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Solar Installation Labor Market Analysis

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John Carrese
San Francisco Bay Area Center of Excellence

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Technical Report
NREL/TP-6A20-49339
December 2011

Contract No. DE-AC36-08GO28308

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Prepared under Task No. SS10.2420

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401
303-275-3000 • www.nrel.gov

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List of Acronyms

ARRA	American Reinvestment and Recovery Act
BIPV	building-integrated photovoltaics
BLS	Bureau of Labor Statistics
BMU	German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety
DOE	U.S. Department of Energy
DOL	U.S. Department of Labor
EERE	Office of Energy Efficiency and Renewable Energy
EMSI	Economic Modeling Specialists, Inc.
FTE	full-time equivalent
HVAC	heating, ventilating, and air-conditioning
IREC	Interstate Renewable Energy Council
ISP	Institute for Sustainable Power
ISPQ	Institute for Sustainable Power, Quality Standard
JEDI	Jobs and Economic Development Impact
NABCEP	North American Board of Certified Energy Practitioners
NAICS	North American Industry Classification System
NREL	National Renewable Energy Laboratory
O*NET	Occupational Information Network
PV	photovoltaic
SEIA	Solar Energy Industry Association
SEPA	Solar Electric Power Association
SITN	Solar Instructor Training Network
SOC	Standard Occupational Classification
SOCPC	Standard Occupational Classification Policy Committee
SHC	solar heating and cooling
SWH	solar water heating (solar thermal)
TD	technology development

Executive Summary

The potential economic benefits of the growing renewable energy sector have led to increased federal, state, and local investments in solar industries, including federal grants for expanded workforce training for U.S. solar installers. However, there remain gaps in the data required to understand the size and composition of the workforce needed to meet the demand for solar power. Through primary research on the U.S. solar installation employer base, this report seeks to address that gap, improving policymakers' and other solar stakeholders' understanding of both the evolving needs of these employers and the economic opportunity associated with solar market development. Included are labor market data covering current U.S. employment, expected industry growth, and employer skill preferences for solar installation-related occupations. This study offers an in-depth look at the solar installation sectors. A study published by the Solar Foundation in October 2011 provides a census of labor data across the entire solar value chain.

The data in this report were gathered using a mixed-method (telephone and Web) questionnaire for solar photovoltaic (PV) and solar heating and cooling (SHC) technology installers throughout the United States in August 2010. Utilizing standard methodological approaches, the report represents the first statistically valid job count in the solar installation sector. The sample of respondents includes 1,425 unduplicated completed questionnaires from a census of solar installers and from a random sample of firms in construction industries. These responses were used to extrapolate data about solar installation workforce demand in the United States. It is the first study to use a random sample of the broader construction economic sectors to ensure their inclusion in the solar installation job count.

As of August 2010, the sector employed approximately 46,500 permanent solar workers, defined for this study as employees that spend at least 50% of their time on solar-related work. Three in four of these, or approximately 33,000 employees, are engaged in solar activity for more than 75% of their time. These estimates represent a range of approximately 32,000–38,000 full-time equivalent workers (FTEs). Because some workers do not work on solar installations on a full-time basis, estimates of the number of workers with varying degrees of solar focus always exceeds estimated FTEs. About half of the jobs identified in this study were derived from the random sample of the broader construction sectors, for which solar installation activity was not previously quantified. Solar installation firms also employ nearly 20,000 additional temporary and seasonal employees. These estimates represent *gross* jobs associated with the solar installation sector; measuring *net* jobs is a separate question beyond the scope of this report. Net job estimates would account for potential lost jobs through displacement from other fields.

Other key findings include:

- In most regions of the United States, installation companies expressed strong interest in workers with real-world construction and electrical experience and knowledge. They place an emphasis on the importance of informal on-the-job or hands-on training.
- Most installation companies surveyed (about 8 in 10) were optimistic about the future.

- Companies prefer experienced workers and are having difficulty finding them. About half (52%) of firms reported "some" or "great" difficulty in finding entry-level candidates who have the appropriate skills and training; 59% reported difficulty finding non-entry-level employees. Although unemployment is high in most solar markets, in many cases workers seeking employment do not possess the skill sets or hands-on experience that employers seek. In some cases, they may lack sufficient knowledge of effective pathways to solar careers.
- Critical skills and desired experience include those associated with electrical and construction trades, customer service, and specialized solar knowledge.
- To be most effective, training programs need to understand local market trends and continue developing partnerships with local solar employers.
- For a variety of reasons, most notably increased competition, worker experience, and the expansion of large utility-scale PV installations, U.S. labor productivity is likely to improve in the future, suggesting caution about future projections of jobs needed based on current labor intensities.

As with any early stage market, one would expect improvement in labor productivity over time, scale, and industry development. SEIA and GTM Research estimates a total of 878 MW_{dc} of PV was installed in 2010 (SEIA/GTM 2011a. Based on global estimates of expected labor intensities (e.g., New Energy Finance 2009), the U.S. installation workforce is larger than would be expected to serve a market that size. Further, respondent data show that 64% of U.S. installers employ 10 or fewer people, and many of these small start-up firms would be expected to consolidate over time in the natural course of market development. Increasing competitive market forces and worker experience tend to improve labor productivity. In addition, given the fact that the United States is still early in market development, supply and distribution chains will likely become more efficient over time. The solar market may be over-staffed relative to the size of the market for various reasons. For example, there may be extra staff required to manage state, local, and utility regulations and requirements that tend to be inconsistent or cumbersome. In addition, human resources and extra staff time are required for any new business, especially one in a new industry, for such disparate organizational development tasks as building and training staff, conducting market research, business development, establishing credit, and raising capital. Labor intensity, as defined by jobs per installed megawatt, is also likely to decrease as large utility-scale plants currently planned move into construction and become a significantly larger portion of U.S. installed capacity. Finally, at least in the near-and-mid-terms, labor demand growth may be impinged by the expiration of recovery funds and programs aimed at solar markets, such as the cash grant in lieu of tax credit program administered by the U.S. Treasury Department, set to expire December 31, 2011.

More than half of U.S. installation employers report difficulty in meeting their labor needs for both skilled and unskilled workers, particularly for installers and sales staff. In the face of very high unemployment in construction sectors of the U.S. economy, these findings underscore the opportunity to provide solar training to unemployed workers in these sectors, such as those with the foundational construction or electrical experience preferred by solar installation employers. The construction industry (NAICS 23) has consistently had the highest unemployment rate of all industries in the United States at 34%, expressed as a percentage of jobs in the industry—one in three of the 12–15 million unemployed workers. Unemployed workers can be found in many

regions, but it is not yet clear that they are accessing the information or the training they need to fill the demand. Because of the current mortgage crisis, some workers who would otherwise be suited for solar installation jobs may lack the mobility that might be required to relocate to be in proximity to the available jobs. In other cases, solar installation wages may be insufficient to justify relocation to available jobs.

One of the critical roles of the emerging solar installation training infrastructure is to better understand local labor supply-demand dynamics. Training workers into nonexistent job markets, or providing training programs without sufficient regard to available local jobs and the needs of local employers, could be counter-productive. It is incumbent upon training programs to know their local markets and offer a conduit to local solar employers.

Despite the generally optimistic outlook of solar installation employers and their difficulty in finding suitable workers, the jobs opportunity represented by solar industry growth should not be overestimated. Current labor intensities are not likely to remain constant. Rather, labor productivity is likely to improve as the market expands, and proportionally fewer workers per installed megawatt will be required as the market seeks to drive down costs, even as labor demand increases in absolute terms. For example, design, process, and technology improvements to streamline installation represent potential opportunities for improvements in labor productivity in future years.

Although the overall growth rate reported by solar employers is approximately five times higher than what is expected among similar traditional construction industries and nine times higher than the expected overall job growth rate nationwide, when applied to the very small solar industry, this high growth rate still signifies less than 10,000 new installation jobs per year. Additionally, there is still little or no job market in more than half of the states where the solar industry has yet to gain much traction at all. There is an ongoing need for training programs around the country to take a targeted approach to the dynamic needs of the labor market, both in terms of geography and specialized skills. For example, at the present time there is a need for specialized training in codes, permitting, and inspection for both code officials and installers, as well as for sales professionals or installers with sales skills.

This report also provides employer preferences in regards to critical education, training, and skill sets for solar installation-related occupations. Electrical and construction skills and experience, customer service skills, and a general understanding of solar power are the most important skill sets for employees.

The information contained in this report provides a picture of a small but growing economic sector. For most occupations, employers are facing difficulties finding qualified applications to meet this new demand. Provided with this new information, training providers can assess priorities, evaluate how best to communicate employer needs to their students, and work with local employers and government agencies to equip and re-train workers to obtain the skills that are most important to potential employers.

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Introduction

Globally, the solar PV industry represents about 300,000 direct and indirect jobs (Pernick et al. 2010). Though still small relative to the global market, U.S. solar photovoltaic (PV) installations more than doubled in 2010 to about 878 MW_{dc} during an otherwise slow economic period (SEIA/GTM 2011a). This pace of growth increased in the first two quarters of 2011, with 582 MW_{dc} installed, compared to 339 MW_{dc} in the first two quarters of 2010. In some state and local markets, additional trained workers are needed to design, manufacture, sell, install, and maintain solar systems to meet the increasing labor demand. Sixteen states each installed more than 10 MW of PV in 2010, up from only four in 2007. The top 10 states for PV installation in 2010 were: California, New Jersey, Nevada, Arizona, Colorado, Pennsylvania, New Mexico, Florida, North Carolina, and Texas, with eight states doubling their capacity over 2009 (Sherwood 2011).

The economic opportunity represented by the U.S. solar energy market has not yet been fully defined and there has been a lack of data about the exact size and composition of the U.S. solar installer workforce, as these statistics had not been tracked through the U.S. Department of Labor (DOL) or through Standard Occupational Classification (SOC) and North American Industry Classification Systems (NAICS). In 2010, the DOL's Bureau of Labor Statistics (BLS) took a significant step toward rectifying this situation by revising their solar occupational classification (SOC) system of 840 occupations for the first time since 2000.[1] Since the DOL established a new occupational classification for solar installers, researchers have been working to develop standard industry classifications within NAICS for the solar industry. Prior to that point, no primary research existed on solar installation activity among the broader construction-related sectors on a national level.

Accurate, timely data are critical to understanding both the evolving needs of solar employers and the labor impact of solar-market development. To address this deficiency, this study gathered data from a statistically valid sample of solar companies, including firms in the broader construction industries that are engaged in solar installation within their business activities. These firms employ workers engaged in system design, sales, installation, and service. In addition to informing the solar industry and the public, this study is also meant to provide labor market data to the Solar Instructor Training Network (SITN), a train-the-trainer program funded and administered by the U.S. Department of Energy (DOE). [2]

[1] For more information, see http://www.bls.gov/soc/2010_responses/response_08-0012.htm.

[2] The SITN was established to improve the quality of solar training and to make it accessible, with the ultimate goal of reducing costs and improving the quality of solar installations. In August 2010, the DOE selected the Interstate Renewable Energy Council (IREC) to serve as the national administrator for the SITN, conducting outreach to disseminate its products, to offer recommendations for best practices, and to manage the SITN's collaboration and joint activities. For more information on SITN, visit http://www1.eere.energy.gov/solar/instructor_training_network.html.

Methodology Overview

This section provides an overview of the study methodology. For detailed information about the study methodology, see Appendix A. This study is the first of its kind to measure the number of solar installers and solar installation jobs in the United States.[3] For the study, a questionnaire was sent to the 2,540 known U.S. solar installation employers, as identified in existing solar employer databases. These include databases from the Solar Energy Industry Association (SEIA), the Solar Electric Power Association (SEPA), the Interstate Renewable Energy Council (IREC), the California Public Utilities Commission (CPUC), and the GoSolar Initiative. Of the 2,540 firms (after accounting for duplicates), 1,328 (52%) completed the questionnaire.

In addition, a sample of the approximately 92,000 firms in the broader U.S. construction-related industry sectors was selected for the study. In many cases, these firms in the previously "unknown" universe had not been identified as solar installers in any existing solar installer databases. This study component is critical in that it enables conclusions on the overall level of solar installation labor demand and represents the first study to gage solar installation incidence in the broader construction industries. Approximately 2,000 construction firms were reached in several thousand attempts, with 97 engaged in solar installation, for an incidence rate of approximately 4.3% and an extrapolated total of approximately 10,800 U.S. solar installation employment sites.

In all, the sample of respondents includes 1,425 unduplicated completed questionnaires. A copy of the questionnaire instrument may be found in Appendix C. All respondent questionnaires were completed and data were gathered in August 2010. The questionnaire took 12 minutes to complete[4] and was designed to capture industry information to the following areas:

- Respondent profile data
- Labor force size
- Employer skills and experience preferences
- Solar training employer needs
- Assessment for 11 occupations, including size and growth data.

In addition, regional versions of this report were prepared for the eight regions of the SITN, highlighting any differences between the region and national data. Each region is represented by a sample size of at least 100 complete employer responses. These regional versions will be published in coming weeks.

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[3] "Installers" or "installation employers" refer to companies engaged in selling, installing, or maintaining solar installations, including PV and solar thermal technologies. The methodology used for this report was thoroughly reviewed and approved by John A. Bunge and his team at the Department of Statistical Science, Cornell University.

[4] Because of data showing completion rates fall significantly for questionnaires more than 15 minutes in length, the number of questions was limited on that basis.

Concurrent with the primary labor demand research, the National Renewable Energy Laboratory (NREL) gathered data from a sample of 126 education and training providers in the United States covering the same study period. Results of that research may be found in Appendix B of this report, including respondent data on number of graduates, rigor of training, acquired skill sets, and methods of training.

Size of U.S. Solar Installation Workforce

In August 2011, U.S. installers employed approximately 46,500 permanent solar workers, defined for this study as employees that spend at least 50% of their time on solar-related work.[5] About 33,000 employees are engaged in solar activity for more than 75% of their time, for a range of approximately 32,000 to 38,000 FTEs. In addition to these permanent workers, companies that install solar systems hired 19,897 seasonal and temporary workers over the 12-month study period.[6]

These approximate 46,500 workers should be clearly distinguished from full-time equivalent workers (FTEs), a metric often used by the research community. A solar installation FTE is defined as full-time employment—approximately 2,080 labor hours—for one person for the duration of a year, or two people for six months each, or four people with a quarter-time focus, and so on. Because typical residential rooftop installations often employ construction labor for a few weeks or less, it can be useful to convert such jobs to FTEs.

In addition to the overall employment estimates, this study provides information on specific occupations related to PV and solar thermal installation, insight into employee development practices, and an in-depth review of employers' preferences and challenges. To complement these survey data, this report also provides an analysis of existing aggregated data for traditional occupations within which most solar installers are classified. This analysis is based on Occupational Information Network (O*NET) data, including its draft "green occupations" report to the DOL; Economic Modeling Specialists, Inc. (EMSI), data; and SOC and NAICS codes drawn from numerous recent reports on the solar industry.

This report presents primary data gathered on the U.S. labor market during the period June 2010 to August 2010, including forward-looking employer expectations at that time on the 12-month period from August 2010 to August 2011. Employers expected to add an additional 9,900 employees during the 12-month study period. This would represent an expected growth rate of approximately 22% during the period.

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[5] In addition to workers with at least 50% solar installation focus in August 2010, approximately 103,000 workers were engaged in solar work less than 50% of their time. In total, firms that derive at least some of their revenue from solar installations currently employ 147,500 permanent workers and expected to add 27,000 new permanent positions over the 12-month study period (18% growth) of August 2010 to August 2011, across all divisions (including non-solar activities).

There is a variance on the solar installation employment figure based on whether vertically integrated PV companies, engaged in both solar manufacture and installation, primarily defined themselves as installation firms. A few large companies in this category defined themselves differently in 2011 than they did in 2010. As a result, the 2011 Solar Foundation's census found approximately 52,500 workers with at least 50% solar installation-related focus. For consistency, the figure cited here (46,500 workers) reflects the respondent base as defined in the August 2010 data collection effort. Only by defining the respondent base identically in both years can year-over-year growth be accurately gauged.

[6] Due to the nature of these seasonal positions, survey data regarding employment growth is unreliable and therefore excluded from the survey. We did not seek to ascertain the average percentage of a full-time permanent employee equivalent for which these workers are focused on solar work.

However, these estimates reflected relative employer optimism at the time the data were collected, in part because of the broader economic outlook at that time. When the Solar Foundation repeated the installation survey in August 2011, actual growth in installation labor demand was only 5.6% (The Solar Foundation et al. 2011), suggesting that employers' forecasts were overly optimistic in August 2010. This may be partly attributable to potential self-reporting bias on questions with inherent self-interest involved, such as anticipated corporate growth. Interestingly, the PV industry itself is on a faster growth trajectory for the period than the workforce and faster even than the 55% annual growth projected in August 2010, when these data were gathered. In fact, U.S. PV installations increased by about 72% for the first two quarters of 2011 (582 MW_{dc} installed, compared to 339 MW_{dc} in the first two quarters of 2010), with new PV capacity doubling in 2010 compared with 2009. The discrepancy between PV industry growth and labor demand growth is likely due to a combination of factors and recent trends:

- General employer pessimism in the period and a reflection of the broader trend of employer conservatism on new hiring relative to profits
- Industry growth attributable to large central station PV plants with lower labor intensity
- Inclusion of solar heating and cooling jobs in the questionnaire; szolar heating and cooling has not grown as quickly as PV.[7]

Rather than the 9,900 additional workers that employers expected to add for the study period of August 2010 to August 2011, only about 2,500 additional workers with 50% or more solar focus were in fact added. In the study, employers attributed this slower than expected job growth to general economic conditions (30% of respondents) and lack of state incentives and other policy supports (25% of respondents).

Expansion of Labor Demand in 2010

Several policy and market developments combined to generate unprecedented opportunity and support for the U.S. solar market and consequent labor demand growth in some states in 2010. In addition to markedly lower module prices, three other factors were among those critical to market growth—the availability of cash grants in lieu of tax credits, known as "§1603 Treasury grants," the tax credit for manufacturing investments, and the availability of third-party ownership and lease options.

The §1603 program was established in 2009 under the American Recovery and Reinvestment Act (ARRA). With a total cost basis of nearly $3.6 billion, 15,900 PV energy projects were installed as a result of the program between January 2009 and July

[7] Although data were not yet available for 2011, U.S. solar water heating grew by 6% in 2010 and solar pool heating grew by 13% for the year (Sherwood 2011), compared to a doubling of PV capacity for the year.

2011, with a total nameplate electric capacity of about 597 MW.[8] These projects contributed to total jobs in the PV installation sector during the period. Ongoing operation and maintenance of the PV installations accounted for an additional 700 FTEs. If the §1603 Treasury grants expire as scheduled on December 31, 2011, that development could impinge on the availability of investment capital, markedly increase demand for tax equity capital, and reduce market growth. There is also the potential for a spike in installations in the fourth quarter of 2011, given developers' anticipated needs to meet safe harbor "commence construction" requirements to qualify by the end of December (SEIA/GTM 2011b).

Second, the 30% manufacturing tax credit for renewable energy manufacturing investments, under Section 48 of the Internal Revenue Code, helped drive utility-scale projects. The utility-scale segment of PV demand, comprised of ground-mounted solar plants larger than 1 MW that directly feed into the transmission grid, increased its U.S. market share by a factor of 3.5 in the two-year period of 2009–2010, from 8% to 28% of the market. This activity increased construction labor demand significantly in states with announced projects. The highest concentration of activity has been in California, Nevada, Arizona, and New Mexico. As of September 2011, approximately 1.5 GW of utility-scale PV or concentrating solar power (CSP) capacity is under construction, centered in California and Arizona, with this segment of the market forecasted to overtake the combined total capacity of residential and commercial installations by 2015 (SEIA/GTM 2011a).

Third, the rapid expansion of third-party ownership business models for solar installations also drove the labor market expansion in 2010, as a function of increased consumer and business demand for solar fostered by these models. The value proposition of guaranteed savings and no up-front costs was particularly appealing to consumers and businesses during a period of slow economic growth.

Labor Supply-Side Data

The purpose of the supply-side questionnaire was to gain a first-level indicative snapshot of how well current curricula reflect employer preferences.[9] Because there are no unified national standard licensing requirements or mandates, determining the supply of adequately trained workers is difficult. A first step is to characterize offerings of certified training providers. Respondents encompass more than 60% of all North American Board of Certified Energy Practitioners (NABCEP)-certified training providers and can be taken as a reasonable census of such entities. To date, many training providers have no consistent mechanism to track their graduates' employment, though most (71%) responding training programs have an advisory board made up of local employers.

[8] The ranges noted are the result of using two different values for the percentage of equipment/components manufactured and purchased in the United States (i.e., domestic content). This includes a lower value of 30% and a higher value of 70%. The PV project cost basis includes approximately $1.1 billion in grant funds, with the remainder comprised of cost-share. Across all 15 renewable technologies, the total S. 1603 program investment, as of July 201, include approximately $8 billion in grants and nearly $19 billion in cost share, resulting in between 200,000 and 300,000 FTEs.

[9] Unlike the labor demand data presented in this report, the supply-side data was not intended to be a statistically valid sample.

Other key labor supply-side findings include:

- About half (46%) of current training is provided by community colleges, with about 7% provided by four-year universities.
- Most entry-level PV courses include content on site assessment and sales, but the majority of time is spent on design and installation. Only about 6% of training time is spent on sales. This is noteworthy because employers expect a 42% increase in the number of individuals engaged in sales over the study period of August 2010 to August 2011, and more training may be required. Among the 11 occupations studied, PV sales is second only to PV installation in the rankings of employer demand.
- About two in three advanced PV courses feature curriculum aligned with the NAPCEP Job Task Analysis for solar PV installers.[10]
- Just as employers tend to do when hiring installers, training institutions demonstrate a preference for industry experience over an advanced education when hiring instructors. More than half of responding PV training programs (52%) require only a two-year associate's degree or less for their faculty, and many (91%) prefer licensed electricians or, in the case of solar heating and cooling, licensed plumbers or heating, ventilating, and air-conditioning (HVAC) technicians (36% and 35%, respectively) to teach their courses. Among solar heating and cooling training programs, the response rate was lower, but about half of those responding indicated a preference for a bachelor's degree when hiring faculty.
- Approximately one in four responding PV courses are affiliated with PV installation/design union training or apprenticeship programs, while far fewer (less than 4%) solar thermal installation courses report these affiliations.
- Entry-level PV training courses, which vary widely in scope and length, average about 110 hours, with about 40 of those hours spent on hands-on activities.
- Thirty-eight percent of training providers are funded at least in part by the public workforce system (e.g., DOL).

These findings are presented in full in Appendix B.

[10] The Job Task Analysis can be found at http://www.nabcep.org/wp-content/uploads/2008/11/2010_NABCEP-PV-Installer-Job-Task-Analysis_Low_Res.pdf.

Respondent Data

The profile for the 1,425 solar installation firms completing the questionnaire for this report provides insight into the size, scope, and geographic distribution of the solar installation firms in the United States. Most U.S. solar installation firms (approximately 64%) are small, employing 10 or fewer permanent workers (Figure 1).

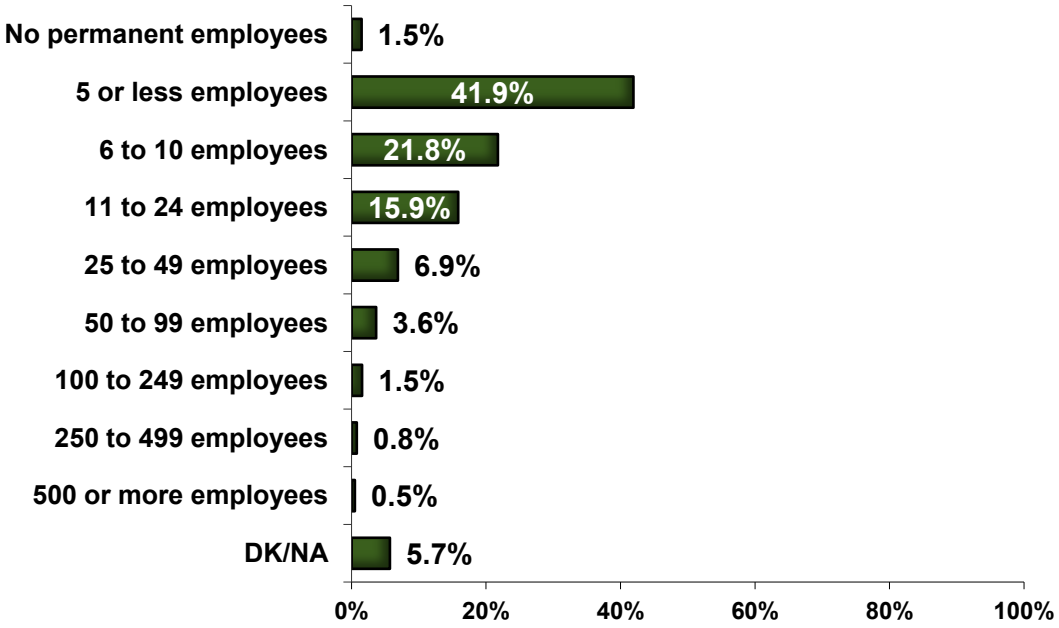

Figure 1. Solar installer respondents by number of employees

Note: DK/NA is "don't know/not applicable."

More than half of the respondent firms completing questionnaires or interviews for this report are "primarily engaged" in solar practices (based on revenues) (Figure 2). Approximately one in four of the respondent firms receive less than one-quarter of total revenue from solar installations.

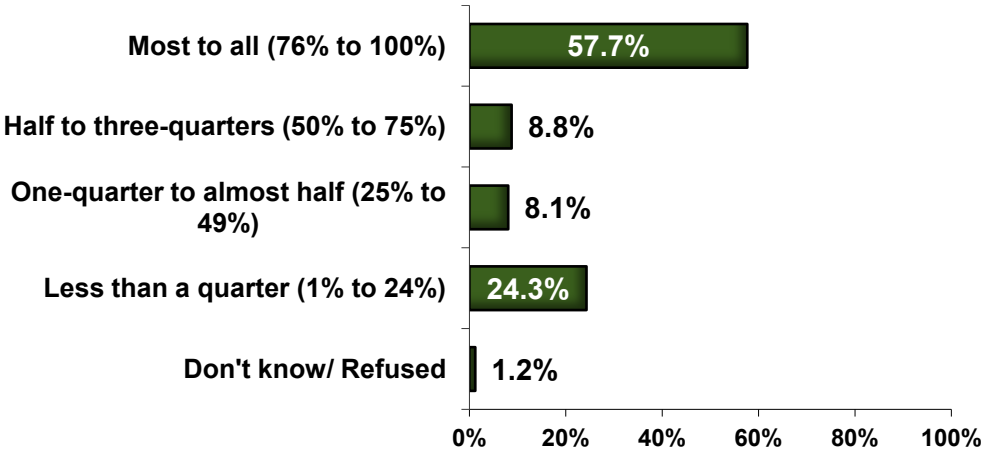

Figure 2. Percent of respondents' revenue from solar installations

Respondents include firms installing multiple technologies, including solar PV, water heating, and space heating and cooling (Figure 3). Ninety-two percent of firms are involved in PV, and about half install water heating systems.

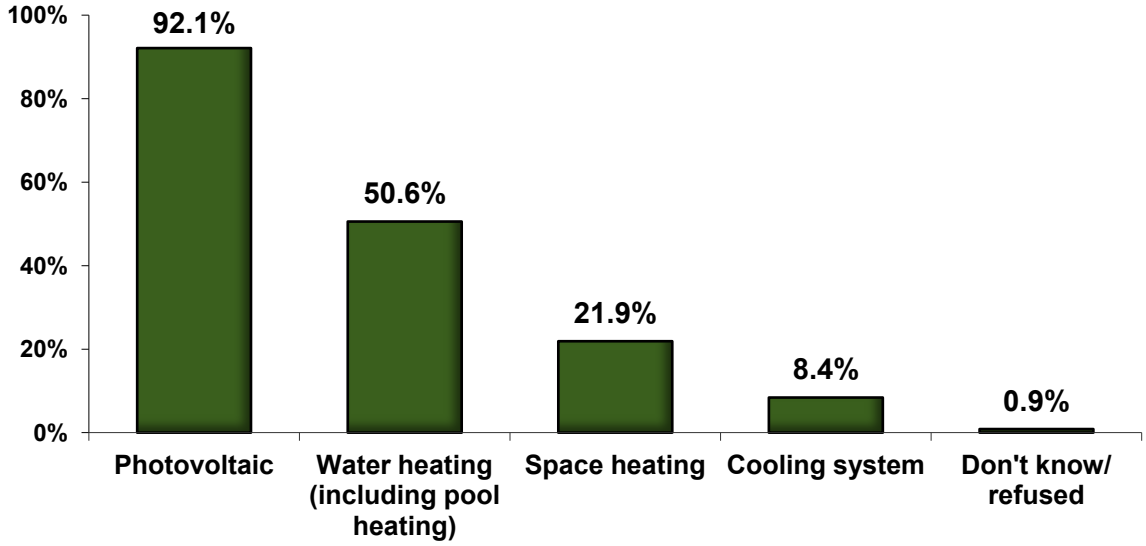

Figure 3. Percent of respondent locations engaged in each technology segment

Of the respondent employer sites, 76% install residential systems and approximately one-quarter install large commercial or utility-scale systems (Figure 4). Many firms work on multiple system sizes.

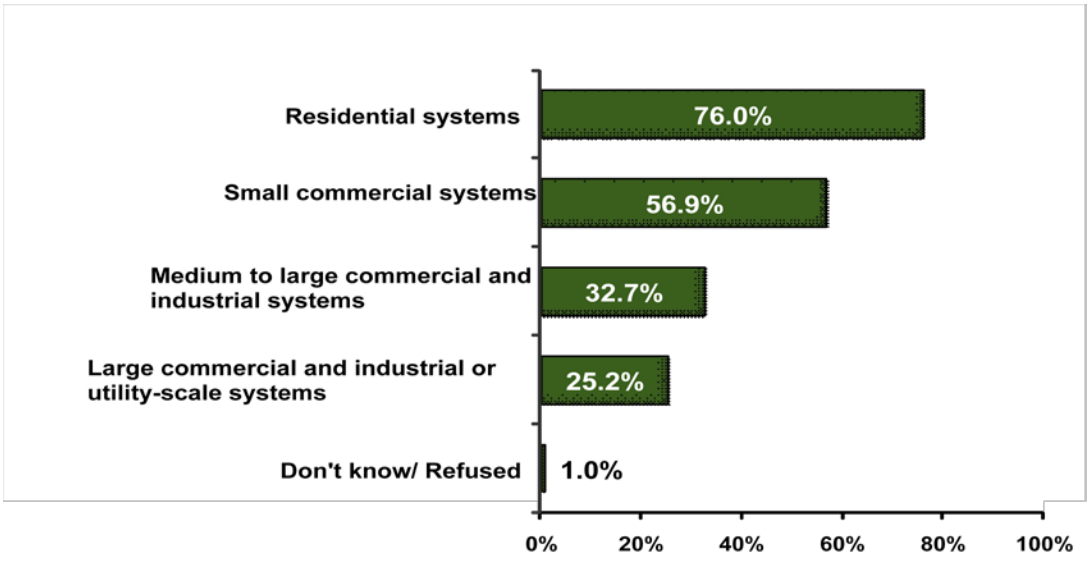

Figure 4. Percentage of respondent locations by system size

Traditional solar employment estimates from existing labor market data include a wide array of construction-related sectors, including eight major categories that traditionally have been associated with solar. These industry sectors are broad, however, and do not

accurately reflect the solar installation industry. In fact, together, the sectors include more than twice the number of firms actually installing solar projects. Similarly, installer occupations also typically are included within broad categories, including the Standard Occupational Classification for electricians (SOC 47-2111), plumbers (SOC 47-2152), roofers (SOC 47-2181), and other construction-related jobs, such as remodelers and roofing contractors.

To project the impact of reported employment growth for the entire sector (rather than just the respondent sample) and to develop a more reliable sampling plan, we measured the incidence rate, or the percentage of firms engaged in solar activity, within the five economic sectors[11] most likely to be installing solar projects (Table 1).

Table 1. Five Sectors Traditionally Engaged in Solar Installation, by NAICS Code

NAICS Code	Description
236118	Residential Remodelers
238160	Roofing Contractors
238210	Electrical Contractors and Other Wiring Installation Contractors
238220	Plumbing, Heating, and Air-Conditioning Contractors
238990	All Other Specialty Trade Contractors

The broader construction-related aggregated data from these industries can be instructive for the solar industry, as it offers a point of reference for the solar growth. According to EMSI data, the traditional six industry categories are expected to experience job growth of approximately 3.75% during the period from August 2010 to August 2011, as compared to the 18% growth rate reported by the sampled solar installation firms during the same period.[12] This overall growth rate would deliver 92,000 new permanent jobs across these sectors, with some small percentage focused on solar. The 3.75% broader growth rate is nearly double that of the anticipated overall U.S. job growth rate of 2% during the same period.[13] For comparative purposes, Figure 5 shows forecasts made in 2010 for occupations in traditional industries related to solar installation for the two-year period of 2010–2011.[14]

[11] Secondary data sources typically distinguish between residential and nonresidential construction firms, which is why these data sources include 10 NAICS codes.
[12] Subscription dataset used for economic forecasting, derived from data from the DOL's BLS.
[13] For the identified sectors, the most job growth is expected for nonresidential plumbing and HVAC contractors (29,039 new jobs) closely followed by nonresidential electrical contractors (22,068 new jobs) (EMSI 2010).
[14] Note that Figure 5 shows forecasted data only, not actual data.

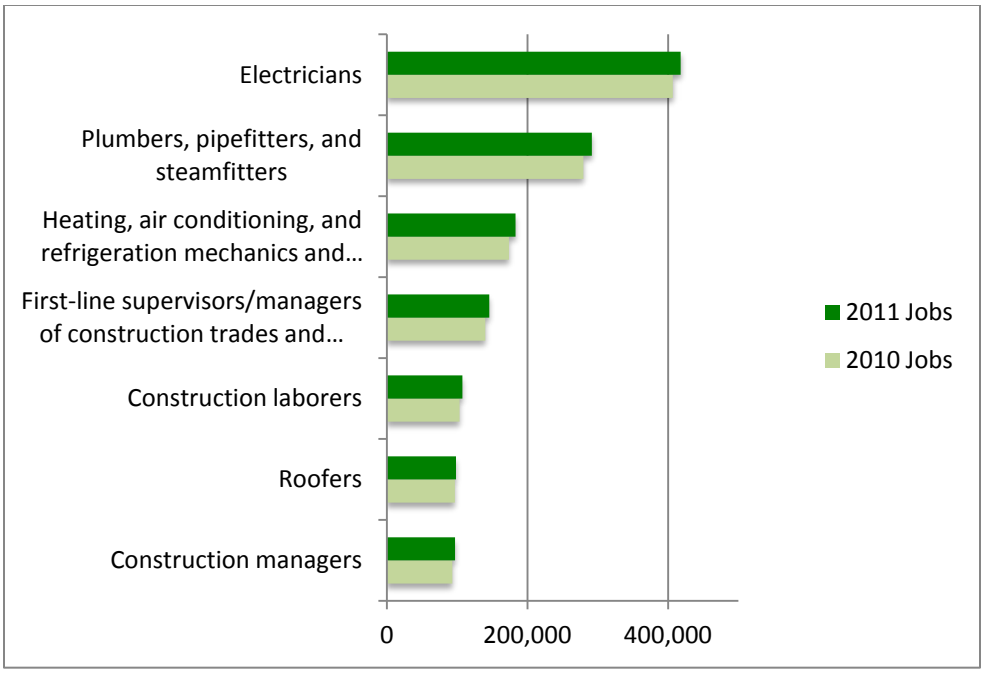

Figure 5. Twelve-month occupational growth in traditional industries related to solar installations

Source: EMSI 2010

Labor Demand Composition/Occupational Overview

Critical employment data on 11 key occupations relevant to the solar industry was gathered for this study. These are as follows:

- Solar water and pool heating installers and technicians
- Solar PV installers and technicians
- Sales representatives and estimators
- Solar designers and engineers
- Solar installation managers and project foremen
- HVAC technicians with specific skills in solar installation
- Energy auditors
- Site assessors and remote evaluators
- Plumbers with specific skills in solar installation
- Electricians with specific skills in solar installation
- Roofers with specific skills in solar installation.

For each of these occupations, the anticipated growth rates, degree of difficulty hiring,[15] and percentage of firms that hire (Figure 6 and Table 2) were gathered. In Figure 5, the size of the bubble corresponds to the percentage of firms hiring that occupation. For example, the bubble sizes indicate that more than 70% of solar firms employ PV installers and sales representatives; more than 60% employ solar designers and installation managers; and more than 50% employ electricians with specific solar skills. Conversely, fewer than 15% employ roofers and HVAC technicians that have specific solar-related skills. The vertical and horizontal axis in Figure 8 provides the other two metrics as indicated.

[15] Difficulty hiring is the percentage of firms that report some or great difficulty finding applicants that meet their firms' hiring standards.

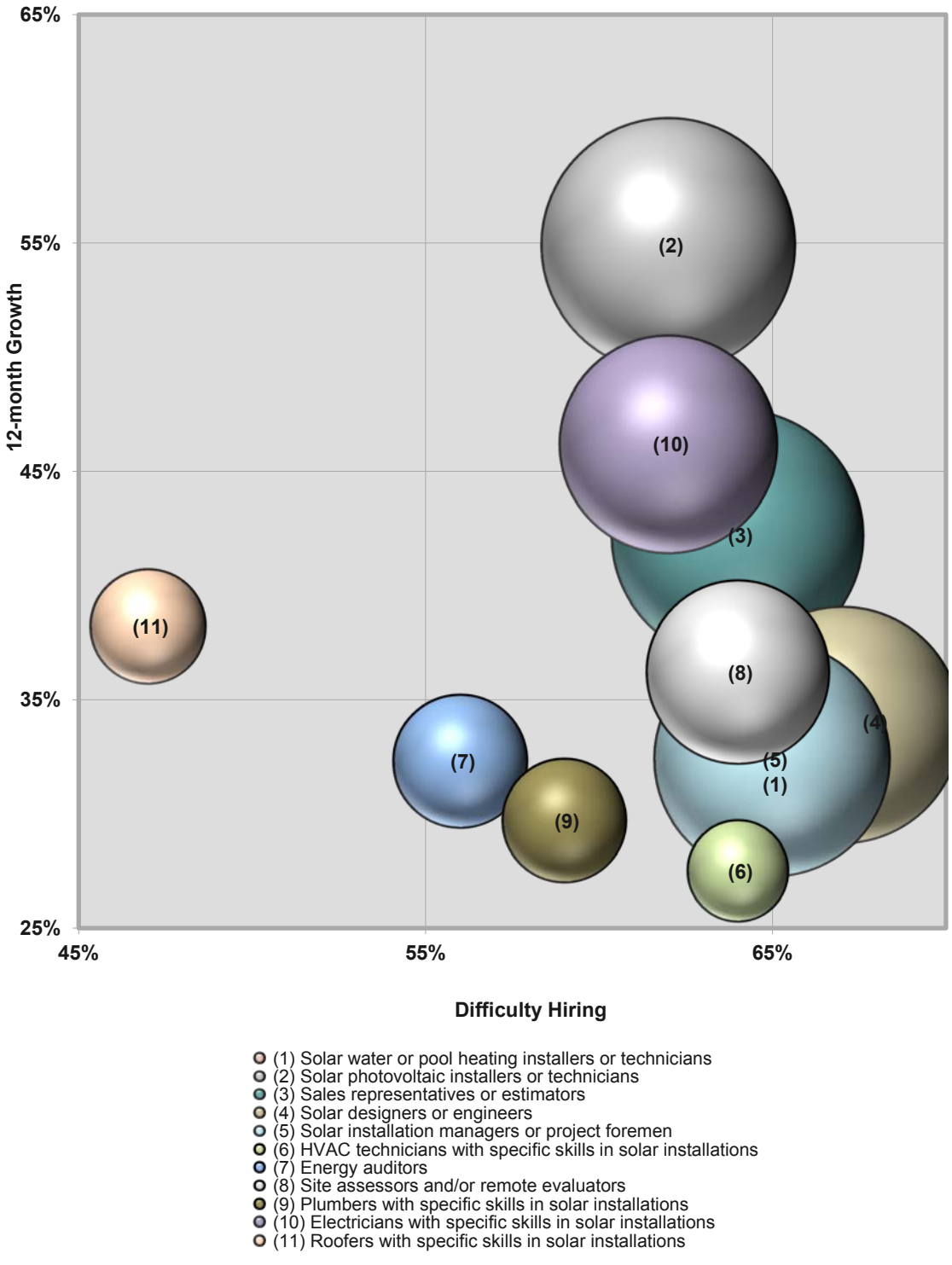

Figure 6. Growth, difficulty hiring, and number of employing firms

Table 2. Firms Reporting Difficulty Hiring, Firms Employing, and Wage Range, by Occupation

Occupation	Firms Reporting Difficulty Hiring	Firms Employing	Median Hourly Wage
Solar water and pool-heating installers and technicians	65%	33%	$15–$24
Solar PV installers and technicians	62%	72%	$15–$25
Sales representatives and estimators	64%	70%	$19–$32
Solar designers and engineers	67%	62%	$19–$31
Solar installation managers and project foremen	65%	61%	$20–$30
HVAC technicians with specific skills in solar installation	64%	11%	$14–$25
Energy auditors	56%	20%	$17–$25
Site assessors and remote evaluators	64%	37%	$16–$25
Plumbers with specific skills in solar installation	59%	17%	$18–$30
Electricians with specific skills in solar installation	62%	53%	$20–$31
Roofers with specific skills in solar installation	47%	15%	$15–$25

Like traditional aggregated data that serve as a proxy for an accurate solar category, labor market data for solar installation-related occupational categories are limited in their efficacy. Solar installers often are involved with other types of work (e.g., electrical work, plumbing, and construction). As a result, it can be difficult to properly ascertain solar-related activities within a traditional occupation. For example, existing aggregated data on electricians include information about electricians who install solar panels but cannot distinguish between solar and non-solar electricians. Within traditional construction-related sectors, it is expected that the categories that will add the most jobs over the next year are laborer, construction manager, and electrician (Table 3).

The United States Department of Labor (DOL)'s Bureau of Labor and Statistics (BLS) took a significant step in 2010 towards enabling a better understanding of the U.S. solar installer labor market, revising their SOC system of 840 occupations for the first time since 2000. Among more than 80 "green" occupations evaluated by the SOC Policy Committee (SOCPC) for new SOC codes under the 2010 revision, only two new renewable energy occupations were selected—solar PV installers (47-2231) and wind turbine service technicians (49-9081).[16] In each of the other cases, the SOCPC found that the work performed by a proposed "green" job was already covered by the description of an existing SOC occupation. The SOC system is not scheduled for another revision until 2018.[17]

[16] SOCPC, "Responses to comments on 2010 SOC," http://www.bls.gov/soc/2010_responses/response_08-0012.htm.

[17] The SOC system classifies workers into occupational categories "for the purpose of collecting, calculating, or disseminating data." http://www.bls.gov/soc/revisions.htm.

The task description for the new PV Installers SOC is as follows: "assemble, install, or maintain solar photovoltaic (PV) systems that generate solar electricity" (O*NET 2011). In conjunction with the revised SOC, O*NET, sponsored by the Employment and Training Administration (ETA) of the DOL, also established a new job title for solar PV installers (O*NET-SOC code # 47-4099.01).[18] Within the O*NET system, the solar PV installer occupation is designated as both a "Green New and Emerging" occupation and a "Bright Outlook" occupation, signifying rapid anticipated growth.[19]

Inclusion of the new solar PV installer classification is a significant step in enabling federal and other agencies to better count solar installation jobs in the future. The 2010 SOC system contains 840 detailed occupations, aggregated into 461 broad occupations and is used by federal statistical agencies to classify workers and jobs into occupational categories for the purpose of collecting, calculating, analyzing, or disseminating data.

[18] http://www.onetonline.org/link/summary/47-4099.01 and http://www.onetcenter.org/.

[19] The O*NET system describes the PV Installer job tasks as follows: "assemble solar modules, panels, or support structures, as specified. Install active solar systems, including solar collectors, concentrators, pumps, or fans. May include measuring, cutting, assembling, and bolting structural framing and solar modules. May perform minor electrical work such as current checks." For more information, see http://www.bls.gov/soc/2010_responses/response_08-0012.htm.

Table 3. EMSI Employment Demand Projections Made in 2010

SOC Code	Description	2010 Jobs	2011 Jobs	Openings (Including Replacements)	Median Hourly Earnings
47-2061	Construction Laborers	1,230,182	1,270,695	48,856	$15.58
11-9021	Construction Managers	703,519	728,712	30,707	$23.53
47-2111	Electricians	657,642	670,446	30,787	$21.98
47-2073	Operating Engineers and Other Construction Equipment Operators	384,214	392,416	15,472	$18.99
51-4121	Welders, Cutters, Solderers, and Brazers	370,668	369,955	14,954	$17.03
51-2022	Electrical and Electronic Equipment Assemblers	185,146	178,318	3,610	$13.77
49-9099	Installation, Maintenance, and Repair Workers, All Others	153,881	156,373	5,041	$15.71
17-2071	Electrical Engineers	150,634	150,660	4,899	$39.28
17-3023	Electrical and Electronic Engineering Technicians	150,620	149,416	3,640	$26.23
49-9098	Helpers—Installation, Maintenance, and Repair Workers	133,775	135,553	8,366	$11.73
51-2041	Structural Metal Fabricators and Fitters	93,908	93,580	3,002	$16.37
47-3013	Helpers, Electricians	86,654	90,010	5,415	$13.11
49-2094	Electrical and Electronics Repairers, Commercial and Industrial	71,524	70,956	1,571	$24.31
51-2023	Electromechanical Equipment Assemblers	54,237	52,752	1,108	$14.73
47-3019	Helpers, Construction Trades, All Others	21,669	22,204	998	$12.66
Total		**4,448,274**	**4,532,047**	**178,426**	**$19.26**
(EMSI 2010)					

Employer Needs and Challenges

Most solar installation employers report either some difficulty or great difficulty in recruiting both entry-level and more experienced employees (Figure 7). This is true despite persistent U.S. unemployment rates of more than 9% and a far greater unemployment rate—more than 34% expressed as a percentage of jobs in the sector—within construction-related trades (EMSI 2010).[20] This is the highest rate of any sector in the economy (Figure 8). The differential between the difficulty in recruiting entry-level employees and those with previous work experience in a given occupation) is less than 10%, suggesting that lack of experience is not the fundamental obstacle to labor supply meeting demand. The most important qualifications that installation employers seek within the labor pool are electrical and construction skills and experience, customer service skills, and a general understanding of solar power. Employers also indicate a clear preference for hands-on experience and hands-on or on-the-job training more than coursework.

Installation firms are experiencing difficulty finding entry-level workers who have some construction background and are having almost the same difficulty finding workers with solar-related experience and skills. It is unclear what the reasons for this are, given the high levels of construction unemployment. One possible factor is that solar wages and benefits may not meet the standards of traditional construction jobs, particularly for more experienced workers. The majority of employers indicated no difficulty in retaining valuable employees or providing training opportunities.

[20] Based on EMSI May 2010 unemployment data.

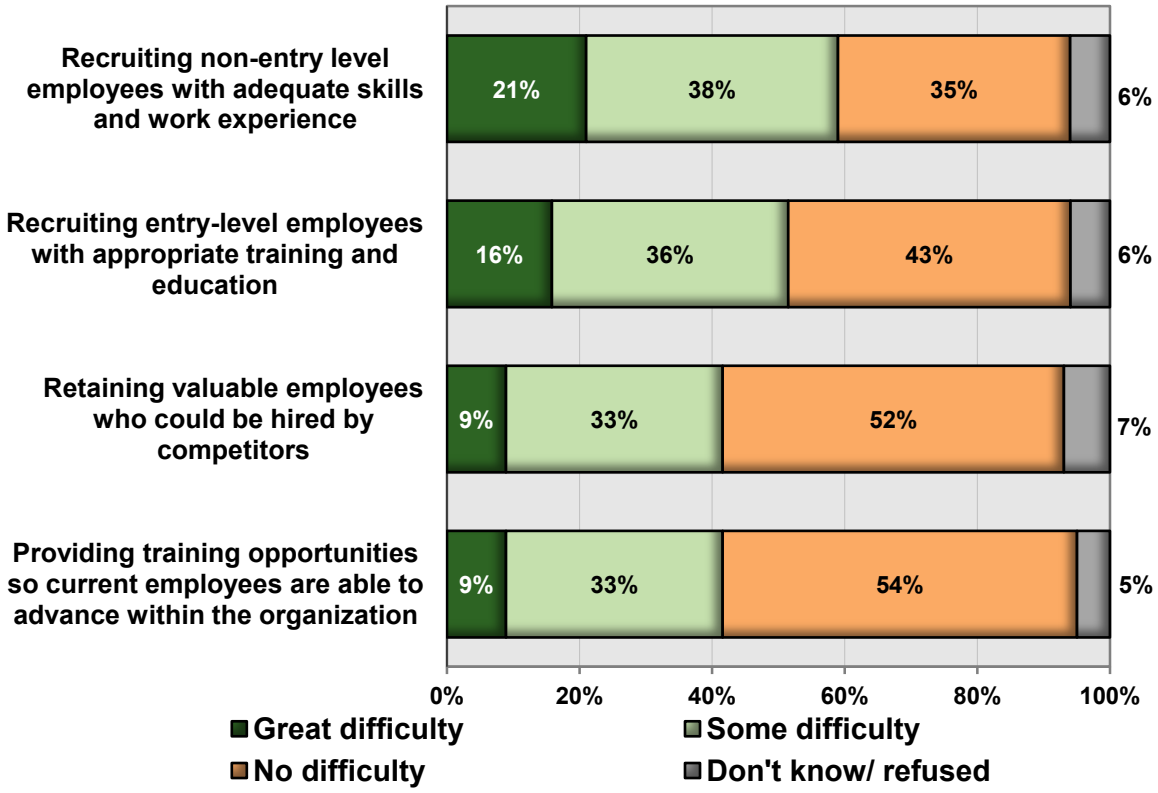

Figure 7. Solar workforce challenges

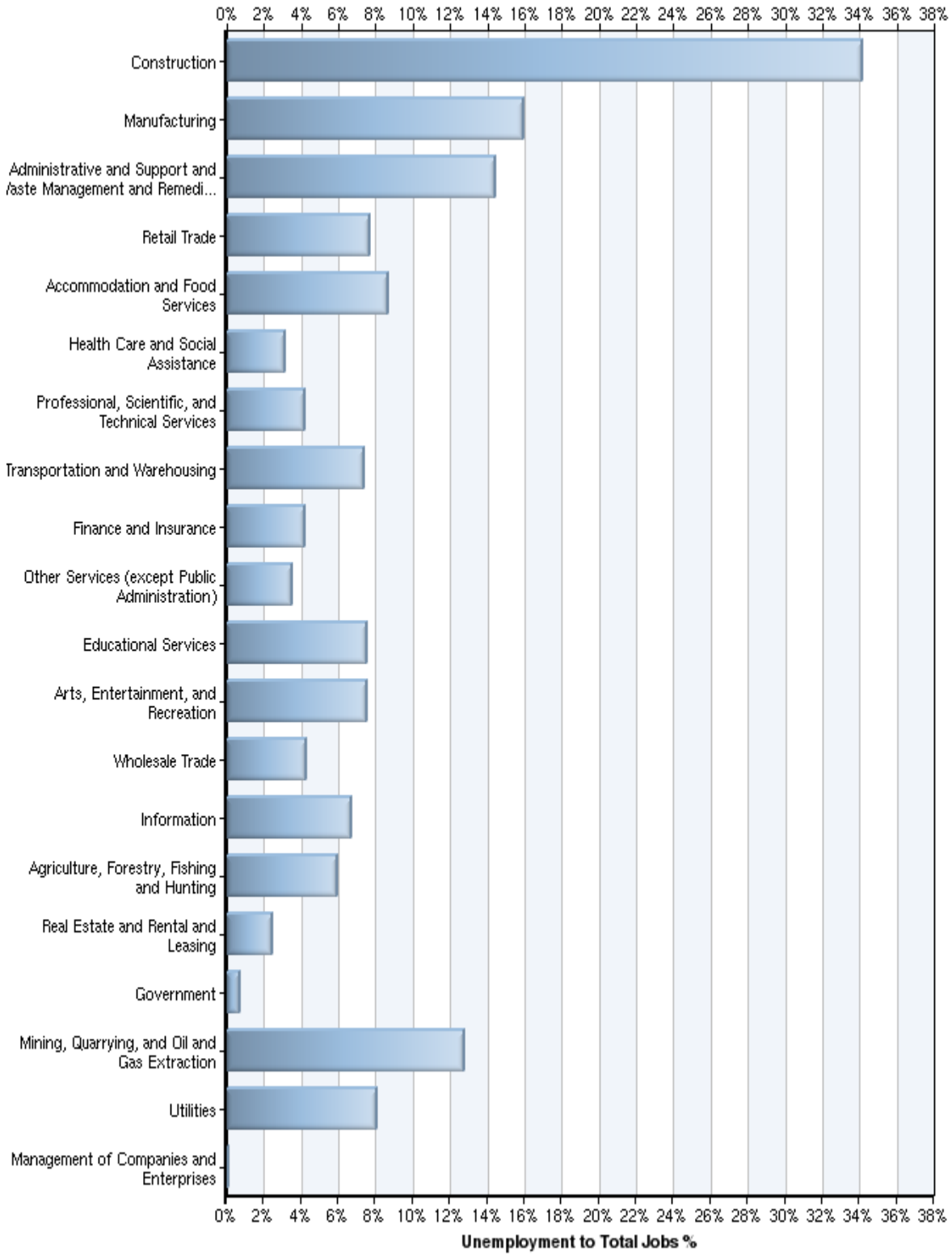

Figure 8. Unemployment by sector (May 2010)

Source: EMSI 2010

Employer Training/Experience Preferences

Employers were asked how their firms prefer to train employees. The vast majority prefers on-the-job training (82%), which was a significant preference over the other options, courses taught through industry-specific associations or groups—such as IREC and the American Solar Energy Society (ASES)—and customized training for employees (Figure 9). Training providers usually do not offer on-the-job training, but many offer hand-on components, such as physical skills training of problem-solving in lab or simulated site environments. Partnerships with firms engaged in local installation can create opportunities for on-the-job training, where employers are willing to participate.

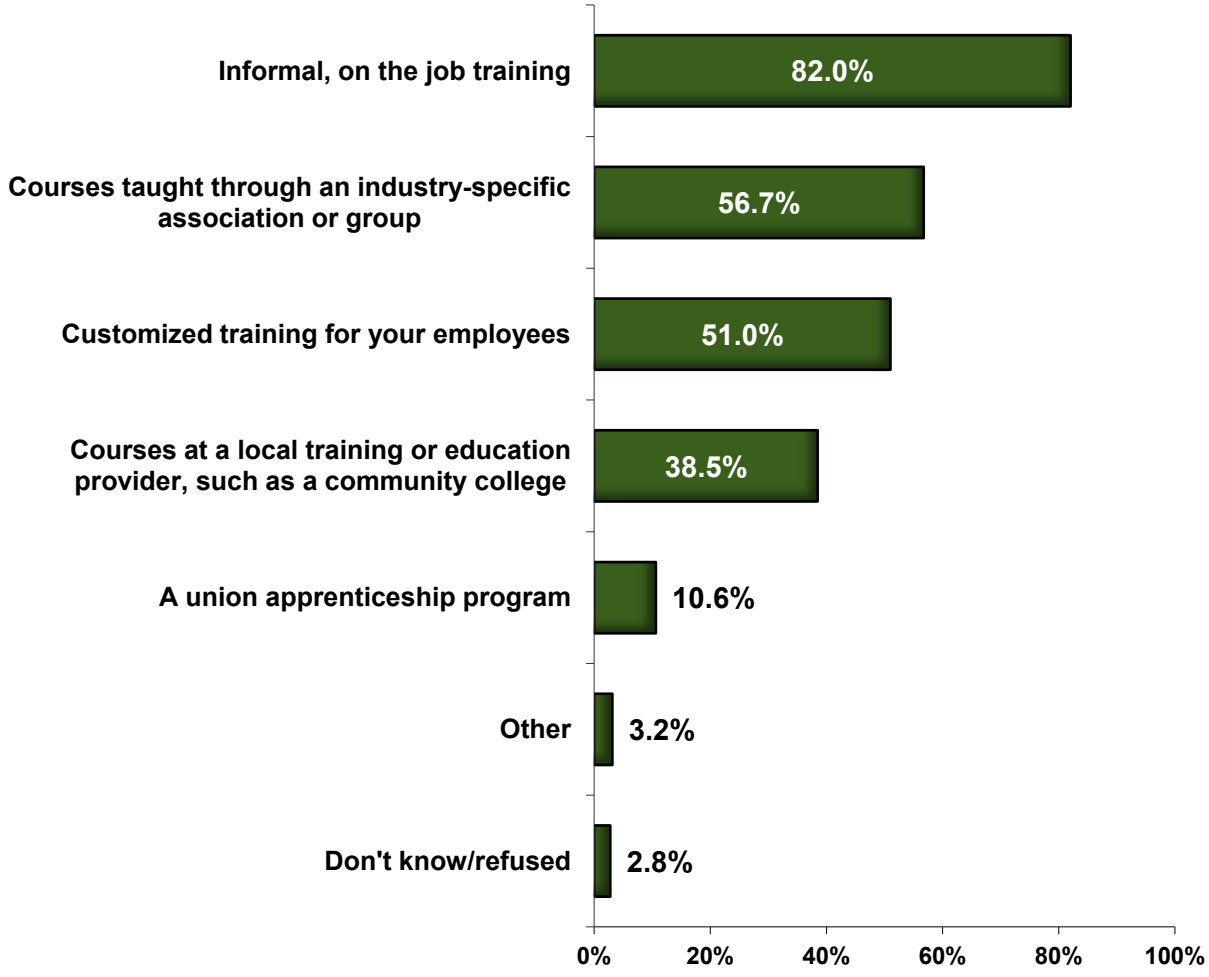

Figure 9. Training preferences

Employers are most interested in workers with customer service, construction, and electrical experience and knowledge of electrical code (Figure 10). Firms that employ technicians and installers who work on PV installations reported that it is "very important" that new hires possess electrician experience or skills (61%); knowledge of the National Electric Code Section 690, which covers safety aspects of PV systems (59%); and a general understanding of the mechanics and engineering of solar power (58%). Over half report that they would prefer to hire a licensed electrician. Generally,

employers emphasize the need for skills and experience over such factors as certification and licensure.

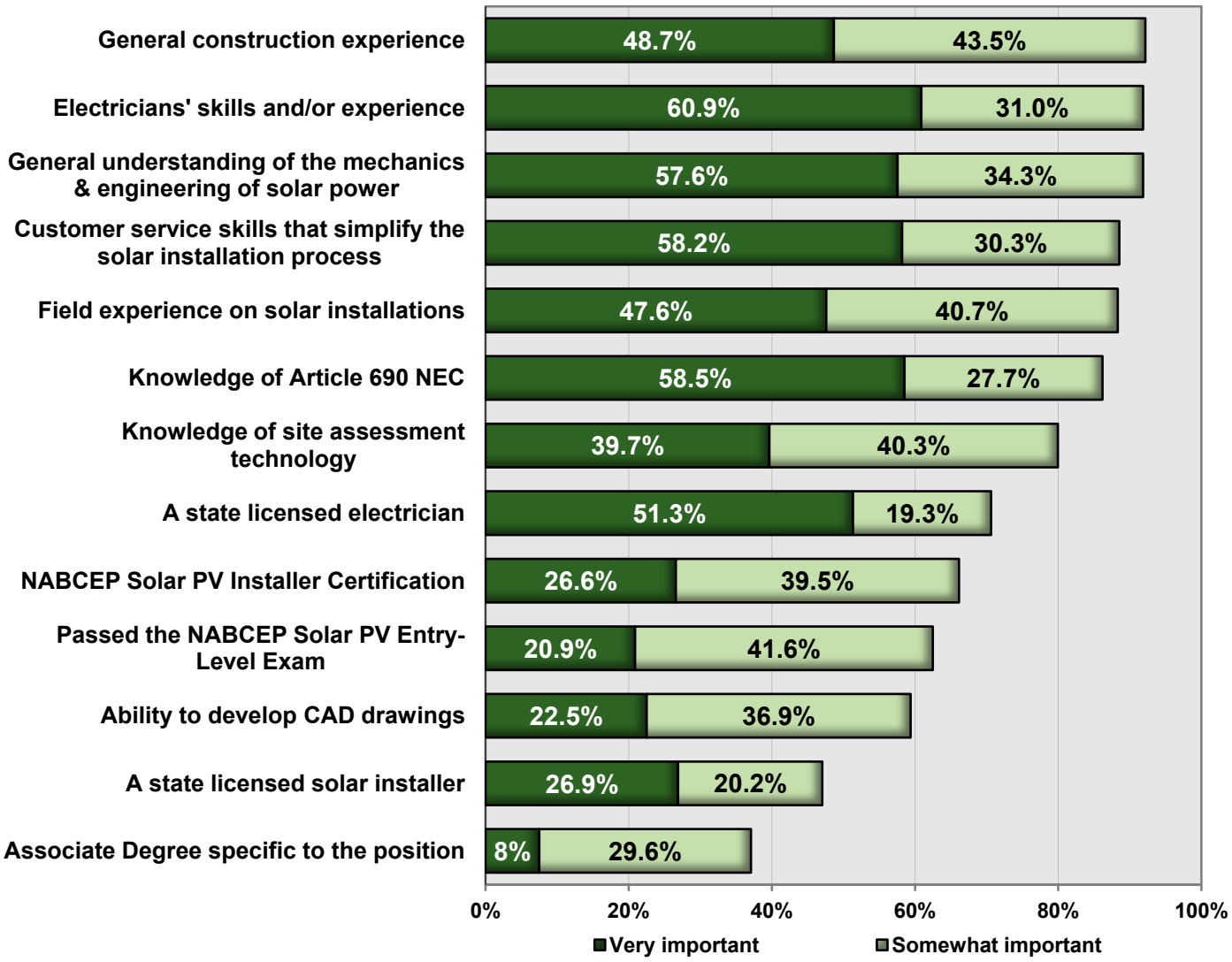

Figure 10. Skills, areas of knowledge, and educational certifications needed for employment with solar PV installers

Firms that employ technicians and installers who work on solar heating and cooling installations reported that it is "very important" that new hires have customer service skills (65%), a general understanding of the mechanics and engineering of solar power (52%), and general construction experience (49%) (Figure 11).

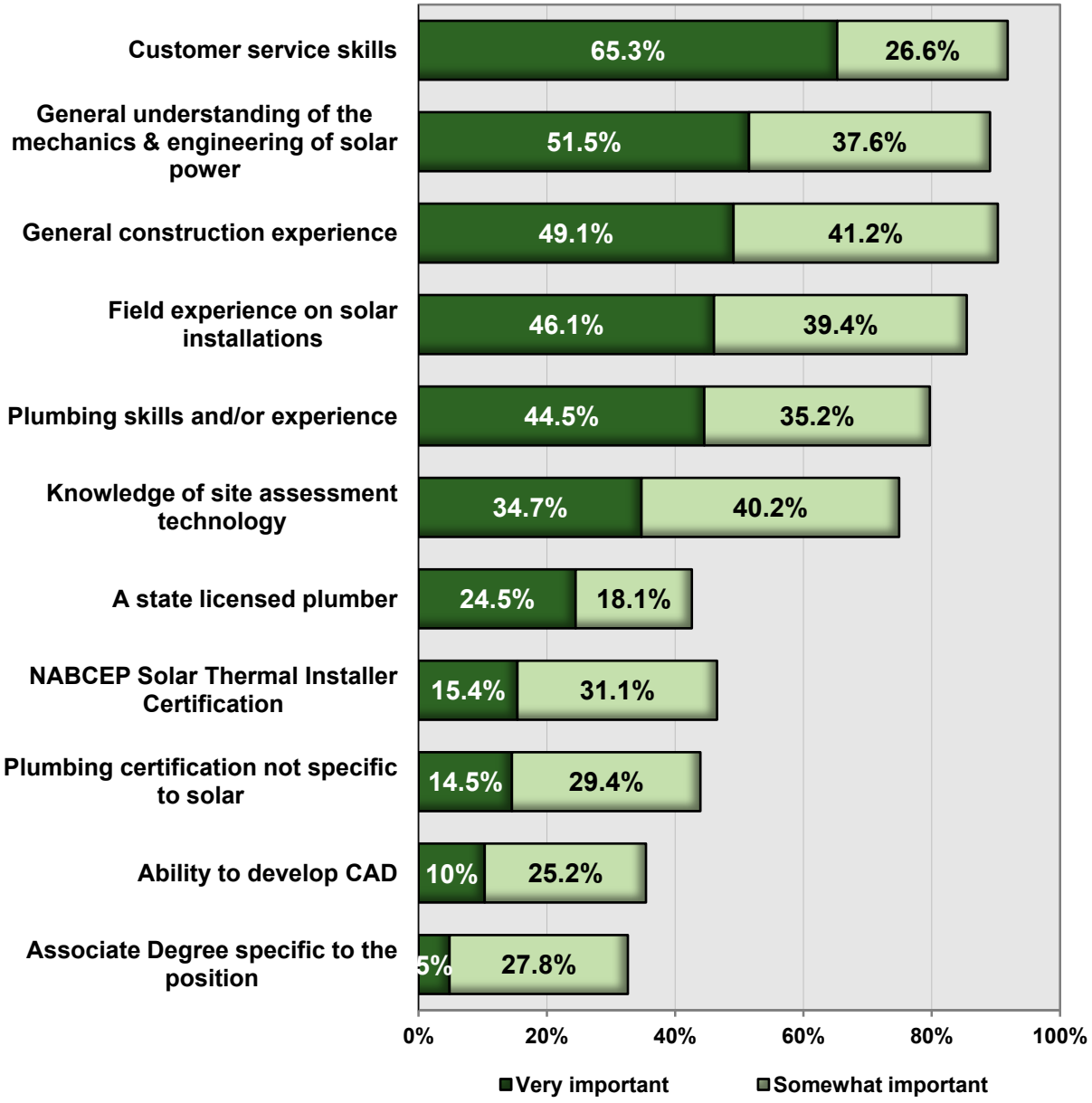

Figure 11. Skills, areas of knowledge, and educational certifications needed for employment with solar heating or cooling installers

Regional Distribution of Solar Installation Jobs and Expected State Market Growth

National and regional information on current and projected jobs for 11 solar installer-related occupations was evaluated. All known solar installers were contacted until each region of the country was sufficiently represented to draw conclusions about the region, with a minimum sample size of 100 respondents per region. The regions correspond to those of the SITN. National and regional versions of this report were distributed to leads in each region of the SITN in October 2010 (Figure 12).

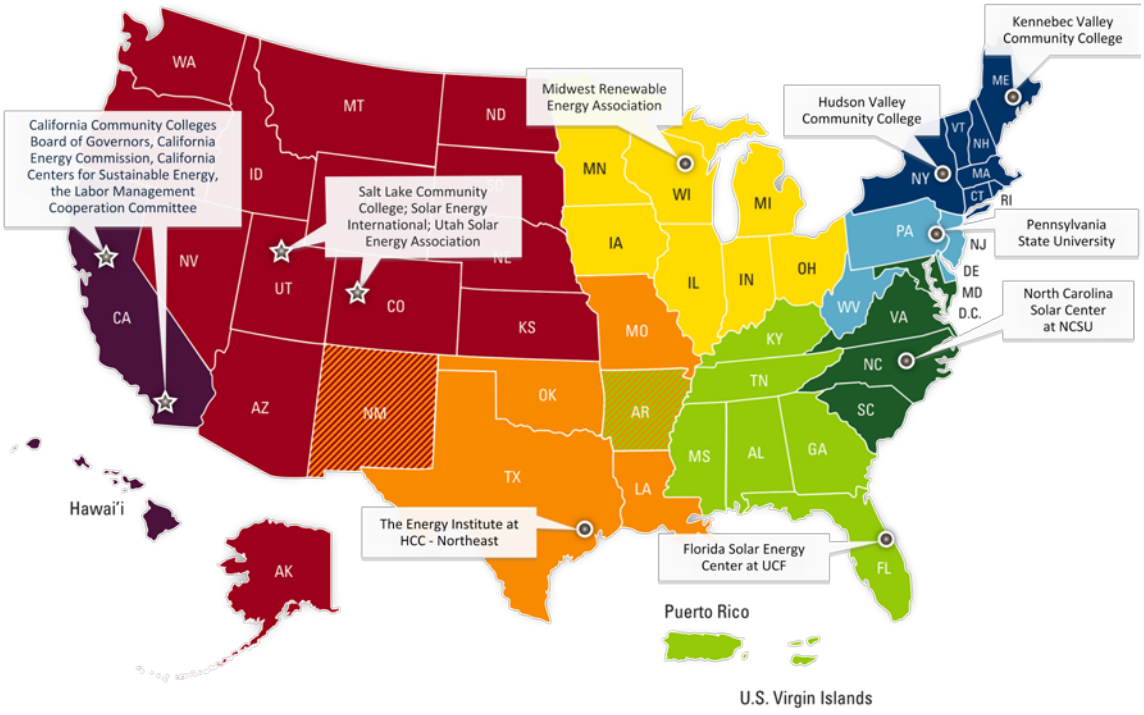

Figure 12. The eight regions and nine regional resource and training providers of SITN[21]

Source: U.S. Department of Energy

The study was designed to focus on the regional level for the SITN, organized regionally. However, the installation labor market is inherently local, so that further study of labor demand at state and sub-state levels will be important to complete the market picture. As one might expect, those regions that include the most robust state markets also employ the most people in the solar installation sectors. The two largest state markets are California, with 36.8% of 2010 U.S. PV installations, and New Jersey, with 14.9% of 2010 installations (SEIA/GTM 2011a).[22] Similarly, their respective regions—the West and Mid-Atlantic—employ 35.5% and 11.1% of the solar installation labor force,

[21] See http://www1.eere.energy.gov/solar/instructor_training_network.html.

combining for nearly half of the total installation labor force in the United States. Figure 13 shows the largest state markets for PV installations in 2010 and expected in 2011.

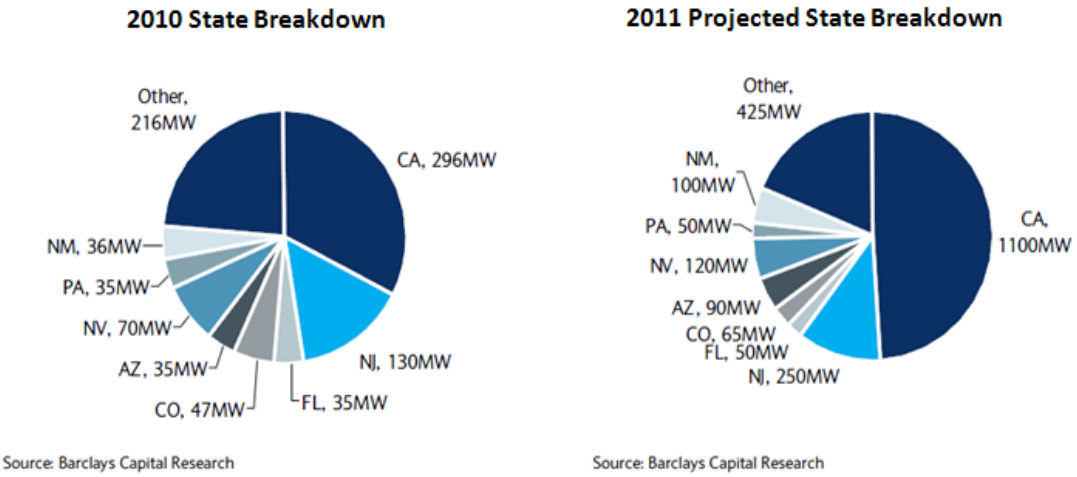

Figure 13. Annual PV capacity additions 2010 and projected annual PV capacity additions 2011, by state

Source: Barclays Capital

Regions with the largest solar markets are likely to continue to experience considerable growth over the next five years. California is expected to continue to lead market growth during the period, followed by two states in Region 2—New Jersey and Pennsylvania. Table 4 shows expected state market composition in 2015 (SEIA/GTM 2011a). Other growth state markets include those of Arizona, Colorado, and Nevada—all in Region 7. State policies continue to help drive markets. These policies include solar "set-asides" as well as those supporting net metering, interconnection, and third-party solar PV power purchase agreements. Solar set-asides, or "carve-outs," are requirements or added incentives for solar power within renewable portfolio standard (RPS) policies.

[22] California is on a track to becoming more than half of all U.S. annual installations by 2015.

Table 4. Installed Capacity by State, Top 21 States, 2010 and 2015 (Projected), Ordered by Market Size

State	2010 (as % of U.S.)	2015 (as % of U.S.)	2010 Rank	2015 Rank	SITN Region
California	36.8%	55.6%	1	1	8
New Jersey	14.9%	7.1%	2	2	2
Arizona	5.4%	6.9%	3	3	7
Colorado	5.0%	2.3%	4	6	7
Pennsylvania	4.4%	1.8%	5	9	2
Florida	4.4%	1.7%	6	10	4
New Mexico	3.9%	1.5%	7	12	6
Nevada	3.4%	2.7%	8	4	7
North Carolina	2.8%	0.9%	9	15	3
New York	2.7%	1.6%	10	11	1
Texas	2.7%	2.0%	11	8	6
Ohio	2.5%	1.1%	12	13	5
Massachusetts	2.2%	2.2%	13	7	1
Hawaii	1.9%	1.0%	14	14	8
Oregon	1.5%	0.7%	15	18	7
Illinois	1.3%	2.0%	16	5	5
Maryland	0.8%	0.8%	17	16	3
Connecticut	0.6%	0.7%	18	17	1
Delaware	0.4%	0.7%	19	19	2
Washington	0.4%	0.5%	20	20	7
Wisconsin	0.2%	0.3%	21	21	5

Source: GTM/SEIA 2010

Although the expectations of proportional growth are fairly uniform among regions, their respective market sizes are not. For example, the seven-state Region 1 (Northeast) is less than 10% of the size of the two-state Region 8 (California and Hawaii). Moreover, growth within regions is not expected to be uniform. Installation labor demand currently remains relatively small outside the leading state markets and may remain so for the foreseeable future.

It is difficult to quantify precisely what the labor demand will be beyond 2011. Factors include uncertainty in the policies and cost reductions that drive markets, as well as the variability in labor efficiency that occurs in maturing markets. As the market develops, labor productivity improves as a consequence of increasing competition, and more utility-scale plants are built, fewer jobs per installed megawatt may be required, partly slowing the labor demand created by expanding markets.

Understanding state-level and county-level markets is particularly important in the current economic climate. The mortgage crisis has impeded workers' abilities to sell homes in order to relocate for jobs in other states (Fletcher 2010). Figures 18 and 19 show the states in which this problem is more acute, as well as how this picture has changed for 2009 compared to 2000. In addition, faced with the added risk in the housing market, workers may also be less likely than they were in the past to leave their current

job for new employment with a startup company or in an industry that is not yet fully established. The worker immobility issue is less of a concern in states like California and Arizona, where although the housing market issue is acute, the solar market is also growing. In those states, using county-level data may offer a better understanding of whether current immobile workers can service anticipated future installations. Immobility may not be an issue in the case of lower paying, where relocating for the job would not be viable in any case. Understanding local markets will help training programs adjust their expectations of future labor demand to local market trends.

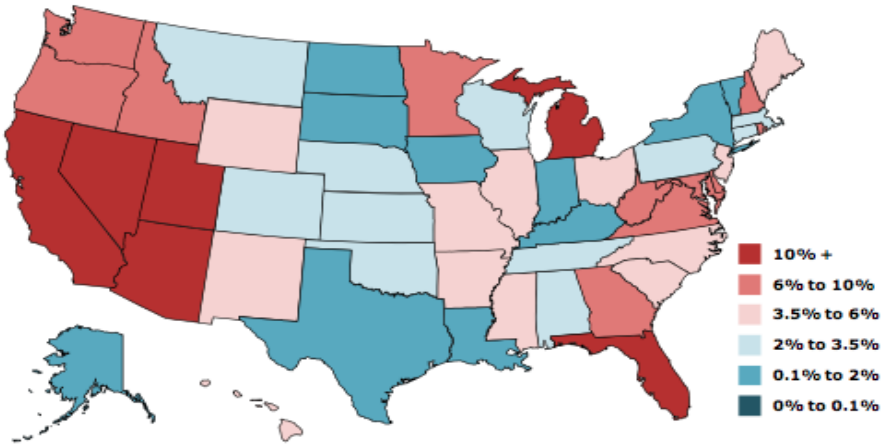

Figure 14. Share of mortgages with principal balance exceeding estimated home value: 2009: Q4

Sources: LPS Applied Analytics and Financial Times (2010)

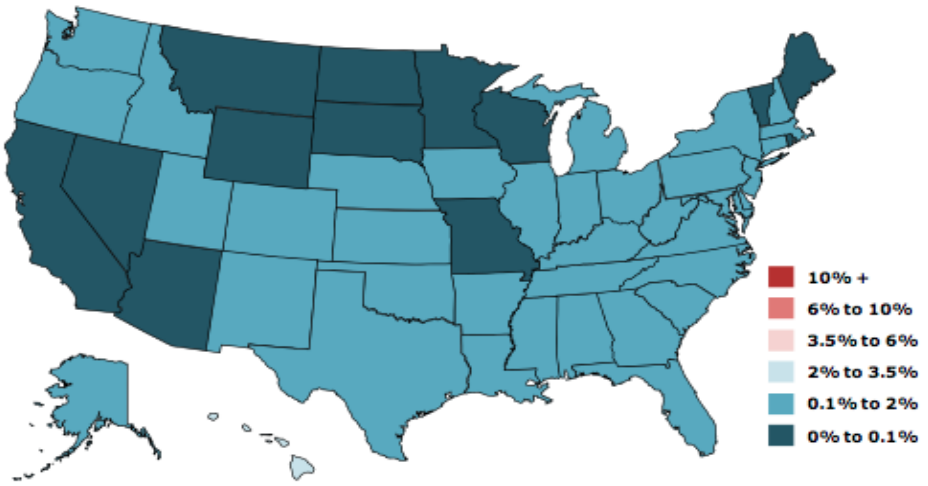

Figure 15. Share of mortgages with principal balance exceeding estimated home value: 2000: Q4

Sources: LPS Applied Analytics and Financial Times (2010)

U.S. Installation Labor Productivity

SEIA and GTM Research estimates a total of 878 MW_{dc} of PV was installed in 2010. Based on global estimates of labor intensity (e.g., New Energy Finance 2009), an installation workforce of 44,000 with a 50% or more solar installation focus, the jobs number counted in August 2010, is larger than would be expected to serve a market that size. For various reasons, the U.S. workforce is unlikely to stay this large relative to annual installed capacity as the market expands and develops.

As with any nascent market, one would expect improvement in labor productivity over time, scale, and industry development. More developed global solar markets display higher installation labor efficiency/productivity, defined as fewer FTEs per installed megawatt or fixed unit of investment. For example, a March 2010 report on the German market, published by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), reported a total of 79,000 solar jobs in Germany in 2009 (O'Sullivan et al. 2010),[23] a year in which Germany installed about 3.8 GW of PV compared to 878 MW installed in the United States in 2010. By comparison, the October 2010 Solar Foundation study of U.S. jobs throughout the value chain found 93,500 solar workers in the United States, defined by the study as those workers who spend at least 50% of their time supporting solar-related activities (Jordan et. al 2010). Although many variables could influence this disparity, it does provide some indication of the significant potential reduction in labor intensity (and associated costs) that may be expected as the U.S. market matures**.**

The SunShot Initiative, launched in January 2011 by DOE's Solar Energy Technologies program, reflects in its cost objectives the potential savings through increasing the labor productivity of the installation labor force relative to annual installed capacity. The initiative established the objective of "making solar energy technologies cost-competitive with other forms of energy by reducing the cost of solar energy systems by about 75% before 2020" (DeCesaro 2011).[24] To this end, the program conducted a workshop in February 2011 focused specifically on balance-of-system process costs associated with installing PV. The workshop identified an approach to defining and lowering these costs, including those associated with installation labor.

In its "Achieving Low-Cost Solar PV" report, the Rocky Mountain Institute also cited installation labor as a significant area for reducing solar costs: "Increased installation efficiency can come with innovation, experience, and scale, as designers continue to develop tool-less systems, automated equipment, and higher levels of preassembly. For ground-mounted systems, these strategies could save an estimated 30 percent of labor time and cost. For rooftop installations, where labor is a large share of the cost, the opportunity is expected to be even greater" (Bony et al. 2010, p. 14).

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[23] This estimate included both direct jobs in solar manufacturing and installation as well as persons indirectly employed as a result of the demand of these activities for goods and services.

[24] U.S. Department of Energy. "SunShot Initiative." http://www1.eere.energy.gov/solar/sunshot/index.html. Accessed August 25, 2011.

Much of this productivity gain, as well as consistency in quality assurance measures and quality standards for solar installers among states and regions, will occur over time through the increased competition and industry consolidation that are the natural byproducts of developing markets. Over the next three to five years, labor intensity will further decrease as large utility-scale installations increase as a portion of installed capacity, requiring fewer workers per installed megawatt.

Currently, 64% of U.S. installers employ 10 or fewer people, and it is likely that many of these small firms will either go out of business or consolidate over time. In addition, nascent markets are burdened by relatively inefficient supply and distribution chains and the need for staffing start-up related tasks, such as those related to market research, as well as extensive planning activity. Learning curves for corporate management and extra staff time spent on the other tasks inherent to any new business also suggest the potential for improved labor efficiencies over time.

Other factors will likely contribute as well, including:

- Improving worker training and agreement on best practices
- Developing labor-saving technologies and increased technology and practice standardization
- Encouraging uniformity among state and local installation labor requirements in areas such as licensure and accreditation.

Proper training of solar installers can decrease installation costs while improving safety. Well-trained installers are better positioned to innovate ways to reduce installation time, troubleshoot issues in real time, maximize system safety and performance, and keep workers and occupants safe from fire and other potential hazards through proper on-the-job safety protocols. By following best practices in areas such as wire sizing and caulking, well-trained installers can reduce repair costs. Long-term, market efficiency can be gained through wider agreement on quality standards and best practices in installation. Inconsistent quality standards create the potential for substandard installations that can threaten to undermine long-term consumer confidence and the industry's potential to grow.

Advances in technology can also result in significant installation labor productivity gains and concomitant reduction in staff required per project and per installed megawatt. These improvements include interlocking panels, automated pile-drive systems, simplified design, tool-less assembly, customized layout tools, paint-on, various plug-and-play potential options, building integrated PV (BIPV), and other streamlined technologies. More evaluation of the technical and market potential for these hardware-based technologies is required and is being pursued by the DOE through the SunShot Initiative.[25]

In addition, PV systems can be installed more efficiently when integrated into new construction, compared with retrofitting existing structures with PV systems. In

[25] See http://www1.eere.energy.gov/solar/sunshot/index.html.

California in 2009, residential PV systems installed in new construction cost $1.60/watt less on average than comparably-sized residential retrofit systems (Barbose et. al. 2010). This savings was higher still ($1.90/watt) when comparing rack-mounted residential systems installed in new construction with rack-mounted retrofit installations on an apples-to-apples basis (new construction installations in California are proportionally more BIPV than retrofits).

Lack of uniformity and inconsistent regulations, market expectations, and information on labor and wage requirements among U.S. solar markets may also contribute to labor installation being more costly and less productive than it otherwise might. State and local regulations vary as to levels of skilled, trained, or certified staff required for solar PV projects. For example, some states require solar-specific licenses, while others require an electrical license with no solar-specific component, and still others require certification to participate in a rebate program. These differences restrict workforce mobility and add complications and costs to installers working in multiple states. Depending on regulations and company practices, there is also variance in project requirements, such as the amount of professional electrician labor needed for PV projects. For example, depending on the region, company, or even project, residential rooftop PV installers might use less than 5% of project time on electrician labor, or as much as 40% or more.

Conclusions

To be most effective, training programs need to understand local market trends, including occupational demand, employer preferences, and the size of their local markets. The labor market data contained in this report provide critical information to SITN and other stakeholders on the current employment market. These include the size of the labor market by region and by occupation, as well as employer challenges and skill preferences for solar installation-related occupations. At this early stage of market development, labor productivity is low but likely to improve in the future, suggesting caution about future labor demand projections based on current workforce estimates. Labor intensity will be reduced through competition and worker experience and as more large-scale PV projects move into construction. Labor demand may experience a temporary decline with the expiration of the S. 1603 grant program set to expire December 31, 2011.

Although U.S. solar installation employers are optimistic about the growth prospects of the labor market, more than half report difficulty in finding even entry-level workers. Yet, the construction industry has the highest unemployment rate of all economic sectors in the United States at 34% (EMSI 2010). Depending on the region, training providers that find ways to identify, recruit, and up-skill unemployed construction workers for solar may find that their construction experience is desirable to prospective employers, making solar an important option in their job search. Employer data collected for this report also indicate a strong preference for workers with some background knowledge or experience, most critically:

- Hands-on construction experience
- Electrical knowledge or experience and knowledge of the National Electrical Code S.690
- Customer service/sales skills or experience
- An understanding of basic principles of solar power, which can be shown through completion of certification programs.

The growth rate expected by solar employers is significantly higher than what is expected among traditional construction industries and the expected overall job growth rate nationwide. On review of many of the existing solar training programs in the nation, it appears that more emphasis could be given to providing work experience or other fieldwork related to installations. Job projections reported by the solar industry suggest expectations for continued growth, with employers facing difficulties finding qualified workers to meet this new demand despite high levels of unemployment in construction sectors. Provided with this new and timely information, training providers can realistically assess their training priorities, how they should be communicating employer needs to their students, and how they can equip and re-train workers to obtain the skills that are most important to their potential employers. Finally, this report raises questions not yet answered; to name just a few, more detail on state and sub-state labor markets, detailed employer profile data by state, and data to further explore the gap between unemployed workers and difficulty hiring would be useful to continue to complete the picture of this growing renewable energy sector.

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Appendix A. Methodology Detail

This study was conducted by NREL in conjunction with Green LMI Consulting and BW Research Partnership. The goals of the study were to estimate the size of the U.S. solar installation industry, the size and characteristics of the labor force engaged in solar installation by occupation, and employer characteristics and skill preferences. To do so, we gathered data, via telephone and online questionnaire, from U.S. solar installation firms in the two major categories: those employers known to install solar ("known universe") and those in the broader construction sectors, surveyed to determine their "incidence rate," the frequency with which they were engaged in solar installations ("unknown universe"). Questions were carefully worded based on accuracy, clarity, and completion speed, as well as consistency in expected responses. Questions were organized in skip patterns to enable questioners to ask only questions relevant to the respondent based on previous responses.

In particular, a decision was made to avoid asking employers for full-time equivalencies or job-years because of the significant risk of misunderstanding or inconsistent understanding of these terms by respondents, and the difficulty in explaining them within the time constraints of the questionnaire. Instead the question asked how many workers were focused on solar installation activity for various portions of their time, information deemed more likely to be readily available to human resource professionals. In determining the number of employees with 50% or more solar installation focus, no attempt was made to combine employees' time; for example, if a respondent indicated they had 25 employees each working 20% of their time on solar installation activity, but no employees working 50% or more of their time on this activity, that employer site would have counted as zero employees working 50% or more.

All firms listed in existing industry association solar employer databases were contacted. These associations include SEIA, SEPA, IREC, CPUC, and the GoSolar Initiative (known universe). All known solar installation employers were invited to participate in the study, either online or via telephone, with multiple invitations provided to those not initially responsive. This sample yielded 1,328 completed responses. Based on the total number of listings from the database and factoring in the duplication rate, we have estimated that there are 2,540 employment sites in the United States from this known universe, for a completion rate of 52%.

The questionnaire was also deployed via telephone to a random sample of those firms in the five NAICS codes that comprise U.S. construction and related industry sectors (unknown universe). Those surveyed were selected from among the 211,350 firms (142,500 with fewer than five employees and 68,900 with five or more employees) in the sectors on the basis of diversity in terms of size, location, and construction industry sector. More than 10,000 calls were made and more than 2,000 establishments reached. They were asked whether they were engaged in solar installation activities. Of these, 97 were so engaged, yielding a "solar incidence" rate of approximately 4.3% (97/>2,000) among these NAICS industries, yielding an estimated additional 8,200 employment sites engaged in solar installation from these NAICS industries, for a total of approximately 10,800 sites in the United States, or about 1 in 20

construction-related firms. The 97 respondents from the random sample reported that 22% of their workers were engaged in solar activities for at least 50% of their time. Extrapolating to the 101,000 workers employed in the five industries yields about 22,000 workers from the random sample of construction-related firms not previously identified as solar installers, or about half of the total estimated solar installation workforce of 44,000.

The total respondent sample included 1,425 unduplicated completed questionnaires. The total dataset included full completions and significant partial completions, from which the information in this report was gathered.

Based on the total number of listings from the databases, the churn rate (the average rate at which the employer dataset experiences net attrition, that is, at which drop-offs are replaced by new entrants) and the duplication rate, we have estimated that there are 2,541 employment sites in the United States from the known universe.

The complete employer questionnaire can be found in Appendix C. The responses to the questionnaire are presented in this report, including responses to questions designed to capture industry information to the following areas:

- Respondent profile data
- Labor force size
- Employer skills/experience preferences
- Solar training employer needs
- Size and growth data for 11 occupations.

To ensure geographical diversity, study respondents included at least 100 firms from each of eight major U.S. regions. The study focused on solar installation companies. Data from the other solar supply chain sectors were gathered during the same period under a separate study funded via the Solar Foundation.

The random sample provides an empirical basis, with a margin of error of 5.9% to 9.9% (depending on the question), upon which to draw conclusions about the impact of expected solar installation industry growth on the full spectrum of sector labor demand rather than simply from a census of known solar employers.

We gathered data in three phases from the following sources:

- Self-identified or ("known") solar installer employers (those firms that are connected to solar industry associations and can be found on solar employer databases)
- Other solar employers found in construction industry NAICS classifications; in many cases, these are small, less established firms that were previously unidentified in existing solar installer databases ("unknown").

Phase 1: Develop, Classify, and Analyze a Database of Self-Identified or Known Solar Employers

For Phase 1, we developed a unified, comprehensive database of all self-identified, or "known," solar employers across the country. This database was developed through a collaborative effort between the national solar industry associations and partners. The comprehensive database was developed from all of the partners' contact information of employers. Duplicates were identified and removed following a stringent evaluation of firm phone numbers, locations, and firm names.

The database of employers did *not* include variables that consistently identified what sector (i.e., manufacturing, installation, wholesale trade, or research and development) each employer was involved in, the size of the employer, or whether the employer had a single location or represented multiple locations.

Phase 2: Survey of Self-Identified or Known Solar Employers

The second phase of the survey research was a census, using online and telephone surveys of all solar employers from the database developed in Phase 1. Employers were asked what sector they were involved in (installation, manufacturing, wholesale trade, research and development, or other) and, based on their response, were forwarded to the appropriate survey instrument. Respondents answering that their business activities were in a sector other than installation were forwarded to The Solar Foundation for inclusion in their separate study, published in October 2010 (The Solar Foundation 2010). All employers in the database with email information were sent multiple online invitations, and for those that did not complete an online survey, they were called up to three times. The employers without email information were called up to five times and asked to participate by completing a phone survey. These results represent the solar employer community that is connected to regional and national solar trade associations.

It is important to note that surveys were completed for each employment location and not necessarily for each firm. So if a solar installation employer was asked to participate in a survey, that employer would be asked about the employment profile of a given location and not of the entire firm.

Margin of Error: Survey of Self-Identified or Known Solar Employers

The survey results were examined by solar installers separately from all other sectors, as well as combined with all other solar employers. The following margin of error is for survey results that were shown for solar installers only. The overall margin of error for the known universe of solar employer installers survey, at the 95% level of confidence, is between ± 1.12% and ± 1.86% (depending on the distribution of each question) for questions answered by all 1,328 employers from the universe of 2,541 primary solar installer employment locations estimated of the known universe. This also represents a response rate of 52%, assuming the estimate of known solar installer employment locations is correct.

It is important to note that questions asked of smaller sub-groups will have a margin of error greater than ±1.86%, with the exact margin of error dependent on the number of respondents within each sub-group as well as the distribution of responses.

Phase 3: A Random Sampling of Employers in Industry Classifications that are Most Likely to Have Unknown Solar Employers

A phone survey was conducted of a random sample of construction industry employers designed to be representative of construction industry sectors, U.S. regions, and firm sizes (four or less employees and five or more employees). These results represent the solar installation employers that make up the construction industry employers within the industry classifications noted below. The overlap between the known and unknown universes of solar employers was calculated, and this calculation was taken out of the total estimate of firms in the known universe of solar employers to reduce the possibility of double-counting firms in both universes.

Construction: Industry classifications for the construction industry related to solar were not specifically identified with solar work. Five NAICS codes were identified with the highest expected concentration of firms that provide solar installation services. These NAICS codes were:

- 236118 Residential remodelers
- 238160 Roofing contractors
- 238210 Electrical contractors
- 238220 Plumbing and HVAC contractors
- 238990 All other specialty trade contractors.

There are 214,131 firms that indicated one of these five construction designations as their primary industry classification. A total of approximately 10,000 firms stratified by employer size and region within the country were called and asked whether they were in the solar industry and if they would participate in the survey.[26]

Margin of Error: Survey of Unknown Solar Employers in Specific Industries

The overall margin of error for the unknown or random universe of solar employer installers surveyed, at the 95% level of confidence, is between ± 5.94% and ± 9.89% (depending on the distribution of each question) for questions answered by all 97 employers from the universe of 8,215 solar installer employment locations estimated in specific industries within construction.

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[26] - Firms with fewer than five employees had a churn estimate of 8.56%, yielding a revised count of 130,268 firms.
- Firms with five or more employees had a churn estimate of 5.07%, yielding a revised count of 65,391 firms, for a total of 195,659 firms.
- Of firms with fewer than five employees, 3.64% reported hiring solar workers.
- Of firms with five or more employees, 5.3% reported hiring solar workers.
- Based on these figures, there are an estimated 8,215 employment sites in the United States. From the random sample, 97 firms completed the survey, with an average employment of 12.3 workers.
- The 97 respondents from the random sample reported that 22.3% of their workers were engaged in solar activities at least 50% of their time, yielding a "solar employment rate" of 22,483.
- The 97 respondents reported anticipated 22% overall growth, yielding 5,045 workers.

It is important to note that questions asked of smaller sub-groups have a margin of error greater than ±9.89%, with the exact margin of error dependent on the number of respondents within each sub-group as well as the distribution of responses.

Appendix B. Supply-Side Labor Data

Despite high levels of unemployment in the United States, employers responding to this questionnaire indicate difficulty finding qualified applicants for vacant positions within their firms. These data suggest the existence of a wide gap between the supply and demand of qualified labor. In order to more fully understand the supply-side contribution to this gap within the solar installation sector and the extent to which training institutions are incorporating employer preferences such as these into their curricula, NREL deployed a questionnaire for NABCEP-certified and Institute for Sustainable Power Qualified Standard (ISPQ)-certified education and training providers in the United States. Because of the lack of a national mandated licensure, determining the supply of adequately trained workers is difficult. The respondents to the survey encompass more than 60% of all NABCEP- and ISPQ-certified training providers and can be taken as a reasonable census of such entities. However, given the non-random sample of institutions surveyed, the data presented below are not necessarily representative of all training providers in the United States. It should be emphasized that these labor supply data are meant to be indicative, not statistically valid.

Respondent Profile

As shown in Figures B-1, B-2, B-3, and B-4, of the 126 training providers participating in the questionnaire:

- 23% are ISPQ-certified (another 10% have an application in process)
- 80% are registered providers of the NABCEP Entry-Level Exam
- 97% offer training (or plan to offer training in the next 12 months) on PV installations
- 55% offer training (or plan to offer training in the next 12 months) on solar thermal installations
- 38% of training providers reported that some of their courses are funded by the public workforce system (e.g., DOL funding)
- 71% have an advisory board made up of local employers
- About 46% of the respondents represent community colleges.

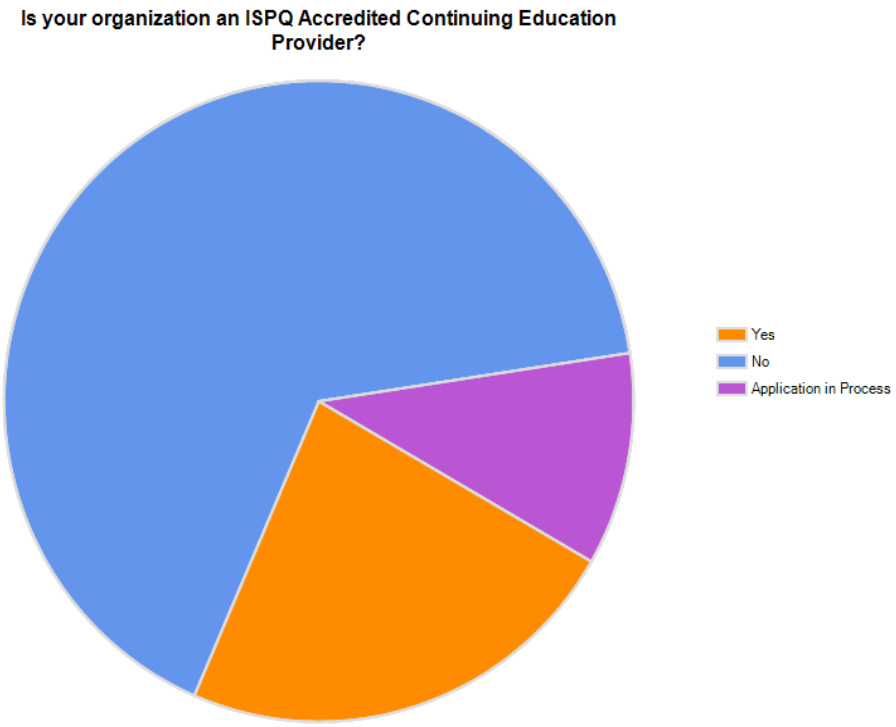


Figure B-1.

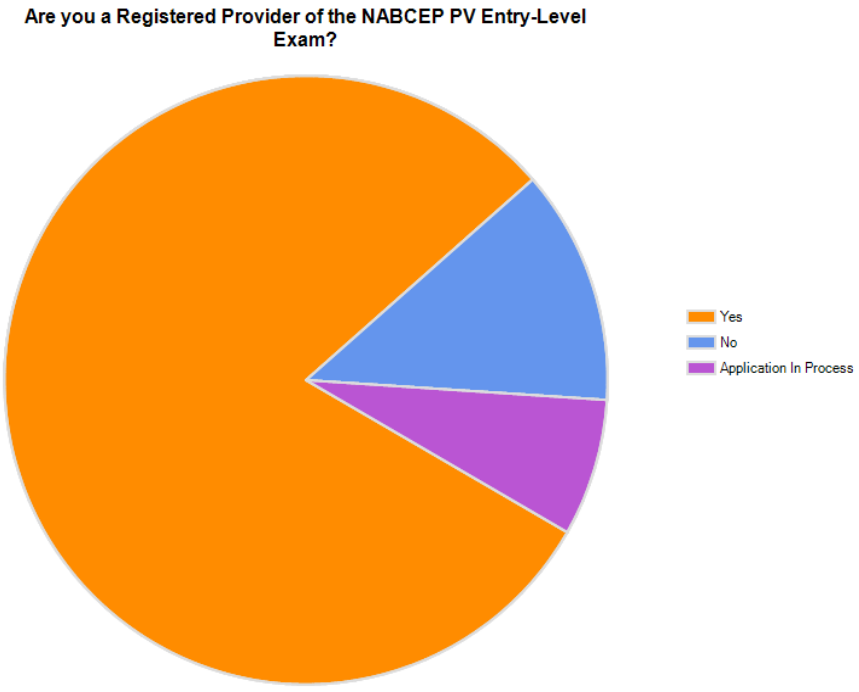


Figure B-2.

The following two charts on training courses offered or planned present raw number of responses, not percentages.

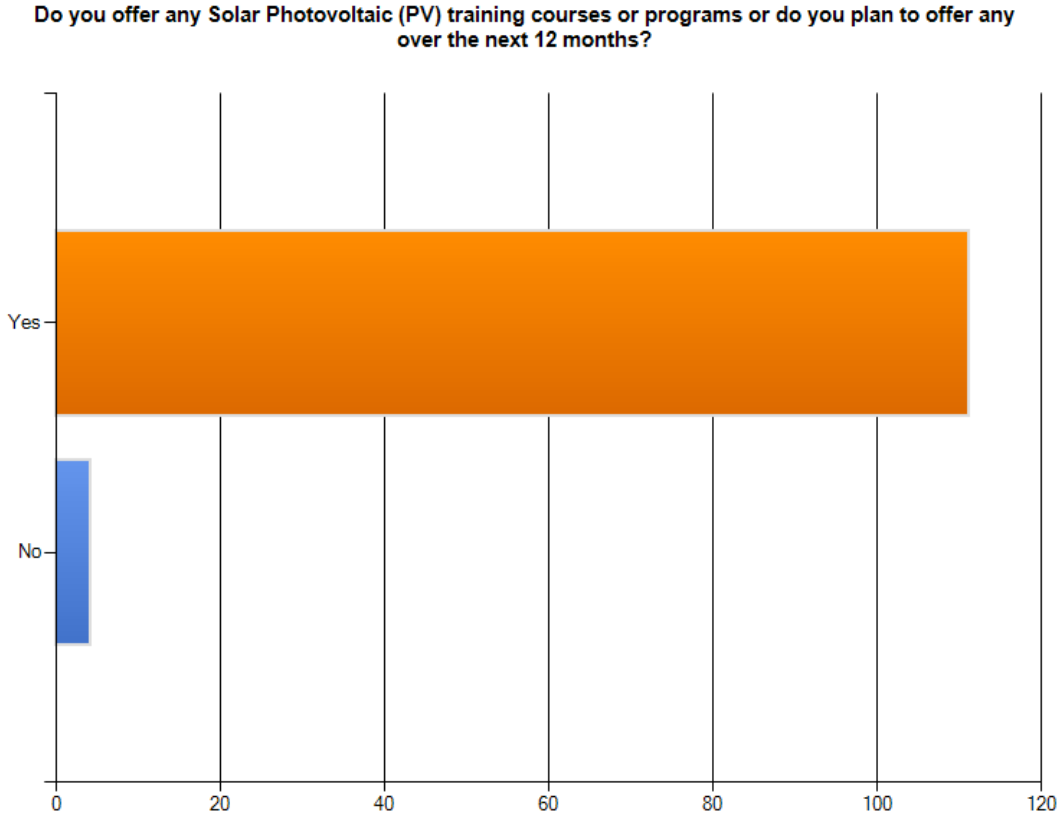


Figure B-3.

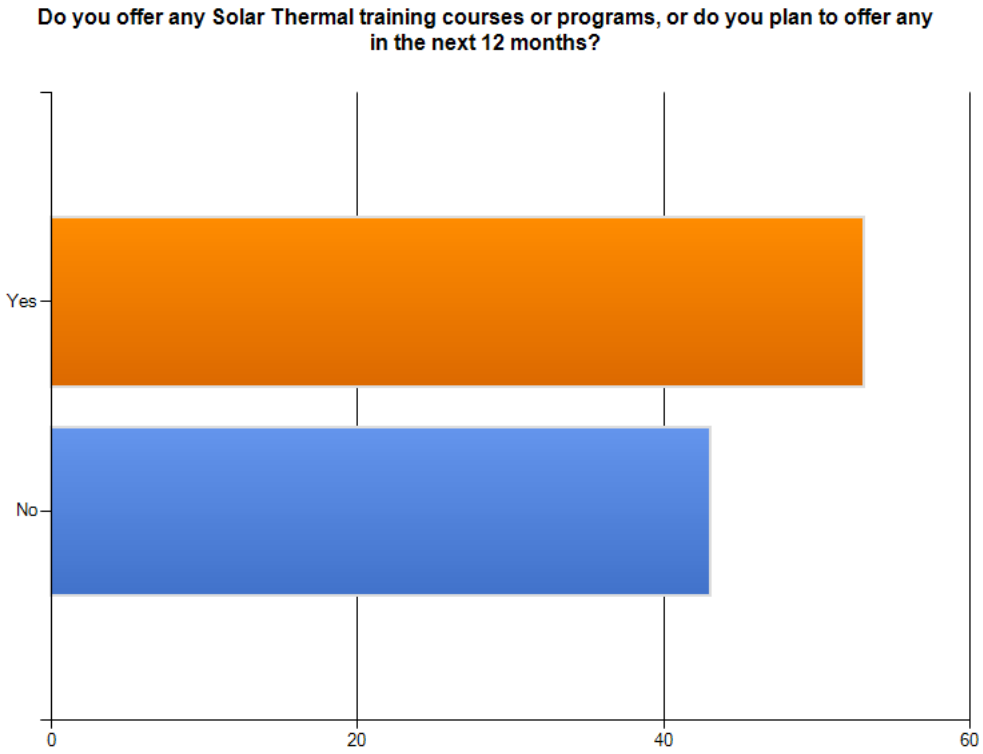


Figure B-4.

For each subsequent bar chart except where noted, the horizontal axis represents percentage of respondents.

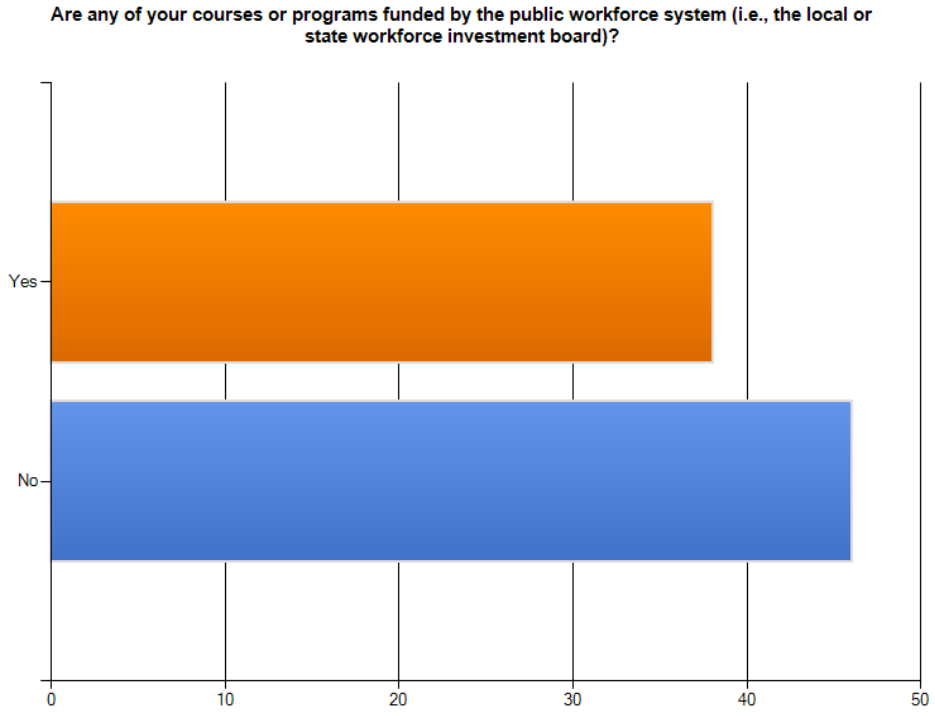

Are any of your courses or programs funded by the public workforce system (i.e., the local or state workforce investment board)?
Yes
No
0
10
20
30
40
50

Figure B-5.

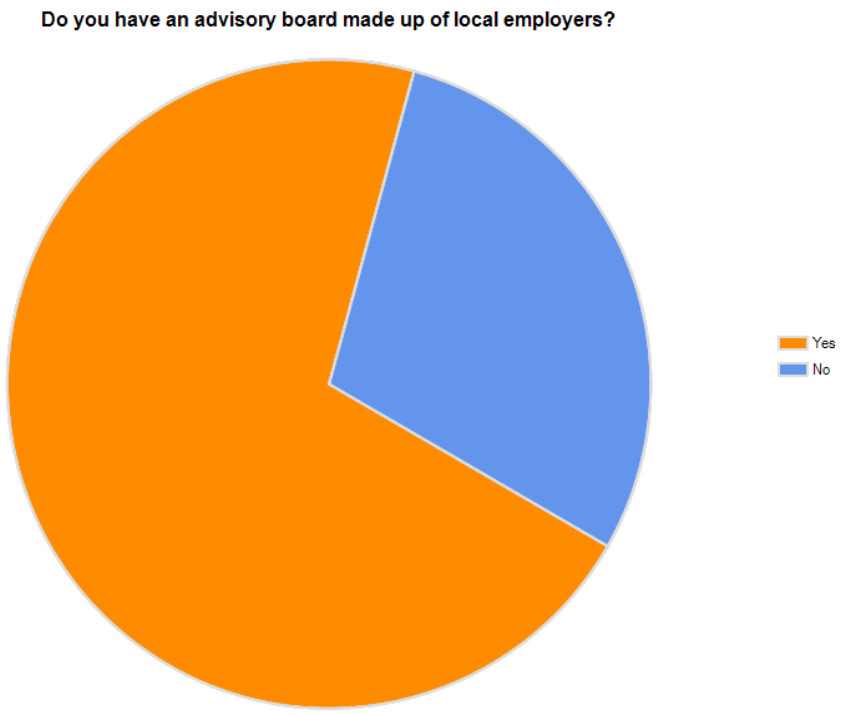
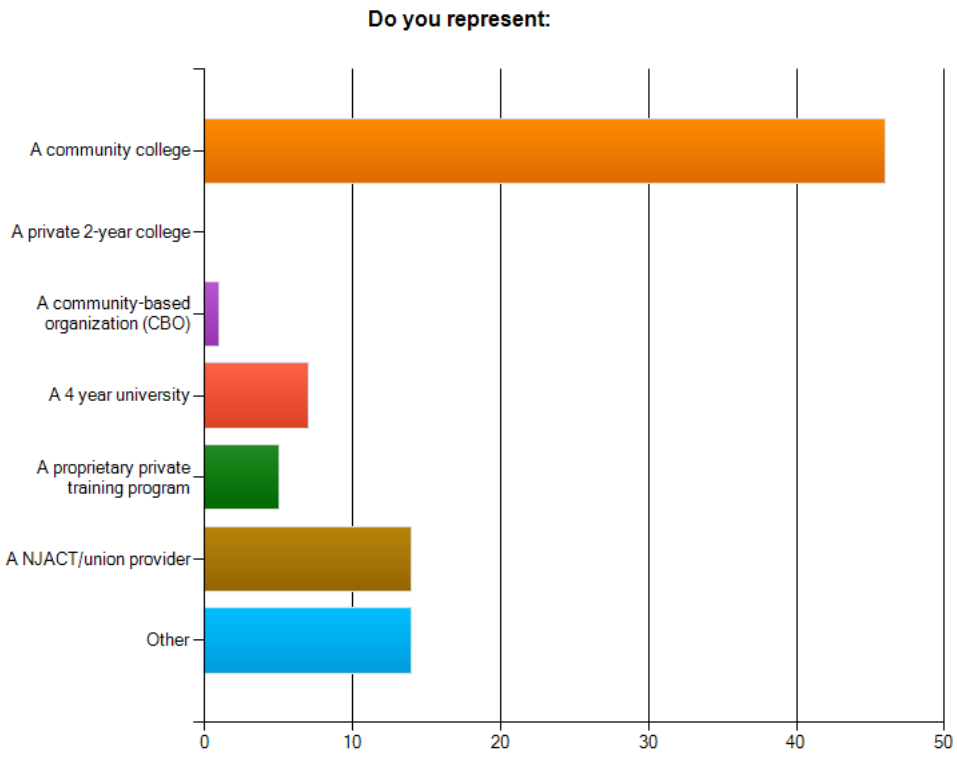


Figure B-6.



NJACT is the National Joint Apprenticeship and Training Committee.

Figure B-7.

Solar PV Programs

Approximately 97% of respondents offer training in solar PV installations. Of those that do, 98% offer classroom instruction, and 15% offer at least some of their coursework online.

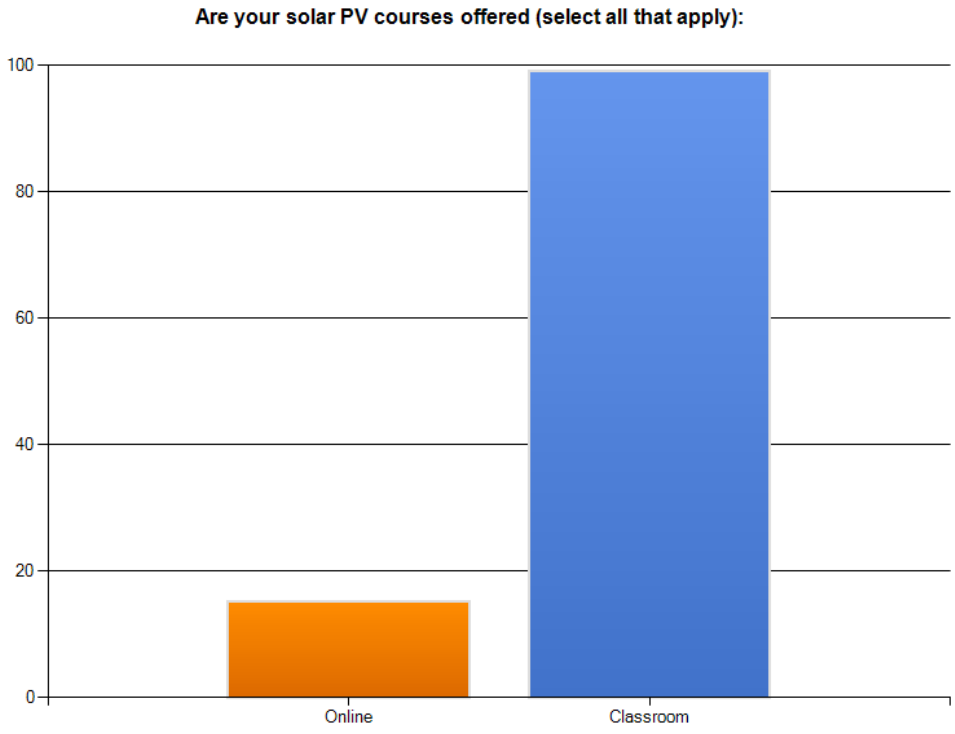


Figure B-8.

Survey respondents report training approximately 8,500 students in entry-level PV courses over the past 12 months, with the capacity to train about 10,000 more over the next 12 months. Overall, PV trainers report the capacity to train 25,000 PV workers annually (including entry-level, experienced, and customized training).

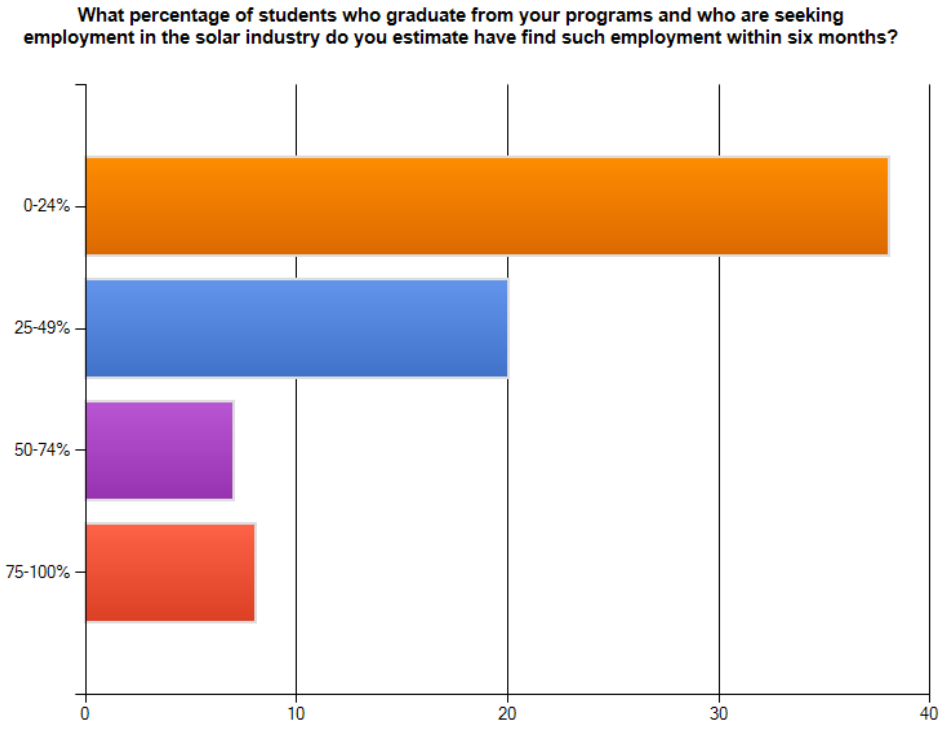


Figure B-9.

Entry-level PV training courses are an average 110 hours, with about 40 of those hours spent on hands-on activities. Advanced PV courses are somewhat shorter, averaging 84 hours (with about half of that time spent on hands-on activities).

Training institutions average just over one full-time instructor and approximately three part-time instructors. These institutions demonstrate a preference for industry experience over an advanced education when hiring instructors.

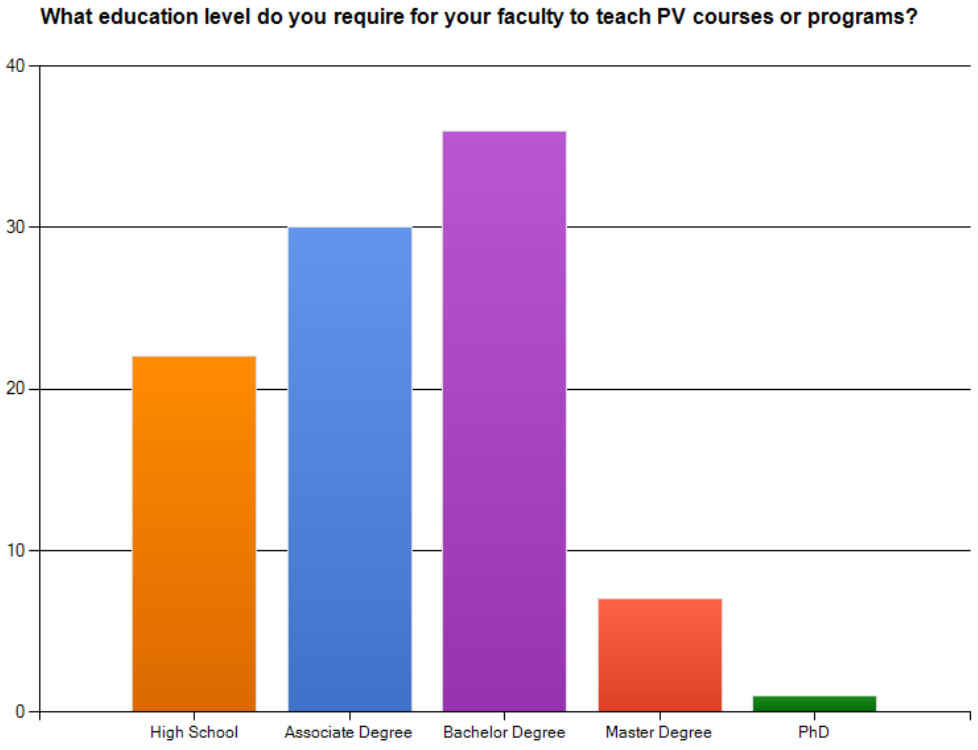


Figure B-10.

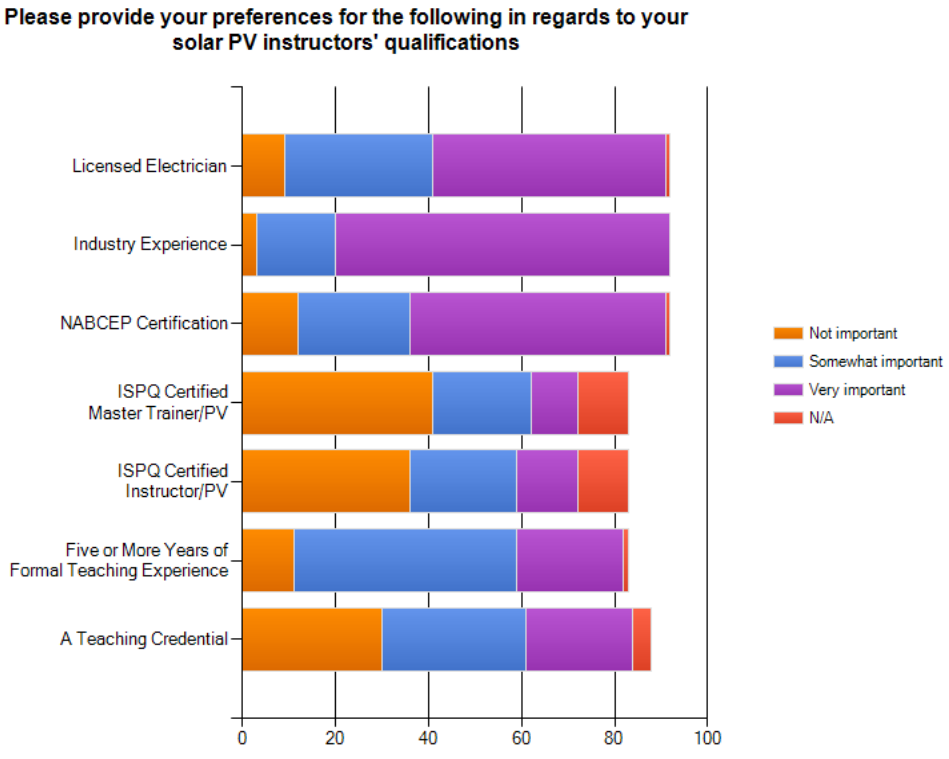


Figure B-11.

Regarding the content of entry-level PV courses, the majority of time is spent on installation and design, while about one-quarter of total time is spent on site assessment and sales. For advanced PV courses, about two in three are aligned with the NABCEP Job Task Analysis for solar PV installers

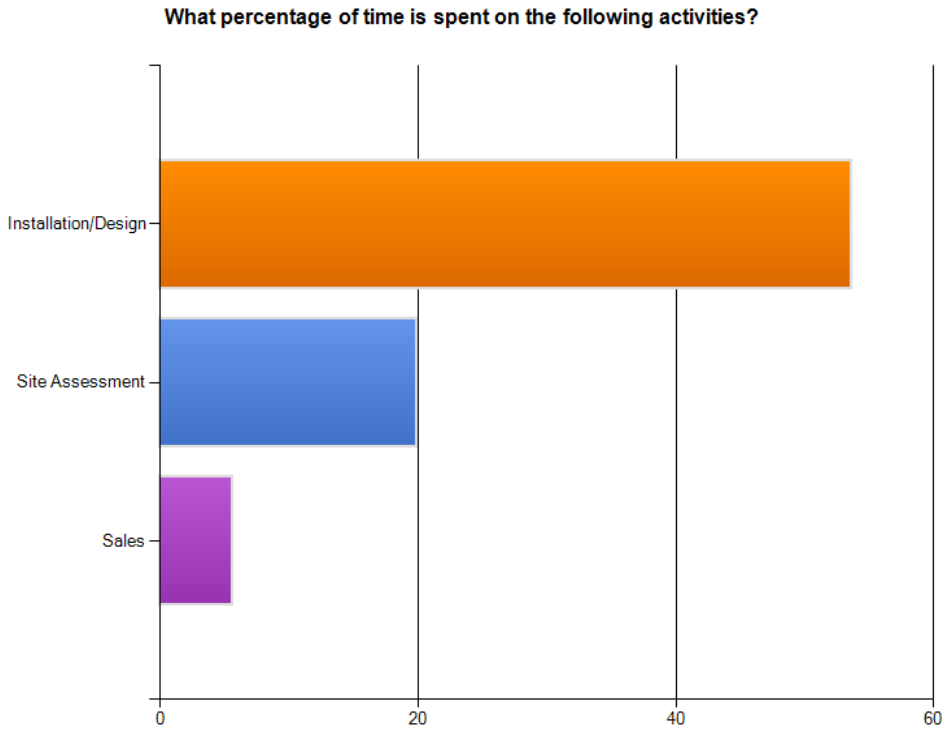


Figure B-12.

Solar Thermal Programs

Of the 126 respondents to the questionnaire, 44 train students in solar thermal installations. Similar to PV courses, about 98% of the courses are offered in a classroom setting, while 9% offer some of the coursework online.

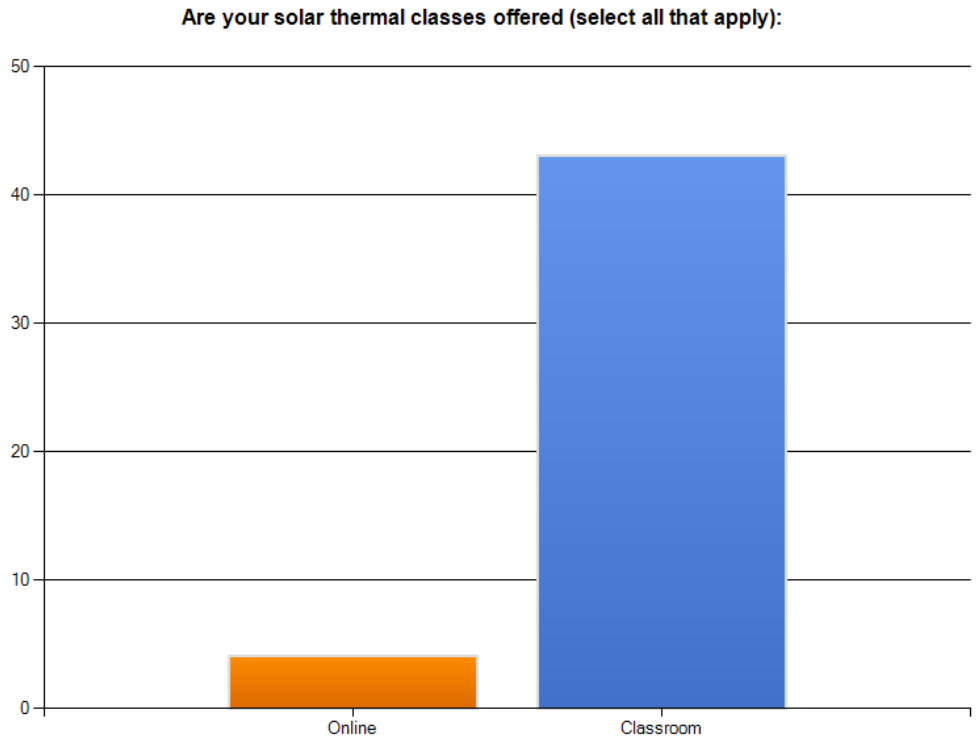


Figure B-13.

The respondents report training over 1,800 entry-level solar thermal installers over the last year, with capacity to train another 3,400 over the next 12 months (4,400 overall, including advanced training).

The average entry-level course is about 62 hours, 25 of which are spent on hands-on activities. The average advanced course is shorter by about 10 hours, with a slightly higher percentage of time spent on hands-on activities than for the typical entry-level course. However, only 11 respondents offer advanced courses and caution should be taken in interpreting these results.

On average over half of the time in entry-level courses is spent on installation and design while nearly one-quarter of the time is spent on site assessment and sales.

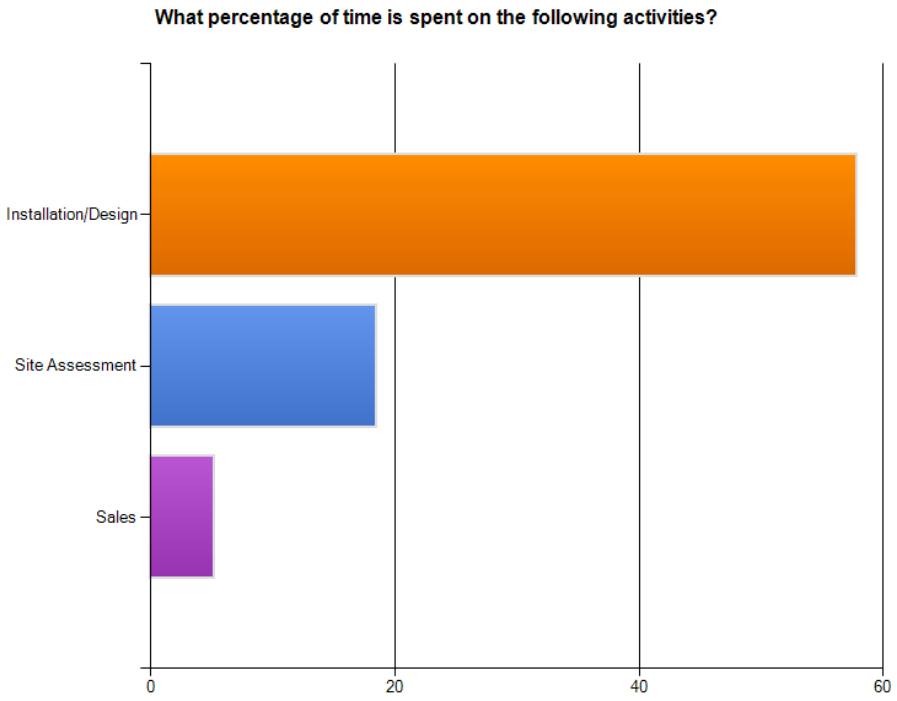


Figure B-14.

The respondents have, on average, one full-time instructor and two part-time instructors for their program. Training institutions showed a strong preference for industry experience when hiring instructors.

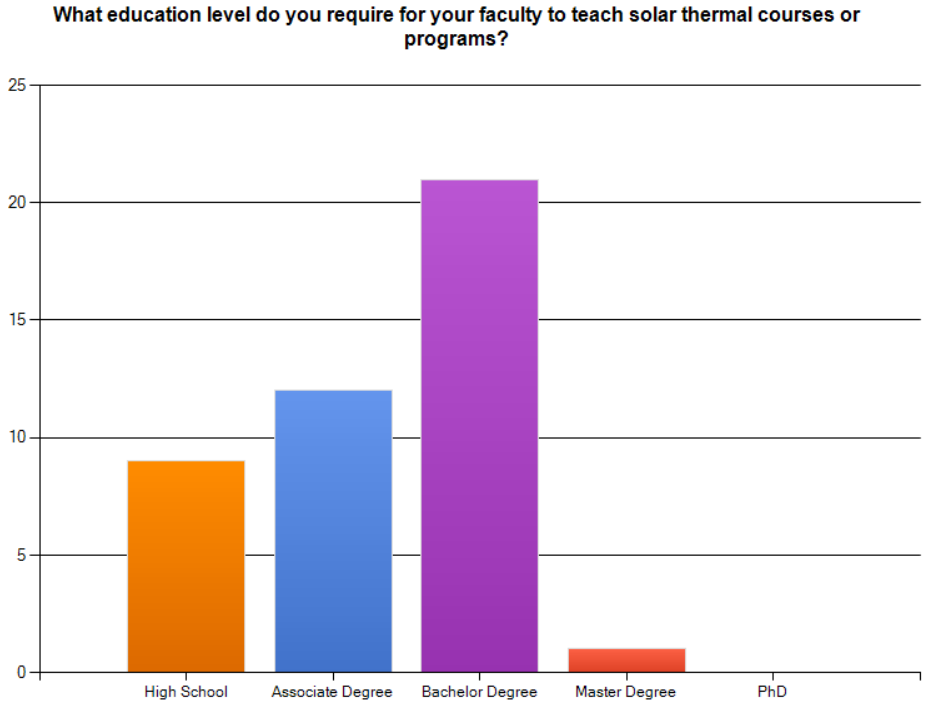


Figure B-15.

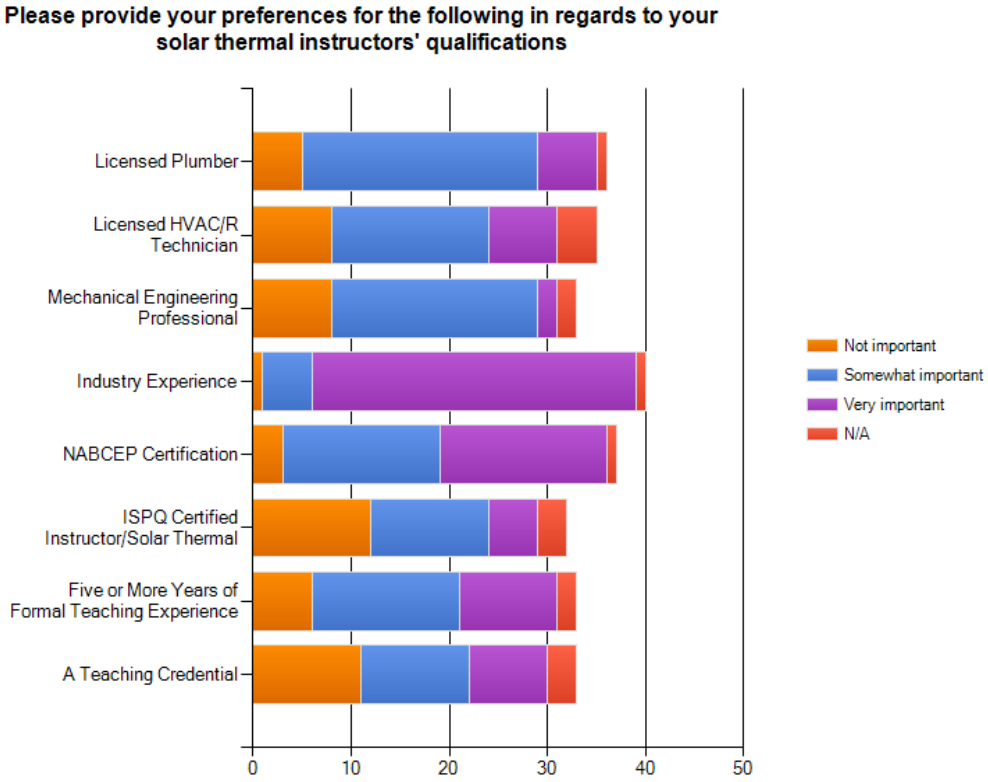


Figure B-16.

Partnerships

Lastly, the survey indicates that courses in PV installation/design are more likely to be affiliated with union or non-union training/apprenticeship programs, internships, or work experience programs than courses in solar thermal installation or solar sales.

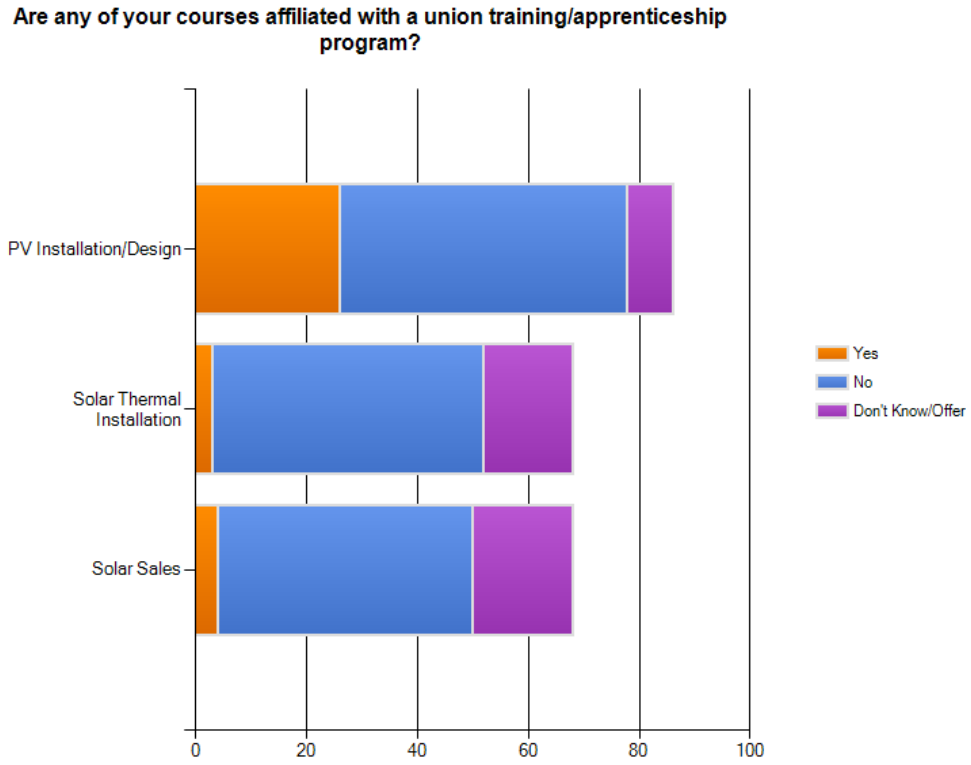


Figure B-17.

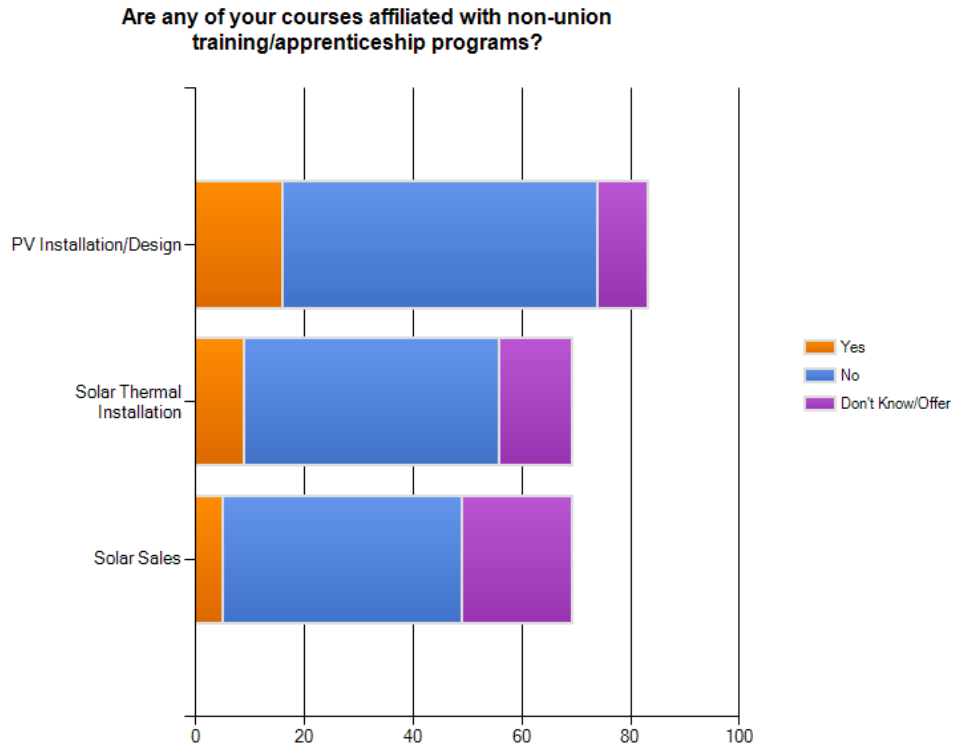


Figure B-18.

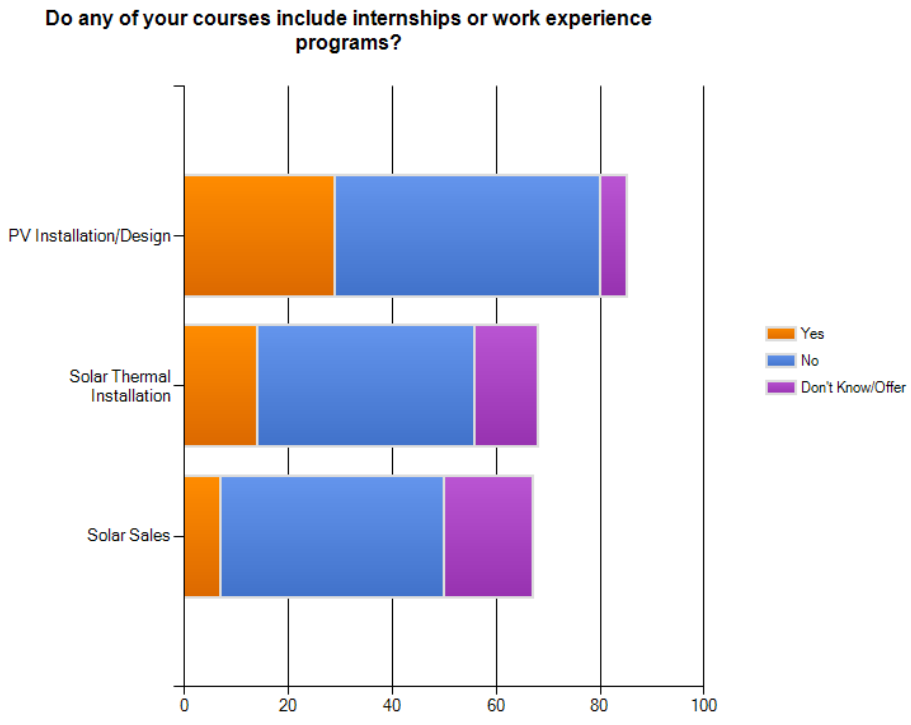


Figure B-19.

Appendix C. Solar Installer Employer Questionnaire

(Italics were provided for questioner emphasis.)

Introduction:

Hello, my name is _____. May I please speak to a Human Resources Manager or person responsible for staffing at [organization]?

Hello, my name is _____, and I'm calling on behalf of **regional education and training providers** who would value your participation in a brief survey that will help address your future organization needs for trained and educated employees in the solar industry.

(If needed): The survey should take approximately 10 minutes of your time. By answering this questionnaire, you can help us develop the appropriate type of training that will prepare the employees you will be looking for in the future.

(If needed): The data will support a national solar installation labor market analysis being conducted by Green LMI Consulting for the National Renewable Energy Laboratory (NREL). The survey is being conducted by BW Research, an independent research organization.

(If needed): Your individual responses will **not** be published; only aggregate information will be used in the reporting of the survey results.

Screener Questions:

A. Does your firm install solar systems or provide services for installation of solar systems?

1 Yes [CONTINUE]
2 No [TERMINATE]
3 Not sure [TERMINATE]

For this survey, please only answer for your current business location. If your firm has more than one location, please do not include their data.

B. What is the zip code of your current business location?

1 *I am answering for my business location in Zip:_____*
2 We are not located within the United States [TERMINATE]
3 (DON'T READ) Refused [TERMINATE]

[PHONE – CHECK DATABASE OF COMPLETES AND END SURVEY IF ALREADY HAVE ONE FOR THAT SAME COMPANY IN THE ZIP CODE GIVEN.]

SECTION 1 - Organization-Related Questions

I would like to begin by asking you a few general questions about your *location*.

1. Thinking about employees that work 30 hours a week or more regularly, how many **permanent full-time** employees work at *your current business location*?

   Record # of employees _____

2. For those employees that work less than 30 hours a week, how many **permanent part-time** employees work *at your current business location*?

   Record # of employees _____

3. If you currently have [TAKE Q1 # + Q2#] full-time and part-time **permanent** employees *at your current business location*, how many more or less permanent employees do you expect to have at *your location* 12 months from now?

   1 More [record #_____]
   2 Less [record #_____]
   3 (DON'T READ) Same number of permanent employees

   [If amount differs by 10% or more in either direction, ask:]
   Just to confirm, you currently have ____ permanent employees and you expect to have _____ (more/less) employees, for a total of ____ permanent employees 12 months from now.

4. Excluding work sub-contracted to other firms, how many temporary, seasonal, or independent workers have you employed at *your current business location* in the last 12 months?

Record # of employees _____
   998 Firm has never employed temporary or independent workers
   999 (DO NOT READ) DK/NA

Next, I would like to ask about your firm's experience with solar installation.

5. Approximately how much of your firm's work *at your location*, in terms of total revenue, is focused on solar installations and/or providing services for solar installation? [IF NEEDED, THIS INCLUDES SOLAR POOL HEATING.]

    1 Most to all of it (76% to 100%)
    2 Half to three-quarters (50% to 75%)
    3 A quarter to almost half of it (25% to 49%)
    4 Less than a quarter (1% to 24%)
    5 (DON'T READ) DK/NA

SECTION 2 – Solar Profile Questions

6. Which of the following types of solar services has your *location* firm been involved in?

[ALLOW MULTIPLE RESPONSES]

    1 Photovoltaic
    2 Water heating, which includes pool heating
    3 Space heating
    4 Cooling System
    5 (DON'T READ) DK/NA

[ASK Q7 FOR EACH ITEM IDENTIFIED IN Q6]

7. Thinking about your current employees, over the last 12 months, how much of their time has been focused on _____ (INSERT RESPONSES FROM Q6) work: most to all of it (76% to 100%), half to three-quarters of it (50% to 75%), a quarter to almost a half (25% to 49%), or less than a quarter (1% to 24%):

    1 = Most to all of it (76% to 100%)
    2 = Half to three-quarters (50% to 75%)
    3 = A quarter to almost half of it (25% to 49%)
    4 = Less than a quarter (1% to 24%)
    5 = (DON'T READ) DK/NA

1	Photovoltaic	1	2	3	4	5
2	Water heating, including pool heating…….....	1	2	3	4	5
3	Space heating.....	1	2	3	4	5
4	Cooling system.....	1	2	3	4	5

[DEFINE SOLAR INSTALLATION FIRM - PV FIRMS IF Q6 = 1 (ONLY) OR Q6 = 1 (OF MULTIPLE) AND Q7A > B + C + D; ALL OTHER FIRMS = NON-

PV SOLAR – THIS DEFINITION DETERMINES WHETHER THEY GET Q8, Q20, AND Q22 FOR PV FIRMS OR Q21, Q23, AND Q24 FOR NON-PV FIRMS – USE MIDPOINT OF EACH PERCENT BREAKDOWN TO SUM AMOUNTS]

[ASK Q8 OF PV SOLAR FIRMS ONLY, ALL OTHERS SKIP TO Q9]

8. Which of the following types of photovoltaic projects is your *location* primarily engaged in? [Multiple responses permitted]
   - 1 Residential systems
   - 2 Small commercial systems from 6 to 50 kilowatts
   - 3 Medium to large commercial and industrial systems from 51 to 200 kilowatts
   - 4 Large commercial or utility-scale projects (>200 kilowatts)
   - 5 (DON'T READ) DK/NA

SECTION 3 – Workforce Development & Training Needs

9. Now I am going to read a list of issues facing solar industry employers in the coming years. Please tell me how much difficulty your *location* faces in addressing each workforce need.

   Here is the (first/next) one _____ (READ ITEM): Please tell me whether your organization has no difficulty, some difficulty, or great difficulty in dealing with this issue.

1 = No difficulty
2 = Some difficulty
3 = Great difficulty
4 = (READ DON'T) DK/NA

1	Providing training opportunities so current employees are able to advance within the organization ……..	1	2	3	4
2	Recruiting entry-level employees with appropriate training and education	1	2	3	4
3	Recruiting non-entry level employees with adequate skills and work experience	1	2	3	4
4	Retaining valuable employees who could be hired by competitors	1	2	3	4

10. Next I would like to ask you about employee development practices at your business *location*. As I read each of the following employee development practices, please indicate whether your *location* uses each practice.

RANDOMIZE

1 = Yes
2 = No
3 = (DON'T READ DK/NA)

A. Offers internships either paid or unpaid..... 1 2 3
B. Offers apprenticeships or other certified on-the-job training programs……..... 1 2 3

Q12 ONLINE ONLY
[IF Q10A = 2, THEN ASK Q11, OTHERWISE SKIP]
11. Has your location ever offered internships, either paid or unpaid?

1 Yes
2 No
3 (DON'T READ) DK/NA

[IF Q10B = 2 THEN ASK Q12, OTHERWISE SKIP]
12. Has your location ever offered apprenticeships or other certified on-the-job training programs?

1 Yes
2 No
3 (DON'T READ) DK/NA

13. How does your *location* prefer to train current employees? [ALLOW MULTIPLE RESPONSES.]

[RANDOMIZE PRESENTATION OF ITEMS 1 – 5]

1 Informal, on-the-job training
2 Customized training for your employees
3 Courses at a local training or education provider, such as a community college
4 A union apprenticeship program
5 Courses taught through an industry-specific association or group
6 (DON'T READ) Other, Please specify_____
7 (DON'T READ) DK/NA

Q14 ONLINE ONLY
[IF Q13 = 3, THEN ASK Q14, OTHERWISE SKIP]

14. For which of the following types of training programs or services has your location worked with a local education or training provider? [ALLOW MULTIPLE RESPONSES]

    1 Internships
    2 On-the-job training programs
    3 Coursework or classes
    4 (DON'T READ) DK/NA

SECTION 4 – Occupational Assessment

Occupation-Related Questions

[NOTE - PLEASE COMMUNICATE TO RESPONDENT THAT WE WILL BE USING GENERAL OCCUPATIONAL TITLES RATHER THAN SPECIFIC JOB TITLES THAT MAY BE USED WITHIN EACH ORGANIZATION.]

15. Now I am going to ask you about specific occupations within your organization related to your solar business. The occupational titles we are using may differ from the specific position titles used in your organization. For these questions, I would like you to try to equate your organization's specific position titles with the more general ones we will use here.

    Please only assign one occupation to each employee. If they fall into more than one category, please assign them to the occupation in which they devote more of their time.

    Please tell me if your organization employs, at *your location*, individuals in positions matching the following general occupational titles:

    Here's the (first/next) one: _____ (READ ITEM, THEN ASK): Do you have employees who fit this occupational description at (any of your business locations/your current business location)?
    (1 = Yes, 2 = No, 3 = DK/NA)

    [Occupational List (Read brief definition of occupation only if needed by respondent)]

Occupations

Occupation 1: Solar water or pool heating installers or technicians

Occupation 2: Solar photovoltaic installers or technicians

Occupation 3: Sales representatives or estimators

Occupation 4: Solar designers or engineers

Occupation 5: Solar installation managers or project foremen

Occupation 6: HVAC technicians with specific skills in solar installations

Occupation 7: Energy auditors

Occupation 8: Site assessors and/or remote evaluators

Occupation 9: Plumbers with specific skills in solar installations

Occupation 10: Electricians with specific skills in solar installations

Occupation 11: Roofers with specific skills in solar installations

[SELECT UP TO FOUR OF THE OCCUPATIONS THAT THE RESPONDENT INDICATED ARE REPRESENTED AT THEIR LOCATION(S) IN Q15 – TO BE ASKED THE FOLLOWING OCCUPATIONAL QUESTIONS]

[NOTE: FOR DATA COLLECTION, EACH OCCUPATION SHOULD HAVE ITS OWN NUMBER AND THAT NEEDS TO BE USED FOR ENTIRE DATA COLLECTION – FOR EXAMPLE, OCCUPATION 6 SHOULD ALWAYS BE OCCUPATION 6 – RESPONSES TO Q16 FOR OCCUPATION 6 SHOULD BE FOUND UNDER Q16.6]

Next I am going to ask you a few questions about some of the occupations you mentioned, including _____ (READ LIST OF OCCUPATIONS TO BE USED).

16. As I read each of the following occupations, please tell me how many individuals you have at *your current business location* that are currently employed either full-time or part-time in this occupation.

    (IF NEEDED: Please exclude temporary, seasonal, and independent workers from these counts.)

Occupation 1	#### (Record Number)
Occupation 2	#### (Record Number)
Occupation 3	#### (Record Number)
Occupation 4	#### (Record Number)

[CREATE INTERNAL CONTROL SO THAT THE COMBINED OCCUPATIONAL EMPLOYMENT IS NOT MORE THAN OVERALL EMPLOYMENT Q1 + Q2]

17. As I read each of the occupations again, please tell me how many more or less employees you estimate will be employed in each of the occupations 12 months from now.

[Use the following format for each one:]

If you currently have [TAKE Q16 #] [INSERT OCCUPATION TITLE] _____ *at your current business location*, how many more or less [INSERT OCCUPATION TITLE] do you expect to have at your *location* 12 months from now?

(IF NEEDED: Please exclude temporary, seasonal, and independent workers from these counts.)

A Occupation 1
- 1 More [record #_____]
- 2 Less [record #_____]
- 3 (DO NOT READ) Same number of Occupation 1

B Occupation 2
- 1 More [record #_____]
- 2 Less [record #_____]
- 3 (DO NOT READ) Same number of Occupation 2

C Occupation 3
- 1 More [record #_____]
- 2 Less [record #_____]
- 3 (DO NOT READ) Same number of Occupation 3

D Occupation 4
- 1 More [record #_____]
- 2 Less [record #_____]
- 3 (DO NOT READ) Same number of Occupation 4

[If amount differs by 10% or more in either direction, ask:]
Just to confirm, you currently have ____ (insert occupation title) and you expect to have _____ (more/less), for a total of ____ (insert occupation title) 12 months from now.

18. For the same list of occupations, I'm interested in the level of difficulty your *location* has in finding applicants who meet the organization's hiring standards. As I read each occupation, please tell me whether your *location* has no difficulty, some difficulty, or great difficulty finding qualified applicants. (PRESENT IN ORDER THEY WERE PREVIOUSLY PRESENTED.)

    1 = No difficulty
    2 = Some difficulty
    3 = Great difficulty
    4 = (DO NOT READ) DK/NA

1	Occupation 1.....1	2	3	4
2	Occupation 2.....1	2	3	4
3	Occupation 3.....1	2	3	4
4	Occupation 4.....1	2	3	4

SECTION 5 – Occupational Wage Assessment

[Q19 ONLINE ONLY]

19. What is the typical pay range for each occupation, from entry-level to most experienced employees in that occupation? [After each response to the pay range, please clarify whether the intended response was for hourly [1], monthly [2], or annual salary[3] [IF NEEDED: CLARIFY THIS IS WAGES ONLY NOT BENEFITS]

1 = Hourly
2 = Monthly
3 = Annually
4 = (DON'T READ) DK/NA

1	Occupation 1.....1	2	3	4
2	Occupation 2.....1	2	3	4
3	Occupation 3.....1	2	3	4
4	Occupation 4.....1	2	3	4

SECTION 6 – Skills & Experience Assessment

We have completed all of the questions about specific occupations. Next I want to ask about the type of educational backgrounds your firm prefers for those individuals that work on solar projects.

[ASK Q20 OF PV FIRMS ONLY, ALL OTHERS SKIP TO Q21]

20. Thinking about the different types of technicians and installers that work at your **photovoltaic installations**, do any of these individuals require the following skills sets or educational certifications, and if so, are they somewhat important or very important?

As I read each skill or area of knowledge, please indicate whether you have technicians that require this skill or area of knowledge and if so, whether it is somewhat important or very important.

1 = No this is not needed
2 = Somewhat important
3 = Very Important
4 = (DON'T READ) DK/NA

RANDOMIZE

1	Ability to develop CAD (computer-aided design) Drawings……	1	2	3	4
2	NABCEP (North American Board of Certified Energy Practitioners) Solar PV Installer Certification	1	2	3	4
3	Customer service skills that simplify the solar installation Process……	1	2	3	4
4	General construction experience……	1	2	3	4
5	General understanding of the mechanics and engineering of solar power……	1	2	3	4
6	A state licensed solar installer.....	1	2	3	4
7	A state licensed electrician	1	2	3	4
8	Electricians' skills and/or experience.....	1	2	3	4
9	Knowledge of site assessment technology.....	1	2	3	4
10	Passed the NABCEP (North American Board of Certified Energy Practitioners) Solar PV Entry-Level Exam	1	2	3	4
11	Knowledge of Article 690 NEC (National Electrical Code)……..	1	2	3	4
12	Associate Degree specific to the position.....	1	2	3	4
13	Field experience on solar installations.....	1	2	3	4

[ASK Q21 OF NON-PV FIRMS ONLY, ALL OTHERS SKIP TO Q22]

21. Thinking about the different types of technicians and installers that work at your **solar heating or cooling installations**, do any of these individuals require the following skills sets or educational certifications, and if so, are they somewhat important or very important?

    As I read each skill or area of knowledge, please indicate whether you have technicians that require this skill or area of knowledge, and if so, whether it is somewhat important or very important.

    1 = No this is not needed
    2 = Somewhat important
    3 = Very Important
    4 = (DON'T READ) DK/NA

1	Ability to develop CAD (computer-aided design)..	1 2 3 4
2	NABCEP (North American Board of Certified Energy Practitioners) Solar Thermal Installer Certification	1 2 3 4
3	Customer service skills.....	1 2 3 4
4	General construction experience……	1 2 3 4
5	General understanding of the mechanics and engineering of solar power…….	1 2 3 4
6	A state licensed plumber	1 2 3 4
7	Plumbing certification not specific to solar.....	1 2 3 4
8	Plumbing skills and/or experience.....	1 2 3 4
9	Knowledge of site assessment technology.....	1 2 3 4
10	Associate Degree specific to the position.....	1 2 3 4
11	Field experience on solar installations.....	1 2 3 4

SECTION 7 – Solar Experience Profile

Lastly, I want to ask you about the last 12 months of your business as it relates to solar installation.

[ASK Q22 IF PV FIRM, THEN SKIP TO Q25]

22. Approximately, how many kilowatts did your firm install over the last 12 months?

1	1 to 100 kilowatts
2	101 to 500 Kilowatts
3	501 kilowatts to 1 megawatt
4	1 megawatt to 2 megawatts
5	More than 2 megawatts
6	(DON'T READ) DK/NA

[ASK Q23 & Q24 IF NON-PV FIRMS ONLY]

23. What would you estimate is the average size, in square feet, of the solar collectors you installed over the last 12 months?

#_____	SQUARE FEET
999	(DON'T READ) DK/NA

24. Approximately, how many collectors have you installed over the last 12 months?

1 1 to 50 collectors
2 51 to 500 collectors
3 501 to 1,000 collectors
4 1,001 to 5,000 collectors
5 More than 5,000 collectors
6 (DON'T READ) DK/NA

Before we finish, I'd like to ask you a general question and verify your contact information.

SECTION 8 – Permission Questions

25. Do we have your permission to give your contact information to the National Renewable Energy Lab, or NREL, who is currently looking at ways to best support the solar industry in the United States?

1 Yes
2 No
3 (DON'T READ) DK/NA