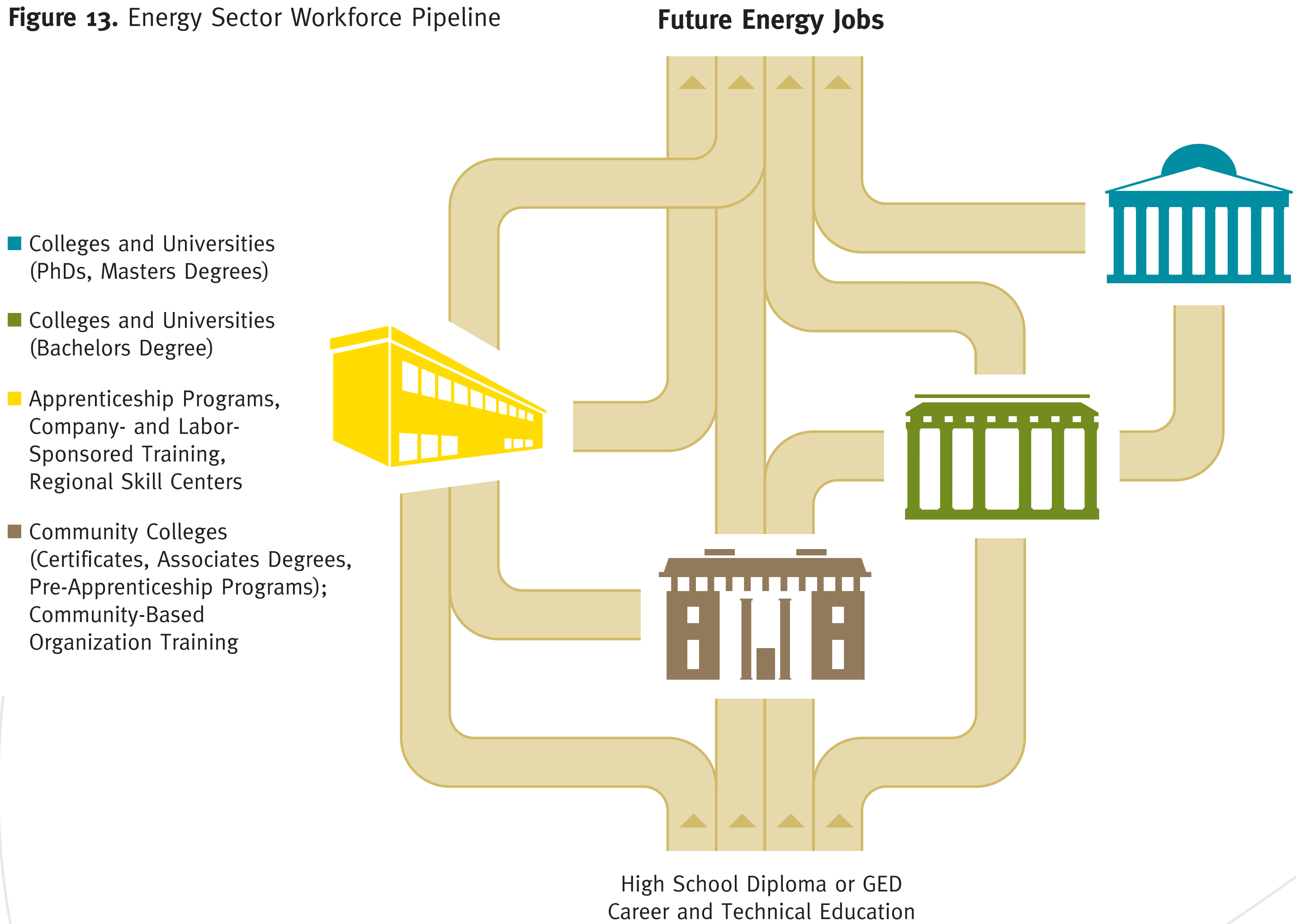
Within the Task Force, discussion focused on the robustness of the post-secondary education pipeline for skilled craft workers in the electric power sector. The number of people trained to take part in the skilled craft electric power workforce has fluctuated over the years as the needs of the industry, macroeconomic conditions, the attractiveness of alternate career paths, and other factors have changed. After a period of relatively rapid growth in the 1970s, when electricity demand grew by 5 percent annually, the electric industry faced much lower growth rates in the 1980s and 1990s.[49] As some states created a competitive marketplace for the electric sector, companies increased their focus on productivity, which dampened hiring trends and led to an overall decline in workforce levels through the end of the 1990s.[50] As the industry's demand for new workers slowed during this period, training programs were scaled back, and the pool of qualified candidates for jobs and training programs decreased dramatically.

At the same time, U.S. education policy became increasingly focused on access to higher education as the key to career success. Specifically, access to and completion of a four-year college degree has become a major goal of national

[49] 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.

[50] Ibid.

Figure 13. Energy Sector Workforce Pipeline



policy. This focus on preparation for four-year college programs has led to the closure of many technical high school programs across the country, removing a traditional pool of potential new workers for the electric power sector. As suggested by Figure 13, companies in the electric sector now look to diverse sources for potential employees, including community colleges, certificate programs, and apprenticeships. While the broadening of potential conduits to a career in the power sector is certainly a positive development because it potentially opens these careers to individuals and groups for whom this path was not traditionally an option, the standards and curricula for these diverse education and training programs often vary widely, complicating electric companies' hiring decisions.

A declining emphasis on career and technical education at the high school level has similarly affected the flow of potential workers into skilled craft construction; however, that sector continues to benefit from a relatively intact training infrastructure. One of the key differences between skilled craft construction workers and skilled craft electric power workers is that construction workers are accustomed to moving as workforce needs shift from region to region. Further, skilled craft construction work-

Of the approximately three million students who complete high school annually, many leave ill-prepared in the STEM skills necessary to pursue a technical career.

ers serve the industrial and commercial sectors in addition to the electric power sector. Partly because the construction industry is geographically fluid and highly mobile, it has developed national standards to guide its apprenticeship system. This apprenticeship system has been the primary source of skilled labor in the U.S. construction industry.

Developing the Foundation for Technical Careers: K-12 Education

A solid K–12 education is the starting point for any career, not just an electric sector or construction sector career. To the extent that the United States has fallen behind in K–12 education, it is also falling behind in the ability to deliver technically-trained individuals to any part of the economy. This has potentially significant implications for the ability of individuals to adapt to changes in workforce demand and the ability of the United States to serve as leader in the innovation of technologies.

Addressing broader challenges and shortcomings in the nation's K–12 educational system is thus essential to success in developing a workforce to staff the transition to a low-carbon economy and to encourage the development of technologies and strategies that will lower costs and improve the reliability during the transition. Students in grade school, middle school, and high school must be exposed to the foundational skills that will help them succeed in a technology-driven economy. It is particularly important to expose students to this set of skills (science, technology, engineering, and math, or STEM) early in their academic career and reinforce the lessons throughout the educational pipeline.

In a recent National Academy of Sciences (NAS) report titled "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future," industry leaders and academic experts contend that the nation faces an impending crisis as the result of a K–12 educational system that fails to provide students with a basic foundation for success in the math, science and engineering fields.[51]

The Gathering Storm report argues that "[t]he state of US K–12 education in science, math and technology has become a focus of intense concern. With the economies and broader cultures of the US and other economies becoming increasing dependent on science and technology, US schools do not seem capable of producing enough students with the knowledge and skills to prosper."[52] Norman Augustine, who chaired the NAS committee that developed the Gathering Storm report and who coauthored the forward to this report, stated in stark terms

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[51] National Academy of Sciences. "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future." 2007 (Revised July 2008). Available http://www.nap.edu/catalog.php?record_id=11463#toc.

[52] Ibid.

the unanimous view of the committee: "[T]he United States is perilously close to falling decisively behind other nations in key categories of science and engineering."[53]

K-12 Education Challenges

The Task Force identified several key challenges to improving K–12 education in the United States.

Low Graduation Rates. U.S. Census data estimate that less than 75 percent of those who begin ninth grade will graduate from high school.[54] Since 2000, graduation rates, or the percent of ninth graders who graduate four years later, have ranged from 72 to 74 percent. This means that of the approximately four million students who will begin high school this fall in the United States, less than three million are expected to complete high school.[55]

Dropping out of school before graduation is a particular problem among minority students. In 2007, approximately 22 percent of Hispanic and 11 percent of Black high school-aged students were not in school, compared to 6 percent of White students and 9 percent overall.[56] This disparity, if it continues, will affect overall educational attainment and the potential future energy workforce. By 2050, the Hispanic population is projected to nearly triple, reaching 128 million and 29 percent of the projected population. Hispanics will represent approximately 60 percent of the United State's expected population growth.[57]

Lack of Technical and STEM-Related Skills. Of the approximately three million students who complete high school annually, many leave ill-prepared in the STEM skills necessary to pursue a technical career. As Figure 14 illustrates, national science assessment tests rate nearly 50 percent of U.S. twelfth graders as having below basic proficiency in understanding scientific concepts, 35 percent have a basic understand-

[53] Statement before the U.S. House of Representatives, Committee on Appropriations, Subcommittee on Commerce, Justice, and Science. "The Gathering Storm: Three Years Later." March 2009. Available http://appropriations.house.gov/Witness_testimony/CJS/norman_augustine_03_05_09.pdf.

[54] U.S. Department of Education, National Center for Education Statistics. "The Condition of Education 2009." June 2009. Available http://nces.ed.gov/pubs2009/2009081.pdf.

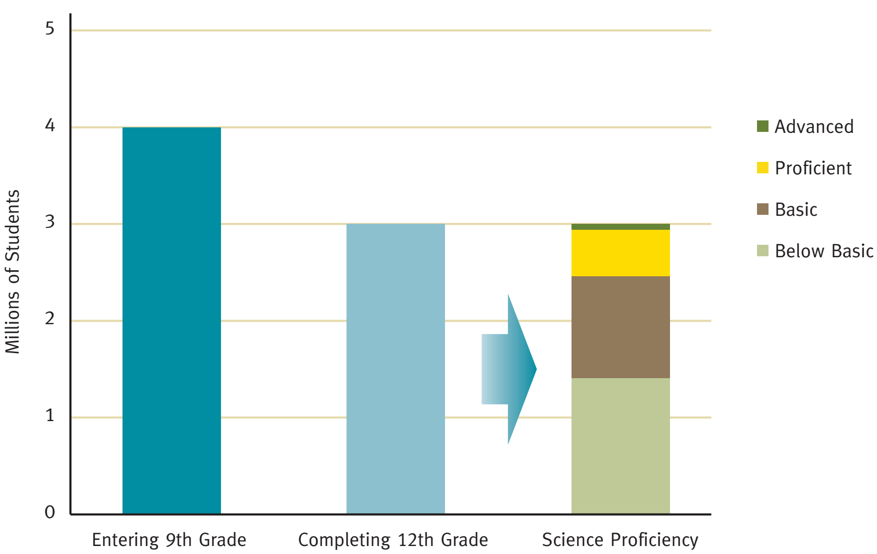
[55] U.S. Department of Education, National Center for Education Statistics: http://nces.ed.gov/pubs2001/proj01/chapter3.asp.

[56] This represents the status dropout rate, which is the percentage of 16- through 24-year-olds (civilian, non-institutionalized population) who are not enrolled in high school and who have not earned a high school credential. The status dropout rate includes all dropouts regardless of when they last attended school, and is measured differently from the graduation rate noted earlier. U.S. Department of Education, National Center for Education Statistics: http://nces.ed.gov/pubs2009/2009081.pdf and http://nces.ed.gov/fastfacts/display.asp?id=16.

[57] Jeffrey S. Passel, Senior Demographer, Pew Hispanic Center. Testimony to the U.S. Equal Employment Opportunity Commission. October 23, 2008. Available http://www.eeoc.gov/abouteeoc/meetings/10-23-08/passel.html.

ing, 16 percent are considered proficient, and only two percent are considered advanced.[58] By this metric, at most 53 percent of high school graduates (about 1.5 million students) and probably only 18 percent (about 550,000 students) are prepared to pursue careers in STEM-related fields or enter technical careers upon high school graduation. The Gathering Storm report concludes that "[w]ithout fundamental knowledge and [STEM] skills, the majority of students scoring below ... [a] basic level ...lack the foundation for good jobs and full participation in society."[59] The number of students with solid basic skills is of great interest to the electric industry, because these are the individuals who are best equipped to enter the industry's workforce.

Figure 14. U.S. High School Graduation Rate and Science Proficiency



The decline in career and technical training at the high school level noted above has increased the challenge of preparing students for careers in the skilled craft trades.[60] An APPA workforce study notes that since the mid-1990s, "the number of high school students taking trade- or industry-related career and technical courses has declined 35 percent."[61] This decline has significantly increased the challenge of preparing students for careers in the skilled craft trades.

Lack of Industry-Specific Training for Educators. Providing the nation's teachers with the resources and training they need to equip students with basic technical and scientific skills is a critical issue. The text box regarding the Los Alamos National Laboratory Math and Science Academy teacher's academy in New Mexico provides an example of one approach for addressing this issue.

Training and Educating Skilled Craft Workers

Individuals can acquire the technical skills and training needed to enter the skilled craft electric power or construction workforce from one or several of many institutions or programs, such as:

- community colleges,
- CBOs,
- apprenticeship programs,
- company-specific training programs, and
- worker retraining programs.

Community Colleges

The nation's 1,200 community colleges provide essential post-secondary education and training to

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[58] National Academy of Sciences. "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future." 2007 (Revised July 2008). Available http://www.nap.edu/catalog.php?record_id=11463#toc.
[59] Ibid.
[60] U.S. Department of Education, National Center for Education Statistics. "Vocational Education in the United States: Toward the Year 2000." February 2000. Available http://nces.ed.gov/pubs2000/2000029.pdf.
[61] APPA. "Work Force Planning for Public Power Utilities: Ensuring Resources to Meet Projected Needs." 2005. Available http://www.appanet.org/files/PDFs/WorkForcePlanningforPublicPowerUtilities.pdf.

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 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.

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

[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.

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[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]

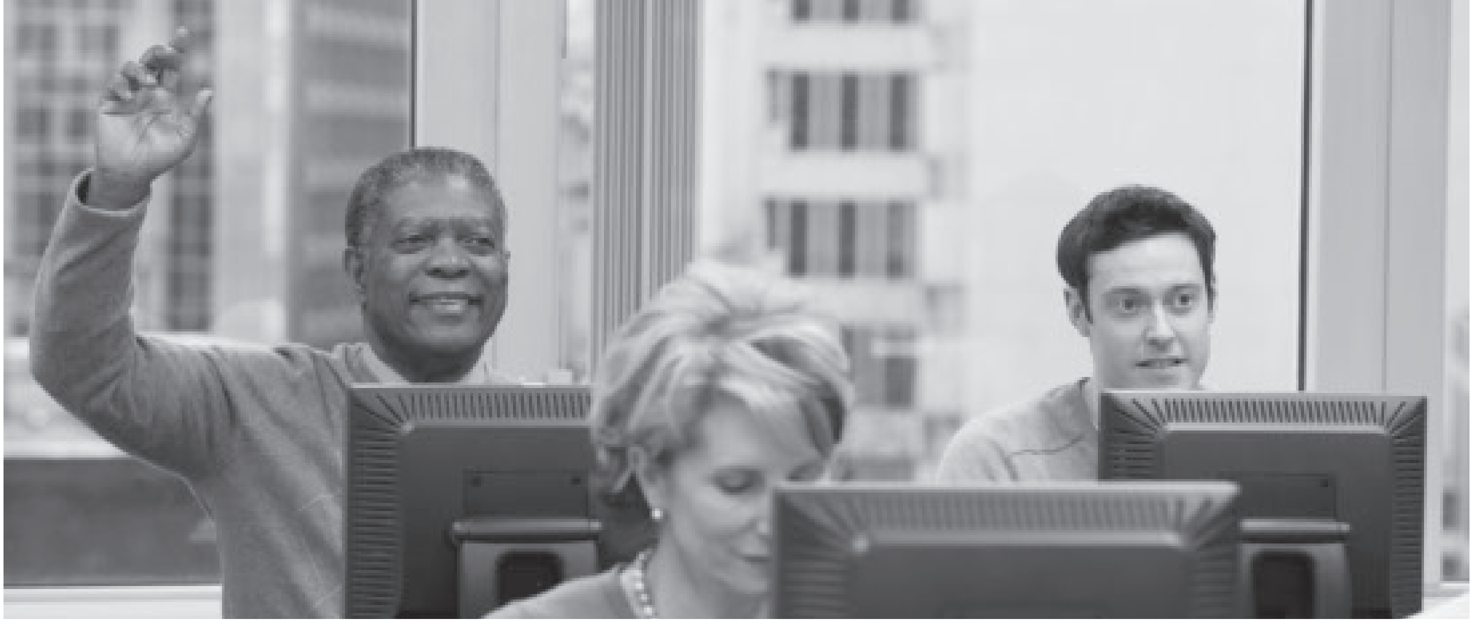
Apprenticeship Programs

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]

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.

[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.

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.

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.

[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.

FOCUSED NATIONAL POLICY SUPPORT AND INVESTMENT IS NEEDED TO ADDRESS WORKFORCE CHALLENGES IN THE ELECTRICAL SECTOR IN A TIMELY WAY.

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.

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

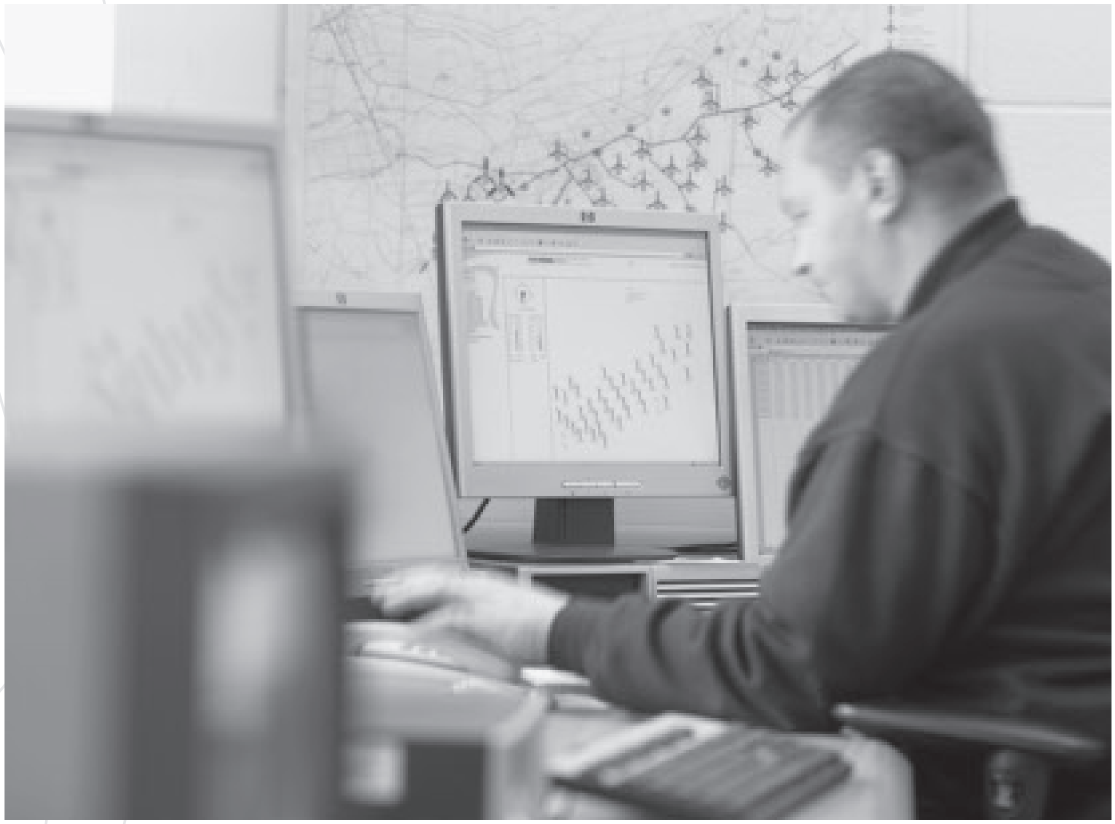
    - deploying energy efficiency in the retrofitting of the nation's building stock and in Smart Grid technologies.

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. 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.

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.



- 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 technol-

ogy, 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.

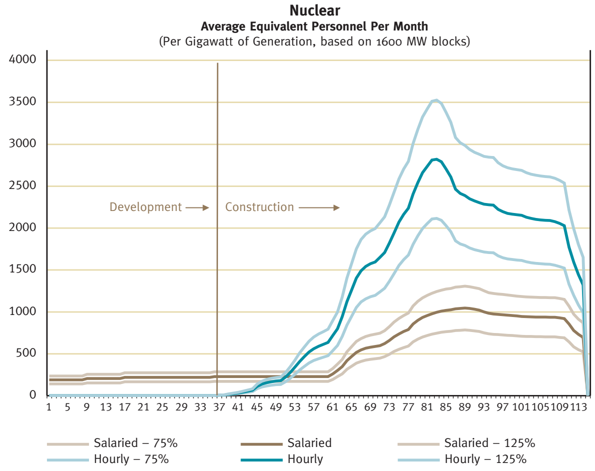
Attachment 2 - Details of generating capacity additions for the NCEP-provided scenarios

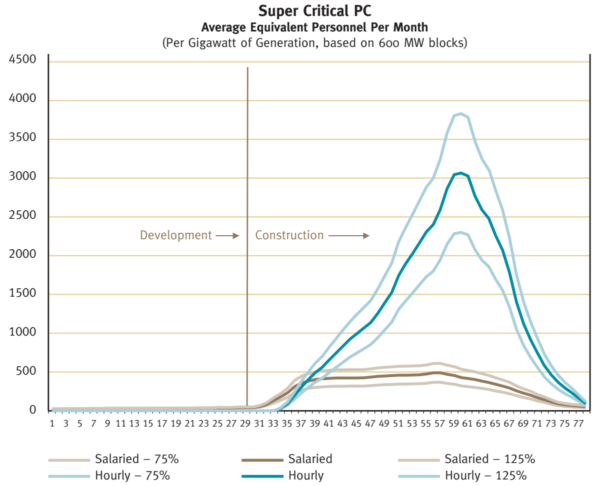
This table shows the total GW additions by technology and by year for each of the scenarios provided by NCEP. Results of the workforce requirements analyses associated with each of these scenarios are provided in Attachment 3.

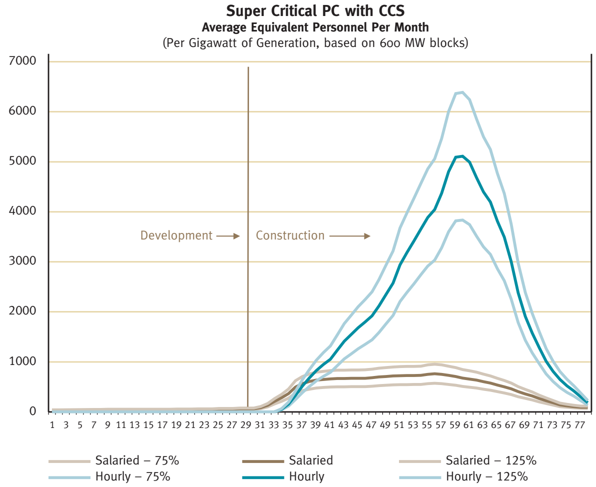
Attachment 3 - Staffing curves for the NCEP-provided scenarios

- 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

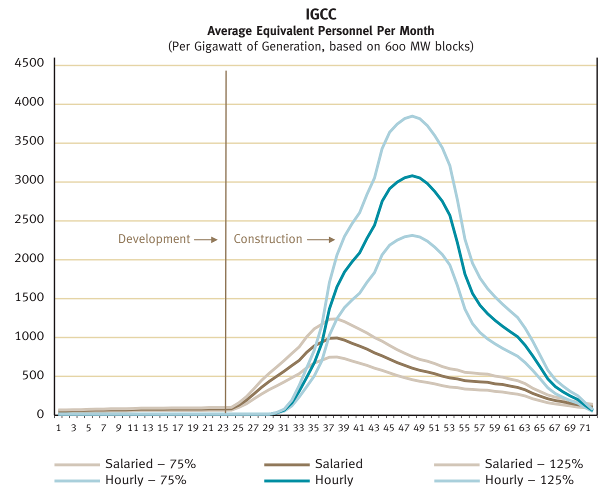
Bechtel Report Attachment 1 – Staffing Curves for 1 GW of Generation

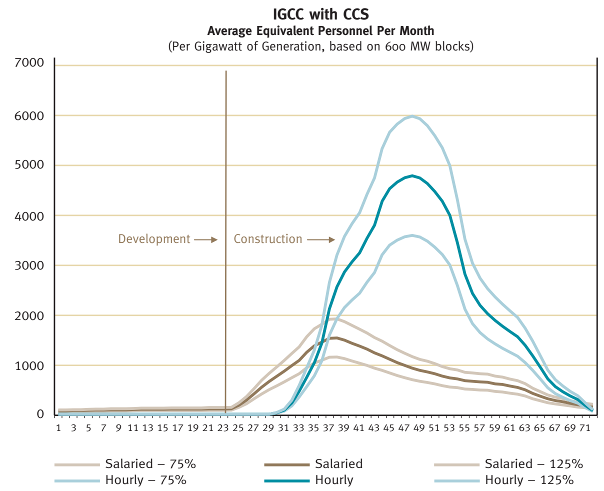


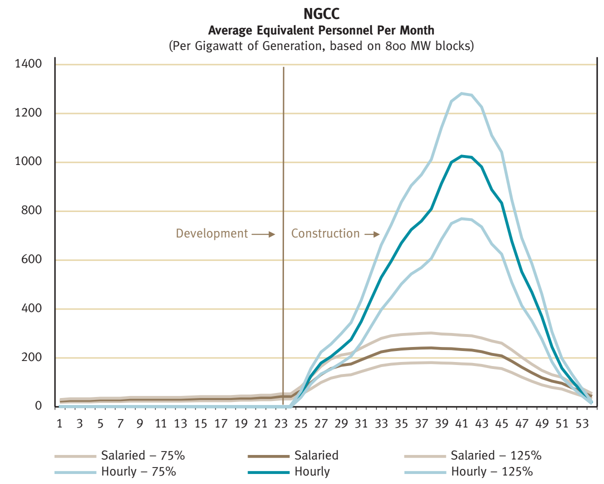




Note: The information presented above is not to be used independently of or without reference to the study and its qualifications and assumptions, or for any commercial purposes.







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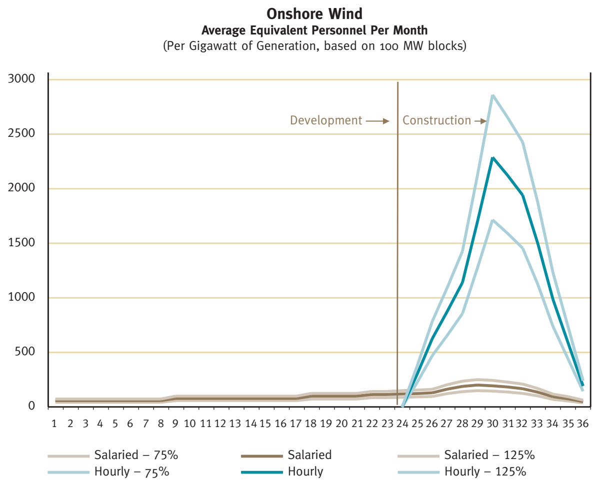

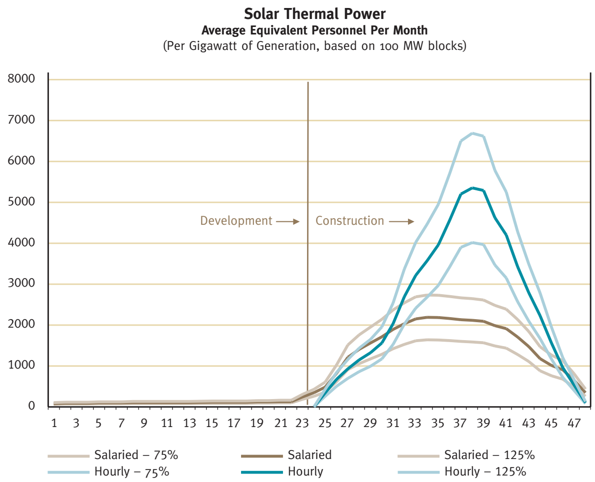

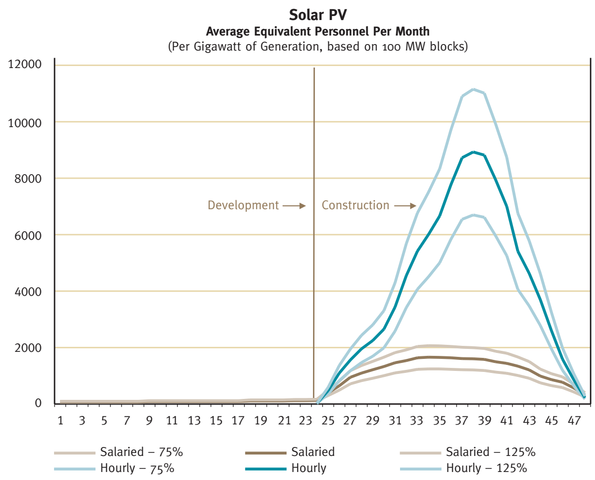

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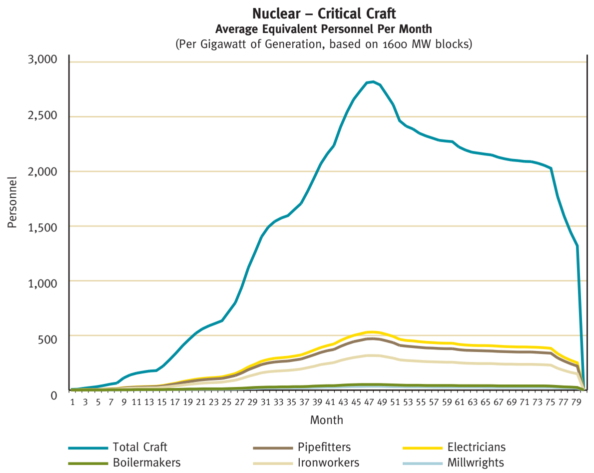
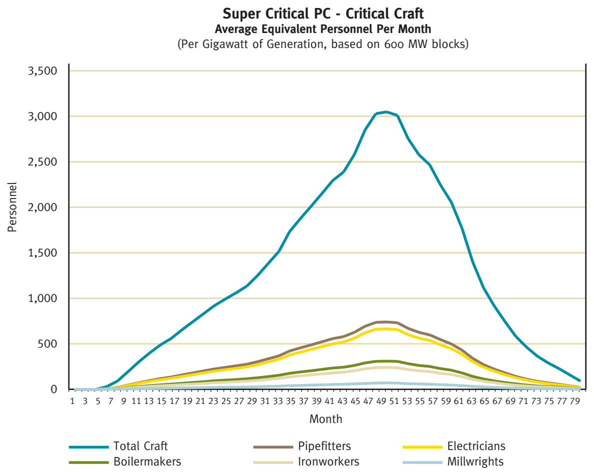
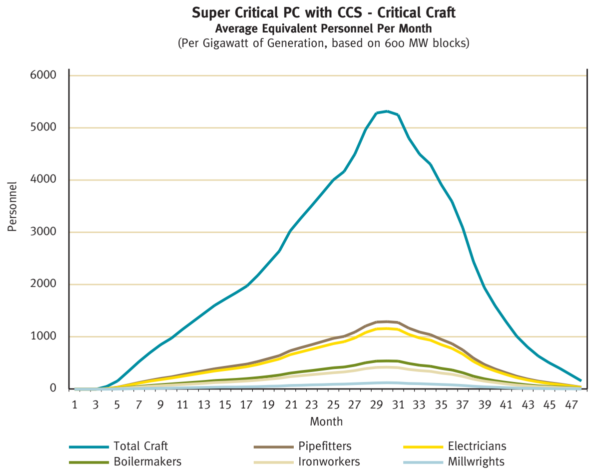
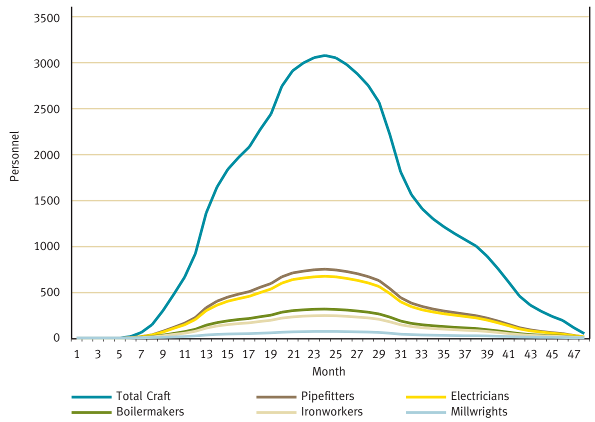




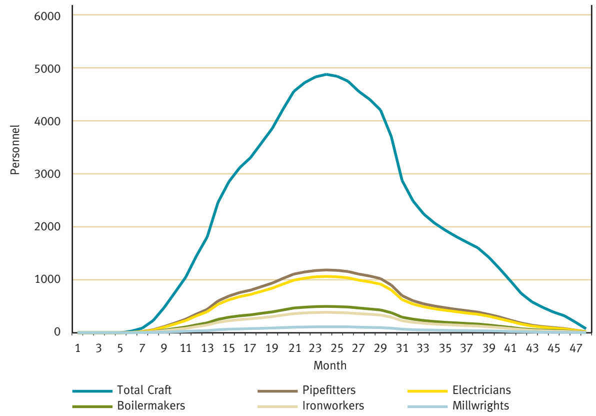


Note: 1. The information presented above is not to be used independently of or without reference to the study and its qualifications and assumptions, or for any commercial purposes.
2. Base case data exclusive of ranges shown for clarity, however +/-25% level of accuracy applies to all data.

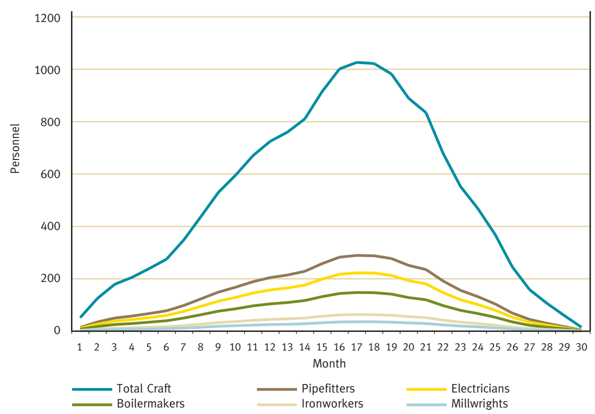
IGCC – Critical Craft
Average Equivalent Personnel Per Month
(Per Gigawatt of Generation, based on 600 MW blocks)



IGCC with CCS – Critical Craft
Average Equivalent Personnel Per Month
(Per Gigawatt of Generation, based on 600 MW blocks)



NGCC – Critical Craft
Average Equivalent Personnel Per Month
(Per Gigawatt of Generation, based on 800 MW blocks)



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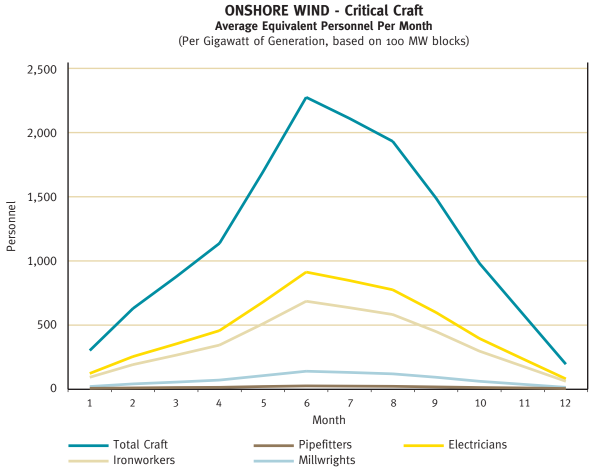

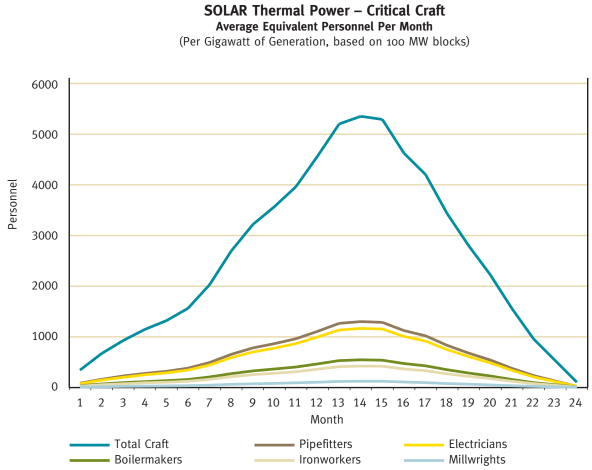

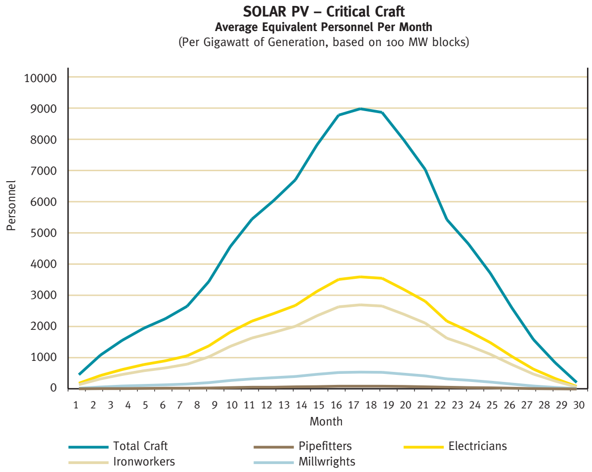

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Bechtel Report Attachment 2

Generating Capacity Deployment Scenarios

Capacity Addition Summary for EPRI Analysis

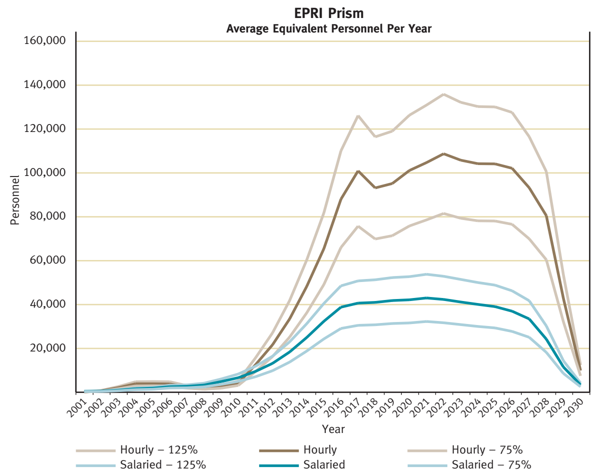
Annual Capacity Additions (GW)

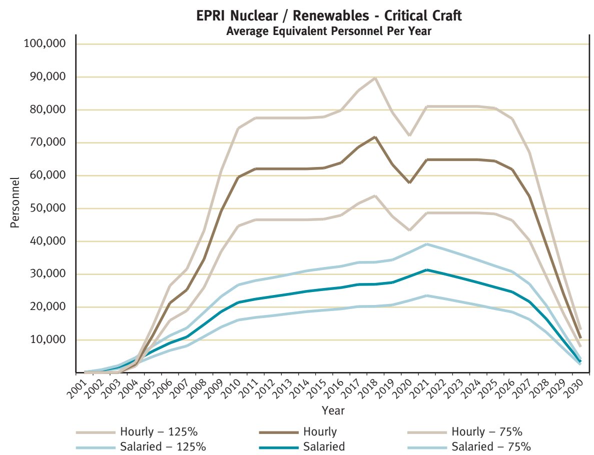
Scenario	Source	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
"EPRI Prism"	Nuclear	1.6	-	-	0.2	0.3	0.3	0.2	0.0	3.8	4.0
	Super Critical PC	-	-	-	-	-	-	-	-	-	-
	Super Critical PC with CCS	-	-	-	-	-	-	-	-	-	-
	IGCC	-	-	-	-	-	-	-	-	-	-
	IGCC with CCS	-	-	-	-	-	-	-	-	0.4	0.9
	NGCC	-	-	-	-	-	-	-	-	-	-
	Onshore Wind	-	-	-	-	3.0	3.0	3.0	3.0	3.0	3.0
	Solar Thermal	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.1
	Solar PV	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
	Total GW	**1.6**	**-**	**-**	**0.2**	**3.4**	**3.4**	**3.3**	**3.1**	**7.3**	**7.9**
"EPRI Nuclear/ Renewables"	Nuclear	-	-	-	-	2.4	2.4	2.4	2.4	2.4	2.4
	Super Critical PC	3.2	3.2	3.2	3.2	7.8	7.8	7.8	7.8	7.8	7.8
	Super Critical PC with CCS	-	-	-	-	-	-	-	-	-	-
	IGCC	-	-	-	-	-	-	-	-	-	-
	IGCC with CCS	-	-	-	-	-	-	-	-	-	-
	NGCC	3.8	3.8	3.8	3.8	-	-	-	-	-	-
	Onshore Wind	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.1
	Solar Thermal	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
	Solar PV	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
	Total GW	**7.0**	**7.0**	**7.0**	**7.0**	**10.4**	**10.4**	**10.4**	**10.4**	**10.4**	**10.4**
"EPRI Coal + CCS"	Nuclear	-	-	-	-	-	-	-	-	-	-
	Super Critical PC	0.5	0.5	0.5	0.5	5.1	5.1	5.1	5.1	5.1	5.1
	Super Critical PC with CCS	-	-	-	-	-	-	-	-	-	-
	IGCC	-	-	-	-	-	-	-	-	-	-
	IGCC with CCS	-	-	-	-	1.8	1.8	1.8	1.8	1.8	1.8
	NGCC	5.5	5.5	5.5	5.5	-	-	-	-	-	-
	Onshore Wind	-	-	-	-	3.0	3.0	3.0	3.0	3.0	3.0
	Solar Thermal	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.1
	Solar PV	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
	Total GW	**6.0**	**6.0**	**6.0**	**6.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**

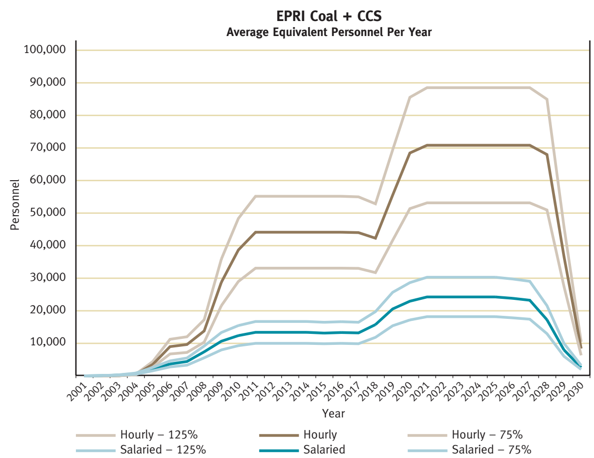
Notes:
Plant Retirements not included.
Renewable power capacity additions derived from EPRI data using renewable power shares from the U.S. Department of Energy Annual Energy Outlook 2008.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030		Total GW
4.6	5.4	6.0	6.7	4.7	4.9	4.9	5.0	5.1	5.0	4.5	4.0	4.7	2.4		78.3
-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
2.6	5.8	5.5	2.8	6.5	6.1	7.6	7.4	6.5	7.4	7.5	8.0	7.4	7.9		90.1
-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
3.0	3.0	3.0	3.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2		41.5
0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		1.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.3
10.2	**14.2**	**14.6**	**12.6**	**12.4**	**12.2**	**13.7**	**13.6**	**12.9**	**13.6**	**13.1**	**13.2**	**13.3**	**11.5**		**211.2**
2.4	2.4	2.4	2.4	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2		86.0
7.8	7.8	7.8	7.8	-	-	-	-	-	-	-	-	-	-		90.8
-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
-	-	-	-	-	-	-	-	-	-	-	-	-	-		15.2
0.1	0.1	0.1	0.1	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		41.5
0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		1.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.3
10.4	**10.4**	**10.4**	**10.4**	**10.3**	**10.3**	**10.3**	**10.3**	**10.3**	**10.3**	**10.3**	**10.3**	**10.3**	**10.3**		**234.8**
-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
5.1	5.1	5.1	5.1	-	-	-	-	-	-	-	-	-	-		53.0
-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
1.8	1.8	1.8	1.8	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5		103.0
-	-	-	-	-	-	-	-	-	-	-	-	-	-		22.0
3.0	3.0	3.0	3.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2		41.5
0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		1.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.3
10.0	**10.0**	**10.0**	**10.0**	**9.7**	**9.7**	**9.7**	**9.7**	**9.7**	**9.7**	**9.7**	**9.7**	**9.7**	**9.7**		**220.8**

Bechtel Report Attachment 3 – Staffing Curves for the Deployment Scenarios







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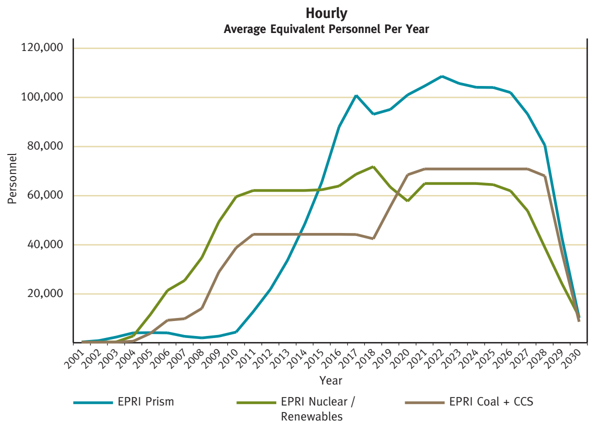

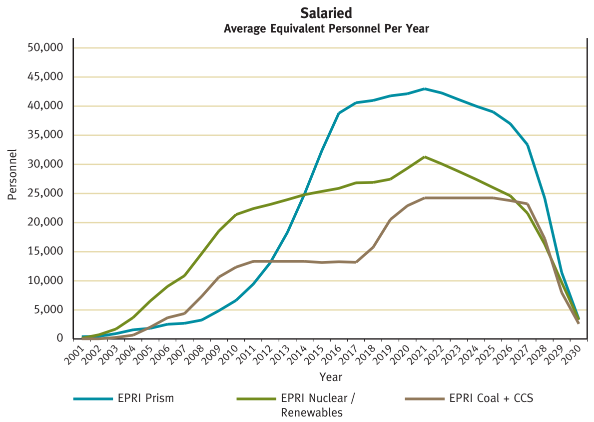

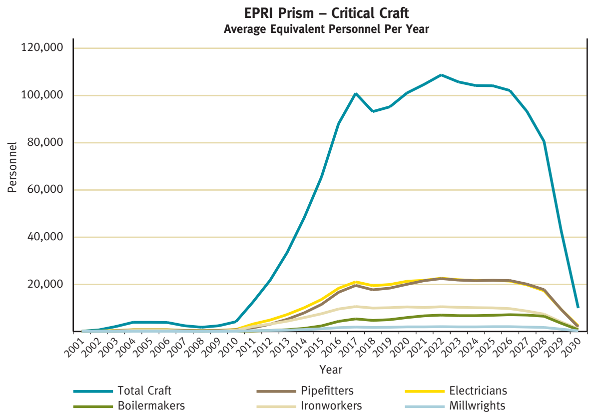

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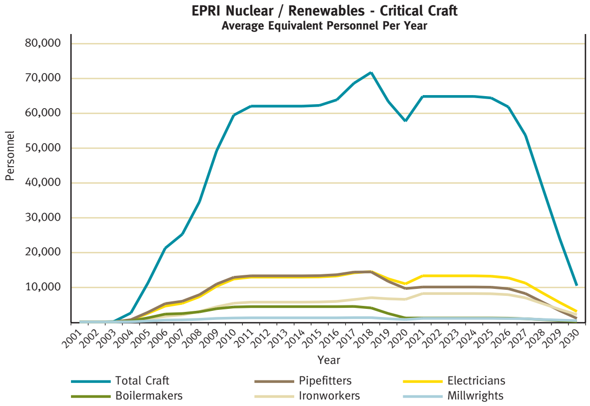
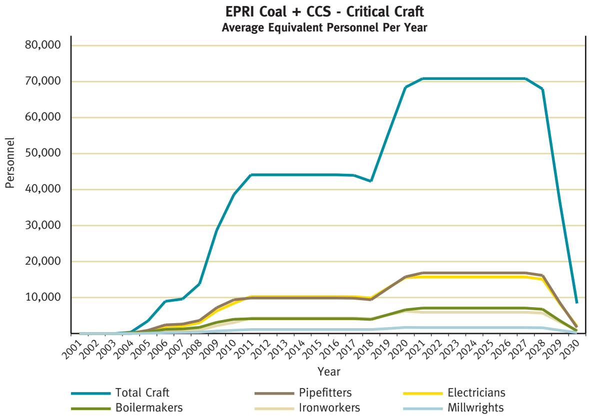
2. Base case data exclusive of ranges shown for clarity, however +/-25% level of accuracy applies to all data.





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Appendix B: Alternative Scenarios

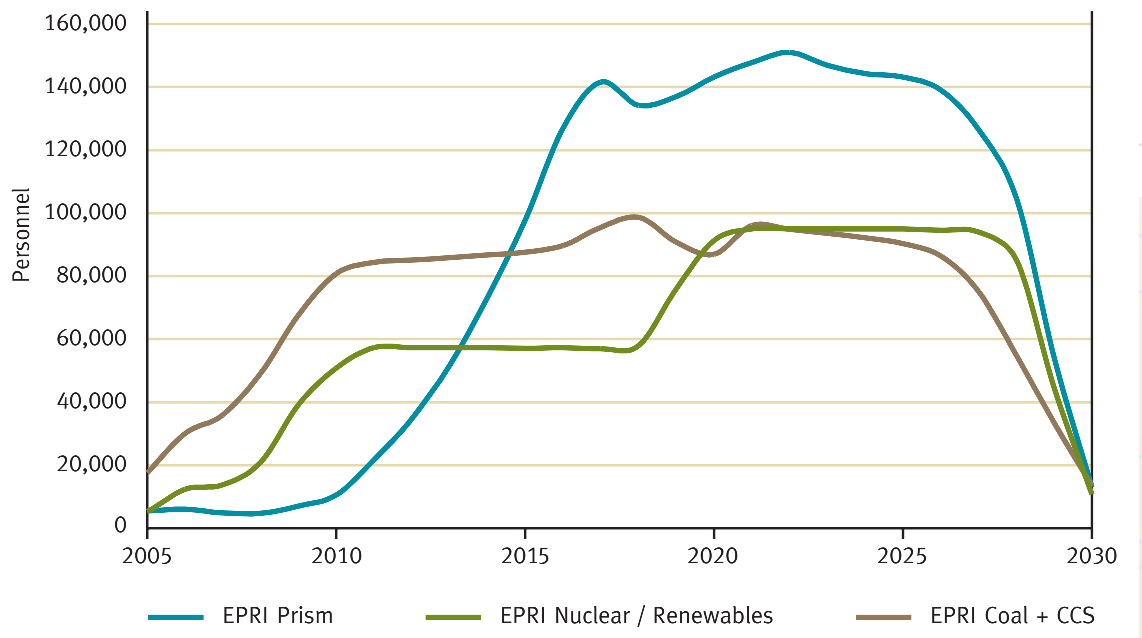
To test the robustness of results from the EPRI Prism analysis, NCEP asked Bechtel to model two alternative scenarios that were based on EPRI's economic model, MERGE.[85] Using MERGE, EPRI tested the impact of various constraints on the rate and type of generation deployment. Bechtel's report to the Task Force is included in Appendix A and includes detailed results of these analyses.

The Task Force chose two significantly different alternative deployment scenarios from the EPRI MERGE modeling effort:

- Scenario 1 (EPRI Nuclear/Renewables Scenario in the Bechtel report): Assumes the technologies associated with CCS are not available until 2030 and the cost associated with transport and storage is three times higher than in the base case. As a result, a significant number of nuclear and conventional coal units are deployed. Attachment 2 to the Bechtel report includes this deployment path.
- Scenario 2 (EPRI Coal + CCS Scenario in the Bechtel report): Assumes the levelized cost of electricity from nuclear is 18 percent higher than in the base case. As a result, no new nuclear generation is deployed and a significantly higher amount of IGCC with CCS is deployed. Attachment 2 to the Bechtel report includes this deployment path.

As with the EPRI Prism, Bechtel developed the workforce demand projections associated with these alternative deployment scenarios. The projections are shown in Figure 15 alongside the projections Bechtel developed using the EPRI Prism.

Figure 15. Total Salaried and Hourly Jobs Created Under Each Scenario



Note: 1. The information presented above is not to be used independently of or without reference to the study in Appendix A and its qualifications
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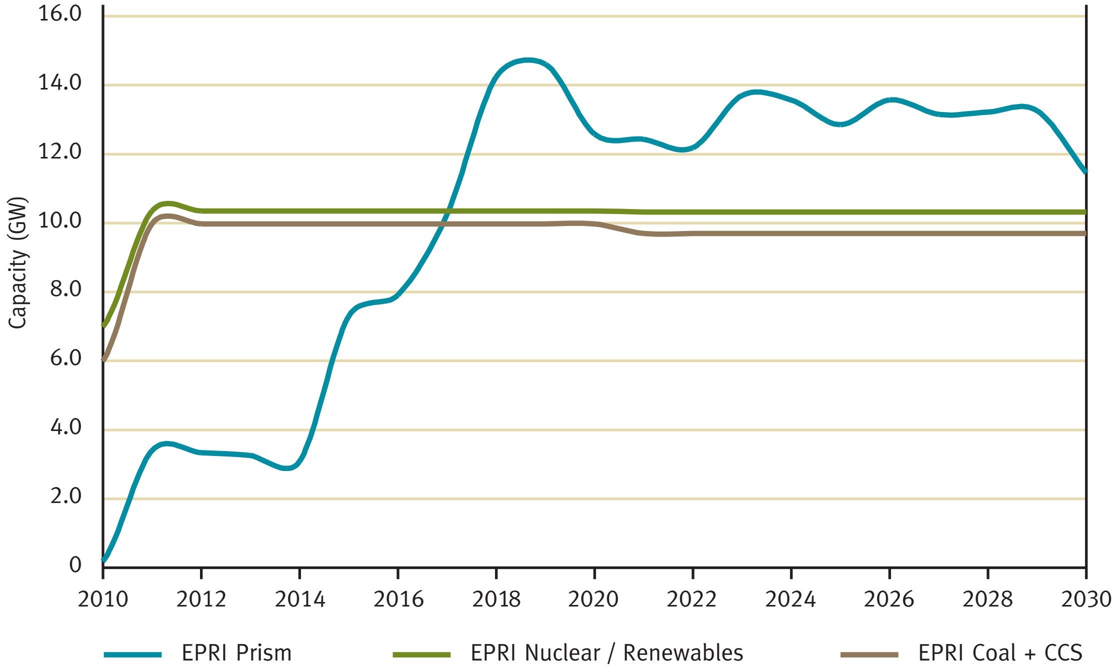
[85] MERGE uses a top-down model of economic growth to examine the economy-wide impacts of climate policy. Electric Power Research Institute (EPRI). "The Power to Reduce CO_2 Emissions: the Full Portfolio - 2008 Economic Sensitivity Studies," EPRI Report 1018431. 2008.

In the alternative scenarios, the peak workforce demand is not as high as it is in the EPRI Prism scenario. However, the workforce demand increases much more quickly in the early years. The workforce demand path in each case is driven by the generation deployment paths of the respective scenarios. Both of the alternate scenarios assume six to seven GW of new generation are built annually between 2007 and 2010 while the Prism analysis assumes a total of 1.8 GW are constructed during those years. Figure 16 shows the deployment pathway for all three scenarios.

Figure 16. Deployment Pathway Under Each Scenario



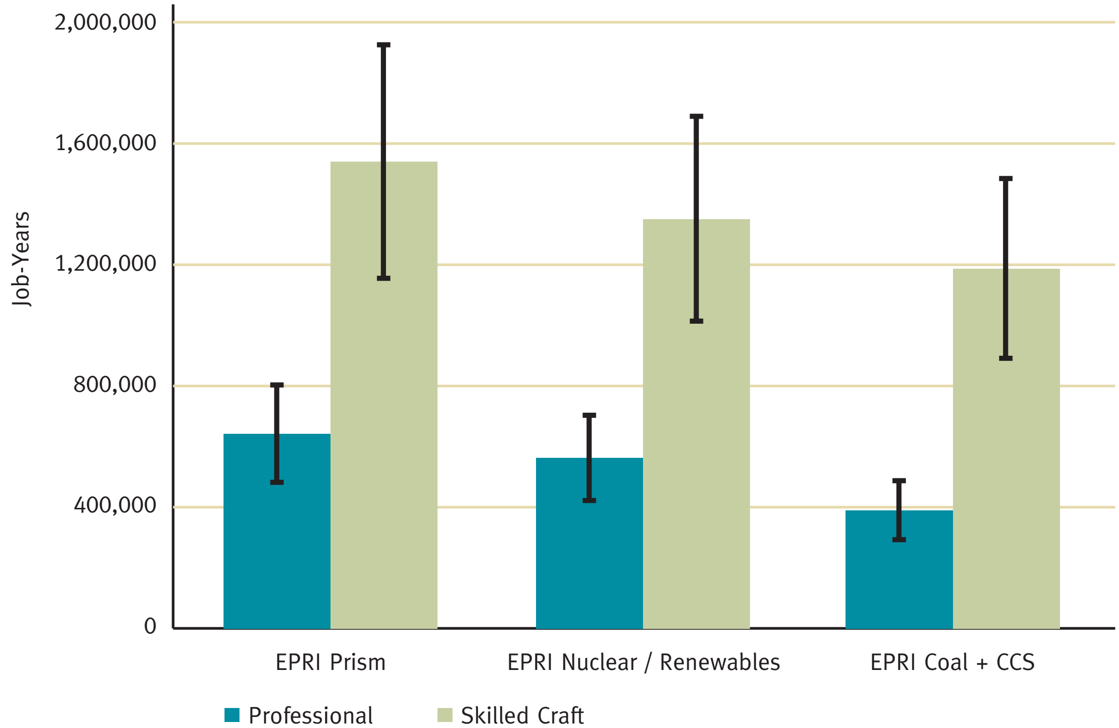
The total GW added to U.S. generation capacity under each scenario is roughly comparable: 211 GW in the EPRI Prism, 235 GW in Scenario 1, and 221 GW in Scenario 2.

One way to compare the number of jobs created under the scenarios is to normalize them by looking at "job-years" instead of peak jobs. Job-years are calculated as the area under the workforce demand curves (i.e., the sum of the annual jobs). For example, consider a generating unit that employs 1,000 people continuously during a five-year construction period. If two units are built simultaneously, 2,000 people will be needed for five years to complete the construction (since each person can only work on one unit at a time). If the two units are built in sequence, 1,000 people will be needed for 10 years to complete the construction. While the peak demand is different (2,000 jobs versus 1,000 jobs), the total number of jobs-years is equal. In each case the total number of job-years would be 10,000 (2,000 jobs times five years or 1,000 jobs times 10 years).

Figure 17 shows the cumulative job-years for each of the three scenarios with error bars representing the 25 percent uncertainty embedded in the Bechtel assumptions. As shown, the EPRI Prism has the highest number of total job-years followed by the EPRI Nuclear/Renewable scenario and then the EPRI Coal + CCS scenario. While the trend is consistent with the peak jobs comparison (i.e., the EPRI Prism is the highest), the difference between the scenarios is not as dramatic.

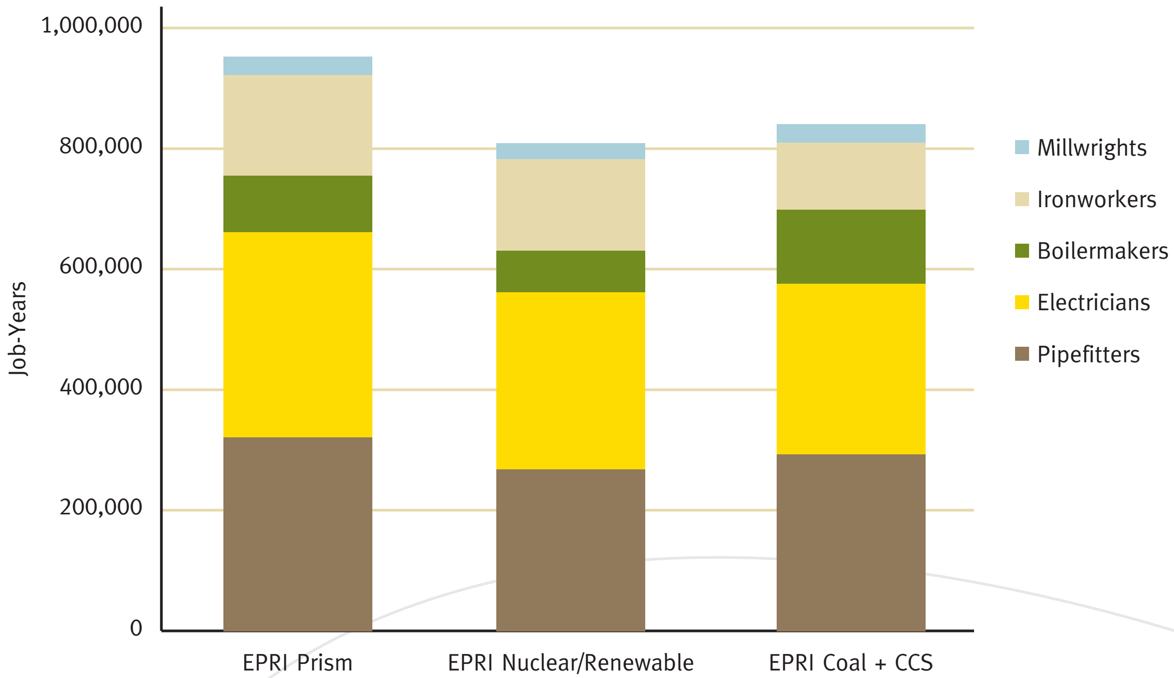
The difference in job-years highlights the observation that the type of generation deployed can affect the workforce demand. The one-GW building blocks developed by Bechtel (Attachment 1 in Appendix A) based on their expertise constructing generation facilities show that designing and constructing one GW of nuclear power will require more labor over a longer period of time as compared to the other building blocks.

Figure 17. Cumulative Job-Years for Each Scenario



The Task Force wanted to assess the impact of the different scenarios on the demand for the critical skilled crafts identified by Bechtel. Figure 18 compares the demand for the various critical crafts under each of the different scenarios in job-years.

Figure 18. Critical Craft Workforce Composition under Modeled Scenarios



Appendix C: Coordinated Training Program Case Studies

The NCEP Task Force on America's Future Energy Jobs discussed the need to improve or reestablish the training pipeline for skilled workers in the electricity generation sector. After reviewing a number of local and regional examples of coordinated training programs, the Task Force chose three examples to study further. The three programs, sponsored by Centralia College, IBEW, and PG&E, respectively, are:

- Washington State Center of Excellence for Energy Technology, Centralia College,
- IBEW Regional Training Centers, and
- PG&E PowerPathway™.

Brief program summaries and key findings are summarized below. In general, the key points shared across these three successful programs were

1. participation by multiple stakeholders (e.g., industry, academia, labor, and community groups),
2. the importance of national or regional standards, and
3. a long-term approach by stakeholders, funders, and students.

The Task Force's Policy Recommendation 1 is a direct result of lessons learned in these programs. These programs also informed our understanding of multi-stakeholder programs generally, and contributed to several other recommendations.

Case Study A: Washington State Center of Excellence for Energy Technology, Centralia College

In response to a lack of strategic policy coordination between the state's educational centers, Washington State developed a network of Centers of Excellence to serve as points of contact and resource hubs for industry trends. The distributed and duplicative nature of many in-demand fields (for example, nursing/health care, energy) prompted the state Board of Education to call for one central program of study with common course numbering, which would enable credit transfer and standardization of programs, with associated reduced administrative costs and content certainty. Each Center focuses on a targeted industry considered important to the state's economy and intends to create fast, flexible, quality education and training programs. The Washington State Board of Community and Technical Colleges designated Centralia College a Center of Excellence for Energy Technology in 2004. The Center serves as a statewide resource hub for students seeking training for a career in the energy industry.

Role of the Center of Excellence for Energy Technology

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.

The Center also:

- Maintains an institutional reputation for innovation and responsive education and training delivery to the energy industry.
- Acts as a broker of information and resources related to the energy industry for industry representatives, community-based organizations, economic development organizations, community and technical colleges, secondary education

- institutions, and four-year colleges and universities.
- Translates industry research into best practices.
- Provides system coordination, coaching, and mentoring to assist in building statewide seamless educational and work-related systems.
- Builds a competitive workforce for the energy industry in Washington.

Industry Partners

- Avista
- Bonneville Power Administration
- Bureau of Reclamation, Grand Coulee Dam
- Centralia City Light
- Energy Northwest
- Grays Harbor County Public Utility District (PUD)
- Hampton Lumber
- Lewis County PUD
- Mid Columbia PUDs (Chelan PUD, Douglas County PUD, Grant PUD)
- North West Public Power Association
- PacifiCorp
- Portland General Electric
- Puget Sound Energy
- Seattle City Light
- Seattle Steam
- Tacoma Power
- TransAlta Centralia Power

Labor Partners

Community college programs are considered pre-apprenticeship, and labor representatives play an advisory role in each program. Labor partners include:

- IBEW Local #77
- IBEW Local #125
- Washington State Labor Council

Initial Lessons

The Task Force identified territorialism among community colleges and policy and market uncertainty as the key challenges to program development. Elements of the Centers of Excellence models critical to success have included support from the state board of education; ownership of the initiative by stakeholders including educators, industry representatives, and union representatives; and pathways for communication between stakeholders.

Case Study B: IBEW Regional Training Centers

The International Brotherhood of Electrical Workers (IBEW) signed an agreement with electric power leaders in January 2009 to develop a training trust to support multiple IBEW regional electric power training centers across the United States. The goal of the program is to partner with electric power companies to train a new generation of workers. The training centers will offer hands-on training for potential electric power employees.

Program Components

The IBEW regional training centers provide a centralized location for electric power workers to learn skills necessary to future employment in the electric power industry. One of the core offerings of the program is an eight-week “boot camp” to provide foundational training for a variety of potential electric power employment paths (i.e., operators, linemen, etc.). The boot

camp is designed to address remedial education, drug testing, and basic electric power skills (e.g., climbing a pole for lineworkers or time inside a power plant).

The boot camp also screens potential workers and prepares them for industry pre-employment tests such as the Edison Electric Institute's Construction and Skilled Trades Selection System (CAST). CAST is a battery of aptitude tests designed to aid in the selection of candidates for diverse construction and skilled trades occupations. CAST aims to predict candidates' probability of success in the following categories of construction and skilled trade jobs:

1. Transmission and Distribution
2. Power Generation
3. Facilities and Repair
4. Other Facilities (e.g., Carpentry)
5. Electrical Repair
6. Machining and Vehicle Repair
7. Meter Service and Repair

Utility Partners

The IBEW is currently working to develop regional training centers with the following utility partners:

- Kansas City Power and Light (Missouri)
- DTE Energy (Detroit)
- Tucson Electric (Arizona)

The IBEW is currently working to identify sites for additional centers in the southeast, the northeast, the northwest, and Texas. Once the centers are established, the IBEW envisions them as being regional resources utilized by a range of stakeholders. Toward this goal, the Kansas site is developing a mobile training trailer to enable training in rural areas.

Initial Lessons

There is tension between the efficiencies of developing regional training centers and challenges of recruiting a workforce locally. Task Force participants suggested pairing regional training centers that offered capital-intensive training elements (e.g., hands-on lineworker training components) with localized classroom-based training (e.g., basic skills, electricity basics). Classroom-based skills would benefit from integration with local community colleges and CBOs. Additionally, technical training centers could develop mobile classrooms to bring some skills training to community colleges or community-based training centers.

The Task Force believes that developing national skill standards and providing funding to students are important parts of a strategy for training the workforce. National skill standards could increase portability of credits and certifications from school to school, company to company, and state to state. In addition to portability concerns, a major barrier remains funding. Many students are reluctant to undertake adequate training programs without an employment guarantee; similarly, employers are reluctant to offer employment guarantees before course completion. One option discussed was potentially pooling employer resources to ensure a greater pool of available jobs. Additionally, national skills standards may alleviate some risk as students would be guaranteed a widely-recognized certification upon successful completion (similar to a degree that is recognized nationwide) and employers would be guaranteed what skills successful students mastered.

Case Study C: PG&E PowerPathway™

The PowerPathway™ program, offered at community colleges throughout California, trains and prepares individuals for high-demand positions at PG&E and throughout the energy sector. In addition to one- and two-year curricula at selected institutions, individuals may participate in a customized short-term course designed to strengthen their candidacy for employment and their knowledge of the industry.

Benefits of PG&E PowerPathway™ Program for Participants

PowerPathway™ helps individuals better prepare for employment at PG&E and other high-growth energy sector jobs. The coursework covers a range of topics, including technical skills, industry knowledge, pre-employment test preparation, soft skills, physical conditioning, and interview and resume preparation. With the support of state, federal, and foundation grants, most course tuition is covered; however, individuals are not paid while in the program and there is no guarantee of employment to participants.

There are three types of PG&E PowerPathway™ programs:

- Bridge (a standalone course usually 10-16 weeks in length).
- Endorsed Program (a community college certificate or associates degree program that is 1- or 2-years in length).
- Capstone (additional coursework for students who have completed a prerequisite associates degree or certificate).

Benefits of PG&E PowerPathway™ Program For PG&E

PowerPathway™ graduates qualify at an unprecedented level on PG&E's Physical Test Battery pre-employment test. Rates at which students qualified increased over time as the program was refined, with the final class reaching a 100 percent qualifying rate. One hundred percent of PG&E supervisors would consider hiring another PowerPathway™ graduate.

Classes in the PowerPathway™ College Curriculum

Using the Bridge to Utility Worker course as an example, in general, candidates must demonstrate mastery of at least 8th-10th grade level literacy and mathematics skills to be considered for PowerPathway™ courses. Spatial reasoning, the ability to follow directions, the candidate's comfort with working at heights, and the ability to handle the physical demands of the jobs are evaluated during the selection process. If accepted into the Utility Worker / Apprentice Lineworker course, candidates will undergo a training curriculum that will include:

- Reading and Comprehension: This will strengthen the candidate's ability to read and understand required documents such as job instructions and drawings, construction standard manuals, and material lists essential to performing the work.
- Applied Mathematics: Understanding calculations involving addition, subtraction, and multiplication of percentages and fractions.
- Physical conditioning: Exercises that strengthen and prepare a student for the rigors of pole climbing, lifting, and other

required physical tasks.
- Industry-specific knowledge: safe working practices, basic electricity, pole climbing, using ropes, confined working spaces, and other areas of knowledge required to perform the work.
- Soft skills training: Time management, interviewing skills, general workplace communication skills.

Initial Lessons

The Task Force identified a long-term approach as a key to success, including:
- Consistent funding versus short-term grants,
- Involvement of multiple employers to increase the employment opportunities over time and reduce hiring volatility from the student perspective,
- Building a regional program that connects with local educators and employers, and
- Developing a program structure with a coordinating body (employment panel) that can bring together numerous community colleges, companies, labor groups, and other stakeholders including CBOs and potentially WIBs.

Additionally, establishing consistent training standards and a common curriculum is a key to success. Industry partners are looking for skilled workers who can pass or have already passed company entrance exams, while community college partners are looking for approved programs and labor groups are looking for training that complements existing apprenticeship structure.

Appendix D: Insights from the Analysis and Next Steps

The NCEP Task Force on America's Future Energy Jobs brought together representatives from the labor, electric industry, and training and educational sectors to explore the existing demographic makeup and anticipated professional needs of the electricity industry, along with the training institutions and programs that support this sector. The report summarizes the analysis and recommendations resulting from this effort. Following this analysis, the NCEP staff wants to highlight a number of specific insights about possible next steps in support of policymaking.

Additional Modeling

NCEP staff contracted with Bechtel to conduct the analysis summarized in Appendix A. The report applies the per-GW workforce estimates developed by Bechtel for the EPRI Prism scenario and two alternative scenarios (summarized in Appendices A and B). NCEP staff believes it is important to conduct updated estimates of workforce demand as policy choices are debated to gain additional insight.

As discussed in Appendix C, the types of technologies available for deployment and the rate of deployment determine the size, and potentially the desired skill sets, of the workforce needed. Both the types of technologies deployed and the rate of deployment are heavily dependent on the direction of policy decisions that are currently being considered in Congress. For this reason, we propose that economic models that incorporate emissions limits and complimentary policies (such as renewable energy standards or transmission deployment incentives) contained in proposed climate bills be used as a foundation for updated workforce demand estimates. These updated estimates should reflect potential policy decisions that will drive actual workforce demand. NCEP staff believes that the workforce demand building blocks presented in this report can assist government agencies and other organizations as they develop these economic models because, without substantial intervention, workforce shortages may be a significant constraint on deployment paths.

Additionally, as noted in the report, there will be state and regional variability in the deployment of generating assets, retrofit technologies, infrastructure, and other technologies. The building blocks used in this report could also be used in developing future state and regional workforce models.

Consideration of Supplementary Factors

The workforce estimates presented in this report focus on direct jobs associated with the construction and operation of electric generating assets and the associated infrastructure and technologies. In these workforce estimates no constraints on the feasibility of low-carbon infrastructure build out were examined aside from workforce availability. Policymakers may, however, want to evaluate potential constraints as they work towards low-carbon infrastructure policies.

Additional macroeconomic factors beyond the scope of the report contribute to the complexity of projections of future workforce demand and supply and should be considered as a part of future work to help inform federal policy decisions.

- Competition for workforce: The construction workforce is not specific to the electrical industry and the industry will likely face competition for skilled craft workers with other sectors that may also be concurrently investing in infrastructure projects.
- Industrial policy: Manufacturing implications should also be considered for the technology mixes and deployment paths considered in updated workforce estimates. The manufacturing jobs associated with the low-carbon technologies deployed could be very significant and could both increase the demand for skilled workers and contribute to competitive pressures in the labor market.
- Worker re-training: There is a potential for displacement of traditional electric power jobs as the industry deploys new technologies. This implies that there may be significant re-training needs for some of the current workforce and that the net number of new employees needed in this sector will be affected by the extent of this displacement.[86]

[86] According to the KEMA/GridWise Alliance study, as a result of smart grid deployment, about 32,000 existing utility jobs, such as meter-readers, will be transitioned to other jobs in the electric sector.

Notes

Notes

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