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.

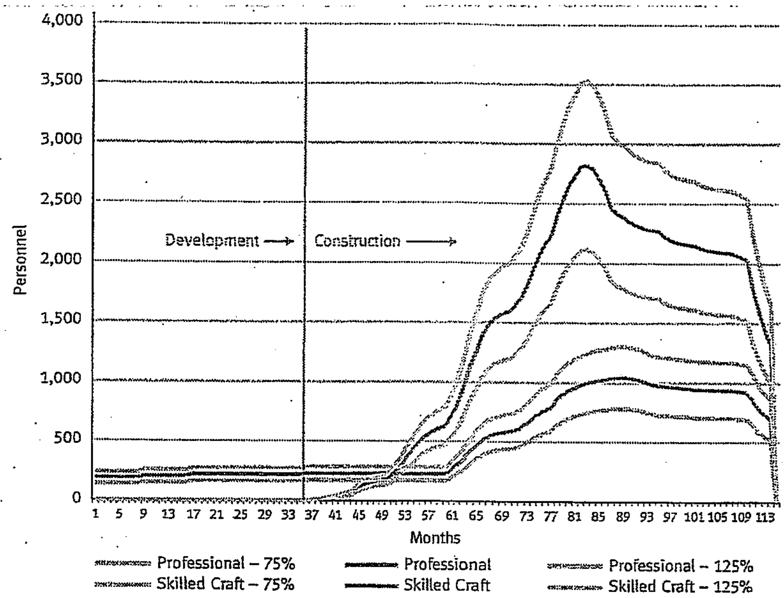
[29] BBC Research & Consulting (Prepared for Industrial Union Council, AFL-CIO; International Brotherhood of Boilermakers; Iron Ship Builders, Blacksmiths, Forgers, and Helpers; International Brotherhood of Electrical Workers; United Mine Workers of America; and American Coalition for Clean Coal Electricity). "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.

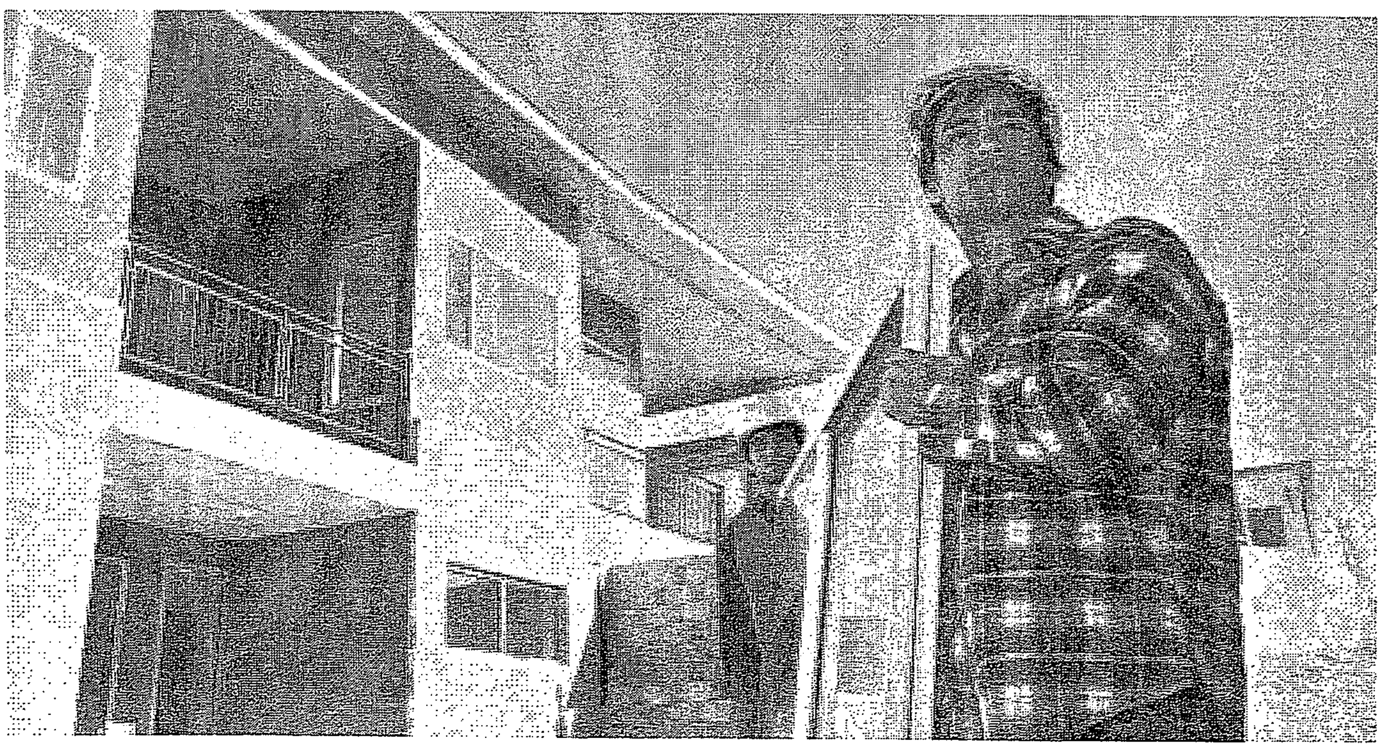
In assessing workforce needs, Bechtel considered two categories of workers: professional employees and skilled craft employees. Each designation is short-hand for a broad category of employees.

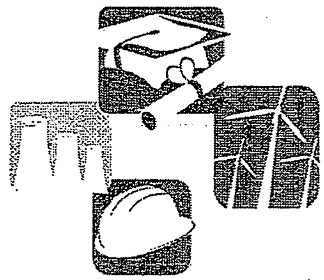
- Professional employees include individuals who provide services in engineering, procurement, project management, construction oversight, and other support services. These include employees at the project site, at corporate offices, and at offshore design facilities.
- Skilled craft employees include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





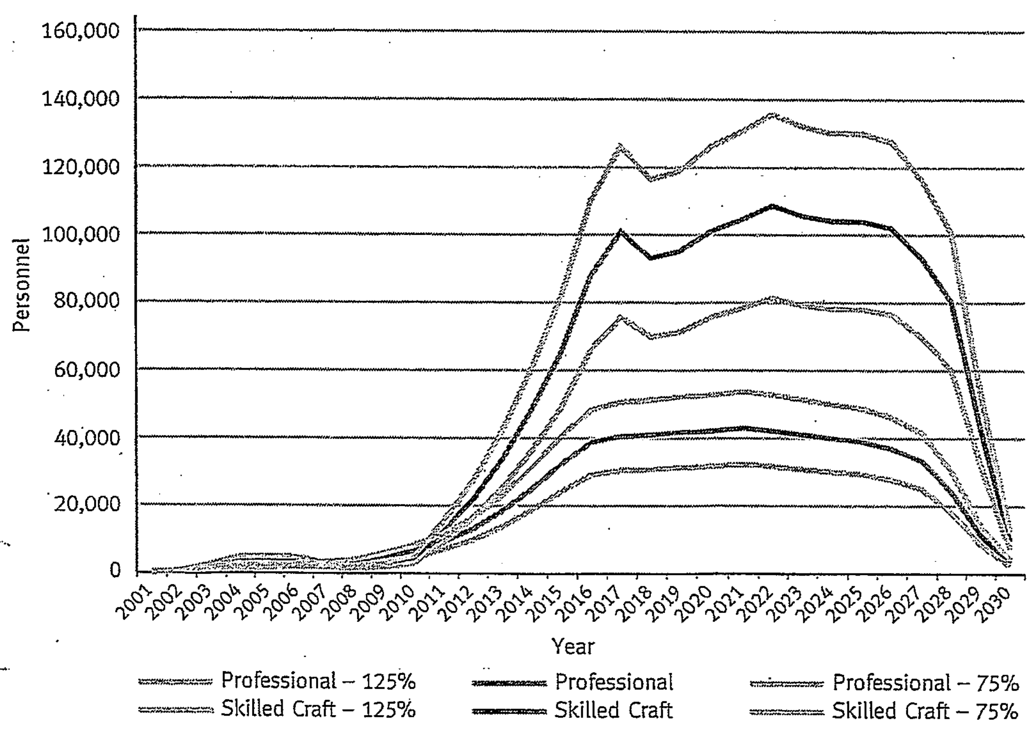
THE TASK FORCE ESTIMATES THAT ROUGHLY 113,000 TO 189,000 WORKERS WILL BE NEEDED TO DESIGN AND CONSTRUCT THE NEW GENERATING ASSETS ENVISIONED IN THE PRISM SCENARIO.

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.

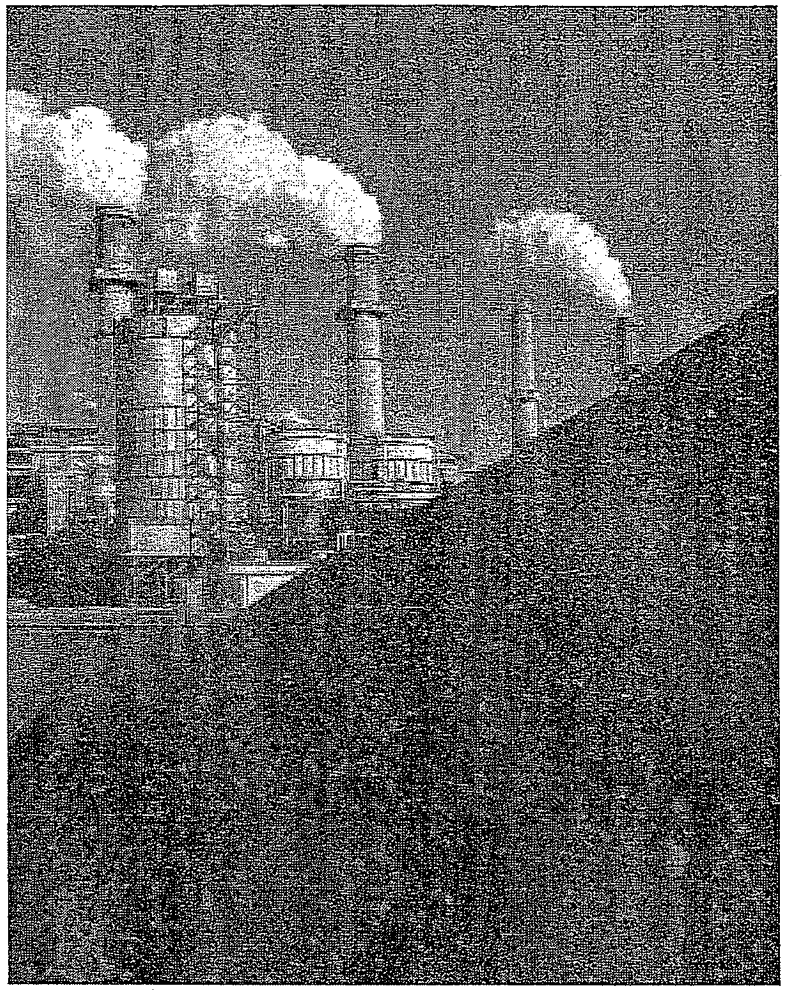


Figure 6. Comparison of the Workers Needed to Design and Construct the New Generating Assets in the EPRI Prism Analysis to Existing Employment Levels and Other Sources of Worker Demand

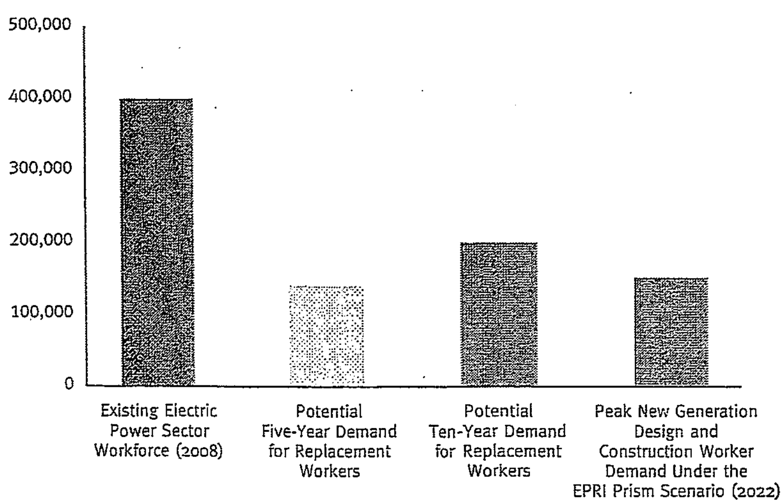
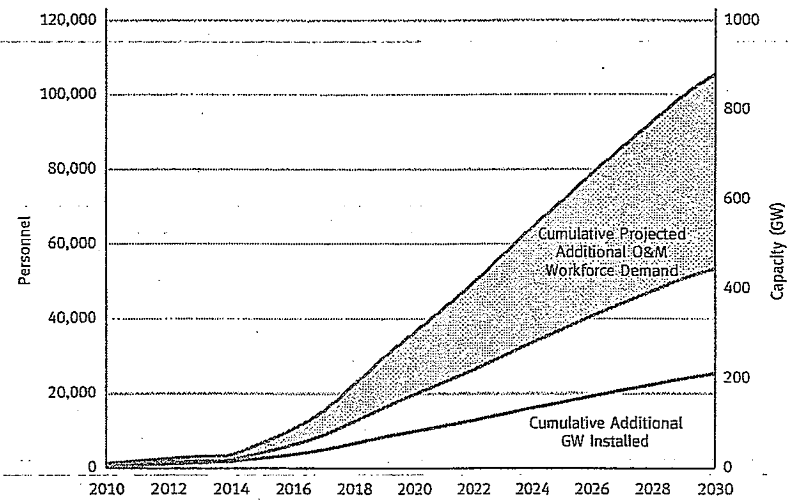


Figure 7. Estimated Cumulative O&M Workforce Requirements at Projected New Generating Assets under the EPRI Prism Analysis



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.

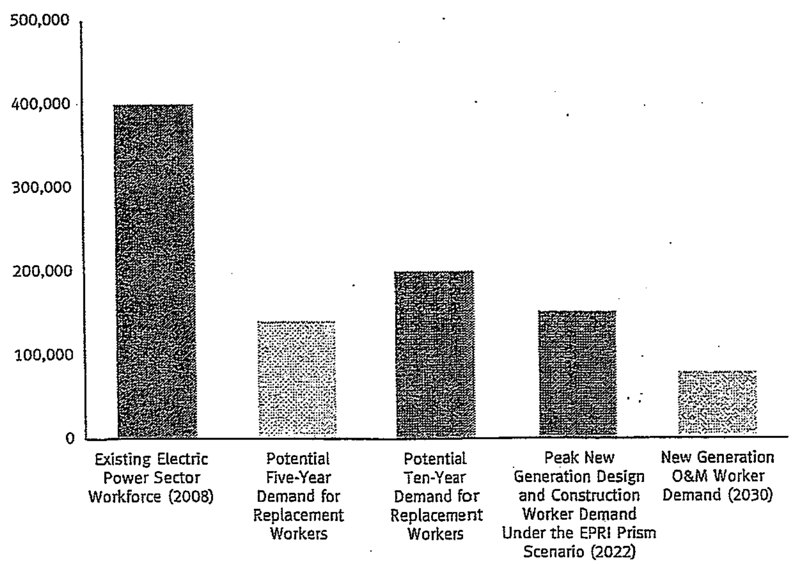
Three of the most prominent areas of infrastructure expansion are likely to include:

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]

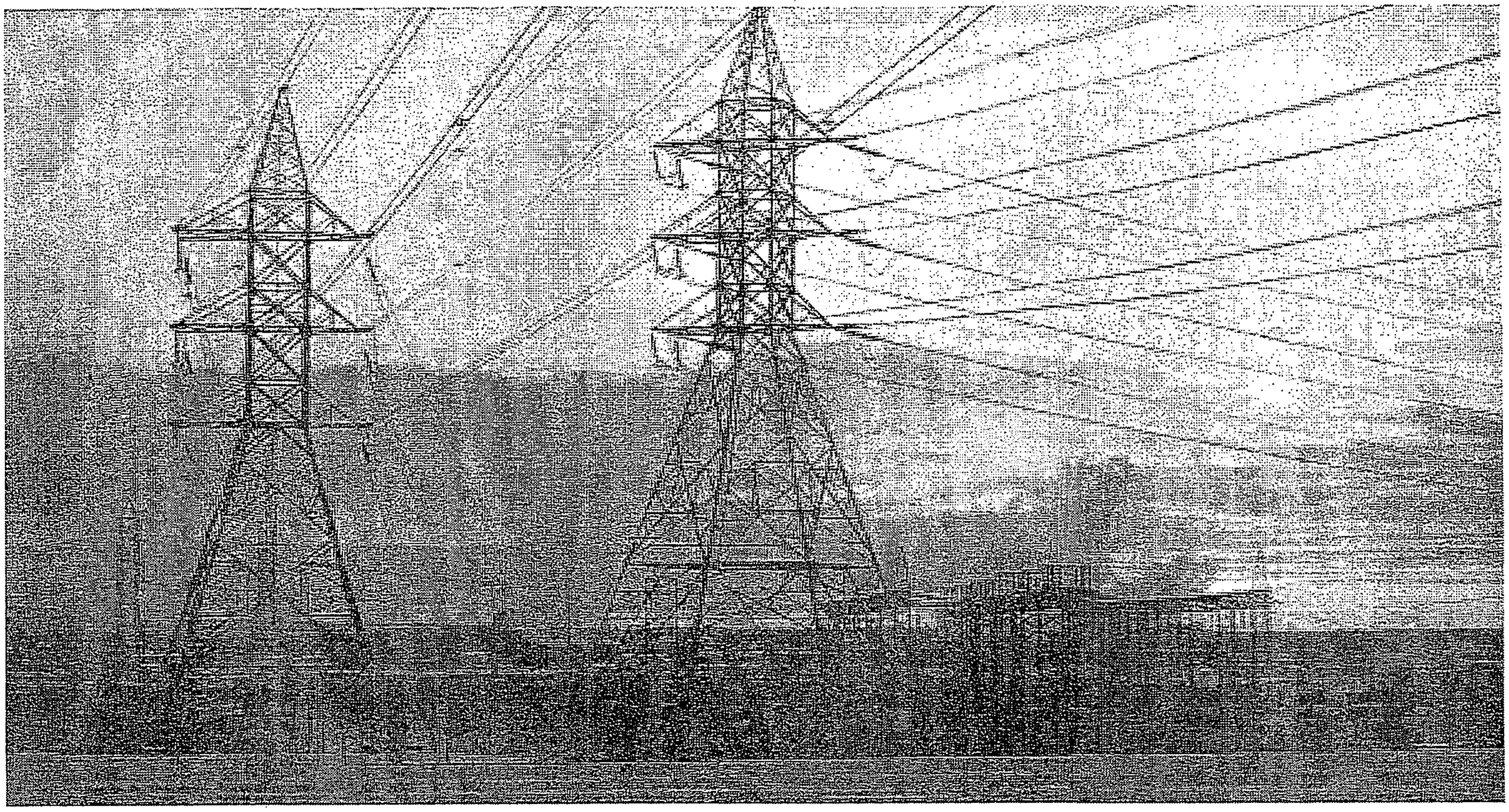
The types of skills that are needed for an outage depends on the scope of the work being conducted. The types of workers a utility might supplement its full time staff with includes radiation protection technicians, operator engineers, teamsters, non-manual supervisors, pipefitters, millwrights, laborers,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

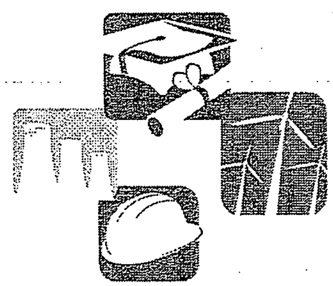


NCEP also considered the new resources provided under ARRA to support transmission investments. ARRA funding is expected to accelerate the construction of approximately 3,000 miles of high-voltage transmission lines by 2012.

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.

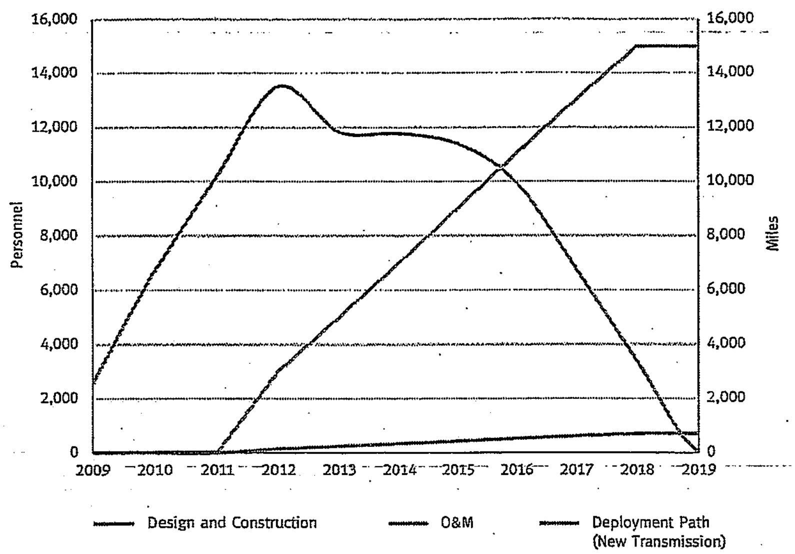
To estimate the scale of the workforce required to build and operate new high-voltage transmission lines and substations, NCEP worked with Task Force members who had experience designing, constructing, and maintaining such lines and could provide relevant data. Only workforce requirements in terms of 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



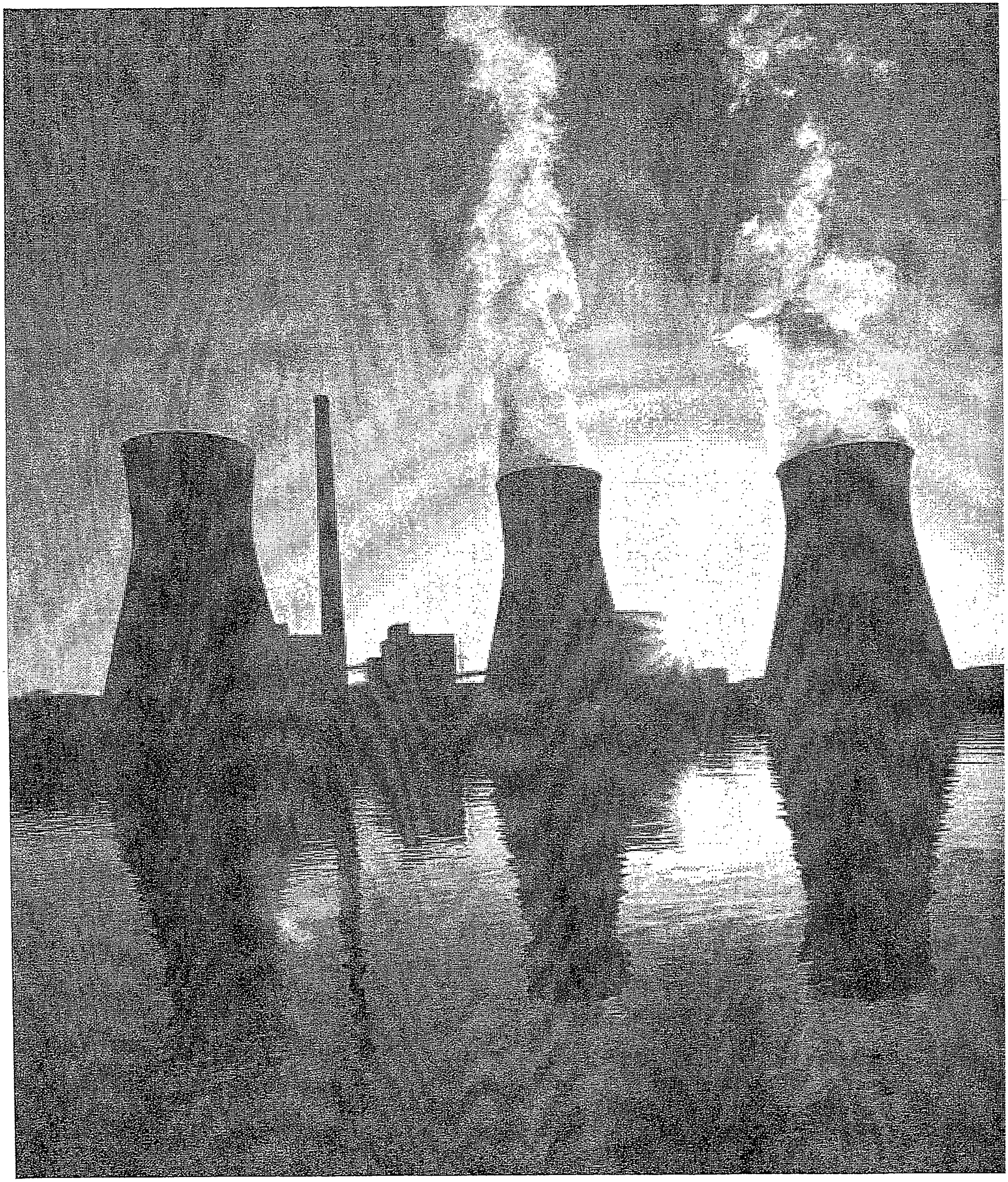
The workforce demand in annual full-time equivalents for the modeled deployment path is shown in Figure 9. Building a transmission line is a multi-year process. Even in a best-case scenario where a project moves quickly through the regulatory process, it will take more than five years from design to 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.

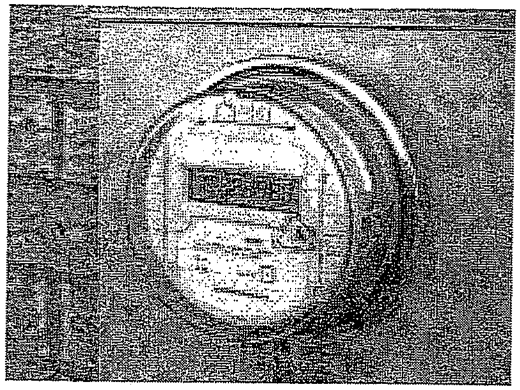
Note that workforce demand peaks in 2012 as the 3,000 miles of high-voltage transmission associated with ARRA come online. Demand for design and construction workers declines closer to 2019 because 2018 is the last year additional transmission is added in the model. Demand for workers to operate and 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.

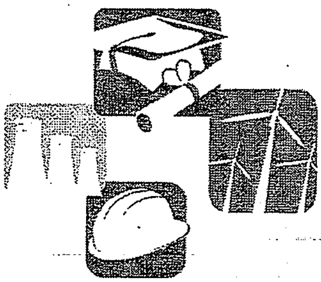
Table 5 shows the average estimates for the skill types and numbers of workers needed for design and construction in the peak year (2012). The largest demand is for workers on line construction crews. These crews include workers with a variety of skills including truck drivers, equipment operators, safety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

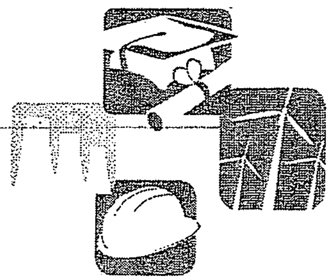
	450 ppm Stabilization Target	550 ppm Stabilization Target
Average annual number of power plants adopting CCS	~dozen per year through 2030	1-3 per year through 2030
Average growth in CO_2 pipelines 2010-2030	<900 miles per year	~300 miles per year
Additional CO_2 pipelines in operation in 2030	~18,000 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-4WoSFYG-7D-1&_cdi=59073&_user=10&_orig=search&_coverDate=02%2F28%2F2009&_sk=999899998&view=c&wchp=dGLzVtb-zSkWz&md5=94d879be99ab31340ce9ffbce7eb8a64&ie=/sdarticle.pdf.

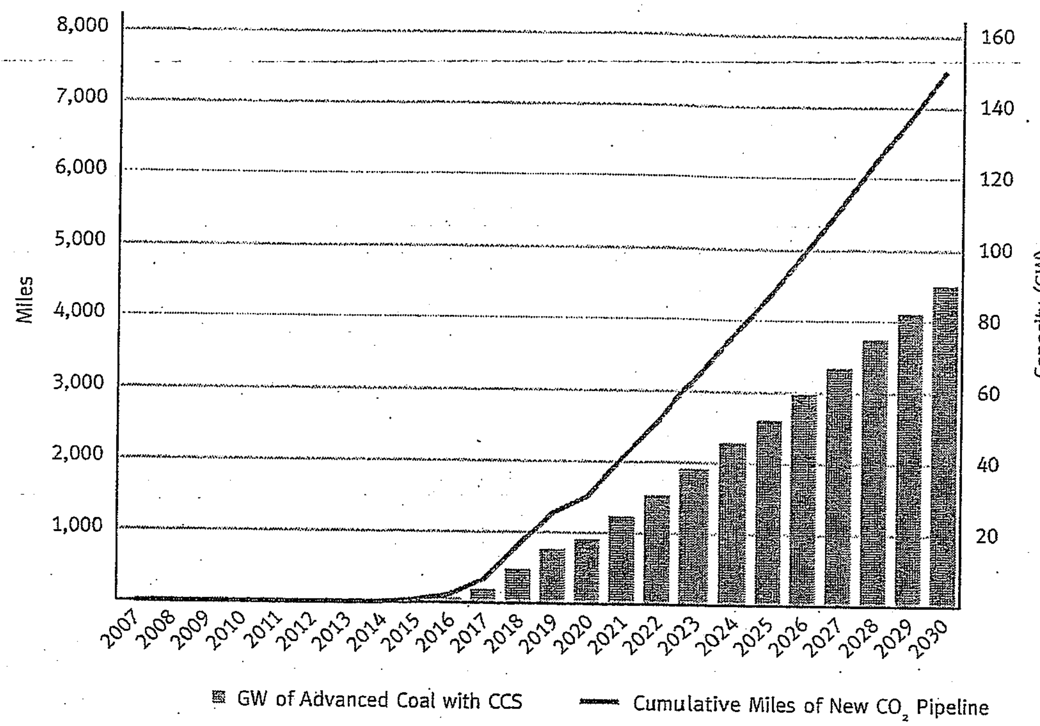
[39] WRI. "CCS Guidelines: Guidelines for Carbon Dioxide Capture, Transport, and Storage." October 2008. Available http://pdf.wri.org/ccs_guidelines.pdf.

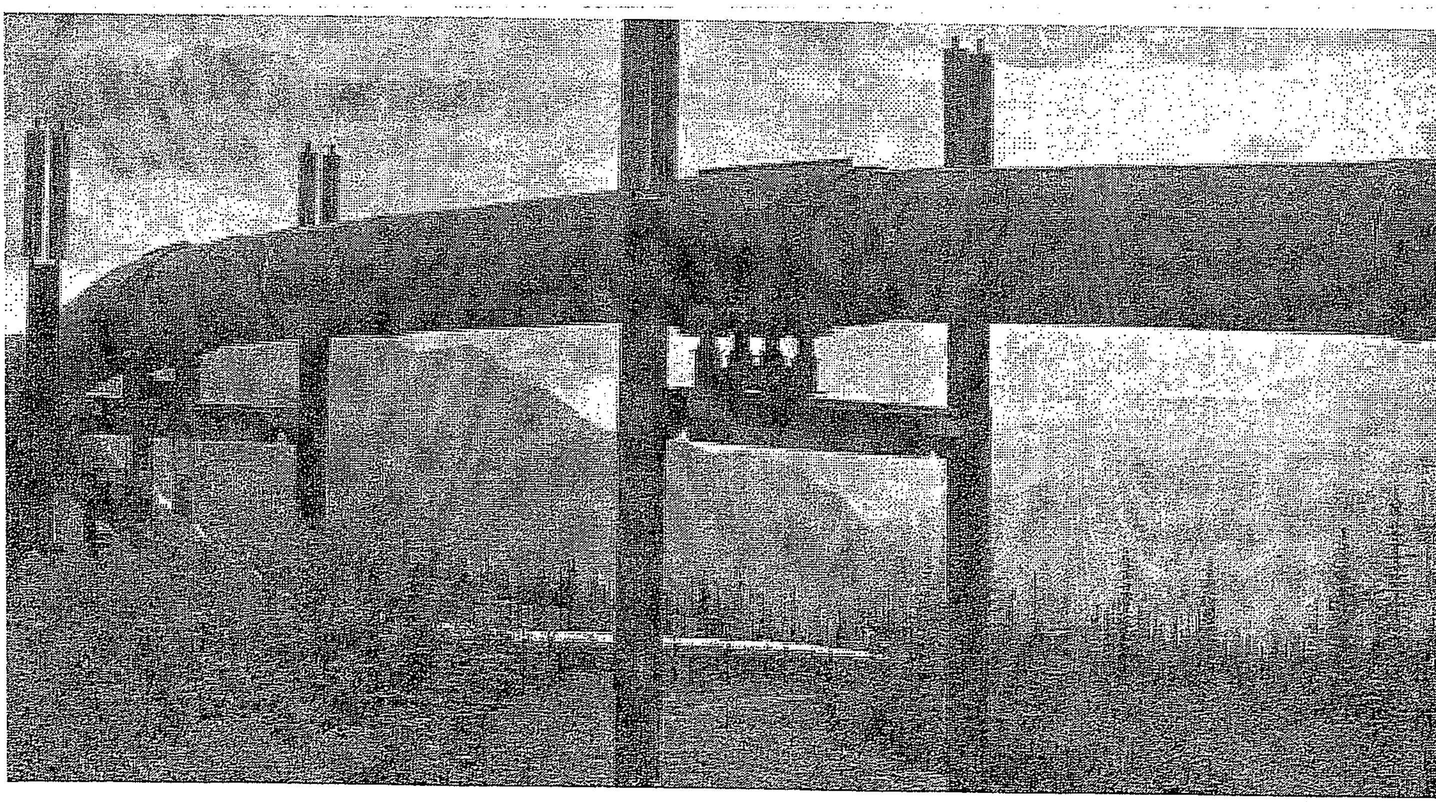
[40] Dooley, JJ, R.T. Dahowski, C.L. Davidson. "Comparing Existing Pipeline Networks with the Potential Scale of Future U.S. CO_2 Pipeline Networks." (Presented at the 9th Greenhouse Gas Technologies Conference, Washington, D.C.). November 16-20, 2008. Available http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B984K-4WoSFYG-7D-1&_cdi=59073&_user=10&_orig=search&_coverDate=02%2F28%2F2009&_sk=999899998&view=c&wchp=dGLzVtb-zSkWz&md5=94d879be99ab31340ce9ffbce7eb8a64&ie=/sdarticle.pdf.



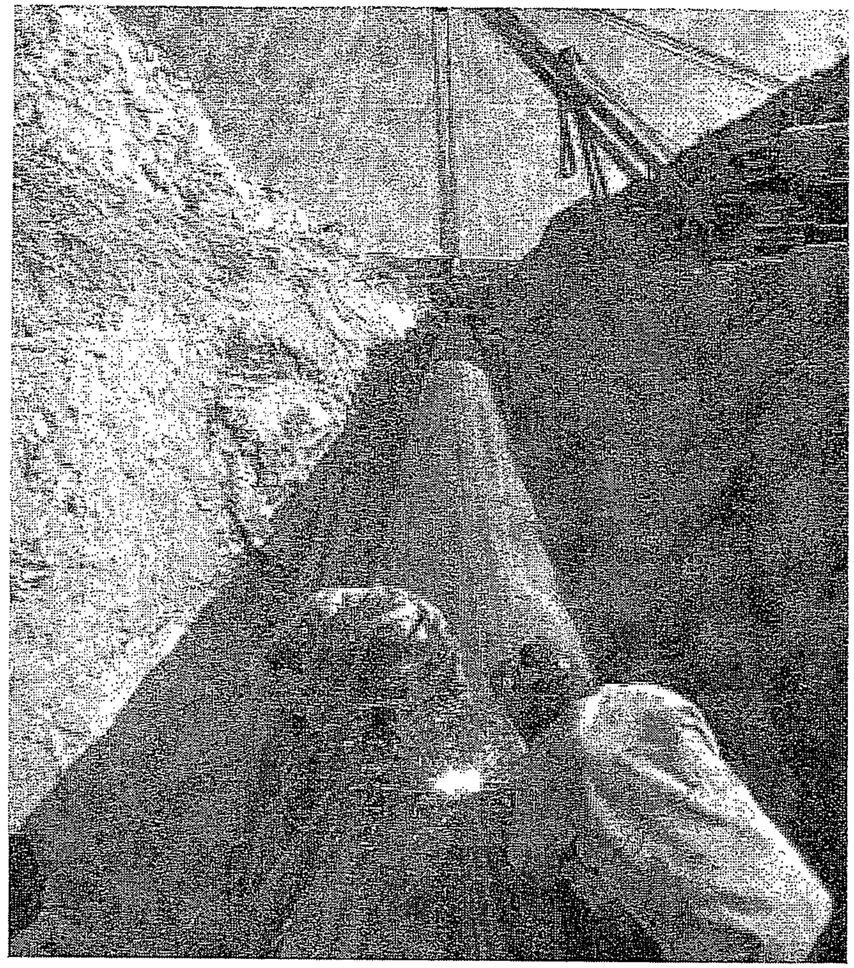
THE SIZE OF THE WORKFORCE NEEDED TO DEPLOY CO_2 PIPELINES PEAKS BETWEEN **830** AND **1,400** WORKERS IN **2028**, WHEN APPROXIMATELY **660** MILES OF **16**-INCH PIPELINE ARE INSTALLED TO SUPPORT ABOUT **8 GW** OF ADDITIONAL ADVANCED COAL POWER PLANTS WITH **CCS**.

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



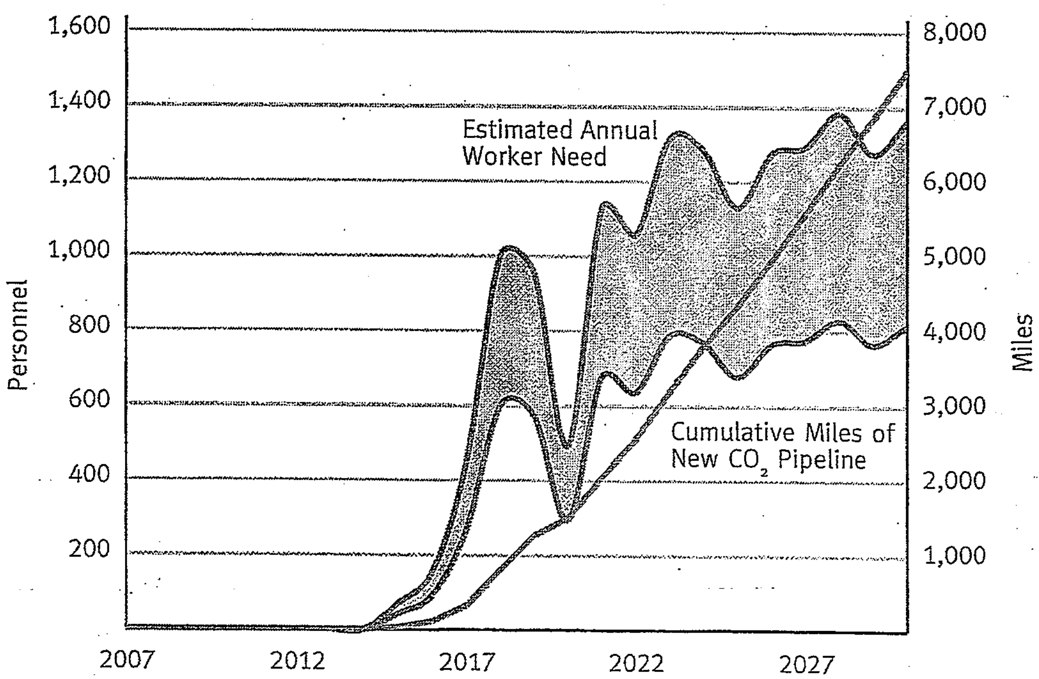


scenario in the EPRI Prism will require approximately 7,500 miles of additional CO_2 pipelines—an estimate that is closer to PNNL's 550 part per million (ppm) stabilization target scenario.[41] Figure 10 shows the modeled deployment path.



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

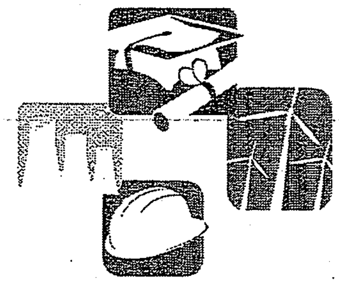
[42] Information Insights, Inc. "Stranded Gas Development Act: Municipal Impact Analysis for the application by BP Exploration (Alaska) Inc., ConocoPhillips Alaska, Inc., and ExxonMobil Alaska Production, Inc." (Prepared for the Alaska Department of Revenue Municipal Advisory Group.) November 2004. Available 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.

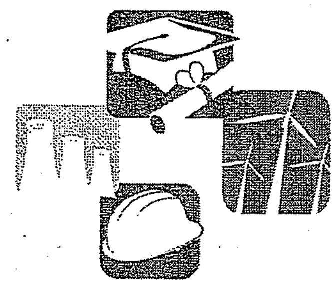
Based on feedback from Task Force members, a large utility-based energy efficiency program that includes residential, commercial, and industrial energy efficiency components and realizes about 1,000 GWh of annual efficiency savings would require approximately 600 employees who spend all or part of their 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.

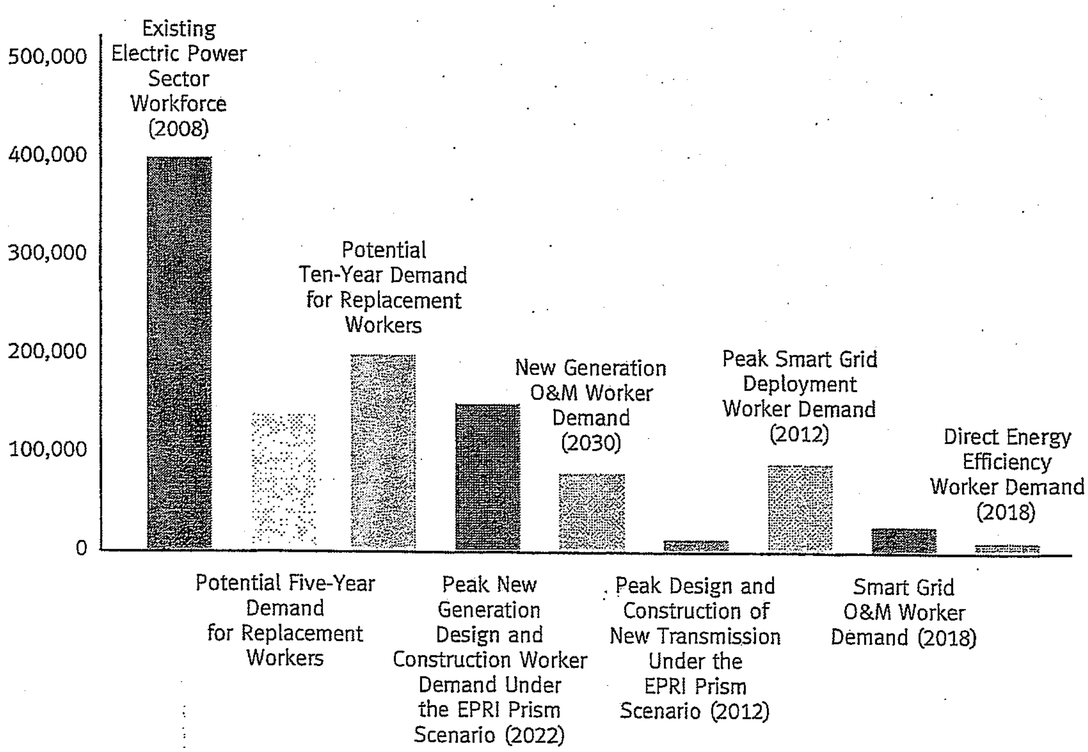
On the contractor side, it is important to note that the analysis conducted by Global Energy Partners and The Brattle Group suggests early deployment of residential energy efficiency measures and a movement towards commercial efficiency in the middle years. As shown in Table 10, while residential measures 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.

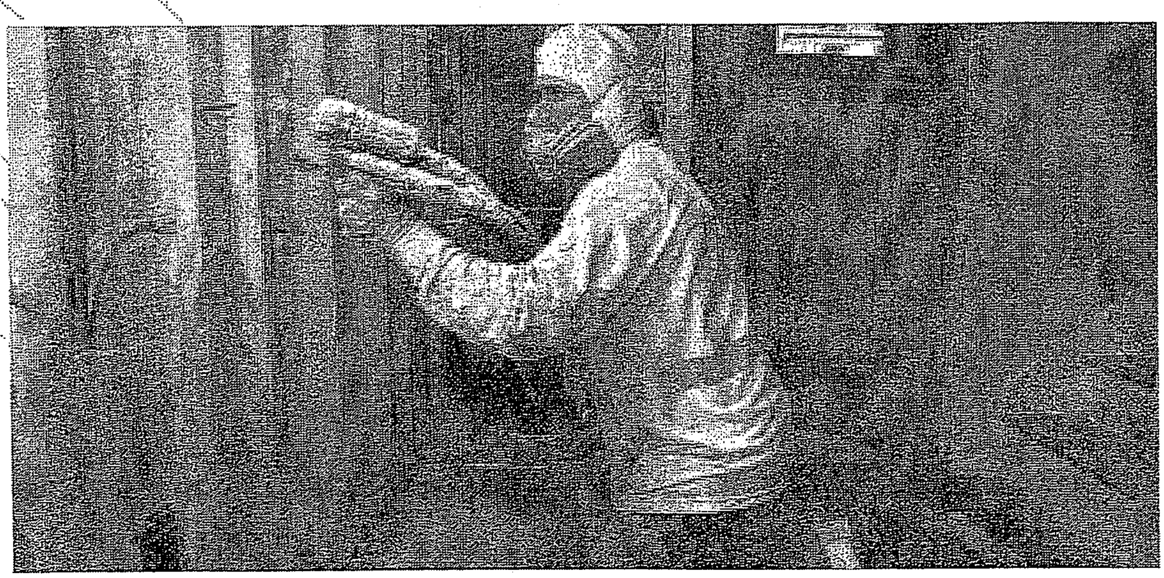
(b) Based on surveys conducted by CEWD (as above).

(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.

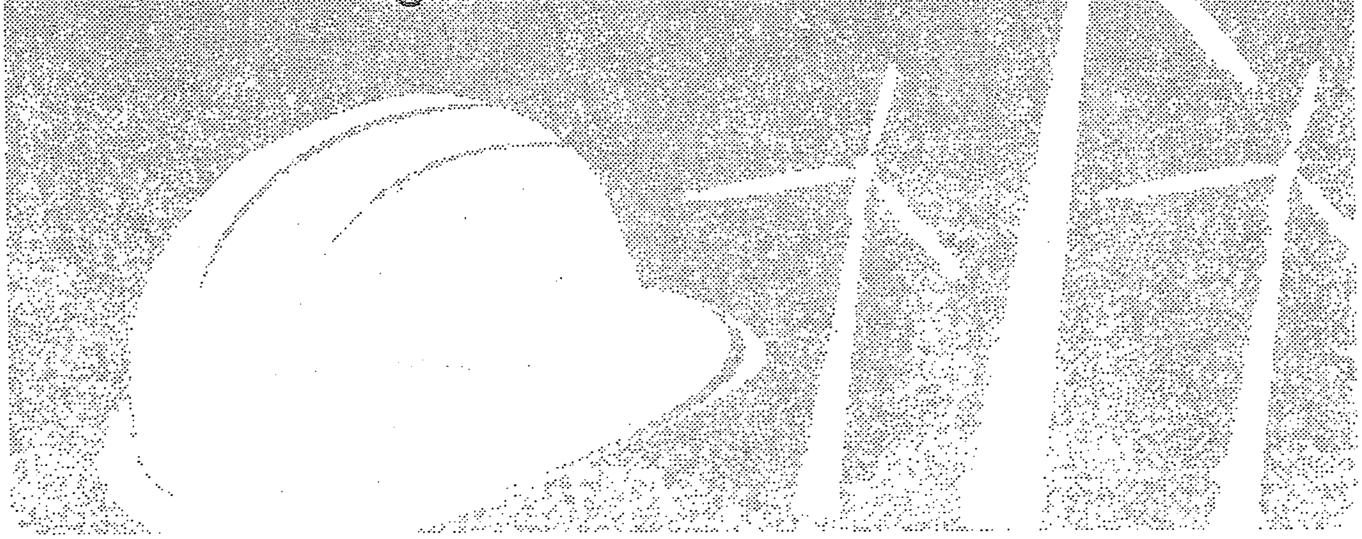


CHAPTER 3.

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.



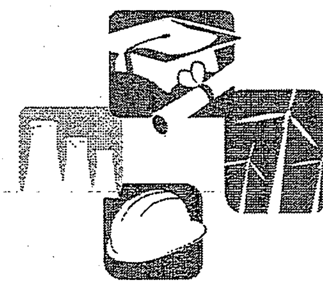
As highlighted in Chapters 1 and 2, demand for skilled craft electric power workers is going to be driven, at least in the near term, mainly by retirements as well as some attrition for other reasons. Over the longer term, demand for electric sector workers will remain high as new generation comes on 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

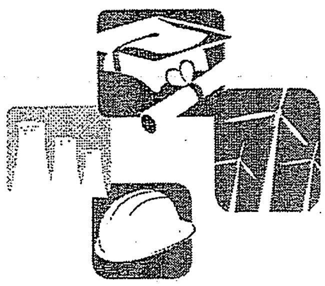
Task Force members are concerned that the existing pipeline for skilled craft electric power workers, skilled craft construction workers, and engineers is unprepared to meet the challenges of the next two decades as the United States seeks to transition to a low-carbon economy. Several reports in recent 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.

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.



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.

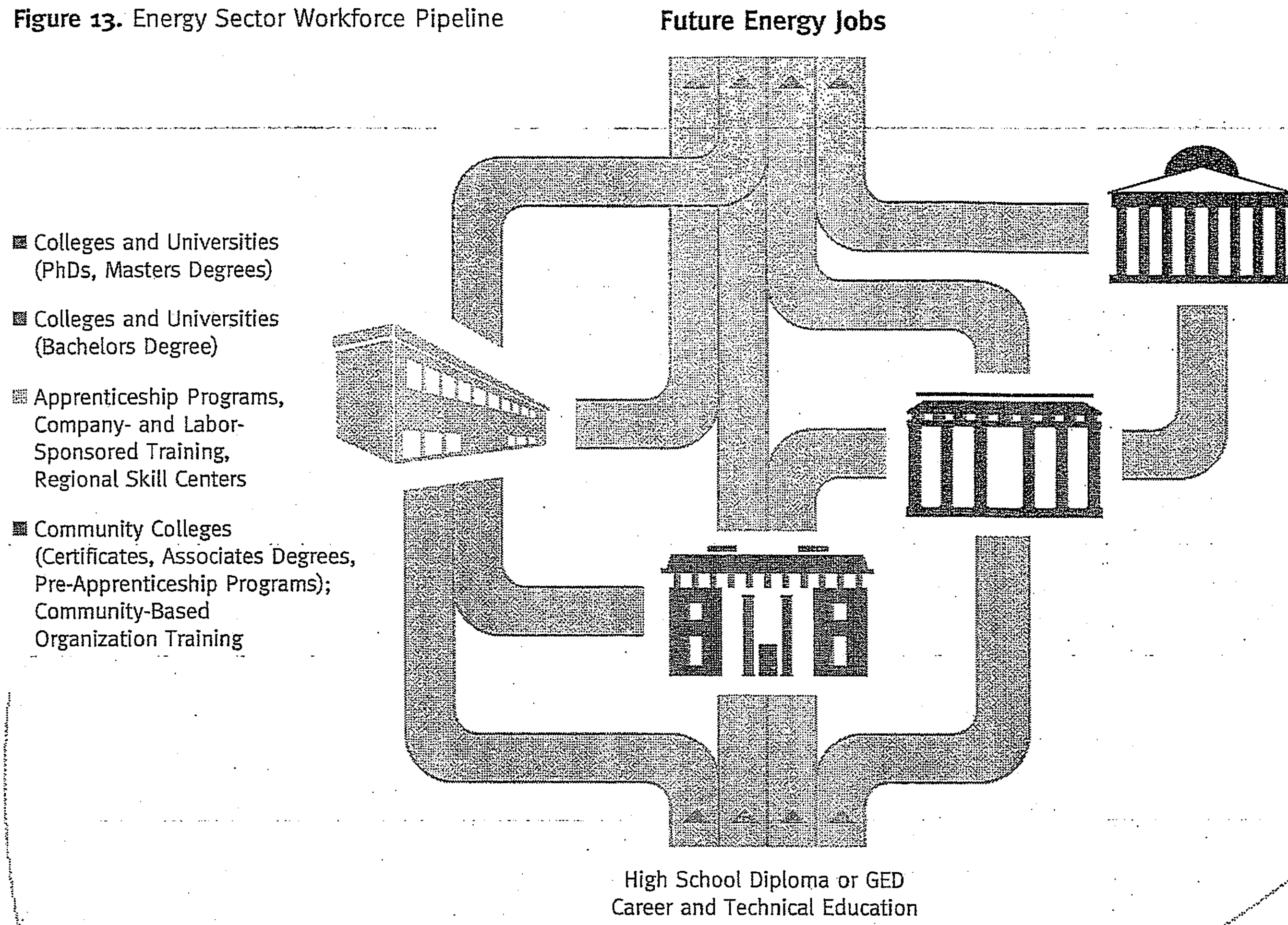
Two key insights emerge from this graphic representation. First, K–12 education is essential. Students who do not complete high school or the equivalent frequently do not have the skills they need to enter the skilled craft or engineer workforce. Second, there are multiple pathways into the workforce. 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

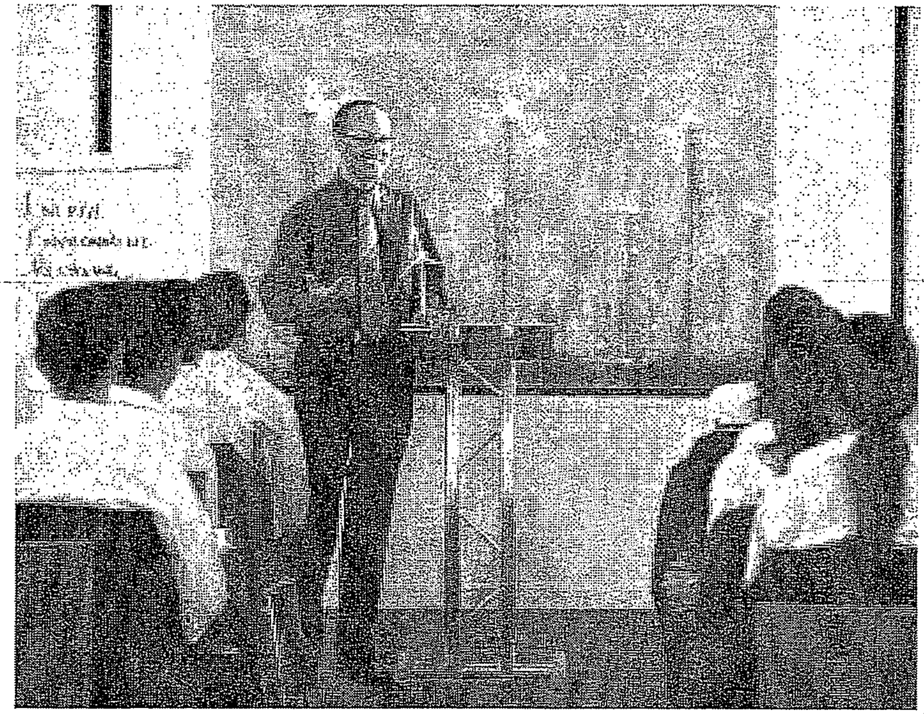
[49] U.S. Department of Energy. "Workforce Trends In The Electric Utility Industry: A Report To The United States Congress Pursuant To Section 1101 Of The Energy Policy Act Of 2005." August 2006. Available http://www.oe.energy.gov/DocumentsandMedia/Workforce_Trends_Report_090706_FINAL.pdf.
[50] Ibid.

Figure 13. Energy Sector Workforce Pipeline

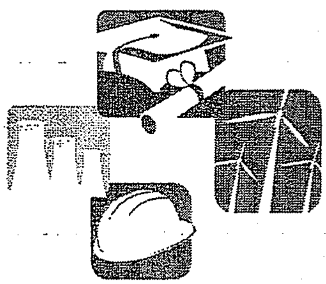


policy. This focus on preparation for four-year college programs has led to the closure of many technical high school programs across the country, removing a traditional pool of potential new workers for the electric power sector. As suggested by Figure 13, companies in the electric sector now look to 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-



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.



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.

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]

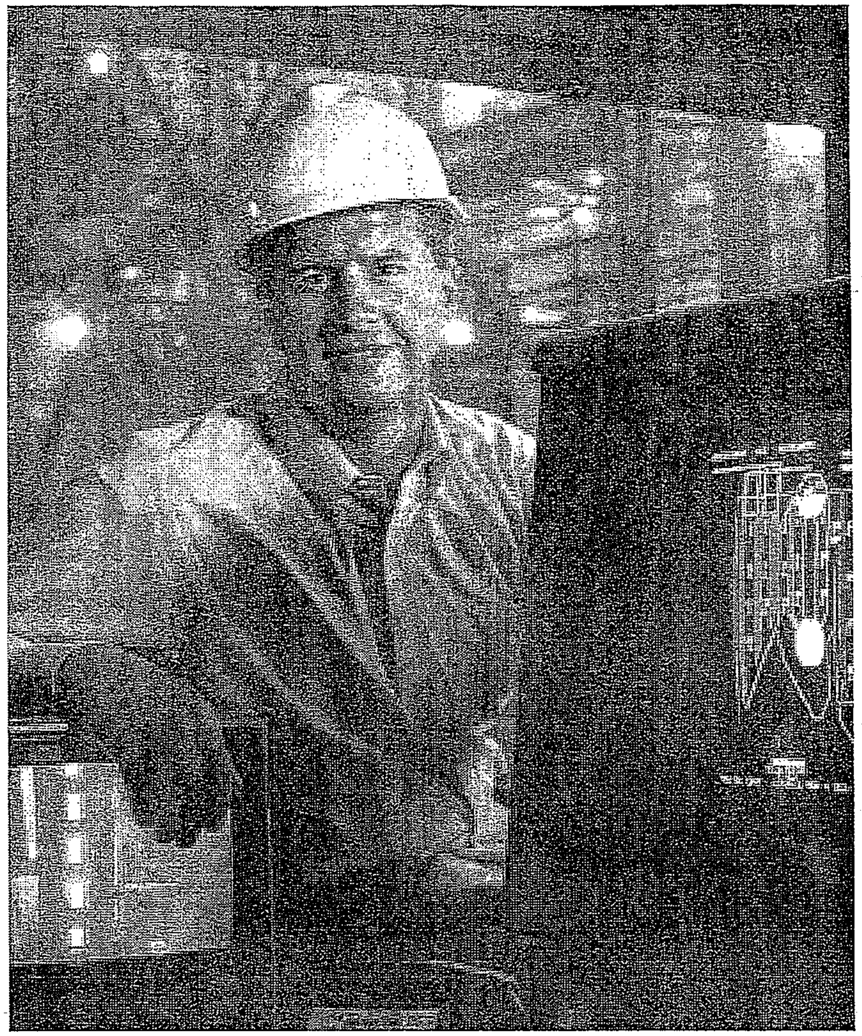
The Gathering Storm report argues that "[t]he state of US K–12 education in science, math and technology has become a focus of intense concern. With the economies and broader cultures of the US and other economies becoming increasing dependent on science and technology, US schools do not seem capable 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

[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-

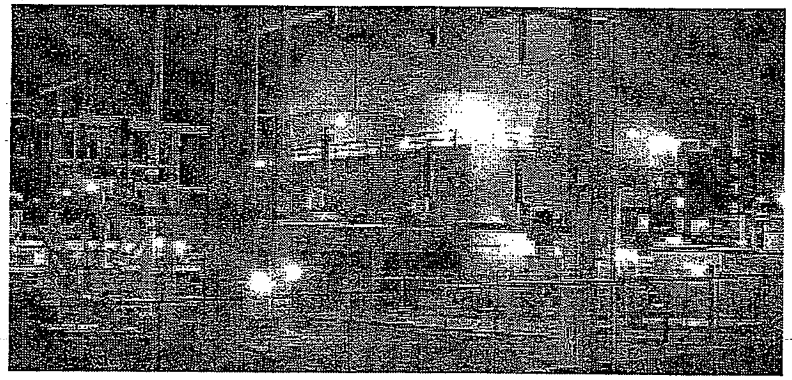
[53] Statement before the U.S. House of Representatives, Committee on Appropriations, Subcommittee on Commerce, Justice, and Science. "The Gathering Storm: Three Years Later." March 2009. Available http://appropriations.house.gov/Witness_testimony/CJS/norman_augustine_03_05_09.pdf.

[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.

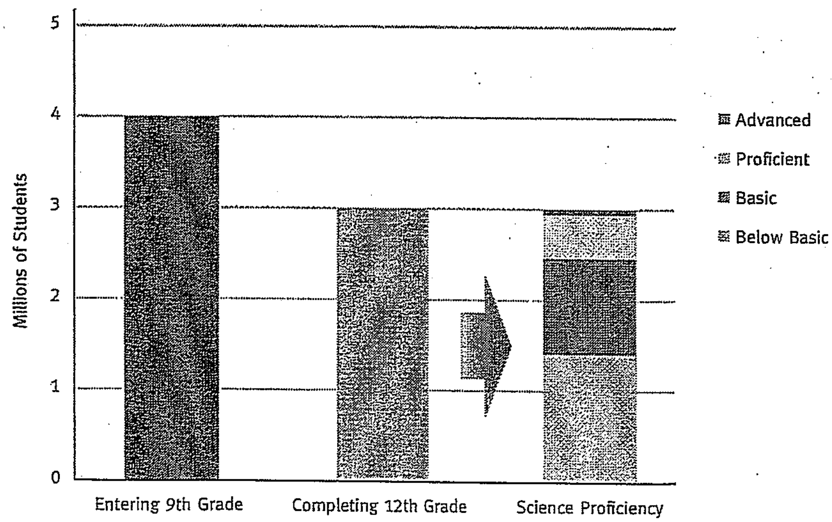
[56] This represents the status dropout rate, which is the percentage of 16- through 24-year-olds (civilian, non-institutionalized population) who are not enrolled in high school and who have not earned a high school credential. The status dropout rate includes all dropouts regardless of when they last 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

[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.