WORKFORCE DEVELOPMENT: A SURVEY OF INDUSTRY NEEDS AND TRAINING APPROACHES

Jerry Ventre
Interstate Renewable Energy Council
P.O. Box 621346
Oviedo, FL 32762-1346
e-mail: gventre@pegasus.cc.ucf.edu

Jane M. Weissman
Interstate Renewable Energy Council
P.O. Box 1156
Latham, NY 12110-1156
e-mail: jane@irecusa.org

ABSTRACT

This paper presents information and data collected during 2008 on PV workforce needs by the Interstate Renewable Energy Council (IREC) for the U.S. Department of Energy and the New York State Energy Research and Development Authority (NYSERDA). The data was collected from licensed contractors, PV practitioners, educators and expert instructors at training sessions, and at focus group and advisory committee meetings. Respondents were primarily from three states: Florida, New York and California. Other states were represented, but to a lesser extent. For data collection, a 12-item questionnaire was developed that addressed key workforce development issues from the perspectives of both the PV industry and training institutions. A total of 63 responses were collected, although not every respondent answered every question. Industry representatives slightly outnumbered the educators, although the difference in responses was not significant.

1. INTRODUCTION

The rapid expansion of photovoltaic (PV) markets poses great challenges to the PV industry in meeting workforce needs. Data presented by Navigant Consulting, Inc. at Solar Power International 2008 showed a projected increase in U.S. solar supported employment of 440,000 jobs over the next eight years. Of this number, 110,000 are estimated to be directly related to the solar industry – both PV and solar thermal (1). Additional studies performed for ASES and by various groups in California and Florida confirm the need to seriously ramp up the workforce to meet these projections (2, 3, 4). And, most recently, the American Recovery and Reinvestment Act places strong emphasis on growing the solar industry and creating green collar jobs. The questions that these projections raise are: What types of jobs will be most needed and what are some approaches to training that may be implemented to help meet these challenges?

2. GOALS AND OBJECTIVES OF PHOTOVOLTAIC WORKFORCE DEVELOPMENT EFFORTS

The primary goal is to create a well trained and highly qualified workforce of sufficient size and diversity to meet the projected needs of this country. Training should be widely accessible and offered locally. The goal of the skilled workforce is to improve the quality of solar products and system installations, thereby increasing consumer acceptance and product demand. From an educational perspective, the training approaches used must be sensitive to the different needs of local and regional markets. The objective is to ensure the marketability of graduates – there must be local jobs for students trained locally. Finally, traditional education and training institutions, especially community colleges and vocational-technical institutions, must be actively engaged to play a major role in this national PV workforce development effort.

3. PV PROBLEMS THAT CAN BE ADDRESSED BY TRAINING

There are many potential problems with PV systems that training can address. Starting with *PV components*, the rapid increase in the number of new PV products from around the world (many from companies new to PV) requires that trainers be aware of which products comply with relevant standards and meet applicable certification requirements.

Problems that have been encountered with *PV system design* that can be addressed with proper training include a lack of design documentation; poor system designs that do not or will not meet code; and the widespread lack of familiarity among trainers with three-phase systems that

are used in large commercial and utility-scale applications – rapidly growing sectors within the PV industry.

Much of workforce development has focused on *PV system installation* training, and for good reason. For over two decades, technical professionals at the Photovoltaic Southeast and Southwest Regional Experiment Stations (SE RES and SW RES), which are operated for the U.S. Department of Energy by the Florida Solar Energy Center and New Mexico State University respectively, have been involved in numerous acceptance tests and inspections of PV system installations. They have also had extensive experience monitoring the performance of PV systems in the field. Recurring problems that have been identified include the following: insecure structural attachment of PV arrays; inadequate weather sealing of roof penetrations; unsafe wiring methods; improper ratings of electrical components; improper configuration of protection and disconnect devices; unsafe installation of batteries; use of unlisted equipment or improper application of listed equipment; improper system grounding; inadequate labeling of major system components and disconnect devices; and inadequate documentation of system designs and operation and maintenance procedures. All of the above problems can be addressed through proper training. Poor quality installations are not uncommon and the problem is compounded by a lack of qualified PV system installers and knowledgeable contractors in a rapidly increasing market. Local training has not been readily available in many parts of the country and the training that is available may not be sufficient. Opportunities for on-the-job (PV specific) training experience need to be expanded. In addition, variations in building codes among states and jurisdictions reinforce not only the need for high-quality PV training, but also the need to make the training available locally.

The process of *PV permitting and inspection* is designed to identify, avoid and alleviate problems encountered with the PV system design and/or installation. The process, however, has been spotty at best and has presented problems for industry, building officials, and consumers. Not only do building officials need PV systems training, but permitting and inspection should be included topics in PV installation training courses and programs.

Other areas where problems have been encountered include *PV sales, site assessment and project cost estimating*. These three functions are closely related and involve the early interaction between the PV installation contractor and the customer. Improperly performed site assessment and/or project cost estimating (for example, underestimating the effects of shading, over or under estimating the cost of materials and labor required to install a system, or improperly sizing the system) can have seriously financial consequences for the contractor, customer or both. These potential problems can often be avoided through training programs that specifically target marketing and sales personnel, site assessors, licensed contractors, architectural and engineering firms, energy managers and facilities personnel.

4. PROBLEMS WITH EXISTING PV EDUCATION AND TRAINING

Although there are a number of highly regarded PV systems training programs in the U.S., in general they can be characterized as follows:

- Often they are not widely accessible or offered locally.
- They are often expensive considering time, transportation and lodging, etc.
- They do not provide sufficient on-the-job experience.
- They do not sufficiently cross disciplines.
- They do not differentiate among the types of jobs that are emerging.
- They do not clearly target solar occupational areas, titles, tasks and skill sets.
- They do not adequately define career paths.
- With few exceptions, they have not been embedded into existing community college, vocational-technical and university curricula or continuing education offerings.

If training is to be made widely available at the local level, which organizations should provide it? There are several possibilities, including construction trade organizations and traditional educational institutions. For example, the NJATC (i.e., the National Joint Apprenticeship and Training Committee) has recently become much more active in providing training at the apprentice, journeyman and electrical contractor levels. The NJATC is jointly sponsored by the International Brotherhood of Electrical Workers (IBEW) and the National Electrical Contractors Association (NECA). With over 300 well-equipped training centers, a highly regarded curriculum package, and a well-defined apprenticeship program that provides both classroom and on-the-job learning experience, the electrical industry has arguably the best model for training PV installers. However, because a large percentage of solar installations have been and will continue to be installed by independent contractors using non-union tradespersons, there is a pressing need for other education and training institutions to get involved in meeting growing workforce development needs.

Much of the training in the U.S. over the last decade has been concentrated among a relatively small number of

institutions, including the Florida Solar Energy Center (FSEC), Solar Energy International (SEI), New Mexico State University (NMSU), North Carolina Solar Center (NCSC), Midwest Renewable Energy Association (MREA), Great Lakes Renewable Energy Association (GLREA), Lane Community College (LCC), Hudson Valley Community College (HVCC), and several other organizations. Also, a number of excellent industry training programs have been offered by component manufacturers and system suppliers for their professional staffs, distributors, dealers and technicians. These include training in PV system design, sales, installation, and maintenance.

Although many of the above programs are of high quality, travel costs alone severely limit the number of individuals that can be trained. With the recent expansion of renewable energy markets and projected future growth, the need to provide local and accessible training has never been greater. Although many organizations will contribute to meeting this need, community colleges and vocational-technical institutions will most likely have the most significant role.

5. WORKFORCE DEVELOPMENT SURVEY

To obtain a better understanding of workforce development issues, needs and preferred training approaches, a 12-item questionnaire was developed and distribute to representatives of both the PV industry and education and training organizations. The following twelve items were on the questionnaire, and additional comments were encouraged.

1. Prioritize each target group listed below according to their need for training from A=highest priority/greatest need to D=lowest priority/not too important.
   - Solar installers ____
   - Licensed contractors ____
   - System designers and engineers ____
   - Code officials ____
   - Accountants for construction cost accounting __
   - Sales people and site assessors ____
   - Architects and building designers ____
   - Utility personnel ____
   - Others? _____

2. For licensed electrical and solar contractors seeking to hire solar installers, from which group is there the greatest need? Circle your answer.
   - Apprentices and entry level
   - Journey level construction trades people
   - Advanced or master level supervisors and project managers
   - Other? _____

3. For training solar installers, is it better to train electricians (or others from the construction trades) to give them the needed add-on skills required to install PV systems, or should emphasis be placed on creating solar specialists?

4. Does it make sense to train solar specialists in areas with large and stable markets, or should emphasis be placed on developing add-on skills even in these areas? Yes__ No__

5. For community colleges and vocational-technical schools interested in PV installation training, from what groups should they recruit potential students? Circle your answer(s).
   - Existing construction trades
   - Technical professionals
   - High school graduates
   - Other?

6. For community colleges and vocational-technical institutes interested in training PV installers and code officials, what criteria should be used in selecting the institutions to do the training (i.e., what kind of programs should they have and what kind of qualifications should their faculty have)?

7. What delivery methods are most appropriate for training PV installers (i.e., face-to-face with labs, or online, or other options)? Circle your answer or list options.

8. What delivery methods are most appropriate for training code officials (i.e., face-to-face, online, or other options)? Circle your answer or list options.

9. What programs and degree offerings at community colleges and vocational-technical schools match well with solar industry needs? Circle what you think are good matches.
   - Continuing education courses for code officials (half- or one-day programs)?
   - Electrical construction apprenticeship programs for PV installers, including cross-discipline training in roofing, glazing, etc. (two to three-year programs)?
   - AAS degree courses for solar technicians and building energy managers?
   - AS degree courses for curriculum enrichment in system design, building sciences and energy

management (to interface with BSET degree programs)?
- Applied Technology Diplomas as part of new AS or AAS degree programs for solar system design, building design and energy management?
- Post-Secondary Adult Vocational (PSAV) certificate programs for PV technical sales people, site assessors, accountants, or PV technicians.
- PV entry level courses aligned with the NABCEP PV entry level certificate of knowledge.

10. What roles can well-established training centers (e.g., FSEC, NMSU, SEI, NJATC, HVCC, NCSC, LCC, others) play in assisting community colleges and vocational-technical institutes in meeting local solar training needs? Circle your answer(s).
    - Training trainers and assisting faculty in developing needed courses
    - Providing updates on relevant changes to codes and standards
    - Acting as a resource center for information on new technology developments
    - Other? _____

11. What options might be pursued by interested community colleges and vocational-technical institutes in equipping their hands-on training facilities? Circle your answer(s).
    - Partnerships with utilities
    - Partnerships with component and system suppliers
    - Local corporate sponsors
    - Contracts and grants from various agencies
    - Shared-use facilities
    - Other? _____

12. For training the identified target groups, which group(s) can most easily be trained online? Circle your answer(s).
    - Building officials and inspectors
    - Designers and engineers
    - Accountants, sales people and site assessors
    - Architects and building designers
    - Utility staff
    - Others? _____

5.1 Who Needs To Be Trained?

One of the objectives of the survey was to obtain a priority ranking of those jobs in the photovoltaic industry that were most in need of training. The results were as follows:

- PV installers. Representatives from both industry and education agreed strongly that "PV installers" were the number one priority, ranking them considerably higher than the seven other categories. This group is and will continue to be the primary target group because it most significantly impacts the quality of system installations. It includes construction trade apprentices, journeymen electricians, incumbent workers who need to update and upgrade skills, and PV manufacturers and suppliers who need skilled technicians for market growth and maintenance. This is a large and growing group, and training needs to be provided locally for the most part.
- PV system designers and engineers. In the past, PV system design has been handled by the solar or electrical contractor, and this works well for small, simpler systems. However, with the rapid increase in large, three-phase, commercial and utility-scale systems, there is a growing need for training among electrical, mechanical and civil engineers to oversee the design process.
- Contractors licensed to install PV systems. Electrical, solar and other construction contractors are becoming increasingly interested in PV systems as the market develops, and they need to become much more knowledgeable about PV technology. With this increased involvement, they will provide more opportunities for PV-specific on-the-job training for apprentices and journeymen installers.
- Building code officials and inspectors. The two separate functions of plan review and approval (i.e., permitting) and field inspection of installed systems need to be addressed because code officials typically provide the last assurance of satisfactory installations. Poorly trained installers and poorly trained building officials present a prescription for big problems for both customers and suppliers.
- Sales and site assessment personnel, including estimators. Over the past several years, there has been a growing realization of the important role for these individuals. Project cost estimation is one of the most critical functions within the construction industry. Because this task is typically performed by the PV sales and site assessment professional, greater emphasis is now being placed on specific training for these individuals.
- Architects and building designers. The overall trend has been toward more and larger residential and commercial PV systems on buildings. This requires more training of architects and building designers. Building-integrated PV (BIPV) applications are leading to more PV courses in schools of architecture. In addition, the design, integration and installation of large commercial and utility-scale

applications have spurred new training specifically for architectural and engineering (A&E) firms.

- Utility personnel. The combination of investment tax credits, net metering, renewable portfolio standards, and energy efficiency and conservation programs has produced a surge of interest and activity among utility companies in solar applications. These applications range from residential-size systems to multi-megawatt commercial and utility-scale systems. Utilities are seeking more training for their professional staffs.
- Construction cost accountants and financing professionals. The PV industry is expanding rapidly, larger systems are being installed, and projects are becoming more complex. Consequently, finance and accounting professional need to become more knowledgeable of PV system technology, including all the cost parameters that affect economic viability.

5.2 At What Level Is Industry Looking To Hire PV Installers?

In the survey and supporting assessments, PV installers were clearly identified as the number one workforce development priority. For hiring PV installers, both industry representatives and educators agreed that there was a strong need at all three levels: the entry or apprentice level, the journeyman level, and the foreman or supervisor level. Industry indicated a slight preference for practitioners at the journeyman level.

5.3 Add-On Skills versus Solar Specialists

In developing and expanding the PV workforce, respondents were asked whether it was best to provide add-on skills to existing construction trades, for example by providing already skilled electricians with additional training in solar and PV, or to train "solar specialists" from the ground up. Two different results were obtained, depending on the size of the PV market. By a two to one margin, respondents felt that the "added skills approach" was best in areas with smaller, emerging markets, which characterize much of the U.S. However, for large, rapidly growing and well-established markets, such as in California, respondents indicated that programs for educating and training solar specialists from the ground up were preferred.

5.4 Recruiting PV Installer Trainees

Educational institutions are reluctant to establish new courses or programs until they are convinced not only of the workforce need, but also of their ability to attract students. Respondents were asked to identify potential students for PV installer training. The existing construction trades, such as electrical construction workers, were identified as the key target group from which education and training institutions should recruit students. This group ranked significantly higher than two other groups that were mentioned, which were high school graduates and technical professionals.

5.5 Selection Criteria for Training Institutions

Respondents were asked to suggest criteria to be used in selecting institutions to train PV installers and building code officials. Results can be categorized in the following areas: types of programs, qualifications of faculty, and training facilities.

Concerning the types of programs, the majority of responses indicated that the training institutions should have strong construction trades programs, including electrical and building construction. Many felt that the training of PV installers and code officials should be done through continuing education programs – at least initially.

For faculty criteria, most respondents felt that instructors should be highly qualified installers, knowledgeable in design and have actual experience in PV system installation. They should have a strong background in the construction trades, preferably electrical. They should be knowledgeable and experienced in AC and DC electricity, the National Electrical Code and local building codes, occupational safety, and mathematics. Others suggested that instructors should be certified, and should be required to update skills on a periodic basis to maintain certification. Last but not least, they should possess good teaching skills.

Most respondents indicated a need for appropriately sized classrooms, and laboratory facilities adequately equipped to effectively teach the hands-on skills required to install PV systems.

5.6 Methods of Delivering Training

Data was also collected on preferred training delivery methods. For PV installers, face-to-face classroom training combined with hands-on practice of PV installation was strongly preferred over online delivery or a combination of on-line and face-to-face delivery. Both industry representatives and educators agreed. Respondents indicated not only the need for hands-on training in a laboratory environment, but also for practical hands-on training on the job, such as would be available in apprenticeship programs. In fairness, it should be noted that, as a group, the respondents had not had significant experience with online training and possibly did not fully appreciate the potential for combining online

preparatory training followed by face-to-face and hands-on training.

Similar results were obtained when questioned about delivery methods for training code officials, although respondents indicated that it was acceptable for hands-on installation practice to be replaced with hardware demonstrations.

5.7 What Groups Can Be Trained Online?

If online training is to be used, for what groups is it most appropriate? Both industry and training representatives indicated that PV system designers and engineers may be the easiest groups to train online, followed in order by building code officials and inspectors, architects and building designers; accountants, sales personnel and site assessors; and finally utility personnel.

5.8 Preferred Types of Courses and Training Programs

Both industry and educators indicated a preference for *PV training at the entry level via continuing education* offerings. Continuing education courses of a week or less in PV system installation should be directed at journey level construction workers, especially those in electrical construction. Continuing education courses in PV system permitting and inspection at community colleges make sense because of the local nature of building code requirements.

Respondents also strongly supported *construction trade apprenticeship programs* such as currently being used by the electrical industry to train PV installers. The PV systems curriculum developed by NJATC is now used by many of their training centers, which typically offer more than 40 hours of classroom instruction in PV system installation to complement on-the-job mentoring in the field. It should be noted that community colleges and vocational-technical institutions have the advantage of offering cross-discipline training in their vocational curriculum and apprenticeship programs (e.g., electrical plus roofing for PV, and plumbing plus roofing plus electrical for solar thermal, etc.).

Next in preference, especially by educators, was the *Associate in Applied Science (AAS) degree program*. These programs stress technology to prepare students for employment in a specific occupation, such as a PV technician. They do not require general education credits and are generally not meant as preparatory for a follow-on degree. Lane Community College very effectively uses the AAS degree for its energy management and renewable energy technician programs.

Certificate programs, typically consisting of three to five courses, are becoming increasingly popular among community colleges for PV education and training. Respondents to the survey indicated support for these programs for training in PV system design, installation, sales and site assessment. Certificate programs are usually designed to prepare students for entry-level employment, or to supplement employed workers with education and training to increase competency in their occupational field. Although most popular among community colleges, they can be offered at any level from high school to post graduate.

There was less support for both *Applied Technology Diplomas (ATD) and Associate in Science (AS) degree programs* than for the other options mentioned above. A nice feature of the AS degree is that it can be transferred from the community college to a four-year program, such as a Bachelor of Science in Engineering Technology. These programs are well suited for curriculum enrichment for students who might want to pursue PV system design or energy management.

Once the institutional goal has been established based on a local needs assessment, education and training organizations have to develop an implementation plan. The easiest and most preferred approach for these organizations to get started is by offering continuing education courses – either at the PV entry level or more advanced courses in PV system design and/or installation. With experience and proven demand for training, more emphasis can be placed on multi-course certificate programs, two-year degree programs and, depending on market size, four-year programs. Some institutions are providing prospective students with several different options. For example, Hudson Valley Community College in Troy, New York offers a 40-hour non-credit continuing education course in PV system installation; a 19 credit-hour certificate program of approximately one-year duration that includes courses in AC and DC electricity, residential and commercial electrical wiring, and two PV courses; and a two-year degree program leading to an Associate of Occupational Studies (AOS) in Electrical Construction and Maintenance that includes two PV courses.

Finally, it should be mentioned that some states are structuring articulation agreements beginning with middle school, through high school to post secondary and college. Also, universities are actively looking into four-year degree programs, post-graduate certificate programs, and even graduate programs in renewable energy.

5.9 Roles of Established Training Centers

Respondents agreed that a primary role of well-established training centers, such as FSEC, SEI, NMSU, NCSC, MREA, GLREA, LCC and HVCC, should be to leverage their training capabilities by training trainers. The NJATC has been actively doing this for years to make PV installation training available to a large portion of the electrical industry. Secondary roles for these established training organizations should include acting as resource centers for new technology developments, and providing updates on changes in codes, standards and other applicable regulatory requirements.

5.10 Resources To Develop Training Facilities And Equipment

Desirable training equipment for instruction in PV system installation includes complete PV systems, PV modules, inverters, batteries, charge controllers, electrical balance-of-system components, support structures and mounting hardware, site assessment tools, testing and measurement equipment, power and hand tools, and safety equipment. Laboratory equipment can be expensive, and respondents were asked to identify potential sources of funding. At the top of the list were component and system suppliers. Related to this response, training organizations were strongly encouraged to establish partnerships with local solar companies to provide not only equipment for training, but also adjunct instructors. Utilities companies ranked second as potential supporters of laboratory development. At several advisory and focus group meetings, utility representatives reacted favorably to the idea of assisting training organizations in equipping laboratories. The third priority was to apply for contacts and grants from various agencies, including proposals to the National Science Foundation for Advanced Technological Education (ATE) projects. Next, local (non-solar) corporate sponsors were suggested as a source for funding. Finally, proposals or applications to departments of labor and workforce development agencies were mentioned as possible funding sources. It should also be noted that shared use of facilities, for example between a high school and community college, or between a system supplier and a training organization, has been used effectively in various parts of the country.

6. RECRUITING FACULTY

In many cases, education and training organizations interested in helping to build a strong renewable energy workforce may not have instructors with the appropriate knowledge, skills and attitudes to train in areas such as PV system installation. Consequently, they will have to recruit new faculty. In doing so, they should seek individuals with a strong background in the construction trades, preferably electrical. And, as mentioned in an earlier section, they should be knowledgeable and experienced in AC and DC electricity, the National Electrical Code and local building codes, and occupational safety. They should also be knowledgeable and experienced in PV technology, including system design and installation, and have an appropriate background in mathematics. Most importantly, they should possess excellent teaching skills.

7. TRAIN-THE-TRAINER WORKSHOPS

Four IREC train-the-trainer workshops were offered during the past year in New York and California. In addition, Workforce Florida, Inc. sponsored two workshops at the Florida Solar Energy Center through the Employ Florida Alternative Energy Banner Center. The purpose of the workshops was to help faculty at community colleges, vocational-technical institutions, high schools and universities to not only develop high-quality PV systems courses and programs that will help meet workforce goals and objectives, but also to do so in significantly less time than it would normally take. For all of the workshops, attendees received a comprehensive set of PV course materials designed and developed by the National Joint Apprenticeship and Training Committee and published by American Technical Publishers. These teaching materials included a textbook entitled *Photovoltaic Systems* (5) and a companion document entitled *Photovoltaic Systems Resource Guide* (6). Among other items, the latter document contained a complete set of PowerPoint presentations for all 15 chapters of the text, an instructor's guide; test development software and answer keys; video clips demonstating PV system installations; solar radiation data sets; sun path charts; a solar time calculator; a variety of useful forms and worksheets; an illustrated glossary; and up-to-date reference materials. In addition, attendees received course manuals for each workshop.

The backgrounds of faculty that attended the workshops can be broken down in three categories: 1) Those with teaching experience in the construction trades, but not in PV, 2) Those well versed in PV systems, but new to teaching PV, and 3) Those with teaching experience in related disciplines (e.g., energy management, building sciences, electronics), but not in PV nor in the construction trades. There were also some attendees at the workshops with hardly any relevant experience to prepare them to teach a course in the PV systems area.

Many of the faculty at the Florida workshops fell into the first category. Because they were experienced instructors in the construction trades, their primary need was training in PV systems design and installation, which they received as part of FSEC's highly regarded week-long

training program. The combination of PV training and the teaching materials discussed above allowed them to begin offering courses within months following the workshops.

Although most of the faculty members at the New York workshop and some at the California workshops were well versed in PV, too many were not. Those that were benefited from a better understanding of the course development process using instructional systems design, and knowledge of how to use the PV teaching materials that they received. However, those who did not have a strong grounding in PV systems technology (i.e., those in category 3 above) were much more in need of PV training, which was not part of the two-day workshop because of time limitations. These individuals were encouraged to pursue PV training at a well established institution prior to attempting to introduce PV courses or programs. In addition to the two types of workshops mentioned above, efforts are underway to develop a new three-day PV systems course development workshop that will address the needs of a broader spectrum of faculty backgrounds.

As a result of the PV train-the-trainer workshop experience, IREC has developed a "best practices" document (7) for renewable energy training in general.

8. CONCLUSIONS

The continued rapid expansion of PV markets poses significant challenges to developing a highly qualified workforce. To significantly address these workforce needs, training must be offered locally from established education and training organizations. Because of the nature and diversity of their programs, including those in the construction trades and building-related technologies, community colleges and vocational-technical institutions should play an ever increasing role in PV workforce development.

For the photovoltaics industry, the IREC workforce development survey indicated that the greatest need is for well trained PV installers, followed by PV system designer and engineers, licensed contractors, building code officials and inspectors, and sales and site assessment personnel. Other priority groups include architects and building designers, utility personnel, construction cost accountants and financing professionals. Existing construction tradesmen are the preferred group from which to recruit PV installation trainees. Rather than developing solar specialists from the ground up, developing add-on solar skills to existing construction trade skills is the preferred training approach for much of the U.S.

The preferred delivery method for PV installer training is a combination of face-to-face classroom training, hands-on laboratory training, and on-the-job mentoring in the field. Survey respondents listed PV system designers and engineers as the easiest groups to train online, followed by building code officials and inspectors, architects and building designers, accountants, sales personnel and site assessors, and utility personnel.

The fastest and most direct way for educational institutions to get started in PV training is by offering continuing education courses. PV installation courses should be narrowly targeted for the electrical or related construction trades. PV entry level courses are appropriate for a much wider audience.

Well established training centers can leverage training capability by offering train-the-trainer workshops, thus playing a key role in PV workforce development.

9. ACKNOWLEDGEMENTS

The authors gratefully acknowledge the following individuals and organizations for their help and support in addressing workforce development issues: Katie Bolcar, U.S. Department of Energy; David Block, Florida Solar Energy Center; and Adele Ferranti, New York State Energy Research and Development Authority.

10. REFERENCES

(1) Navigant Consulting, Inc., Economic Impacts of Extending Federal Solar Tax Credits, prepared for the Solar Energy Research and Education Foundation, September 15, 2008
(2) Bezdek, Roger, Green Collar Jobs in the U.S. and Colorado: Economic Drivers for the 21st Century, American Solar Energy Society, January 2009
(3) Carrese, John, et al., California Solar Industry Workforce Study, Centers of Excellence, Economic and Workforce Development, California Community Colleges, April 2008
(4) Block, David, Employ Florida Banner Center for Alternative Energy: Strategic Plan, prepared for Workforce Florida, Inc., Florida Solar Energy Center, November 30, 2008
(5) Dunlop, Jim, Photovoltaic Systems, National Joint Apprenticeship and Training Committee, American Technical Publishers, 2007
(6) Photovoltaic Systems Resource Guide, American Technical Publishers, 2007
(7) Weissman, Jane, et al., Renewable Energy Training: Best Practices and Recommended Guidelines, Interstate Renewable Energy Council, September 2008